Power 'n Motors

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

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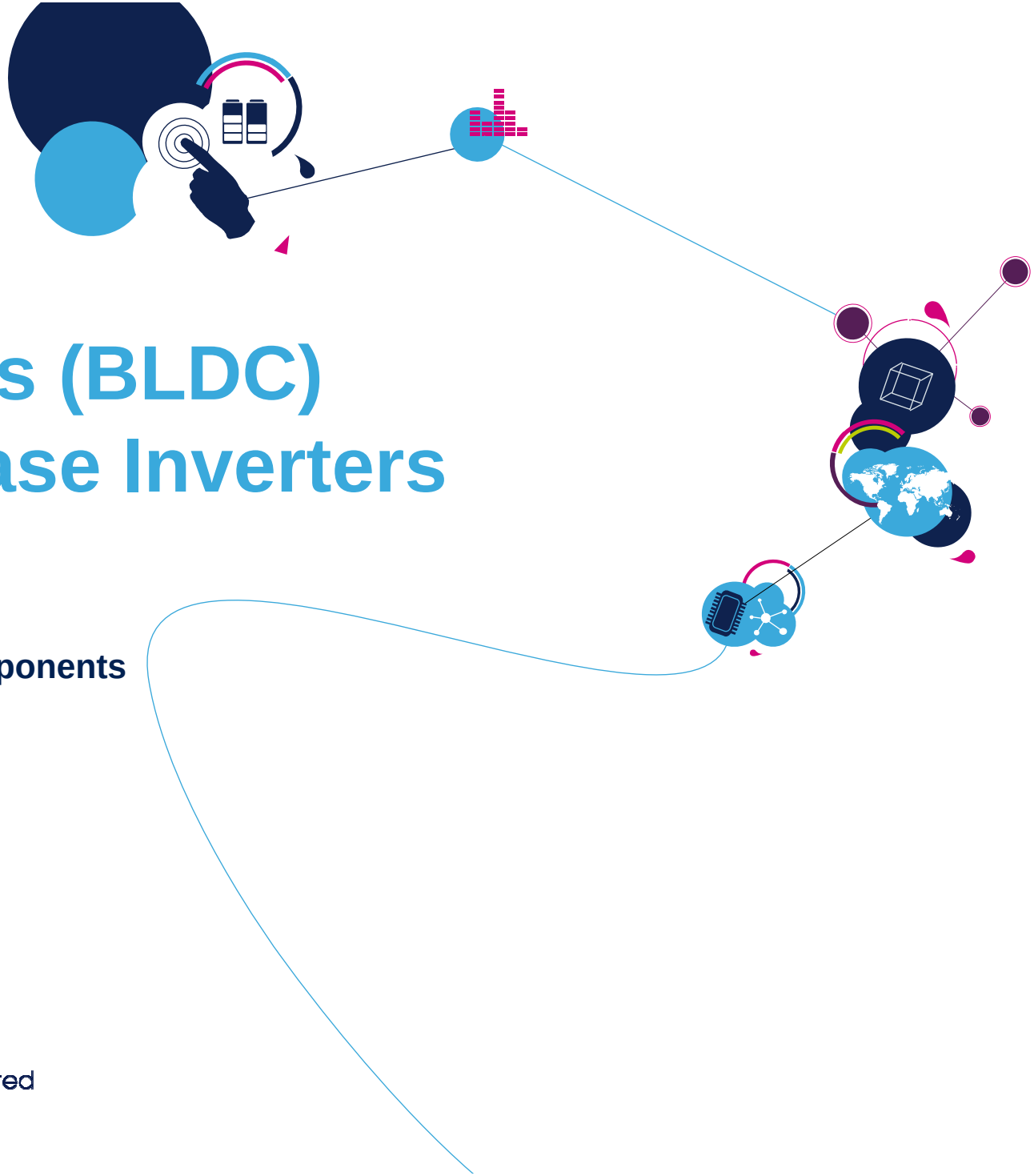
SILICA An Avnet Company

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**



HV Motors (BLDC) and 3-phase Inverters

Architectures & Components

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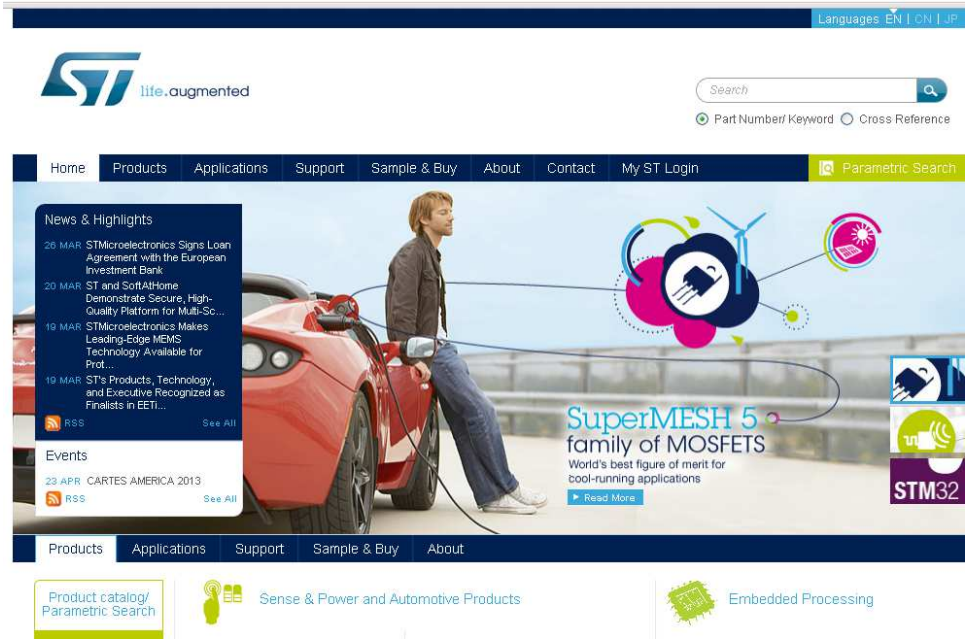
Introduction

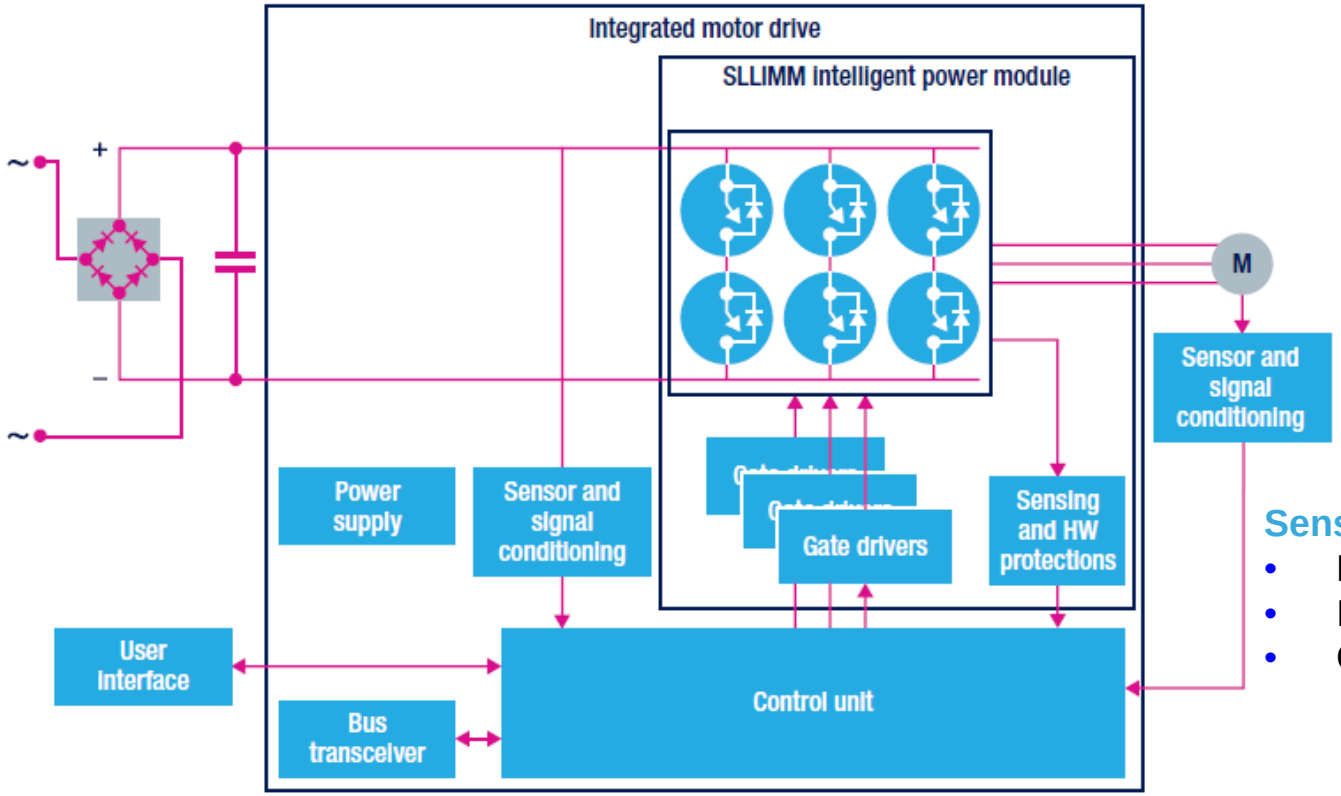
- STMicroelectronics is a worldwide leading provider of innovative solutions for various motor control applications.
- Applying an advanced experience we offer a strong portfolio of electronic devices covering the ever growing demands of industries with ease.
- On ST website you find a dedicated section about our motor control products:

http://www.st.com/motorcontrol



3-phase brushless motors: Application topology

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



Sensors

- Hall sensors
- Incremental sensor
- Current sensors

3-phase brushless motors: Product map

- To give the greatest freedom, ST's product portfolio supports a discrete-based approach for applications with wide package choice for discrete MOSFETs or IGBTs.
  For highly-integrated configuration the SLLIMM product family offered.

KEY BENEFITS

- High start-up torque
- Reliability, long lifetime
- Silent operation
- High efficiency

Motor type	Applications addressed	Suitable products
3-phase brushless motors	• Home appliances • Industrial applications like pumps, fans, etc.	• **IGBTs** • **MOSFETs** • **Gate drivers**

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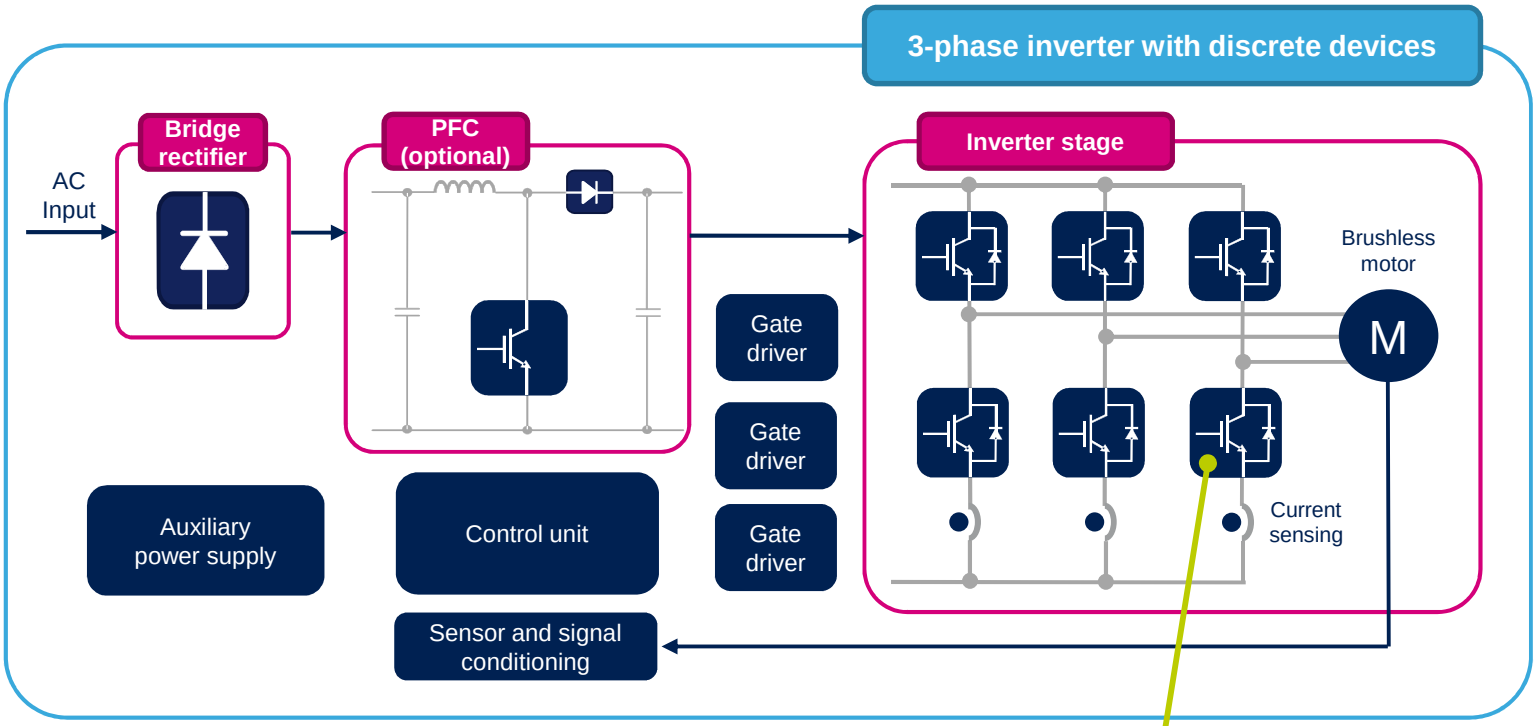
3-phase Inverter for Brushless Motors



IGBT for inverter stage

- **Trench gate field stop**
  - 600/1200V

600V-650V TFS IGBTs series

to serve the industrial market

600V

650V

H

2 – 30 kHz

Home Appliances
(fan, pump, washing, dryer)
3Φ & H-bridge inverters

STGxnn**H**60(**D**)F

5A, 7A, 10A, 15A, 20A

DPAK, D2PAK, TO-220, TO-220FP

V

50 – 100 kHz

Welding
DC-DC
Full Bridge, Two switch forward

AC-DC
PFC-CCM

STGxnn**V**60(**D**)F

20A, 30A, 40A, 60A, 80A

D2PAK, TO-220, TO-220FP, TO-247, TO-3P

M

2 – 20 kHz

Solar Inverters
Asymmetrical, Full Bridge & Three level converter

Motor Control
3Φ and H-bridge inverter

UPS
Three level converters

Aircon
Compressor

STGxnn**M**65DF**2**

4A, 6A, 10A, 15A, 20A, 30A, 50A, 75A, 100A, 120A

DPAK, D2PAK, TO-220, TO-220FP, TO-247, MAX247

HB

16 – 60 kHz

Solar, Welding
DC-DC
Full Bridge, Two switch forward

Welding, Solar Boost, Aircon, Washing
AC-DC
PFC -CCM

Induction Heating, Microwave, Printer
Half Bridge Current Resonant

STGxnn**H**65(**D***)F**B**

20A, 30A, 40A, 60A, 80A

D2PAK, TO-220, TO-220FP, TO-247, TO-3P

Energy Saving
Extremely low switching-off combined with a low conduction losses.

Robustness and Reliability
The Increasing up to 175°C of the max Junction Temperature Tj(max), Ensures an higher lifetime

*) DL diode option for resonant converters

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≥ 1200V TFS IGBTs series

to serve the industrial market

1200V **1250V**

S

Up to 5 kHz

Motor Control
3Φ and full bridge inverters

Solar Inverter
Asymmetrical and full bridges, three level converters

UPS
Three level converters

Aircon
Compressors

STGxnn**S**120(D)F**3**

15A, 25A, 40A

TO-247, TO-247LL

M

2 – 20 kHz

Motor Control
3Φ and full bridge inverters

Solar Inverter
Asymmetrical and full bridges, three level converters

UPS
Three level converters

Aircon
Compressors

STGxnn**M**120(D)F**3**

15A, 25A, 40A

TO-247, TO-247LL

H

15 – 100 kHz

Solar Inverter, Welding
DC-DC
Full Bridge, Two switch forward

Welding, Solar Boost, Aircon, Washing
AC-DC
PFC-CCM

UPS
Three level converters

Aircon
Compressor

STGxnn**H**120(D)F**2**

15A, 25A, 40A

TO-247, TO-247LL

IH

8 – 60 kHz

Induction Heating, Microwave, Printer
Half Bridge Voltage Resonant

STGxnn**IH**125(D)F

20A, 30A

TO-247, TO-3P

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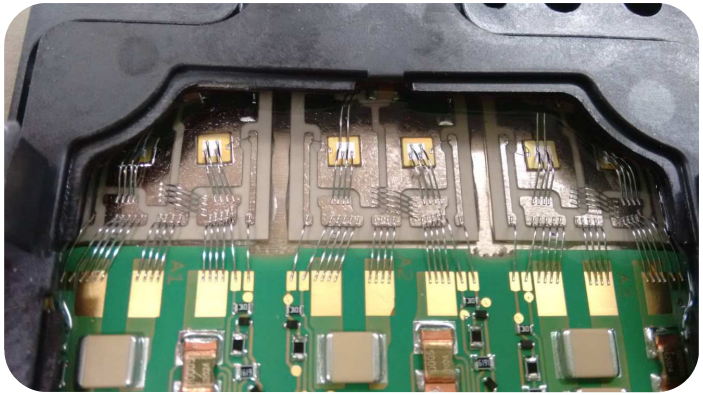
SCT30N120: SiC Power MOSFET …for motor control?

SCT30N120

- **SCT30N120** - SiC Power MOSFET, 45A, 1200V, 80mΩ
- Key parameters:
  - V_{BR} > 1200V
  - In = 45A
  - $R_{on(typ.)}$ < 80mΩ
  - $Q_{g(typ.)}$ < 105nC
  - Gate driving voltage = 20V
  - HiP247™ package → Tjmax = **200°C**
- Key features:
  - Very tight variation of on-resistance vs. temperature
  - Slight variation of switching losses vs. temperature
  - Very high operating temperature capability (200°C)
  - Very fast and robust intrinsic body diode
  - Low capacitance
  - Easy to drive
- Schedule:
  - **Full mature**



- 3-phase motor inverter
- 750V DC bus
- Load 35A RMS max
- 8 kHz switching freq.

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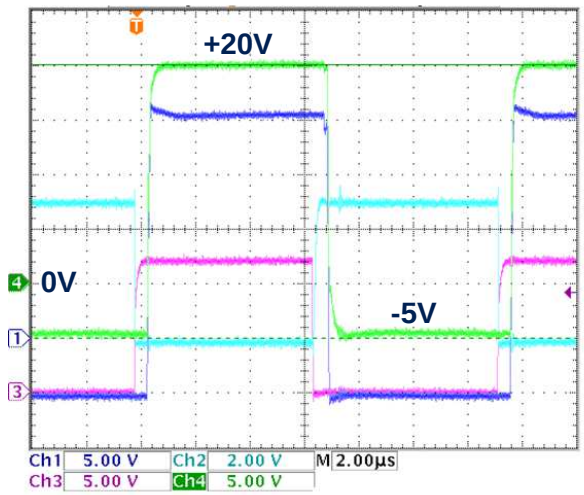
A common mistake: 1-to-1 replacement

- **Driving a SiC MOSFET requires +20V on the gate pin**

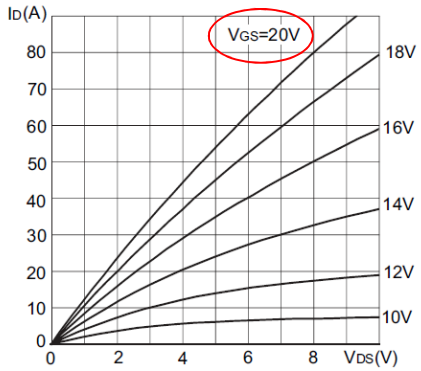
SiC MOSFET gate signal



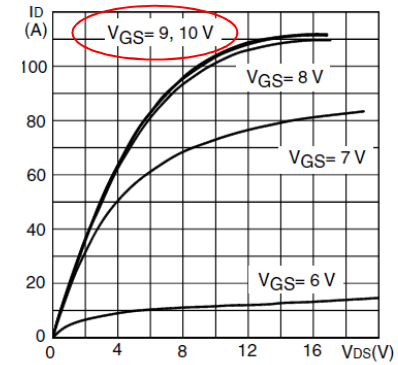
SiC MOSFET

Si MOSFET

SiC MOSFET - OUT characteristic



Si MOSFET - OUT characteristic



One-to-one replacement is not the right way to go!

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AC_{MAINS} Vs. DC_{LINK} - Driver selection table

Mains AC/DC selection table			
Description	**Nominal Voltage (V_{AC})**	**DC link Voltage (V_{DC})**	**What Driver ? (V_{RAIL})**
Japan single phase - neutral	100	140	600
US single phase - neutral	115	160	600
JAPAN phase-to-phase	200	280	600
EU single phase - neutral	230	325	600
EU phase-to-phase old system	380	535	1200
EU phase-to-phase	400	565	1200
UK phase-to-phase old system	415	585	1200
EU phase-to-phase power systems	600	850	1200
Phase-to-phase large power systems	690	970	1500/1700
Phase-to-phase large power systems	750	1060	1500/1700

Remark: only few nominal AC voltage levels below < 1kV are mentioned as example.
Several further voltage levels exist.

STDRIVE$_{smart}$ Family Overview

Gate Driver

L638X SERIES

600V HB drivers for IGBT/MOSFET

- L6384E
- L6385E
- L6386E
- L6387E
- L6388E
- A6387 (Automotive)

TD3XX SERIES

Low-Side Drivers

- TD350
- TD351
- TD352

Robustness

- ***Bootstrap diode integration***
- UVLO on VCC & Vboot
- ***Smart shut down***

System Integration

- ***Op Amp for current sensing***
- Embedded comparator
- Logic interface & shut down

Sustainable Technology

- Bill of material reduction
- EMI improvement

L639X SERIES

600V HB driver for IGBT/MOSFET with integrated OP-AMP and Smart Shutdown

- L6390
- L6391
- L6392
- L6393
- L6395
- L6398

STDRIVE$_{smart}$ L639x - Family Positioning

Features

L6390
+ Comparator & Op AMP

L6391
+ Smart SD integrated
+ Comparator

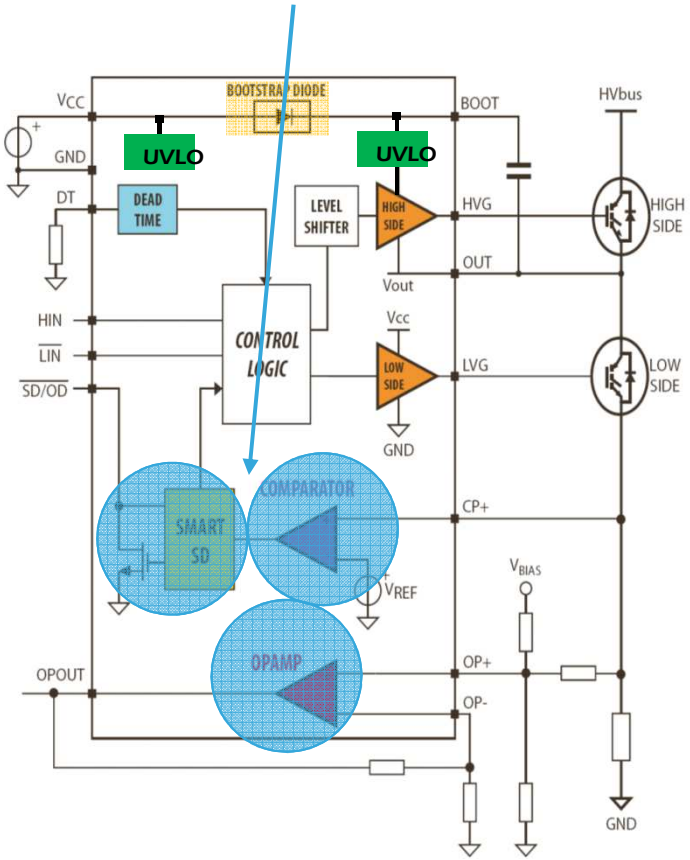
L6392
+ Op Amp integrated

L6393
+ Shutdown inputs
+ uncommitted comparator
+ interlocking & programmable DT

L6395
+ able to drive asymmetrical loads

L6398
High low side inputs, interlocking & DT protections, UVLO Vcc / Vboot

Embedded features optimized for
F**ield **O**riented **C**ontrol **(F.O.C.) applications



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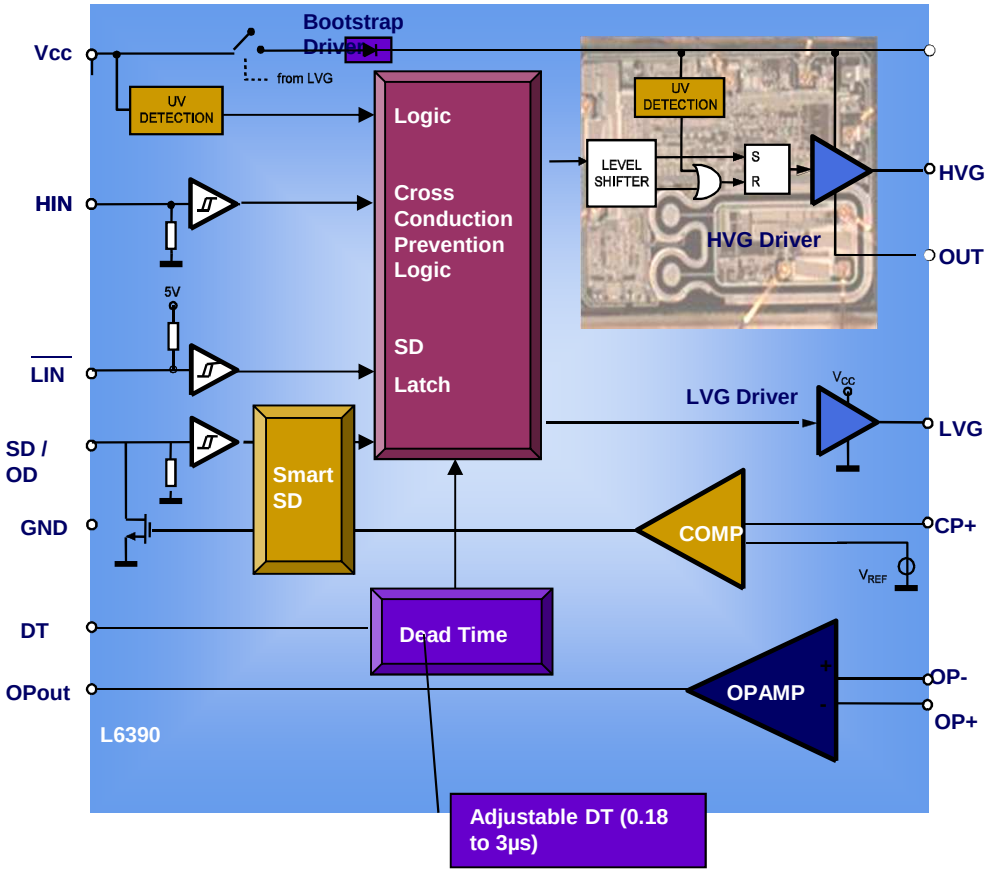
L6390 - Full Featured Half-Bridge Driver

Main features

- High voltage rail up to 600V
- Current capability:
  290mA source, 430 mA sink
- Smart SD protection (200ns)
- Shut down diagnostic
- OP-Amp for current sense
- Adjustable Dead Time DT
- Comparator for fast fault protection
- Integrated bootstrap diode
- SO16 / DIP16 Packages

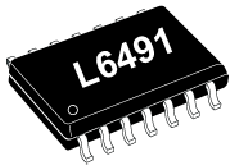
What if the current-capability is not enough?

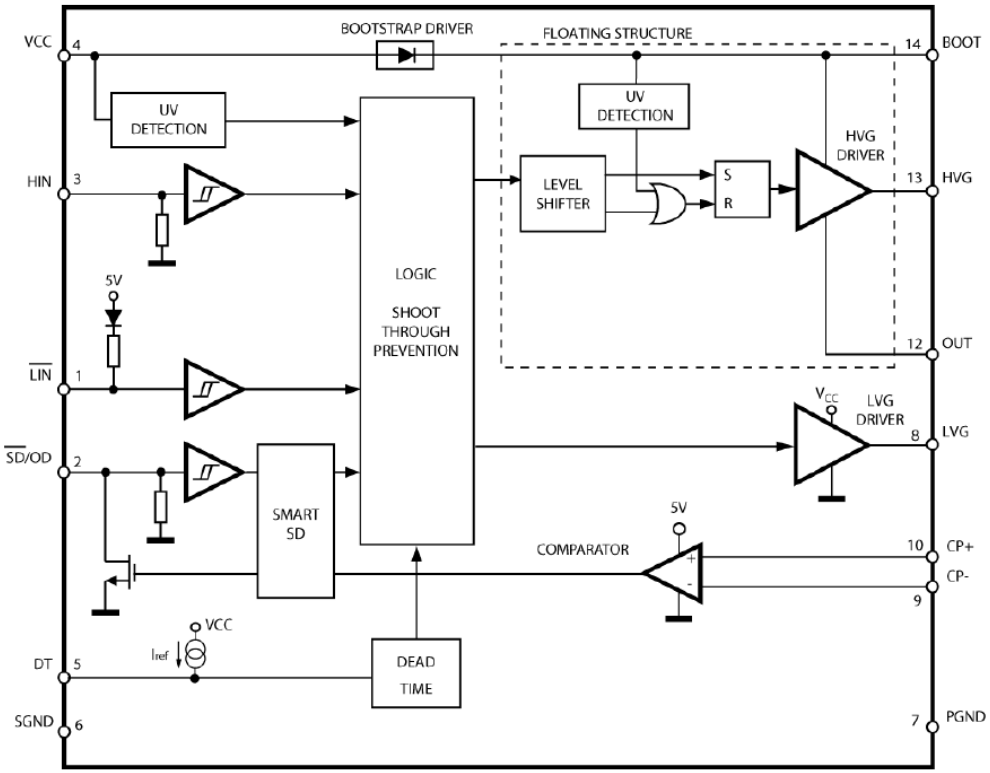


NEW!

Half bridge gate driver **L6491D**

- state of the art **4A driving Power** -





- High voltage rail up to 600V
- **4 A sink / source driver current capability**
- Integrated bootstrap diode
- Embedded comparator for fault protection
- Smart shut-down function
- Adjustable dead-time
- Interlocking (to avoid cross-conduction)
- UVLO on both high-side and low-side sections
- ± 50 V / ns transient immunity

Leading performance of L639x family by adding 4A driving Power!

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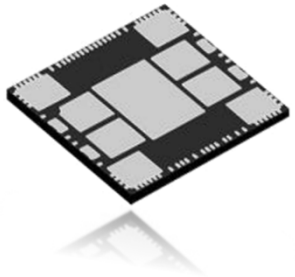
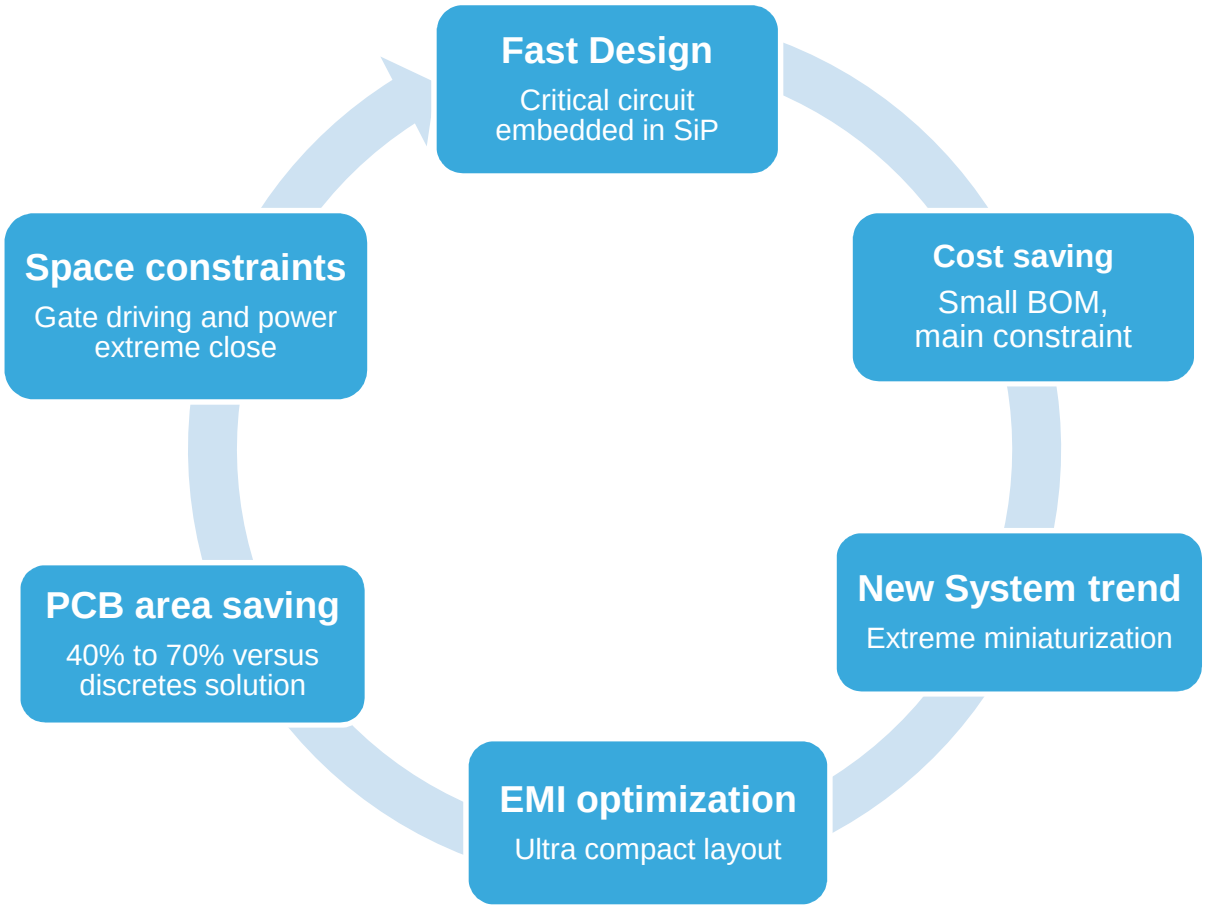
ST**DRIVE**$_{power}$ – Towards System-in-Package

Why System-in-Packages?





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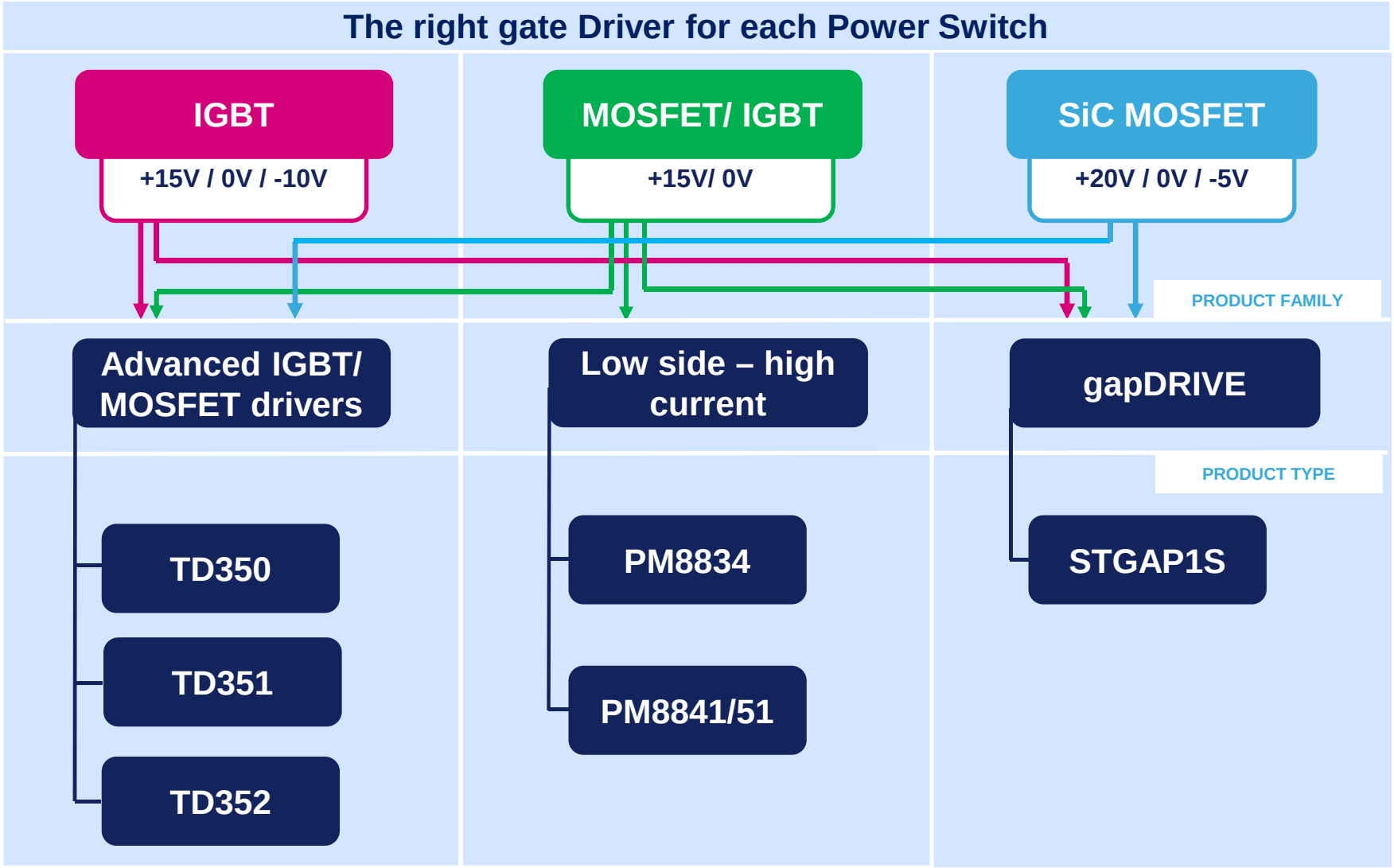
MOSFET/IGBT drivers for 1200V applications – selection table



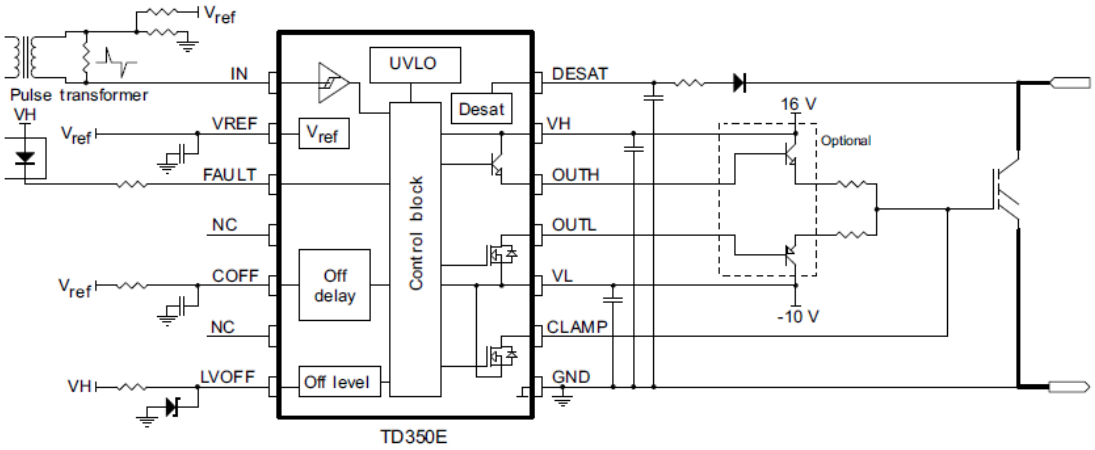
TD350E Advances IGBT and MOSFET Driver

Driver key features

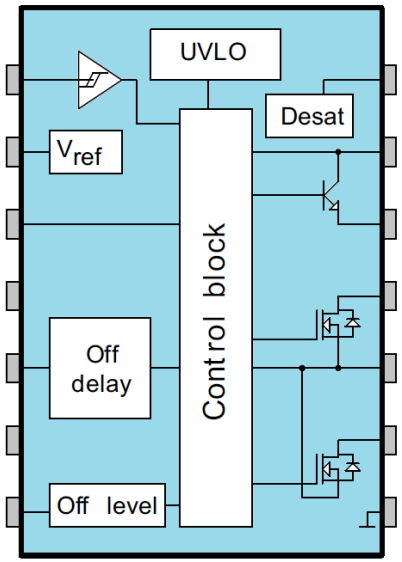
- **2.3A/1.5A typical current capability**
- Max VH = 28V – Max VL=-12V
- **Separate sink & source outputs for easy gate drive**
- **Active Miller Clamp**
- **Desaturation protection**
- Optional 2-step turn-off sequence
- Fault status output
- UVLO protection
- SO14 package
- -40°C/125°C temperature range

Main target applications:

- 1200V 3-phase Inverter
- Industrial motor control
- UPS systems



TD350E

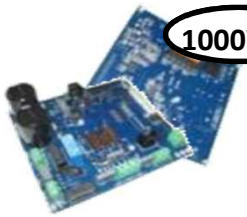


TD350E

Motor Control stages
Evaluation boards

STEVAL-IHM025V1

- 1 x IGBT SLLIMM™ **STGIPL14K60**
- 1 converter based on **Viper16**
- 1 x IGBT **STGP10NC60KD**



STEVAL-IHM027V1

- 1 x IGBT SLLIMM™ **STGIPS10K60A**
- 1 converter based on **Viper16**
- 1 x IGBT **STGP10NC60KD**

STEVAL-IHM028V1

- 1 x IGBT SLLIMM™ **STGIPS20K60**
- 1 x PWM SMPS **VIPer26LD**
- 1 x IGBT **STGW35NB60SD**

STEVAL-IHM035V1

- 1 x IGBT SLLIMM™ **STGIPN3H60**
- 1 x PWM SMPS **VIPer16L**

SLLIMM™ (ST IPMs) based

STEVAL-IHM023V2

- 3 x PWM smart driver **L6390**
- 1 converter based on **Viper16**
- 7 x IGBT power switch **STGP10NC60KD**

STEVAL-IHM021V2

- 3 x PWM smart driver **L6390**
- 1 converter based on **Viper12**
- 6 x MOSFET power switch **STD5N52U**

STEVAL-IHM032V1

- 3 x PWM smart driver: **2xL6392D** and **1x L6391D**
- 1 converter based on **Viper12**
- 6 x IGBT power switch: **STGD3HF60HD**

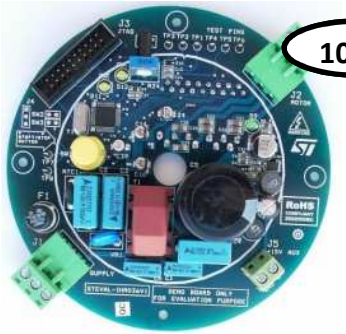
STEVAL-IHM031V1

- 3 x dual PowerMOSFETs **STS8dnh3l**
- 2 x PWM smart driver **L6387E**
- 1x step down converter **L4976D**

Gate drivers & Power Transistors based

Complete 3-phase Motor drive solutions

Evaluation boards



100w

STEVAL-IHM036V1

PMSM FOC Motor Drive

- 1 x 32bit Micro **STM32F100C6**
- 1 x IGBT SLLIMM™ **STGIPN3H60**
- 1 converter based on **Viper16**

1300W

STEVAL-IHM034V1

Dual motor drive + digital PFC

- 1 x 32bit Micro **STM32F103C8T6**
- 1 x IGBT SLLIMM™ **STGIPS20K60**
- 1 converter based on **Viper16L**

40W

STEVAL-IHM038V1

FAN Drive + PFC + IrDA

- 1 x 32bit Micro **STM32100**
- 1 x IGBT SLLIMM™ **STGIPN3H60**
- 1 PFC controller **L6562A**

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