Power 'n Motors

Critical aspects in power applications
design, proper component selection
& experimental results

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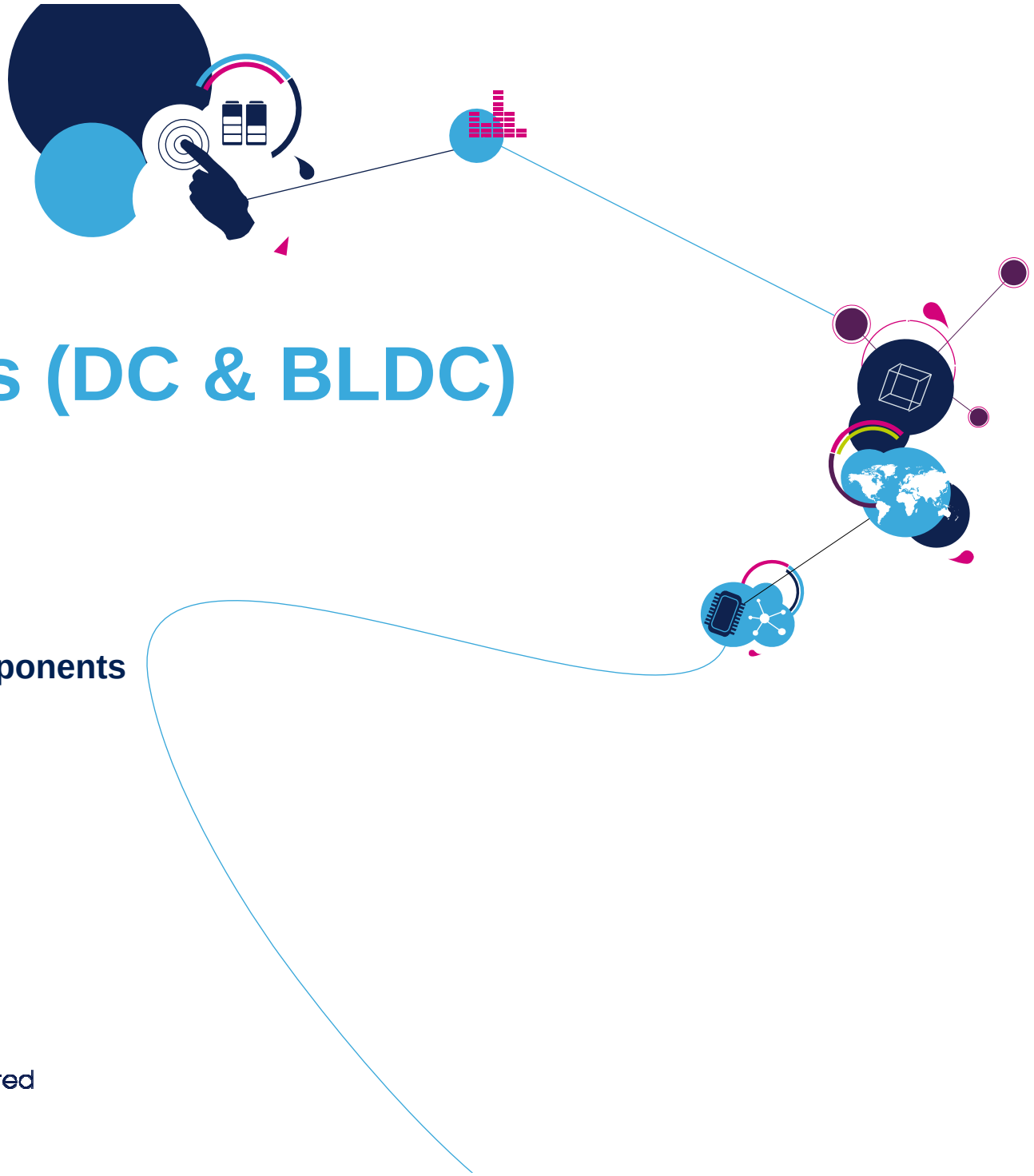
SILICA An Avnet Company

AVNET Memec

Agenda

9:00	**Introduction**
9:15	**HV Motors (BLDC) & 3PHs Inverters** • Architectures & components • New Intelligent Power Modules (IPM) from ST 1. Experimental results: Performance Benchmark 2. Guidelines to minimize EMI
11:00	Coffee break
11:15	**IPM simulation tool**
11:45	**HV driving with isolation** • Driving an isolated 60kW HB driver: experimental results
12:15	**LV Motors (DC & BLDC)** • Architectures & components
12:30	Lunch
13:30	**LV Motors (DC & BLDC)** • Choosing right MOSFET for LV Motor Control (1h) 1. Relationship between MOSFET parameters & EMI behavior 2. Experimental results: Performances of new F7 Technology
14:30	**ST solutions to drive three phases permanent magnet motors** • ST MCU Portfolio for Motor Control • Software & Firmware • Evalboard demonstration
16:00	**Conclusions**



LV Motors (DC & BLDC)

Architectures & Components

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Typical LV motor control applications

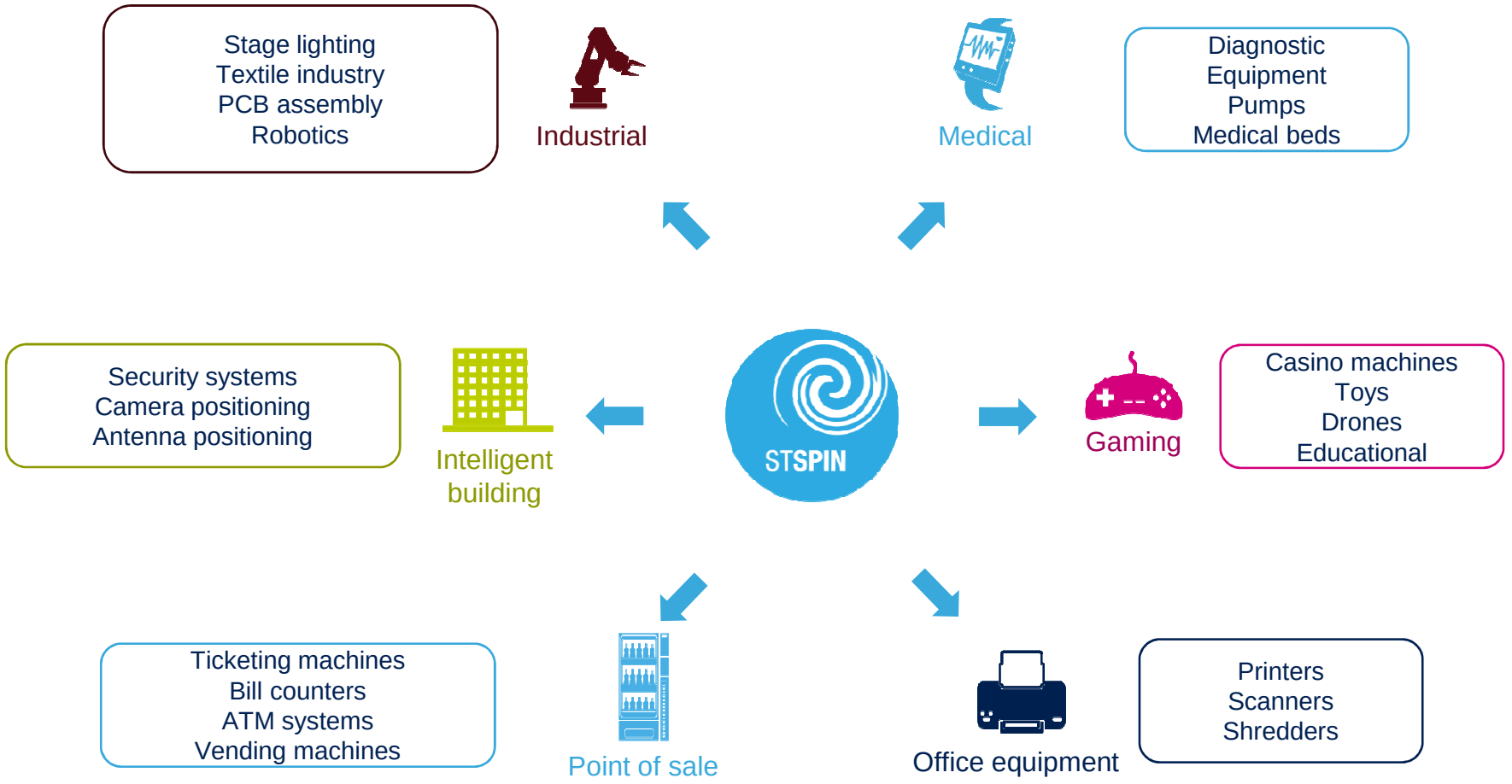
- Low voltage motor control applications range throughout various environments starting from industrial (assembly machines, stage lighting) over point of sale and office equipment applications (ticket machines, printers) to medical (diagnostic equipment, pumps).
- For lower power rated applications (up to ~100W) STMicroelectronics provides monolithic solutions integrating interface with microcontroller together with fully protected power-stage and diagnostics on the same chip.
- High power applications are covered by rich portfolio of Power MOSFETs, IGBT's and Gate Drivers.








Targeted applications



and wherever motors are used

STSPIN & STDRIVE

STSPIN

STSPIN power

Dual H-bridge
- L6205
- L6206
- L6207
- L6225
- L6226
- L6227
- L6206Q
- L6207Q
- L6226Q
- L6227Q

Three ph. bridge
- L6229
- L6230
- L6234
- L6235
- L6229Q
- L6230Q
- L6235Q

Dual H-bridge with controller
- L6208
- L6228
- L6208Q
- L6228Q

µStepper driver
- L6258

STSPIN digital

SPI µStepper controller with motion engine
- L6470 (VM)
- L6472 (CM)
- L6460

SPI µStepper controller
- L6474 (CM)

SPI µStepper driver with motion engine
- L6480 (VM)
- L6482 (CM)

SPI µStepper SiP with motion engine
- powerSTEP01

New Product

STSPIN battery

Product preview

Battery powered drivers:
- bSPINH20
- bSPINH30
- bSPINH40

STDRIVE

ST DRIVE smart

New Product

600V HB driver for IGBT/MOSFET (4A)
- L6491

600V HB driver for IGBT/MOSFET with OP-Amp, smart Shut-Down
- L6390
- L6391
- L6392
- L6393
- L6395
- L6398

600V HB driver for IGBT/MOSFET
- L6384
- L6385
- L6386
- L6387
- L6388
- A6387

Fully protected single ch. driver
- TD350
- TD351
- TD352
- TD310

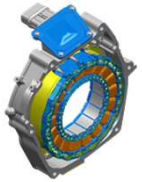
ST DRIVE gap

New Product

4kV Isolated driver for IGBT/MOSFET
- STGAP1S

Product preview

6kV Isolated driver for IGBT/MOSFET
- STGAP2S



ST DRIVE power

Product preview

Scalable System In Package
- PWD13F60
- PWD140H8

Run Rate Introduction: +5 P/N Year

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Brushed DC motor applications

- DC motors have been widely used in wide range of applications.
- STMicroelectronics product portfolio covers various needs of DC motor applications with either monolithic drivers or discrete power MOSFETs.

Motor type	Applications addressed	Suitable products
Brushed DC	• Traditional cost-effective choice for low power motion control applications • Bidirectional rotation required • Small battery-powered appliances, toys, etc.	• **PowerSPIN** (L62x5, L62x6(Q), L62x7(Q),) • **FlexSPIN** (L6460) • **Discrete Power Transistors** (H5, H6, F6, H7, F7 Trench MOSFETs)

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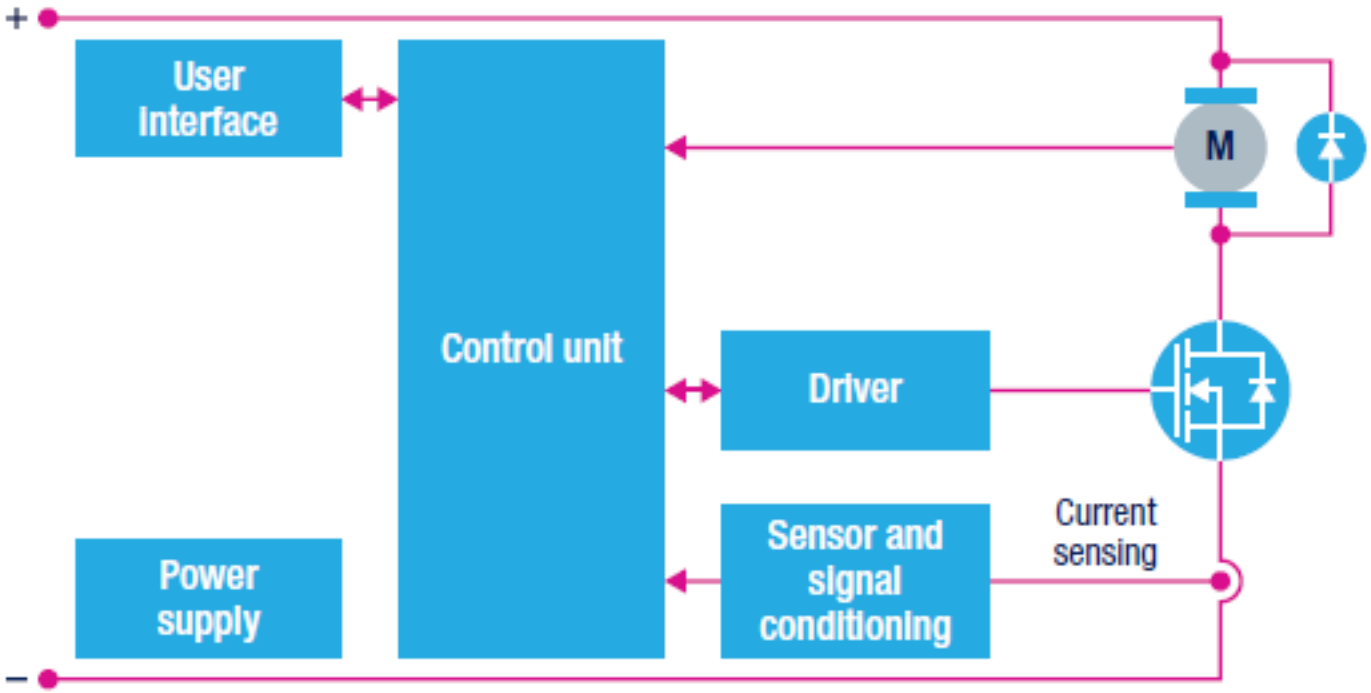
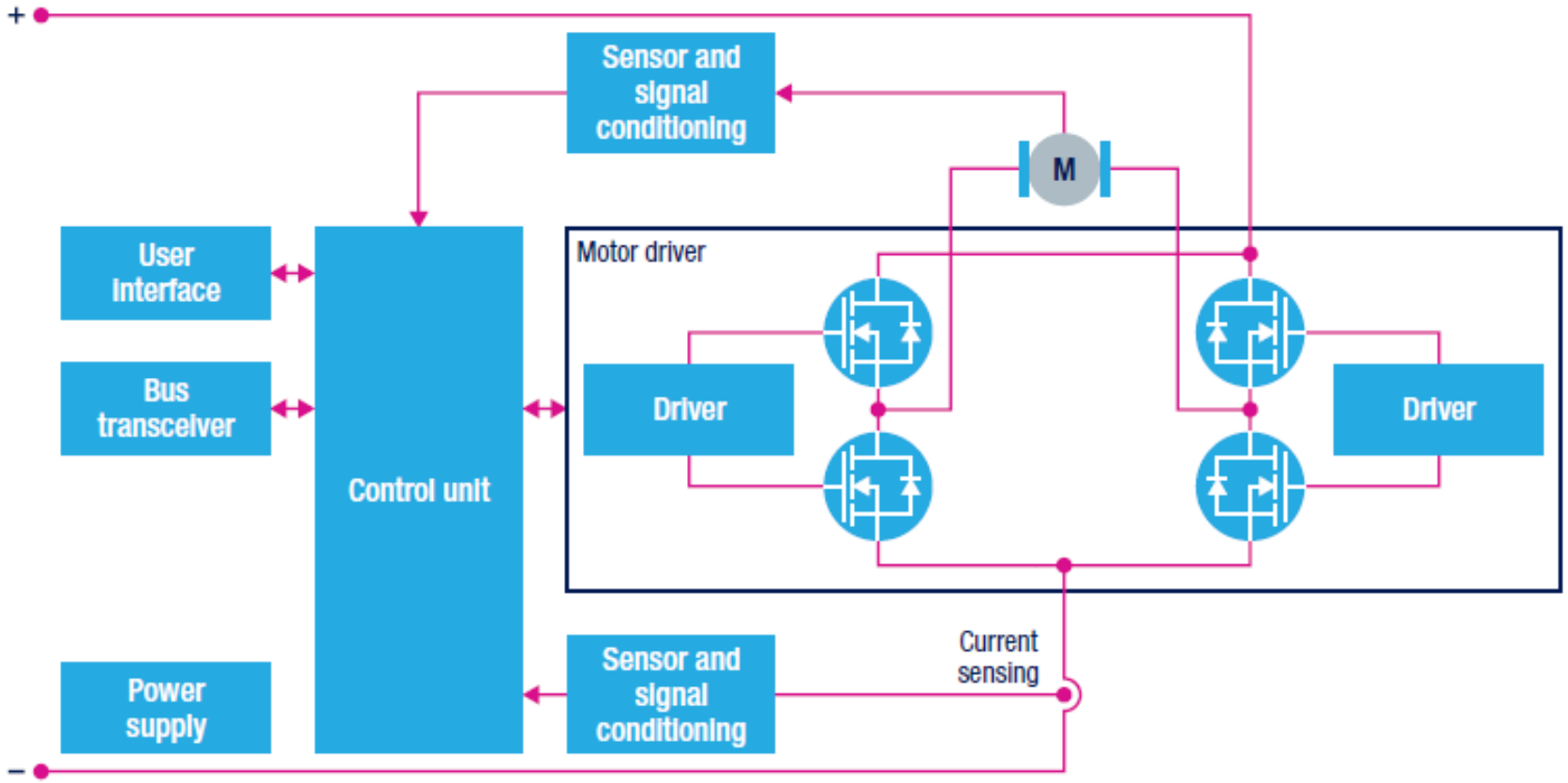
Brushed DC motors: Application topology I.

- Single-switch topology allows control in a single direction of motion.
- Pulse Width Modulation (PWM) is used to vary the voltage applied to the motor and thus to control its speed.



Brushed DC motors: Application topology II.

- Full-bridge converter is used when driving a DC motor in both directions of rotation allowing also braking and angular positioning of the rotor.
- Pulse Width Modulation (PWM) is used for control.



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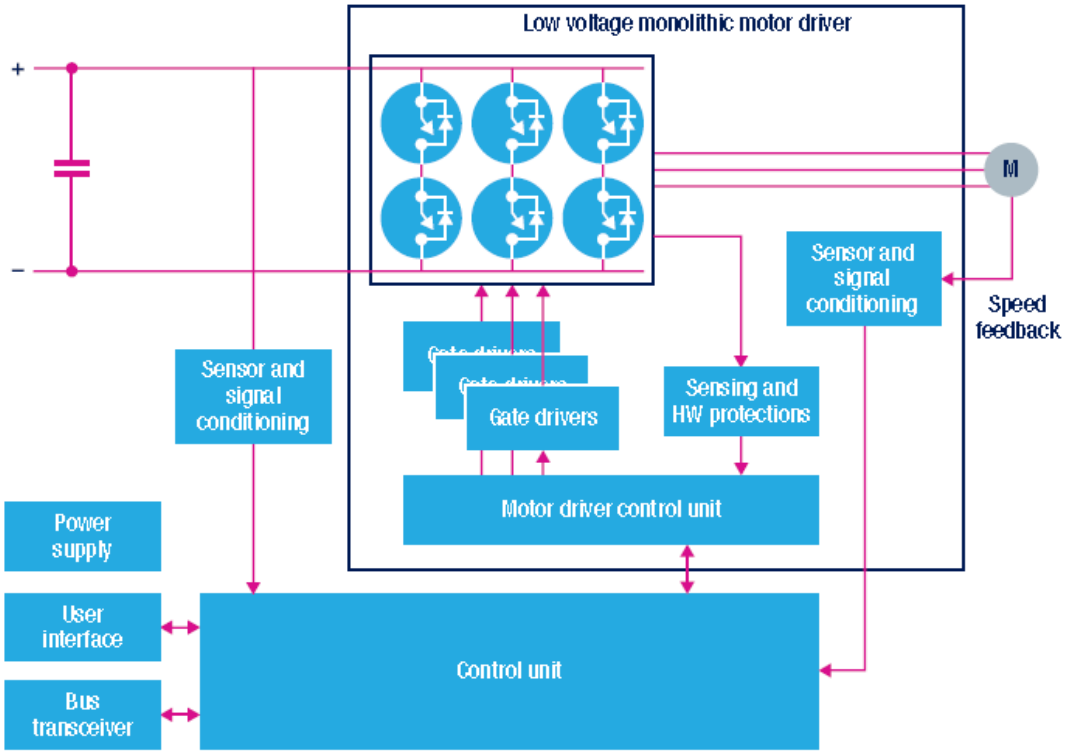
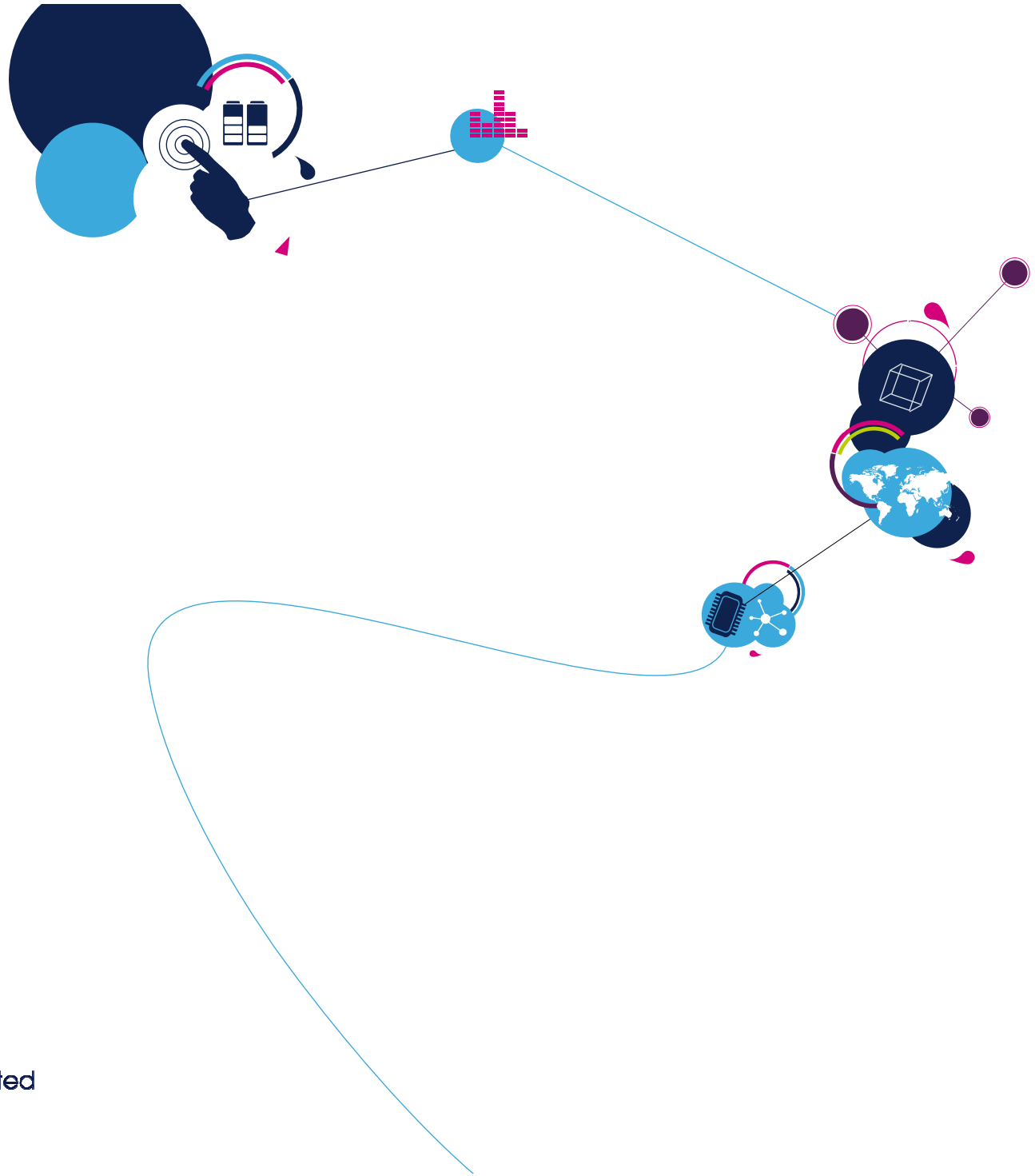
BLDC Typical driving circuits

3 phase bridge (inverter)

- Control methods
  - 6 - step (simple)
  - Sinusoidal
    (scalar or vector control)
- Discrete or integrated solutions
- With or w/o position sensors
  - Hall-effect detectors
- Current sensing
  - Three shunt
  - Single shunt





STSPIN

LV Motor Drivers

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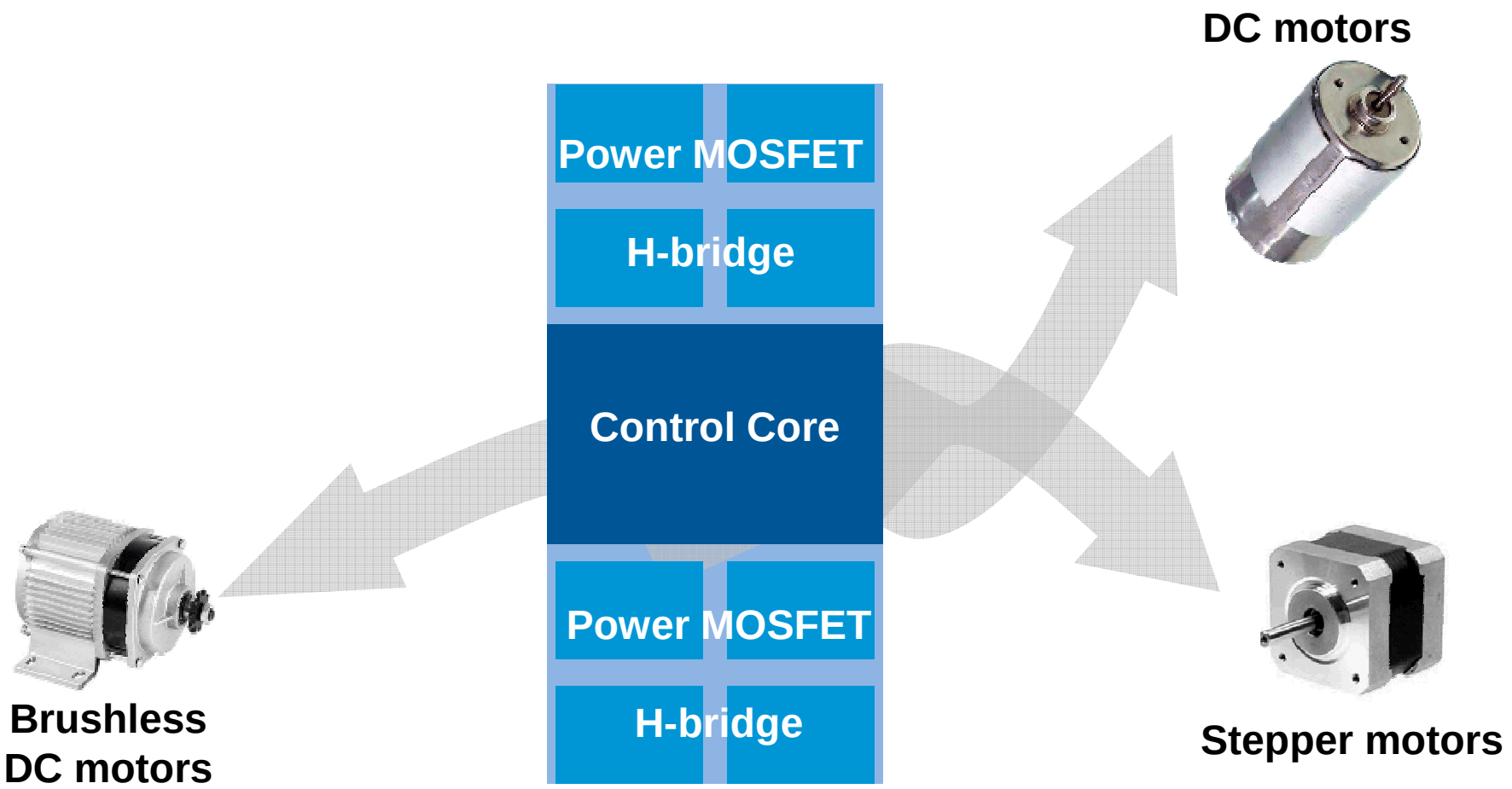
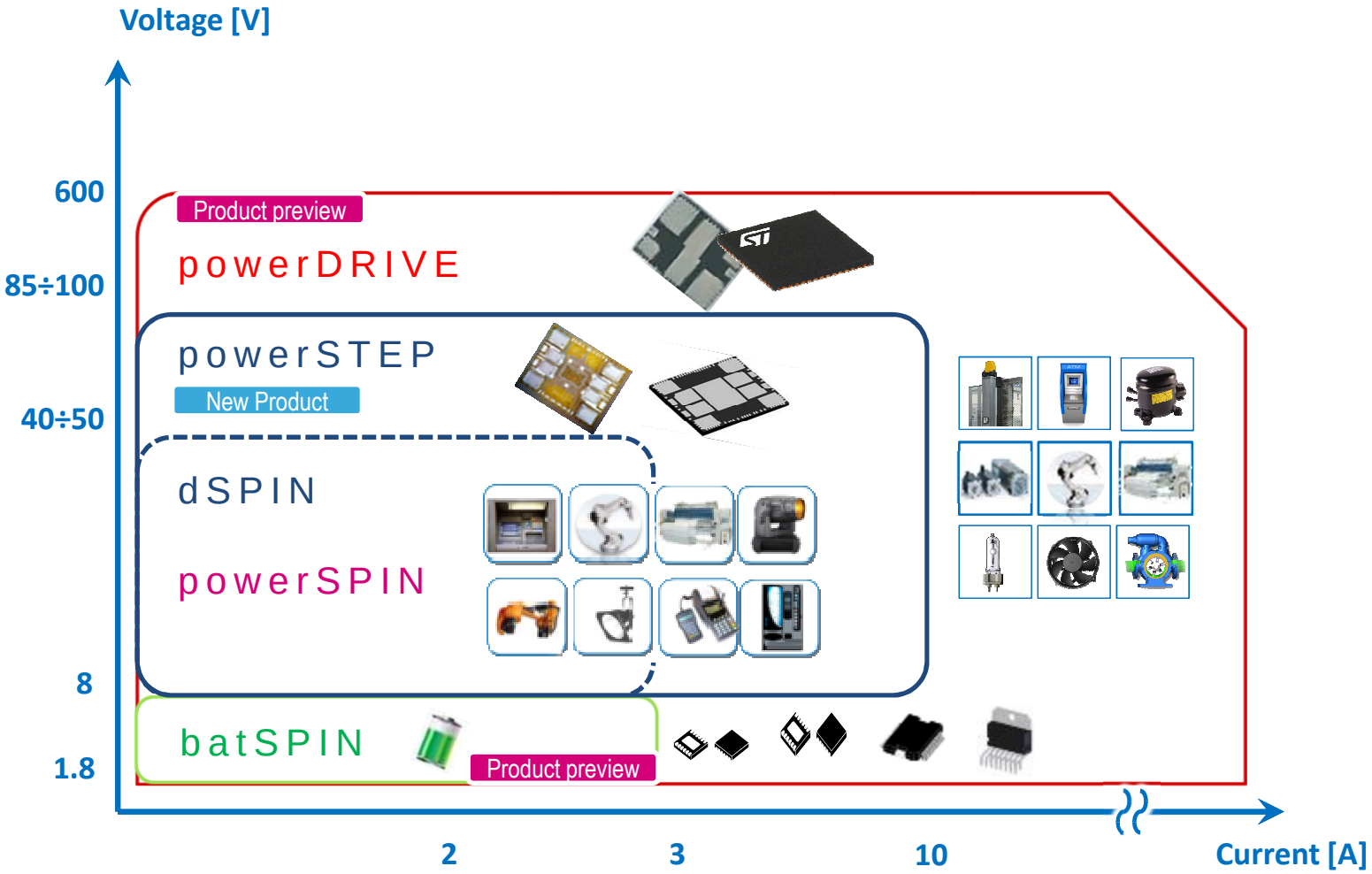
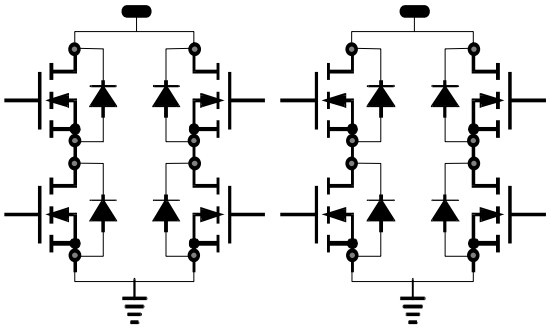
Driving all motor types



STSPIN by Ratings
Monolithic & System In Package



PowerSPIN product family: Dual H-bridge series



Dual H-bridge

Performance

Applications

Stepper motor driver
For bipolar stepper motors

L6208 **L6208Q**
L6228 **L6228Q**

- Stepper motor

Power stage with PWM
Twin current control
For dual DC or stepper motors

L6207 **L6207Q**
L6227 **L6227Q**

L6206 **L6206Q**
L6226 **L6226Q**

- Dual DC motors
- Stepper motors
- High-current DC motors

Enhanced power stage
Settable over current
Diagnostic output
For dual DC or stepper motors

L6205
L6225

Basic power stage
Fixed over current
Smallest package

Integration

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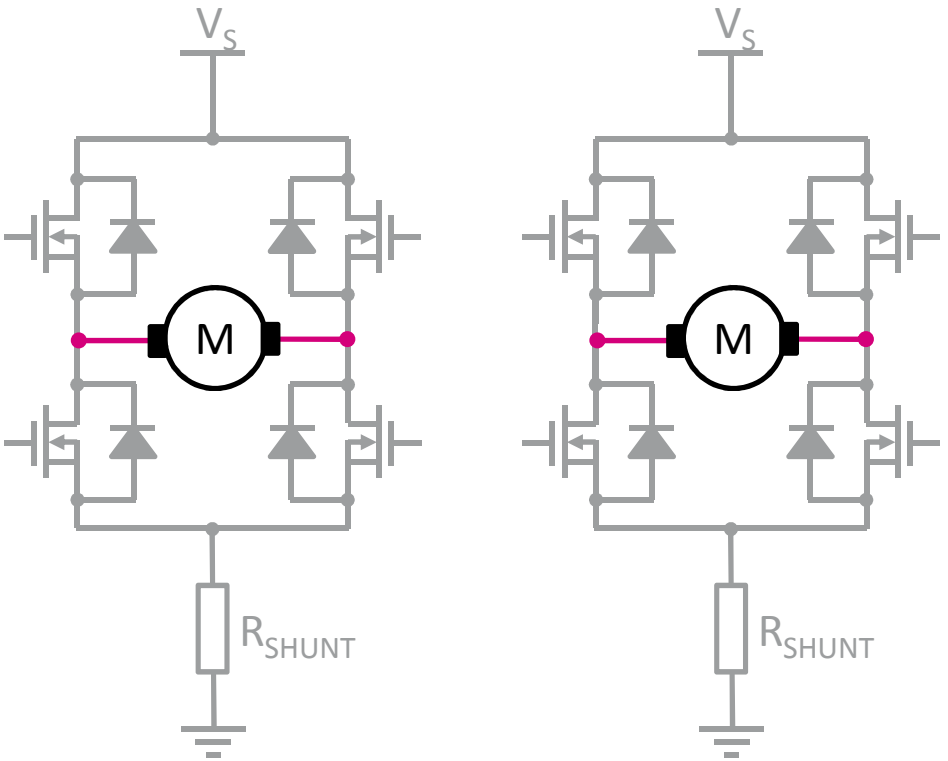
Brushed DC motors: Dual H-bridge driver topologies (1/3)

- Our dual H-bridge versatile products (L62xx) can drive:

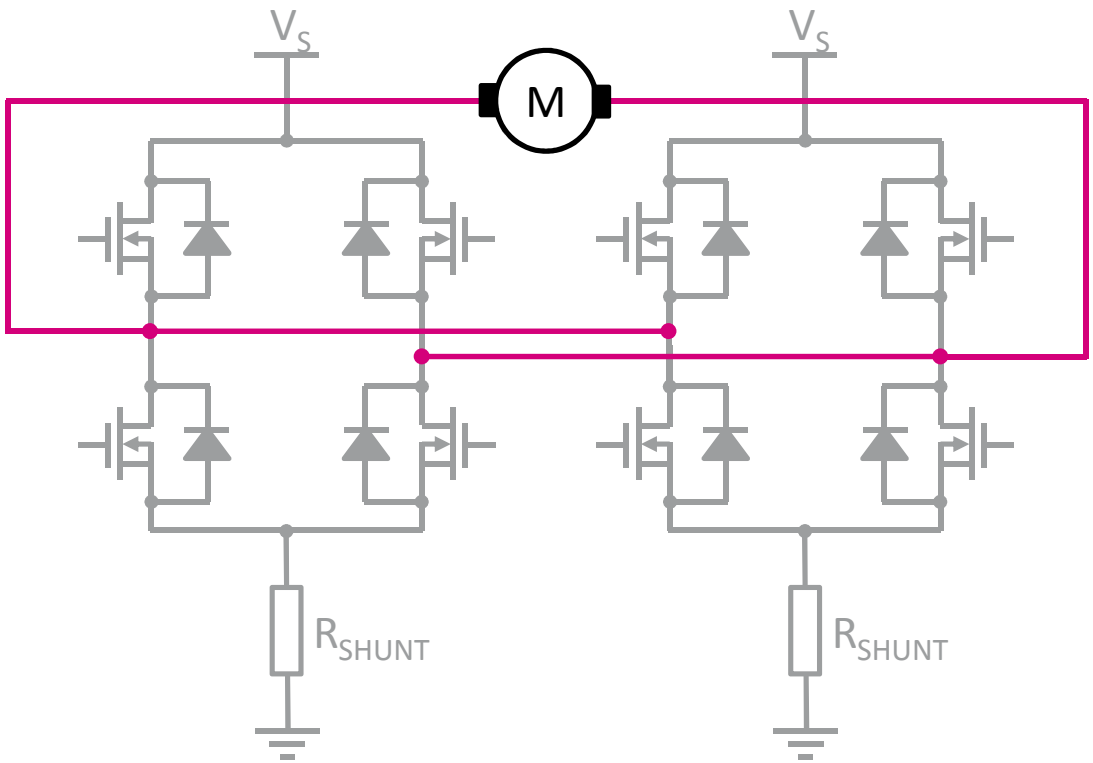
1. **Either two DC motors in both directions of motion**,



Brushed DC motors: Dual H-bridge driver topologies (2/3)

- Our dual H-bridge versatile products (L62xx) can drive :

1. Either two DC motors in both directions of motion,
2. **a single DC motor with better performance in respect to optimization of power losses and dissipation,**

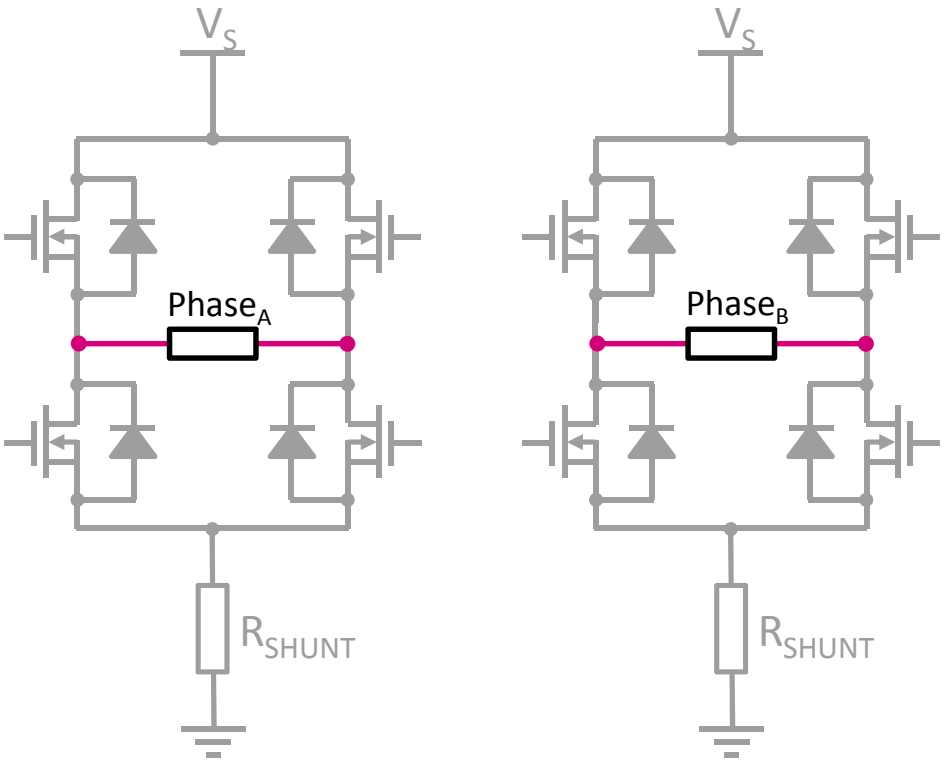


Brushed DC motors: Dual H-bridge driver topologies (3/3)

- Our dual H-bridge versatile products (L62xx) can drive :

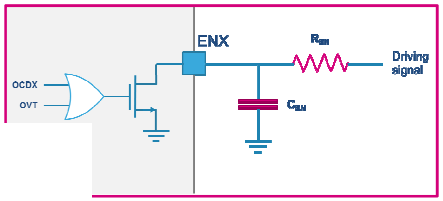
1. Either two DC motors in both directions of motion,
2. a single DC motor with better performance in respect to optimization of power losses and dissipation,
3. **or a two-phase bipolar stepper motor!**

Just using a single QFN device!



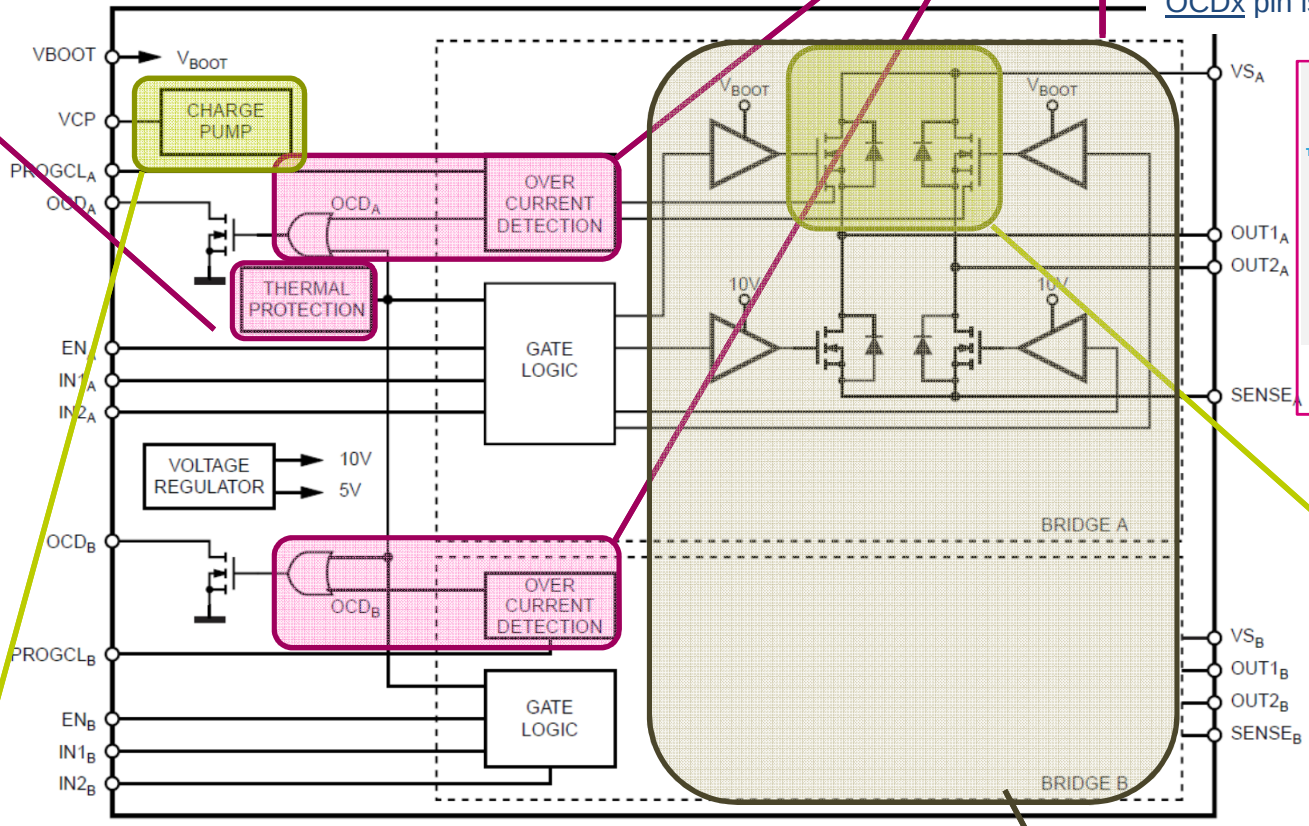
Dual H-bridge series: Family characteristics

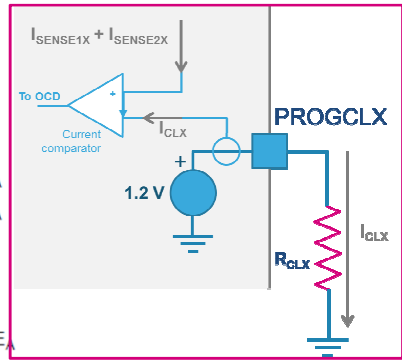
Parameter	L620x family	L622x family
Operating Supply Voltage	from 8 to 52V	
$R_{ds(on)}$	0.3 Ω	0.73 Ω
Max load current	2.8 A_{rms} (5.6 A peak)	1.4 A_{rms} (2.8 A peak)
Max frequency	100 kHz	
Protections	Non-dissipative overcurrent Thermal protection Under Voltage Lock Out	
Packages	PowerSO, SO, PDIP, **QFN 7x7**	PowerSO, SO, PDIP, **QFN 5x5**



Over-temperature protection
When the device temperature exceeds the shutdown threshold both OCDx pins are internally forced low.

Non dissipative adjustable overcurrent protection @ 5.6 A (L620x) or 2.8 A (L622x)
When an overcurrent event occurs on one half-bridge, the respective OCDx pin is forced low.





Integrated current sensing on high side NMOS

Charge pump for the supply of the high side driving circuitry

Dual Full-Bridge

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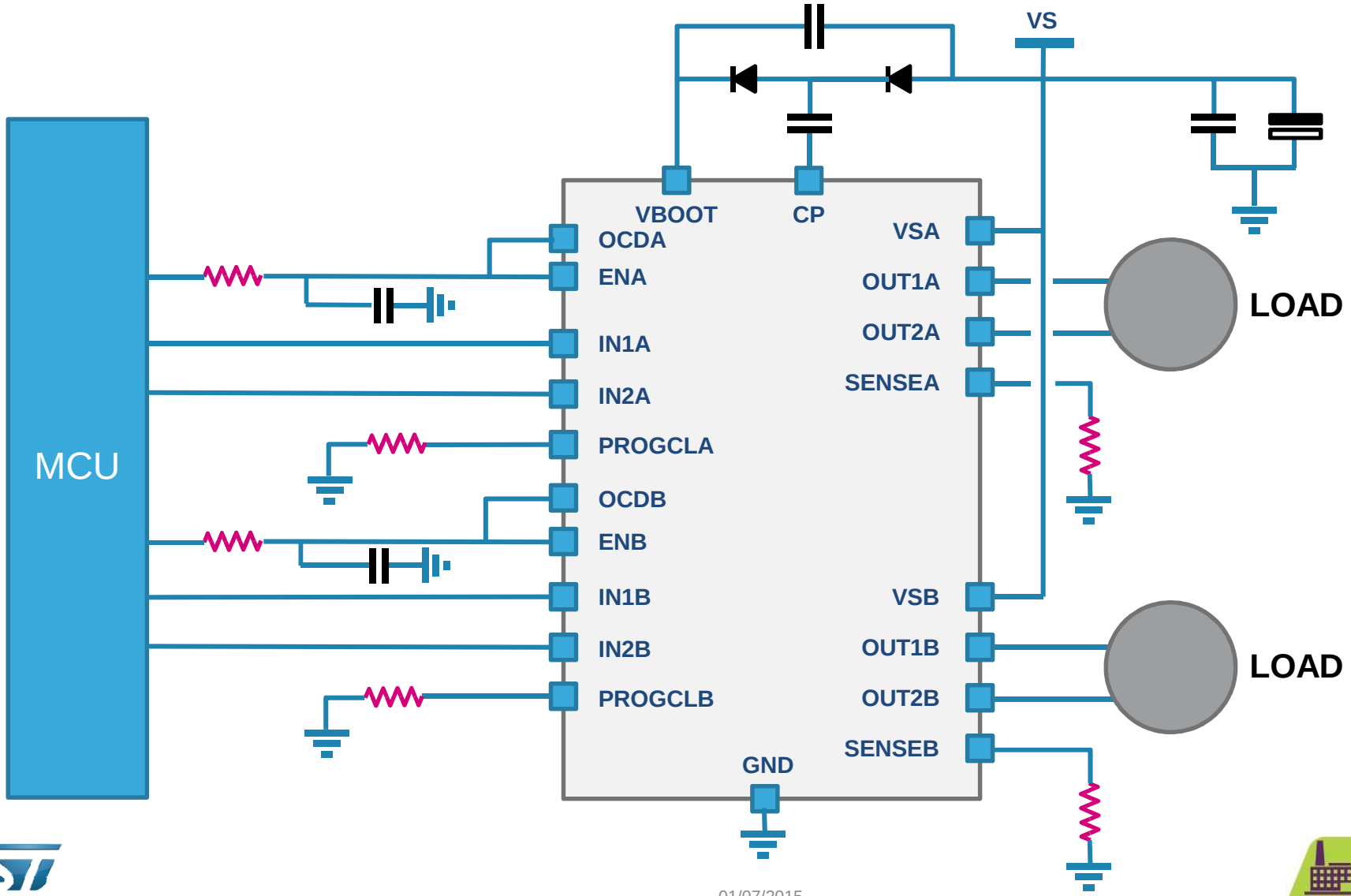
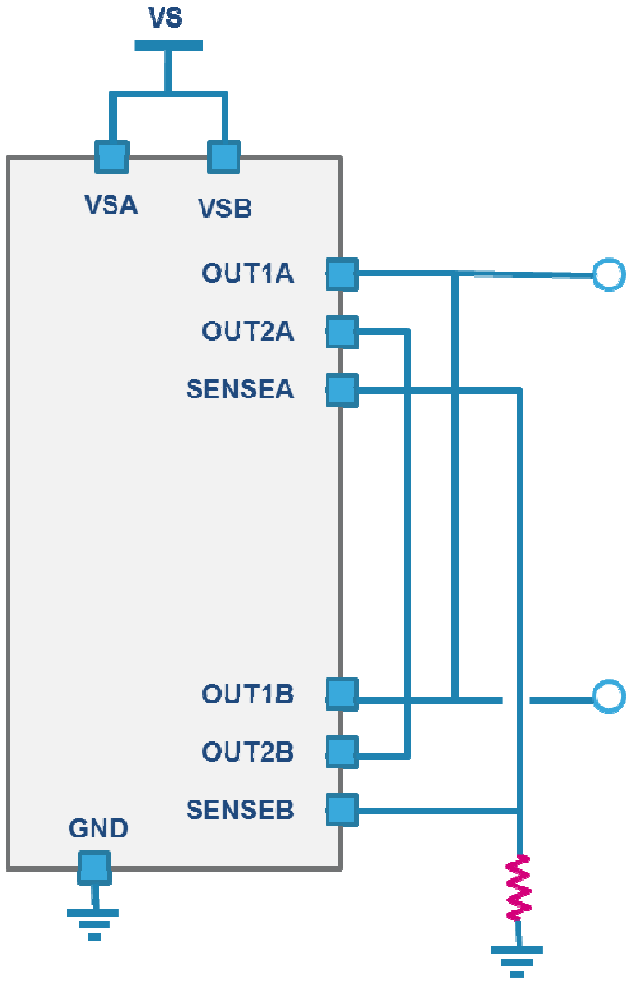
L62x6 Typical Applications

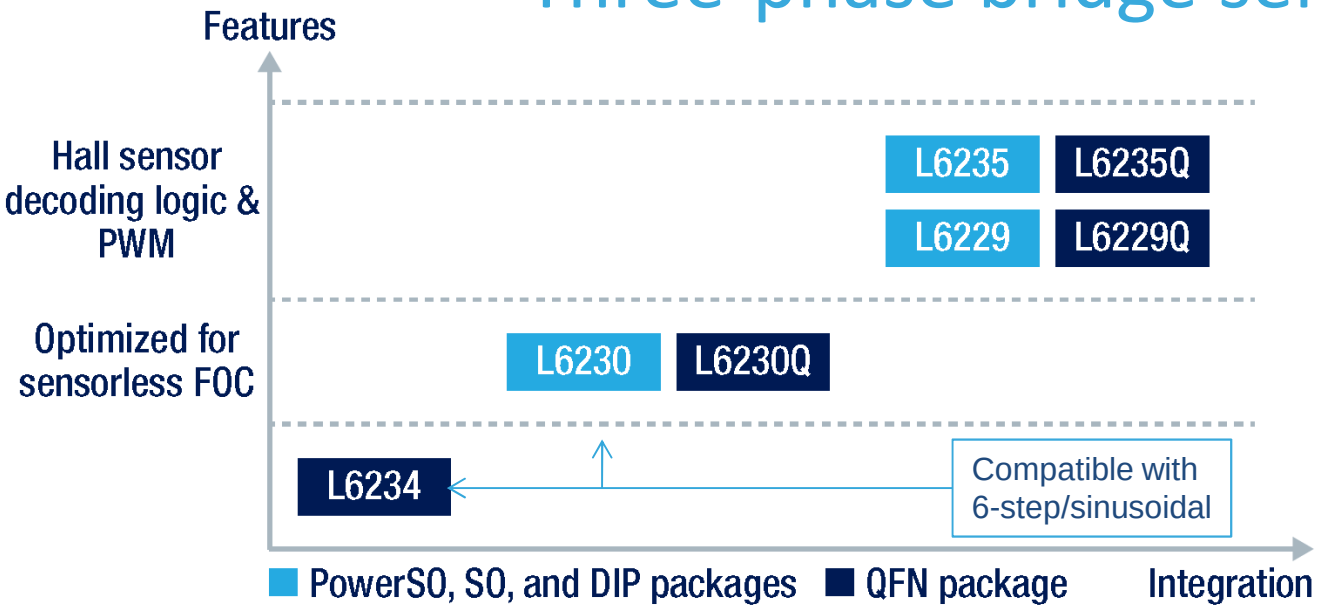


HB Outputs paralleling L62x5 and L62x6



- Halved equivalent $R_{DS(ON)}$: **0.15 Ω** Typ. (0.3 Ω for L622x)
- Doubled max r.m.s. Current: 2.8 A (1.4 A for L622x)
- Doubled max peak Current: 5.6 A (2.8 A for L622x)
- Doubled Over Current Threshold: 11.2 A (5.6 A for L622x)

PowerSPIN product family: Three-phase bridge series



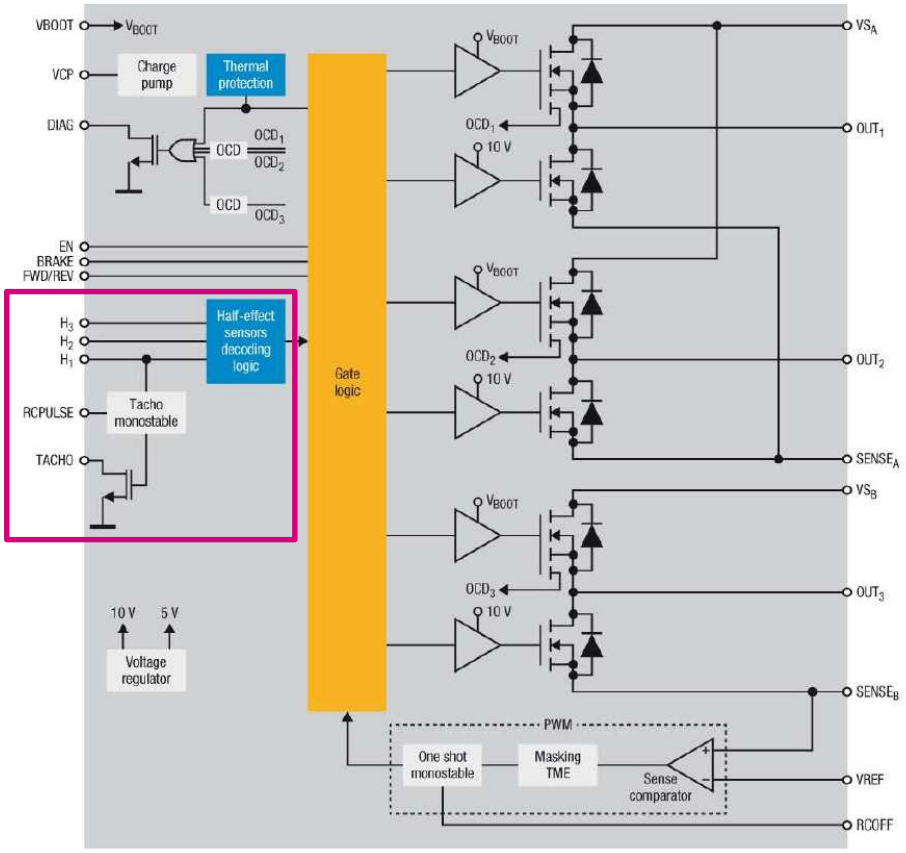
Part number	Description	Supply voltage min-max [V]	Output current r.m.s. [A]	Package	Note
L6229	PowerSPIN: DMOS driver for three-phase brushless DC motor	8-52	1.4	PowerDIP24, PowerSO36, SO24	
L6230	PowerSPIN : DMOS driver for three-phase brushless DC motor	8-52	1.4	PowerSO36, VFQFPN32 5x5	Optimized for sensor-less FOC
L6234	PowerSPIN : DMOS driver for three-phase brushless DC motor	7-52	2.8	PowerDIP20, PowerSO20	Optimized for sensor-less FOC
L6235	PowerSPIN : Three Phase Brushless DC Motor Driver	13-38	2.5	PowerDIP24, PowerSO36, SO24	

3-phase bridge series: Family characteristics

Parameter	L6235	L6229 and L6230
Operating Supply Voltage	from 8 to 52V	
$R_{ds(on)}$	0.3 Ω	0.73 Ω
Max load current	2.8 Arms (5.6 A peak)	1.4 Arms (2.8 A peak)
Max frequency	100 kHz	
Protections	**Non-dissipative overcurrent** Thermal protection Under Voltage Lock Out	
Packages	PowerSO, SO, PDIP, **QFN 7x7**	PowerSO, SO, PDIP, **QFN 5x5**

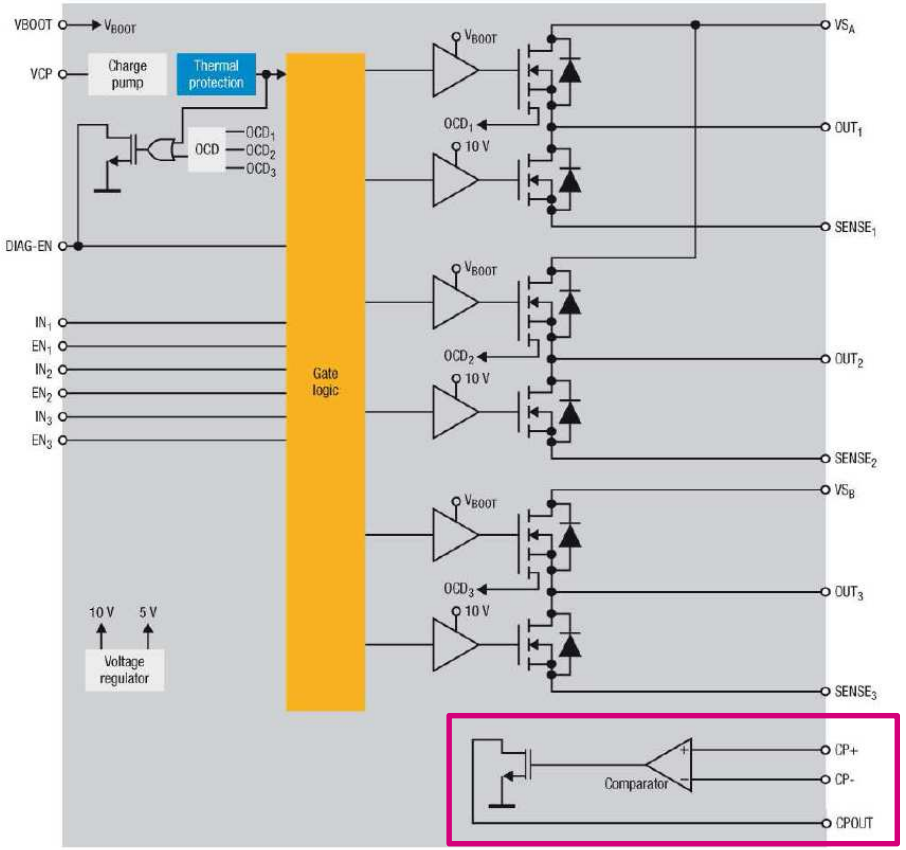
PowerSPIN - BLDC Motor Drivers

L6229 & L6235



Designed for stand-alone operation with 3x Hall-effect detectors

L6230



Optimized for Field Oriented (Vector) Control, 3 shunt or a single shunt

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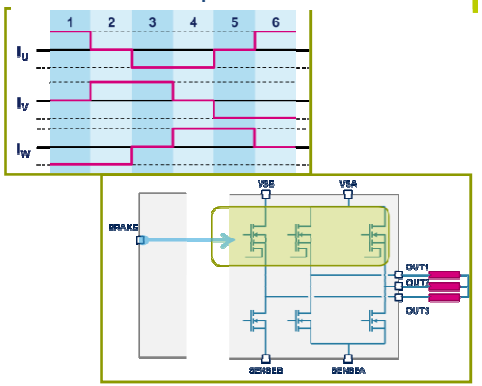
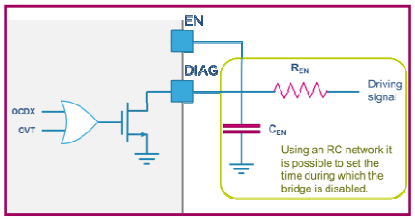
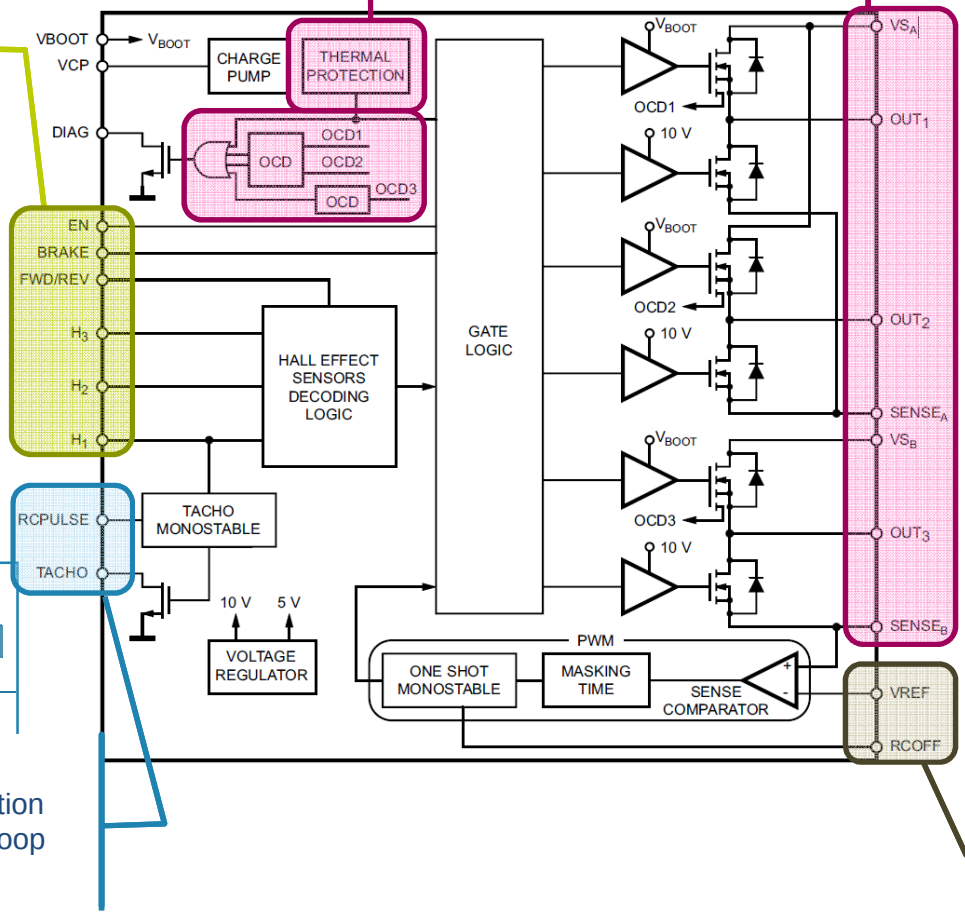
L6235 and L6229

Over-temperature protection
When the device temperature exceeds the shutdown threshold the DIAG pin is internally forced low.

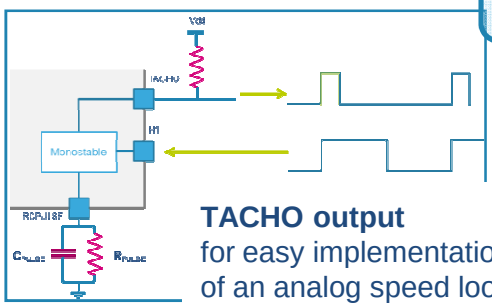
Integrated features:
Hall effect sensor decoding
Six step driving
Overcurrent protected brake



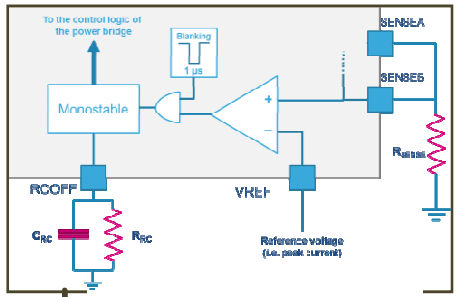




Non dissipative overcurrent protection
@ 5.6 A (L6235) or 2.8 A (L6229)
When an overcurrent event occurs on one half-bridge, the DIAG pin is internally forced low.



TACHO output
for easy implementation of an analog speed loop control



PWM current control
with fixed OFF time.

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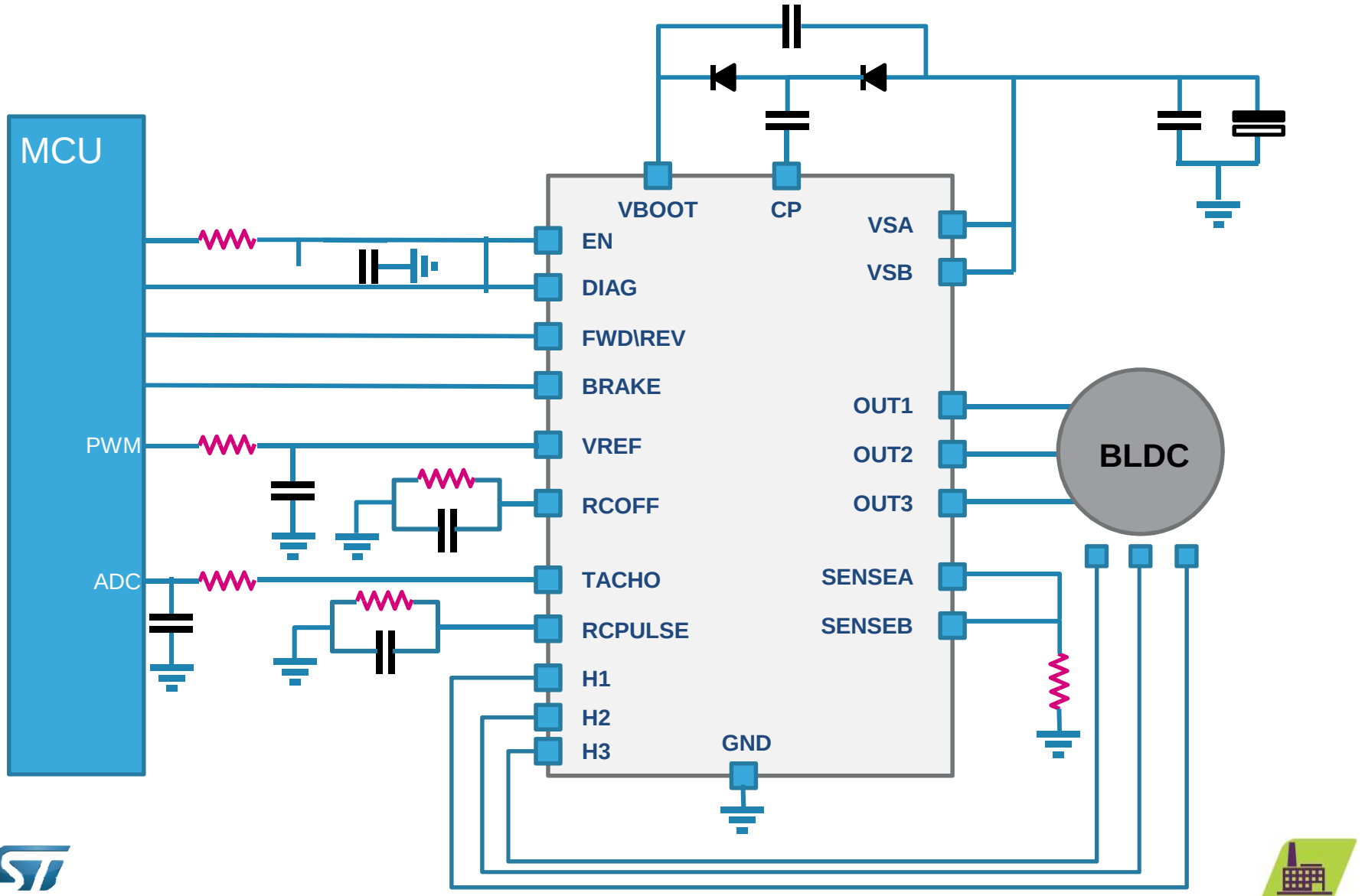
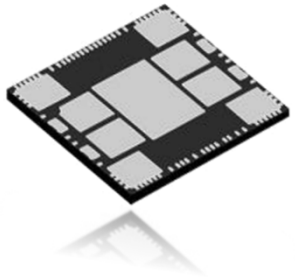
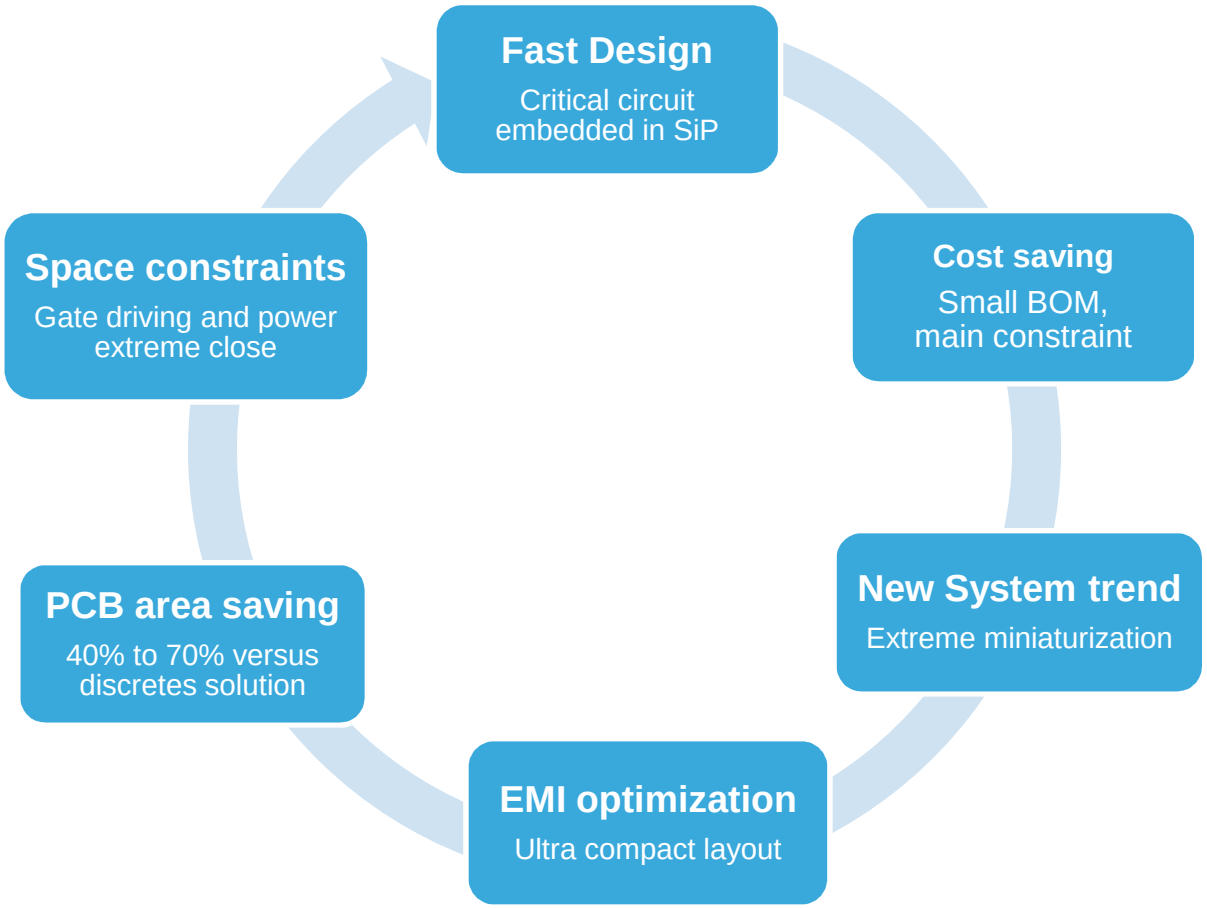
Typical application



STDRIVE$_{power}$ – Towards System-in-Package

Why System-in-Packages?





STSPIN$_{digital}$ – Family Overview

Best-in-class for Stepper Motors Control

- Easy to Control
- Cost Effective
- Programmable
- Space Efficient
- SAFE
- Low BOM guaranteed
- Extreme Performance

Monolithic dual full-bridge drivers (45V)

- L6258
- L6474
- L6470
- L6472

easy SPIN STMicrostepping

dSPIN

85V Stand-alone controllers (45V)

- L6480
- L6482

cSPIN

Power SiP (85V)
(digital controller + power discrete MOSFETs)

- PowerSTEP01

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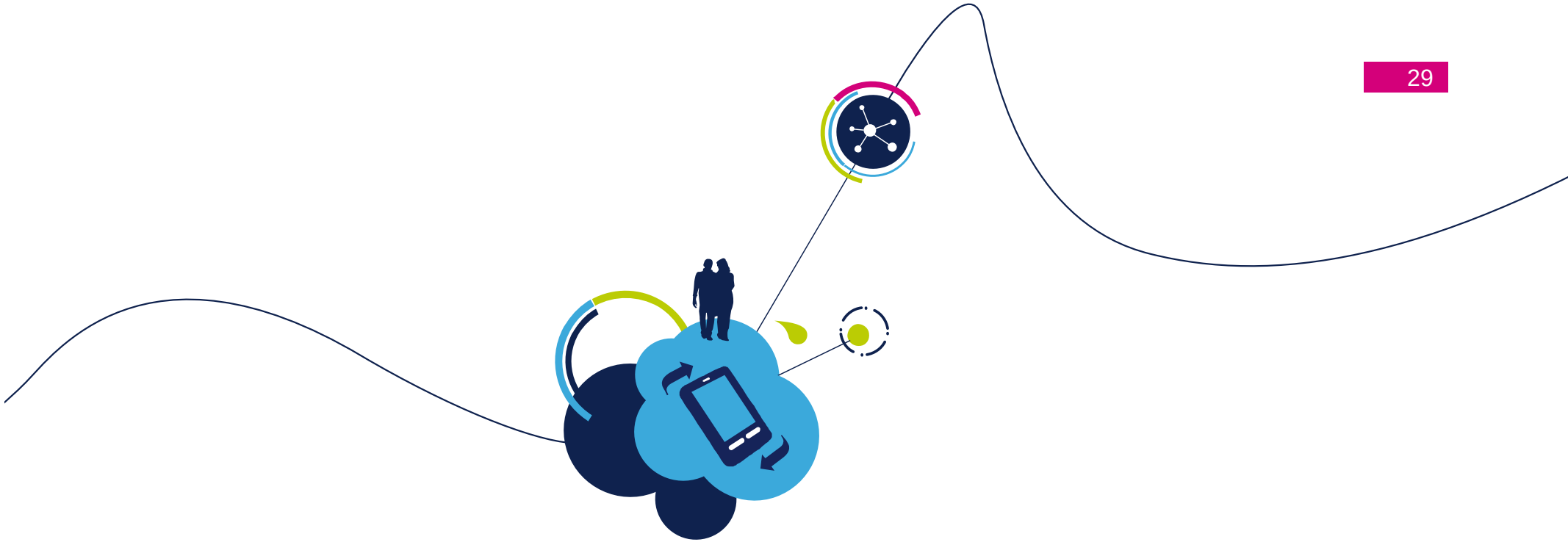

STSPIN™ digital – *KEY DIFFERENTIATORS*

1) Digital Motion Engine
2) Innovative Voltage Mode Control
3) Advanced Current Mode Control
4) Extreme Power integration

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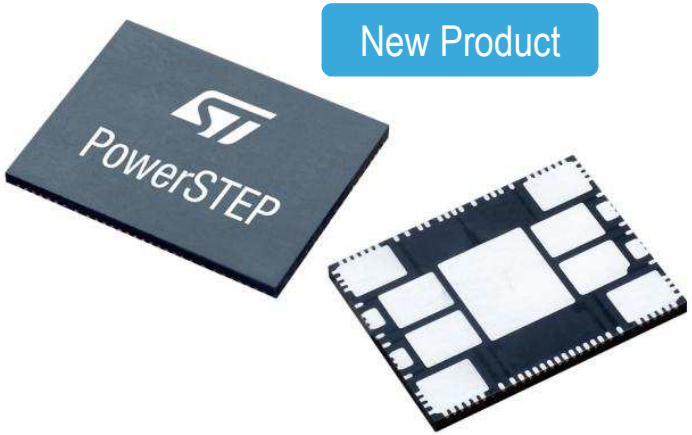
powerSTEP Highlights

Compact, powerful, accurate

New Product



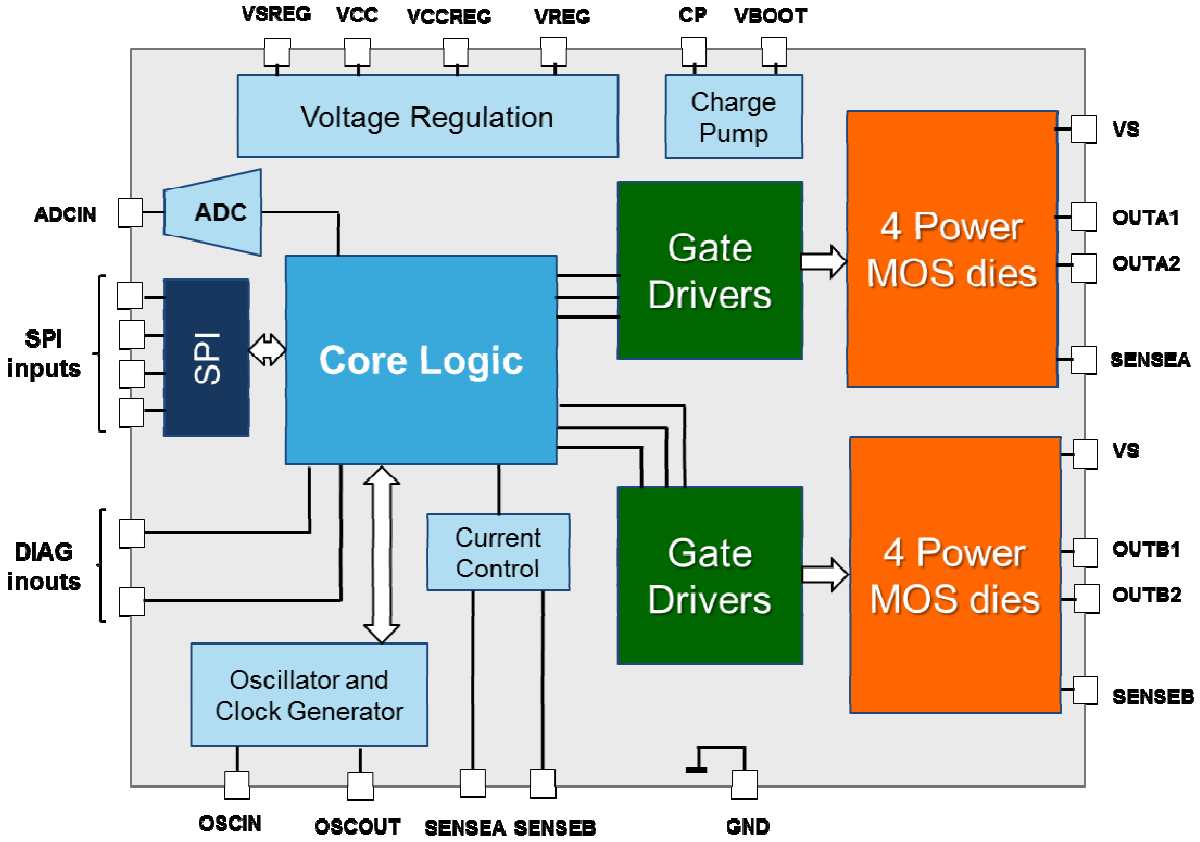
- System in package integrating 8 MOSFETs for stepper applications up to 85 V
- Dual H-Bridge with $R_{DS(ON)}$ 16 mΩ for 10 A_{rms}

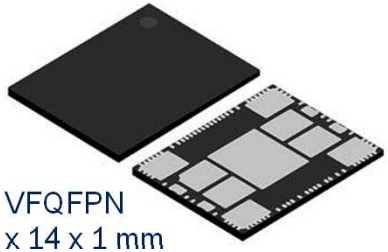
- Smoothness and precision up to 1/128 micro-steps
- Easily programmable with SPI providing full control of speed profile and positioning
- Fully protected with UVLO, OVLO, over-current, thermal warning/SD

STSPIN digital

New Product

powerSTEP01
compact, powerful, accurate





VFQFPN
11 x 14 x 1 mm

- System in package integrating 8x MOSFETs for stepper applications **up to 85 V**
- **Dual H-Bridge** with $R_{DS(ON)}$ **16mΩ** for 10 A_{rms}
- **Smoothness** and **precision** up to **1/128 µ-steps**
- Easily programmable with **SPI** provides full control of speed profile and positioning
- **Fully protected** with UVLO, OVLO, over-current, thermal warning / Shut-Down

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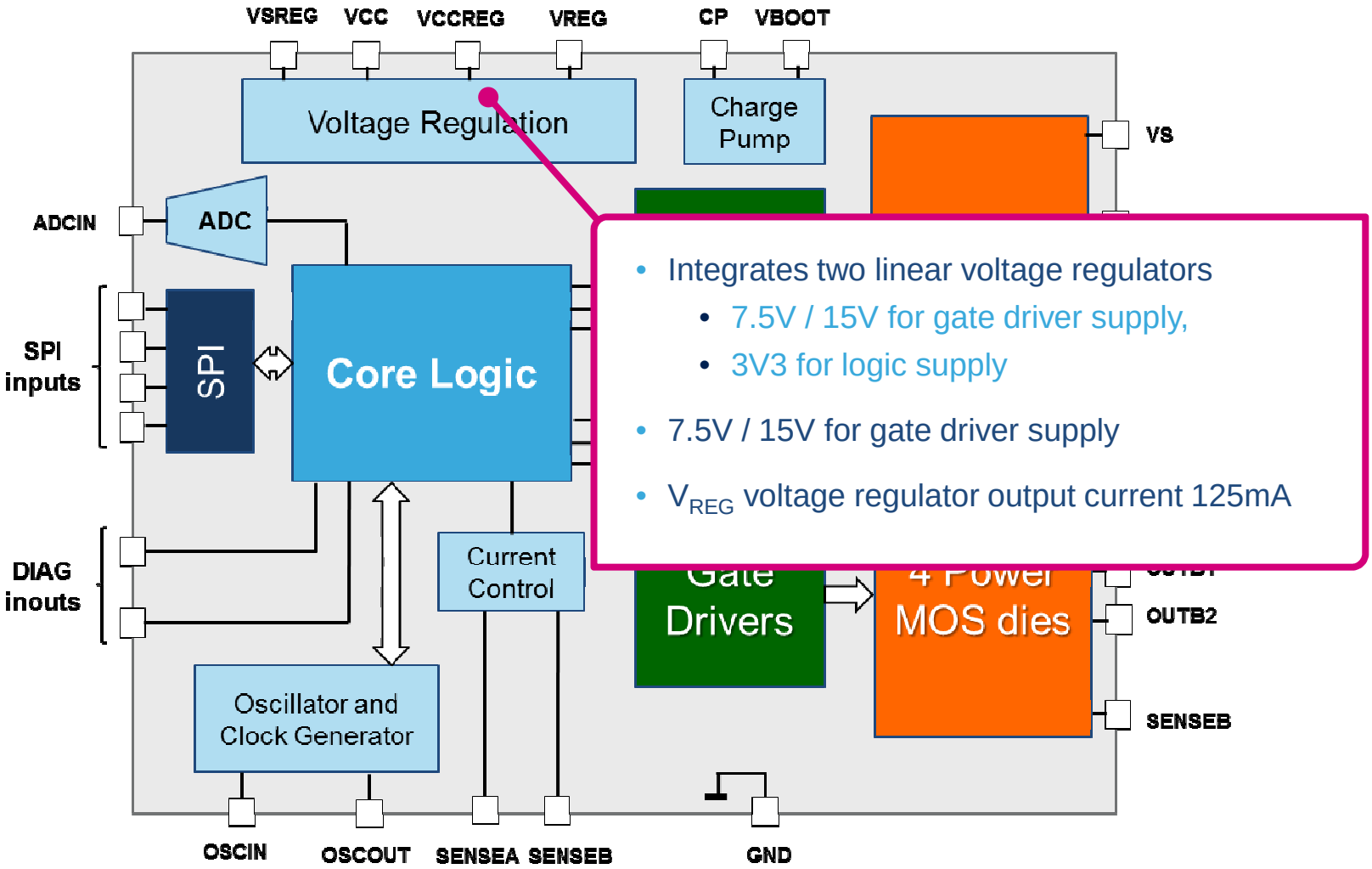
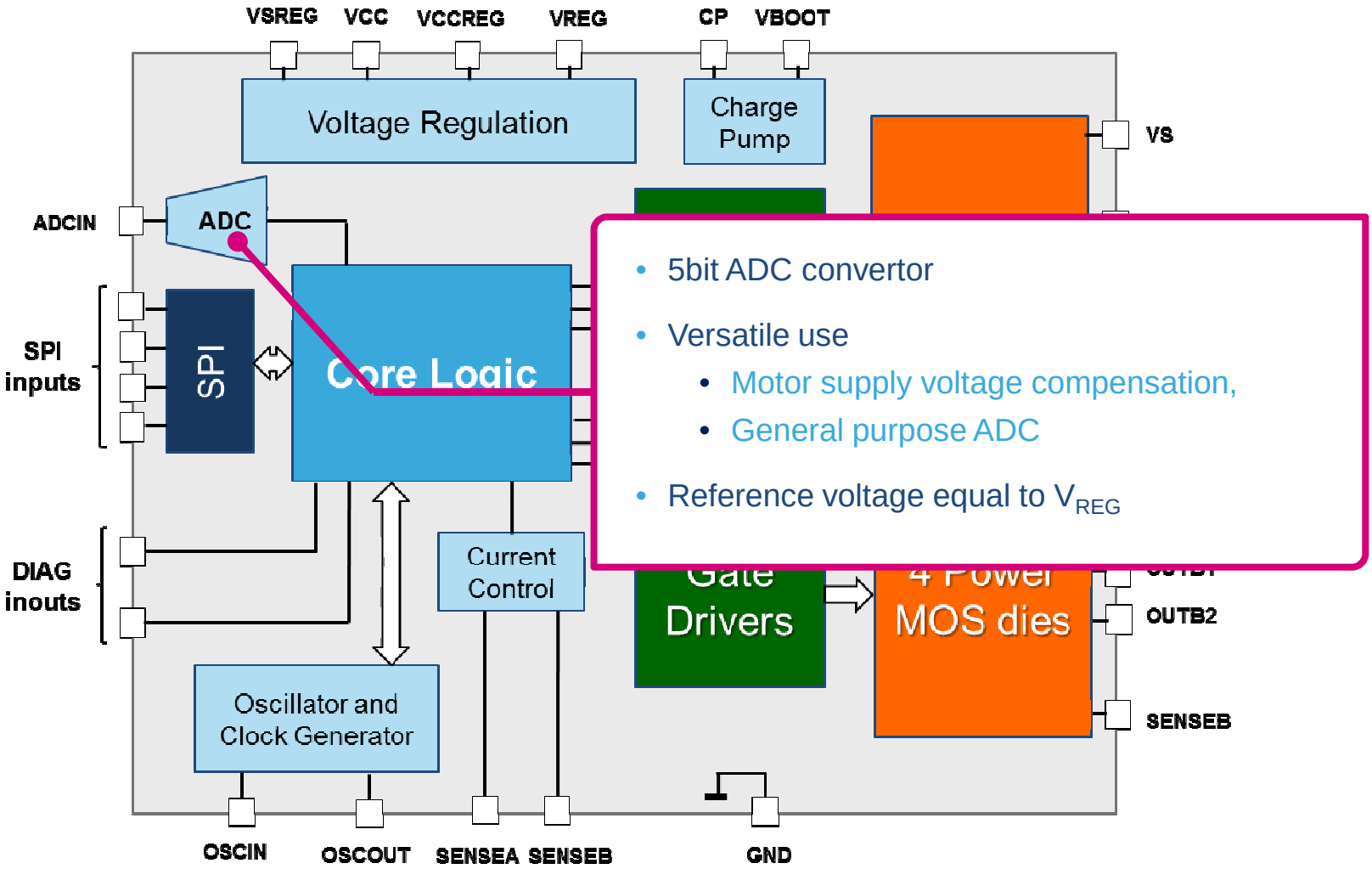
PowerSTEP01 features overview (1/6)



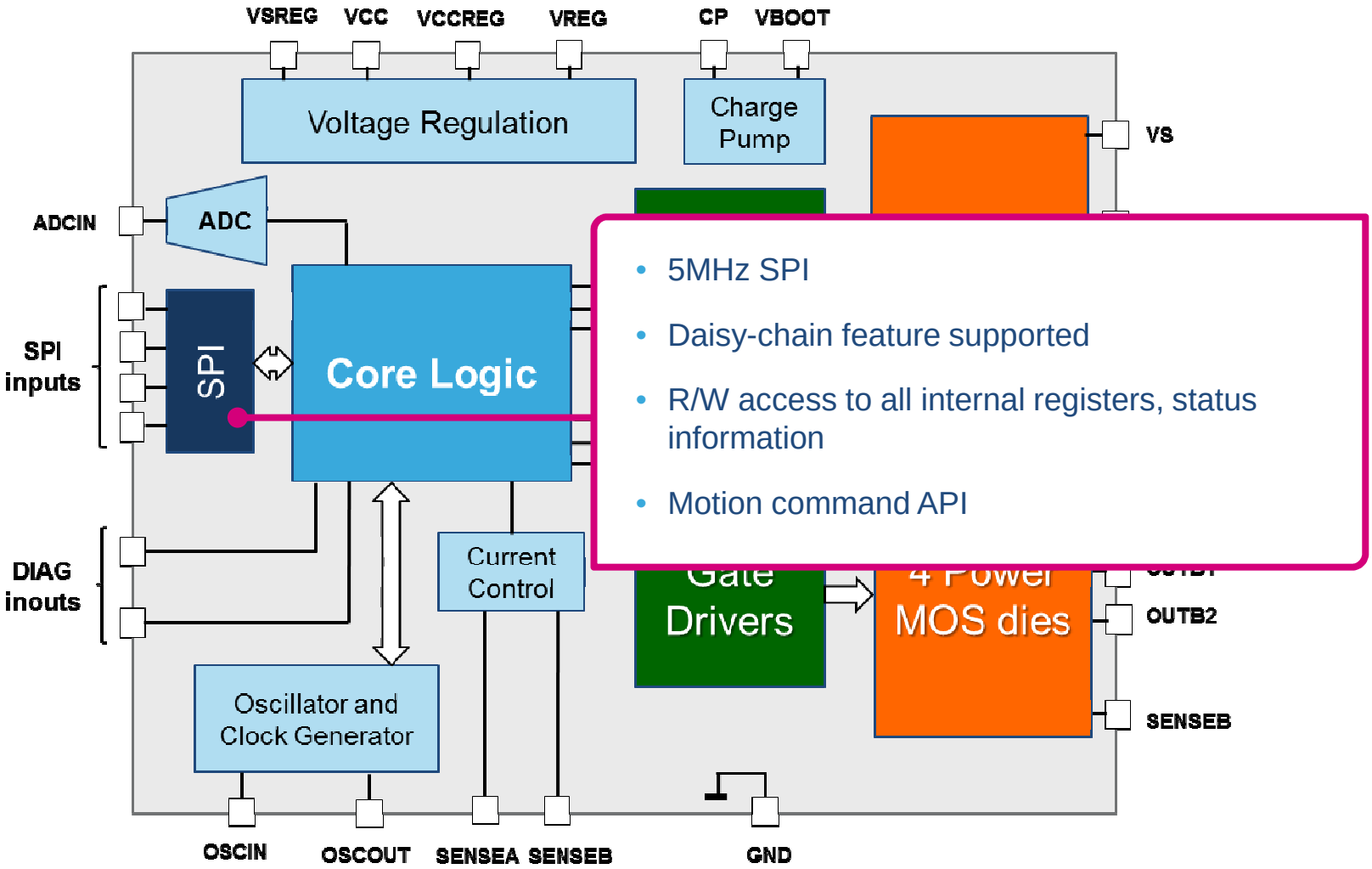
- Integrates two linear voltage regulators
  - 7.5V / 15V for gate driver supply,
  - 3V3 for logic supply
- 7.5V / 15V for gate driver supply
- V_{REG} voltage regulator output current 125mA

PowerSTEP01 features overview (2/6)



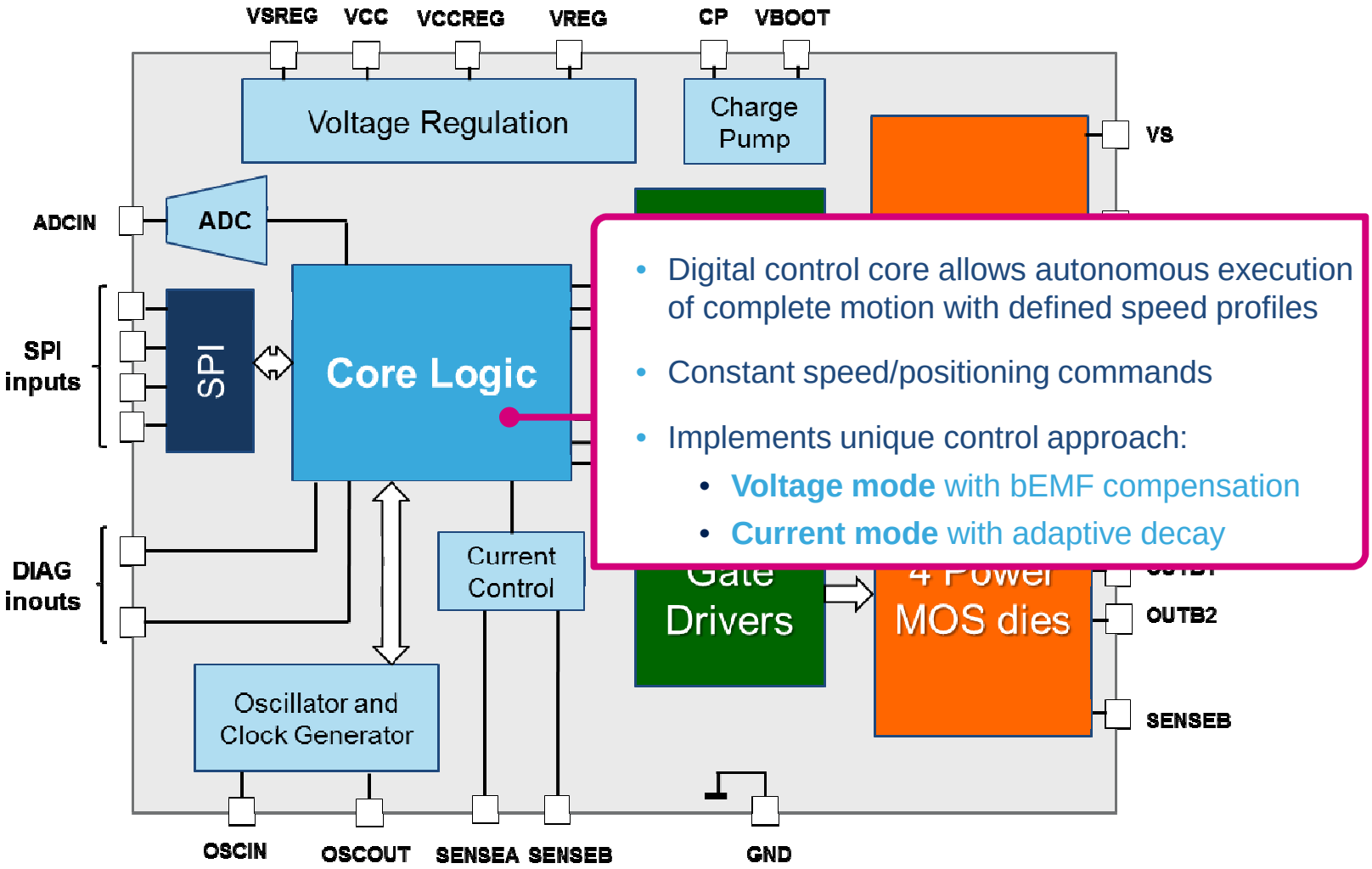
- 5bit ADC convertor
- Versatile use
  - Motor supply voltage compensation,
  - General purpose ADC
- Reference voltage equal to V_{REG}

PowerSTEP01 features overview (3/6)



- 5MHz SPI
- Daisy-chain feature supported
- R/W access to all internal registers, status information
- Motion command API

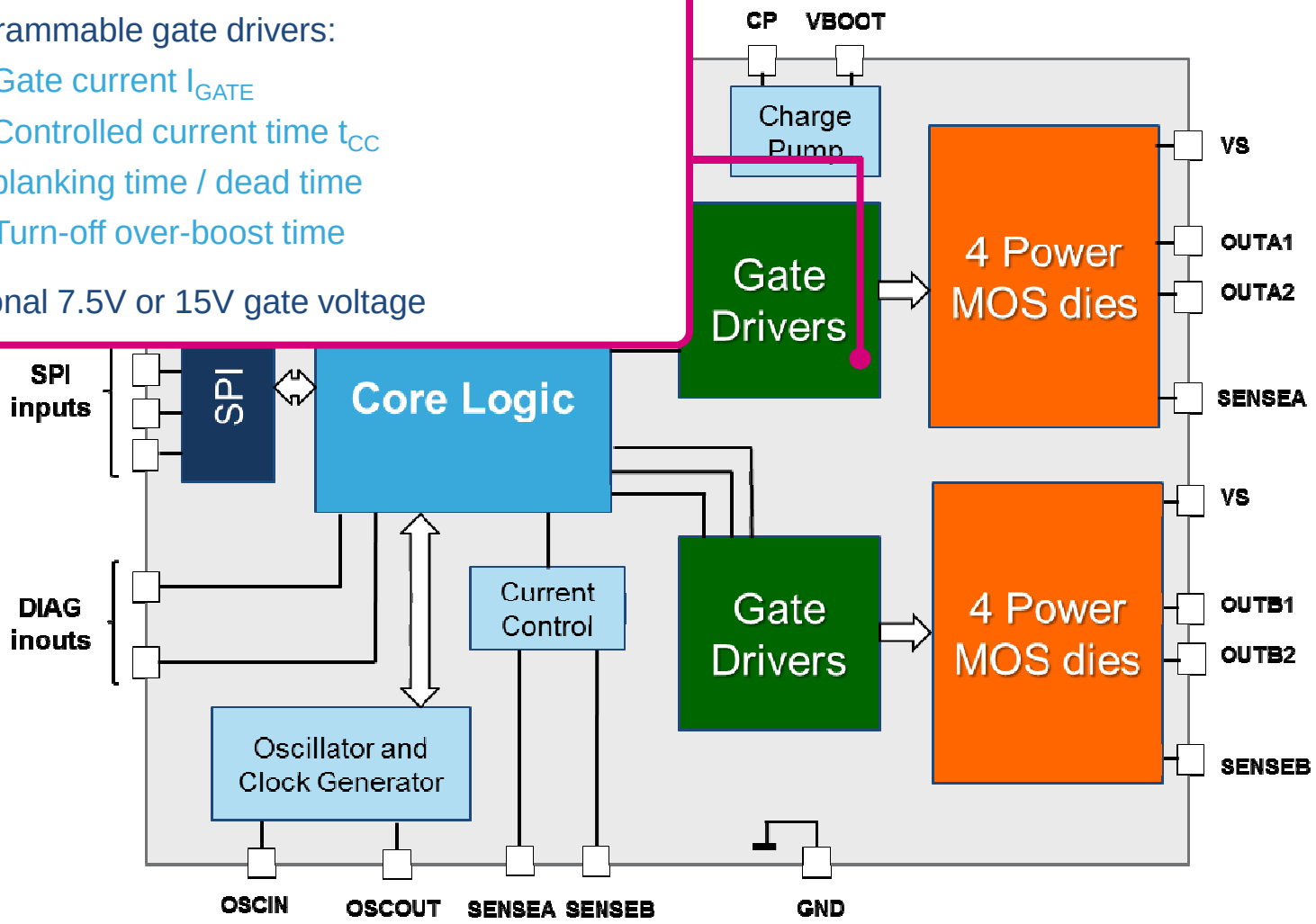
PowerSTEP01 features overview (4/6)



- Digital control core allows autonomous execution of complete motion with defined speed profiles
- Constant speed/positioning commands
- Implements unique control approach:
  - **Voltage mode** with bEMF compensation
  - **Current mode** with adaptive decay

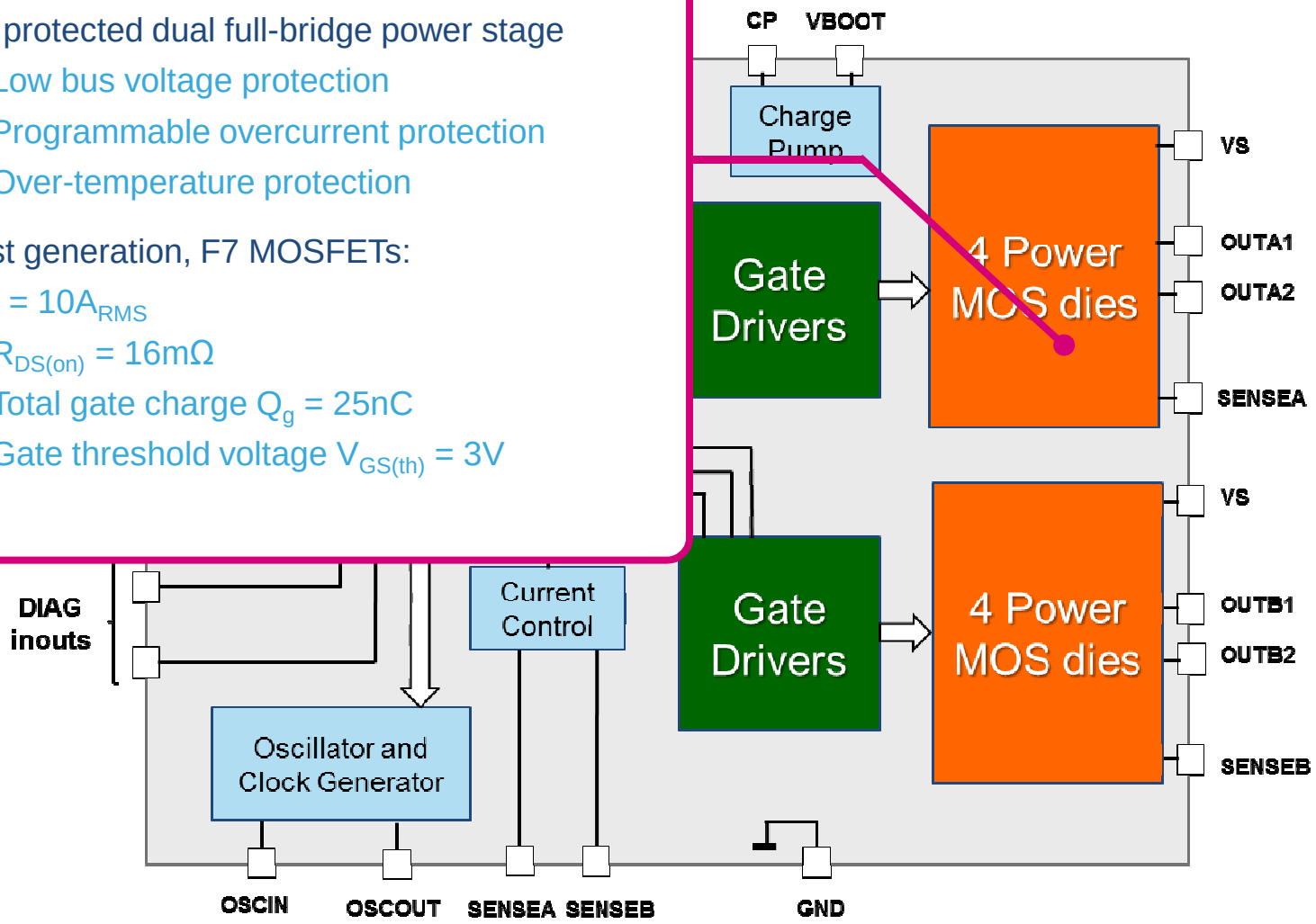
PowerSTEP01 features overview (5/6)

- Programmable gate drivers:
  - Gate current I_{GATE}
  - Controlled current time t_{CC}
  - blanking time / dead time
  - Turn-off over-boost time
- Optional 7.5V or 15V gate voltage



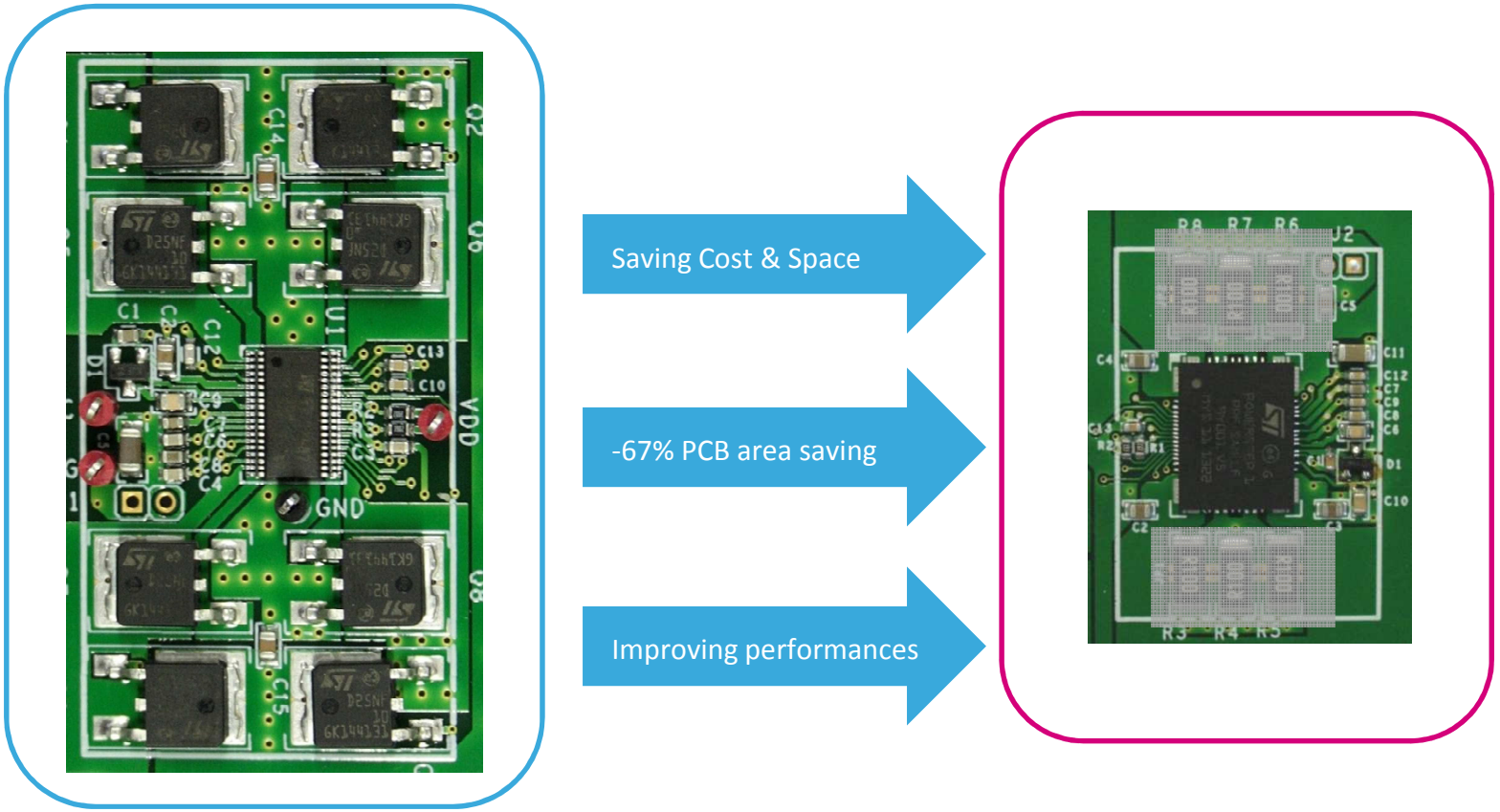
PowerSTEP01 features overview (6/6)

- Fully protected dual full-bridge power stage
  - Low bus voltage protection
  - Programmable overcurrent protection
  - Over-temperature protection
- Latest generation, F7 MOSFETs:
  - I = $10A_{RMS}$
  - $R_{DS(on)}$ = 16mΩ
  - Total gate charge Q_g = 25nC
  - Gate threshold voltage $V_{GS(th)}$ = 3V



New Product

powerSTEP™



From cSPIN demo board (8x MOSFET in DPAK) to **powerSTEP eval**

EVLPOWERSTEP01

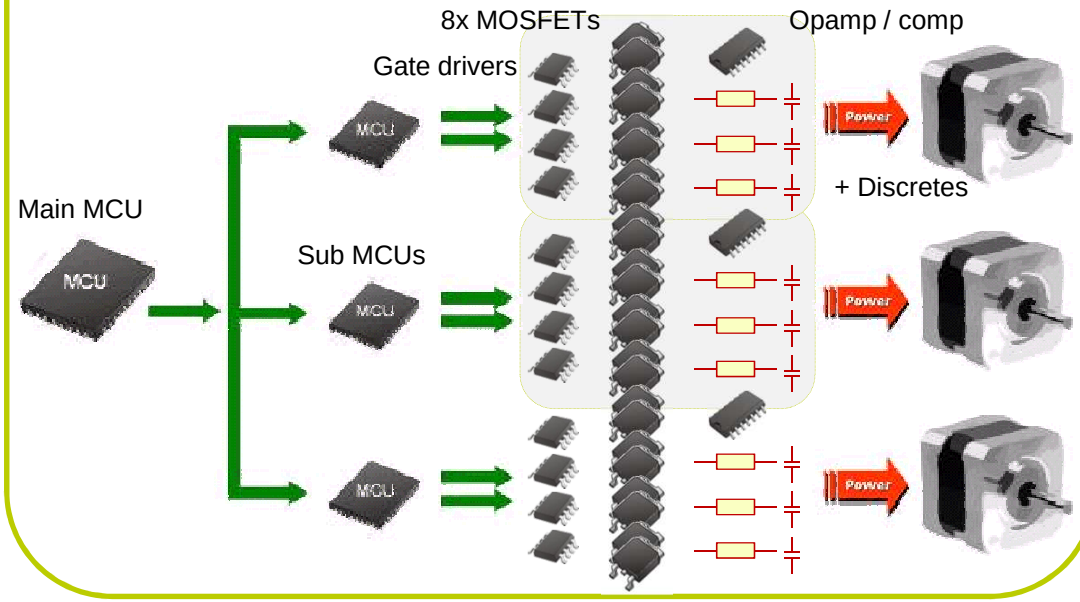
Available now

New Product

powerSTEP™ System Architecture Advantages

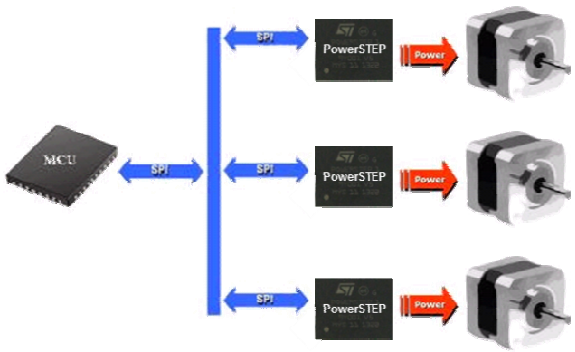
Conventional solution

- Plenty external components
- Limited features
- Limited protection
- High processing power



powerSTEP

- Much less components
- Less space
- Much more features
- Full set of protections
- Less processing power needed



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