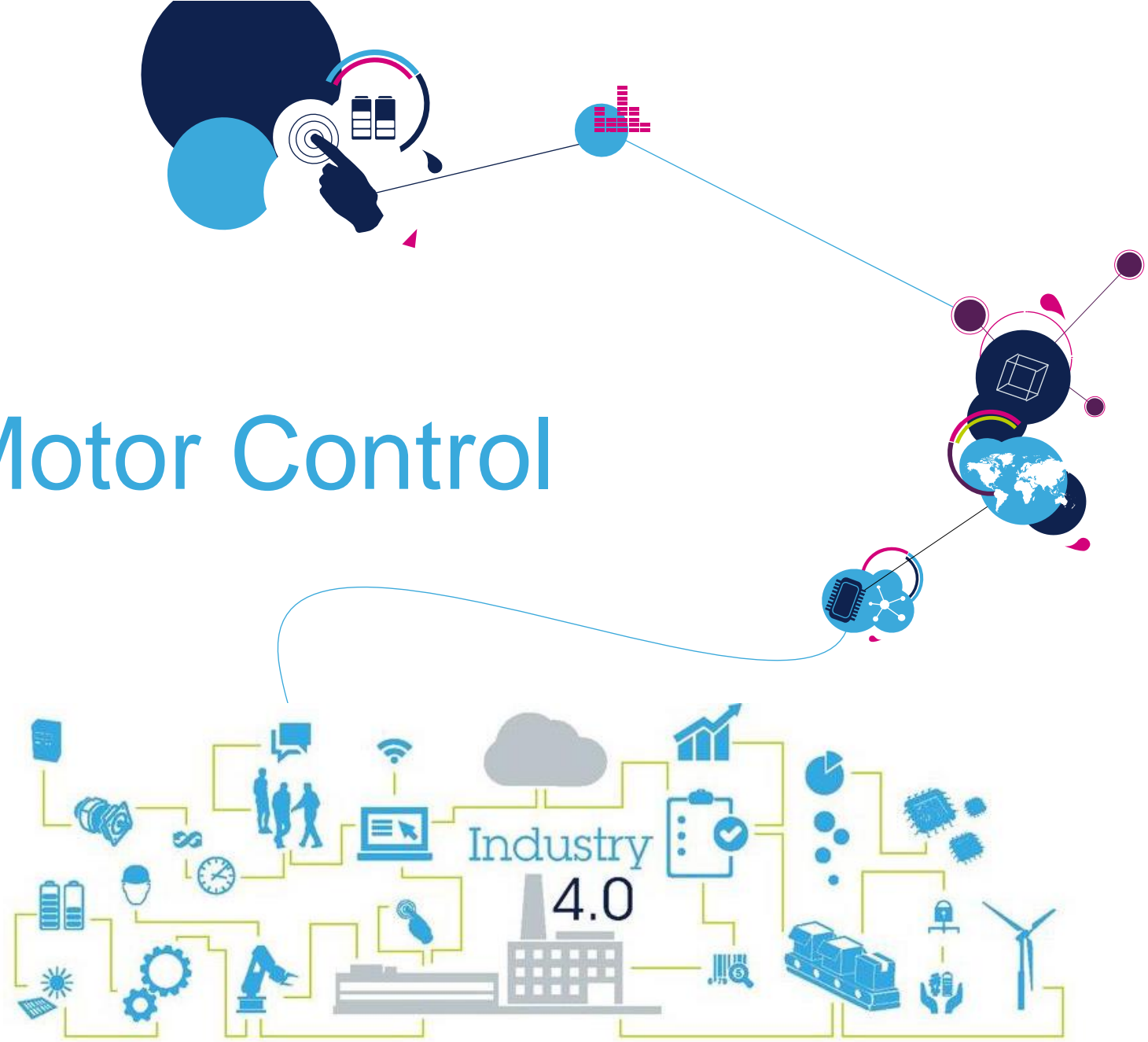
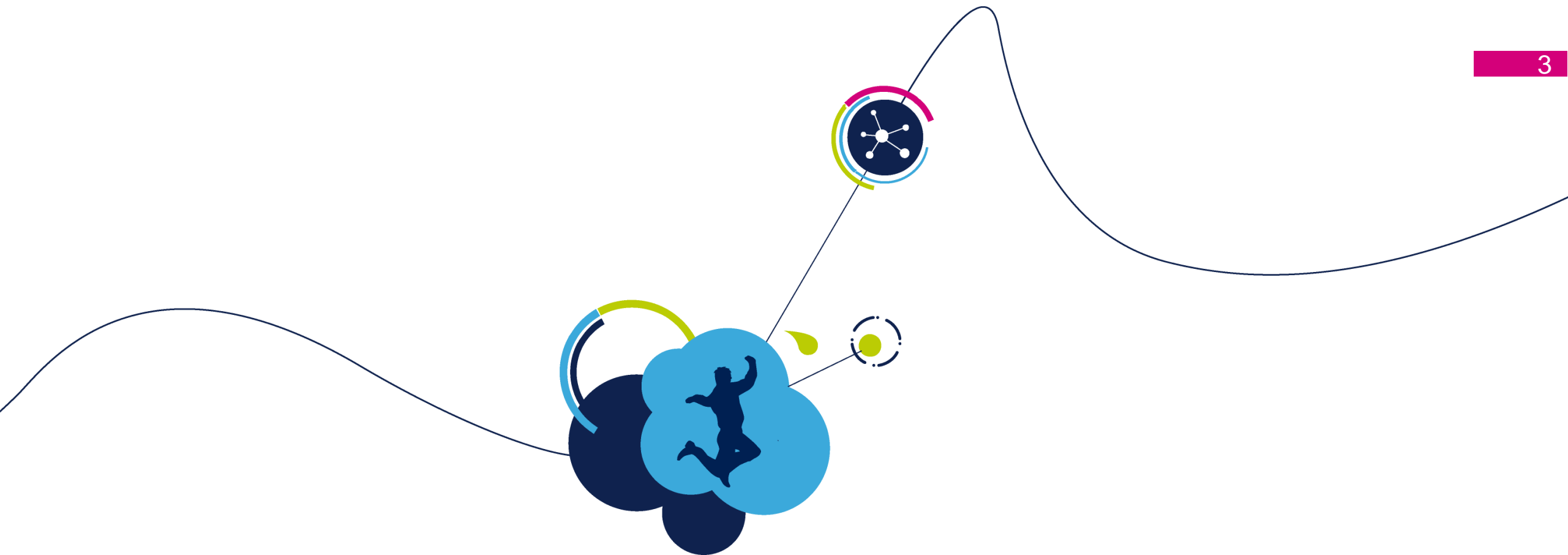


High-Voltage Motor Control



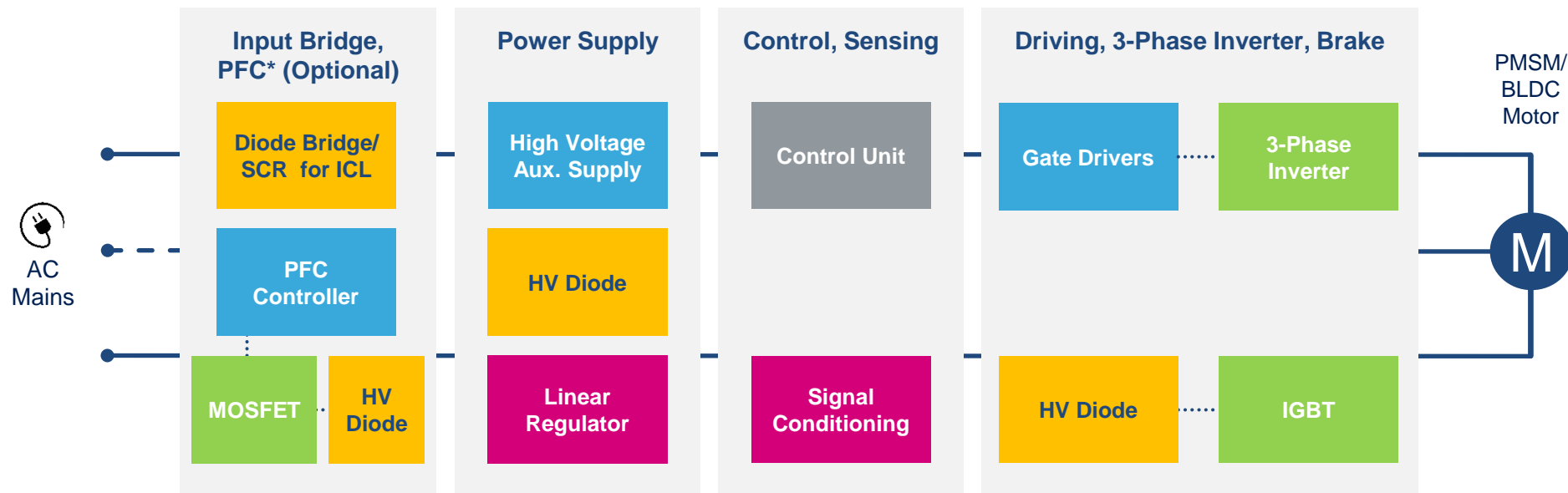
1. System Block Overview
2. 3ph-Inverter with SLLIMM™
3. 3ph-Inverter with ACEPACK™
4. 3ph-Inverter with Discrete
5. Other Components: Aux. AC/DC Supply, Gate Driver, Voltage Regulators, Signal Conditioning



System Block Overview

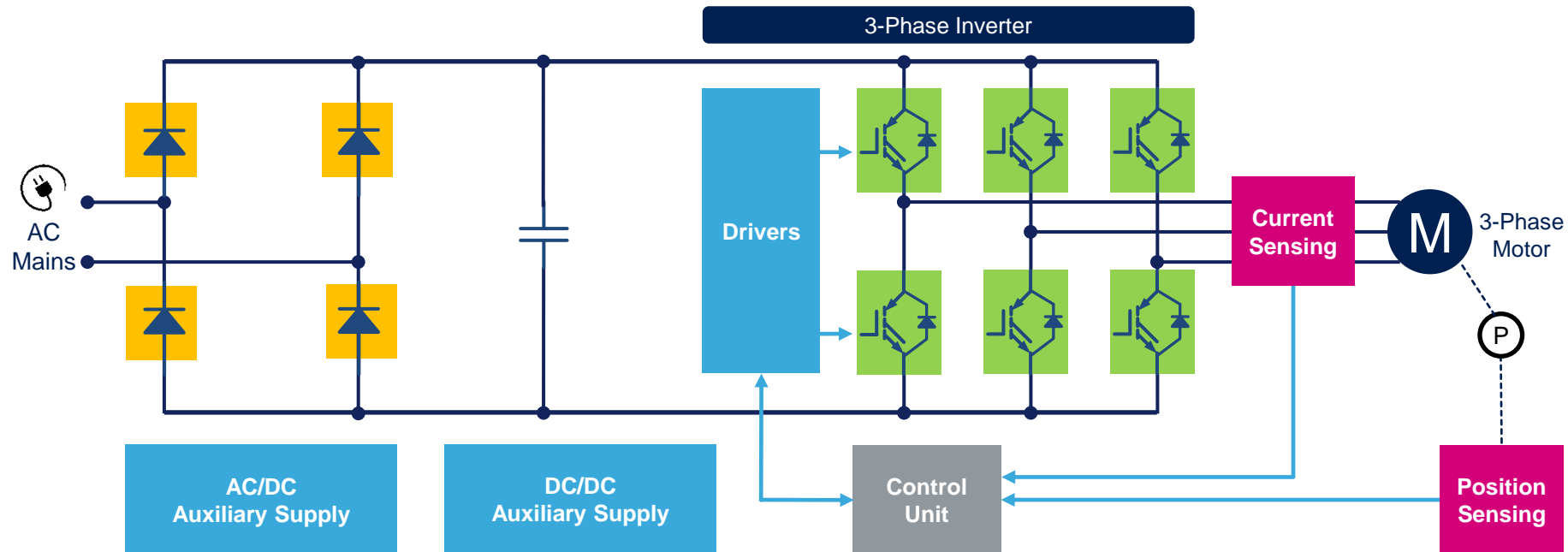
High-Voltage Motor Control

3ph-Inverter System Block Overview

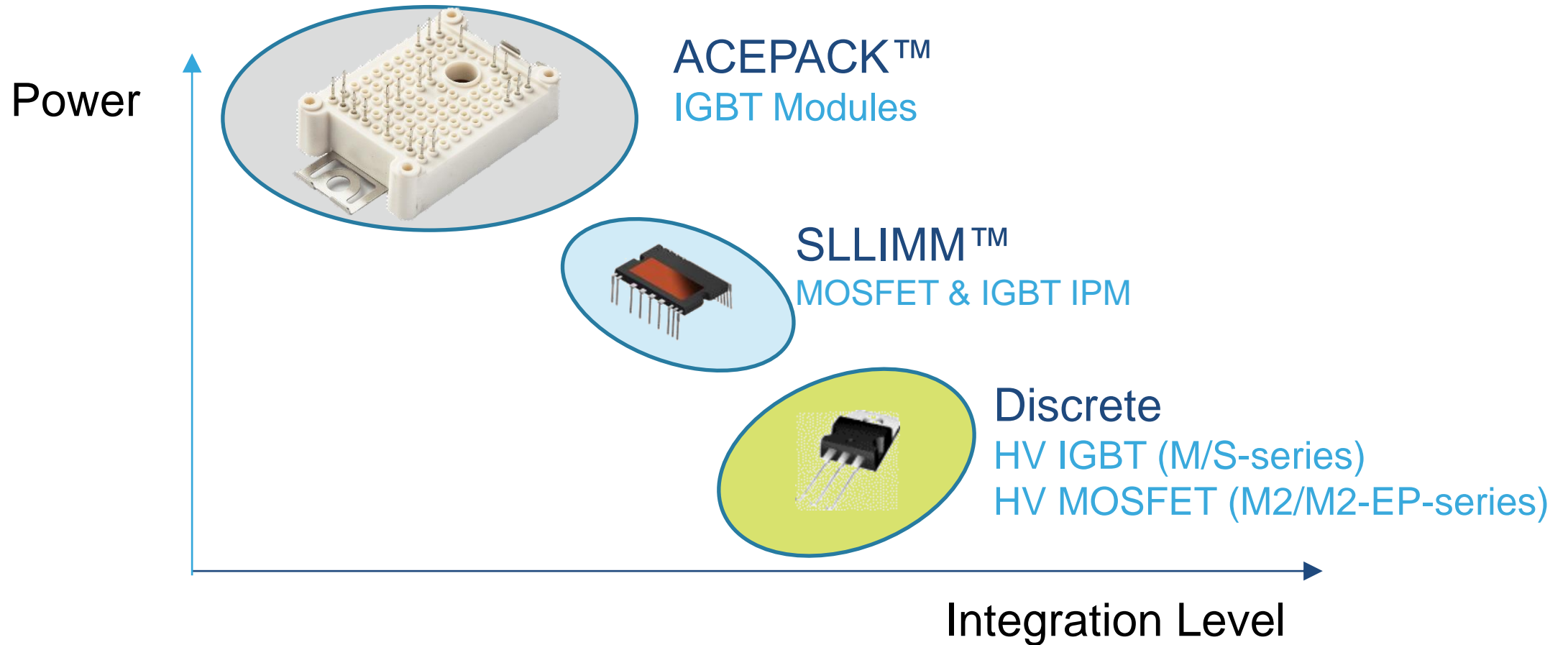


High Voltage Motor Control

Typical schematic for 3ph-Inverter

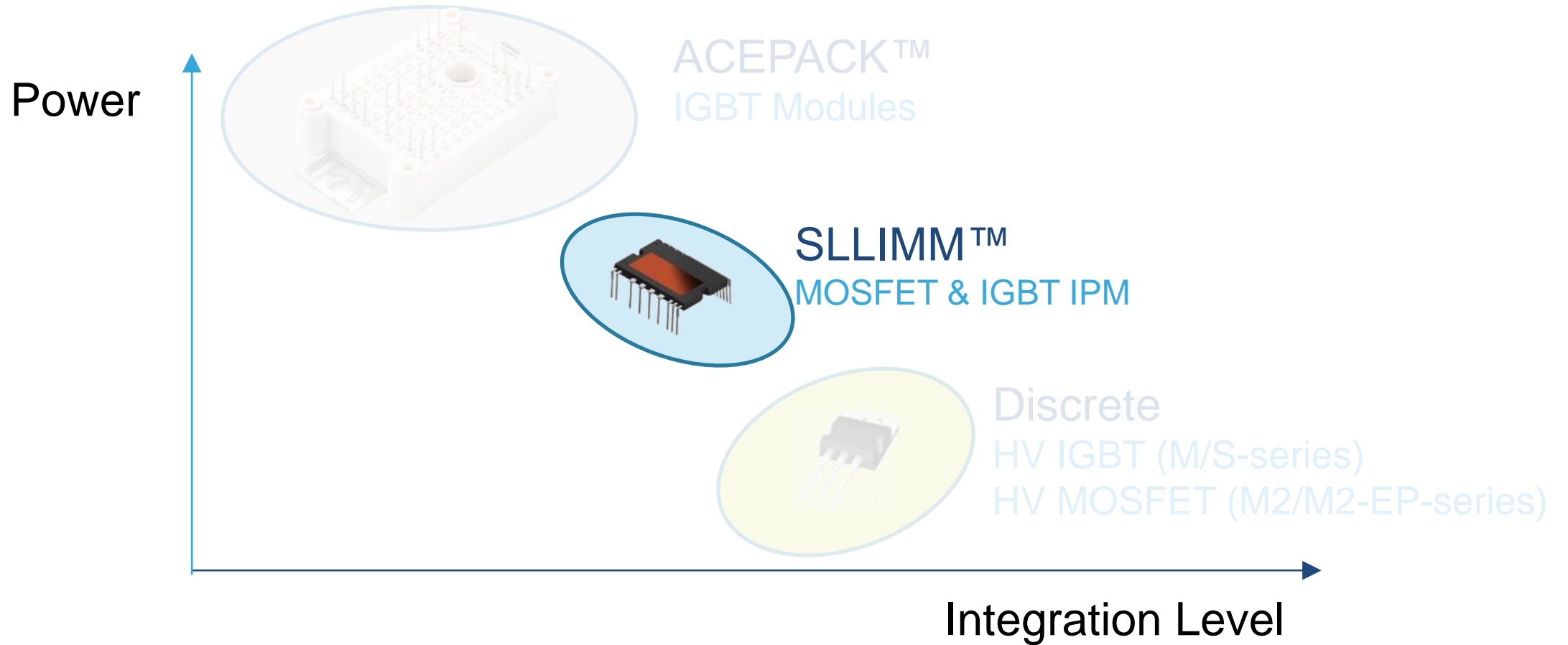


High-Voltage Motor Control Three Approaches



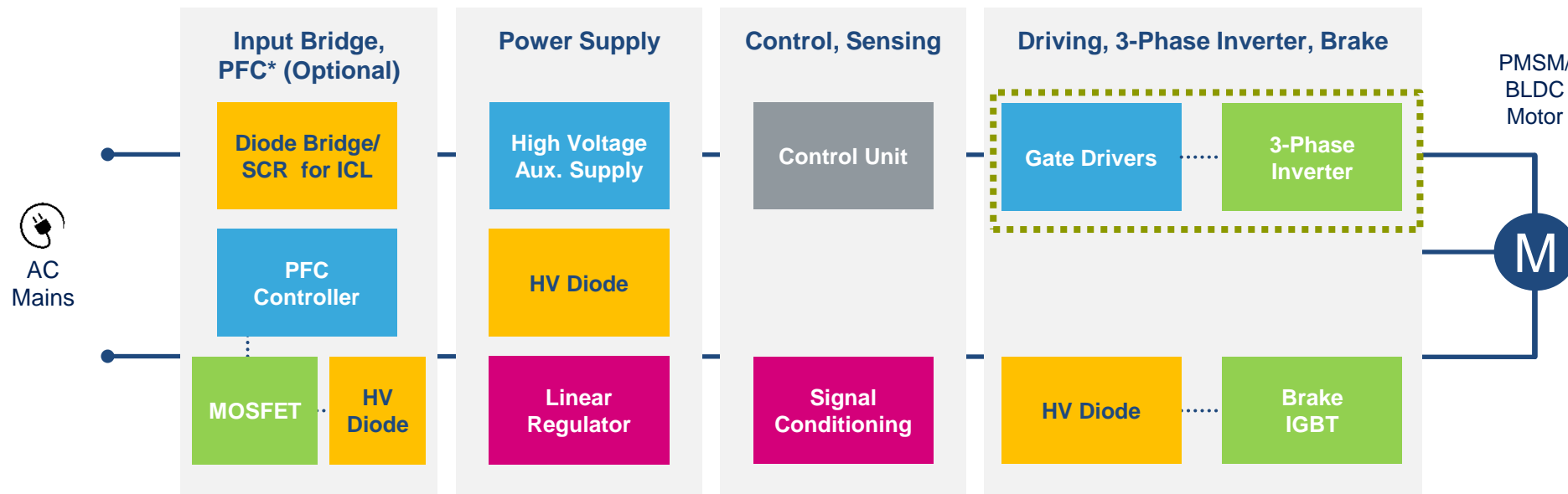
High-Voltage Motor Control

Three Approaches



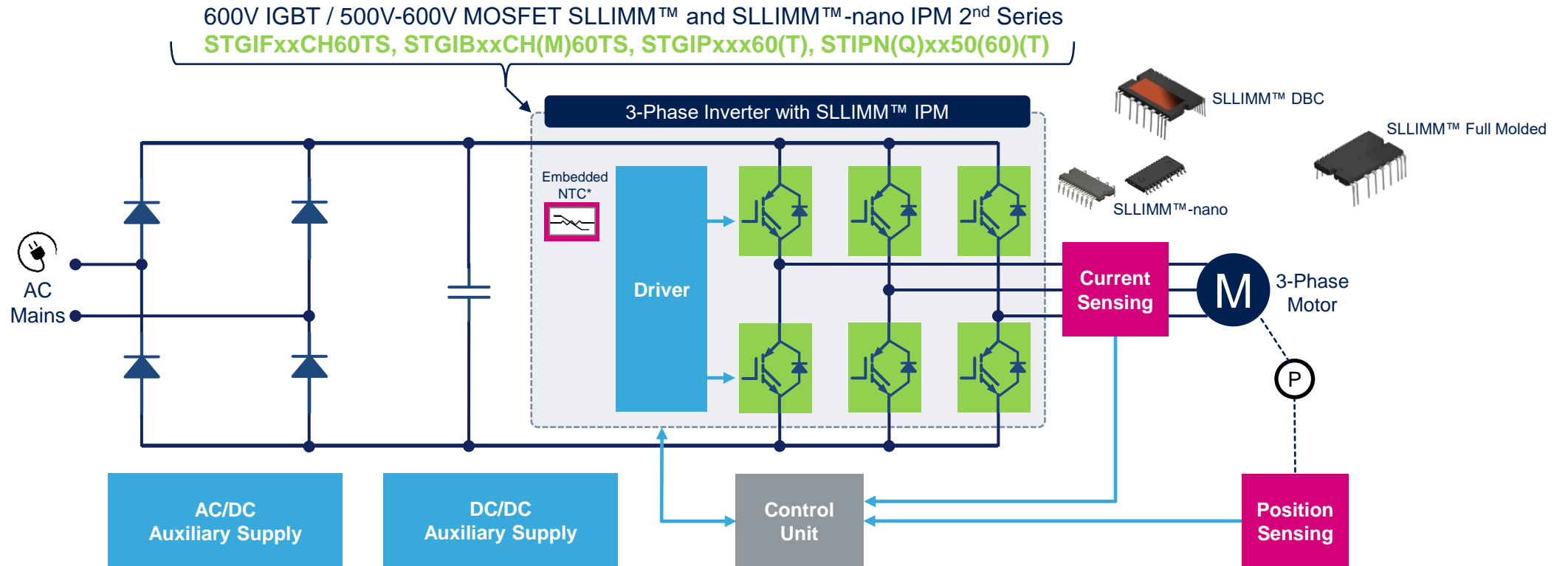
Application Block Diagram

IPM approach – SLLIMM™

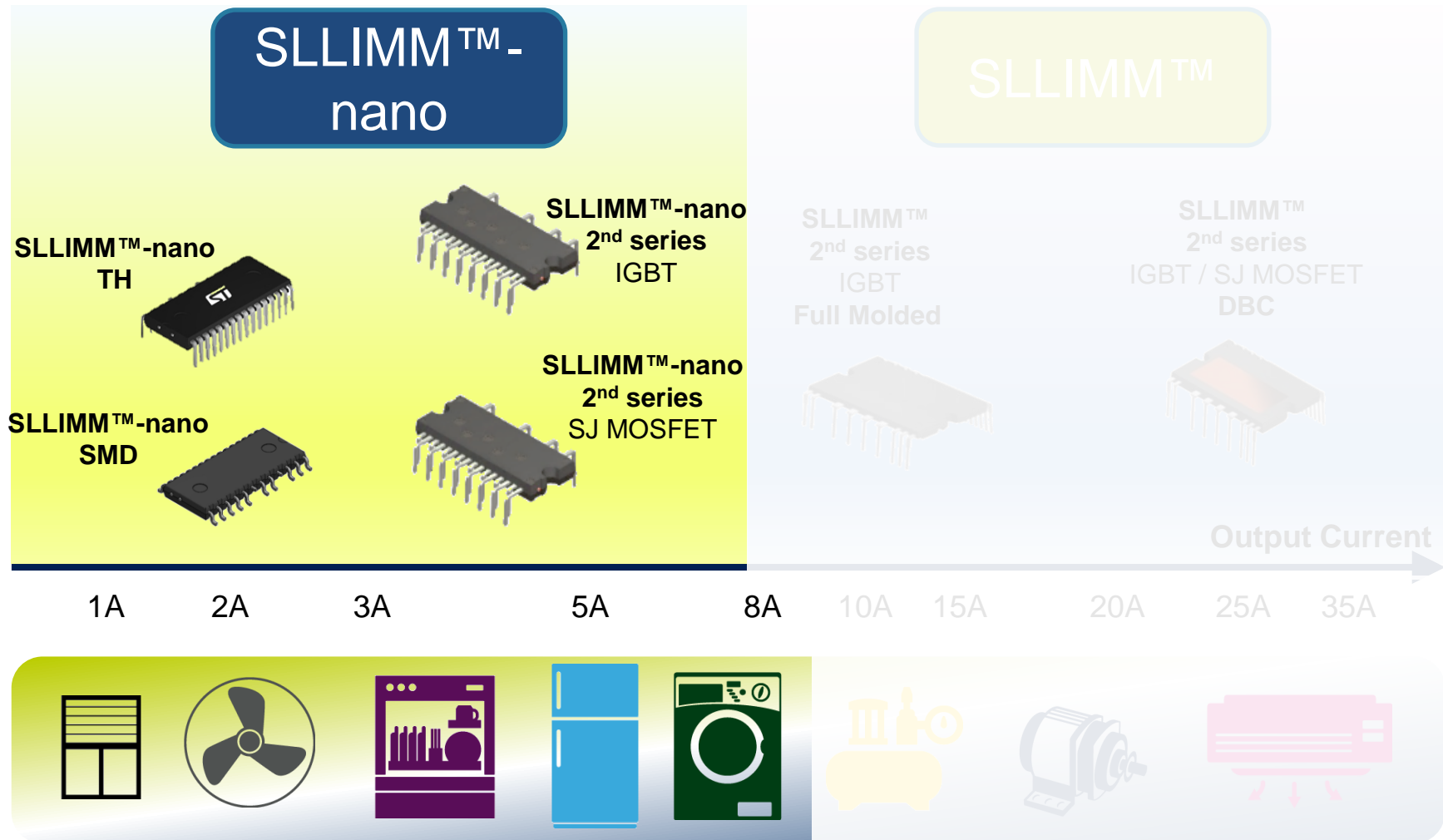


Application Block Diagram

3Ph-Inverter with Intelligent Power Module – SLLIMM™

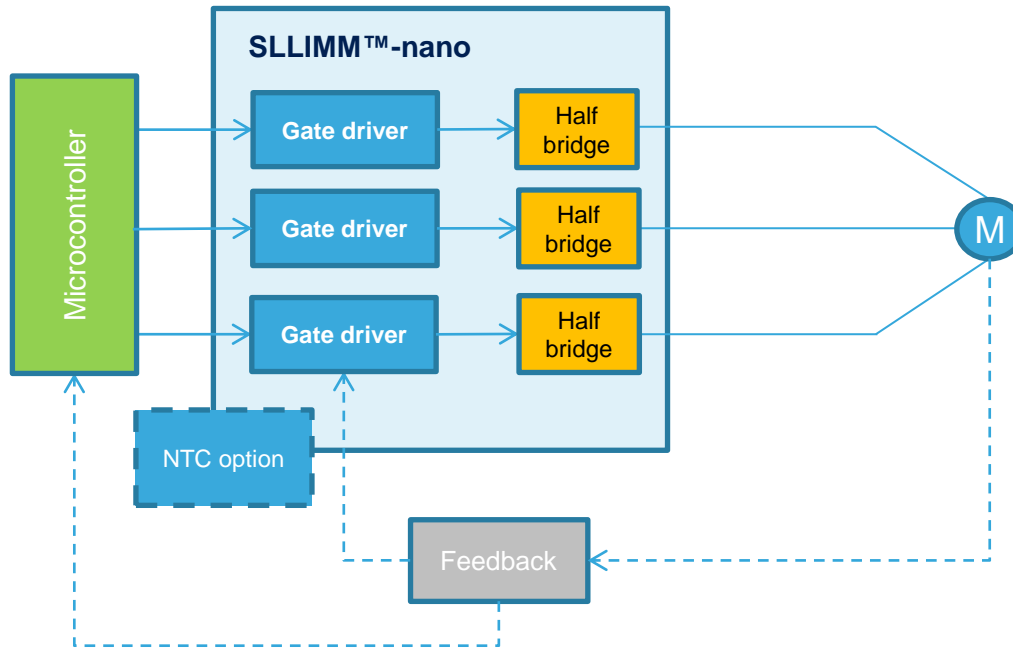


SLLIMM™ or SLLIMM™-nano ?



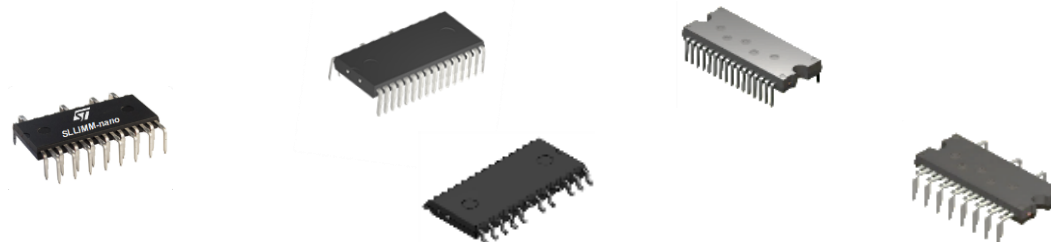
SLLIMM™-nano Overview

11

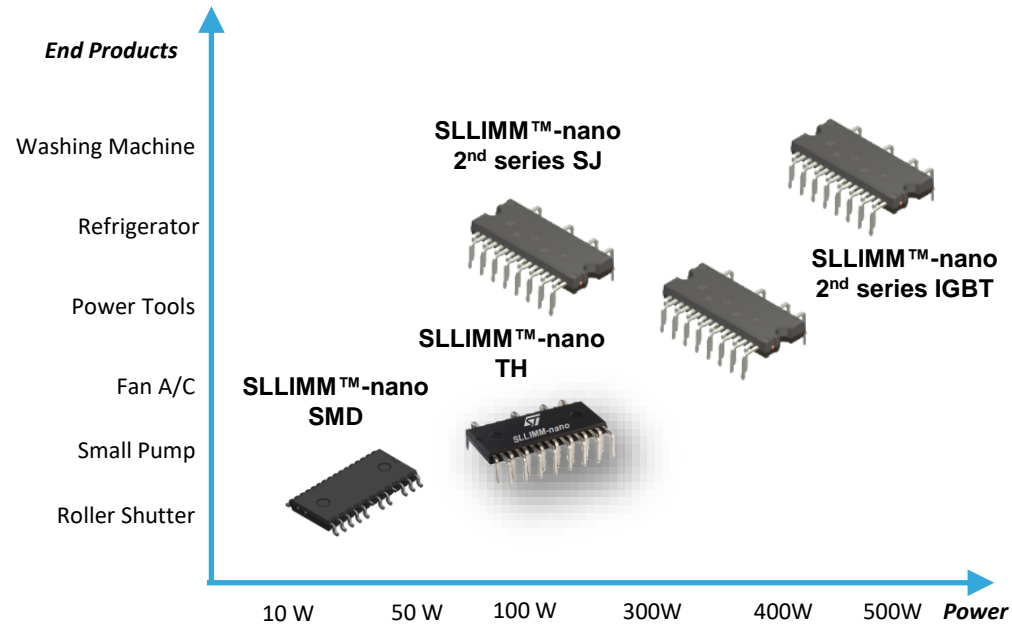


Features

- Optimized voltage drop in conduction
- IGBT and MOSFET based
- 600V and 500V breakdown voltage
- Current availability **up to 8A** at 25°C
- Smart shutdown function
- Comparator for fault protection
- OpAmp for advanced current sensing
- Open emitter configuration for individual phase current sensing (3-shunt)
- NTC option
- Internal bootstrap diodes
- Interlocking function with dead time and under-voltage lockout
- Through-Hole and SMD packages
- In line and zig-zag leads options (w/wo stand-off)



SLLIMM™-nano Product Plan



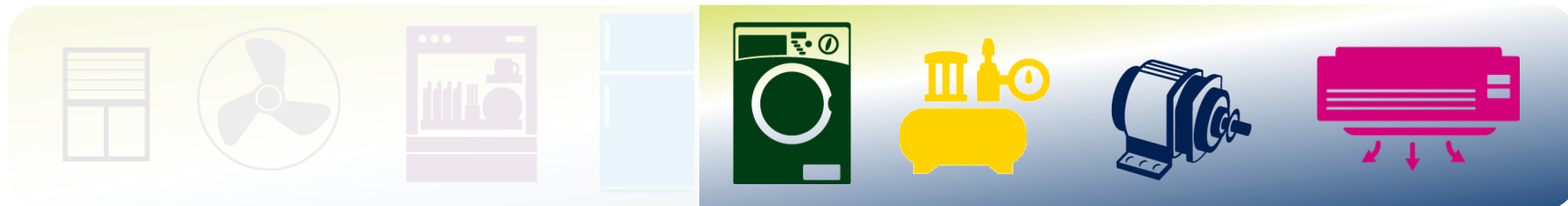
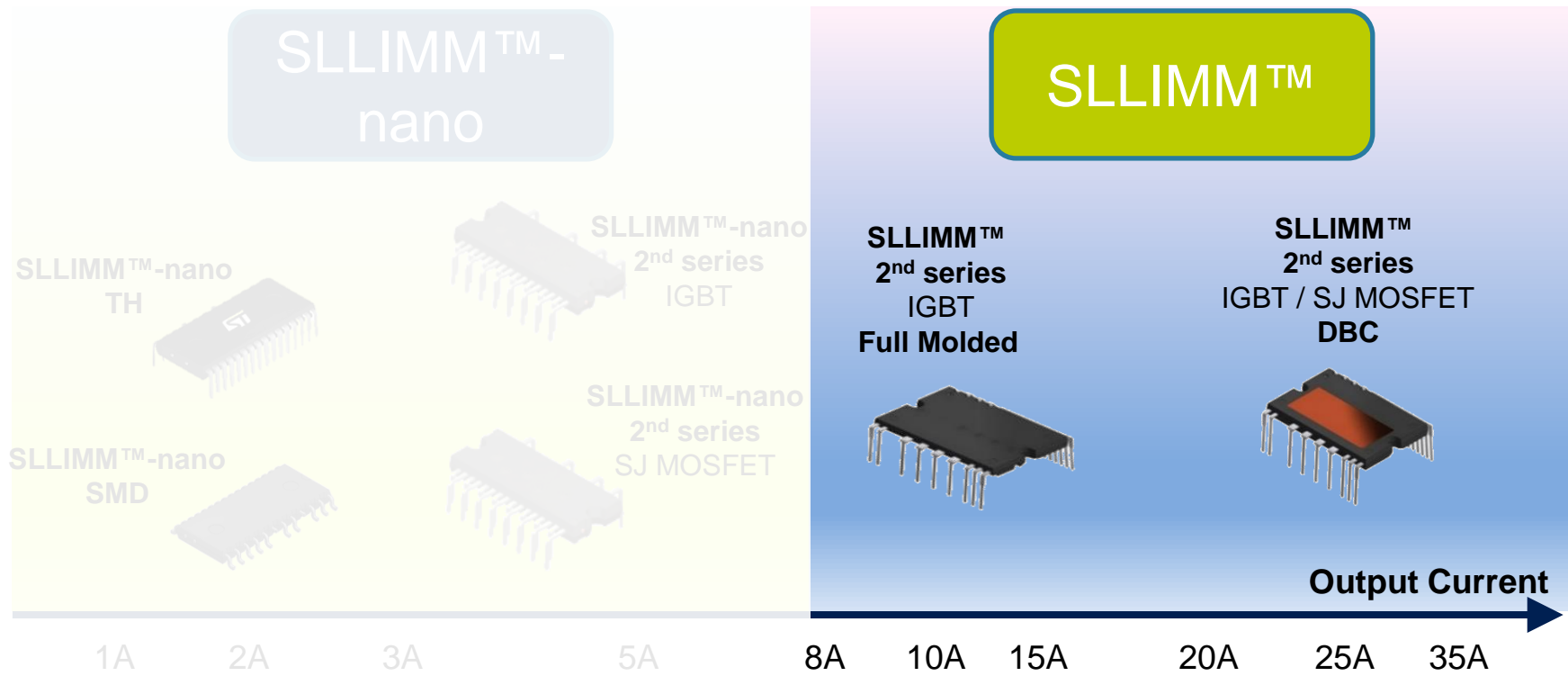
SLLIMM™-nano SMD		BV	I _{CN} 25°C	Max R _{DS(on)}	Max V _{CE(sat)}
IGBT based	STGIPNS3H60T-H	600V	3A	-	2,6
	STGIPNS3HD60-H				2,6
MOSFET based	STIPNS2M50(T)-H	500V	2A	1.7Ω	-
	STIPNS1M50T-H		1A	3.6Ω	
	STIPNS1M50SDT-H				

SLLIMM™-nano TH		BV	I _{CN} 25°C	Max R _{DS(on)}	Max V _{CE(sat)}
IGBT based	STGIPN3H60(A)(T)-(H)	600V	3A	-	2,6
	STGIPN3HD60-H				2,6
MOSFET based	STIPN2M50(T)-H(L)	500V	2A	1.7Ω	-
	STIPN1M50(T)-H(L)		1A	3.6Ω	

UL SLLIMM™-nano 2nd series		BV	I _{CN} 25°C	Max R _{DS(on)}	Max V _{CE(sat)}
IGBT based	STGIPQ3H60T-HZ/L(S)	600V	3A	-	2,6
	STGIPQ3HD60-HZ/L		3A		2,6
	STGIPQ5C60T-HZ/L(S)		5A		2,15
	STGIPQ8C60T-HZ		8A		2,4
SJ MOSFET based	STIPQ3M60T-HZ/L	600V	3A	1.6Ω	-
	STIPQ5M60T-HZ/L		5A	1.0Ω	



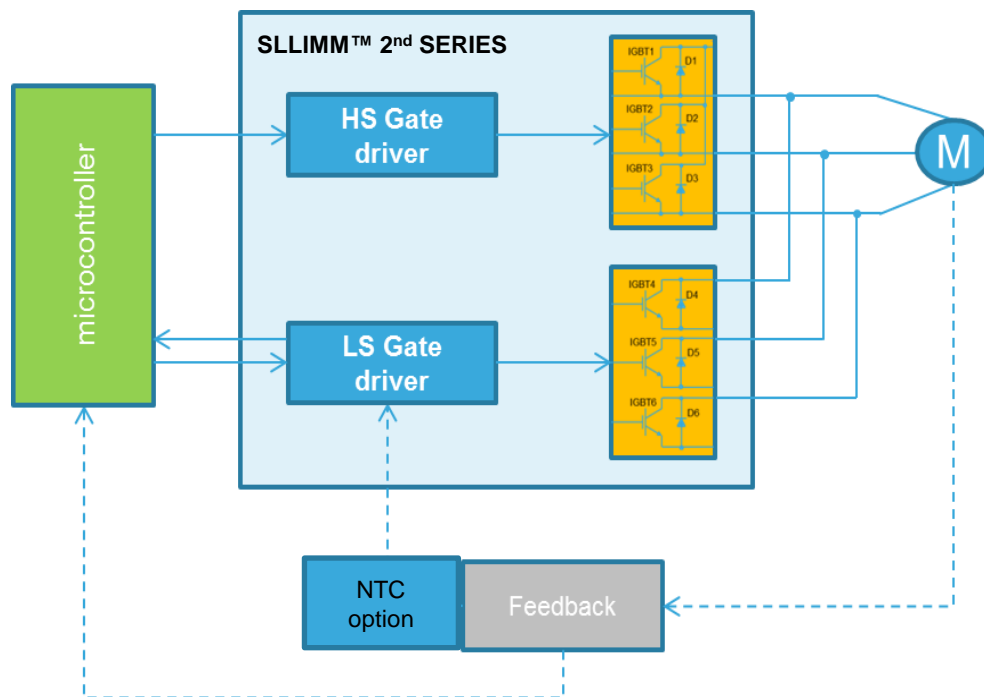
SLLIMM™ or SLLIMM™-nano ?



SLLIMM™ 2nd series overview

- **Two SDIP2x-26L IPM versions available**
Full Molded and the DBC (Direct Bonded Copper) both compatible each other.

- **Enhanced efficiency**
The best compromise between conduction and switching energy with an outstanding robustness and EMI behavior; optimized for operation up to 20 kHz for an application power range from 300W to 3kW



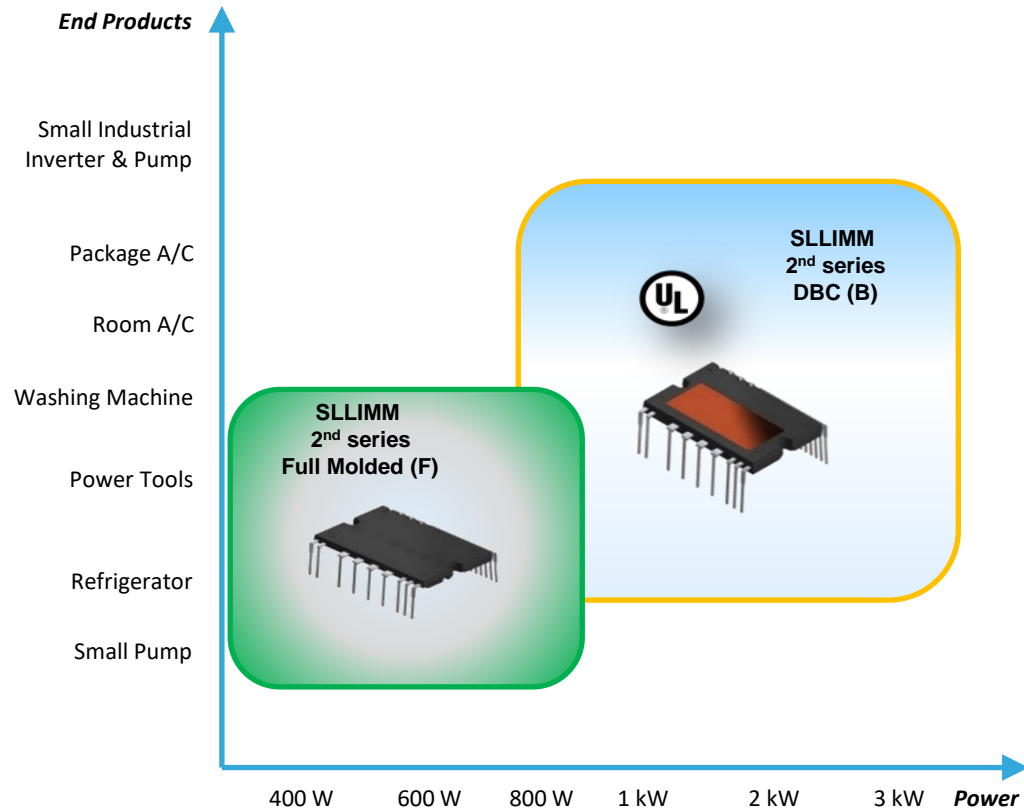
Features

- 600V, from 8A to 35A DC rating at 25°C
- Low VCE(sat)
- Optimized Driver and Silicon for low EMI
- Lowest R_{th} value on the market for the DBC package versions
- Internal **bootstrap diode**
- **175°C** of maximum operating junction Temperature
- Separate open emitter outputs
- **NTC** on board
- Integrated **temperature sensor** on Low Side driver
- **Comparator** for fault protection
- Shutdown input/fault output
- Isolation rating of 1500 Vrms/min.



SLLIMM 2nd series

Product Plan



SLLIMM 2 nd series Full Molded (F)		BV	I _{CN} 25°C	Max V _{CE(sat)}
IGBT based	STGIF5CH60TS-L	600V	8A	1,95
	STGIF7CH60TS-L		10A	1,95
	STGIF10CH60TS-L		15A	1,95

SLLIMM 2 nd series DBC (B)		BV	I _{CN} 25°C	Max V _{CE(sat)}
IGBT based	STGIB8CH60TS-L	600V	12A	2,18
	STGIB10CH60TS-L		15A	1,95
	STGIB15CH60TS-L		20A	2,1
	STGIB20M60TS-L		25A	2,0
	STGIB30M60TS-L		35A	2,0

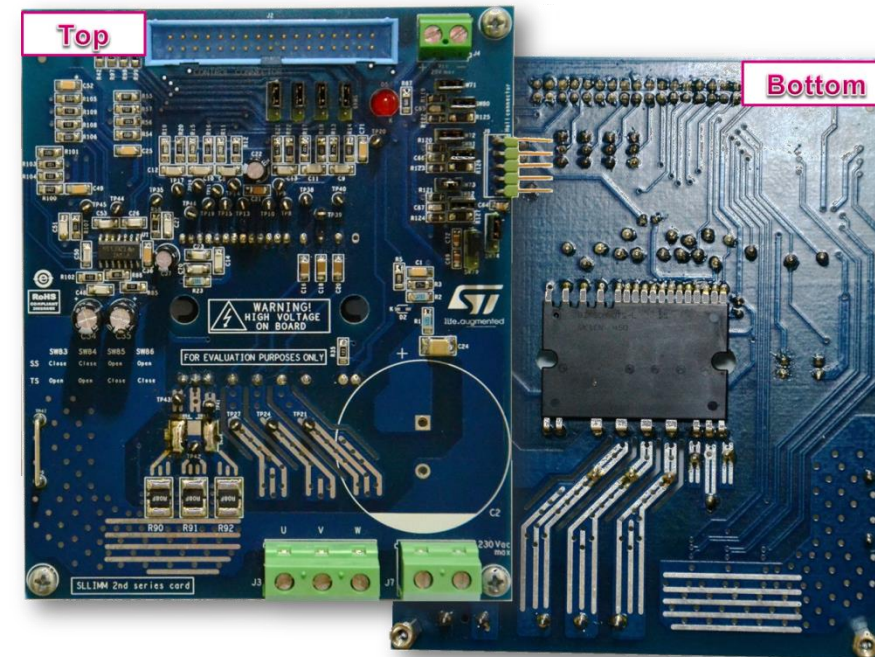


Evaluation Boards for SLLIMM™ 2nd Series

- Fully tested 3-phase inverter bridge
- Different Current Ratings are available for easy evaluation.
- Compatible with ST Motor Control library for easy Firmware development

Features and architecture

- Input bus voltage: $125 \div 400 V_{DC}$
- Nominal power: from 300 W to 3 kW
- Single or three shunt configuration selectable
- Hardware overcurrent protection
- Hall/Encoder feature

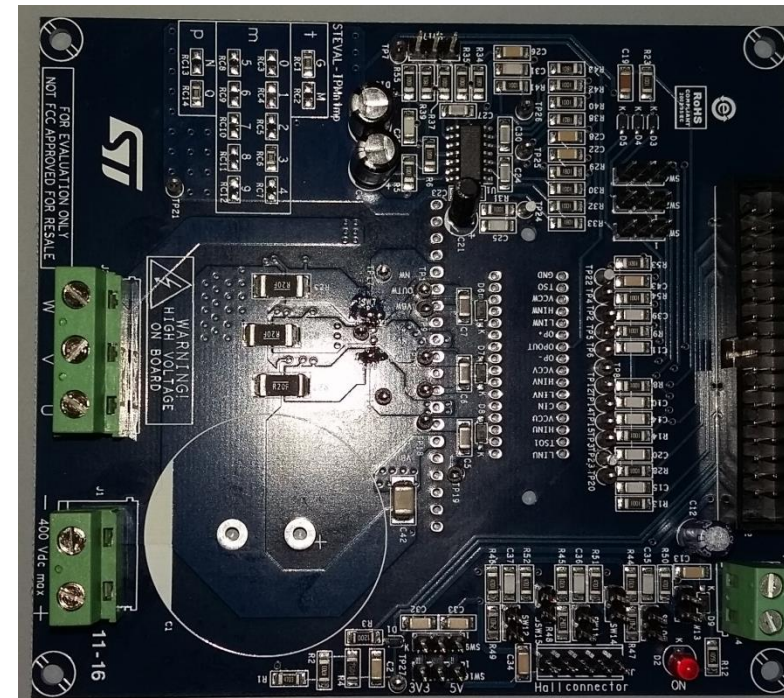


Evaluation Boards for SLLIMM™-nano

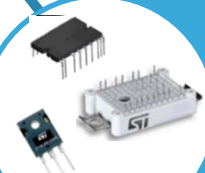
- Fully tested 3-phase inverter bridge
- Different Current Ratings are available for easy evaluation
- Compatible with ST Motor Control library for easy Firmware development

Features and architecture

- Input bus voltage: $125 \div 400 V_{DC}$
- Nominal power: from 20 W to 600 W
- Single or three shunt configuration selectable
- Hardware overcurrent protection
- Hall/Encoder feature




The dynamic electro-thermal simulation software dedicated to power devices by ST




Developed for:

- SLLIMM, ACEPACK, Discrete*
- Several Applications
- Windows, MAC OS X*, Android* and iOS*



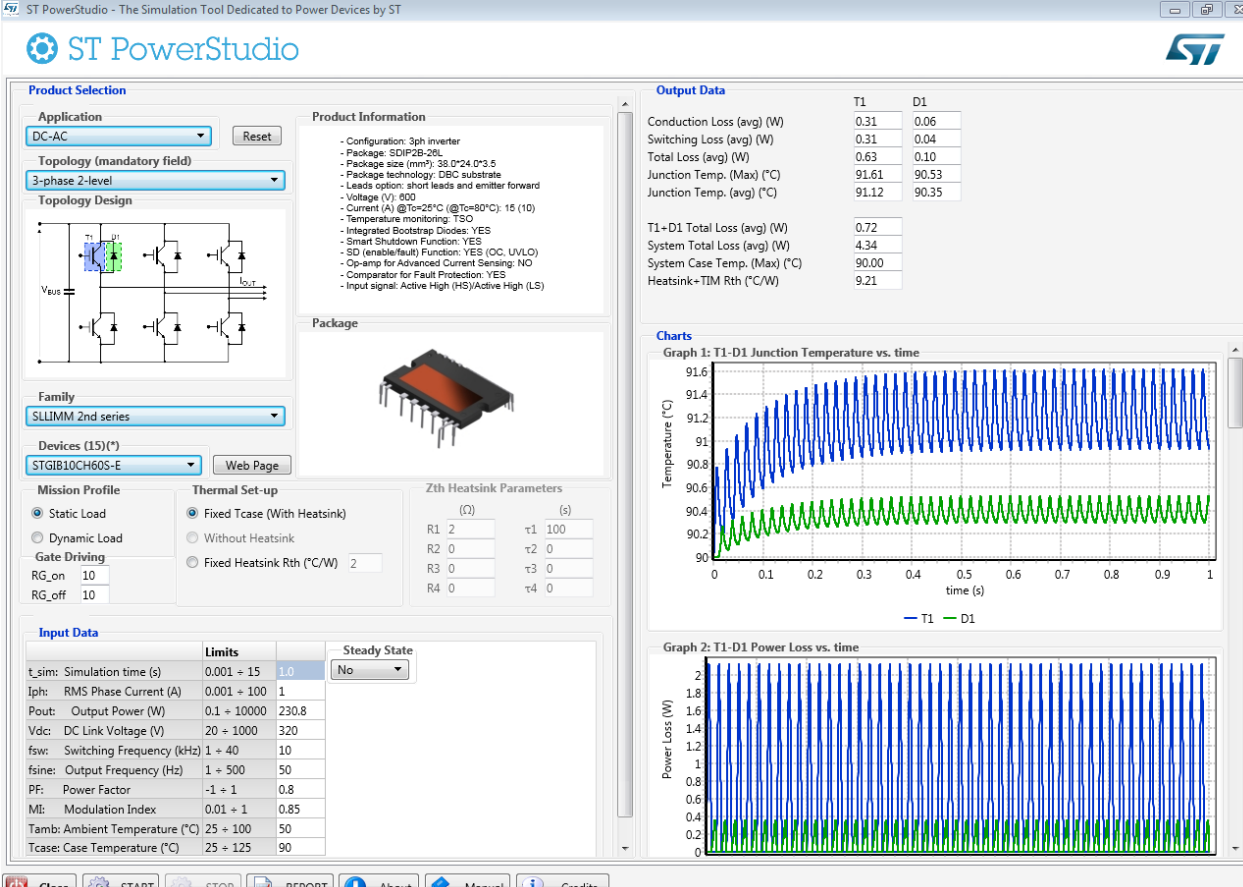
Powerful and flexible:

- Dynamic load sim. (up to 10 steps)
- Long mission profile duration of hours
- Several thermal setup



Connectivity:

- Multilanguage (English, Chinese*, Japan*, ...)
- Quick link with st.com documents
- PDF Output Report



Product Selection

Application: DC-AC

Topology (mandatory field): 3-phase 2-level

Product Information:

- Configuration: 3ph inverter
- Package: SLLIMM2B-20L
- Package size (mm²): 38.0*24.0*3.5
- Package technology: DBC substrate
- Leads option: short leads and emitter forward
- Voltage (V): 600
- Current (A) @Tc=25°C (@Tc=80°C): 15 (10)
- Temperature monitoring: TSO
- Integrated Bootstrap Diodes: YES
- Smart Shutdown Function: YES
- SD (enable/fault) Function: YES (OC_UVLO)
- Op-amp for Advanced Current Sensing: NO
- Comparator for Fault Protection: YES
- Input signal: Active High (HS)/Active High (LS)

Family: SLLIMM 2nd series

Devices (15): STGIB10CH60S-E

Mission Profile: Static Load

Thermal Set-up: Fixed Tcase (With Heatsink)

Zth Heatsink Parameters:

	(Ω)	(s)
R1	2	t1 100
R2	0	t2 0
R3	0	t3 0
R4	0	t4 0

Input Data:

	Limits	Steady State
t _{sim} : Simulation time (s)	0.001 + 15	1.0
I _{ph} : RMS Phase Current (A)	0.001 + 100	1
P _{out} : Output Power (W)	0.1 + 10000	230.8
V _{dc} : DC Link Voltage (V)	20 + 1000	320
f _{sw} : Switching Frequency (kHz)	1 + 40	10
f _{sine} : Output Frequency (Hz)	1 + 500	50
PF: Power Factor	-1 + 1	0.8
MI: Modulation Index	0.01 + 1	0.85
T _{amb} : Ambient Temperature (°C)	25 + 100	50
T _{case} : Case Temperature (°C)	25 + 125	90

Output Data:

	T1	D1
Conduction Loss (avg) (W)	0.31	0.06
Switching Loss (avg) (W)	0.31	0.04
Total Loss (avg) (W)	0.63	0.10
Junction Temp. (Max) (°C)	91.61	90.53
Junction Temp. (avg) (°C)	91.12	90.35
T1-D1 Total Loss (avg) (W)	0.72	
System Total Loss (avg) (W)	4.34	
System Case Temp. (Max) (°C)	90.00	
Heatsink-TIM Rth (°C/W)	9.21	

Charts:

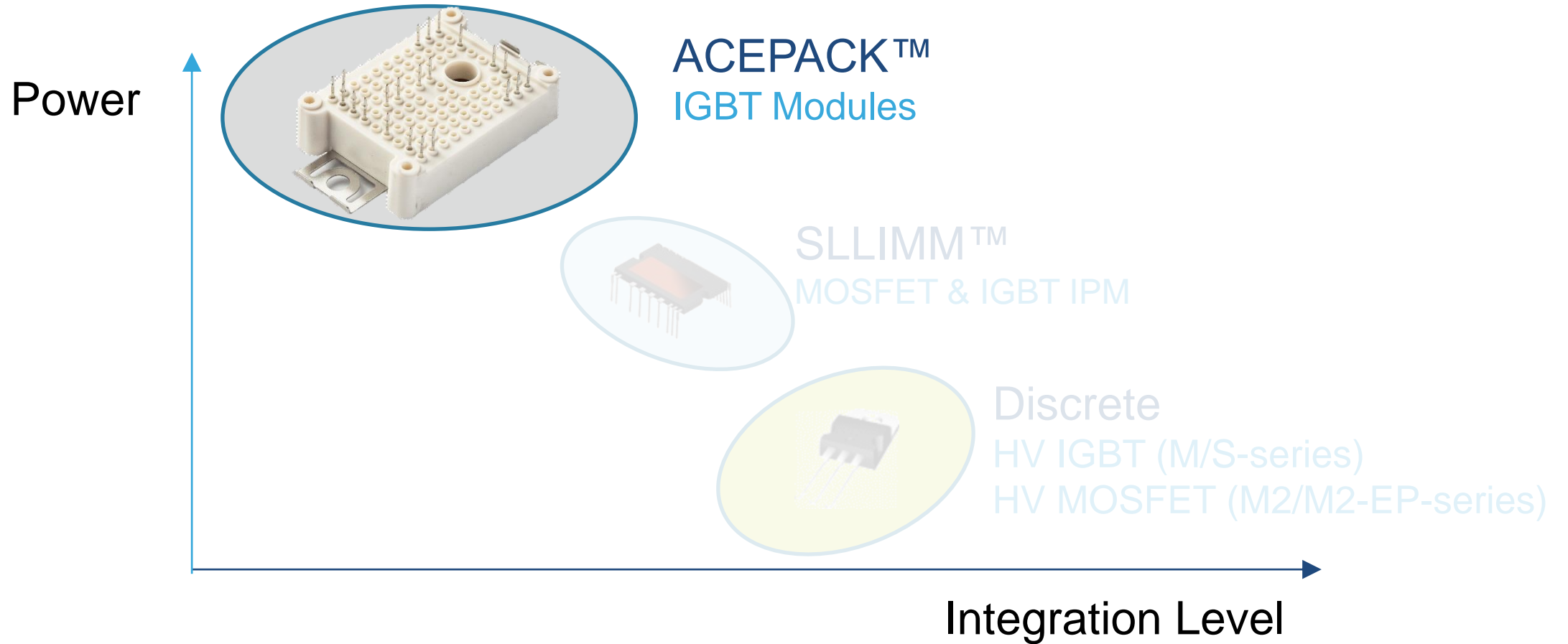
Graph 1: T1-D1 Junction Temperature vs. time

Graph 2: T1-D1 Power Loss vs. time



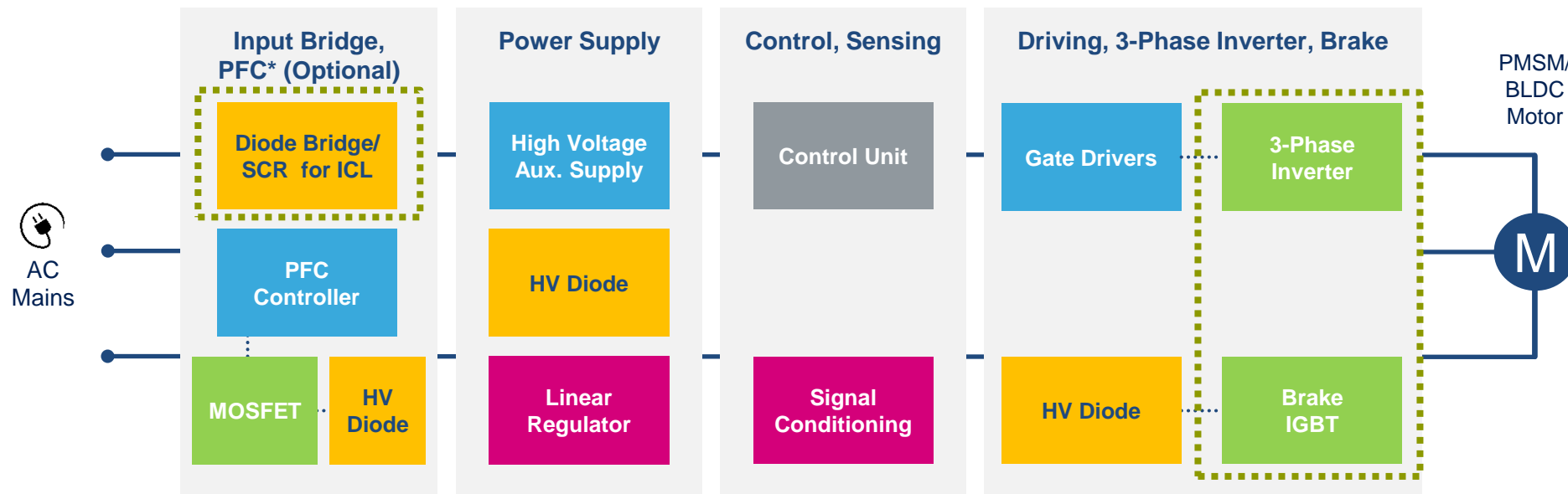
High-Voltage Motor Control

Three Approaches



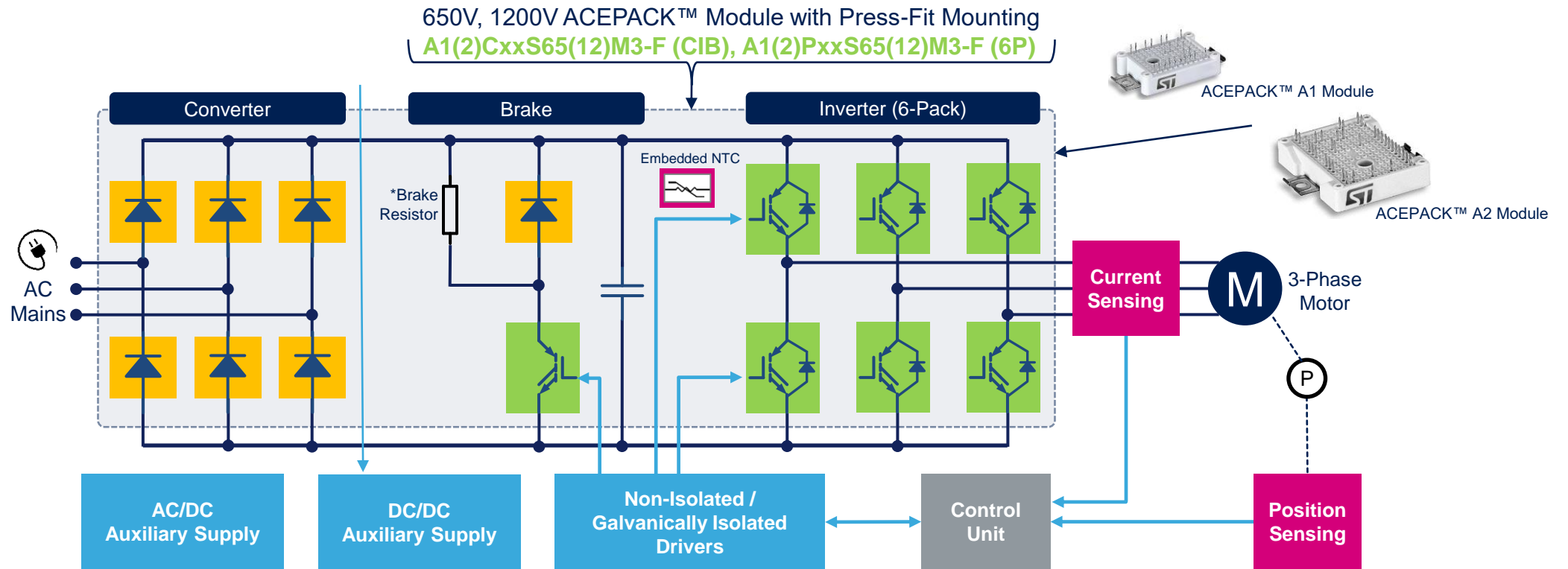
Application Block Diagram

Module approach – ACEPACK™



Application Block Diagram

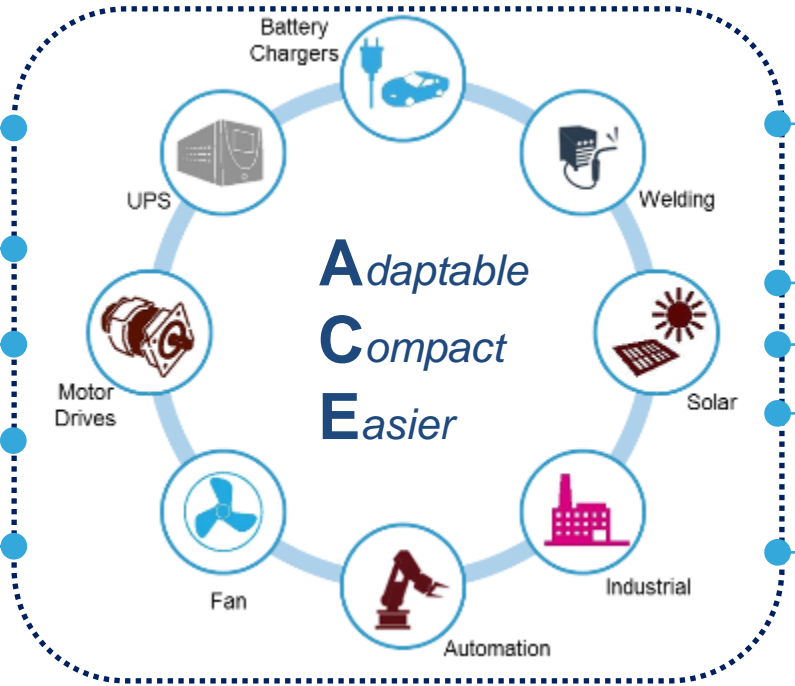
3Ph-Inverter with PIM/CIB- Module – ACEPACK™



* Brake resistor and DC link capacitor are not part of ACEPACK™ Module



- Press FIT and Solder Pins options, configuration flexibility
- Up to 1200V breakdown voltage
- Integrated screw clamps
- All power switches in a module including NTC
- Several current ratings available

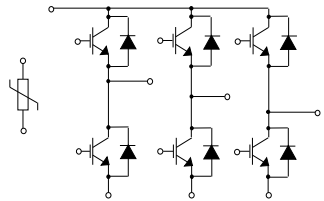


- Several configurations (CIB, 6pack, ..) available and low stray inductance
- High reliability and robustness, miniaturized power side board occupation
- Simplified and stable screwing
- Compact design and cost effective system approach
- Very high power density

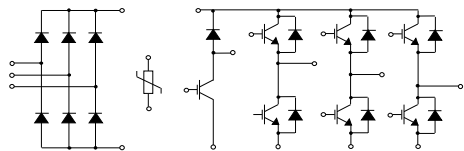


ACEPACK™ Module for Motor Control

Standard products available (Solder and Press-Fit pins)



Six-Pack + NTC



CIB + NTC



ACEPACK™ 1

Part Number*	Topology	BV _{CES}	I _C rating
A1P25S12M3/-F	Six-Pack	1200V	25A
A1P35S12M3/-F			35A
A1C15S12M3/-F	Converter Inverter Brake	1200V	15A
A1P50S65M2/-F	Six-Pack	650V	50A



ACEPACK™ 2

Part Number*	Topology	BV _{CES}	I _C rating
A2C25S12M3/-F	Converter Inverter Brake	1200V	25A
A2C35S12M3/-F			35A
A2P75S12M3/-F	Six-Pack	1200V	75A
A2C50S65M2/-F	Converter Inverter Brake	650V	50A



Evaluation Board for Acepack™

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STEVAL-CTM002V1 board enables quick ACEPACK™ evaluation



Complete board ready to test with AC motor

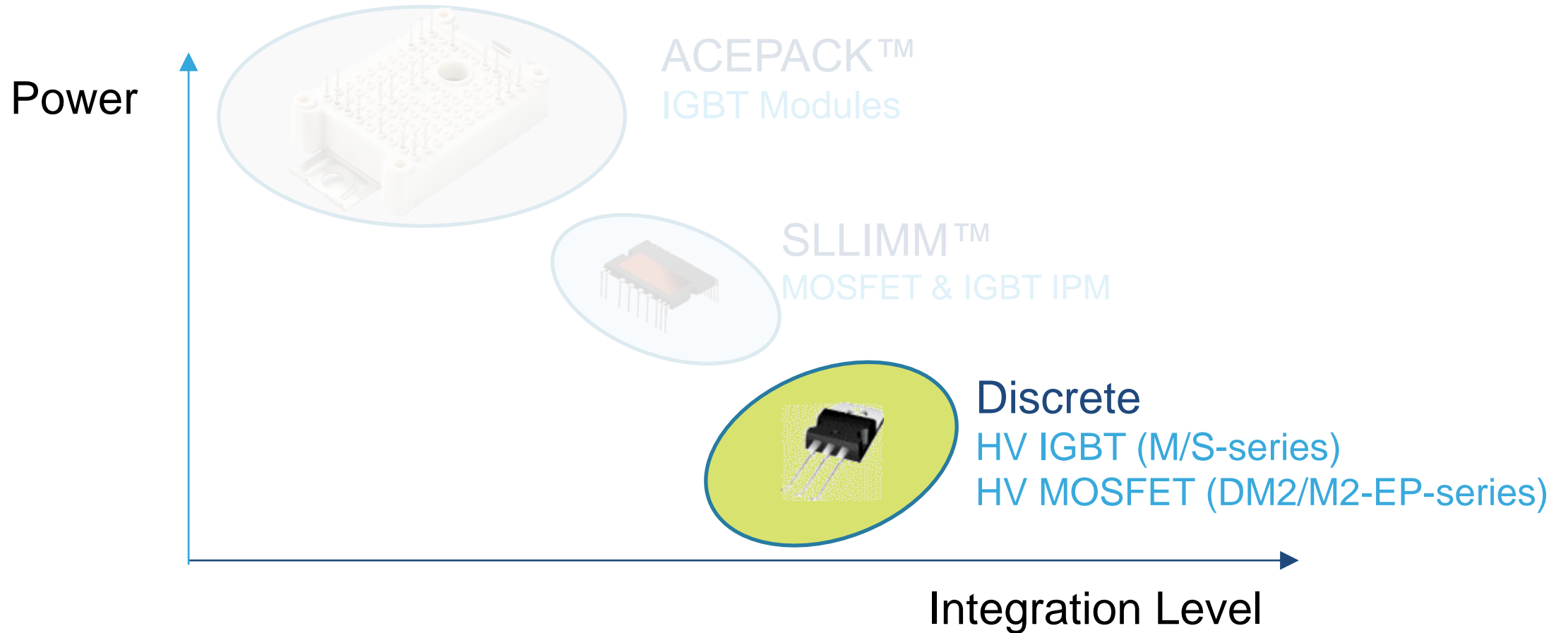
3-phase AC-Input and AC-Output

Overvoltage and Overload protection

Full compatibility with MC STM32 ecosystem

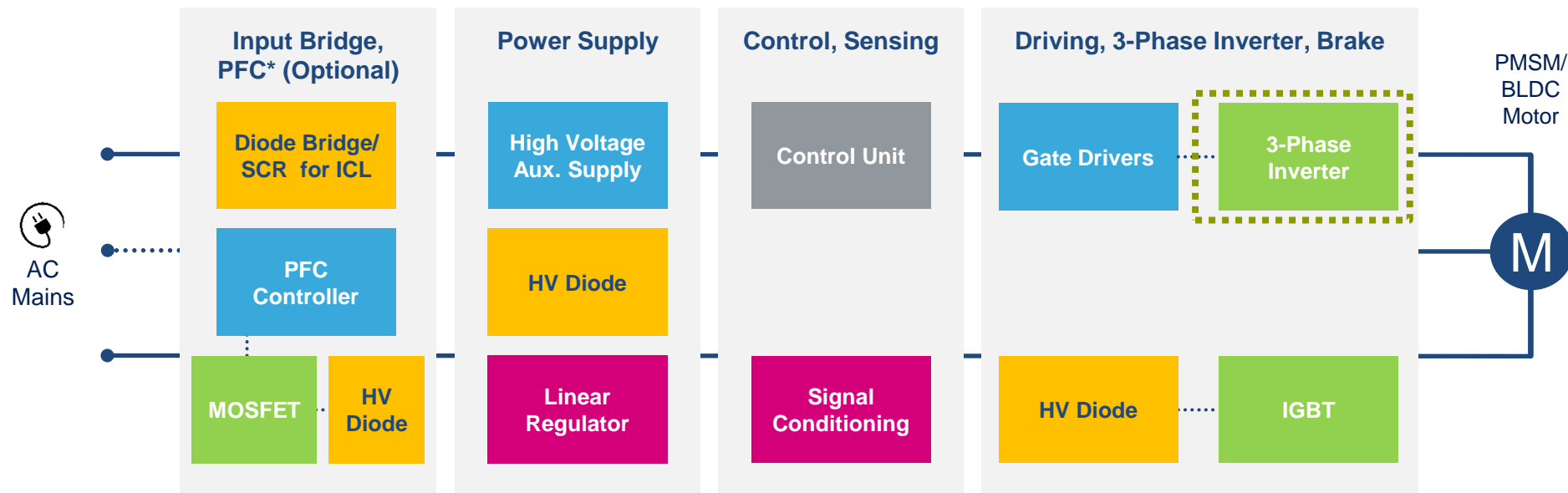
RS232 and CAN connection

High-Voltage Motor Control Three Approaches



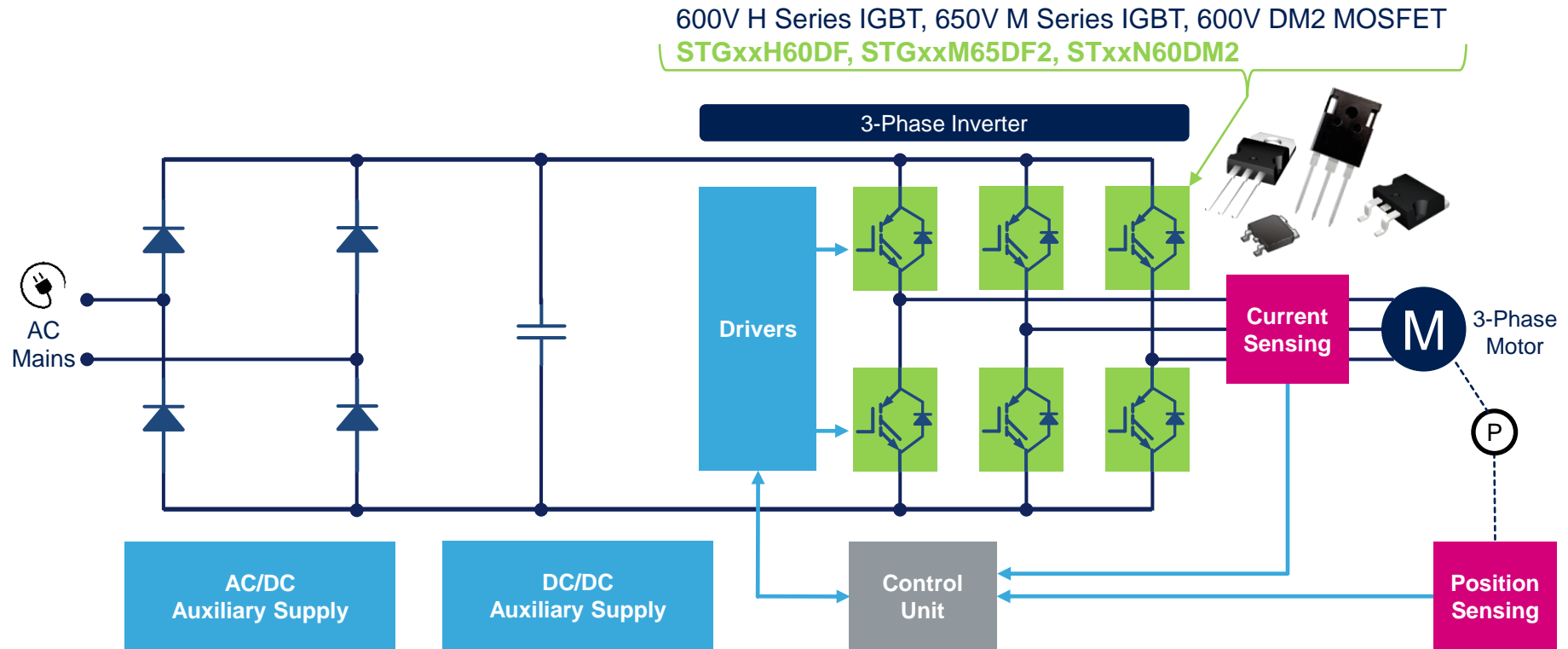
High-Voltage Motor Control

3ph-Inverter - Discrete approach



Application Block Diagram

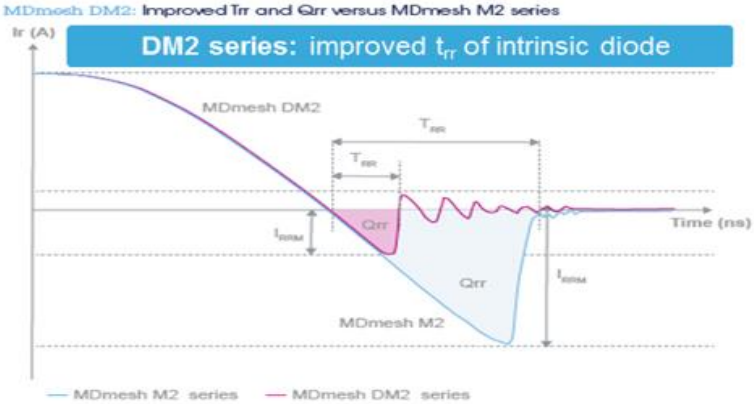
3-Phase Inverter with Discrete



Discrete MOSFET

MDmesh™ DM2 Series

The FAST DIODE solution for the most demanding high efficiency converters



Improved diode recovery performance

- Product Portfolio: 600V, 650V , Automotive grade series
- Ideal for Full-bridge and Half-bridge topologies
Excellent Fast diode performances for Power losses reduction
- Robust & Reliable Design
High immunity to dv/dt 40 V/ns reducing MOSFET failure even when exposed to large voltage transients

MDmesh DM2 MOSFETs
Fast-recovery diode series



Automotive
EV, HEV, Chargers



Renewable
Energy storage systems DC/DC
DC/AC inverters



SMPS



Motor Control
HA, small pumps



PowerFLAT 8x8 HV



D2PAK

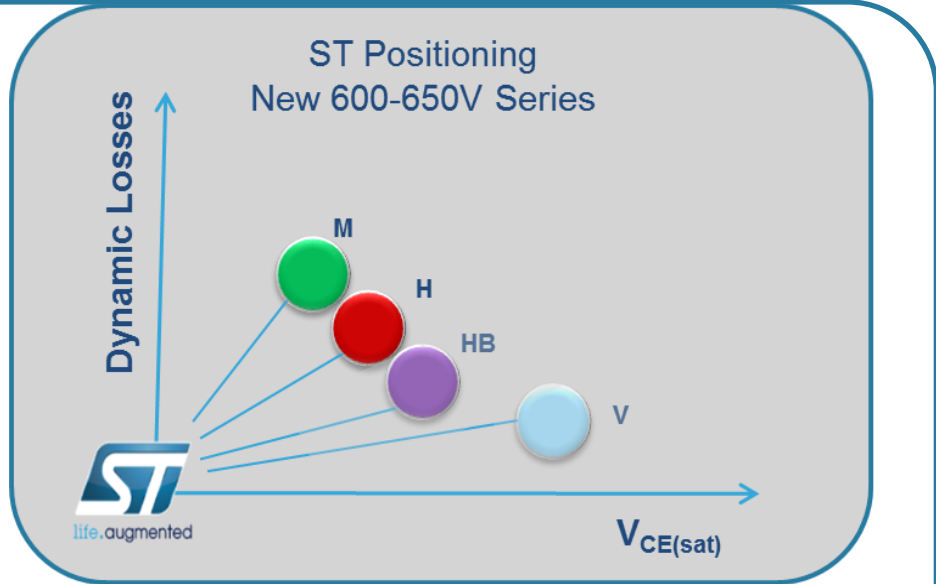


TO-247



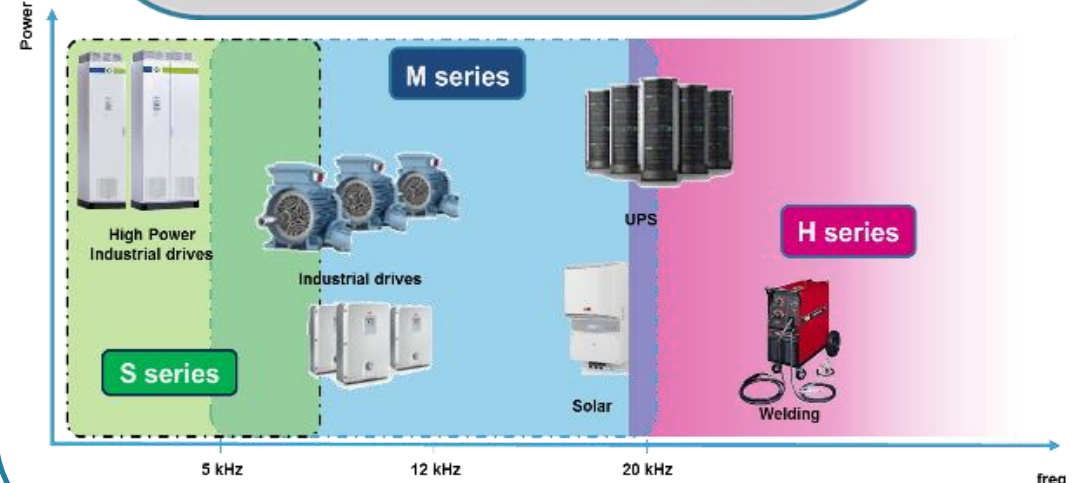
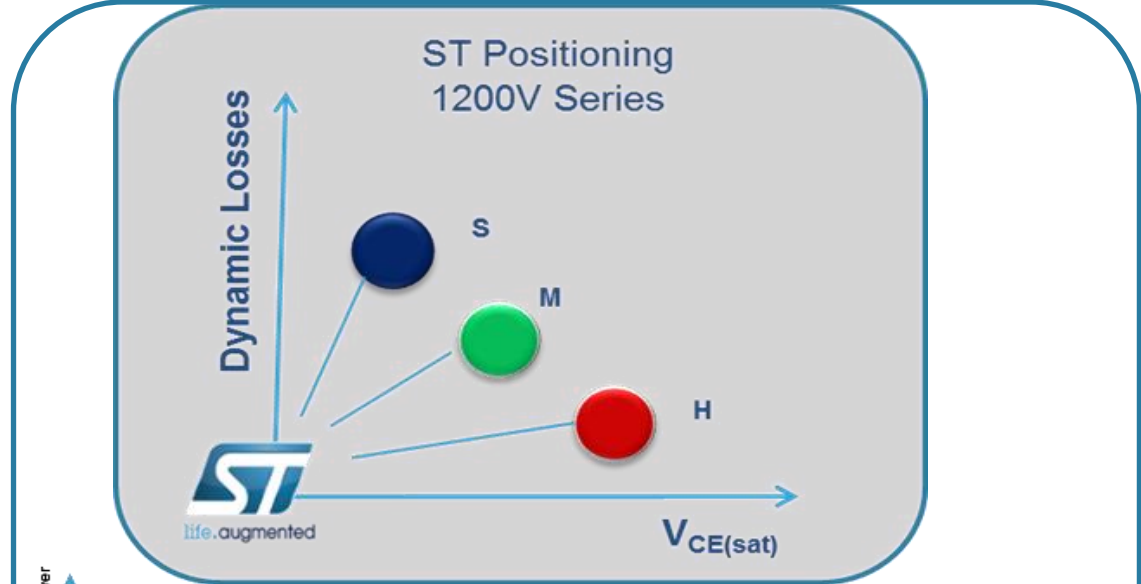
600/650V and 1200V TFS IGBTs

Perfect for Motor Control



M series

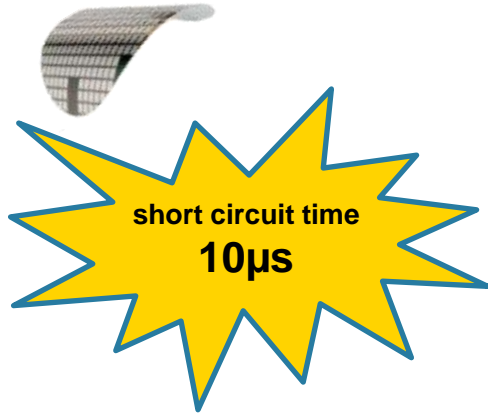
S series



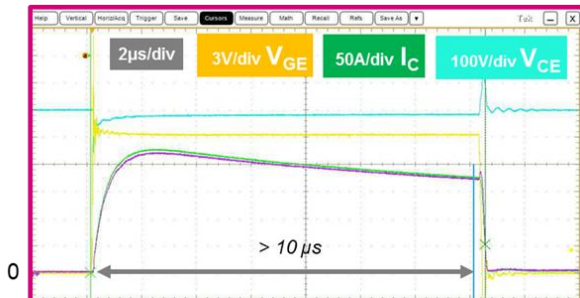
Discrete IGBTs

M and S series

30



@ $V_{CC}=600V$; $V_{GE}=15V$; $T_{j-start} = 150^{\circ}C$



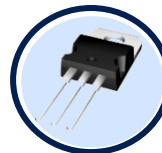
Main Features and benefits

- **175°C** of max operating junction temperature (T_J)
- **Min 10µs** of short circuit rating at start T_J of 150°C
- **Soft switching** waveforms for excellent EMI behavior
- Optimized diode for target applications meaning **low diode losses and fast recovery time keeping the right softness**
- Positive $V_{CE(sat)}$ temperature coefficient meaning **no thermal runaway and easier paralleling**
- M and S series are tailored to **improve efficiency of targeted applications in the whole range of switching frequency up to 20kHz**

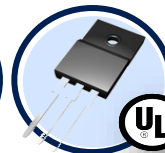
DPAK/D²PAK



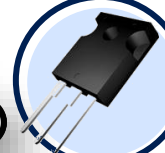
TO-220



TO-220FP



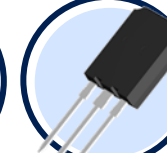
TO-247



TO-247
long leads



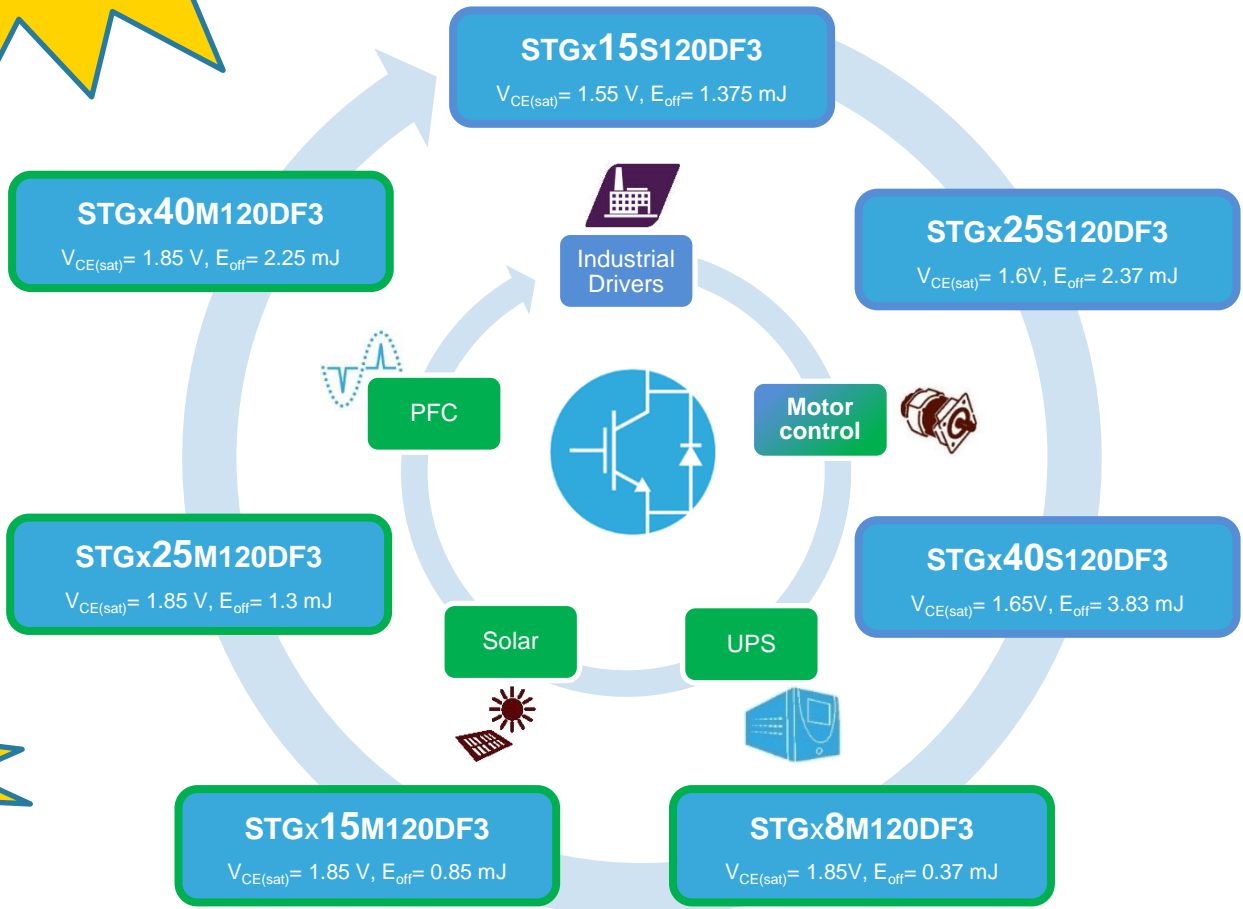
Max247
long leads



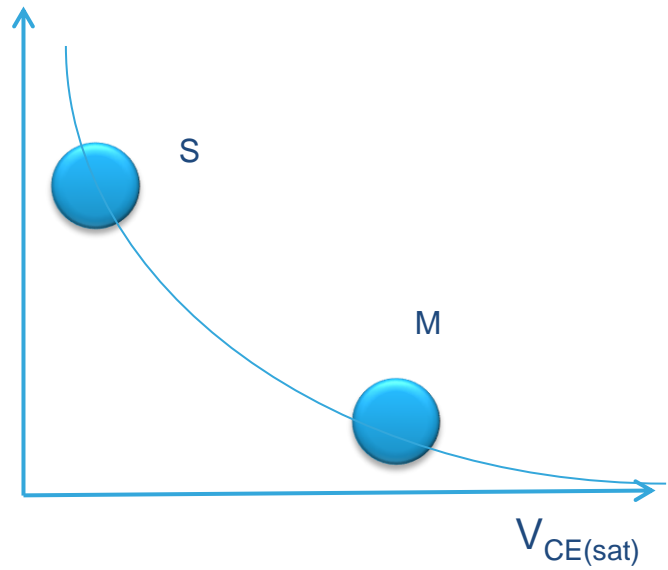
1200V S/M Series IGBTs

S series: Up to 8kHz
M series: 2 - 20kHz

MAX
 $T_j=175^{\circ}\text{C}$



Best Trade-off Static-Dynamic



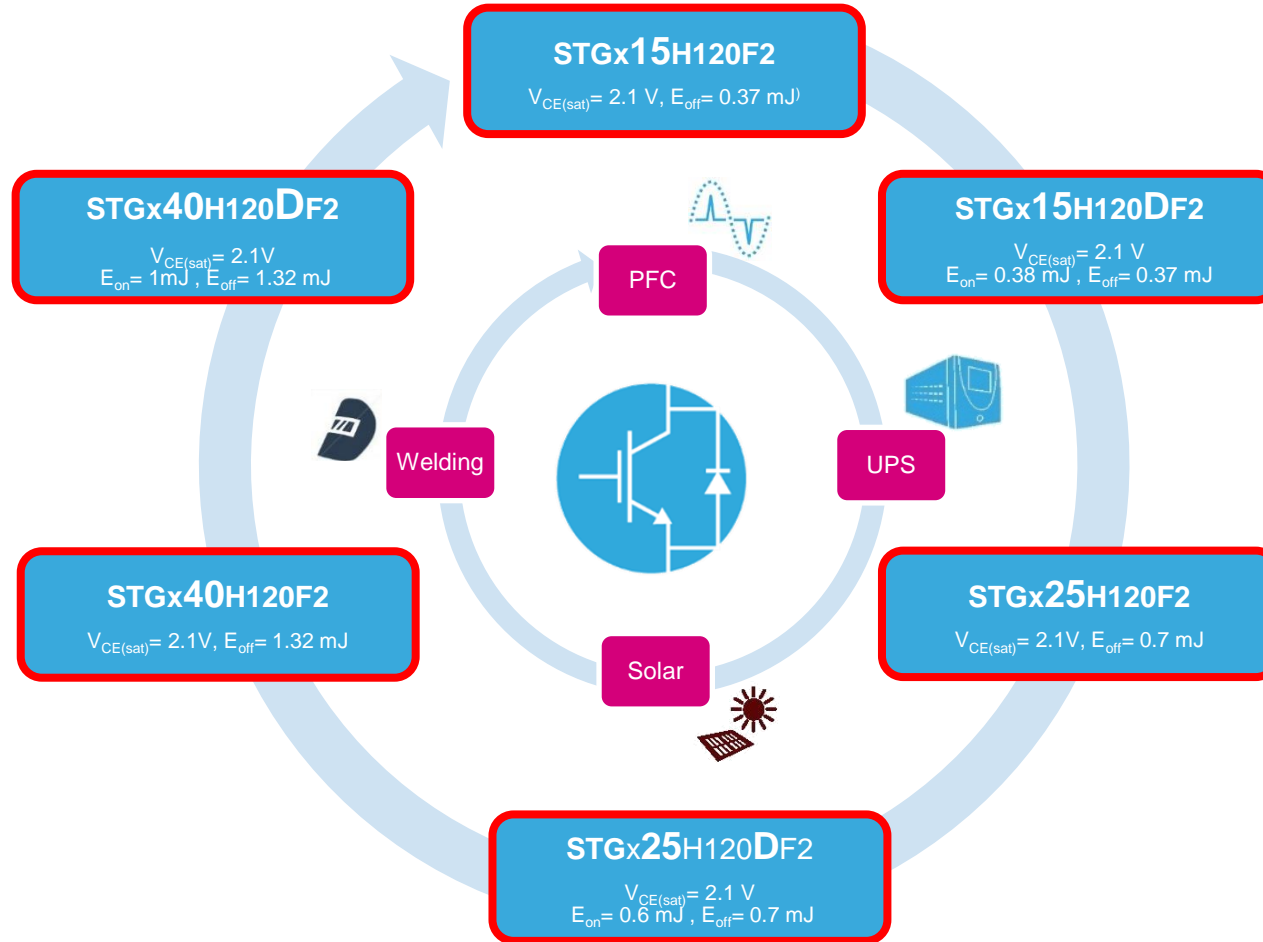
short circuit
time
10 μs



1200V H Series IGBTs

from
20 to 100 kHz

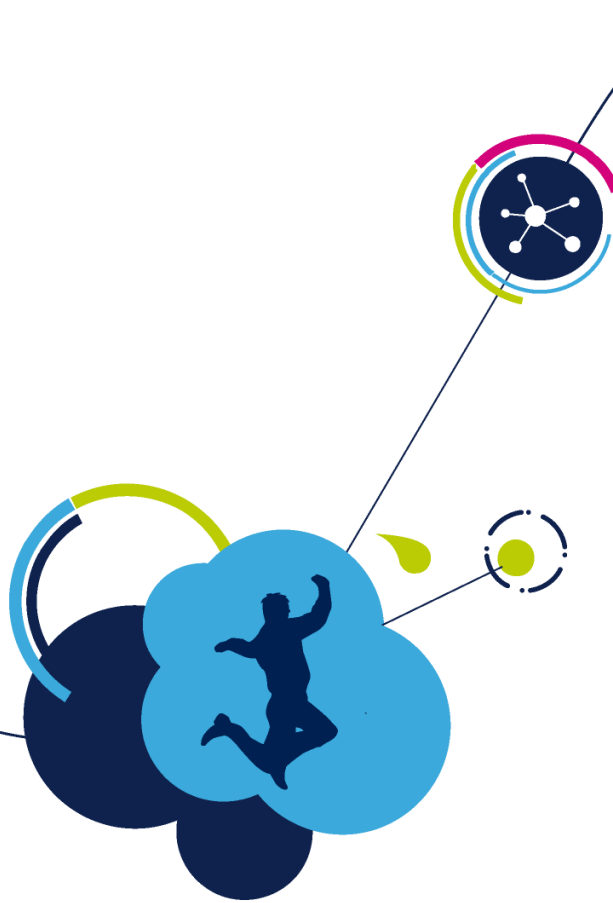
Very fast recovery
diode option



MAX
 $T_J = 175^\circ\text{C}$

short circuit
time³⁾
5 μs

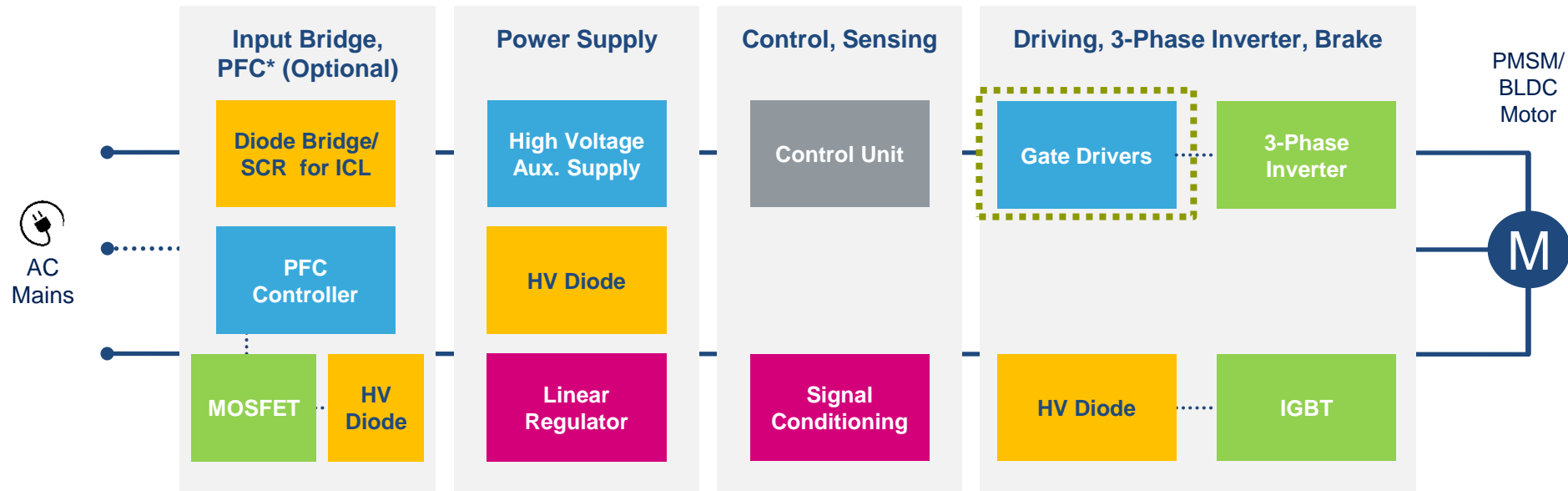




Gate Drivers in High-Voltage Motor Control

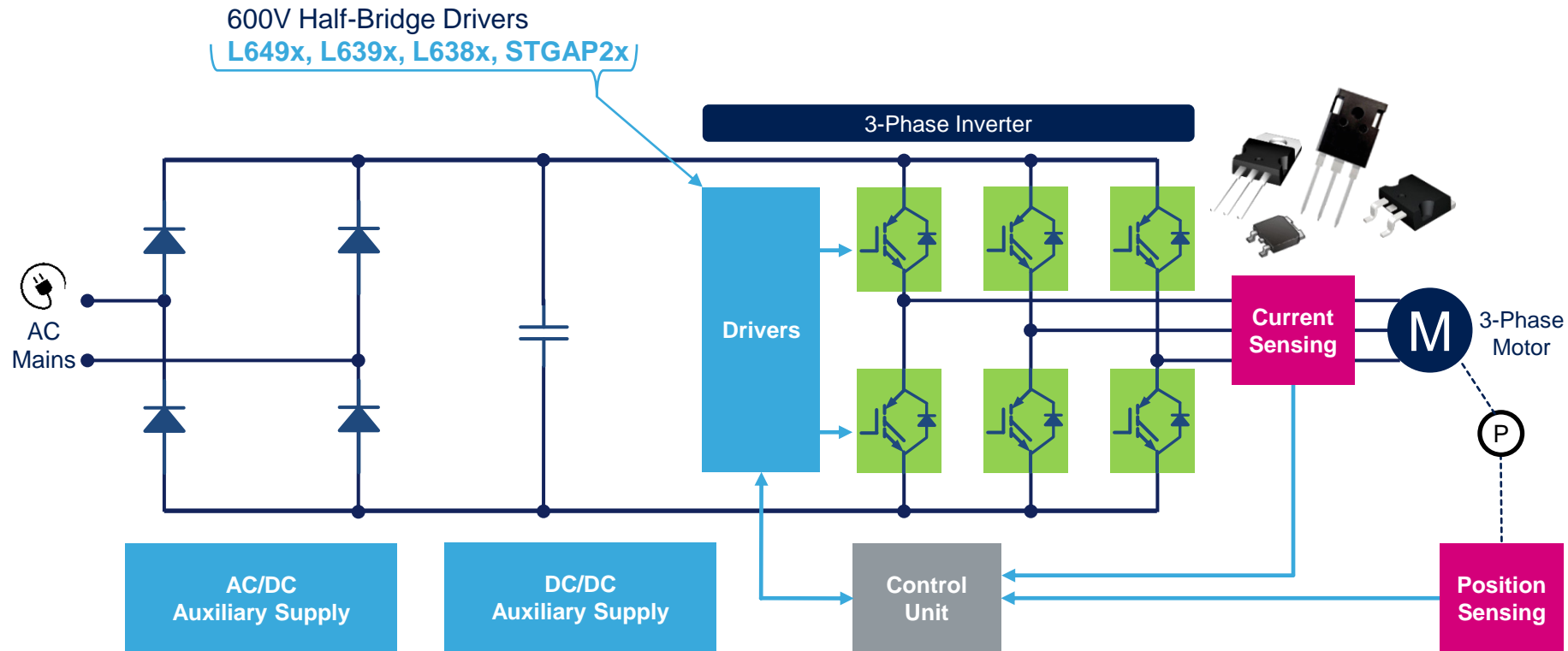
High-Voltage Motor Control

3ph-Inverter – Gate Drivers



Application Block Diagram

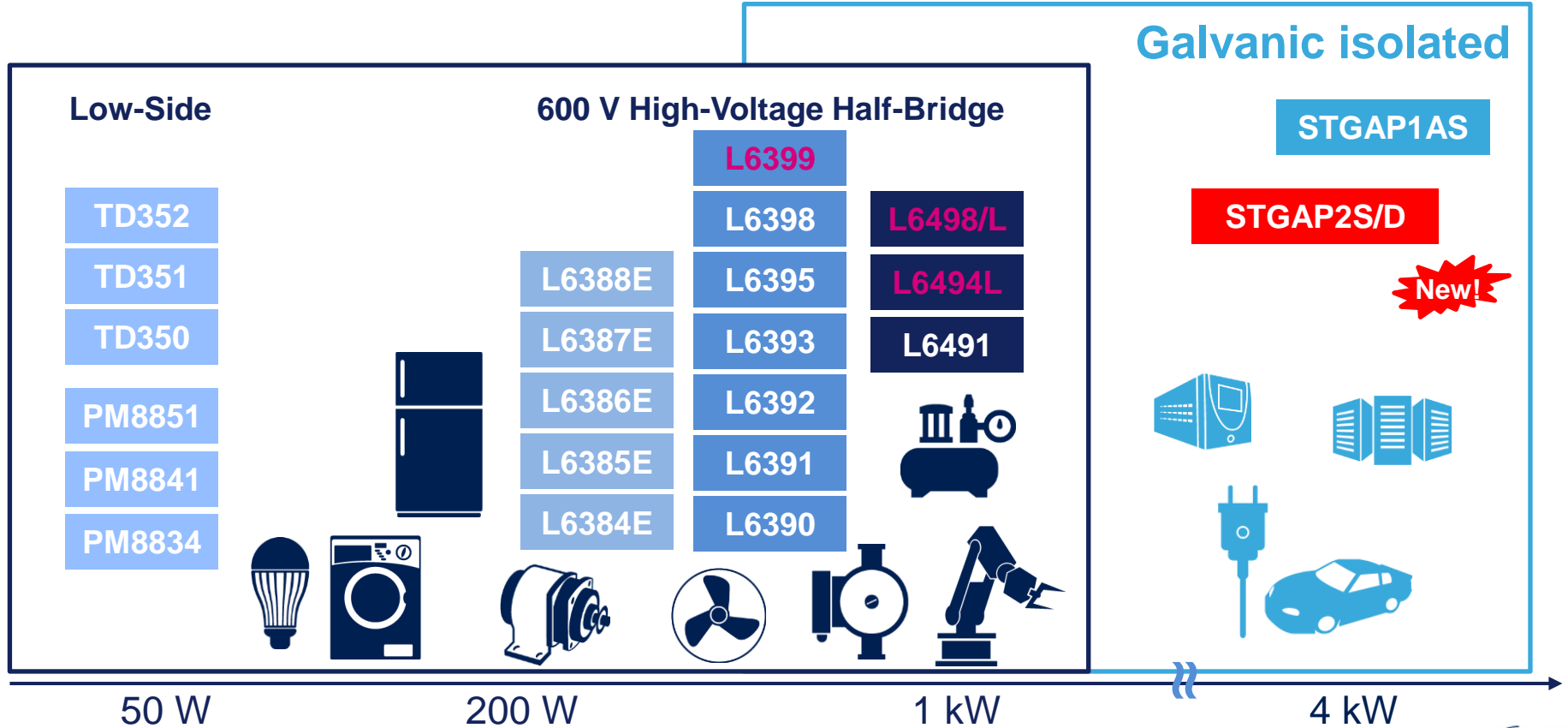
3-Phase Inverter – Gate Drivers





Gate Drivers- Portfolio Overview

- Electric/ Hybrid vehicles
- 1200 V inverters
- Server, UPS
- Compressors
- Factory automation
- White goods
- Solar
- E-bikes





L638xE & L639x Drivers Overview

L6384E

- **Single Input**
- Interlocking & Programmable DT
- **Shutdown Input**

L6385E

- High & Low Side Inputs
- UVLO Vcc / Vboot
- **Able to drive asymmetrical loads**

L6386E
L6386AD

- High/Low Side & Shutdown Inputs
- **Uncommitted Comparator integrated**
- UVLO Vcc / Vboot
- SO/DIP-14 packages

L6387E
A6387

- High & Low Side Inputs
- Interlocking
- **AEC-Q100 qualified version**
- **Leader in Automotive LV HID**

L6388E

- High/Low Side Inputs, 3.3V compatible
- Interlocking & DT protections
- UVLO Vcc / Vboot
- **#1 WW Best Seller**

- High/Low Side & Shutdown Inputs
- **Comparator + SmartSD integrated**
- **OpAmp integrated**
- Interlocking & Programmable DT
- UVLO Vcc / Vboot

L6390

- High/Low Side & Shutdown Inputs
- **Comparator + SmartSD integrated**
- Interlocking & Programmable DT
- UVLO Vcc / Vboot

L6391

- High/Low Side & Shutdown Inputs
- **OpAmp integrated**
- Interlocking & Programmable DT
- UVLO Vcc / Vboot

L6392

- **Phase, Brake & Shutdown Inputs**
- Uncommitted Comparator integrated
- Interlocking & Programmable DT
- UVLO Vcc / Vboot

L6393

- High/Low Side Inputs
- **Able to drive asymmetrical loads**
- UVLO Vcc / Vboot
- SO/DIP-8 packages

L6395

- High/Low Side Inputs
- Interlocking & DT protections
- UVLO Vcc / Vboot
- SO/DIP-8 packages

L6398

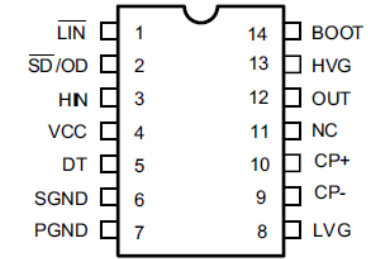




L649x High-Current Drivers Overview

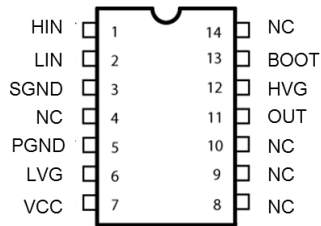
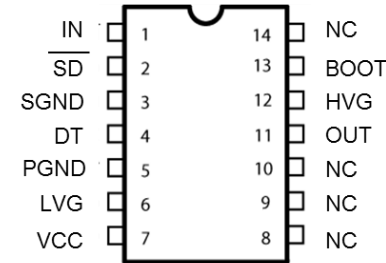
- High/Low Side & Shutdown Inputs
- **Comparator + SmartSD integrated**
- Interlocking & Programmable DT
- UVLO Vcc / Vboot
- **4A sink/source**

L6491D



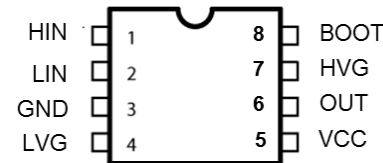
- Single & Shutdown Input
- Interlocking & Programmable DT
- UVLO Vcc / Vboot
- **2,5A sink/ 2A source**

L6494L

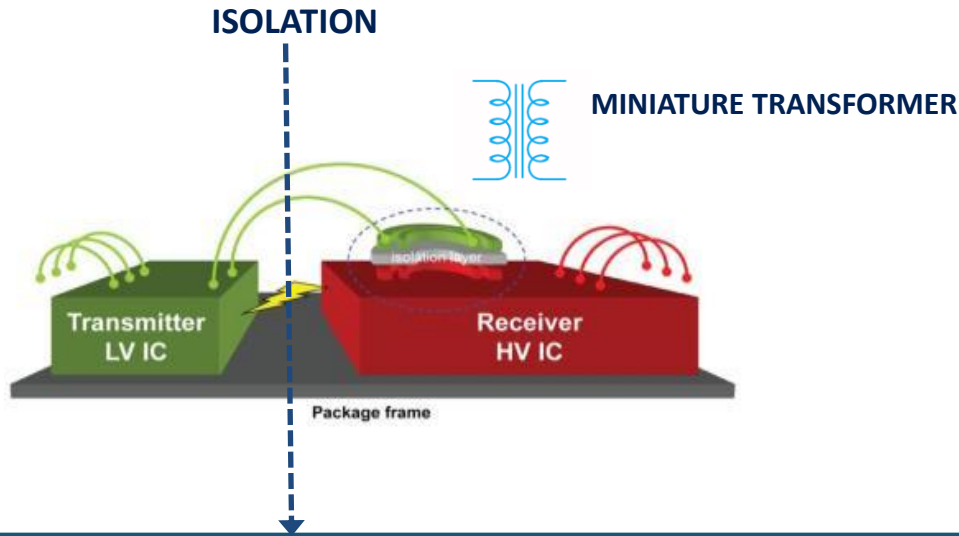


- High/Low Side Inputs
- Interlocking & NO deadtime
- UVLO Vcc / Vboot
- **2,5A sink/2A source**

L6498
L6498L

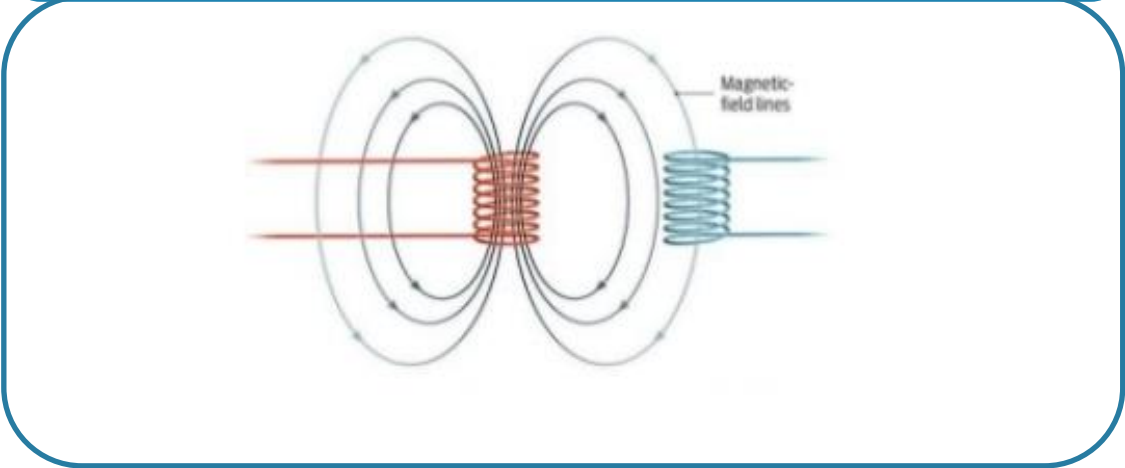


Outstanding robustness, noise immunity and design flexibility



Galvanic separation between input and control stage from high current gate driving and diagnostics

Inductive coupling transfers the logic signal across the isolation





STGAP2S/STGAP2D

40

High Voltage 1700 V, 4A gate drivers



KEY APPLICATIONS

- Motor driver
- Factory automation
- Industrial drives and Fans
- DC/DC converters
- Welding



Key benefits & features

High performance

- Up to 1700 V high voltage rail
- Best In Class for propagation delay 80ns
- 4A sink / source driver current capability
- ± 100 V/ns transient immunity
- 3.3 to 5 V TTL/CMOS inputs with hysteresis

Value for Customer

- Best in Class for fast speed
- Reduced BOM thanks to embedded Isolation and Miller Clamp feature

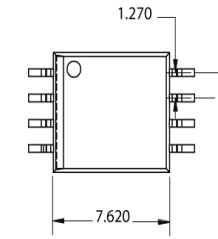
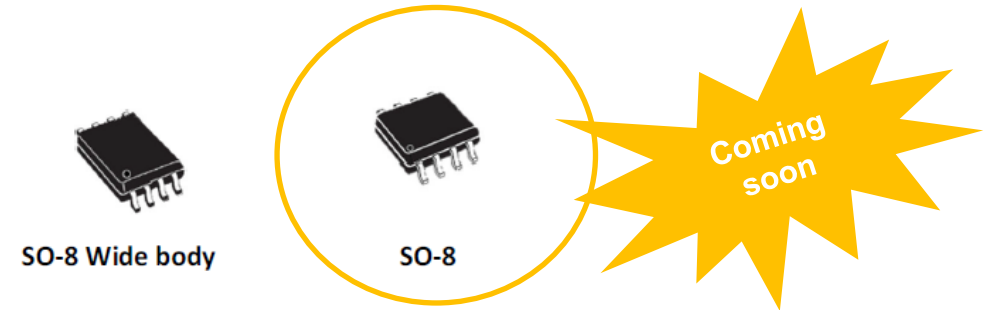
Minimum footprint and lightweight

- Compact and simplified layout SO8 package

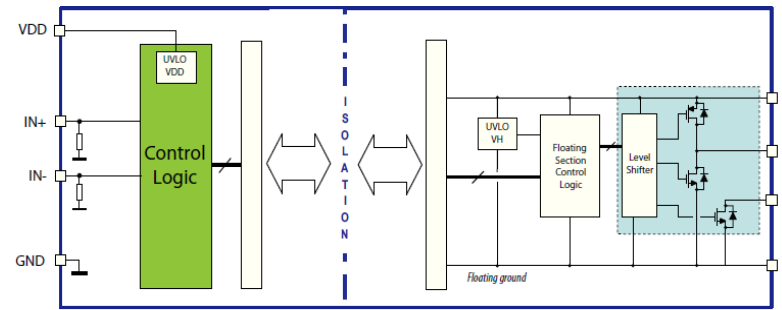


Main features

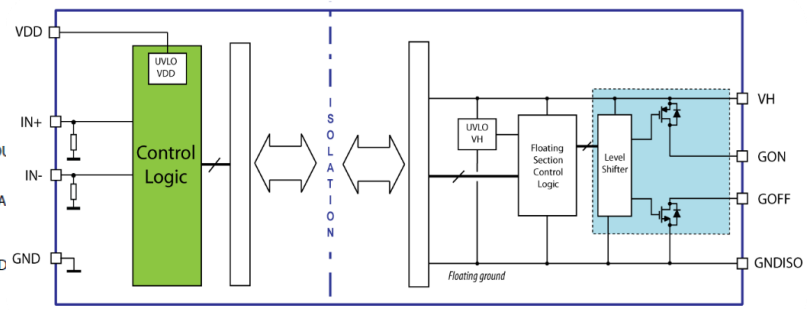
- High voltage rail up to 1700V
- 3V3 / 5 V logic inputs (1/3, 2/3 of VDD thresholds)
- Active High & Active Low input pins, for HW interlocking
- **Up to 26 V supply voltage**
- **4 A Sink/Source current capability**
- Separated Outputs option for easy gate driving tuning
- Miller CLAMP pin option
- UVLO Function
- Temperature shut-down protection
- Stand-by function
- > 100 V/ns CMTI
- Negative gate drive ability



8 mm creepage



Option 1: Single output and Miller CLAMP

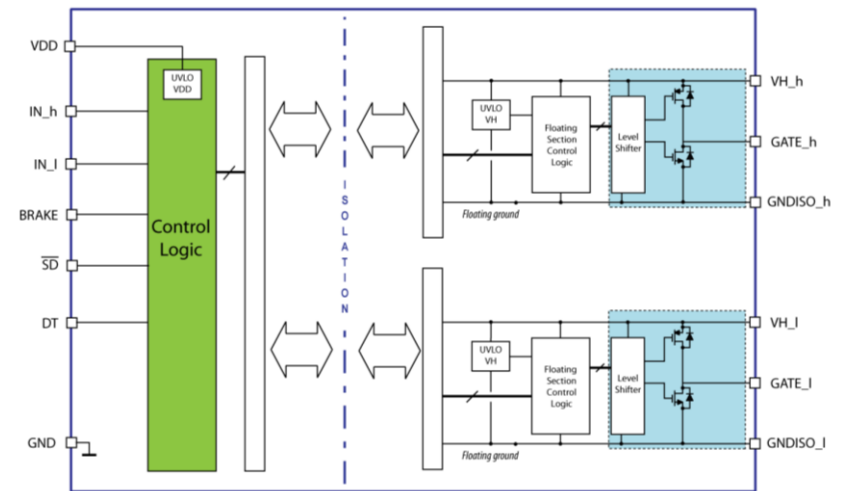


Option 2: Separated sink\source outputs



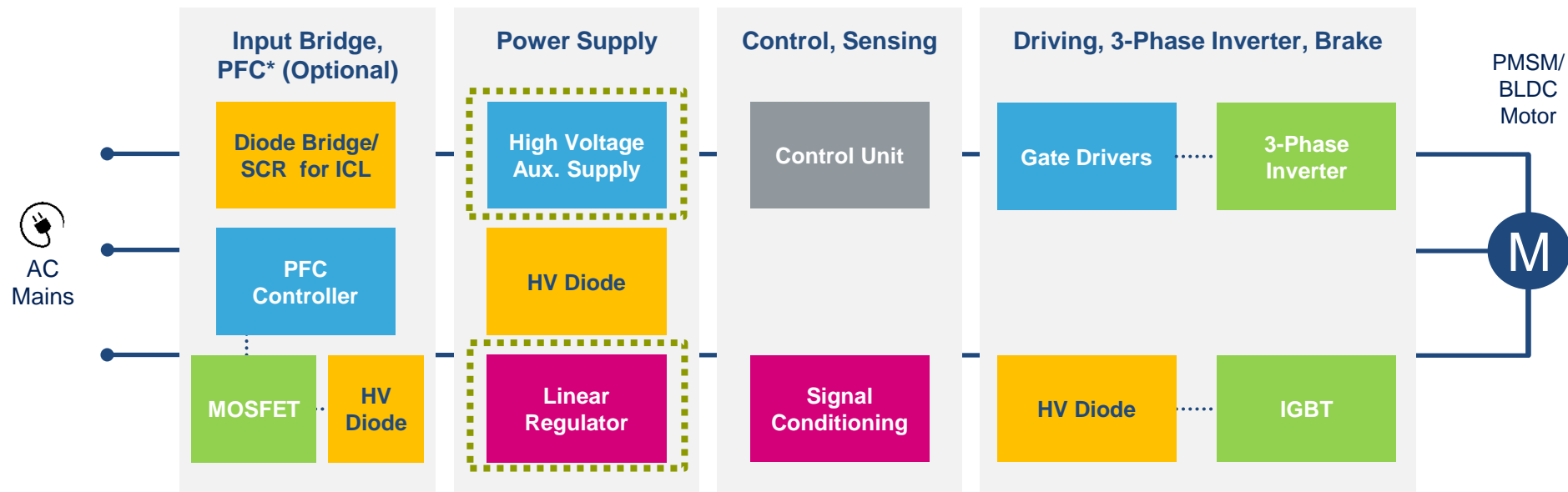
Main features

- High voltage rail up to 1700V
- 3V3 / 5 V logic inputs (1/3, 2/3 of VDD thresholds)
- **Up to 26 V supply voltage**
- **4 A Sink/Source current capability**
- Single input pin, in phase with output
- Shut-down SD pin, with integrated pull-down
- BRAKE pin
- UVLO Function (for each supply)
- Interlocking
- Programmable Dead-Time
- Stand-by function
- Temperature shut-down protection
- > 100 V/ns CMTI
- Negative gate drive ability



High-Voltage Motor Control

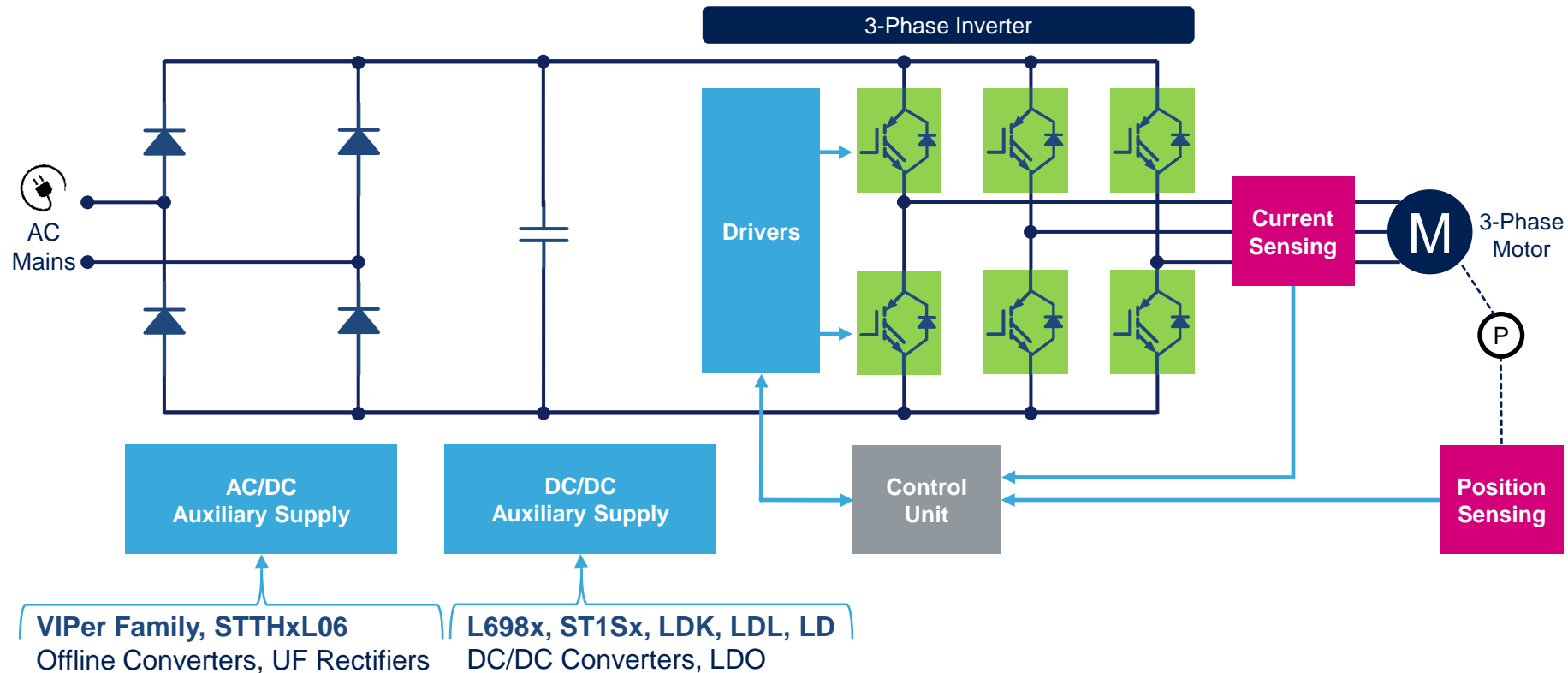
3ph-Inverter – Power Management



High Voltage Motor Control

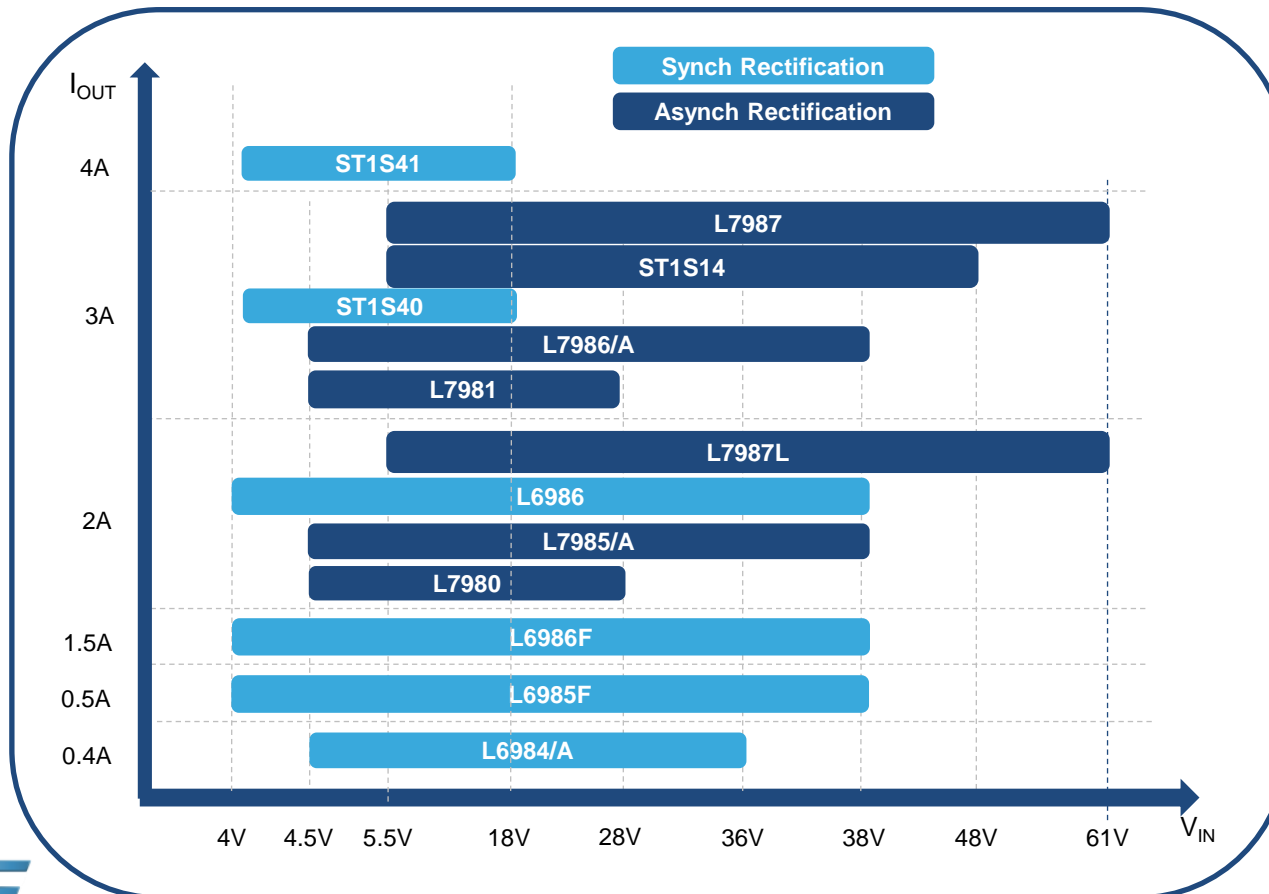
3Ph-Inverter – Power Management

Discrete Approach with IGBT / MOSFET for 3-Phase Motor





Switching Regulators in Motor Control Application



KEY BENEFITS & FEATURES

Wide range of operating voltage and current

- From 4V to 61 V ranging up to 4A.

Premium efficiency with L698x

- Synchronous rectification , quiescent current <100µA & low consumption mode at light load

Best solution for high VIN bus with L798x

- Asynchronous rectification to optimize small duty cycle conversion

Simplest solution with minimal BOM with ST1S

- Internal compensation

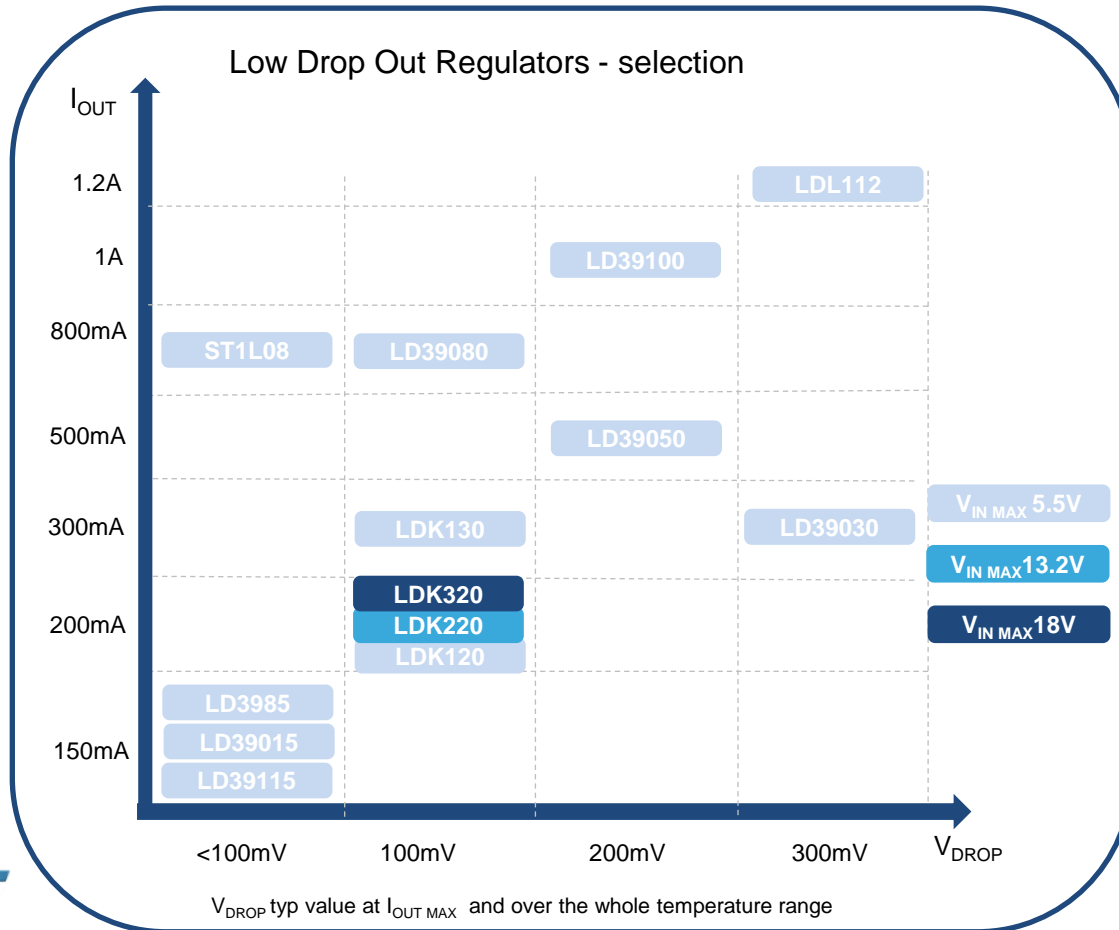
A solution for any soldering & thermal constrain

- Wide package variety: from QFN 3x3 up to HTSSOP16 going through SO* and HSOP8





Linear Regulators in Motor Control Application



KEY BENEFITS & FEATURES

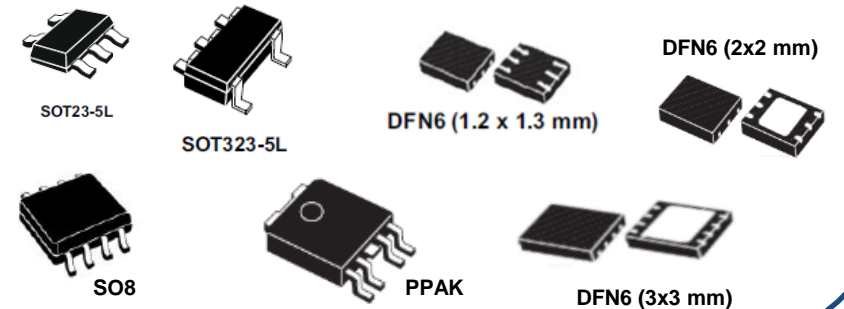
Ultra Low Drop Out: LD39xxx

- When system efficiency and minimum power dissipation are key

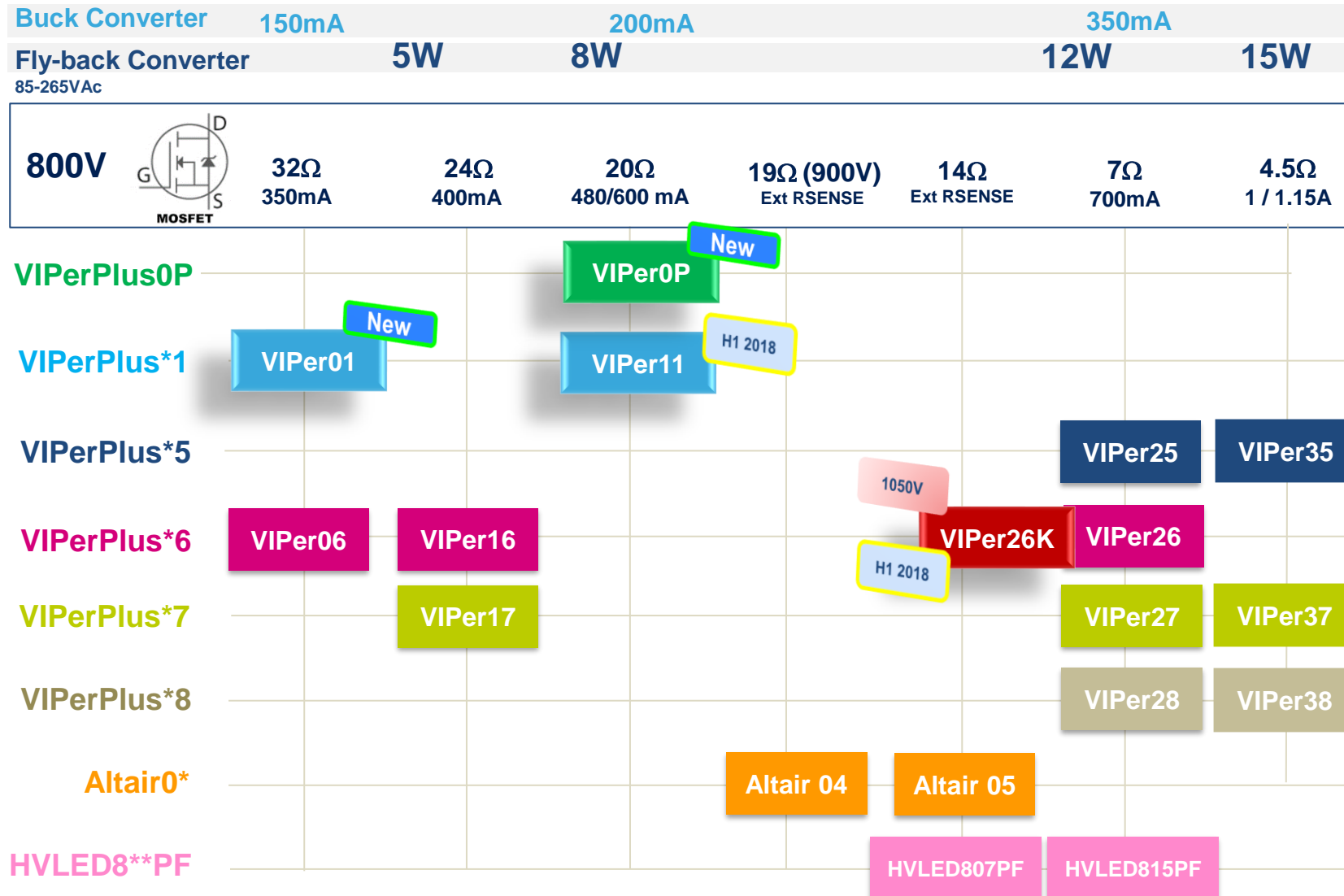
LDL112: with built-in reverse current protection

LDK & LDL: simple and cost effective solutions:

- Several package options are available for easy plug in

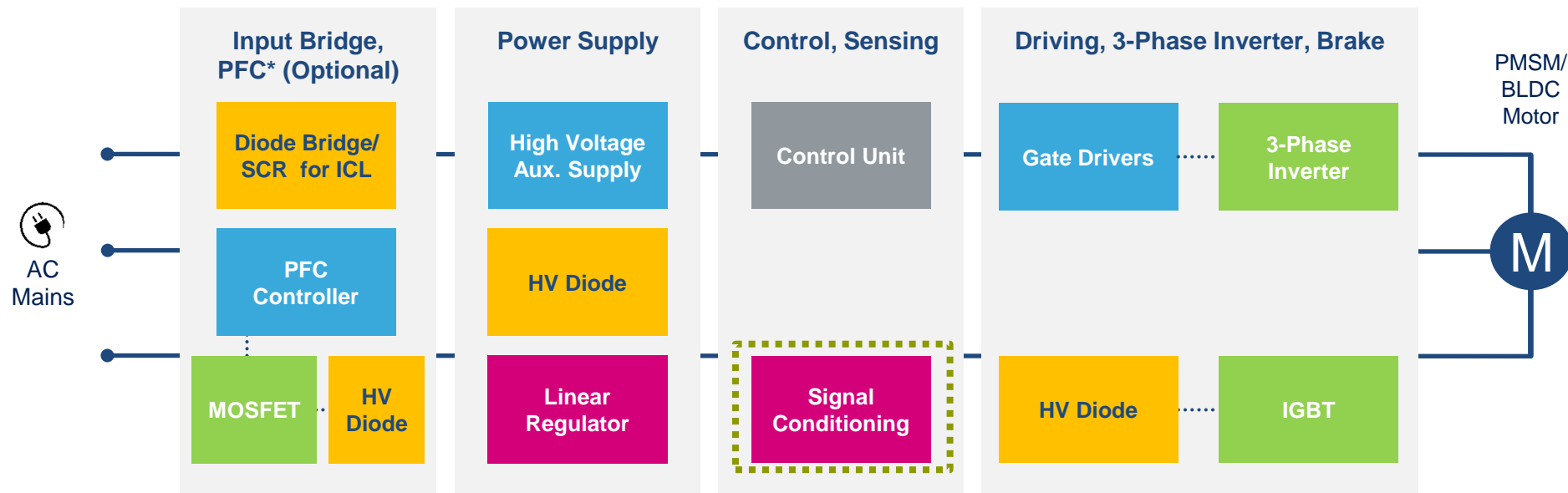


Power Management ST Offline Converters Overview



High-Voltage Motor Control

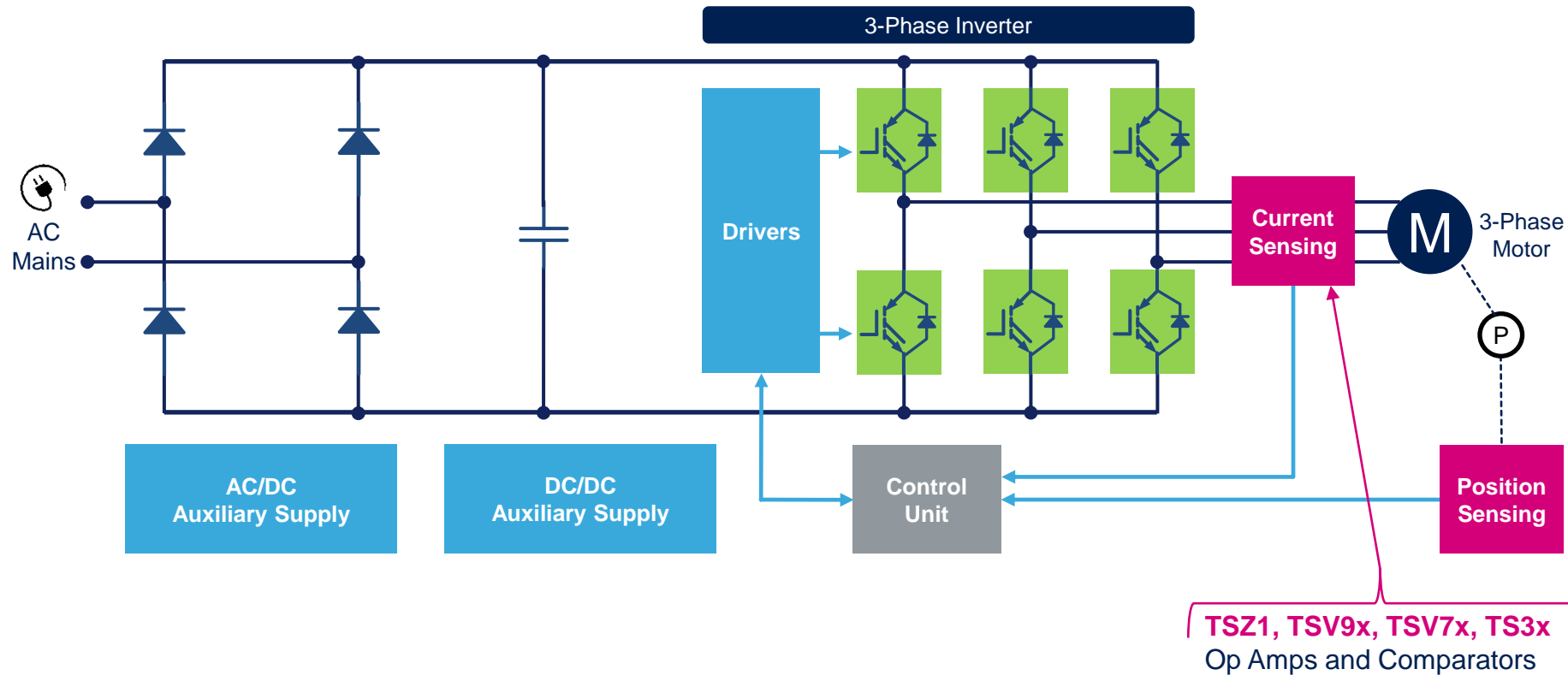
3ph-Inverter – Signal Conditioning



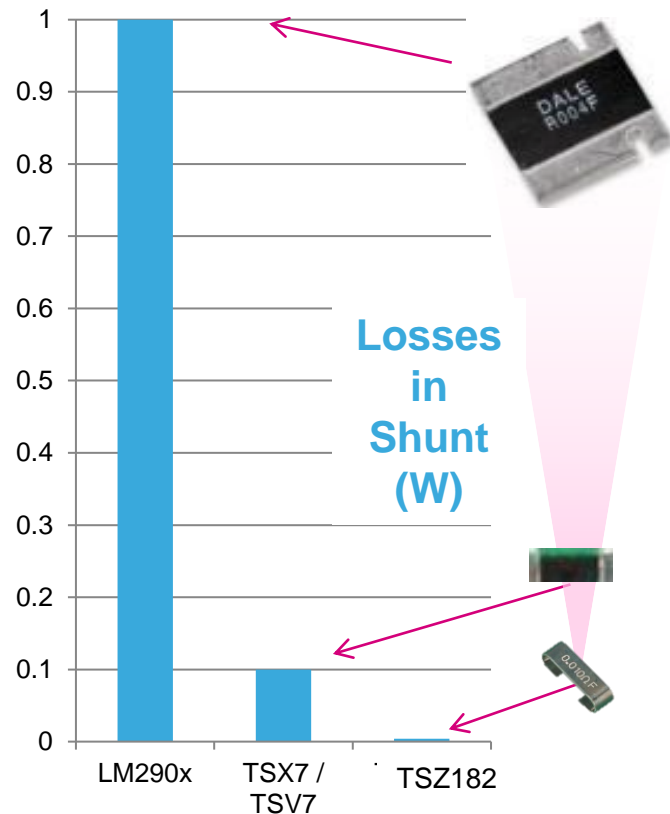
High Voltage Motor Control

3Ph-Inverter – Signal Conditioning

Discrete Approach with IGBT / MOSFET for 3-Phase Motor



Current Sensing in Motor Control Application



High Precision Op-Amp
Smaller shunt → minimize losses

→ **TSZ12x** (5uV, 400kHz)

→ **TSZ18x** (25uV, 3MHz)

High slew rate → track PWM

→ **TSV99x** (1.5mV 20MHz)

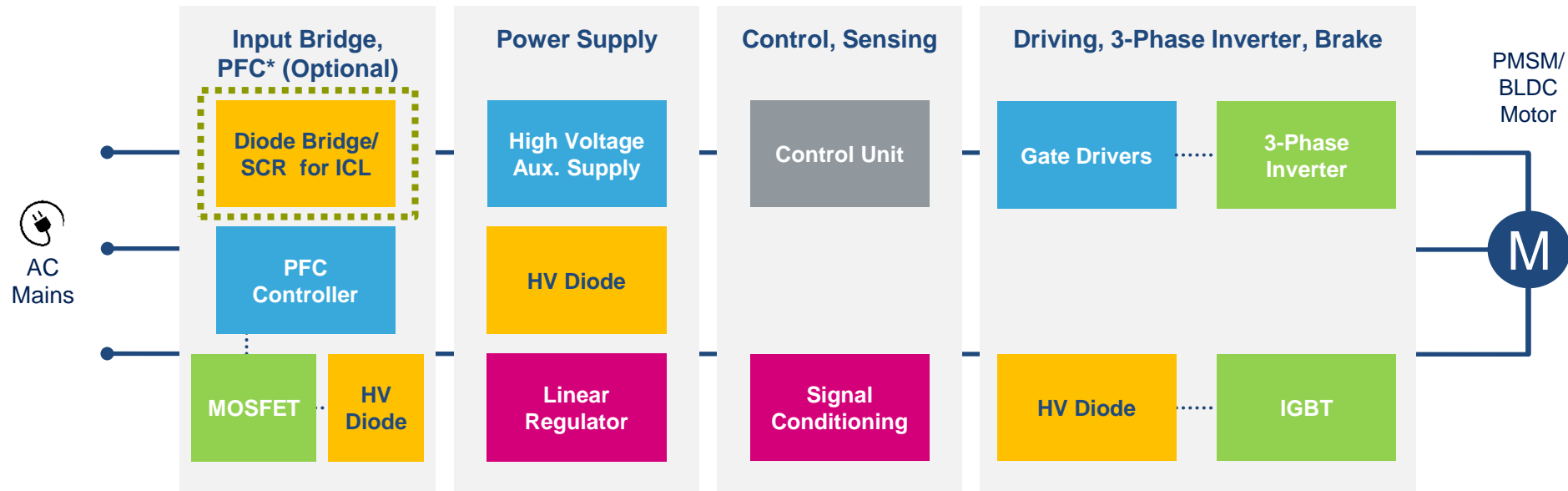
Overcurrent protection

→ **TS3xx** (comparator)

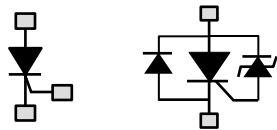
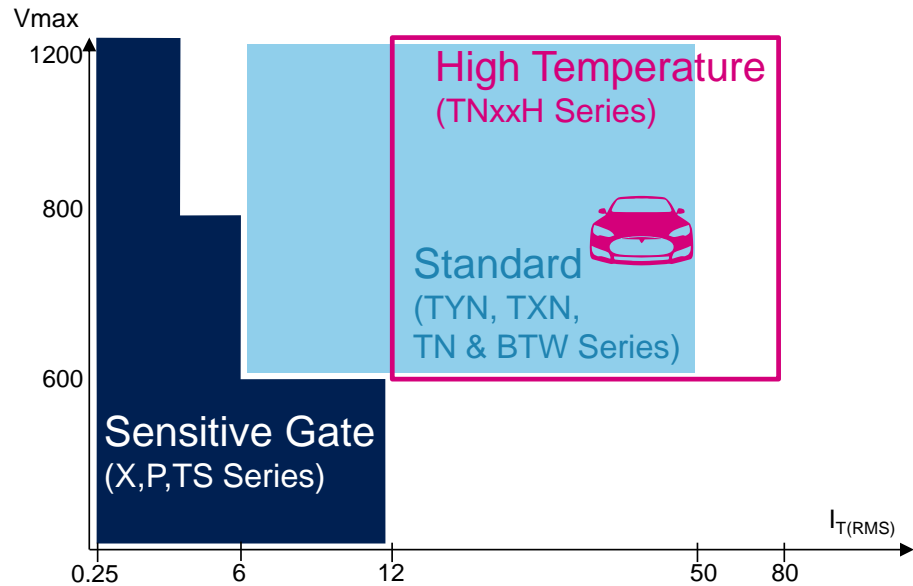
Part	Op-amp	Vio max (mV)	Shunt (mΩ)	Losses (W)
LM290x	Standard	2	40	1
TSV7xx TSX7xx	High-Precision 5V / 16V CMOS	0.2	4	0.1
TSZ18x	Ultra-Precision 5V Zero-Drift	0.025	0.5	0.0125

High-Voltage Motor Control

3ph-Inverter – Inrush Current Limitation

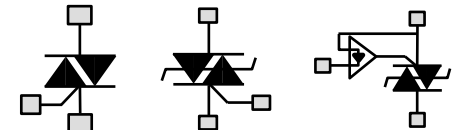
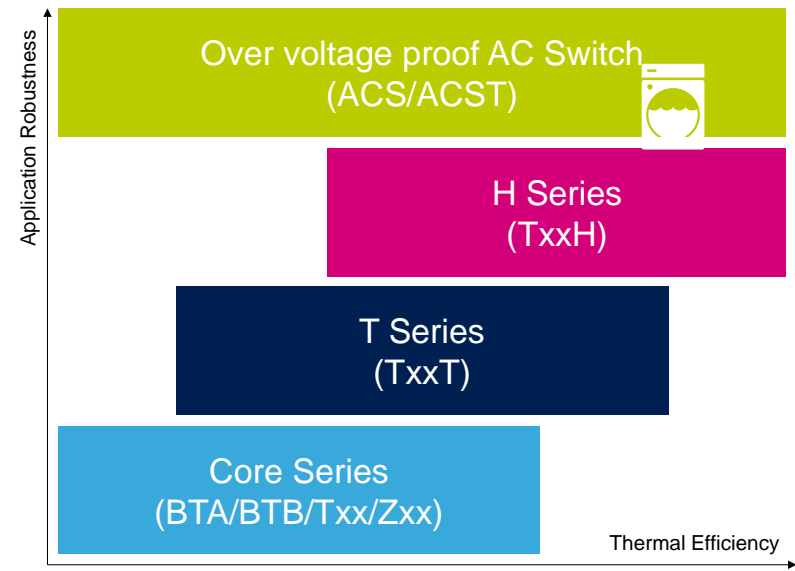


Thyristor & Triac Product Range



The most innovative broad range **SCR** portfolio

V_{DRM} : 400 V to 1200 V
 I_{GT} : 5 μ A to 50 mA
 I_{TRMS} : 0.5 A to 80 A
 T_J : 125 °C and 150 °C



The most complete **TRIAC** portfolio in the industry

V_{DRM} : 600 V to 1200 V
 I_{GT} : 3 mA to 50 mA
 I_{TRMS} : 0.2 A to 40 A
 T_J : 125 °C and 150 °C



life.augmented