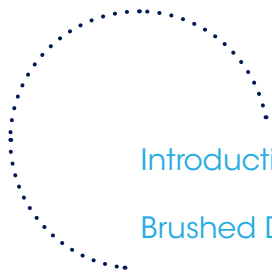


# Motor control Reference Guide

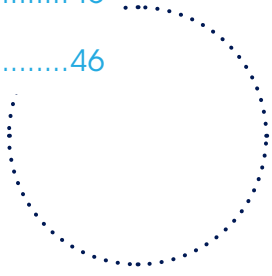


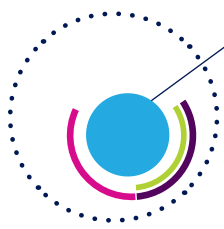


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# Introduction



## ST's commitment to motor control reinforces the green revolution

In line with the green revolution, electric motor control is moving very quickly in the direction of higher efficiency for motors and drives. Moreover, an increased level of integration at optimum cost is required to support market penetration of the new technologies, as well as higher safety and better reliability.

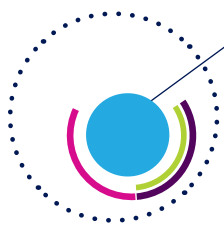
ST has been committed to electric motor control for more than 20 years and was among the first to recognize today's trends. ST is accompanying the change with a set of innovations such as integrated intelligent power modules and monolithic motor drivers, fast and efficient power switches, voltage-transient protected Triacs, and powerful and safe microcontrollers.

Whatever motor technology you use, from traditional and rugged ones to the most modern and efficient, this reference guide will help you identify the right electronic devices from ST.

### STAY UP-TO-DATE

For more information and up-to-date material, visit motor control application page on ST's website at <http://www.st.com/motorcontrol>





# Brushed DC motors

## Overview

A brushed DC motor is an internally-commutated electric motor designed to be run from a direct current power source. Traditionally used in many low-voltage applications, especially where these are powered by batteries, their power can range from a few watts to several horsepower.

When only one direction of rotation is needed, a single-switch topology with PWM modulation can be used to vary the voltage applied to the motor and thus to control its speed.

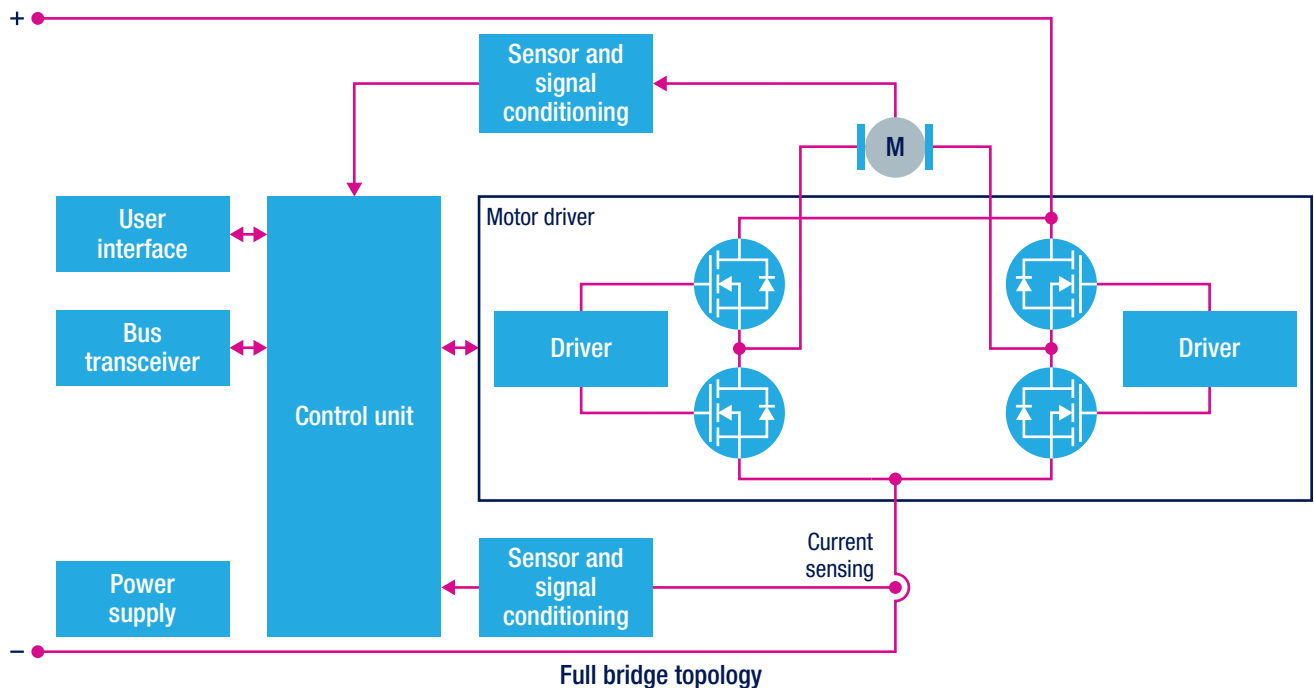
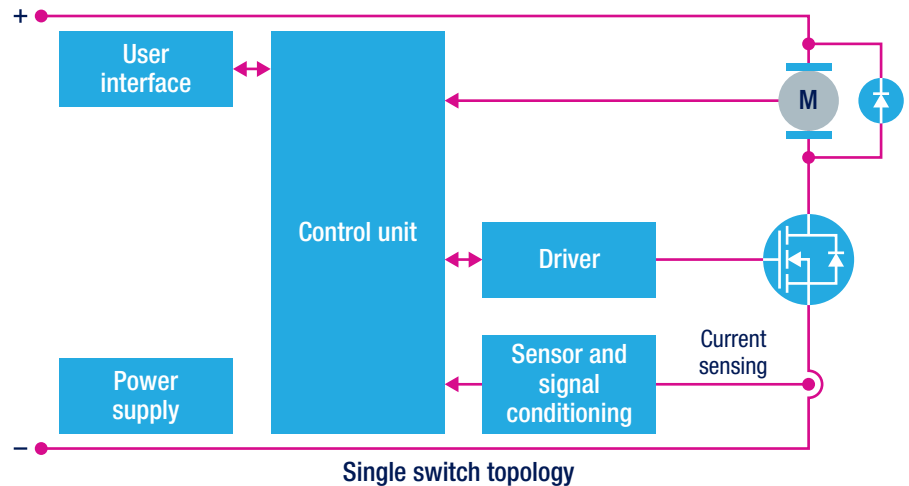
When positioning is required or when both directions of rotation are needed (car windows, for instance) a full H-bridge with PWM control is used.

At lower power levels, ST can offer a wide set of monolithic motor drivers which, with a

progressive choice of integrated

features, may embed gate drivers, power transistors, protection functions and even DC-DC converters. For higher powers, ST's portfolio includes discrete MOSFETs and IGBTs and high-voltage gate drivers to implement the required H bridge.

A general-purpose 8-bit microcontroller such as the STM8S can be used to implement these drives<sup>1</sup>.



Note: 1. Refer to microcontroller chapter on page 40 for more information about suitable part numbers.



# MONOLITHIC MOTOR DRIVER ICs

ST's set of DC motor drivers combine the control logic and power stage in one chip, featuring reliable and cost-effective solutions.

The powerSPIN family addresses stepper, DC and BLDC motors. The family includes the L62x5 and L62x6 that integrate power MOSFETs and gate drivers in one chip, together with a full set of protection functions to reduce the BOM, up to L62x7 that includes PWM current control.

Its four integrated H bridges make flexSPIN (L6460) the best choice for multiple motor systems. With a high level of configurability via the SPI, the four H bridges can be used to drive either DC motors or stepper motors, or used as a DC-DC converter.



## KEY FEATURES

- Multi-package options to deal with both space constraints and thermal requirements, including small QFN and the powerSO featuring 1C/W Rthj-c
- Extensive set of tools to simplify development
- Extensive diagnostic capability
- Robust and fully embedded protection functions to reduce the number of external components, the cost and the complexity
- Wide operating voltage, current and temperature ranges

Part number	Description	Supply voltage min-max (V)	Continuous max output current (A)	Protections	Package
L29*, L2293Q	Basic functionality drivers	2.8 to 36	Up to 2	Thermal	VFQFPN32, PowerDIP16, S020, MW15L, PowerS020
L6201, L6202, L6203	DMOS full bridge drivers	12 to 48	Up to 10	Thermal	PowerS020, S020, PowerDIP18, MW11L
L6205, L6225	Dual full bridge drivers	8 to 52	Up to 2.8	Thermal, overcurrent, undervoltage	PowerDIP20, PowerS020, S020
L6206, L6226	Dual full bridge drivers	8 to 52	Up to 2.8	Thermal, programmable overcurrent, undervoltage	QFN48, PowerDIP24, PowerS036, S024
L6207, L6227	Dual full bridge drivers with PWM current controller	8 to 52	Up to 2.8	Thermal, programmable overcurrent, undervoltage	QFN48, PowerDIP24, PowerS036, S024
L6460	SPI configurable stepper and DC multi motor driver	13 to 38	2.5	Thermal, overcurrent, undervoltage	TQFP64



## POWER SWITCHES

### Power MOSFETs

Specifically for DC brushed motors, ST's MOSFET portfolio offers a broad range of breakdown voltages up to 250 V, with low gate charge and low on-resistance combined with excellent source-drain diode performance for reduced power losses. Additionally, the high avalanche ruggedness and the embedded zener diodes for gate-source and gate-drain clamping make the device rugged and reliable.

<b>T0-220</b>  <b>2.7 mΩ 100 V</b> <b>STP310N10F7</b>	<b>H<sup>2</sup>PAK</b>  <b>2.2 mΩ 80 V</b> <b>STH270N8F7-2</b>	<b>DPAK</b>  <b>3 mΩ 30 V</b> <b>STD155N3H6</b>	<b>PowerFLAT 5x6</b>  <b>21/36 mΩ 30 V</b> <b>STL40C30H3LL</b>
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### KEY FEATURES

- Very low on-resistance
- High avalanche ruggedness
- High current capability
- Low thermal resistance
- Low Qrr and right softness for bridge configuration
- Simplifies driving stage for P-channel FETs (no bootstrap circuitry)

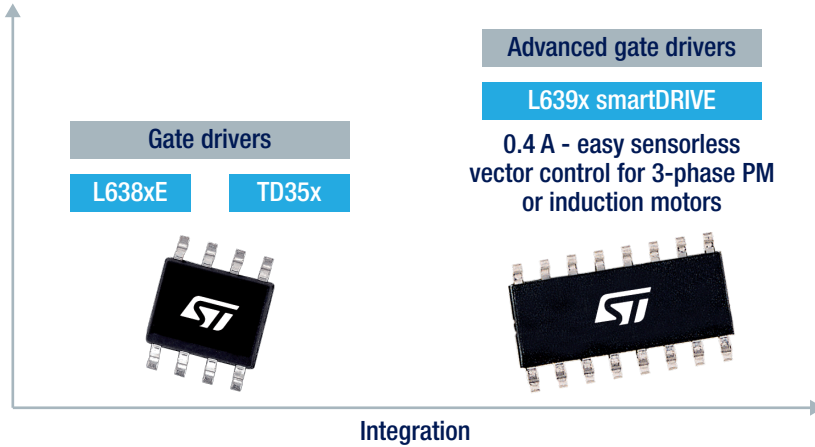
Part number	Polarity	BV <sub>DSS</sub>	R <sub>DS(on)</sub> max @ 10 V (mΩ)	Drain current (I <sub>D</sub> ) max (A)	Package	Note
ST*155N3H6	N-channel	30	3	80	DPAK/D2PAK	
ST*95N3LLH6	N-channel	30	4.2	80	DPAK/D2PAK/IPAK/T0-220	
STP180NS04ZC	N-channel	33	4.2	120	T0-220	Fully clamped
STP90NS04ZC	N-channel	33	6	80	T0-220	Fully clamped
STP70NS04ZC	N-channel	33	10	80	T0-220	Fully clamped
ST*160N4LF6	N-channel	40	3.2	120	T0-220/H2PAK	
STP110N55F6	N-channel	55	5.2	110	T0-220	
ST*270N8F7	N-channel	80	2.2	180	T0-220/H2PAK	
ST*310N10F7	N-channel	100	2.7	180	T0-220/H2PAK	
STP10P6F6	P-channel	60	180	10	DPAK/T0-220	
STS8C6H3LL	N-channel and P-channel	30	21/36	8/6	SO-8	Complementary pair
STL40C30H3LL	N-channel and P-channel	30	21/36	40/30	PowerFLAT 5X6 D.I.	Complementary pair

## Gate drivers for MOSFETs and IGBTs

ST's power MOSFET and IGBT drivers include integrated half-bridge, and single and multiple low-side gate drivers. ST's MOSFET/IGBT drivers provide state-of-the-art integration, reducing BOM cost and final application dimensions, while also increasing robustness and noise immunity. The L638xE and the brand new smartDRIVE™ L639x are the two high-voltage half-bridge gate driver families that are leading the industrial market, from home appliances to HVAC systems, from pumps and fans to factory automation.

The TD35x and TD2xx families complete ST's gate driver offer and feature single-channel drivers. In particular, the TD350E is an innovative gate driver where control and protection functions are included and allows the design of high-reliability systems. The innovative active Miller clamp function eliminates the need for negative gate drive in most applications and allows the use of a simple bootstrap supply for the high-side driver.

Performance



### KEY FEATURES

- Half-bridge, single channel and multichannel gate drivers available
- State-of-the-art integration thanks to:
  - HV bootstrap diode
  - Op amp
  - Comparator
  - Smart shutdown
  - Undervoltage lock out (UVLO)
  - Programmable deadtime

Part number	Logic interface		V <sub>CC</sub> max (V)	UVLO on V <sub>CC</sub> (V)	UVLO on V <sub>BOOT</sub> (V)	Interlocking - DT (μs)	Op Amp	Comparator	# pins
	Input configuration	Input configuration							
Half-bridge drivers									
L6384E	Single in, SD	5, 15 V	18	10 / 12	-	0.5 to 2.7	No	No	8
L6385E	HIN and LIN	5, 15 V	18	8.3 / 9.6	8.2 / 9.5	-	No	No	8
L6386E L6386AD	HIN, LIN, SD	5, 15 V	18	10 / 12 8.3 / 9.6	9.9 / 11.9 8.2 / 9.5	-	No	Yes, uncommitted	14
L6387E	HIN and LIN	5, 15 V	18	5.5 / 6	-	Interlocking	No	No	8
L6388E	HIN and LIN	3.3, 5, 15 V	18	8.3 / 9.6	8.2 / 9.5	0.32	No	No	8
L6390	HIN, LIN, SD	3.3, 5, 15 V	21	10.5 / 12	10 / 11.5	0.18 to 3	Yes	Yes, committed to fault + SSD	16
L6391	HIN, LIN, SD	3.3, 5, 15 V	21	10.5 / 12	10 / 11.5	0.18 to 3	No	Committed to fault + SSD	14
L6392	HIN, LIN, SD	3.3, 5, 15 V	21	10.5 / 12	10 / 11.5	0.18 ÷ 3	Yes	No	14
L6393	Phase, brake, SD	3.3, 5, 15 V	21	8.0 / 9.5	8 / 9	0.18 ÷ 3	No	Yes, uncommitted	14
L6395 <sup>1</sup>	HIN and LIN	3.3, 5, 15 V	20	8.8 / 9.5	8 / 8.6	-	No	No	8
L6398	HIN and LIN	3.3, 5, 15 V	21	8.0 / 9.5	8 / 9	0.32	No	No	8
Single-channel drivers									
TD350	Single in (opto/pulse trans compatible)	5 V	26	11	-	-	No	-	14
TD351	Single in (opto/pulse trans compatible)	5 V	26	11	-	-	No	No	8
TD352	Single in opto compatible)	5 V	26	11	-	-	No	No	8

Signal conditioning

Microcontrollers

Power factor correctors

Universal motors

3-phase brushless motors

Switched reluctance motors

Stepper motors

Single-phase AC induction motors

Brushed DC motors

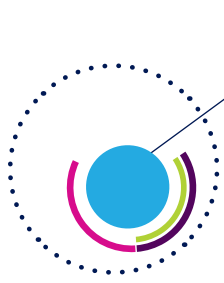
EVALUATION TOOLS

ST proposes a wide range of evaluation boards that may be used to perform a comprehensive evaluation of ST’s products and solutions while reducing your development time.

Order code	Description	Technical documentation
EVAL6205N	L6205 DMOS dual full-bridge driver evaluation board	AN1762, AN1794
EVAL6206Q	L6206 DMOS dual full-bridge driver evaluation board	DB1612
EVAL6207N	L6207 DMOS dual full-bridge driver with PWM current controller evaluation board	AN1762, AN1794
EVAL6225PD	L6225 DMOS dual full-bridge driver evaluation board	AN1794
EVAL6226QR	Demonstration board using dual full-bridge L6226Q	AN2758
EVAL6227PD	L6227 DMOS dual full-bridge driver with PWM current controller evaluation board	AN1794
EVAL6393FB	Low-voltage full-bridge evaluation board	DB1778





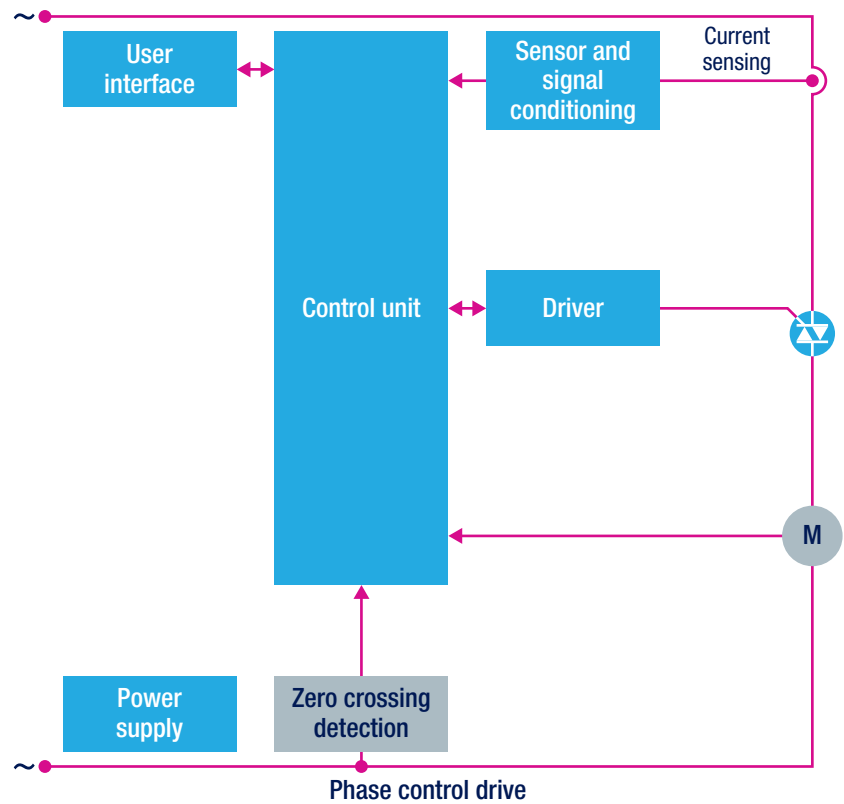
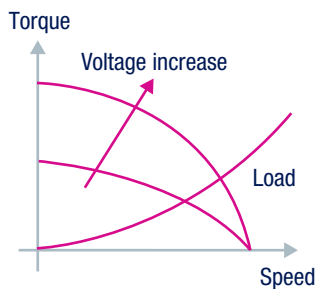
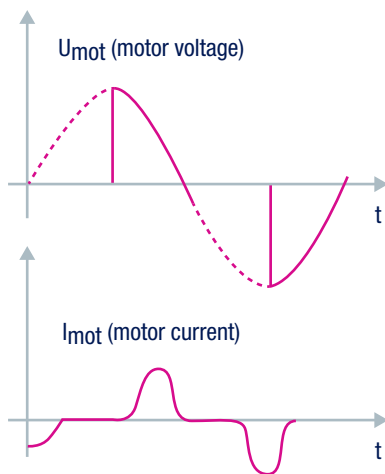


# Single-phase AC induction

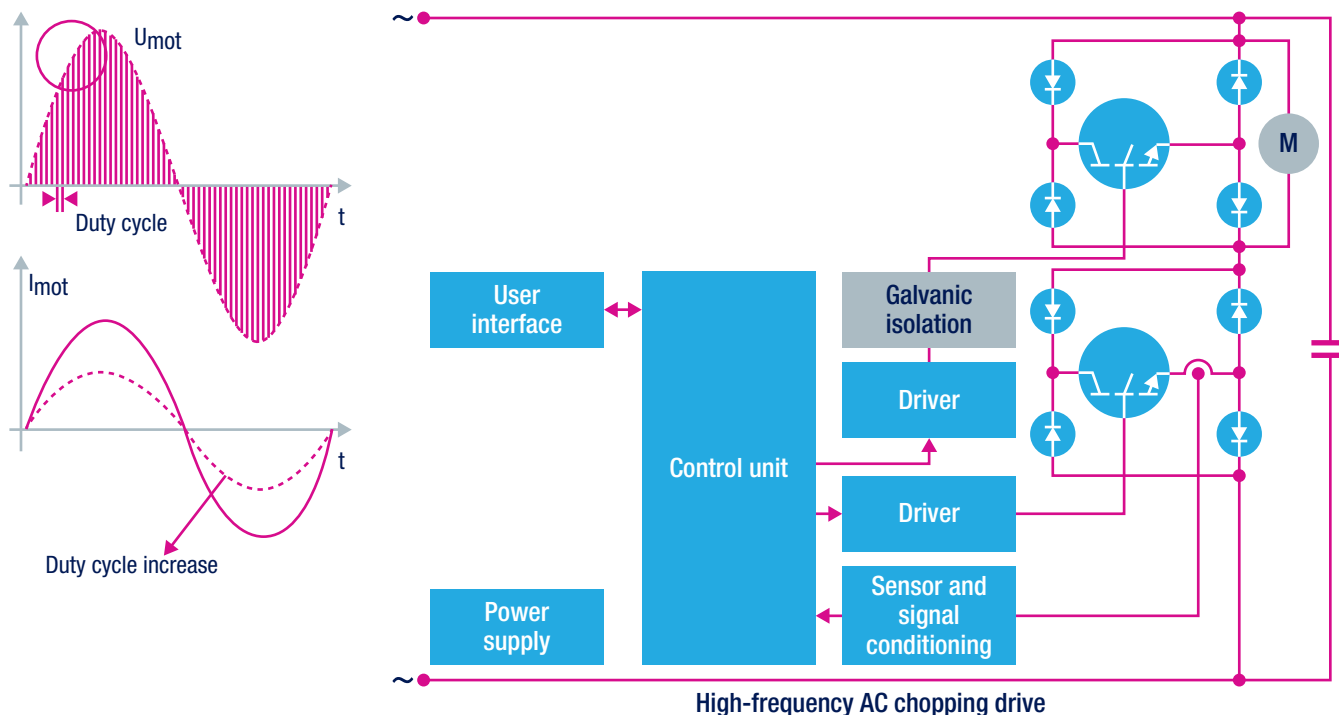
## Overview

ST's long experience in the field of motor control enables us to propose, for the control of single-phase induction motors, a mix of innovative products, new topologies and state-of-art and rugged devices such as Triacs and thyristors, where ST is the well-recognized worldwide leader.

One of the simplest ways to vary the speed of a single-phase induction motor is to change the mains voltage applied to the motor through an AC switch (phase-control).

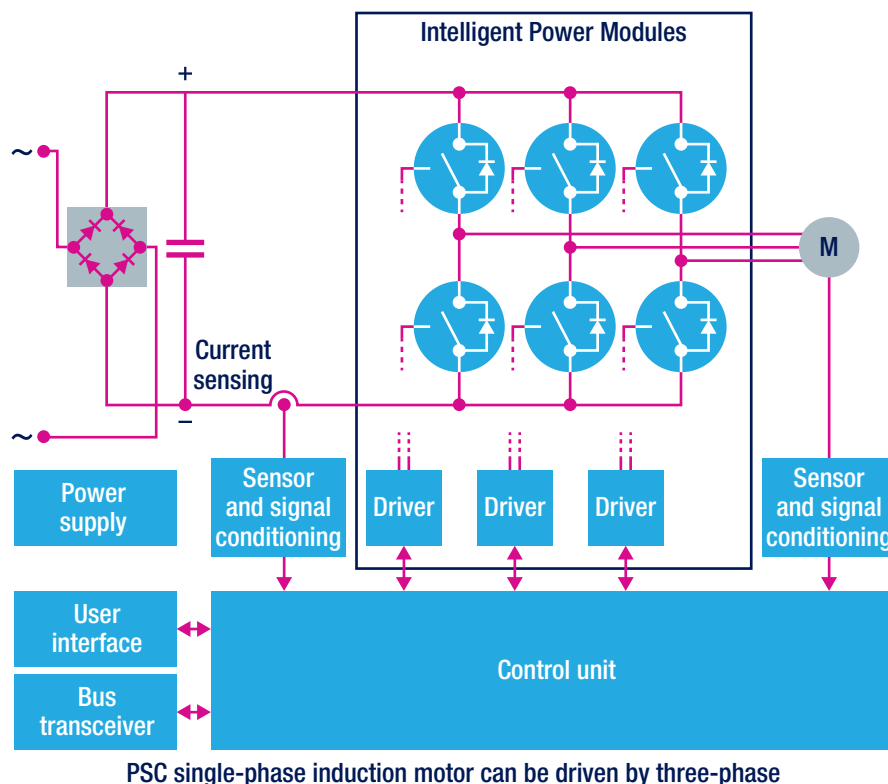


Despite its simplicity, the phase-control drive may lead to torque ripple and thus acoustic noise. These problems may be solved using ST's new proprietary topology delivering a silent and cost-effective drive. The speed is again controlled by the motor voltage; the power switch runs in PWM mode and adjusting the duty cycle according to the required torque enables speed regulation.



10

On the other hand, if your permanent-split capacitor (PSC) single-phase induction motor drive requires high performances in terms of efficiency, quietness and dynamic response, removing the capacitor and connecting the three motor terminals to a 3-phase inverter bridge enables a real variable frequency drive (VFD). The 3-phase motor section on page 24 gives more information about ST's innovative products for 3-phase inverter topology. A general-purpose 8-bit microcontroller such as the STM8S can generally be used to carry out the entire speed control algorithm<sup>1</sup>.



Note: 1. Refer to microcontroller chapter on page 40 for more information about suitable part numbers.

## KEY PRODUCTS

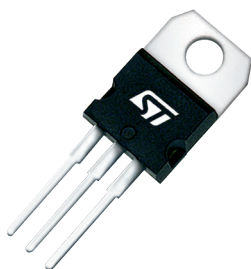
### TRIAC, ACS™ AND ACST FAMILIES

ST offers a complete range of thyristors and AC switches with voltage ratings up to 1200 V, current ratings up to 100 A and a set of packages from miniature surface-mounted packages to high power dissipation isolated and non-isolated packages.

The latest extension to the AC switch range features the SMB-Flat package, which is smaller than SOT-223 and is aimed at the 0.8 A device range. The PCB can be designed so that SMB-Flat and SOT-223 packages are fully interchangeable for increased production flexibility.

#### Triacs

ST's portfolio of Triacs includes devices with voltage ratings up to 800 V and RMS on-currents up to 40 A in general-purpose standard configurations, a new high commutation T series in Snubberless™ technology, and 3-quadrant high-temperature Triacs (H series) for use in harsh environments. They are the reference for universal and induction motor drivers in appliance applications where, due to their ability to manage the stringent inrush conditions when driving inductive loads, they can switch off three times their rating current.



#### KEY FEATURES

- Robustness and reliability
- Wide voltage and current ranges
- Rich portfolio:
  - Standard Triacs
  - Snubberless™ with enhanced switch-off capability, for inductive loads
  - High-temperature T series for hot environments

	Part number	Packages	Current rating (A <sub>RMS</sub> )	Non repetitive surge peak on-state current (A)	Repetitive off-state voltage (V)	Operating Tj max (°C)	I <sub>GATE</sub> (mA)
T series	T435T-600FP	T0220ABFP	6	30	600/800 <sup>1</sup>	125/150 <sup>1</sup>	35
	T635T* <sup>1</sup>	T0-220AB-Insulated 2500 V; T0-220AB-FP <sup>1</sup> ; T0-220AB <sup>1</sup>	8	45			10, logic level, 3Q 20/35, Snubberless™, 3Q 25, standard, 4Q
	T8T		12	60			
	T12T		16	90			
	T16T		6	120			

Note: 1. Available Q3 2013

	Part number	Packages	Current rating (A <sub>RMS</sub> )	Non repetitive surge peak on-state current (A)	V <sub>DRM</sub> - V <sub>RRM</sub> (V)	Operating Tj max (°C)	I <sub>GATE</sub> (mA)
High-temperature Triacs	T410H	T0220	4	40	600	150	10
	T610H	T0220	6	60			10
	T8**H	T0220, D <sup>2</sup> PAK, T0-220I	8	80			10 35 50
	T10**H		10	100			35 50
	T12**H		12	120			
	T16**H		16	160			
	T20**H		20	200			
	T30**H	T0220, T0-220I	30	270			

## ACST™ and ACST

Using innovative ASD application-specific device technology, ST's ACST™ and ACST devices are specific switches developed for home appliances and industrial control applications.

While maintaining very high switch-off capability, logic-level devices allow direct drive by a microcontroller. With integrated overvoltage protection against random transients, no external MOV protection is needed, providing system safety and transient and surge voltage immunity as defined in the IEC 61000-4-4 and -4-5 standards. The ACST series now extends from 2 A to 16 A, housed in TO-220AB and TO-220FP packages, and the ACS series is also extended to 800 V with a lower gate triggering sensitivity of 5 mA.

## KEY FEATURES

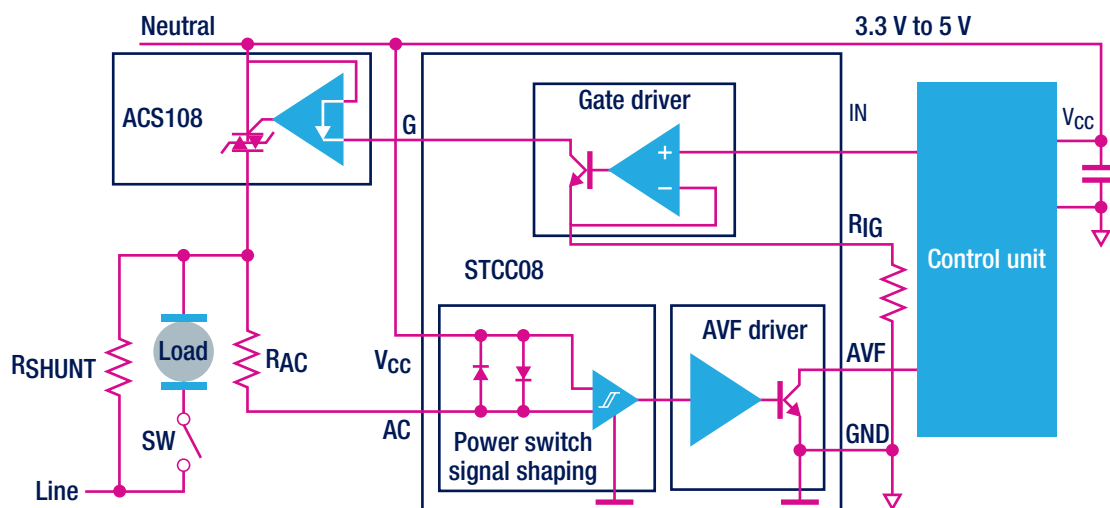
- High switch off capability
- Low gate current for direct connection to MCU
- Internally protected, no need of external circuitry to meet IEC 61000-4-4 and -4-5 standards

Part number	Current rating (A <sub>RMS</sub> )	Non repetitive surge peak on-state current (A)	Repetitive off-state voltage (V)	Operating T <sub>j</sub> max (°C)	I <sub>GATE</sub> (mA)	Packages
ACST2	2	8	800	125	10	DPAK, TO220FPAB
ACST4	4	30			10, 35	DPAK, TO220FPAB
ACST6	6	45			10	D <sup>2</sup> PAK, TO220AB, TO220FPAB
ACST8	8	80			30	D <sup>2</sup> PAK, TO220AB, TO220FPAB
ACST10	10	100	700	125	10, 35	TO220AB, TO220FPAB
ACST12	12	120	700	125	10, 35	D <sup>2</sup> PAK, TO220AB
ACST1635-8FP	16	140	800	150	35	TO220FPAB
ACS302-6T <sup>1</sup>	0.2	7.3	600	125	5	S020
ACS102-6T	0.2	7.3	600	125	5	S08, T092
ACS108	0.8	13.7	800	125	10	SOT223, T092
ACS110	1	8	700	125	10	SOT223
ACS120	2	20	700	125	10	DPAK, TO220AB, TO220FPAB

Note: 1. Available Q3 2013

## Power control, monitoring drivers

The STCC08 drives the AC switch and sends diagnostic data to the MCU in case of switch failure (short and open circuit, diode mode). It helps the whole appliance meet the IEC 60335-1 safety standard.





## IGBTs

With 600 V breakdown voltages, ST's IGBTs feature the optimal trade-off between switching performance and on-state behavior due to their proprietary technology, leading to all-round energy-efficient system designs in many applications.

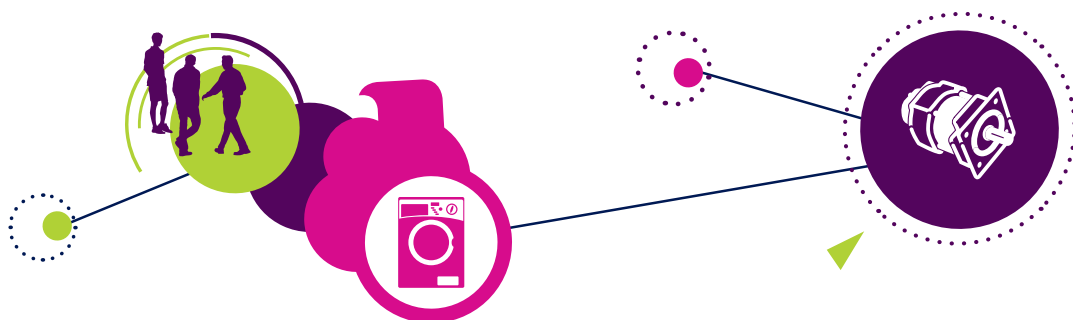
In particular, thanks to the negative temperature derating of  $V_{ce(sat)}$ , the H and K IGBT families are specifically tailored for low-loss motor drive.

IGBT products without free-wheeling diodes are mostly recommended for high-frequency AC chopping drive topology.

### KEY FEATURES

- Low  $V_{ce(sat)}$  for reduced conduction losses
- Short-circuit rugged
- Co-packaged tailored anti-parallel diode option for improved power dissipation and best thermal management
- Negative temperature derating of  $V_{ce(sat)}$
- Several package options

Part number	Collector current max @ 100 °C (A)	$V_{ce(sat)}$ @ $T_j = 125\text{ °C}$ (V)	Collector emitter voltage max (V)	Short-circuit rugged	Packages
STG*10NC60H	10	1.7	600	No	D <sup>2</sup> PAK, DPAK, TO220FP, TO220
STG*10NC60K	10	1.8	600	Yes	D <sup>2</sup> PAK, DPAK, TO220FP, TO220
STG*7NC60H	14	1.7	600	No	D <sup>2</sup> PAK, DPAK, TO220FP, TO220
STG*14NC60K	14	1.8	600	Yes	D <sup>2</sup> PAK, DPAK, TO220FP, TO220
STG*19NC60H	19	1.6	600	No	D <sup>2</sup> PAK, TO220FP, TO220, TO247
STG*19NC60K	20	1.8	600	Yes	D <sup>2</sup> PAK, TO220FP, TO220
STG*20NC60V	30	1.7	600	No	D <sup>2</sup> PAK, TO220, TO247
STG*30NC60K	30	1.9	600	Yes	TO247
STG*40NC60V	50	1.7	600	No	Max247



## Diodes and rectifiers

ST's ultrafast diodes range from 300 V to 1200 V with various VF/TRR and QRR/S factor trade-offs so as to achieve the best performance for any application, including high-frequency AC chopping topology for single-phase AC induction motors. The Turboswitch™ diodes feature ultra-fast recovery while maintaining a low drop voltage. They significantly cut losses in both the diode and the transistor at turn-on.

All ST products are rated up to 175 °C operating junction temperature, as a result of the reduced leakage currents. Low-profile PowerFLAT™ packages are also available.

### KEY FEATURES

- Wide voltage range from 300 V to 1200 V
- Up to 200 A current range
- Low-profile PowerFLAT™ packages
- Different VF/TRR trade-offs available in different packages
- 175 °C operating junction temperature

	Part number	Average rectified current max (A)	Forward voltage max (@ IF) spec (V)	Reverse <sup>1</sup> recovery charges (Qrr) typ (nC)	S factor typ	Package
300 V ultrafast rectifiers	STTH8R03	8	1.8	60	0.4	TO-220AC
	STTH8R03DJF	8	1	120	0.3	PowerFLAT™ 5 x 6
	STTH30R03	30	1.4	63	0.4	D <sup>2</sup> PAK, TO-247
400 V ultrafast rectifiers	STTH8R04	8	1.5	148	0.4	D <sup>2</sup> PAK, TO-220AC, TO-220AC Ins
	STTH20R04	20	1.7	225	0.3	D <sup>2</sup> PAK, TO-220AC, DO-247, TO-220FPAC
	STTH30R04	30	1.45	525	0.4	D <sup>2</sup> PAK, TO-220AC, DO-247, DOP3 Ins
600 V ultrafast rectifiers	STTH5R06	5	2.9	110	0.35	D <sup>2</sup> PAK, TO-220AC, DPAK, TO-220FPAC
	STTH5R06DJF	5	1.2	180	0.5	PowerFLAT™ 5 x 6
	STTH8R06	8	2.9	150	0.3	D <sup>2</sup> PAK, TO-220AC, TO-220AC Ins, I <sup>2</sup> PAK, TO-220FPAC
	STTH12R06	12	2.9	180	0.2	D <sup>2</sup> PAK, TO-220AC
	STTH15R06	15	2.9	220	0.15	TO-220AC, TO-220FPAC
	STTH30R06	30	1.85	1000	0.37	DO-247, DOP3 Ins

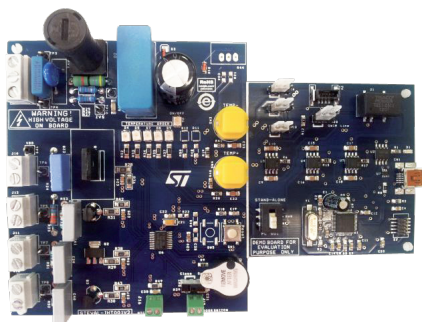
Note: 1. See datasheet for testing conditions.

## EVALUATION TOOLS

ST proposes a wide range of evaluation boards for comprehensive evaluation of ST's products and solutions while reducing your development time.

Order code	Description	Technical documentation
STEVAL-IHT001v2	Cold thermostat kit based on AC switches and the STM8S	UM1542
STEVAL-IHT007v1	Extension board with ACS for STM8S-Discovery kit	UM1494
STEVAL-IHM029v1	Universal motor control evaluation board	UM0922
STEVAL-IHM041v1	Universal motor driver with speed control based on the STM8 and Triac (US version)	UM1559

### STEVAL\_IHT001V2



5% - 15% more energy efficient

USB



### KEY FEATURES

- Up to 15% higher fridge efficiency thanks to digital and programmable temperature control versus traditional electromechanical thermostat
- Spark-free thermostat needing no sealing
- Optimized BOM and cost
- Robust and rugged solution
  - Up to 3.1 kV during IEC 61000-4-4 standard tests with perfect operation
- PC interface SW for communication with embedded application

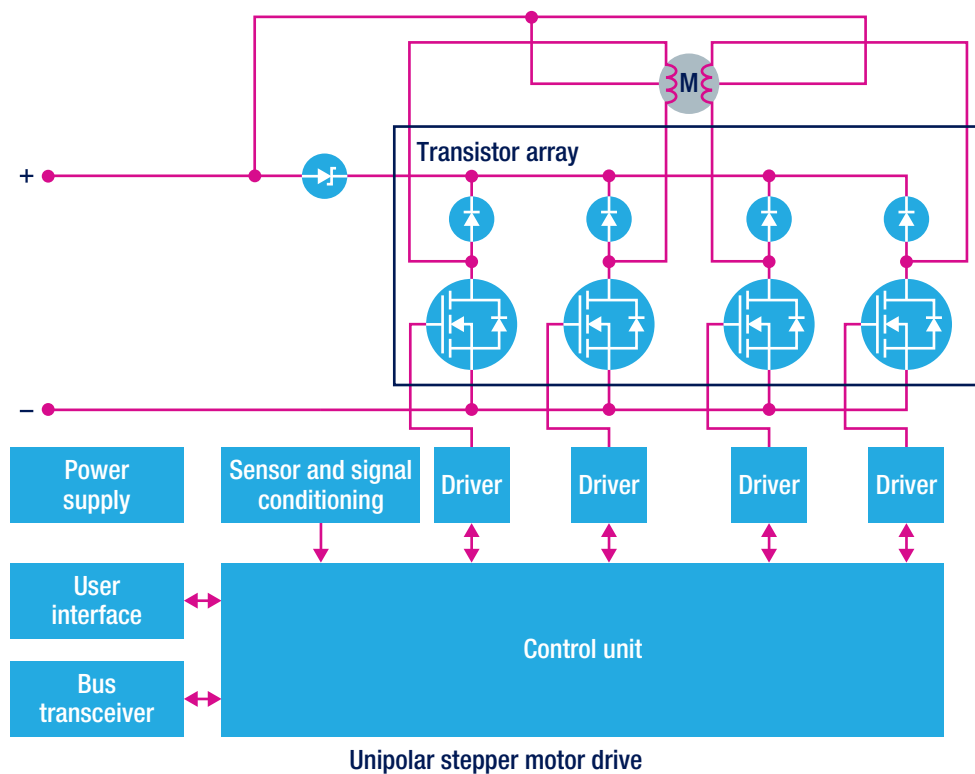
# Stepper motors

## Overview

Stepper motors are widely used in holding and positioning applications in the computer, security, automation and industrial fields. Depending on the number of phases, the winding arrangement and the required level of motion smoothness, several types of stepper motor drives can be used. ST exhaustively supports all these configurations with both monolithic motor driver ICs (embedding digital controllers, power devices and protection functions) and, for higher power, with a controller plus discrete MOSFETs.

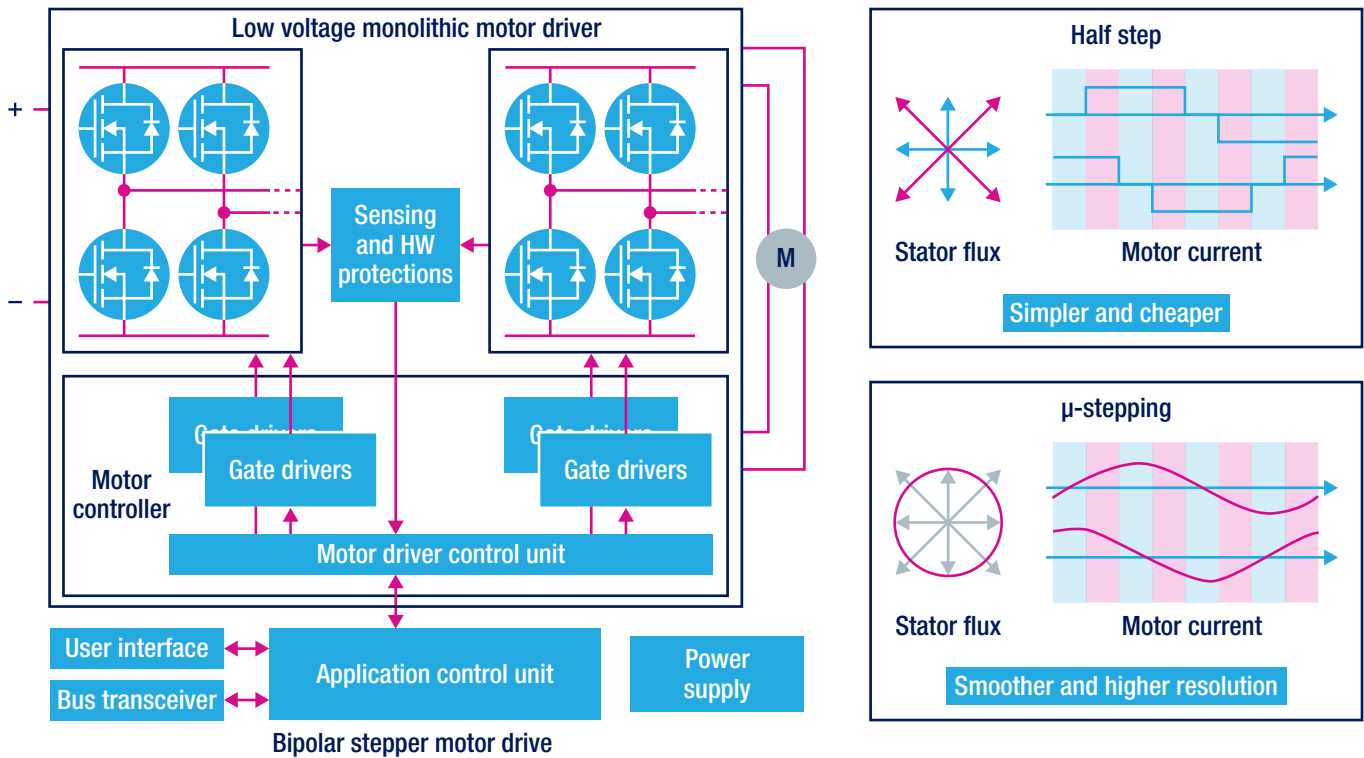
### UNIPOLAR STEPPER MOTOR DRIVE

In unipolar stepper motors, stator windings share a common terminal; the free terminal of each winding is connected to a separate power switch and the current is allowed to flow in one direction through the motor windings. Diodes are used to clamp the voltage across the switches at turn-off.



## BIPOLAR STEPPER MOTOR DRIVE

In bipolar stepper motors, current can flow in both directions; a full-bridge converter is required to drive each of the two windings of a 2-phase motor. During motion, the type of electronic control (full step, half step, microstepping) and the resulting phase current waveform impact the vibration level, the acoustic noise, motion smoothness and sensitivity to resonances.



## KEY PRODUCTS MONOLITHIC MOTOR DRIVER ICS

### cSPIN and dSPIN

A quantum leap in microstepping innovation, dSPIN (L6470/2) and cSPIN (L6480/2) substitute expensive DSP, analog and power components with a single IC. The digital motion engine integrated in these drivers only requires simple commands through the SPI from the system microcontroller to set acceleration, deceleration, speed and target position and to command the movements. The innovative voltage-mode microstepping technique on the L6470 and L6480 achieves up to 128 microsteps with extreme smoothness, reducing noise and vibration, while the predictive algorithm and the adaptive decay technique available on the L6472 and L6482 achieve high accuracy and smoothness with the traditional current-control technique.

cSPIN integrates a dual full-bridge gate driver for up to 8 external MOSFETs, thus featuring a scalable solution for different application ratings up to 85 V buses.



### KEY FEATURES

- Digital motion engine to eliminate expensive DSP
- Voltage mode for impressive smoothness
- Adaptive decay and predictive current control for extreme accuracy
- Great evaluation tools for ease-of-design like never before in microstepping



## easySPIN

easySPIN L6474 is a motor driver featuring up to 16 microstep resolution. It uses an adaptive decay control that outperforms traditional implementations, reducing the current ripple and increasing the resolution. The easy step-clock and direction control through direct pins and the configurability through SPI with no need for external components simplify the BOM for cost effectiveness. The embedded current DAC provides internal control with no need for external shunts, so reducing the system dissipation and allowing a smaller board.



### KEY FEATURES

- Adaptive decay control for higher resolution and lower current ripple
- SPI configurability
- Non-dissipative current sensing



## powerSPIN

The powerSPIN family offers over 30 different parts for stepper, DC and BLDC motors covering all design needs.

The simplest powerSPIN solution (L62x5 and L62x6) integrates the power stage array and gate driver in a single chip with a full set of non-dissipative protection features, making the BOM highly competitive.

The advanced L62x7 adds PWM current control and the L62x8 adds the decoding logic for the stepper.

The MCU implements motion profiles, generates the precise timing required and drives the motor. This solution is ideal where compactness and configurability are needed at the same time; powerSPIN reduces the number of external components needed, while the STM32's computational power and flexible firmware approach make the solution scalable.

### KEY FEATURES

- Scalable products
- Suitable for budgetary  $\mu$ -stepping



Part number	Description	Supply voltage range min-max (V)	Continuous max output current (A)	Package
<b>L6205, L6225</b>	powerSPIN: dual full-bridge driver	8 to 52	Up to 2.8	PowerDIP20, PowerS020, S020
<b>L6206, L6226</b>	powerSPIN: dual full-bridge driver	8 to 52	Up to 2.8	QFN48, PowerDIP24, PowerS036, S024
<b>L6207, L6227</b>	powerSPIN: dual full-bridge driver with PWM current-controller	8 to 52	Up to 2.8	QFN48, PowerDIP24, PowerS036, S024
<b>L6208, L6228</b>	powerSPIN: SPI configurable stepper and DC multi motor driver	13 to 38	2.5	QFN48, PowerDIP24, PowerS036, S024, VFQFPN32
<b>L6470, L6472</b>	dSPIN: fully-integrated microstepping motor driver with motion engine and SPI	8 to 45	3	PowerS036, HTSSOP28
<b>L6480, L6482</b>	cSPIN: fully-integrated microstepping motor controller with motion engine and SPI	7.5 to 85	-	HTSSOP38
<b>L6474</b>	easySPIN: fully-integrated microstepping motor driver	8 to 45	3	PowerS036, HTSSOP28

Signal conditioning

Microcontrollers

Power factor correctors

Universal motors

3-phase brushless motors

Switched reluctance motors

Stepper motors

Single-phase AC induction motors

Brushed DC motors

POWER SWITCHES

Low-voltage power MOSFETs

ST's MOSFET portfolio provides a broad range of breakdown voltages up to 100 V, with low gate charge and low on-resistance, combined with state-of-the art packaging technology in chip scale form factor with a resulting higher power density, without compromising power dissipation.

PowerFLAT 5x6 D.I.



6.5 mΩ 30 V

STL65DN3LLH5

PowerFLAT 3.3x3.3



4.5 mΩ 30 V

STL17N3LLH6

KEY FEATURES

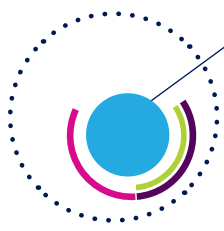
- Very low on-resistance
- High avalanche ruggedness
- High current capability
- Low thermal resistance
- Thin and powerful package
- Low Qrr and right softness for bridge configuration
- Simplifies driving stage for p-channel FETs (no bootstrap circuitry)

Part number	Polarity	BV <sub>DSS</sub> (V)	R <sub>DS(on)</sub> max @ 10 V (mΩ)	Drain current (I <sub>p</sub> ) max (A)	Package
STL17N3LLH6	N-channel	30	4.5	17	PowerFLAT 3.3X3.3
STL65DN3LLH5	Dual N-channel	30	6.5	19	PowerFLAT 5X6 D.I.
STL40DN3LLH5	Dual N-channel	30	18	11	PowerFLAT 5X6 D.I.
STL8DN10LF3	Dual N-channel	100	35	7.8	PowerFLAT 5X6 D.I.

EVALUATION TOOLS

ST proposes a wide range of evaluation boards for comprehensive evaluation of ST's products and solutions while reducing your development time.

Order code	Description	Technical documentation
EVAL6470H	Fully-integrated stepper motor voltage-mode driver based on L6470	DB1539
EVAL6472H	Fully-integrated stepper motor current-mode driver based on the L6472	DB1597
EVAL6474H	Fully-integrated stepper motor current-mode driver based on L6474	DB1550
EVAL6480H	High-power microstepping motor driver with L6480H	DB1755
EVAL6482H	High-power microstepping motor driver with the L6482H	DB1799
EVAL6460	FlexSPIN: SPI configurable stepper and DC multi motor driver evaluation board	AN3097
EVAL6205N	L6205 DMOS dual full-bridge driver evaluation board	AN1762, AN1794
EVAL6206Q	L6206 DMOS dual full-bridge driver evaluation board	DB1612
EVAL6207N	L6207 DMOS dual full-bridge driver with PWM current controller evaluation board	AN1762, AN1794
EVAL6225PD	L6225 DMOS dual full-bridge driver evaluation board	AN1794
EVAL6226QR	Demonstration board using dual full-bridge L6226Q	AN2758
EVAL6227PD	L6227 DMOS dual full-bridge driver with PWM current controller evaluation board	AN1794



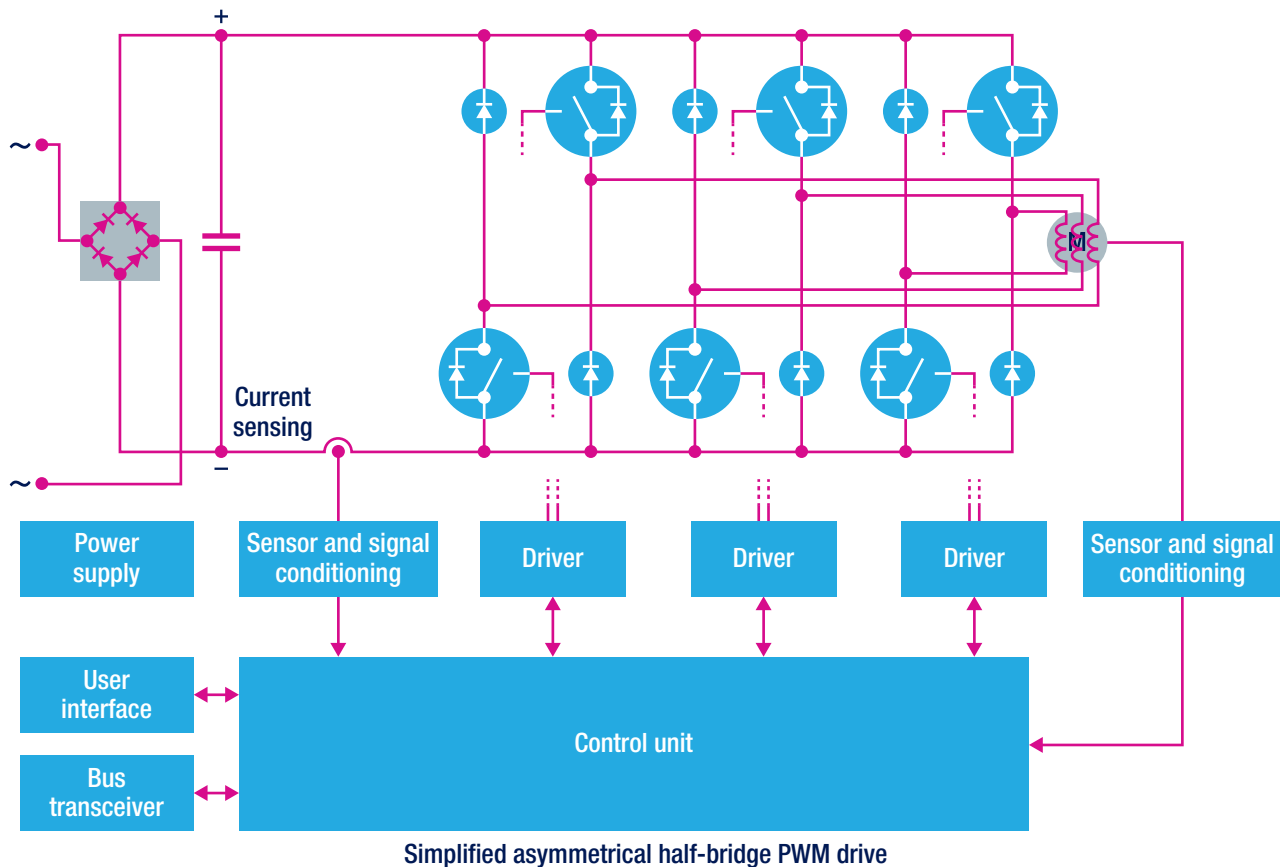
# Switched reluctance motors

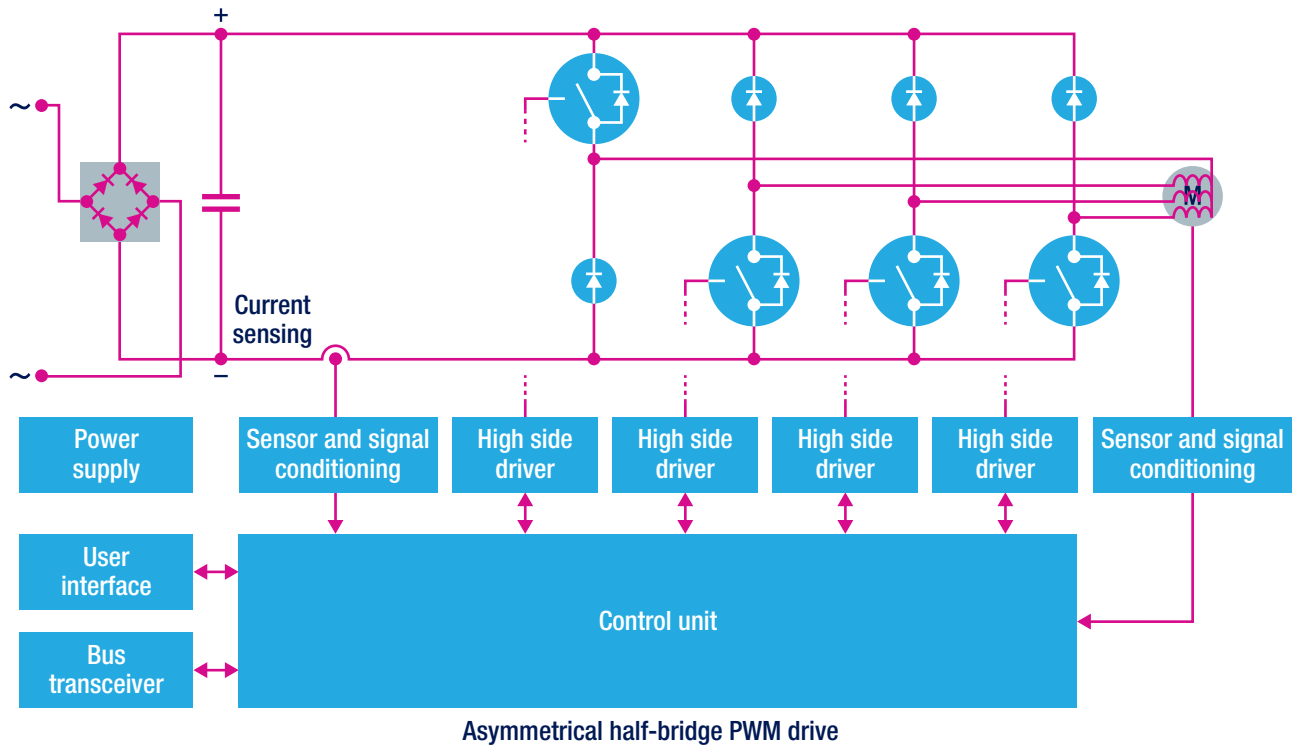
## Overview

Switched reluctance motors are mainly used in traction, industrial and automotive pumps and home appliances (vacuum cleaners and some washing machines). Their structure is similar to that of stepper motors but switched reluctance motors present many fewer magnetic poles. Despite of their simple structure, external electronic commutation is needed, and two topologies are mainly used for this purpose.

The asymmetrical half-bridge PWM drive leverages the motor's best features. An independent current loop is implemented for each motor phase so that some phase current overlap is possible to attain higher speeds. For the drive,  $2 \times n$  power switches are required ( $n$  being the number of motor phases). The simplified asymmetrical half-bridge PWM drive topology only requires  $n + 1$  power switches and is well adapted to medium-speed operation.

Specific products have been developed by ST to better address both of the above topologies.





A general-purpose 8-bit microcontroller such as the STM8S can be generally used to drive a switched reluctance motor, although an entry-level STM32 may be more suited for higher performance<sup>1</sup>.

## KEY PRODUCTS POWER SWITCHES

### IGBTs

With breakdown up to 600 V, ST's IGBTs feature the optimal trade-off between switching performance and on-state behavior

Devices suitable for this kind of motor are tailored to the specific switching frequency of the application itself targeting both low (NC\_S series) and high frequency (NC\_H series).

### KEY FEATURES

- Low  $V_{CE(SAT)}$  for reduced conduction losses
- Improved switch-off energy spread versus temperature for reduced switching losses
- Co-packaged tailored anti-parallel diode option for improved power dissipation and best thermal management
- Negative temperature derating of  $V_{CE(SAT)}$
- Several package options

Switching frequency	Part number	Collector current max @ 100 °C (A)	$V_{CE(SAT)}$ @ $T_J = 125\text{ °C}$ (V)	Collector emitter voltage max (V)	Free-wheeling diode	Package
Up to 5 kHz	STG*10NC60S(D)	10	1.45	600	No (yes)	DPAK, T0220FP, T0220
	STGP19NC60S(D)	20	1.35	600	No (yes)	T0220
	STG*30NC60S	35	1.4	600	No	T0220, 3PF
Up to 20 kHz	STG*6NC60HD	6	1.7	600	Yes	D2PAK, DPAK, T0220FP, T0220
	STG*10NC60H(D)	10	1.7	600	No (yes)	D2PAK, DPAK, T0220FP, T0220
	STG*7NC60H(D)	14	1.7	600	No (yes)	D2PAK, DPAK, T0220FP, T0220
	STG*19NC60H(D)	19	1.6	600	No (yes)	D2PAK, T0220FP, T0220, T0247
	STG*20NC60V(D)	30	1.7	600	No (yes)	D2PAK, T0220FP, T0220, T0247



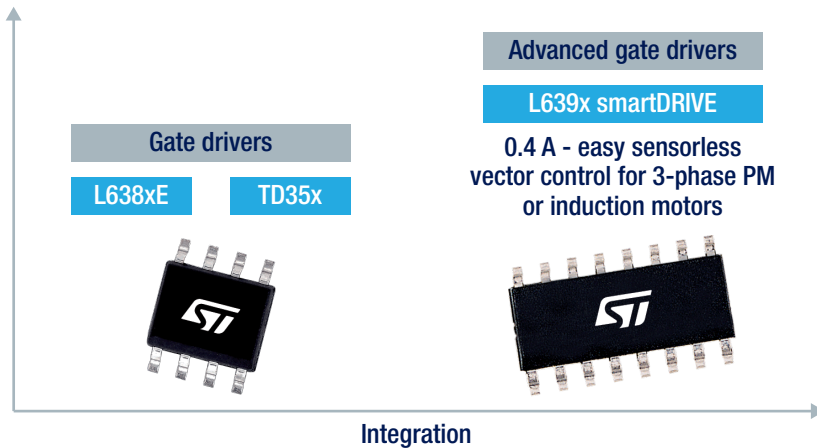
## Gate drivers for IGBTs and MOSFETs

ST's power MOSFET and IGBT drivers include integrated half-bridge, single and multiple low-side gate drivers. ST's MOSFET/IGBT drivers provide state-of-the-art integration, reducing BOM cost and final application dimensions, while also increasing robustness and noise immunity.

The L638xE and the brand new smartDRIVE™ L639x are the two high-voltage half-bridge gate driver families that are leading the industrial market. In particular, thanks to their flexibility, the L6385 and L6395 devices enable any PWM pattern on the driver's inputs to be generated on the outputs (enabling simultaneous turn-on of high-side and low-side switches, for example) which makes them particularly suitable for switched reluctance motor driving topologies.

The TD35x and TD2xx families complete the ST gate driver offer and feature single-channel drivers. In particular, the TD350E is an innovative gate driver where control and protection functions are included and allow the design of highly reliable systems. The innovative active Miller clamp function eliminates the need for negative gate drive in most applications and allows the use of a simple bootstrap supply for the high-side driver.

Performance



### KEY FEATURES

- Half-bridge, single-channel and multichannel gate drivers
- State-of-the-art integration thanks to:
  - HV bootstrap diode
  - Op amp
  - Comparator
  - Smart shutdown
  - Undervoltage lock out (UVLO)
  - Programmable deadtime

Part number	Logic interface		V <sub>CC</sub> max (V)	UVLO on V <sub>CC</sub> (V)	UVLO on V <sub>BOOT</sub> (V)	Interlocking - DT (μs)	Op amp	Comparator	# pins
	Configuration	Configuration							
Half-bridge drivers									
L6385E	HIN and LIN	5, 15 V	18	8.3 / 9.6	8.2 / 9.5	No	No	No	8
L6395	HIN and LIN	3.3, 5, 15 V	21	8.8 / 9.5	8 / 8.6	No	No	No	8
Single-channel drivers									
TD350	Single in (opto/pulse trans compatible)	5 V	26	11	-	-	No	No	14
TD351	Single in (opto/pulse trans compatible)	5 V	26	11	-	-	No	No	8
TD352	Single in (opto compatible)	5 V	26	11	-	-	No	No	8

### Diodes and rectifiers

ST's ultrafast diodes range from 300 V to 1200 V with various VF/TRR and QRR/S factor trade-offs so as to achieve the best performance for any application. Turboswitch™ diodes feature ultra-fast recovery while maintaining a low drop voltage. They significantly cut losses in both the diode and the transistor at turn-on.

All ST products are rated up to 175 °C operating junction temperature, as a result of the reduced leakage currents.

Low-profile PowerFLAT™ package are also available.

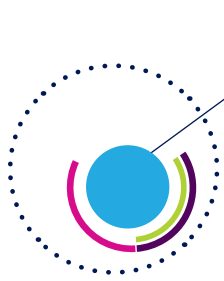
### KEY FEATURES

- Wide voltage range from 300 V to 1200 V
- Up to 200 A current range
- Low-profile PowerFLAT™ packages
- Different  $V_F/T_{RR}$  trade-offs available in different packages
- 175 °C operating junction temperature

	Part number	Average rectified current max (A)	Forward Voltage max (@ IF) spec (V)	Reverse¹ recovery charges (Qrr) typ (nC)	S factor typ	Package
300 V ultrafast rectifiers	STTH8R03	8	1.8	60	0.4	TO-220AC
	STTH8R03DJF	8	1	120	0.3	PowerFLAT™ 5 x 6
	STTH30R03	30	1.4	63	0.4	D²PAK, TO-247
400 V ultrafast rectifiers	STTH8R04	8	1.5	148	0.4	D²PAK, TO-220AC, TO-220AC Ins
	STTH20R04	20	1.7	225	0.3	D²PAK, TO-220AC, DO-247, TO-220FPAC
	STTH30R04	30	1.45	525	0.4	D²PAK, TO-220AC, DO-247, DOP3 Ins
600 V ultrafast rectifiers	STTH5R06	5	2.9	110	0.35	D²PAK, TO-220AC, DPAK, TO-220FPAC
	STTH5R06DJF	5	1.2	180	0.5	PowerFLAT™ 5 x 6
	STTH8R06	8	2.9	150	0.3	D²PAK, TO-220AC, TO-220AC Ins, I²PAK, TO-220FPAC
	STTH12R06	12	2.9	180	0.2	D²PAK, TO-220AC
	STTH15R06	15	2.9	220	0.15	TO-220AC, TO-220FPAC
	STTH30R06	30	1.85	1000	0.37	DO-247, DOP3 Ins

Note: 1. See datasheet for testing conditions





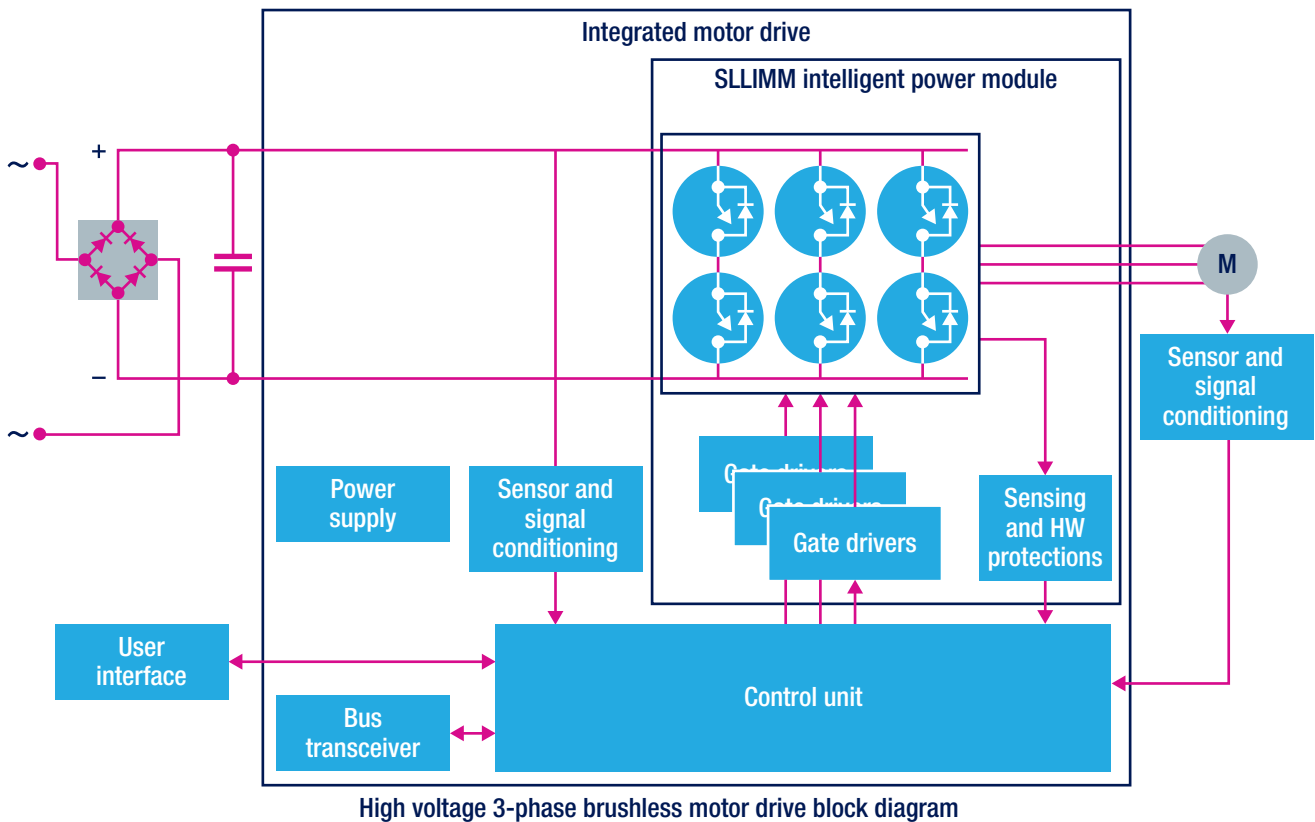
# 3-phase brushless motors

## Overview

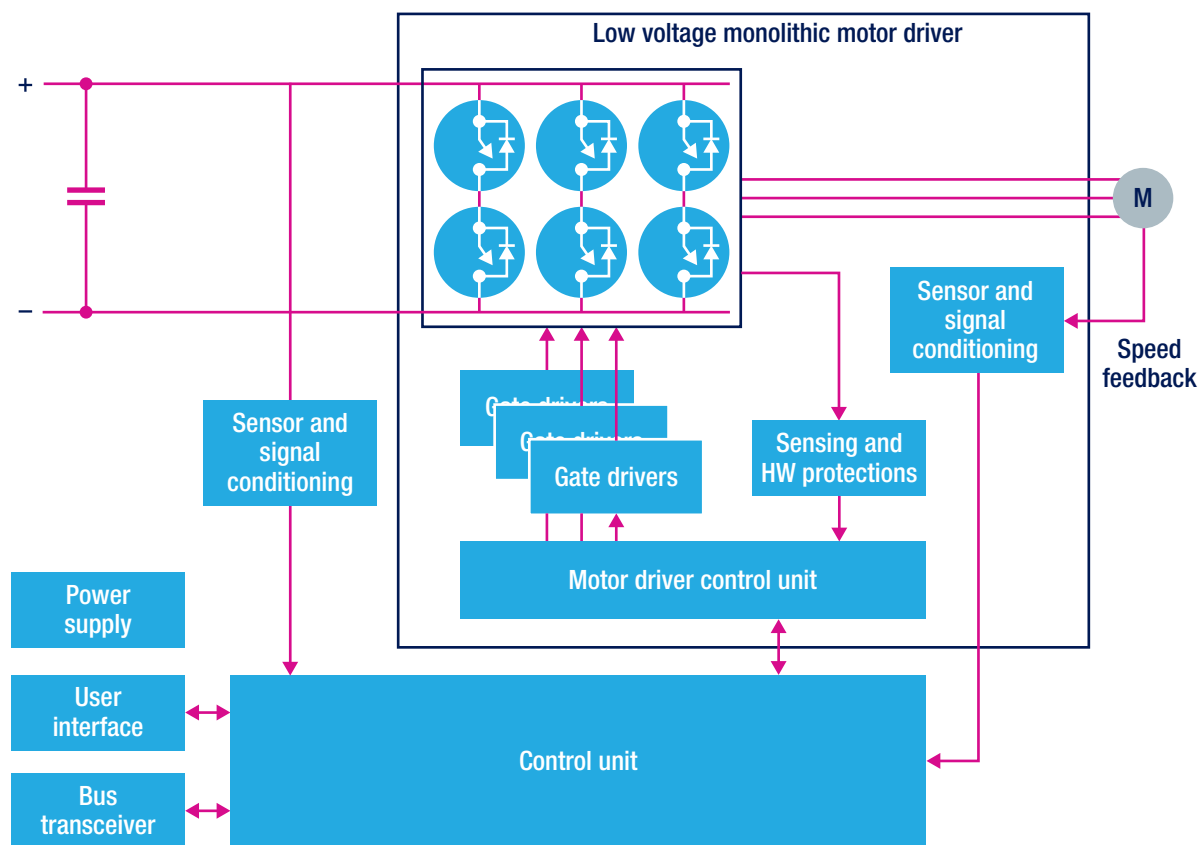
Despite their different structures, all 3-phase AC induction motors (AC IM) and 3-phase permanent magnet motors (BLDC or PMSM or PMAC) are driven by a PWM-modulated 3-phase bridge (3 half bridges) so as to supply the motor with variable frequency and amplitude 3-phase voltages and currents.

To give the greatest design freedom (for example, the selection of turn-on and turn-off power switch resistors), ST's product portfolio supports a discrete-based approach for both high-voltage and low-voltage applications with a wide package choice for discrete MOSFETs or IGBTs and related gate driver circuitry.

For a highly-integrated configuration, the SLLIMM™ family of intelligent power modules integrates over 30 discrete and IC devices. This greatly simplifies the design and reduces the PCB size with consequent reduction of time-to-market and costs.



Additionally, for the industrial automation market, the SPIMD20 is an integrated motor drive with real-time connectivity that enables brushless-motor manufacturers to create a proprietary motion control system. Finally, specifically for low-voltage PMSM and BLDC, ST can also offer a family of monolithic motor drivers that integrates digital intelligence, power devices and protection functions in a smart power IC. Depending on the required drive performance, either the entry-level STM8S or STM32 could be suited for the application<sup>1</sup>.



Low voltage BLDC/PMSM application block diagram

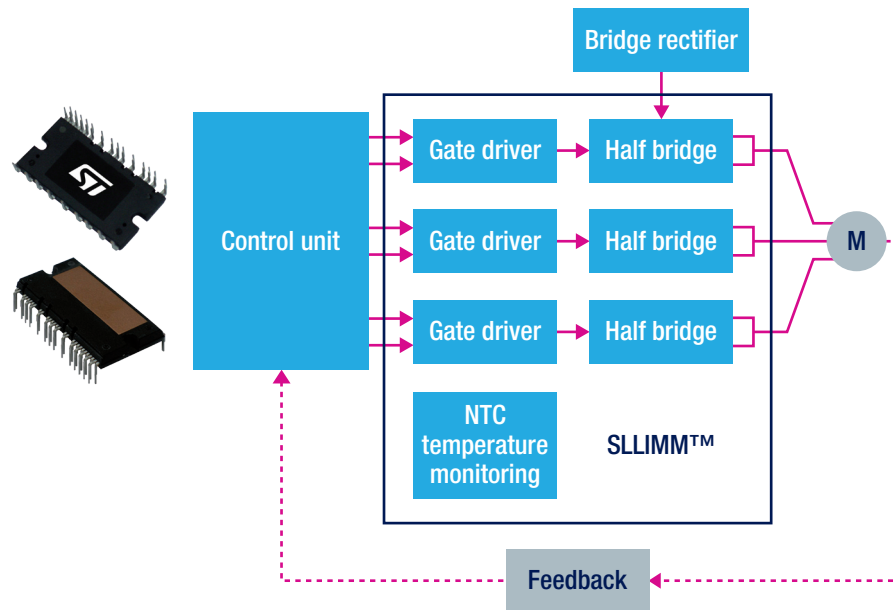
## KEY PRODUCTS

### SLLIMM™ intelligent power modules

Reduce your design time, efforts and costs with ST's portfolio of highly-integrated, high-efficiency power modules for flexible and robust designs ranging from tens of watts up to 3 kW.

ST's SLLIMM™ small low-loss intelligent molded module family of intelligent power modules combine IGBT power switches in a 3-phase IGBT inverter-bridge or half-bridge (single leg) configuration with freewheeling diodes, control ICs for gate driving, protection functions and other optional features in a single package, replacing more than 30 discrete devices.

SLLIMM are available in the DBC-based SDIP package offering extremely low thermal resistance with optimum quality level and cost effectiveness or in the fully-molded 3.5 cm<sup>2</sup> SLLIMM-nano package (NDIP) which is ideal for small, built-in motor applications up to 100 W in free air.



#### KEY FEATURES

- Integrates up to 30 discrete devices to reduce design time and costs
- DBC-based SDIP package for low thermal resistance
- Wide product portfolio covering from tens of watts up to 3 kW

Part number	Voltage (V)	Collector current (@ 25°C) (A)	Pin count	NTC	Shutdown (SD function)	Op amps for advanced current sensing (#)	Smart shutdown function	Rth (max) (°C/W)
STGIPN3H60A	600	3	26	No	No	No	No	N/A
STGIPN3H60 (-H) <sup>1</sup>	600	3	26	No	Yes	Yes (1)	Yes	N/A
STGIPS10K60A	600	10	25	Yes	No	No	No	3.8
STGIPS10K60T (-H) <sup>1</sup>	600	10	25	Yes	Yes	No	No	3.8
STGIPS14K60T	600	14	25	Yes	Yes	No	No	3
STGIPS14K60	600	14	25	No	Yes	No	Yes	3
STGIPL14K60	600	15	38	Yes	Yes	Yes (3)	Yes	2.8
STGIPS20K60	600	18	25	No	Yes	No	Yes	2.4
STGIPL20K60	600	20	38	Yes	Yes	Yes (3)	Yes	2.2
STGIPS20C60	600	20	25	No	Yes	No	Yes	2.7
STGIPS30C60 (-H) <sup>1,2</sup>	600	30	25	No	Yes	No	Yes	2.4

Note: 1. (-H): version with both inputs active high drive

2. (-H): version available Jun 2013

Monolithic motor driver ICs

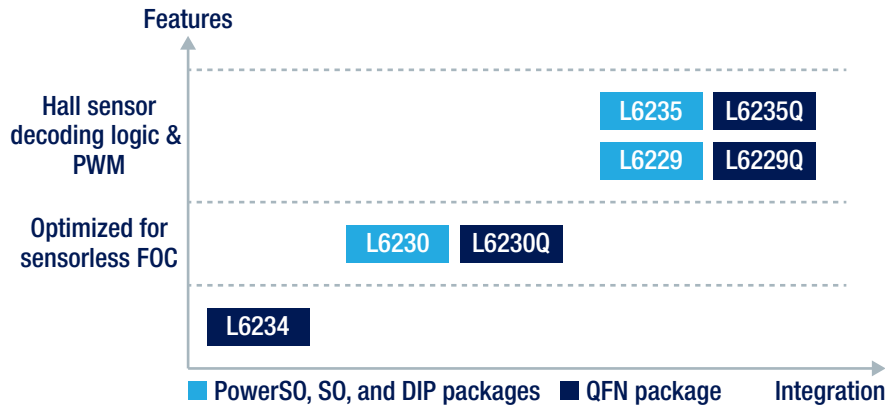
ST’s BLDC motor drivers combine the control logic and power stage on the same chip, providing reliable and cost-effective solutions to drive brushless DC motors. A full set of embedded hardware protection functions and the extensive diagnostic capability ensure a very robust motor drive, further reducing the number of external components, cost and complexity.

The multiple package options together with the wide operating voltage, current and temperature ranges cover most application requirements, from board space constraints to thermally challenging environments.

Easier development is ensured by reference designs, evaluation boards, and, in some cases, a development environment which includes thermal analysis.

KEY FEATURES

- Full set of protection functions and extensive diagnostic capability for more robust and compact designs
- Wide operating voltage, current and temperature ranges
- Multiple package options
- Easier development with reference designs, evaluation boards, and, in some cases, thermal analysis



Part number	Description	Supply voltage min-max (V)	Continuous max output current (A)	Package	Note
L6229	PowerSPIN: DMOS driver for 3-phase brushless DC motors	8 to 52	1.4	PowerDIP24, PowerSO36, S024	
L6230	PowerSPIN: DMOS driver for 3-phase brushless DC motors	8 to 52	1.4	PowerSO36, VFQFPN32 5x5	Optimized for sensorless FOC
L6234	PowerSPIN: DMOS driver for 3-phase brushless DC motors	7 to 52	2.8	PowerDIP20, PowerSO20	Optimized for sensorless FOC
L6235	PowerSPIN: 3-phase brushless DC motor driver	13 to 38	2.5	PowerDIP24, PowerSO36, S024	

## DISCRETE POWER SWITCHES

### IGBTs

With 600 V breakdown voltages, ST's IGBTs feature the optimal trade-off between switching performance and on-state behavior due to their proprietary technology, leading to all-around energy-efficient system designs in many applications.

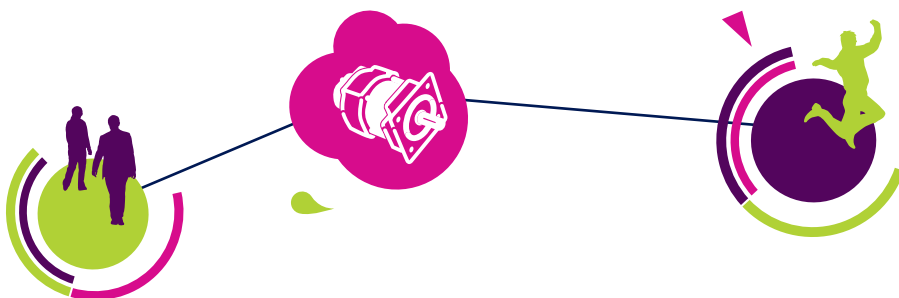
In particular, the negative temperature derating of  $V_{CE(SAT)}$  for the H and K IGBT families make them well suited for low-loss motor drivers. Furthermore, the K series provides the full short-circuit ruggedness that this kind of application requires.

Additionally, Trench Field Stop (TFS) technology enhances the maximum junction temperature up to 175 °C while lowering  $V_{CESAT}$ . Its optimum Trade-off between  $V_{CESAT}$  and  $E_{off}$  leads to power losses reduction thus improving application energy efficiency.

### KEY FEATURES

- Low  $V_{CE(SAT)}$  for reduced conduction losses
- Improved switch-off energy spread versus temperature for reduced switching losses
- Co-packaged anti-parallel diode option for improved power dissipation and best thermal management
- Negative temperature derating of  $V_{CE(SAT)}$
- Several package options

Part number	Collector current max @ 100 °C (A)	$V_{CE(SAT)}$ @ $T_J = 125\text{ °C}$ (V)	Collector emitter voltage max (V)	Short-circuit rugged	Free-wheeling diode	Package
STGD3HF60HDT4	4.5	1.4	600	No	Yes	DPAK
STG*6NC60HD	6	1.7	600	No	Yes	D <sup>2</sup> PAK, DPAK, TO220FP, TO220
STG*10NC60KD	10	1.8	600	Yes	Yes	D <sup>2</sup> PAK, DPAK, TO220FP, TO220
STG*14NC60KD	14	1.8	600	Yes	Yes	D <sup>2</sup> PAK, TO220FP, TO220
STG*19NC60KD	20	1.8	600	Yes	Yes	D <sup>2</sup> PAK, TO220FP, TO220
STG*30NC60KD	30	1.9	600	Yes	Yes	TO247
STG*40NC60KD	40	1.9	600	Yes	Yes	TO247
STG*20H60DF	20	1.75	600	Yes	Yes	D <sup>2</sup> PAK, TO220
STG*30H60DF	30	2.2	600	Yes	Yes	D <sup>2</sup> PAK, TO220FP, TO220





## Power MOSFETs

ST's MOSFET portfolio offers a broad range of breakdown voltages from 40 V to 550 V, with low gate charge and low on-resistance based on the low-voltage trench process and high-voltage planar process with ultra-fast diodes.



### KEY FEATURES

- Up to 550 V breakdown voltage
- Wide package options
- Low-voltage state-of-the-art on-resistance
- Intrinsic fast body diode option
- Very low on-resistance
- Dynamic dv/dt ruggedness
- High current capability
- Correct Crss/Ciss capacitive ratio and Vth average value
- Low thermal resistance
- Thin and powerful package
- Low Qrr and right softness for bridge configuration

Part number	BV <sub>DSS</sub>	R <sub>DS(on)</sub> max @ 10 V (mΩ)	Drain current (ID) max (A)	Qrr (μC)	Trr (ns)	Package
ST*270N4F3	40	2	160	225	70	DPAK, H²PAK, I²PAK, PowerSO10
ST*80N4F6	40	6	80	N/A	N/A	DPAK, I²PAK
STP80N70F4	68	9.8	85	130	55	T0-220
ST*160N75F3	75	3.7	120	150	70	T0-220, T0247, D²PAK
ST*270N8F7	80	2.2	180	N/A	N/A	T0-220/H²PAK
ST*310N10F7	100	2.7	180	200	85	T0-220/H²PAK
STF12N50U	500	800	10	182	73	T0-220FP
ST*5N52U	525	1500	4.4	95	55	DPAK, T0-220FP, I²PAK
STF16N50U	500	470	15	280	85	T0-220FP

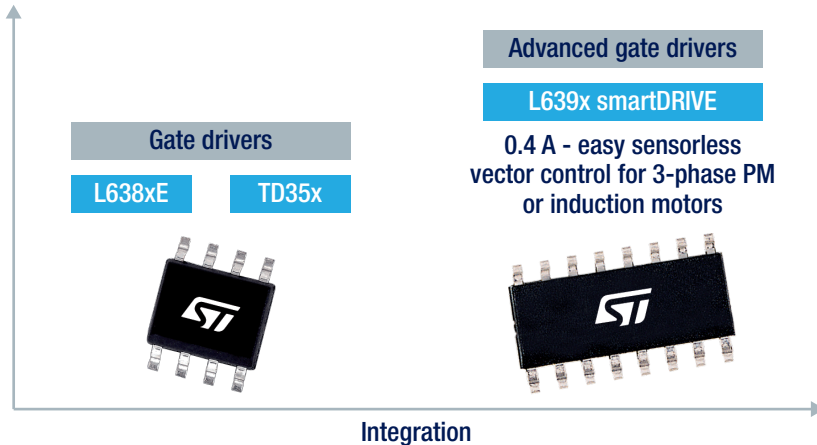
## Gate drivers for MOSFETs and IGBTs

ST's power MOSFET and IGBT drivers include integrated half-bridge, single and multiple low-side gate drivers. ST's MOSFET/IGBT drivers provide state-of-the-art integration, reducing BOM cost and final application dimensions, while also increasing robustness and noise immunity.

The L638xE and the brand new smartDRIVE™ L639x are the two high-voltage half-bridge gate driver families that are leading the industrial market, from home appliances to HVAC systems, from pumps and fans to factory automation.

The TD35x and TD2xx families complete the ST gate driver offer featuring single-channel drivers. In particular, the TD350E is an innovative gate driver where control and protection functions are included and allow the design of highly-reliable systems. An innovative active Miller clamp function eliminates the need for negative gate drive in most applications and allows the use of a simple bootstrap supply for the high-side driver.

Performance



### KEY FEATURES

- Half-bridge, single-channel and multichannel gate drivers
- State-of-the-art integration thanks to:
  - HV bootstrap diode
  - Op amp
  - Comparator
  - Smart shutdown
  - Undervoltage lock out (UVLO)
  - Programmable deadtime

Part number	Logic interface		V <sub>CC</sub> max (V)	UVLO on V <sub>CC</sub> (V)	UVLO on V <sub>BOOT</sub> (V)	Interlocking - DT (μs)	Op amp	Comparator	# pins
	Input configuration	Configuration							
Half-bridge drivers									
L6384E	Single in, SD	5, 15 V	18	10/12	-	0.5 ÷ 2.7	No	No	8
L6385E	HIN and LIN	5, 15 V	18	8.3/9.6	8.2/9.5	-	No	No	8
L6386E L6386AD	HIN, LIN, SD	5, 15 V	18	10/12 8.3/9.6	9.9/11.9 8.2/9.5	9.9/11.9	No	Yes, uncommitted	14
L6387E	HIN and LIN	5, 15 V	18	5.5/6	-	Interlocking	No	No	8
L6388E	HIN and LIN	3.3, 5, 15 V	18	8.3/9.6	8.2/9.5	0.32	No	No	8
L6390	HIN, LIN, SD	3.3, 5, 15 V	21	10.5/12	10/11.5	0.18 ÷ 3	Yes	Yes, committed to fault + SSD	16
L6391	HIN, LIN, SD	3.3, 5, 15 V	21	10.5/12	10/11.5	0.18 ÷ 3	No	Committed to fault + SSD	14
L6392	HIN, LIN, SD	3.3, 5, 15 V	21	10.5/12	10/11.5	0.18 ÷ 3	Yes	No	14
L6393	Phase, brake, SD	3.3, 5, 15 V	21	8.0/9.5	8/9	0.18 ÷ 3	No	Yes, uncommitted	14
L6395	HIN and LIN	3.3, 5, 15 V	20	8.8/9.5	8/8.6	-	No	No	8
L6398	HIN and LIN	3.3, 5, 15 V	21	8.0/9.5	8/9	0.32	No	No	8
Single-channel drivers									
TD350	Single in (opto/pulse trans compatible)	5 V	26	11	-	-	No	-	14
TD351	Single in (opto/pulse trans compatible)	5 V	26	11	-	-	No	No	8
TD352	Single in (opto compatible)	5 V	26	11	-	-	No	No	8

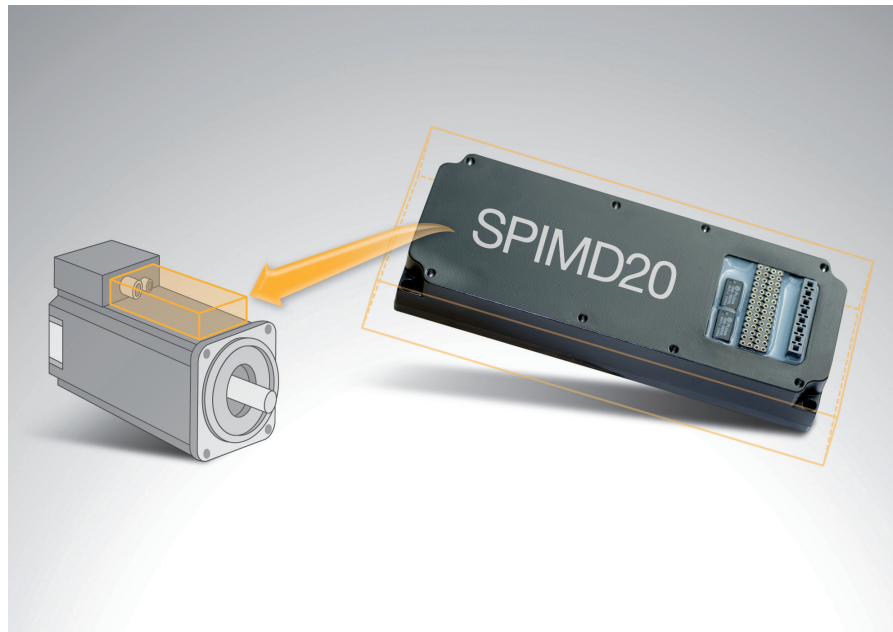
### SPIMD20 integrated motor drive (IMD) module

The SPIMD20 is an integrated high-end motor driver with real-time connectivity suitable for direct integration with permanent magnet synchronous motors (i.e. 6 Nm torque) thanks to the reduced dimensions (165 x 60 x 26 mm). The IMD is designed to operate on a motor with a surface temperature up to 100 °C and performs motor driving functions including speed, position and field-oriented control, plus connectivity.

Connection to the master is performed via a real-time Ethernet Fieldbus, including but not limited to EtherCAT® as per IEC 61158. In fact, the IMD is an open and flexible platform to execute any other communication standard with the on-board FPGA (Altera Cyclone III type) and the two microprocessors from the STM32F103 series. A basic software package is available with the SPIMD20.

Target applications are complex systems where a high number of axes must be synchronized, such as packaging machines, CNC and robotics.

The STEVAL-SPIMD20V1 board simplifies integration with the motor and the debug of the final application.



#### KEY FEATURES

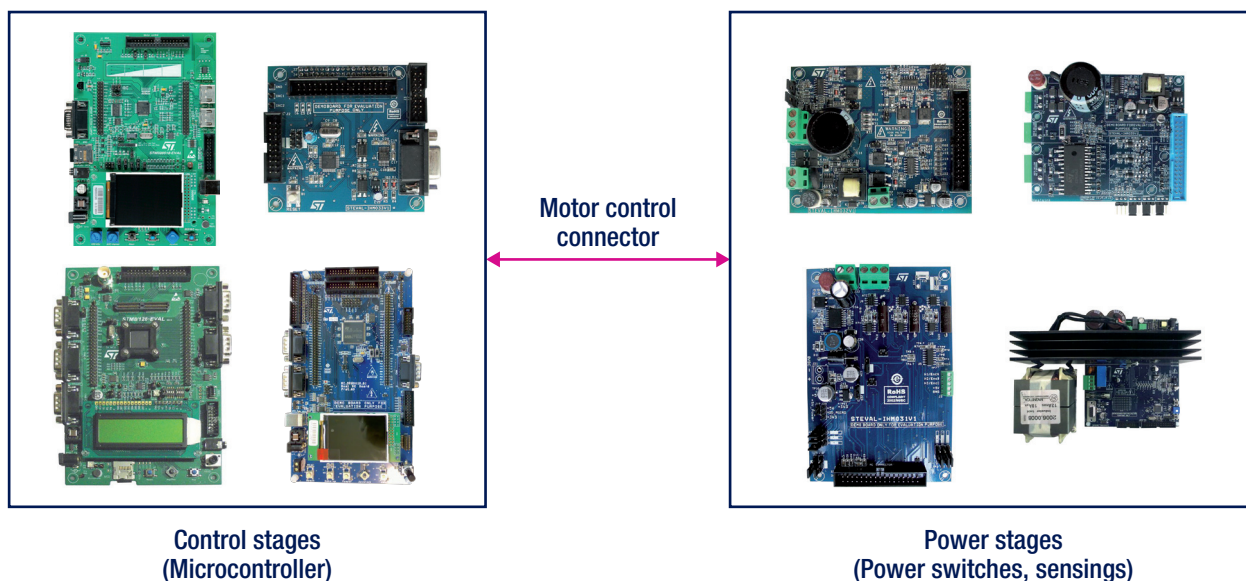
- Extremely compact dimensions
- Up to 2 kW power with 800 Vdc supply, on 100 °C motor surface
- IGBT technology
- Ethernet real-time connectivity (customizable), CAN bus, RS-232 interface
- Supports removable Flash memory cards
- Vibration analysis and thermal sensing
- STO (safe torque off)
- IP65 compliant
- Safe architecture to apply to IEC 61800-5-1 safety standards
- EMI: IEC 61800-3/A11 and UL508C



## EVALUATION TOOLS

To ensure the best flexibility and inter-changeability between the power stages and the control stages (which may use different microcontroller part numbers), many of ST's evaluation boards both for microcontrollers and power devices have an MC connector on-board. This connector is ST's standard and is suitable for different control algorithms such as vector control (or field-oriented control) and scalar control (for example, V/f for AC IM).

Any power stages with an MC connector can be used in conjunction with any of the control stages with the same connector. The microcontroller section on page 40 provides more information about ST's offer for microcontrollers and HW and SW tools.



Order code	Description	Eval board type	Technical documentation	MC connector availability
<b>STEVAL-IHM021V2</b>	100 W, 3-phase inverter based on L6390 gate driver and UltraFASTmesh™ MOSFET for FOC of 3-phase PMSM	Power stage only	UM1491	Yes
<b>STEVAL-IHM023V2</b>	1 kW 3-phase motor control demonstration board featuring L6390 gate drivers and STGP10NC60KD IPM	Power stage only	UM0723	Yes
<b>STEVAL-IHM025V1</b>	1 kW 3-phase motor control demonstration board featuring the IGBT SLLIMM™ STGIPL14K60 IPM	Power stage only	UM0900	Yes
<b>STEVAL-IHM027V1</b>	Power board with MC connector based on the STGIPS10K60A 10 A, 600 V IPM	Power stage only	UM0969	Yes
<b>STEVAL-IHM028V1</b>	2 kW 3-phase motor control demonstration board featuring the IGBT STGIPS20K60 IPM	Power stage only	UM1036	Yes
<b>STEVAL-IHM031V1</b>	3-phase low-voltage inverter power board for FOC and scalar motor control based on STS8DNH3LL MOSFET	Power stage only	UM0971	Yes
<b>STEVAL-IHM032V1</b>	150 W inverter featuring L639x gate driver and STGD3HF60HD IGBT for 1-shunt based FOC and trapezoidal control	Power stage only	UM1078	Yes
<b>STEVAL-IHM035V1</b>	3-phase high-voltage inverter power board for FOC and scalar motor control based on the STGIPN3H60 (SLLIMM™-nano) IPM	Power stage only	UM1517	Yes
<b>STEVAL-IHM036V1</b>	Low-power motor control board featuring the SLLIMM™ STGIPN3H60 IPM and STM32F100 microcontroller	Full inverter (MCU on board)	UM1483	No
<b>STEVAL-IFN003v1</b>	PMSM FOC motor driver based on L6230 motor driver and STM32F103 microcontroller	Full inverter (MCU on board)	UM1478	No
<b>STEVAL-IFN004v1</b>	BLDC six-step motor driver based on L6230 motor driver and STM8S105 microcontroller	Full inverter (MCU on board)	UM1477	No
<b>STEVAL-SPIMD20V1</b>	Power drive system demonstration kit based on the SPIMD20 integrated motor drive	Full inverter (MCU on board)	DB1505	No
<b>EVAL6235PD</b>	L6235 3-phase brushless DC motor driver demonstration board	Full inverter	DB1409	No

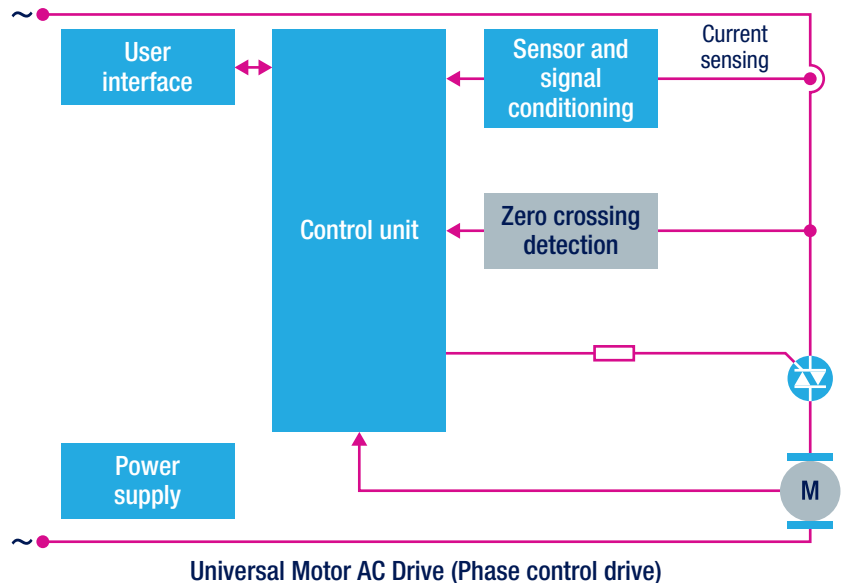
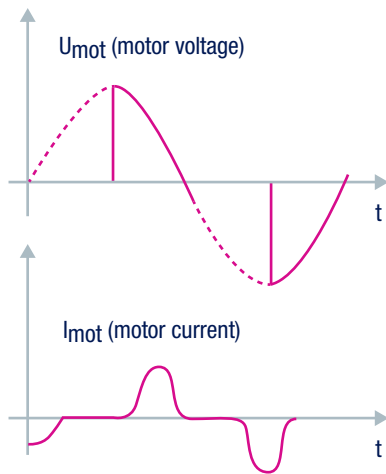
# Universal motor

## Overview

Universal motors can operate on either AC or DC power and are commonly used in many appliances (such as washing machines and vacuum cleaners), normally when the power does not exceed about 1000 W.

One of the simplest and cost-effective ways to vary the speed of the rugged universal motor is by changing the amount of mains voltage actually applied to its terminals by acting on the firing angle of an alternate current switch.

A general-purpose 8-bit microcontroller such as the STM8S can be generally used to implement this drive<sup>1</sup>.



## KEY PRODUCTS

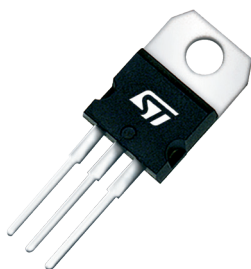
### TRIAC, ACS™ AND ACST FAMILIES

ST offers a complete range of thyristors and AC switches with voltage ratings up to 1200 V, current ratings up to 100 A and a set of packages from miniature surface-mounted packages to high power dissipation isolated and non-isolated packages.

The latest extension to the AC switch range features the SMB-Flat package, which is smaller than SOT-223 and is aimed at the 0.8 A device range. The PCB can be designed so that the SMB-Flat and SOT-223 are fully interchangeable for increased production flexibility.

#### Triacs

ST's portfolio of Triacs includes devices with voltage ratings up to 800 V and RMS on-currents up to 40 A in general-purpose standard configurations, a new high-commutation T series in Snubberless™ technology, and 3-quadrant high-temperature Triacs (H series) for use in harsh environments. They are the reference for universal and induction motor drivers in appliance applications where, due to their ability to manage the stringent inrush conditions when driving inductive loads, they can switch off three times their rating current.



#### KEY FEATURES

- Robustness and reliability
- Wide voltage and current ranges
- Rich portfolio:
  - Standard Triacs
  - Snubberless™ with enhanced switch-off capability, for inductive loads
  - High-temperature T series for hot environments

	Part number	Packages	Current rating (A <sub>RMS</sub> )	Non repetitive surge peak on-state current (A)	Repetitive off-state voltage (V)	Operating Tj max (°C)	I <sub>GATE</sub> (mA)
T series	T435T-600FP	T0220ABFP	6	30	600/800 <sup>1</sup>	125/150 <sup>1</sup>	35
	T635T* <sup>1</sup>	T0-220AB-Insulated 2500 V; T0-220AB-FP <sup>1</sup> ; T0-220AB <sup>1</sup>	8	45			10, logic level, 3Q 20/35, Snubberless™, 3Q 25, standard, 4Q
	T8T		12	60			
	T12T		16	90			
	T16T		6	120			

Note: 1. Available Q3 2013

	Part number	Packages	Current rating (A <sub>RMS</sub> )	Non repetitive surge peak on-state current (A)	V <sub>DRM</sub> - V <sub>RRM</sub> (V)	Operating Tj max (°C)	I <sub>GATE</sub> (mA)
H series	T410H	T0220	4	40	600	150	10
	T610H	T0220	6	60			10
	T8**H	T0220, D <sup>2</sup> PAK, T0-220I	8	80			10 35 50
	T10**H		10	100			35 50
	T12**H		12	120			
	T16**H		16	160			
	T20**H		20	200			
	T30**H	T0220, T0-220I	30	270			

## ACST™ and ACST

Using innovative ASD application-specific device technology, ST's ACST™ and ACST devices are specific switches developed for home appliances and industrial control applications.

While maintaining very high switch-off capability, logic-level devices allow direct drive by a microcontroller. With integrated overvoltage protection against random transients, no external MOV protection is needed, providing system safety and transient and surge voltage immunity as defined in the IEC 61000-4-4 and -4-5 standards. The ACST series is now extended from 2 A to 16 A, housed in TO-220AB and TO-220FP packages and the ACS series is also extended to 800 V with a lower gate triggering sensitivity of 5 mA.

### KEY FEATURES

- High switch off capability
- Low gate current for direct connection to MCU
- Internally protected, no need of external circuitry to meet IEC 61000-4-4 and -4-5 standards

Part number	Packages	Current rating (A <sub>RMS</sub> )	Non repetitive surge peak on-state current (A)	Repetitive off-state voltage (V)	Operating T <sub>J</sub> max (°C)	I <sub>GATE</sub> (mA)
ACST2	DPAK, TO220FPAB	2	8	800	125	10
ACST4	DPAK, TO220FPAB	4	30			10, 35
ACST6	D <sup>2</sup> PAK, TO220AB, TO220FPAB	6	45			10
ACST8	D <sup>2</sup> PAK, TO220AB, TO220FPAB	8	80			30
ACST10	TO220AB, TO220FPAB	10	100	700	125	10, 35
ACST12	D <sup>2</sup> PAK, TO220AB	12	120	700	125	10, 35
ACST1635-8FP	TO220FPAB	16	140	800	150	35
ACS302-6T <sup>1</sup>	S020	0.2	7.3	600	125	5
ACS102-6T	S08, T092	0.2	7.3	600	125	5
ACS108	SOT223, T092	0.8	13.7	800	125	10
ACS110	SOT223	1	8	700	125	10
ACS120	DPAK, TO220AB, TO220FPAB	2	20	700	125	10

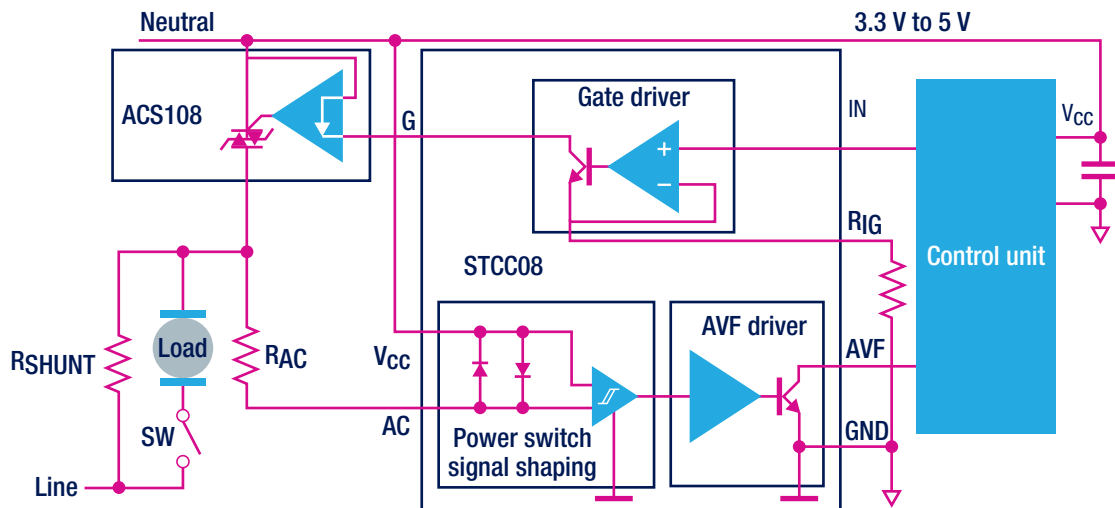
Note: 1. Available Q3 2013





## Power control, monitoring drivers

The STCC08 drives the AC switch and sends diagnostic data to the MCU in case of switch failure (short and open circuits, diode mode). It helps the whole appliance to meet the IEC 60335-1 safety standard.



## EVALUATION TOOLS

Order code	Description	Technical documentation
STEVAL-IHM029v1	Universal motor control evaluation board based on high-temperature junction Triac and STM8S microcontroller	UM0922
STEVAL-IHM041v1	Universal motor driver with speed control based on the STM8 microcontroller and Triac (US version)	UM1559





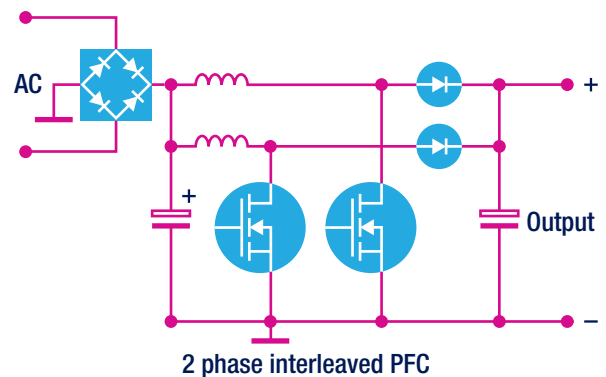
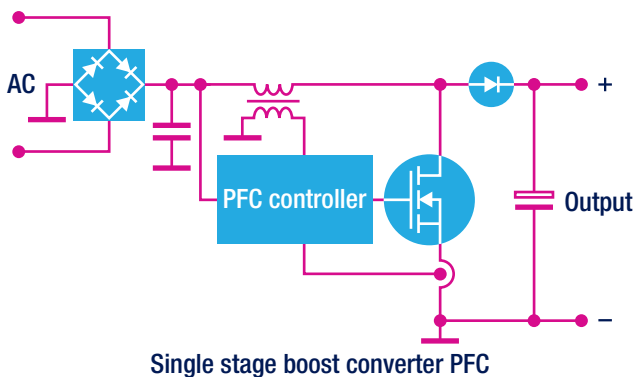
# Power factor correctors

## Overview

ST features products for the two main topologies used for power factor correction associated to motor control applications.

A single-stage boost converter is the most used topology for PFC. ST's portfolio supports both the solution using an integrated PFC controller with external power switch and the topology where the PFC control is executed by a microcontroller and the power switch actuation through a gate driver.

Above 2 kW, an interleaved PFC may be more convenient. Despite a higher number of components, it allows better heat dissipation and smaller silicon devices, reduces input current ripple and RMS current in the bus capacitor and finally helps in reducing the dimension of the filter.



## KEY PRODUCTS POWER SWITCHES

### IGBTs

With breakdown voltages ranging up to 600 V, ST's IGBTs feature the optimal trade-off between switching performance and on-state behavior. When the switching frequency is increased up to 60 kHz, ultra-fast switches, such as the forthcoming V\_F series in new trench gate field stop technology, are required.

	Part number	Collector current max @ 100 °C (A)	$V_{CE(SAT)}$ @ $T_J = 125\text{ °C}$ (V)	Free-wheeling diode	Package
Up to 20 kHz	STG*10NC60H(D)	10	1.7	No (Yes)	D <sup>2</sup> PAK, DPAK, T0220FP, T0220
	STG*7NC60H(D)	14	1.7	No (Yes)	D <sup>2</sup> PAK, DPAK, T0220FP, T0220
	STG*19NC60H(D)	19	1.6	No (Yes)	D <sup>2</sup> PAK, T0220FP, T0220, T0247
	STG*20NC60V(D)	30	1.7	No (Yes)	D <sup>2</sup> PAK, T0220FP, T0220, T0247
	STG*39NC60V(D)	40	1.7	No (Yes)	T0247
Up to 60 kHz	STG*20V60(D)F <sup>1</sup>	20	2.15	No (Yes)	D <sup>2</sup> PAK, T0220FP, T0220
	STG*30V60(D)F <sup>1</sup>	30	2.15	No (Yes)	D <sup>2</sup> PAK, T0220FP, T0220, T0247
	STG*40V60(D)F <sup>1</sup>	40	2.15	No (Yes)	D <sup>2</sup> PAK, T0220, T0247

Note: 1. Available Q3 2013

## Power MOSFETs

ST's MOSFET portfolio offers a broad range of breakdown voltages from 500 V to 650 V, with low gate charge and low on-resistance, combined with state-of-the-art packaging. ST's process technology for both high-voltage and low-voltage MOSFETs has enhanced power handling capability, resulting in high-efficiency solutions.

The MDmesh™ V, MDmesh™ II and MDmesh II Plus™ low Qg families of power MOSFETs are particularly suitable for PFC circuits.

	Part number	BV <sub>DSS</sub> (V)	R <sub>DS(on)</sub> max @ 10 V (Ω)	Drain current max (A)	Qg (nC)	Package
More than 50 kHz	STY105NM50N	500	0.022	110	326	Max247
	STW60NM50N	500	0.043	68	178	T0247
	ST*36N55M5	550	0.08	33	72	T0220, T0220FP, D <sup>2</sup> PAK
	ST*18N55M5	550	0.192	16	31	T0220, T0220FP, D <sup>2</sup> PAK, DPAK
	STY100NM60N	600	0.029	98	330	Max247
	STW70NM60M2 <sup>1</sup>	600	0.04	68	110	T0247
	STW62NM60N	600	0.049	65	174	T0247
	STW56NM60N	600	0.06	51	300	T0247
	STW48NM60N	600	0.07	39	130	T0247
	ST*40N60M2 <sup>1</sup>	600	0.088	34	75	T0220, T0220FP, D <sup>2</sup> PAK, I <sup>2</sup> PAK, I <sup>2</sup> PAKFP, T0247
	ST*33N60M2 <sup>1</sup>	600	0.12	N/A	47	T0220, T0220FP, D <sup>2</sup> PAK, I <sup>2</sup> PAK, T0247, PowerFLAT 8x8 HV
	ST*28N60M2 <sup>1</sup>	600	0.15	N/A	39	T0220, T0220FP, D <sup>2</sup> PAK, I <sup>2</sup> PAK, T0247
	ST*24N60M2 <sup>1</sup>	600	0.19	18	29	T0220, T0220FP, D <sup>2</sup> PAK, I <sup>2</sup> PAKFP, I <sup>2</sup> PAK, T0247, PowerFLAT 8x8 HV
	STY145N65M5	650	0.015	139	414	Max247
	STY139N65M5	650	0.017	130	363	Max247
	ST*88N65M5	650	0.029	84	204	T0247
	STW69N65M5	650	0.045	58	153	T0247, T03P
	ST*57N65M5	650	0.063	42	110	T0220, T0220FP, D <sup>2</sup> PAK, I <sup>2</sup> PAK, T0247
	ST*20NM65N	650	0.25	19	44	T0220, T0220FP
	ST*15NM65N	650	0.35	13	40	T0220, T0220FP
	ST*11NM65N	650	0.41	11	30	T0220, T0220FP, DPAK

Note: 1. Available Q3 2013

## Diodes and rectifiers

ST offers ultrafast, Tandem™ and silicon carbide (SiC) rectifier solutions for all market requirements.

Our SiC and ultrafast diodes range from 600 V to 650 V with various VF/TRR, QC trade-offs so as to achieve the best performance for your PFC application.

For power converter applications where silicon diodes reach the limits of their operating temperature and power density, ST's first and second generation silicon carbide devices offer optimal reliability and performance.

All ST products are rated up to 175 °C operating junction temperature, as a result of the reduced leakage currents.

### PACKAGING OPTIONS

- Single diode for conventional PFC  
Dual common cathode for interleaved configuration
- T0247 with longer leads facilitate bending and heat-sink assembly
- T03P facilitates the mounting of plastic frames

	Part number	Average rectified current max (A)	Forward voltage (V <sub>F</sub> ) max (V)	V <sub>F</sub> measuring condition (A)	Reverse recovery time max (ns)	Reverse current max (mA)	Package
600 V ultrafast rectifiers	STTH8R06	8	2.9	8	25	0.025	D <sup>2</sup> PAK; TO-220AC; TO-220AC Ins; I <sup>2</sup> PAK; TO-220FPAC
	STTH12R06	12	2.9	12	25	0.045	D <sup>2</sup> PAK; TO-220AC; TO-220AC Ins
	STTH15R06	15	2.9	15	30	0.06	TO-220AC; TO-220FPAC
	STTH30R06	30	1.85	30	50	0.025	DO-247; DOP3 Ins

	Part number	Average rectified current max (A)	Forward voltage ( $V_F$ ) max (V)	$V_F$ measuring condition (A)	Reverse recovery time max (ns)	Reverse <sup>1</sup> recovery current max (A)	Package
<b>600 V hyper-fast Tandem rectifiers</b>	<b>STTH8T06DI</b>	8	2.55	8	28	3	TO-220AC Ins
	<b>STTH12T06DI</b>	12	2.55	12	30	TBD	TO-220AC Ins
	<b>STTH8S06DI</b>	8	3.1	8	20	TBD	TO-220AC Ins

Note: 1. See datasheet for testing conditions

	Part number	Average rectified current max (A)	Forward voltage ( $V_F$ ) max (V)	$V_F$ measuring condition (A)	Total capacity charge typ <sup>1</sup> (nC)	Package
<b>600 V 1<sup>st</sup> generation SiC diodes</b>	<b>STPSC606</b>	6	1.7	6	6	D <sup>2</sup> PAK; TO-220AC
	<b>STPSC806</b>	8	1.7	8	10	D <sup>2</sup> PAK; TO-220AC
	<b>STPSC1006</b>	10	1.7	10	12	D <sup>2</sup> PAK; TO-220AC
	<b>STPSC1206</b>	12	1.7	12	12	TO-220AC
	<b>STPSC2006C</b>	2 x 10	1.7	10	12	TO-247
<b>650 V 2<sup>nd</sup> generation SiC diodes</b>	<b>STPSC6H065</b>	6	1.75	6	18	D <sup>2</sup> PAK; TO-220AC; DPAK
	<b>STPSC8H065</b>	8	1.75	8	23.5	D <sup>2</sup> PAK, DPAK, TO-220AC
	<b>STPSC10H065</b>	10	1.75	10	28.5	D <sup>2</sup> PAK, TO-220AC, DPAK
	<b>STPSC12H065</b>	12	1.75	12	TBD	D <sup>2</sup> PAK, TO-220AC, DPAK
	<b>STPSC20H065C</b>	2 x 10	1.75	10	28.5	TO-220, TO-247

Note: 1. See datasheet for testing conditions

## PFC controllers

The new L4984 is a current-mode PFC controller operating with line-modulated fixed-off-time (LM-FOT) control. A proprietary LM-FOT modulator allows fixed-frequency operation for boost PFC converters as long as they are operated in CCM (continuous conduction mode).

The chip comes in a 10-pin SO package and offers a low-cost solution for CCM-operated boost PFC pre-regulators in EN61000-3-2 and JEIDA-MITI compliant applications, in a power range that spans from a few hundred watts to 1 kW and above.

A software design tool based on an Excel spreadsheet is available.

Part number	Description	Package
<b>L4984</b>	Current-mode PFC controller	SO10

## KEY FEATURES

- Current continuous mode FOT
- Adjustable overvoltage protection on  $V_{OUT}$  (unlatched)
- Inductor saturation protection (unlatched)
- Open loop protection
- Input mains undervoltage detection
- Soft start-up for in-rush current limiting
- THD improver
- Remote on/off control input pin
- Small package
- 150 °C operating junction temperature



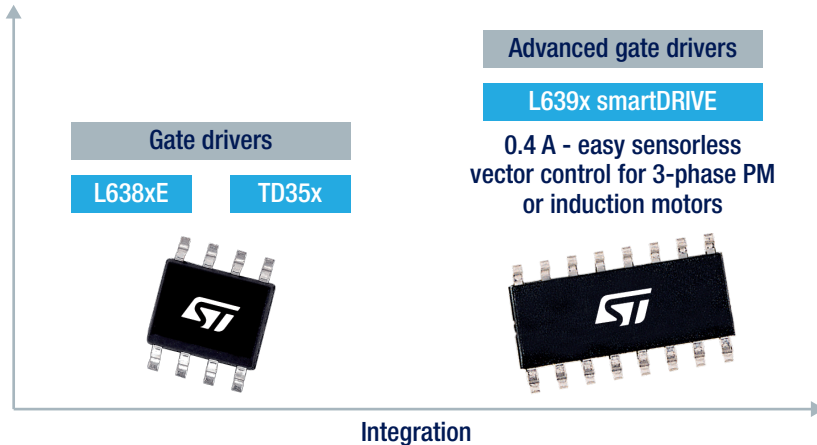
## Gate drivers for IGBTs and MOSFETs

ST's power MOSFET and IGBT drivers include integrated high-voltage half-bridge, single and multiple low-side gate drivers. ST's MOSFET/IGBT drivers provide state-of-the-art integration, reducing BOM cost and final application dimensions, while also increasing robustness and noise immunity.

The TD35x and TD2xx are the two families of single-channel gate drivers featuring an innovative active Miller clamp function which eliminates the need for negative gate drive in most applications and allows the use of a simple bootstrap supply for the high-side driver.

The TD350E, in particular, is an innovative gate driver where control and protection functions are included and allow the design of highly-reliable systems.

Performance



### KEY FEATURES

- Half-bridge, single-channel and multichannel gate drivers
- State-of-the-art integration thanks to:
  - HV bootstrap diode
  - Op amp
  - Comparator
  - Smart shutdown
  - Undervoltage lock out (UVLO)
  - Programmable deadtime

Part number	Logic interface		V <sub>cc</sub> max (V)	UVLO on V <sub>cc</sub> (V)	Op Amp	Comparator	# Pins
	Configuration	Compatibility					
TD350	Single channel (opto/pulse transformer compatible)	5 V	26	11	No	No	14
TD351	Single channel (opto/pulse transformer compatible)	5 V	26	11	No	No	8
TD352	Single channel (opto compatible)	5 V	26	11	No	No	8
TD220	Single channel	3.3, 5 V	17	8	No	No	8
TD221	Single channel	3.3, 5 V	12	8	No	No	8
TD310	Triple channel	3.3, 5 V	18	12	Yes	Yes	16

## EVALUATION TOOLS

Order code	Description	Technical documentation
EVL4984-350W	350 W CCM PFC pre-regulator demonstration board based on L4984	AN4163



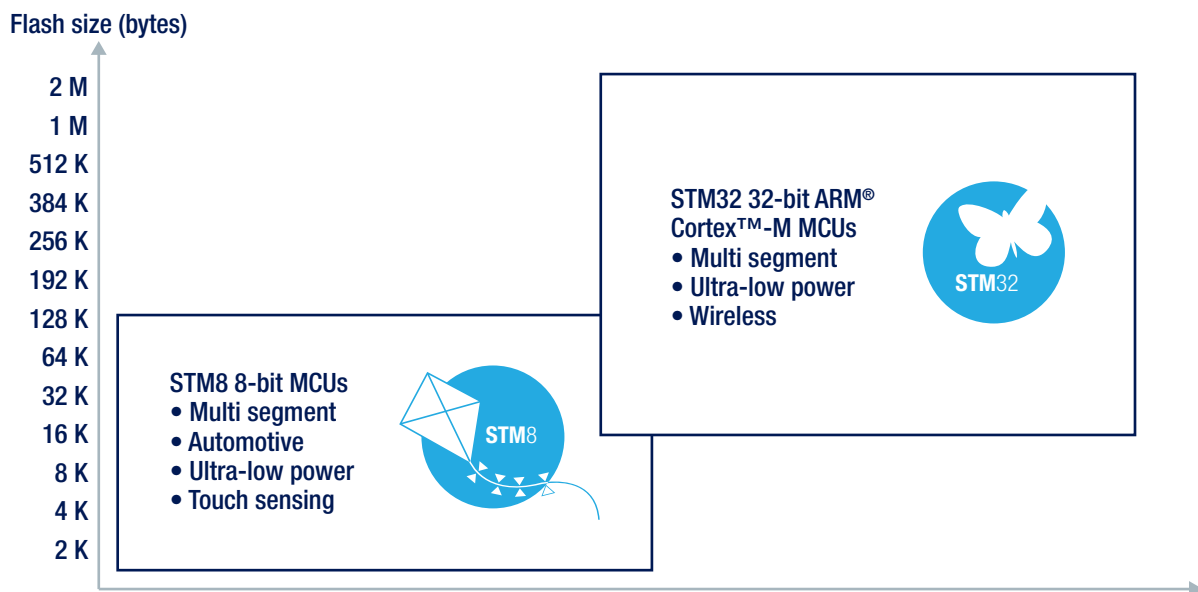
# Microcontrollers

## MCU portfolio

By choosing one of ST's microcontrollers for your embedded application, you gain from our leading expertise in MCU architecture, technology, multi-source manufacturing and support.

ST's product portfolio contains a comprehensive range of microcontrollers, from robust, low-cost 8-bit MCUs, the STM8 family, up to 32-bit ARM-based Cortex™-M0, Cortex™-M3, Cortex™-M4 Flash microcontrollers with a rich choice of peripherals, the STM32 family.

Extensive support through a combination of flexible and powerful development tools, training courses, consultancy and web support gives you a plus for a faster time to market.



## MCU SELECTION GUIDE FOR MOTOR CONTROL

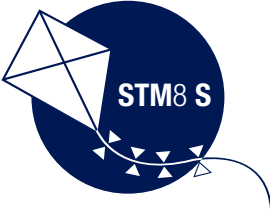
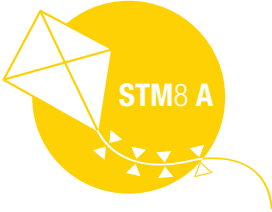
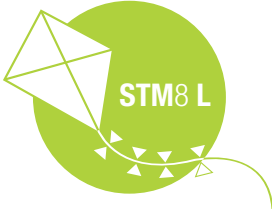

	STM8S	STM32
Brushed DC motors	X	
Single-phase AC induction motors	X	
Stepper motors	X	X
Switched reluctance motors	X	X
3-phase brushless motors	X	X
Universal motors	X	
PFC		X

## STM8 8-BIT MICROCONTROLLERS

The STM8 MCU is part of a platform of technologies, IPs and tools which forms the basis of ST's comprehensive family of 8-bit microcontrollers. These cover, among others, many applications where there is an electric motor, from consumer electronics, including home appliances and factory automation, to automotive segments. The platform provides outstanding levels of digital and analog performance combined with a high level of cost effectiveness.

Implemented around a high-performance 8-bit core and a state-of-the-art set of peripherals and IPs, the microcontrollers in the STM8 family are manufactured using an ST-proprietary 130 nm embedded non-volatile memory technology.

### One series for every need

<b>STM8S Mainstream</b>  <p>Data EEPROM, 3 and 5 V family, precise RC</p>	<b>STM8A Automotive</b>  <p>Data EEPROM, 3 and 5 V family, precise RC, LIN, CAN, grade 0 AEC-Q100</p>	<b>STM8L Ultra-low-power</b>  <p>Data EEPROM, 1.65 and 3 V family, strong analog, LCD drivers, low-leakage technology</p>	<b>STM8T Touch sensing</b>  <p>Proximity sensors, touchkeys, keypads, sliders or wheels</p>
<b>Platform designed and engineered for cost effectiveness</b> <a href="http://www.st.com/stm8s">www.st.com/stm8s</a> Appliance, industrial and consumer motor control applications	<b>Conceived to meet high quality and reliability standards</b> <a href="http://www.st.com/stm8a">www.st.com/stm8a</a> Automotive motor control applications	<b>Architecture and technology focused on power saving</b> <a href="http://www.st.com/stm8l">www.st.com/stm8l</a> Portable / low voltage motor control applications	<b>Hardware and open software solutions</b> <a href="http://www.st.com/stm8t">www.st.com/stm8t</a> Specific for touch-sensing

### Using STM8's peripherals for motor control

The STM8 comes with a set of peripherals that are suitable for many motor control topologies and applications.

The advanced timer available on the STM8S, STM8L and STM8A is a 16-bit timer capable of both centered or edge-aligned PWM pattern generation and, thanks to the availability of complimentary output on 3 of its channels, is specifically designed to address 3-phase and full-bridge topologies (for 3-phase AC IM, 3-phase PMSM/BLDC, bidirectional DC motors, stepper motor drives). The timer is also equipped with a synchronization circuit allowing the ADC to be triggered on specific events and an asynchronous emergency input.

The 12-bit ADC of the STM8L (10-bit on the STM8S and STM8A) allows motor current and voltage to be precisely sensed while its comparator could be used for hysteresis peak current control.

General-purpose 16-bit timers with their input capture capabilities are very well suited for motor speed feedback processing. In particular, the STM8L also features three input XOR gates combining the data coming from three Hall sensors to simplify speed measurement in 3-phase permanent magnet motors.

### KEY FEATURES

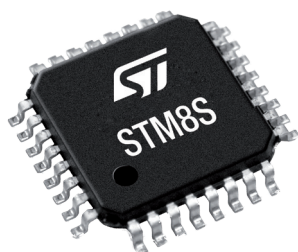
- Advanced timer for 3-phase inverters and full-bridge converter drivers
- Fast and precise ADC can be triggered by timer events
- Rich set of analog IPs on STM32F3xx
- Input capture on general-purpose timers for easier speed feedback processing
- Hall sensor and quadrature encoder operating mode



## STM8S EVALUATION TOOLS FOR MOTOR CONTROL

Order code	Description	Motors covered	Documentation
<b>STM8/128-MCKIT</b>	3-phase brushless motor control starter kit for STM8S microcontroller	3-phase brushless motors: AC IM, BLDC, PMSM	UM0709
<b>STM8/128-EVAL</b>	STM8S MCU evaluation board; any motor control power stage featuring ST's standard MC connector can be connected (see 3-phase brushless motor evaluation tools section)	Depends on power stage connected through MC connector <sup>1</sup>	UM0482
<b>STEVAL-IHM029v1</b>	Universal motor control evaluation board based on high-temperature junction Triac and STM8S microcontroller	Universal, single-phase Induction motors	UM0922
<b>STEVAL-IHM041v1</b>	Universal motor driver with speed control based on the STM8 microcontroller and Triac (US version)	Universal, single-phase induction motors	UM1559
<b>STEVAL-IFN004v1</b>	BLDC six-step motor driver based on L6230 motor driver and STM8S105 microcontroller	3-phase BLDC/PMSM motors	UM1477
<b>STEVAL-IHT001v2</b>	Cold digital thermostat kit	Single-phase induction motors	UM1542

Note: 1. A daughter board may be required to be plugged on STM8/128-EVAL depending on the type of the control and power stage to be connected



### STM8/128-MCKIT STARTER KIT

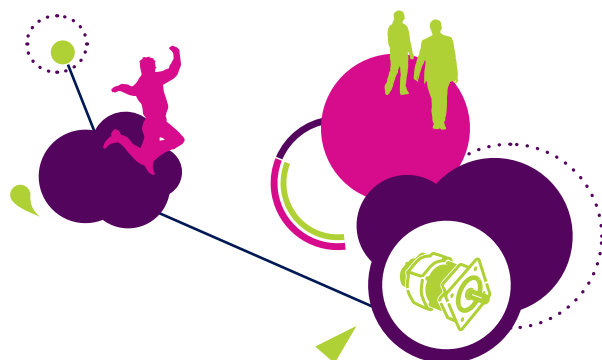
STM8/128-MCKIT is an integrated system designed to provide a complete, ready-to-use kit for evaluation of 3-phase motor control developed around ST's STM8 microcontroller.

This starter kit is particularly suited to drive 3-phase brushless motors (either AC induction or permanent magnet types).

Download for free from [www.st.com](http://www.st.com) the available FW library, configure it through STM8 MC Builder PC software and develop your own applications in conjunction with a third-party IDE and C compiler.

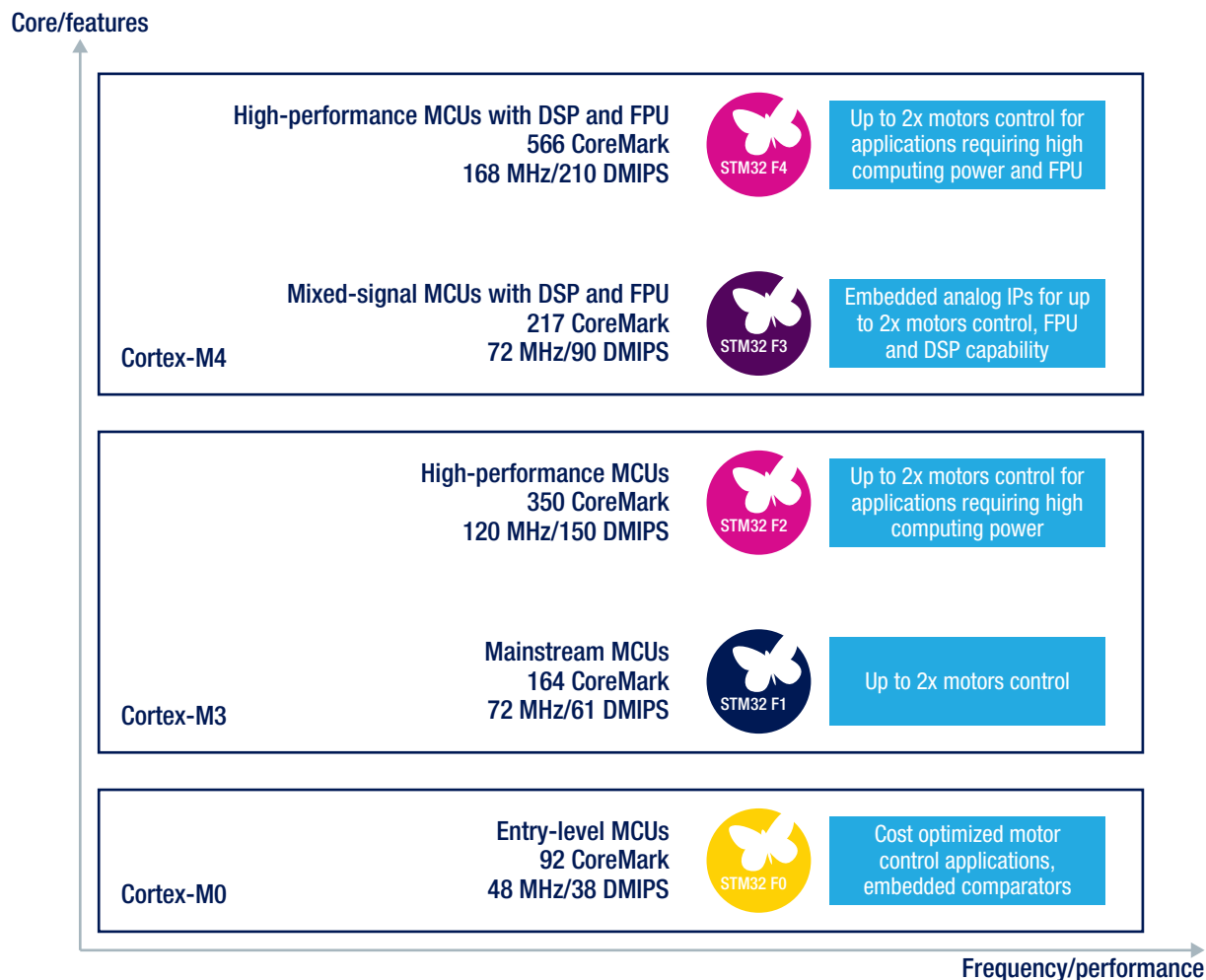
### 3-PHASE BRUSHLESS MOTOR CONTROL WITH STM8S IN 3 STEPS:

1. Visit [www.st.com](http://www.st.com) to download STM8S FW library for 3-phase motor control
2. Configure the FW library through the STM8 MC Builder PC software
3. Develop your own applications in conjunction with a third-party IDE and C compiler

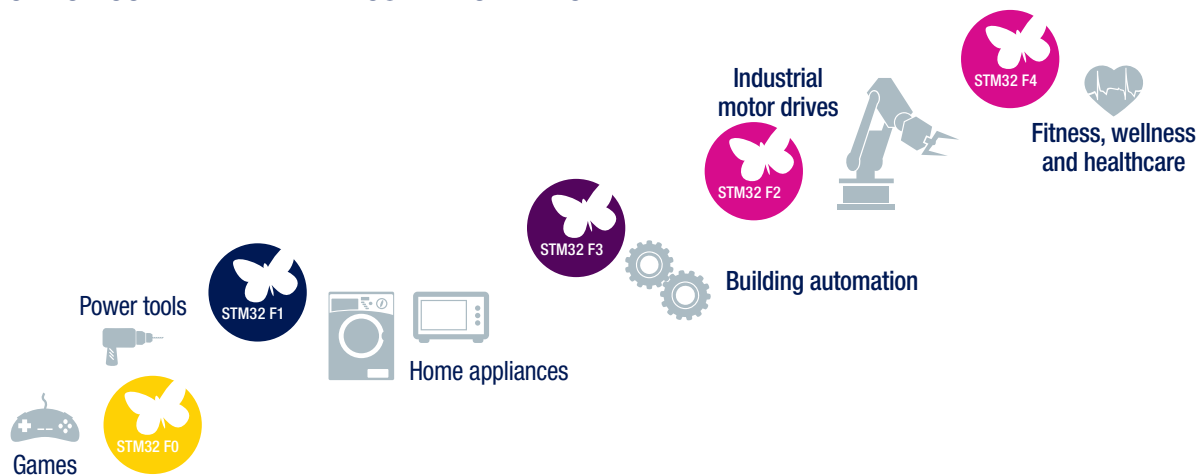


## STM32 32-BIT MICROCONTROLLERS

The STM32 family of 32-bit Flash microcontrollers based on the ARM Cortex™-M processor is designed to offer new degrees of freedom to MCU users. By bringing a complete 32-bit product range that combines high-performance, real-time, low-power and low-voltage operation, while maintaining full integration and ease of development, the STM32 family helps you create new applications and design in the innovations you have long been dreaming about.



## APPLICATION COMPLEXITY AND MCU PERFORMANCE



## Using STM32's peripherals for motor control

Other than the power of ARM Cortex cores, with a floating point unit and DSP capable instruction set for Cortex-M4 devices, the STM32F series comes with a set of peripherals that make them perfectly suitable for the simultaneous control of up to two 3-phase brushless motors in field oriented control (FOC, also known as vector control).

The advanced timer is a 16-bit timer capable of both centered or edge-aligned PWM pattern generation and, thanks to the availability of complimentary output and programmable deadtime on 3 of its channels, is specifically designed to address 3-phase and full bridge topologies (for 3-phase AC IM, 3-phase PMSM/BLDC, bidirectional DC motors, stepper motors drives). The timer also features additional channels that can be devoted to ADC synchronization and generation of specific PWM patterns.

The DMA allows advanced PWM pattern generation such as the one required for 1-shunt resistor based 3-phase current measurement (ST patented method) and advanced ADC synchronization without CPU intervention.

The fast (up to 5.14 MSPS sampling rate for STM32F30xx and STM32F31xx) and precise 12-bit SAR ADCs enable the simultaneous sampling of up to four channels for precise motor current sensing, crucial in vector control algorithms.

General-purpose 16- and 32-bit timers with their input capture capabilities are very well suited for motor speed feedback processing. In particular, the Hall sensor and quadrature encoder dedicated operating modes simplify motor speed and position measurements.

The analog front-end of the STM32F3xx with up to 7 analog comparators and up to 4 op amps guarantees the highest level of integration, simplifying the HW design and validation. The fast comparator (50 ns propagation delay) can be used for cycle-by-cycle current regulation and overvoltage/overcurrent protection. The op amps feature offset compensation, 8 MHz GBW and built-in 1% programmable gains.

### KEY FEATURES

- Advanced timer for 3-phase inverters and full-bridge converter drivers
- Fast and precise ADC can be triggered by timer events
- Rich set of analog IPs on STM32F3xx
- Input capture on general-purpose timers for easier speed feedback processing
- Hall sensor and quadrature encoder operating mode
- DMA for CPU off-loading

Features	STM32 F103	STM32 F303	STM32 F405	Benefits
<b>Timer with dedicated motor control features</b>	1 (2)	2	2	All functions grouped into a single peripheral
<b>Edge or centered PWM patterns</b>	x	x	x	Minimizes acoustic noise for a given switching frequency
<b>Additional timer channel for PWM-synchronized ADC triggering</b>	1	2	1	Simplifies ADC triggering for optimum noise rejection schemes in shunt-based current sensing
<b>Built-in digital deadtime generator</b>	x	x	x	No need for external logic, no variations due to passive components
<b>Critical register write protection</b>	x	x	x	Higher robustness against SW malfunction
<b>Asynchronous fault inputs</b>	x	x	x	Functional safety, protection guaranteed even if clock disappears
<b>Quadrature encoder support</b>	x	x	x	Offloads CPU from sensor feedback management, immediate position/direction reading
<b>Hall encoder input mode</b>	x	x	x	Reduces timer resource needs: a single channel is sufficient for 3 Hall sensors
<b>Versatile output management</b>	x	x	x	Accommodates various gate drivers, handles sine-wave and block commutated drives
<b>Dedicated DMA burst mode for the timers</b>	x	x	x	CPU offloading, multiple registers can be updated in a row
<b>Simultaneous sample and hold ADCs</b>	2 (3)	4	3	Reduces errors due to delay between conversions, ideal for isolated current sensors
<b>High-frequency timer input clock (&gt;144 MHz)</b>		x	x	Finer PWM resolution and current control
<b>Asymmetric PWM modes</b>		x		Easier support of single-shunt current sensing
<b>2 fault inputs</b>		x		Allows overcurrent and overvoltage protection to be managed differently
<b>Ultra-fast comparators</b>		x		Reduces BOM cost, built-in overcurrent and overvoltage protection, cycle-by-cycle current control
<b>Operational amplifiers</b>		x		Reduces BOM cost, direct reading of low-voltage signals from shunt resistors
<b>1% programmable gain amplifiers</b>		x		Reduces BOM cost (no need for gain setting networks), allows dynamically changing gain
<b>External memory interface</b>	(x)		x	Allows interfacing with FPGA for dedicated functions (such as proprietary encoder interfaces)

Legend: x: available; (): available only starting from 256 Kbyte Flash memory devices

## STM32F evaluation boards for motor control

ST proposes a wide range of evaluation boards for comprehensive evaluation of ST's products and solutions while reducing your development time. In particular, all of ST's microcontroller evaluation boards have ST's standard MC connector on-board allowing the use of the board in conjunction with any of the power stage evaluation boards listed in the 3-phase brushless motor paragraph.

Order code	Description	Supported by STM32 PMSM FOC SDK	Benefits
STM320518-EVAL	Evaluation board for STM32 F0 series with STM32F051 MCU	Yes	UM1537
STM32100B-EVAL	Evaluation board for STM32F100 (128-KB Flash) Value line MCUs	Yes	UM0482
STM32100E-EVAL	Evaluation board for STM32F100 (512-KB Flash) Value line MCUs	Yes	UM1055
STM3210E-EVAL	Evaluation board for STM32 F1 series with STM32F103 MCU	Yes1	UM0488
STM3221G-EVAL, STM3220G-EVAL	Evaluation board for STM32 F2 series	Yes	UM1065, UM1057
STM3240G-EVAL, STM3241G-EVAL	Evaluation board for STM32 F4 series with STM32F407 or STM32F417 MCU	Yes	UM1461
STEVAL-IHM033V1	Control stage based on the STM32F100CB microcontroller for motor control with serial communication user interface	Yes	UM1077
STEVAL-IHM036V1	Low power motor control board featuring the SLLIMM™ STGIPN3H60 IPM and STM32F100 microcontroller	Yes	UM1483
STEVAL-IFN003v1	PMSM FOC motor driver based on L6230 motor driver and STM32F103 microcontroller	Yes (SDK v3.0 + plug-in)	UM1478
STM3210B-MCKIT, STM32100B-MCKIT	Motor control starter kit for STM32 (128-KB Flash) Performance and Value line microcontrollers	Yes	UM0486, UM1452

Note: 1. STM3210E-EVAL, due to some resource sharing, overcurrent protection and LCD, cannot be used at the same time.

## STM32 for vector control of PMSM/BLDC

ST's STM32 offers the performance of the industry-standard Cortex™-M core at the service of vector (or field-oriented) control algorithms, widely used in high-performance drives. They provide precise and responsive torque and speed control, and guarantee optimized efficiency during transient operations.

The STM32, offering a wide and compatible portfolio, is part of a complete motor control ecosystem:

- STM32 PMSM FOC SDK, the 3-phase permanent magnet synchronous motor field-oriented control software development kit (SDK)
- ST MC Workbench (STMCWB), a PC SW for graphical configuration and real-time tuning of STM32 PMSM FOC SDK
- STM Studio, a graphical real-time diagnostic tool
- STM3210B-MCKIT and STM32100-MCKIT complete motor control kits



### STM3210B-MCKIT AND STM32100-MCKIT STARTER KITS

The STM3210B-MCKIT and STM32100-MCKIT are integrated systems designed to provide complete, ready-to-use kits for evaluation of 3-phase motor control developed around ST's STM32103B and STM32F100B microcontrollers.

These starter kits are particularly suited to drive 3-phase brushless motors (AC induction or permanent magnet types, AC IM support of STM32100B soon available).



# Signal conditioning

## Operation amplifiers

ST has a wide range of op amps, including both industry-standard and high-performance op amps. Our strengths include:

- Growing 16 V CMOS portfolio including precision and wide bandwidth op amps
- Reliable high-volume supplier of both standard and high-performance op amps
- Space-saving packages, such as DFN, QFN, SOT-23 and SC-70

Our JFET, bipolar, CMOS and BiCMOS technologies allow our products to support:

- A wide supply range, from 1.5 V to 36 V
- High ratios of performance-to-power consumption

Our automotive-grade products are AEC-Q100 qualified and tested with certified high-reliability flow, to meet the very specific, rigorous demands of the automotive market.

Operating voltage

36 V  
16 V  
12 V  
5 V

TL06  
TL07  
TL08

LM324 LM358  
LM2902 LM2904  
LM833 MC33078

TSX56 TSX912  
TSX6 TSX92  
TSX7

TS922 TS952  
TS941 TS93  
TS461 TS972  
TSH72 TSH82

CMOS

JFET

BiCMOS

BIPOLAR

### HIGHLIGHT: TSV9 AND TSX9 SERIES

Their high slew rate, supply voltage range (compatible with most microcontrollers) and input and output rail-to-rail capability make the TSV9 and TSX9 series the best choice for current sensing in vector control (FOC) schemes.

### Applications

Low side current sensing  
Temperature sensing  
Vibration sensing

Angle measurement  
DC brushless motor

High side current sensing

### Features

Precision, low Vio  
High Bandwidth up to 20 Mhz

High output Current,  
> 100 mA

High Common-mode  
Voltage > 30 V

### Products

TS507, TSV7 Series  
TSX56, TSX7 Series  
TSV9, TSX92 Series

TS982

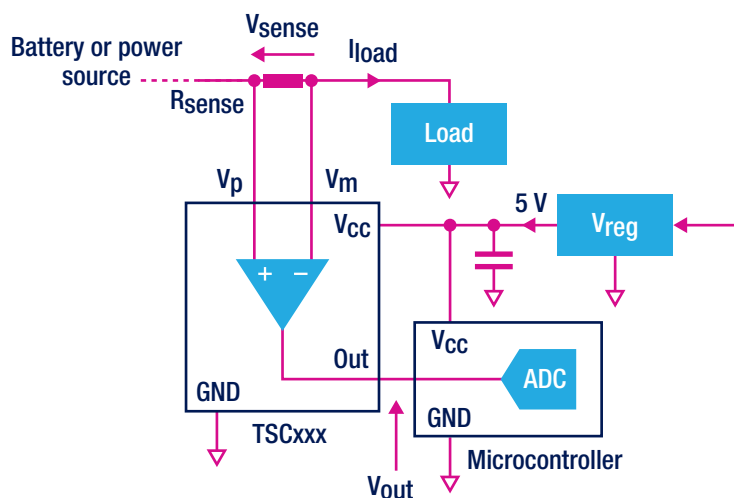
TSC101, TSC102, TSC103

## High-side current sensing (TSC series)

Accurate sensing of currents is central to enhancing application safety. Controlling the current within set boundaries avoids overheating and short circuits. Current measurement is also an essential part of energy metering.

The main features of our growing high-side current-sense amplifier portfolio are:

- Up to 70 V line monitoring
- Integrated solutions (for example, inclusion of EMI filtering on output) for faster design times and a reduced BOM
- Robust devices that do not require external protection
- Automotive-grade qualified current-sense amplifiers



### HIGHLIGHT: TSC103

- Common-mode voltage: 2.9 to 70 V
- Optional dual-supply configuration to reach -2.1 V to 65 V common-mode range
- Rugged input pin sustain -16 to +75 V and 2.5 kV ESD
- Pin-selectable gain: 20 V/V, 25 V/V, 50 V/V, 100 V/V
- Low current consumption: 360  $\mu$ A

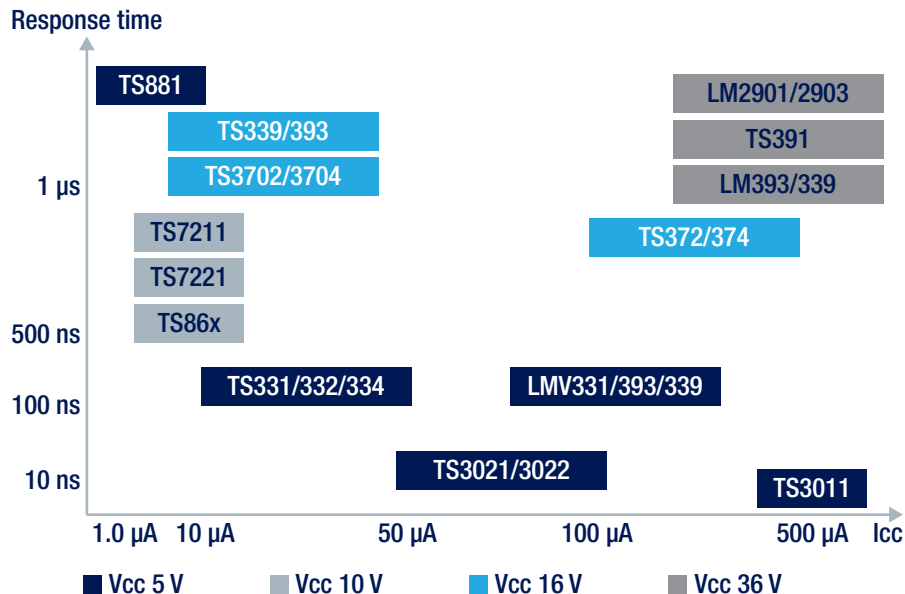
Order code	Description	Documentation
STEVAL-ISQ013V1	High-side current-sense amplifier demonstration board based on TSC101	AN3222
STEVAL-ISQ007V1	Low-side current sensing based on TS507	AN2727

## Comparators

ST is a leading supplier of comparators, and our portfolio offers:

- High-speed comparators, with response times as fast as 8 ns
- Micropower comparators with operating currents as low as 210 nA
- High-temperature (150 °C) qualified devices
- Guaranteed specified min/max electrical performances

Our automotive-grade products are AEC-Q100 qualified and tested with certified high-reliability flow, to meet the very specific, rigorous demands of the automotive market.



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