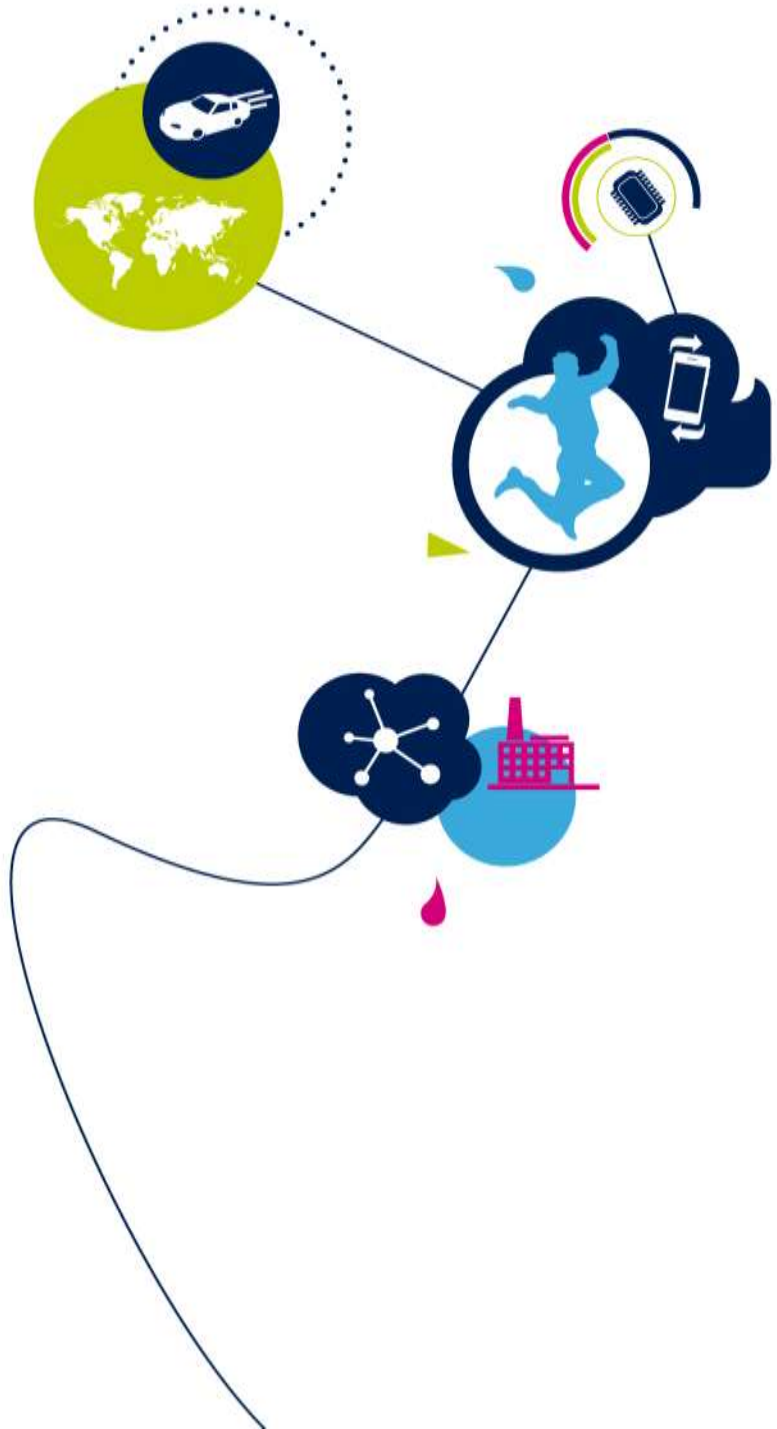
CES 2020 Electro-Mobility Wall

Matt, Alfredo, Khaldoun, Karl, Aravind, Steven

12/4/19 Update



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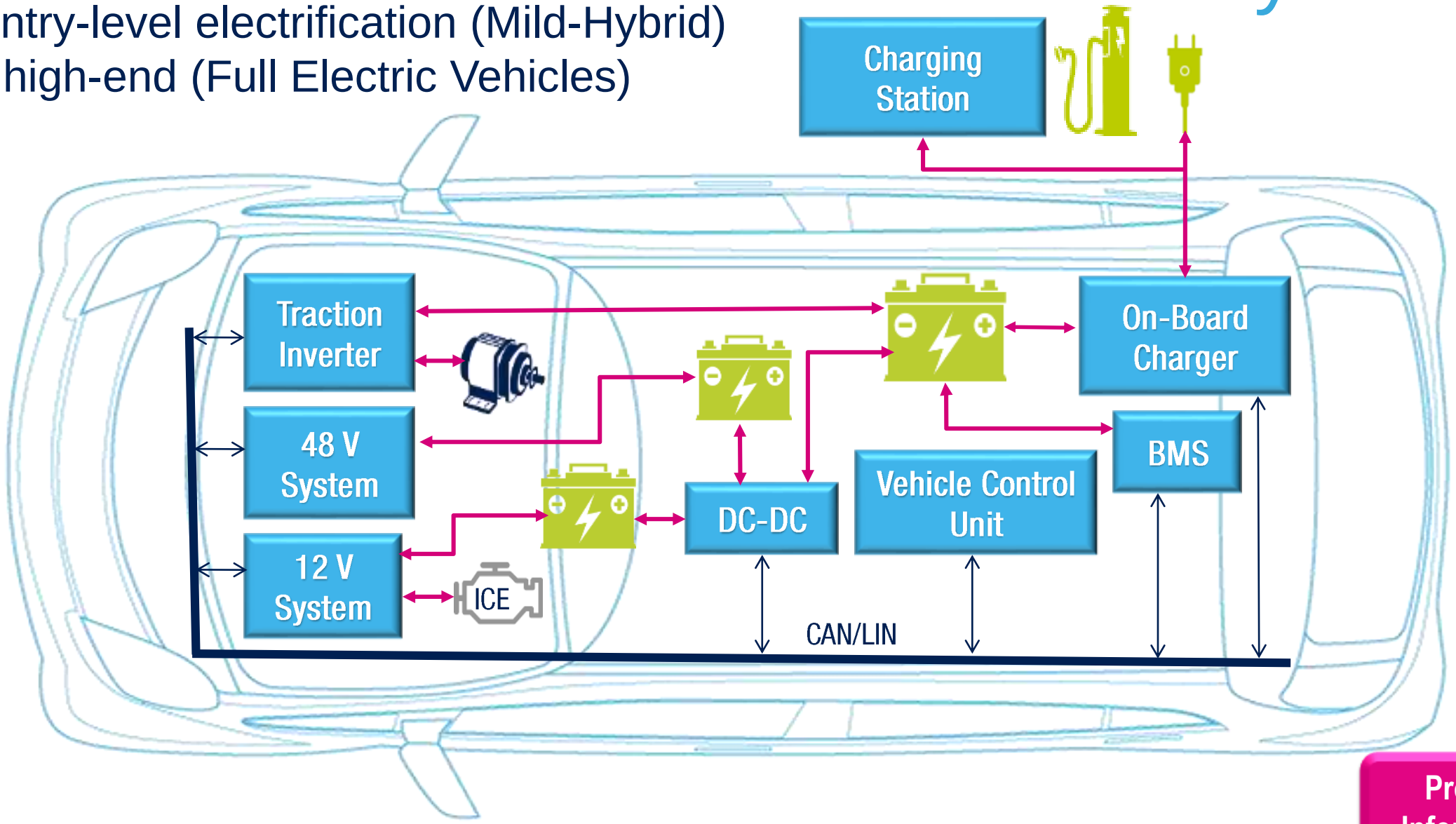
Electro-Mobility Area

From entry-level electrification (Mild-Hybrid)
to high-end (Full Electric Vehicles)



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Product Information

Product Information

SiC MOSFETs and Diodes	VIPower®	Power Management	Integrated and Isolated Drivers	32-bit Automotive MCUs
Si Power MOSFETs and IGBTs	Signal Conditioning	Power Diodes & Thyristors	EOS and ESD Protections	Body Smart Power

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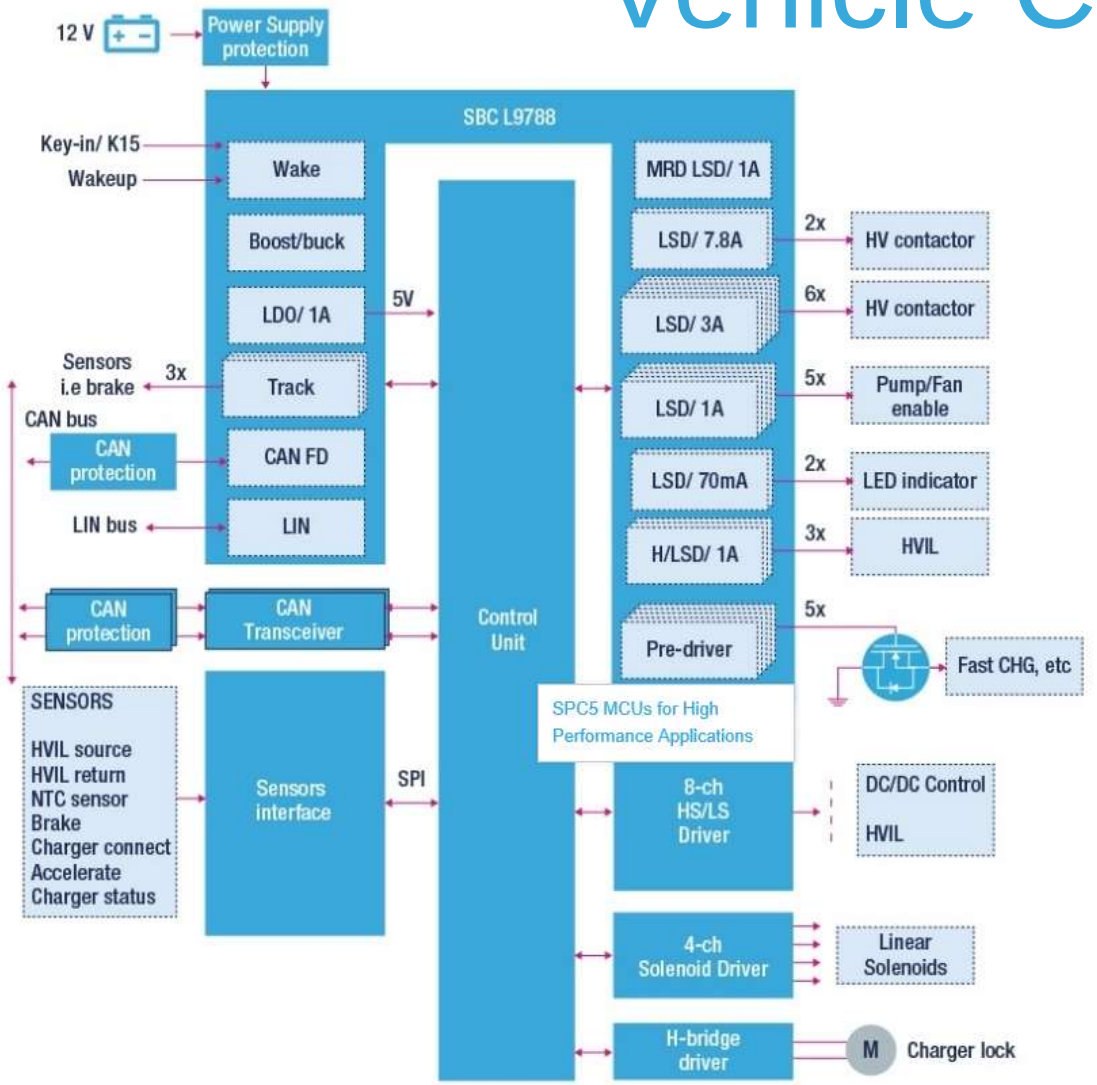
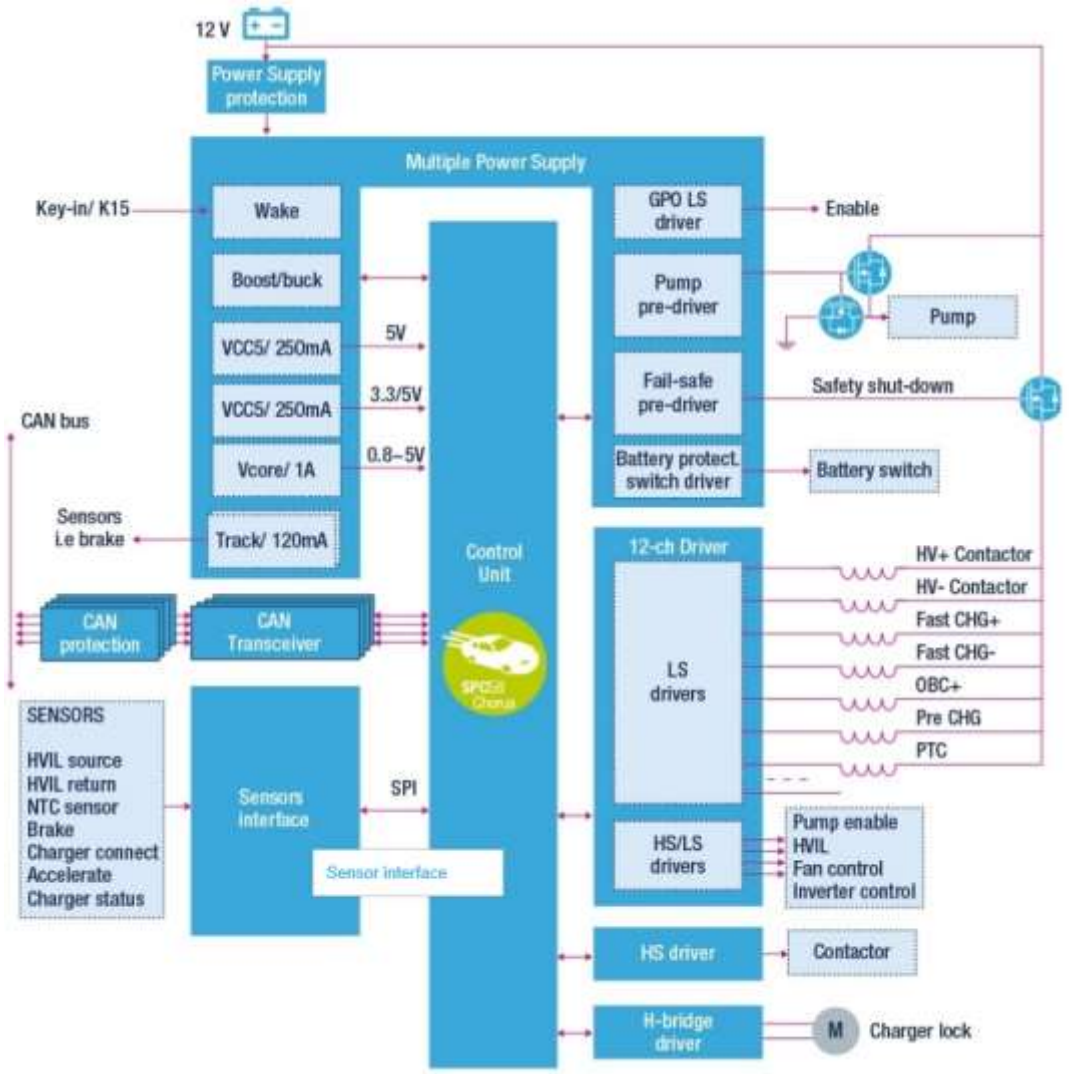
System Information

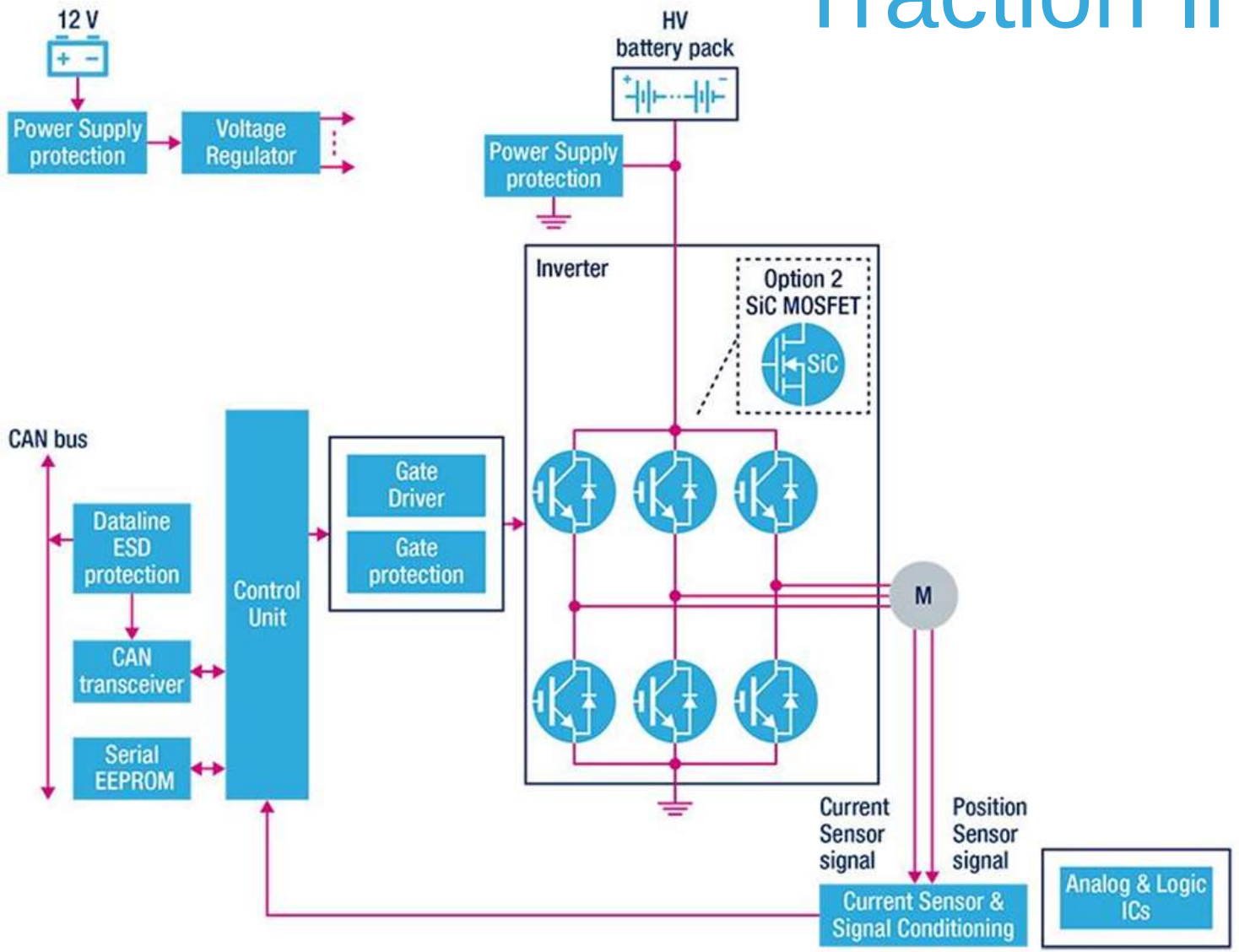
Vehicle Control Unit



Vehicle Control Unit



Traction Inverter



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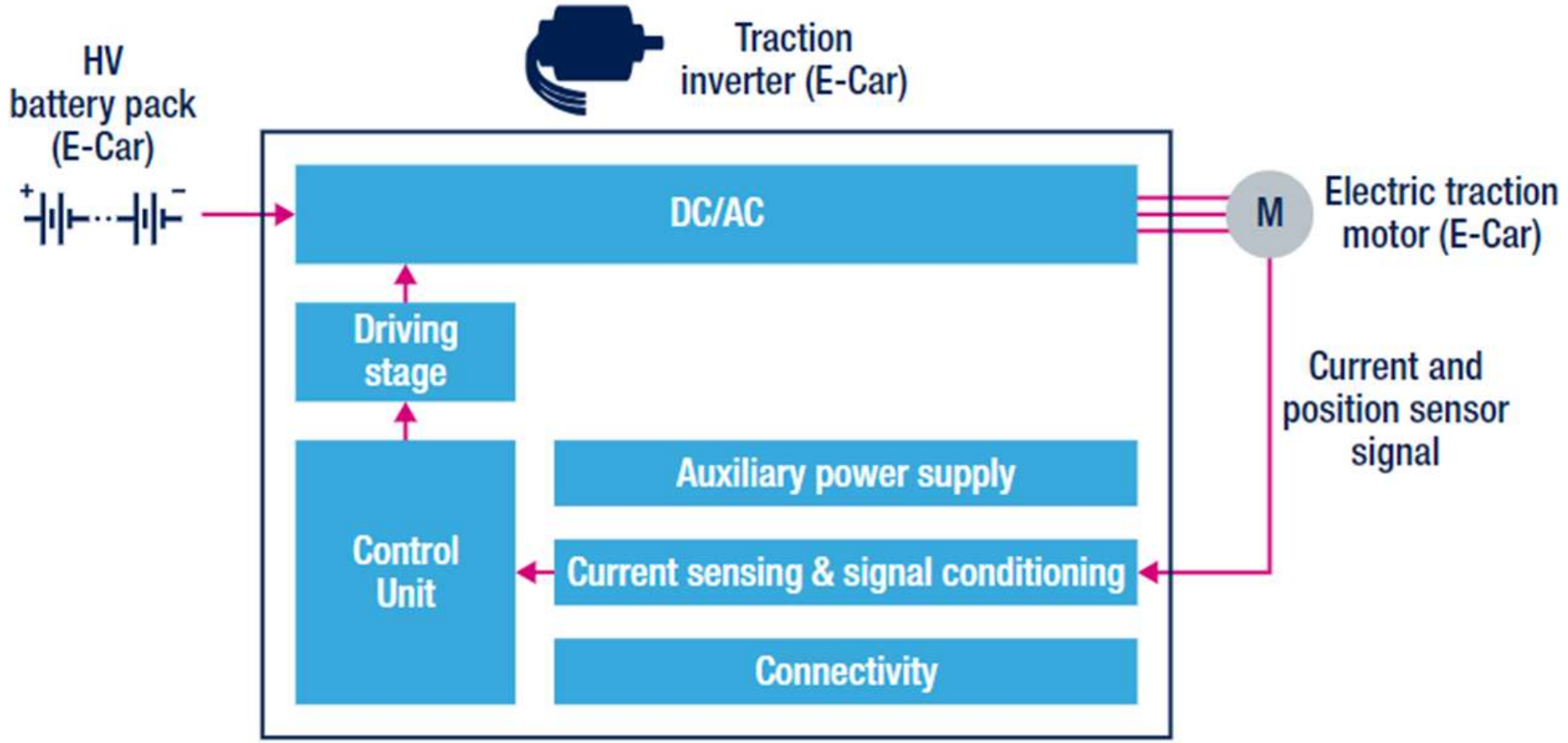
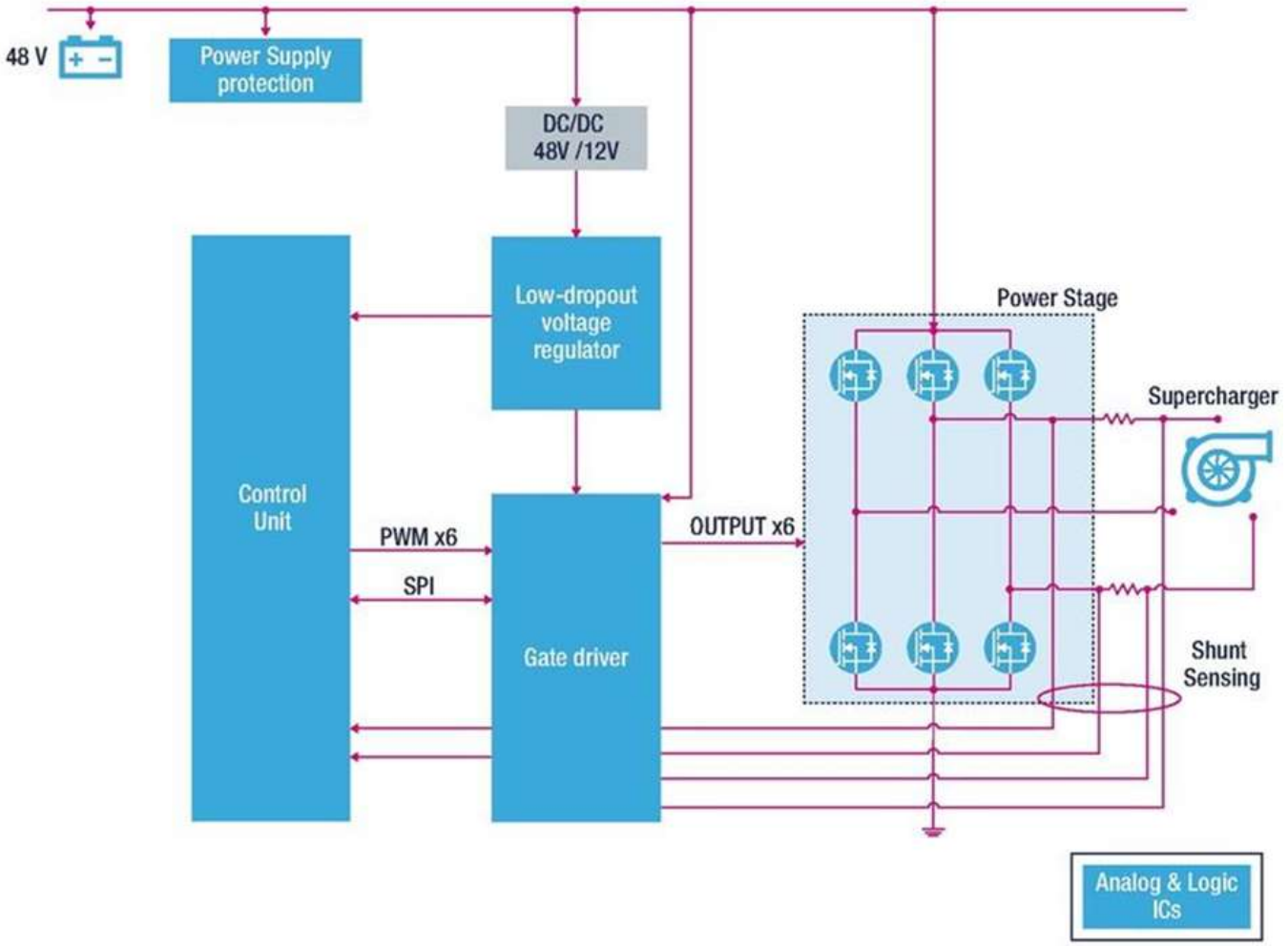
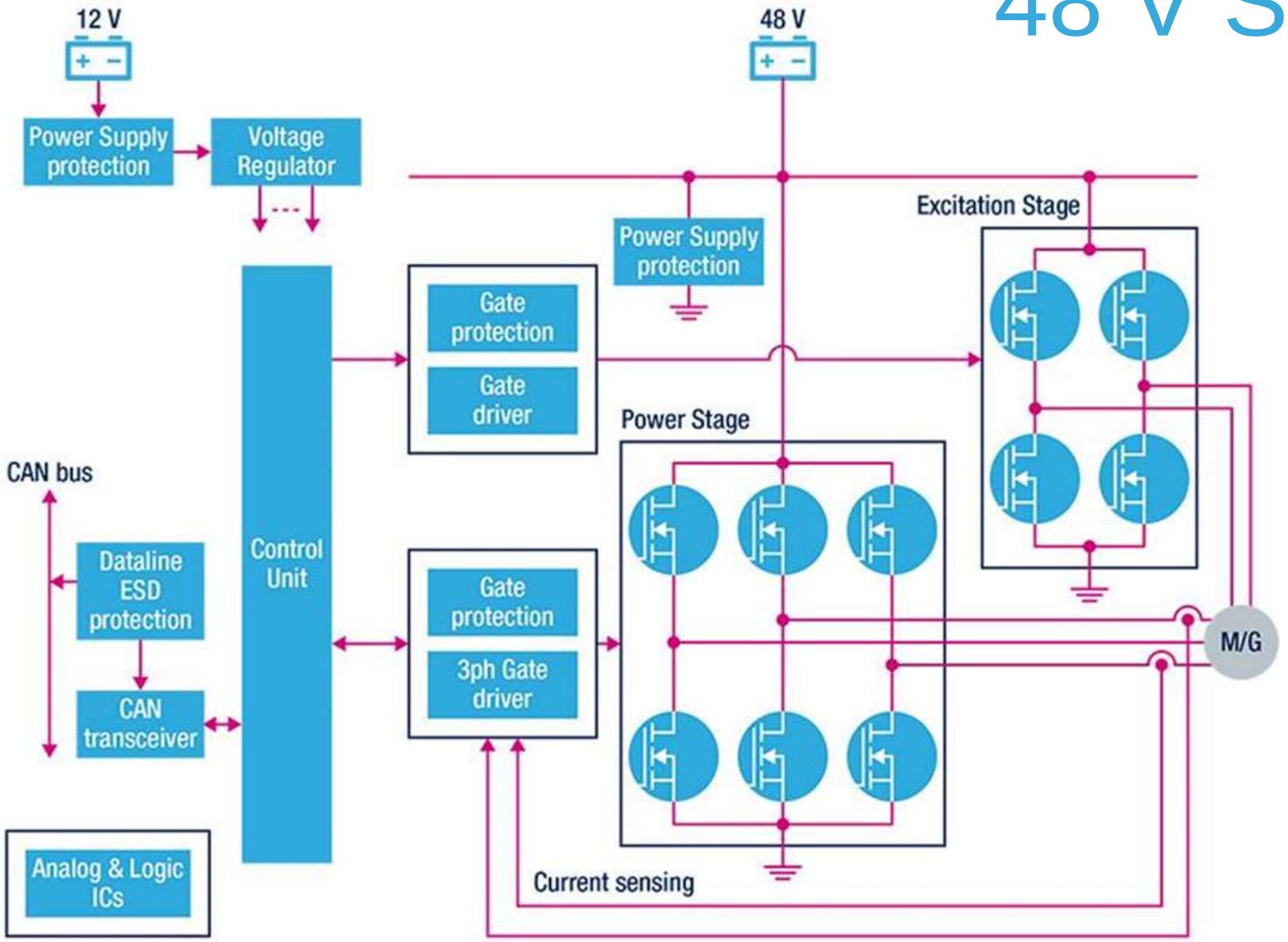
Traction Inverter



48 V System


48 V
Power Supply protection
DC/DC 48V /12V
Low-dropout voltage regulator
Control Unit
PWM x6
SPI
Gate driver
OUTPUT x6
Power Stage
Supercharger
Shunt Sensing
Analog & Logic ICs

48 V System



Body Smart Power | EOS and ESD Protections | Power Diodes & Thyristors | Signal Conditioning | SiC MOSFETs and Diodes | Si Power MOSFETs and IGBTs | VIPower® | Power Management | Integrated and Isolated Drivers | 32-bit Automotive MCUs

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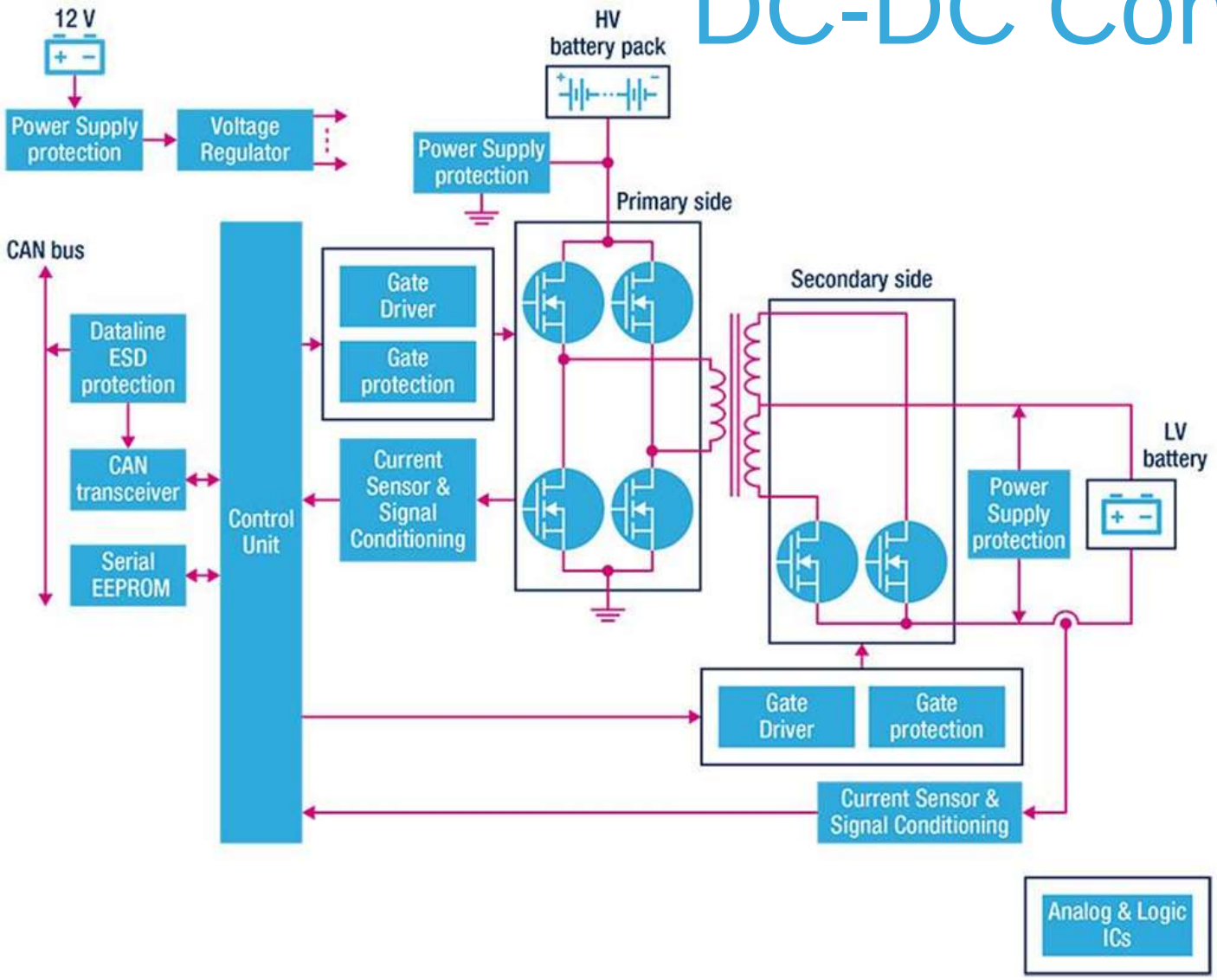
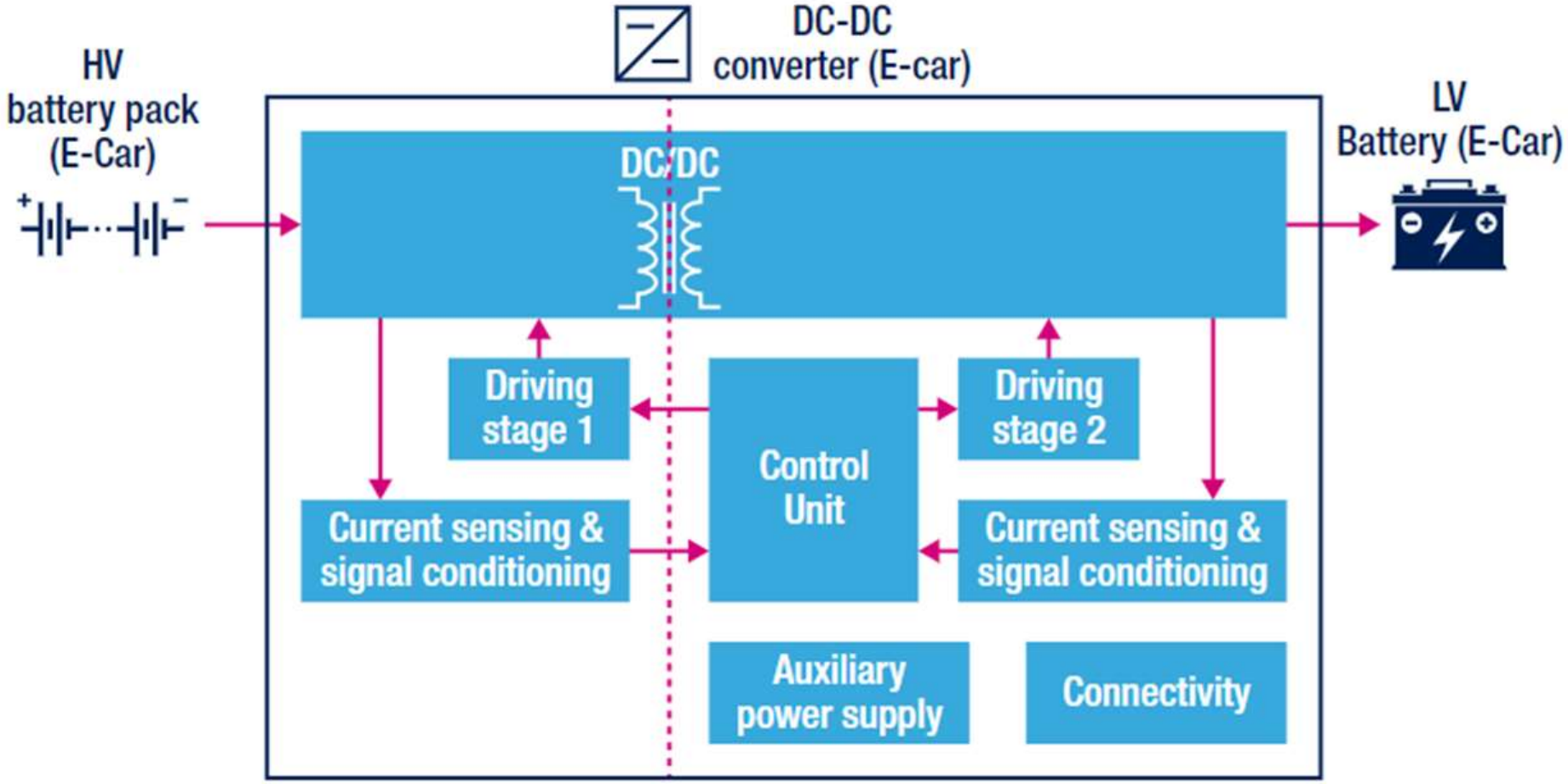
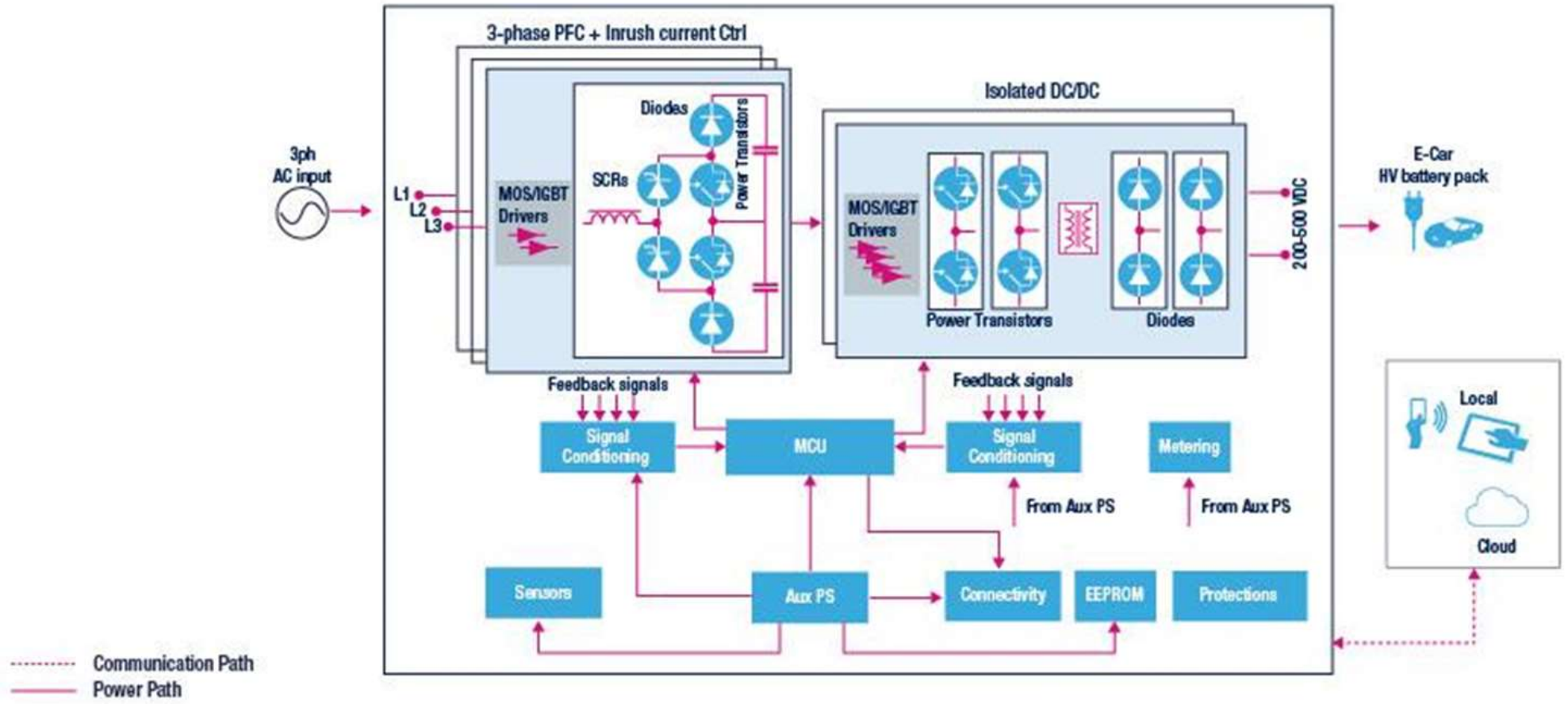
DC-DC Converter



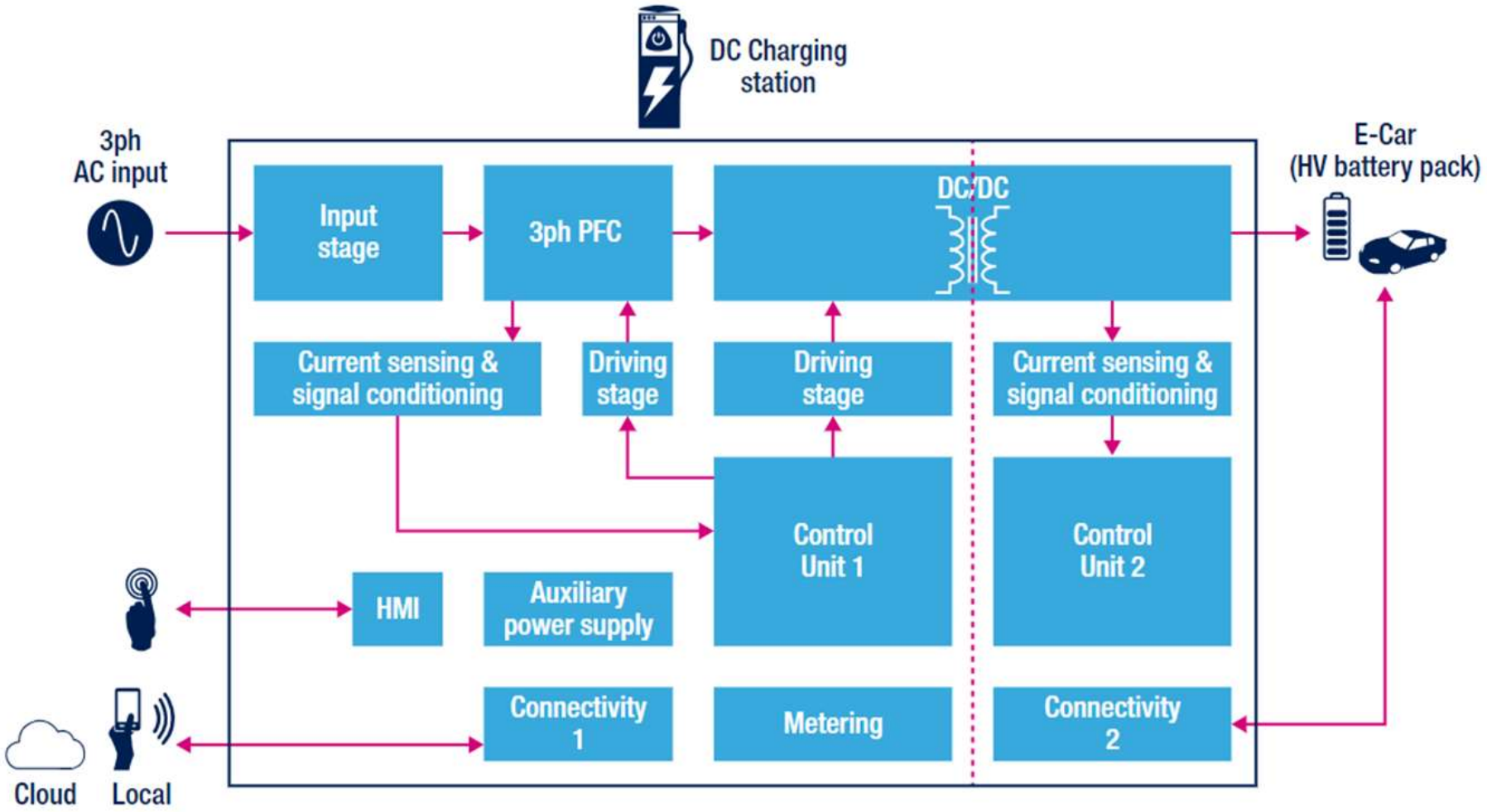
DC-DC Converter



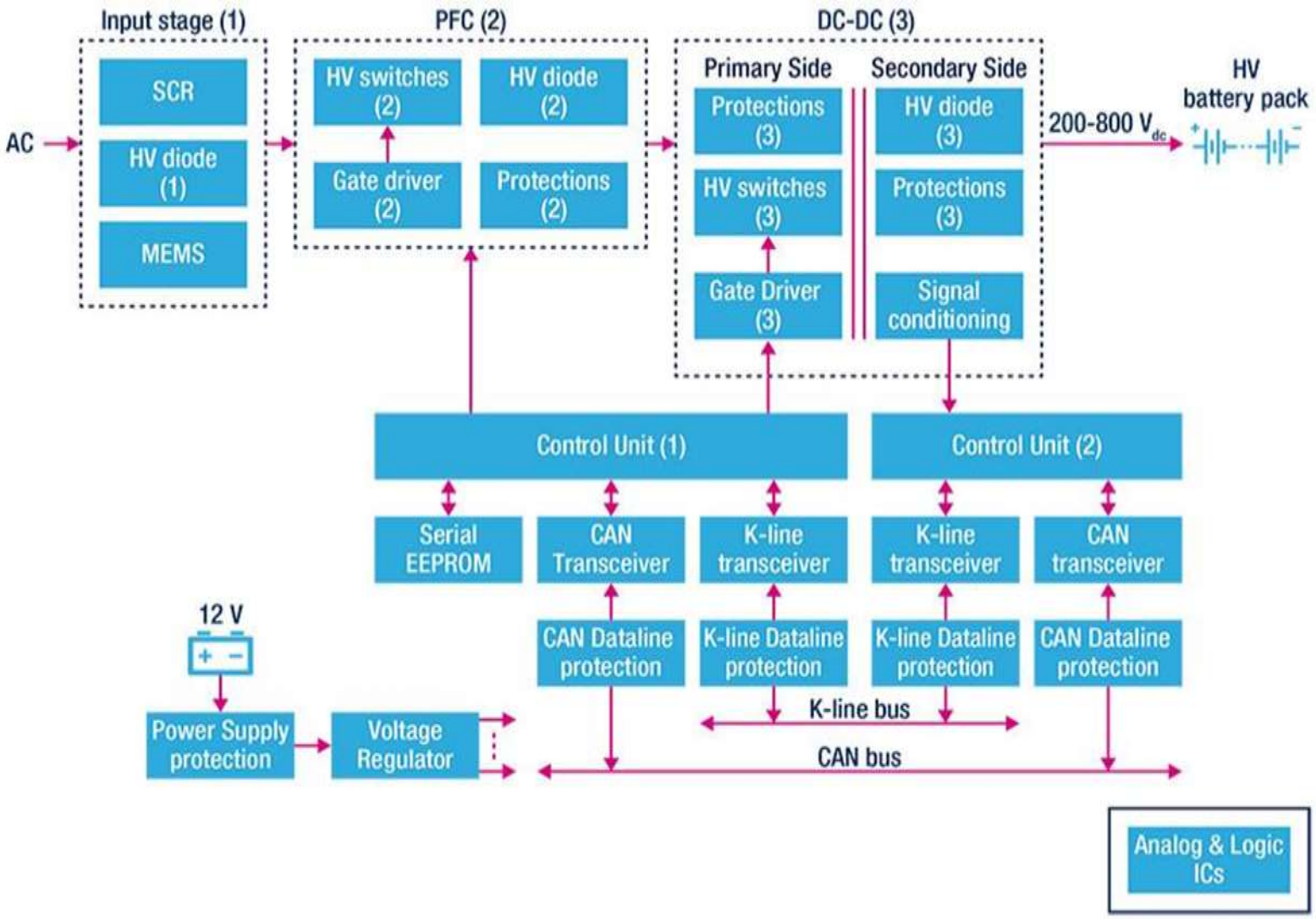
Charging Station



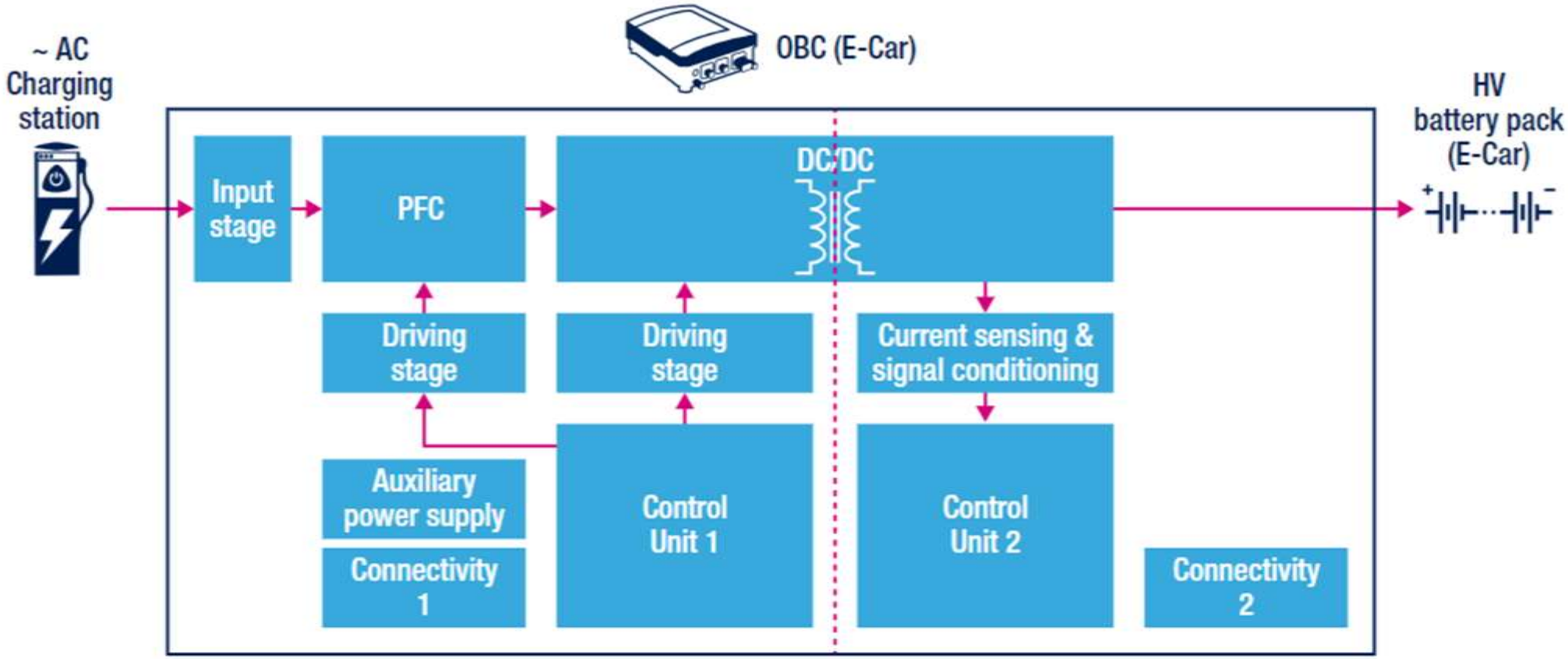
Charging Station



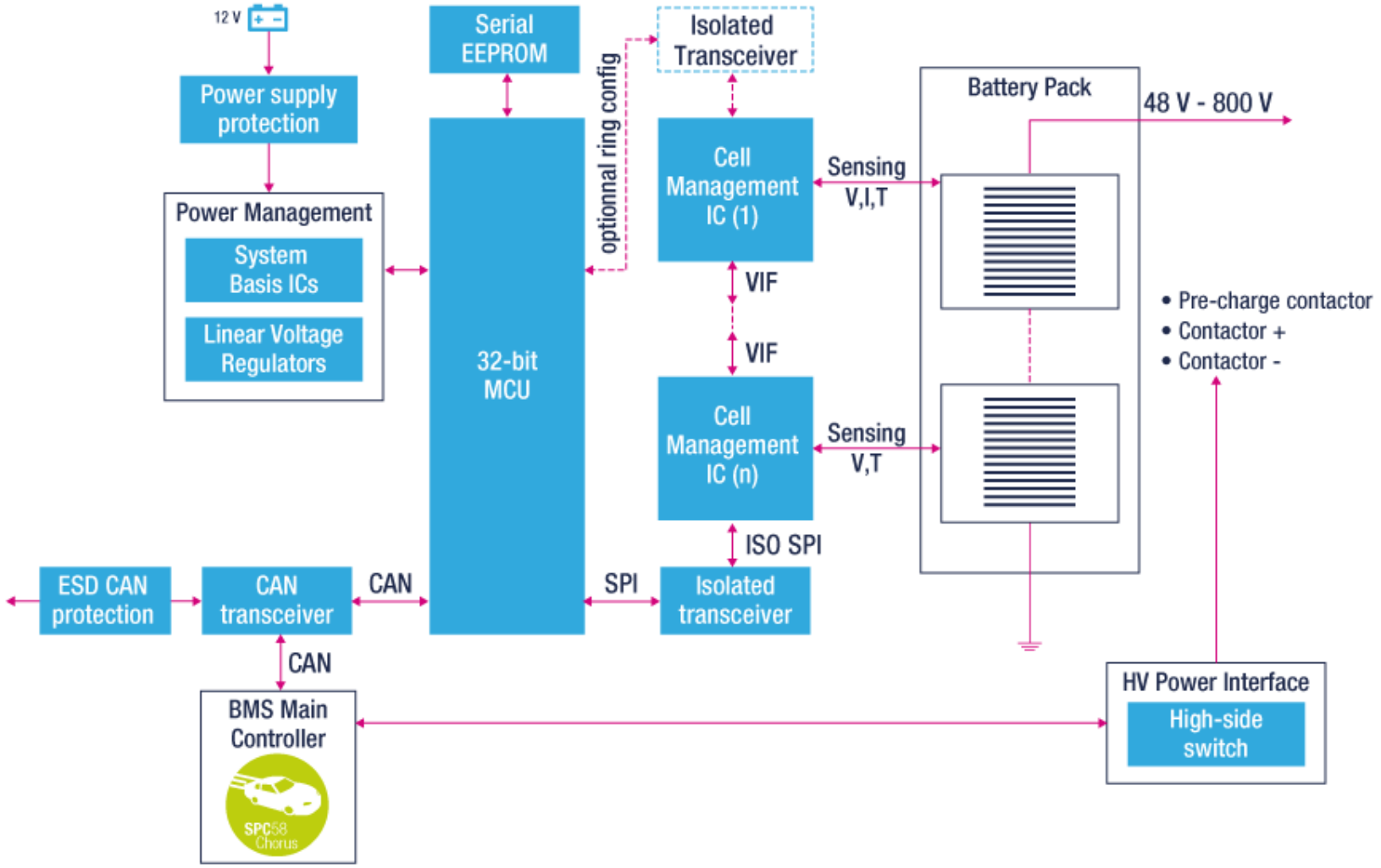
On-Board Charger



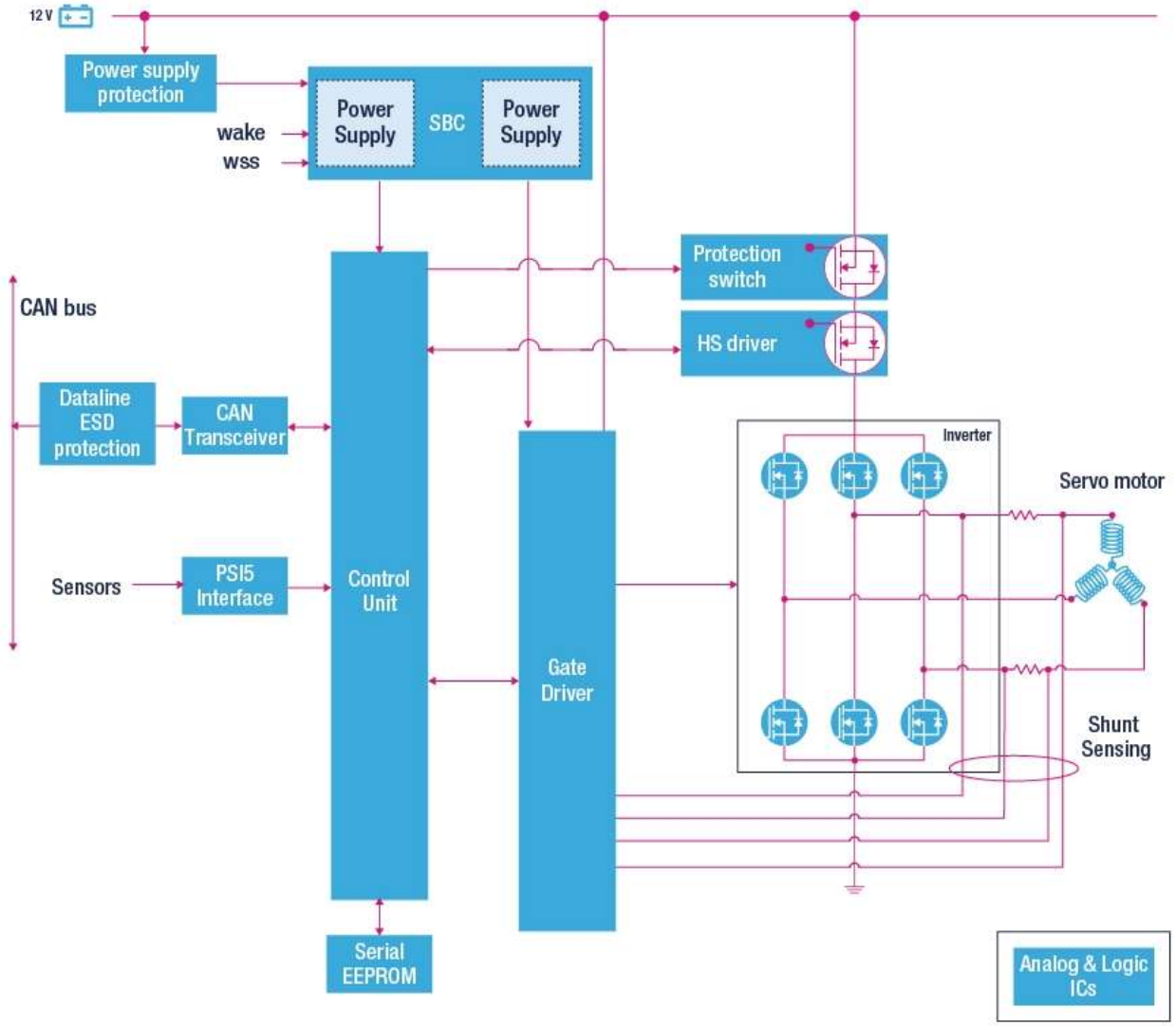
On-Board Charger



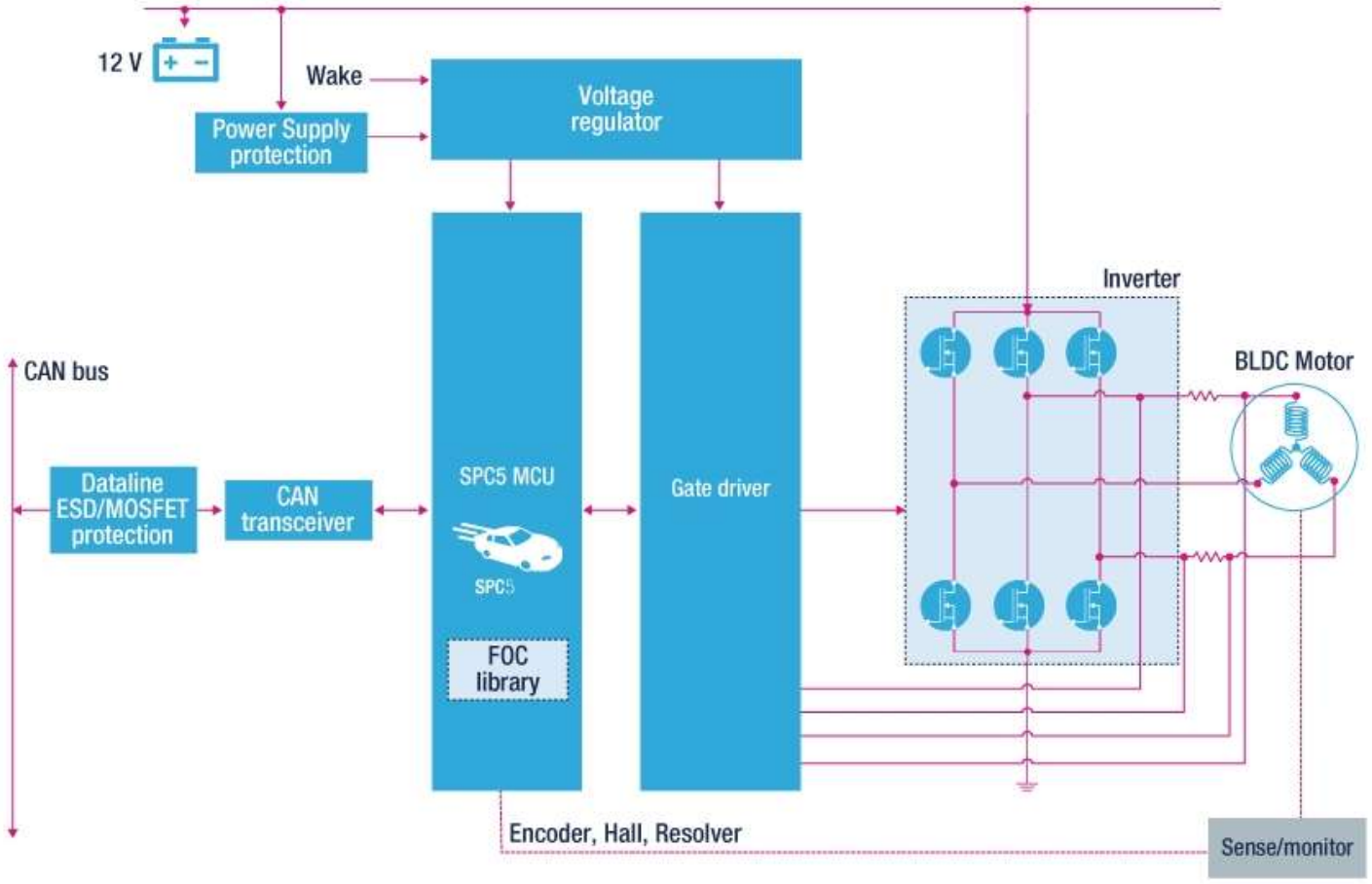
Battery Management Systems



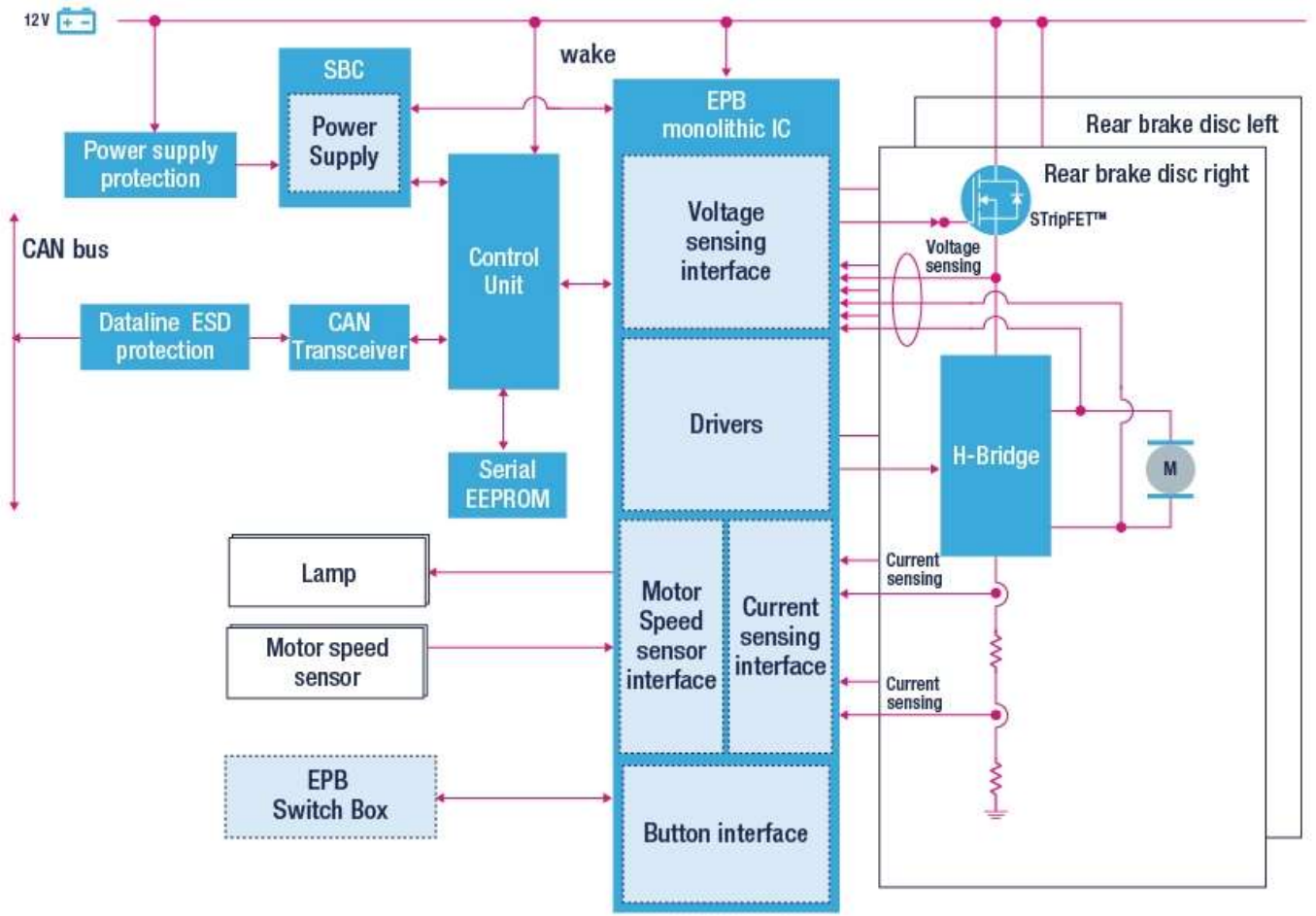
12 V System


12 V
Power supply protection
wake
wss
Power Supply
SBC
Power Supply
CAN bus
Protection switch
HS driver
Dataline ESD protection
CAN Transceiver
Inverter
Servo motor
Sensors
PSI5 Interface
Control Unit
Gate Driver
Shunt Sensing
Serial EEPROM
Analog & Logic ICs

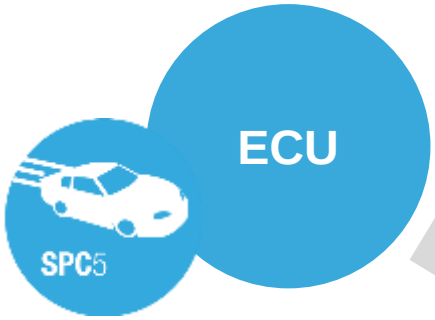
12 V System


12 V
Wake
Power Supply protection
Voltage regulator
Inverter
BLDC Motor
CAN bus
Dataline ESD/MOSFET protection
CAN transceiver
SPC5 MCU
SPC5
FOC library
Gate driver
Encoder, Hall, Resolver
Sense/monitor

12 V System

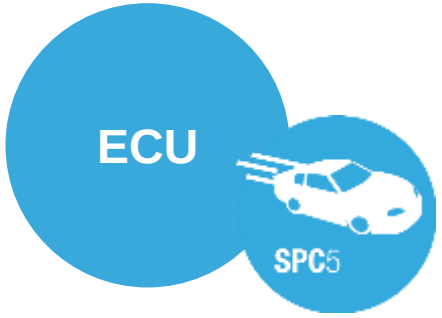

12V
wake
SBC
Power Supply
Power supply protection
CAN bus
Dataline ESD protection
CAN Transceiver
Control Unit
Serial EEPROM
EPB monolithic IC
Voltage sensing interface
Drivers
Motor Speed sensor interface
Current sensing interface
Button interface
Lamp
Motor speed sensor
EPB Switch Box
Rear brake disc left
Rear brake disc right
STripFET™
Voltage sensing
H-Bridge
M
Current sensing
Current sensing
Analog & Logic ICs

32-bit Automotive MCU Evolution



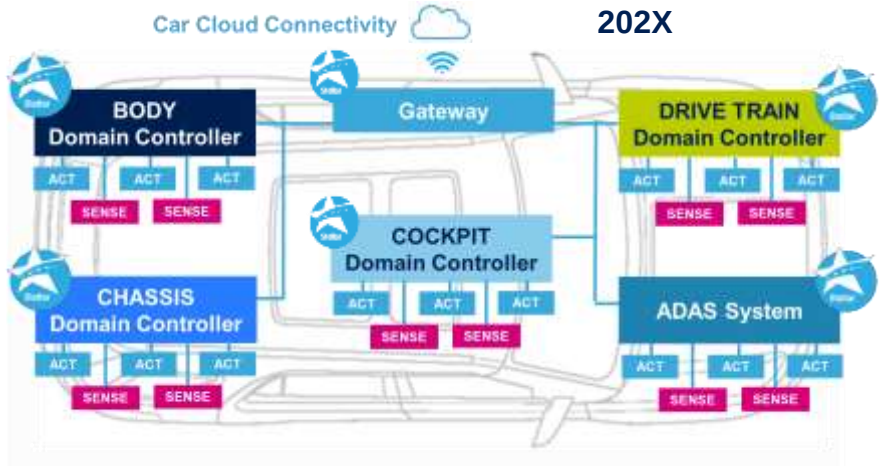
SPC5
Power Architecture

Performance

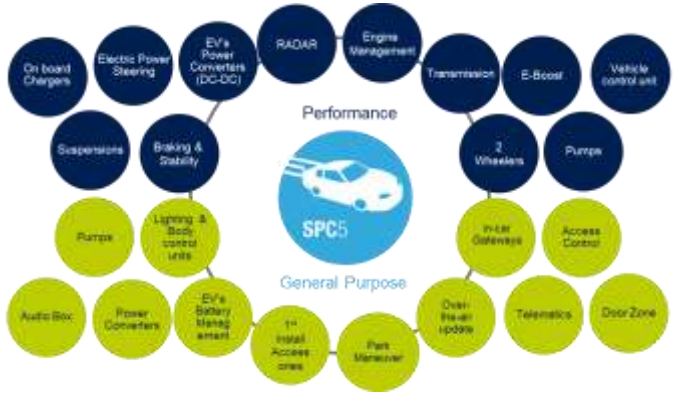


Cost/Performance

Stellar Arm R52 28nm FDSOI PCM for high-end solutions



SPC5 Power Architecture with Flash NVM for Single ECUs



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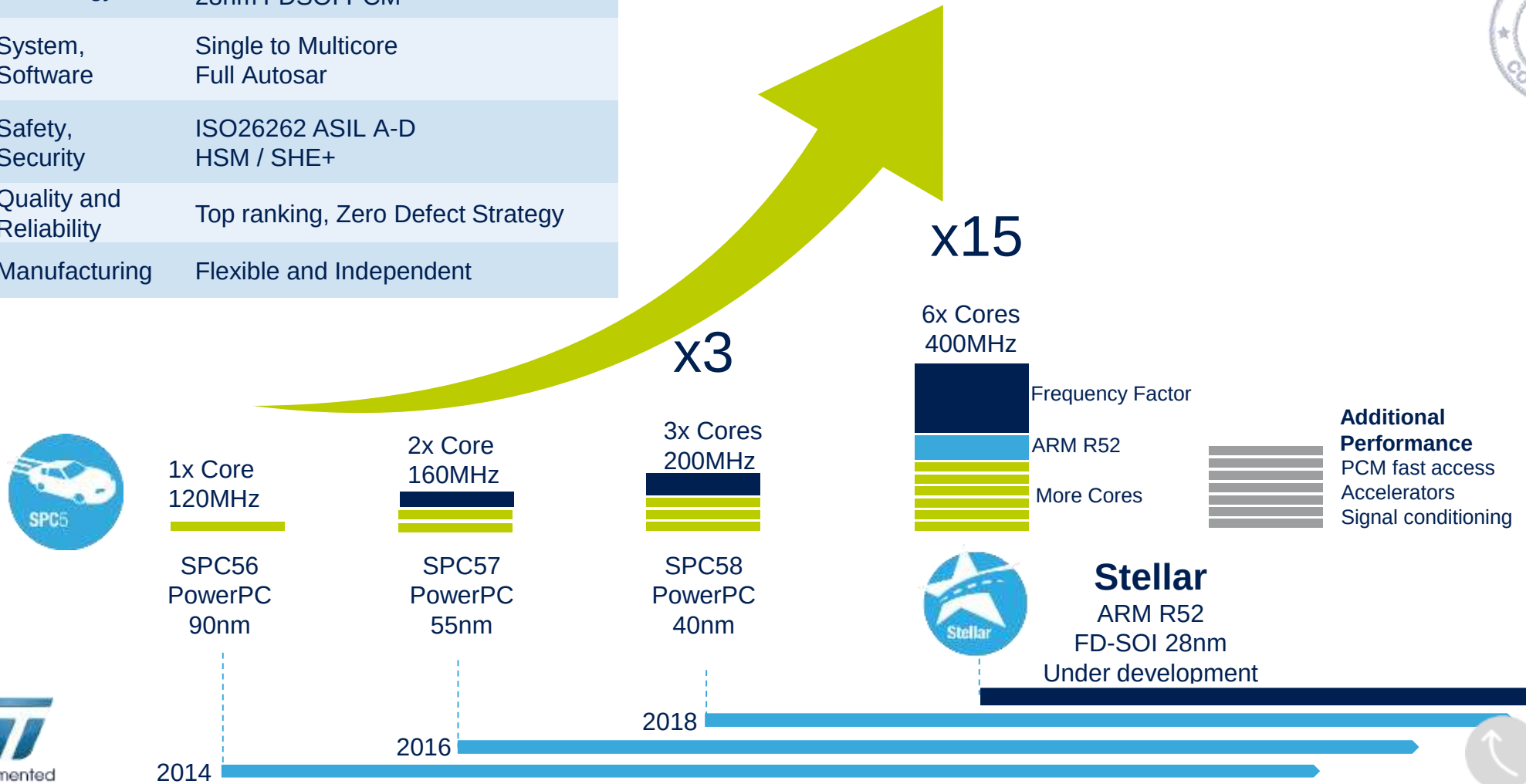
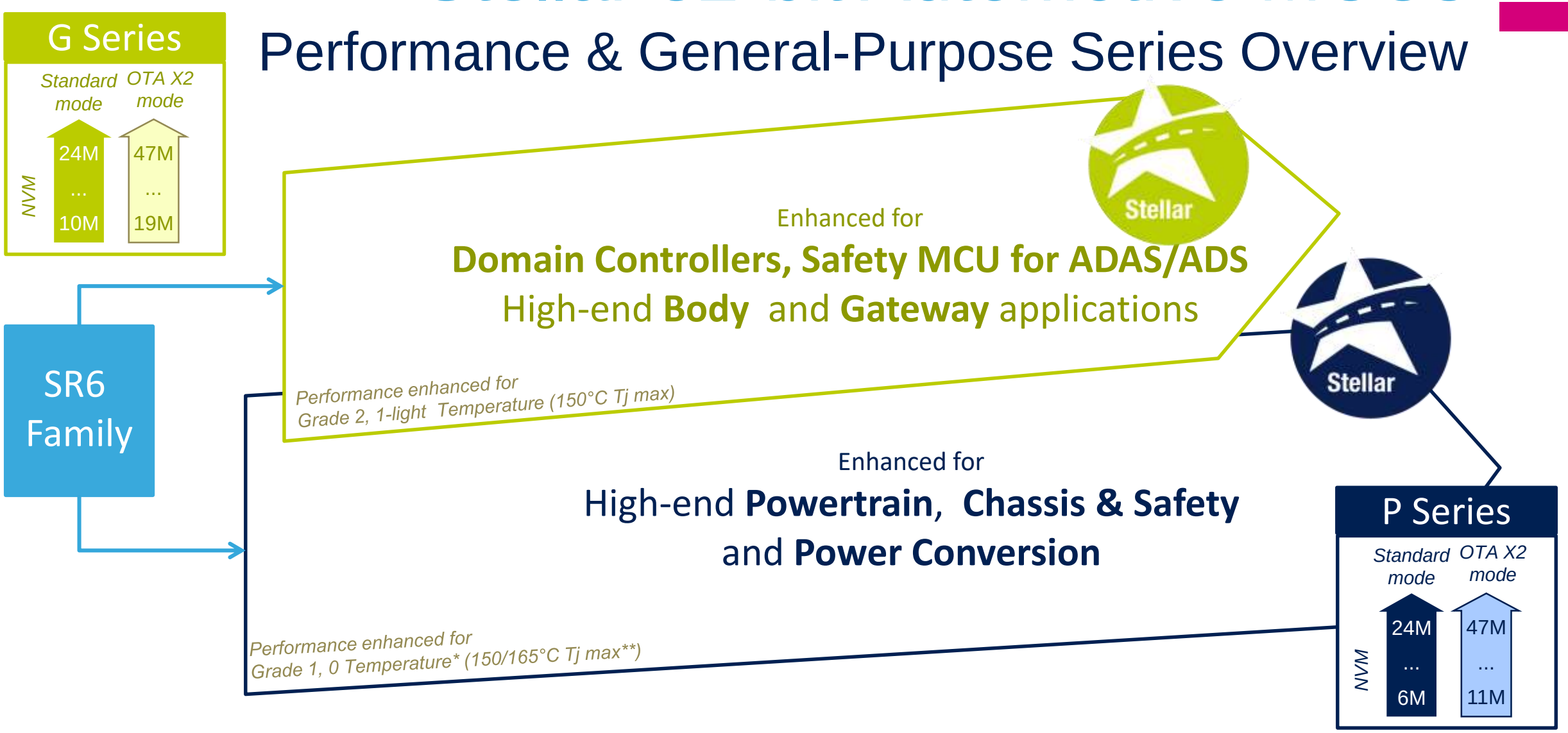
32-bit Automotive MCU Roadmap

Silicon technology	CMOS 90/55/40nm Flash 28nm FDSOI PCM
System, Software	Single to Multicore Full Autosar
Safety, Security	ISO26262 ASIL A-D HSM / SHE+
Quality and Reliability	Top ranking, Zero Defect Strategy
Manufacturing	Flexible and Independent



Stellar 32-bit Automotive MCUs

Performance & General-Purpose Series Overview



*: up to P6 (included). P7 and above as per G Series. Extension can be discussed

**: Product target specification is planned at 150°C Tj max. Functionality (Degraded specification) at up to 165°C will be evaluated.

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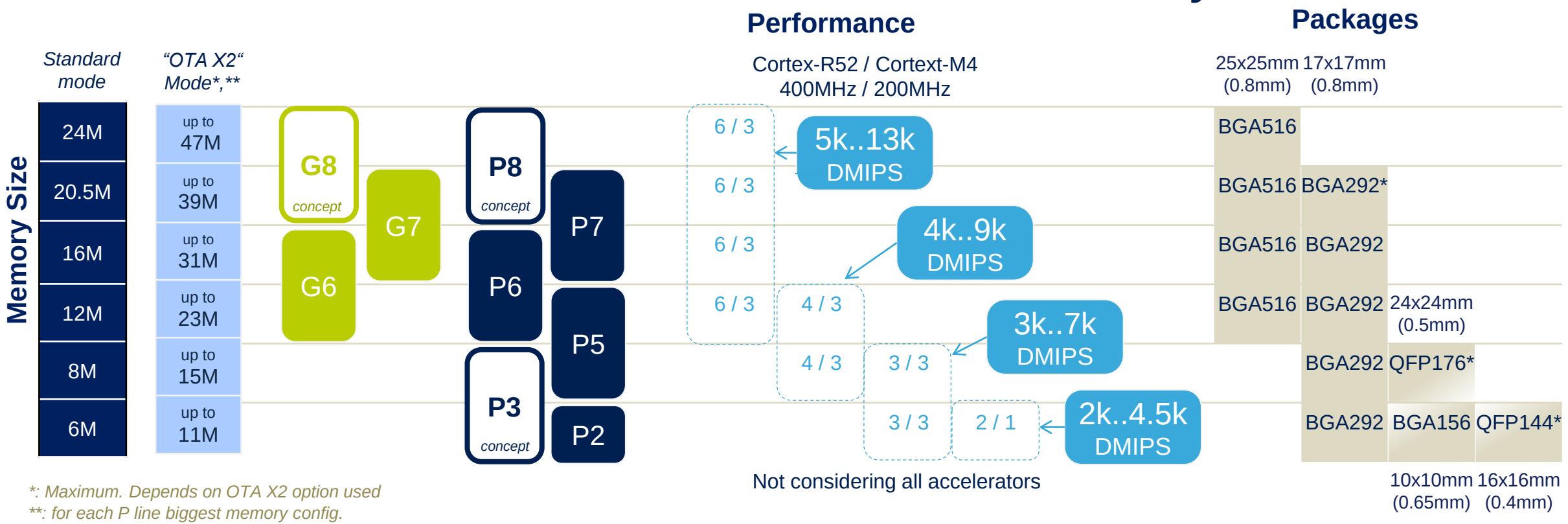
Stellar 32-bit Automotive MCUs

Full Family at a Glance



*: Maximum. Depends on OTA X2 option used
**: for each P line biggest memory config.

*: To be confirmed

Simplified view – for full accurate version please refer to each series presentation

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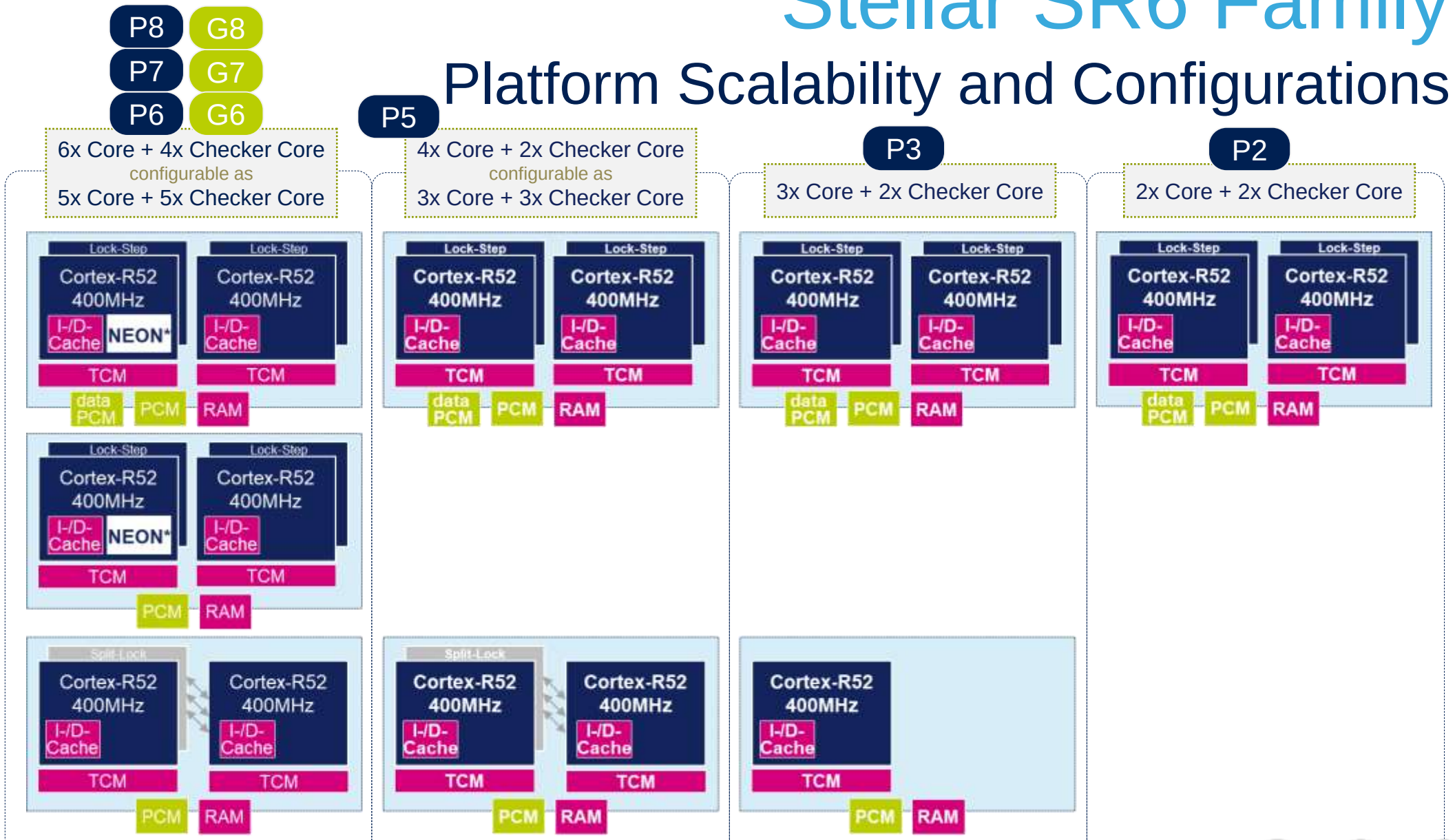
Stellar SR6 Family

Platform Scalability and Configurations



*: except on P6

ST Pioneering Silicon Carbide

…More Than 20 Years of R&D Commitment

Catania: Power Electronics Competence Center

Ecosystem made of Academic **Research Centers** and ST as a semiconductor leader, created a true “incubator”

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Consiglio Nazionale Ricerche

- Everything started from **1’’ wafer**
- More Than **70 Patents** on SiC
- **ST Commitment on SiC**
- Leveraging on **CNR Facilities** at early stage
- **> 30 Years Experience** in Power Semiconductor

ST Milestones

June 1996: Collaboration with Physics Dept.

April 1998: 1st contract on SiC with CNR-IMETEM

May 2002: Schottky Diode Demonstrator (CNR line)

February 2003: ETC Epitaxial reactor prototype installed in ST

May 2004: Schottky Diode Demonstrator (ST)

October 2007: 1st Gen **DIODE Start Production**

March 2009: Power MOSFET 3" Demonstrator

May 2012: 2nd Gen **DIODE Start Production**

June 2014: 3rd Gen **DIODE Start Production**

September 2014: 1st Gen **MOSFET Start Production**

1996 — 2003: 2" ST line — 2006: 3" ST line — 2011: 4" ST line — 2016: 6" ST line — 2016

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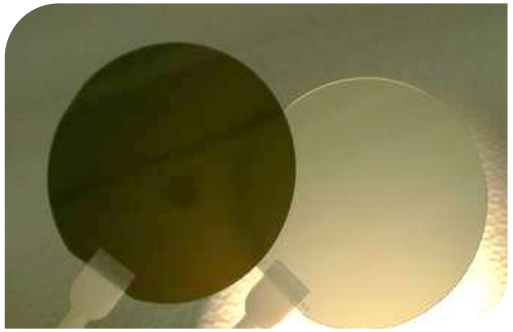

Properties of Silicon Carbide

Ideal for High Power Applications

Property	SiC advantage			
E_g (eV) - band gap	x3	Si	1.1	
		SiC	3.3	
v_{sn} (cm/s) – electron saturation velocity	x2	Si	$1x10^7$	
		SiC	$2x10^7$	
μ_n (cm^2/Vs) – electron mobility	~	Si	1350	
		SiC	950	
e_r - dielectric constant	~	Si	11.8	
		SiC	9.7	
E_c (V/cm) - critical electric field	x15	Si	$2x10^5$	
		SiC	$3x10^6$	
k (W/cm K) - thermal conductivity	x3	Si	1.5	
		SiC	5	

Si
Cubic

SiC
Hexagonal

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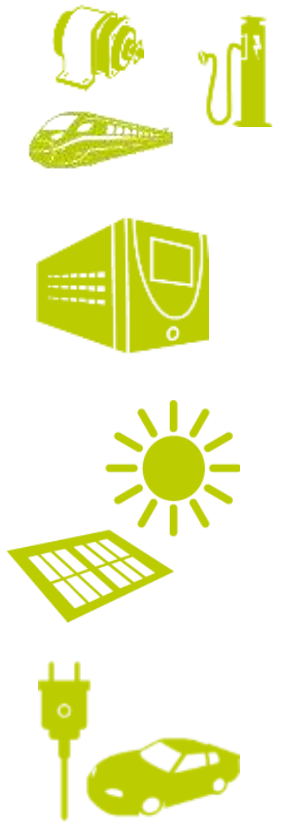
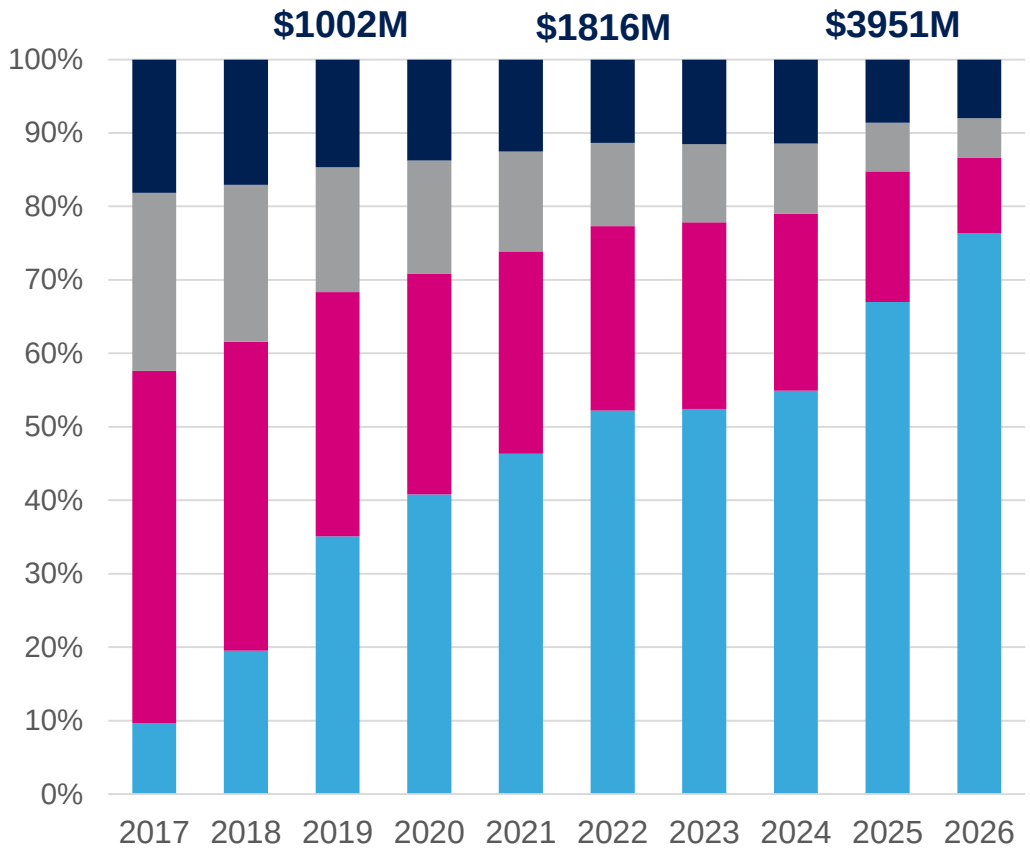
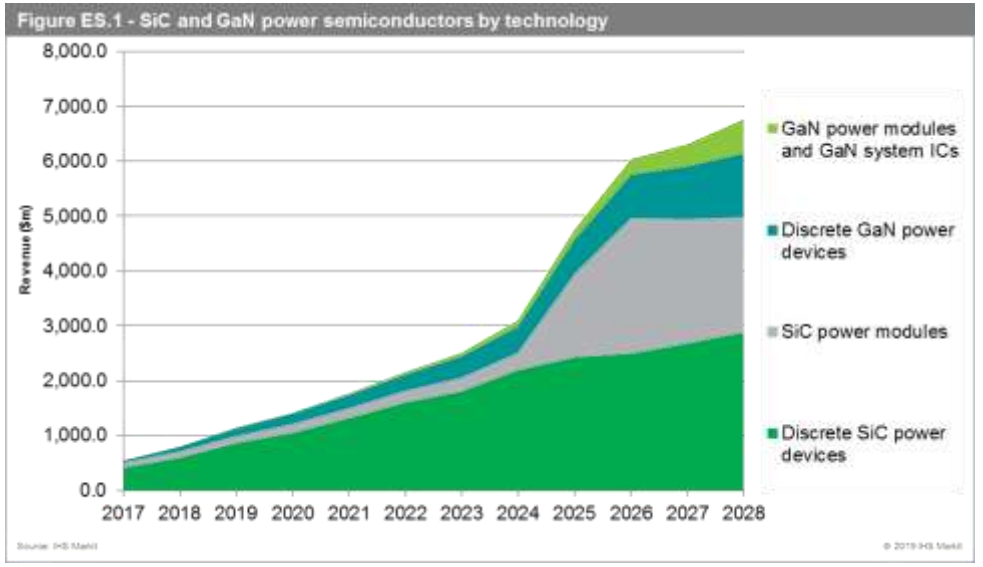
SiC Market Trend by Application







2019 ≈ 160M$(E) *ST SiC MOSFETs*

2023 ≈ 750M$(E) *ST SiC MOSFETs*

Source: IHS Market May 2019

SiC MOSFET Value Proposition

SiC Technology Benefits
SiC vs Conventional Silicon IGBT

Higher Performance & Voltage Operation

- Extremely low power losses
- High efficiency at low current
- Intrinsic SiC body diode (4 quadrant operation)

Higher Operating Frequency

- Lower switching losses
- Excellent diode switching performance

Higher Operating Temperature

- Operating up to 200°C junction

SiC Advantages for Automotive

Electrification - mileage extension, smaller battery (or increased battery reliability), fast & efficient charging

Efficiency gain in average	Switching losses	Chip size	Total loss	Switching frequency
From ~2% (high load) to ~9% (low load)	~7x lower	~5x smaller	~50% lower	~ 5 ..10 times higher

Lower System Cost

~7x reduced form factor	~80% cooling system down sizing	~Simpler Sub-systems: smaller passives, no external freewheeling diode…

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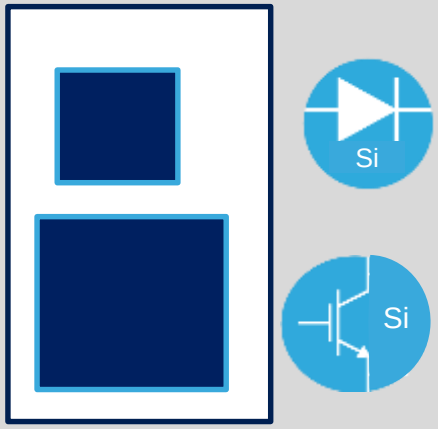
Traction Inverter

SiC MOSFET Vs. Si IGBT

Higher Efficiency for Extra-mileage (Traction Inverter)

Si Solution: IGBT+ Diode

3x75 mm² + 3x50 mm²



4x100 mm² + 4x50 mm²

SiC Solution: Gen3 technology

6x20 mm²

~ 3x smaller semiconductor area

~ 5x smaller semiconductor area

6x20 mm²

400V DC Bus

750V DC Bus

Vbus = 400V 160kW peak, IM=0.5

From 2 to 4.5% higher efficiency

Si IGBT → **SiC MOSFET**

From 3.5 to 8.5% higher efficiency

Vbus = 750V 210kW peak, IM=0.5

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SiC MOSFET Application Savings

Electric Vehicle

+300$
SiC Additional Cost

~2000$
Estimated Saving

Main Saving Contributors

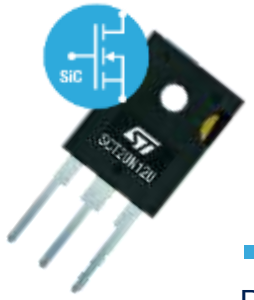
Battery Cost: up to 600$

EV-Space: up to 600$

Cooling: up to 1000$

…and 50% Charging time reduction

Solar Inverter



x5
Switching Frequency

-50%
Power Losses

-20%
System Cost Saving

Main Saving Contributors

Footprint: up to 70%

Weight: up to 80%

Installation Cost: 50% cut

…100% adoption in 10 years

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Source: Goldman Sachs, Nov 2018

SiC MOSFET Roadmap

1st Gen

Planar Technology
1200 V (11mΩ*cm2 0-300kHz)
1700 V (12mΩ*cm2 0-300kHz)

x2 shrink

2nd Gen

Planar Technology
650 V (4mΩ*cm2 0-500kHz)
1200 V (5.5mΩ*cm2 0-500kHz)

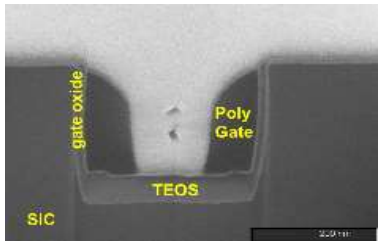
x4 shrink

3rd Gen

Planar Technology
1200 V (3.3mΩ*cm2 0->500kHz)
750 V (2.4mΩ*cm2 0->500kHz)

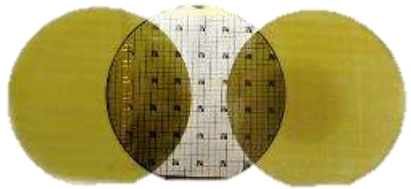
2014 — 2016 — 2018 — 2020

Next Gen



Trench Technology

6” Wafer



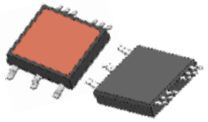
Bare die

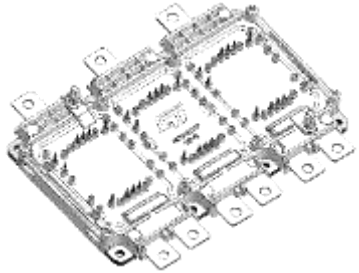
H2PAK-7 **TO220-FP** **High Power**

New coming

Single/Dual-die **Packages**

ACEPACK 1 **ACEPACK 2** **ACEPACK SMIT** **ACEPACK DRIVE**





Multi-die Power **Modules**

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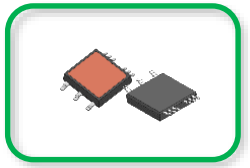
ACEPACK

Automotive-Grade Power Module Roadmap

Industrial

SMIT



Traction Inverter

Heater, Aircon

A1

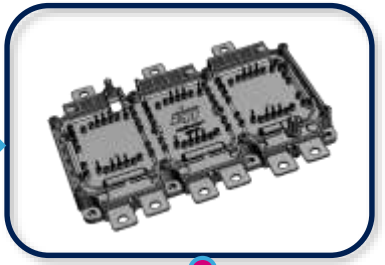
On Board Charger
DC-DC Converter

Charging Station

A2

Traction Inverter

DRIVE



2019

2020

2021

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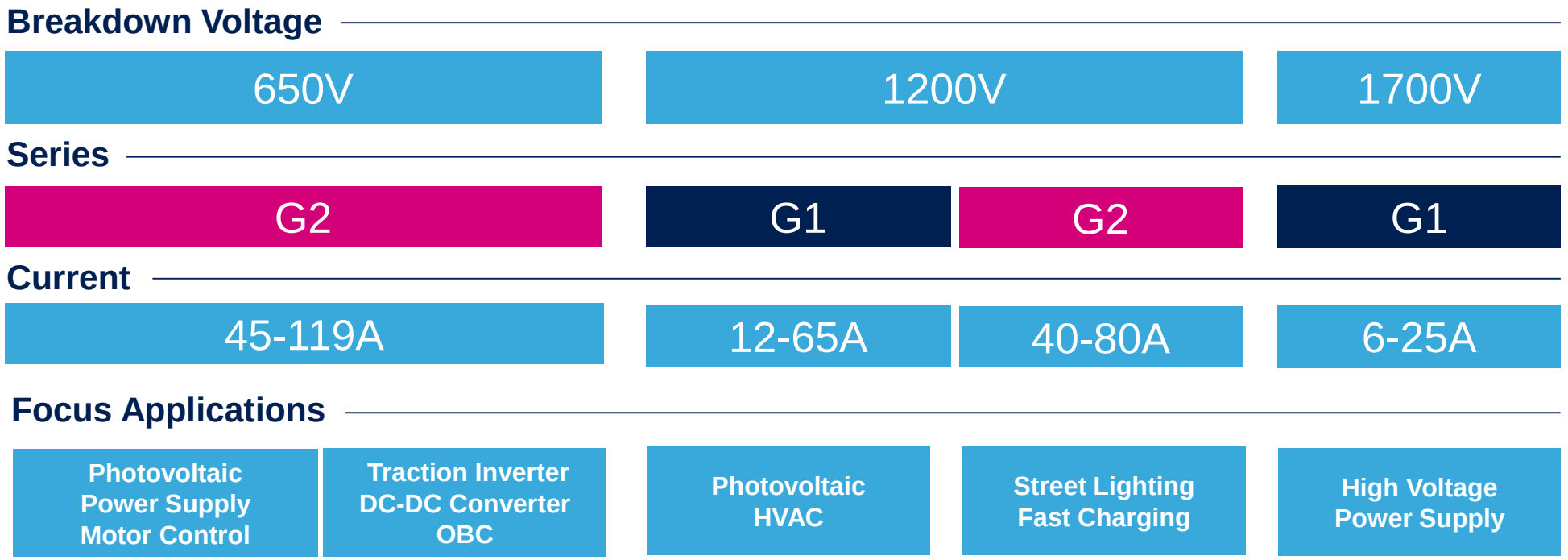
SiC MOSFET Series Positioning



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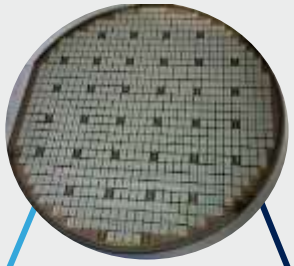
SiC Diode Technology

Increased Power Conversion Efficiency

Energy savings generated by sustainable technology

Power Losses

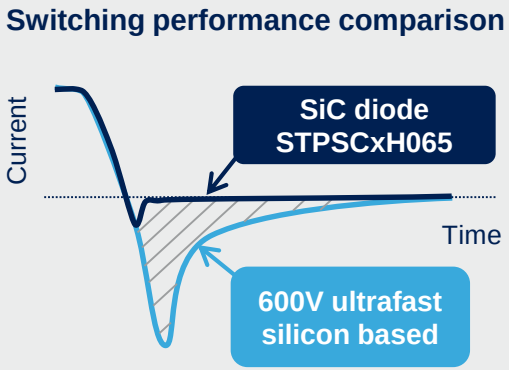


Recovery Losses

Conduction Losses

Si-based ultrafast diodes

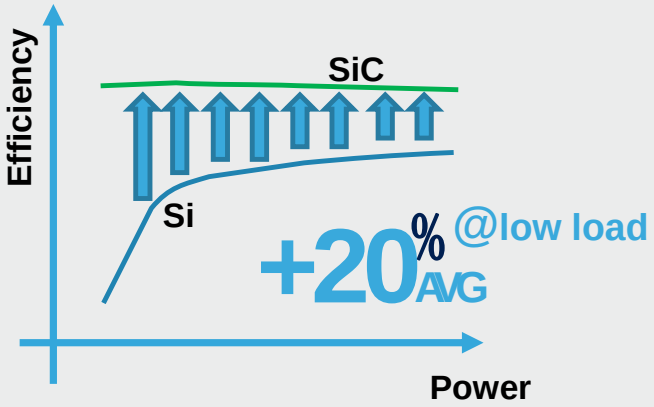
Eliminate Recovery Losses



SiC-based diodes

Reduced Dimensions

- 60%



More efficient power conversion

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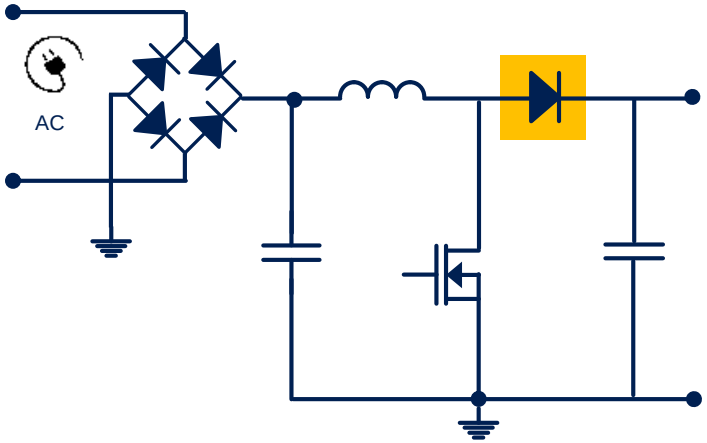
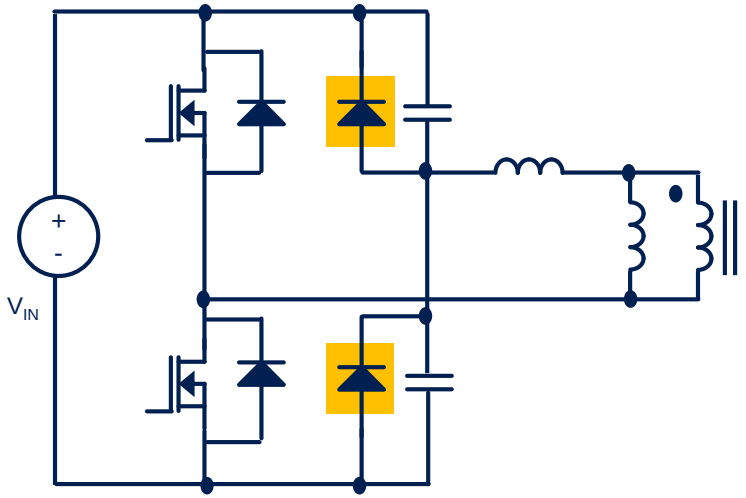
Typical Circuits

650 V SiC Diodes

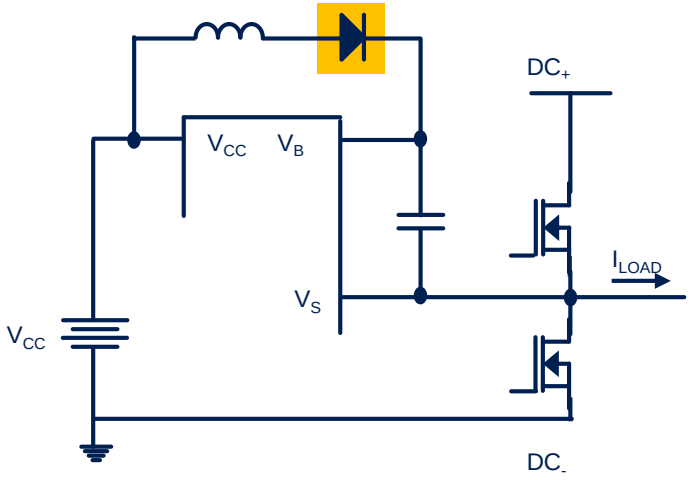
PFC Boost Diode	Clamping Diode	Bootstrap Diode



Single, Interleaved, Bridgeless,
Totem-Pole Configurations



Primary or Secondary Side
Half or Full Bridge Phase Shift



Floating Supply
at High or Low Side Driver

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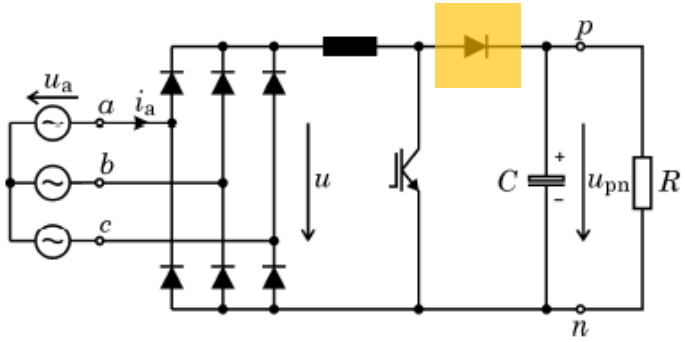
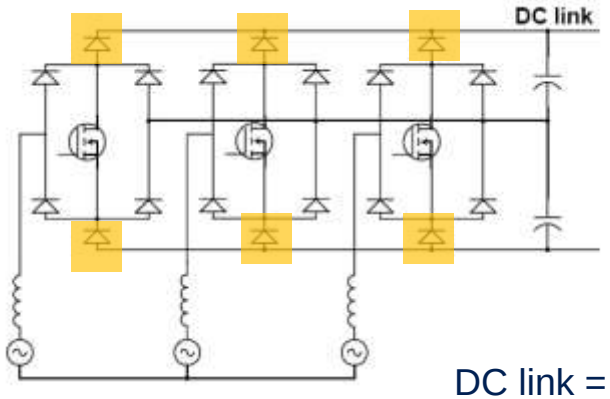
Typical Topologies

1200 V SiC Diodes

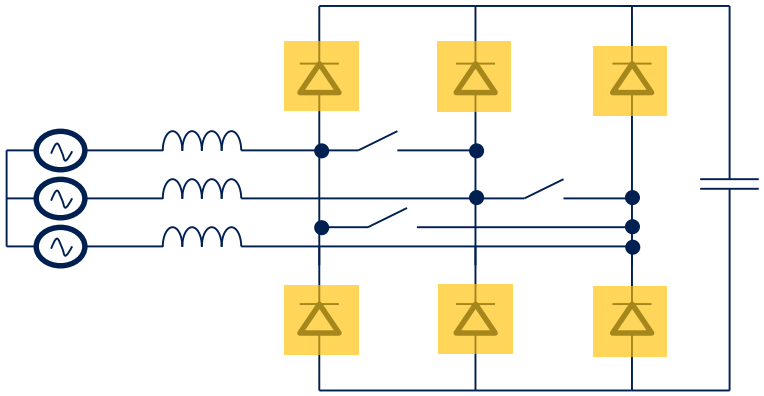
Standard three phase PFC	Vienna Topology	3-phase PFC mixed voltage 3 levels



V_{BOOST} = 800 V



DC link = 800 V



V_{DC} = 800 V

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Low Forward Voltage SiC Diodes

Automotive Grade - STPSCxx065-Y

Root Part number	$I_{F(AV)}$	V_F [V] max (per diode) I_0		I_{FSM} [A] (per diode)		I_R [µA] (per diode)	Q_{cj} [nC] (per diode)	Package									Samples	Qualification
		25°C	150°C	10µs 25°C	10ms 125°C	Vr=650V 150°C	V_R=400V	TO-220AC	TO-220AB	DO-220I	DO-247	TO-247	D2PAK HV	D²PAK	DPAK	I²PAK		
SiC auto 650V																		
STPSC8065-Y	8 A	1.45	1.65	200	38	750	28										√	√
STPSC10065-Y	10A			210	39	900	34										√	√
NEW **STPSC12065-Y**	12 A			220	40	1000	36										√	√
STPSC20065-Y	20 A			400	70	2000	62										√	√
STPSC40065CWY	2x20A			400	70	2000	62										√	√

In mass production
New
Under development

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High Surge Capability SiC Diodes

Automotive Grade: STPSCxxH065 -Y

Root Part number	$I_{F(AV)}$	V_F [V] max (per diode) I_0		I_{FSM} [A] (per diode)		I_R [µA] (per diode)	Q_{cj} [nC] (per diode)	Package									Samples	Qualification
		25°C	150°C	10µs 25°C	10ms 125°C	Vr=650V 150°C	V_R=400V	TO-220AC	TO-220AB	DO-220I	DO-247	TO-247	D2PAK HV	D²PAK	DPAK	DPAK HV		
SiC auto 650V																		
STPSC2H065B2Y	2 A	1.55	1.95	140	18	84	7.9										√	**Q3-19**
STPSC6H065BY	6 A	1.65	2.05	400	52	250	18										√	√
NEW **STPSC8H065BY/G2Y**	8 A	1.65	2.05	420	69	335	23.5										√	√
STPSC10H065-Y	10 A	1.75	2.5	470	80	425	28.5										√	√
STPSC10H065BY	10 A	1.65	2.05	470	80	425	28.5										√	√
STPSC12H065-Y	12 A	1.75	2.5	400	90	500	36										√	√
STPSC20H065C-Y	2 x 10 A	1.75	2.5	470	80	425	28.5										√	√

In mass production
New
Under development

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1200 V SiC Diodes

Automotive Grade: STPSCxxH12-Y

Root Part number	$I_{F(AV)}$	V_F [V] max Per diode $I_F = I_0$		I_{FSM} [A]		I_R [µA] max	Q_{cj} [nC] typ	Package					Samples	Qualification
		25°C	150°C	10µs 25°C	10ms 25°C	Vr=650V 150°C	V_R= 800V	TO-220	DPAK HV	D²PAK	D²PAK HV	TO-247		
STPSCxxH12-Y														
STPSC2H12-Y	2 A	1.5	2.25	105	15	80	15.6						**Q3-19**	**Q1-20**
STPSC5H12-Y	5 A			210	35	200	36						**Q3-19**	**Q1-20**
STPSC10H12-Y	10 A			420	71	400	57						**Q3-19**	**Q1-20**
STPSC15H12DY	15 A			630	105	600	94						√	√
STPSC20H12-Y	20 A			700	140	800	129						√	**Q2-19**
STPSC20H12CWY	2 x 10 A			420	71	400	57						√	√

NEW

In mass production
New
Under development

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Superjunction MDmesh™
Next step for future

MDmesh™ M9/DM9

High voltage MDmesh™ M9/DM9 STPOWER™
Permits to increase High power density e compactness system thanks to low on-state losses per silicon area combined to low Qg and low switching losses in wide range of packages offering also very efficient SMD solution
Tech: MOSFET 600-650V

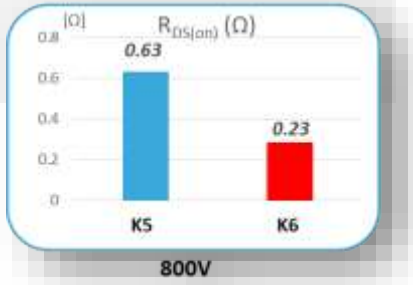
- 650V Enabler for Very High Power PFC
- 600V Enabler for half bridge topology with FAST diode

Less weight → more performance and power/weight ratio

600V	TO-LL	650V
28mΩ		33mΩ

MDmesh™ K6

High voltage MDmesh™ K6 STPOWER™
Industry's lowest $R_{DS(on)}$ in the Very High Voltage Market (<50% than K5 Series)
Zener diode G-S to improve ESD performance
High switching speed
850V BVdss rated
(Enabler for Flyback topology)



Package form factor reduction


SOT223-2L


PowerFLAT™ 5x6 VHV

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Super Junction Technologies Scenario

Application / Topology Positioning

PTD Product Families for SMPS

Power Factor Corrector

M5
- ***MDmesh™ M2***
  - ✓ *400V-650V*
- ✓ ***MDmesh™ M5***
  - ✓ *250V-650V*
- ✓ ***MDmesh™ K5***
  - ✓ *800V – 1500V*

DC-DC / AC-DC

M2
- ***MDmesh™ M2***
  - ✓ *400V-650V*

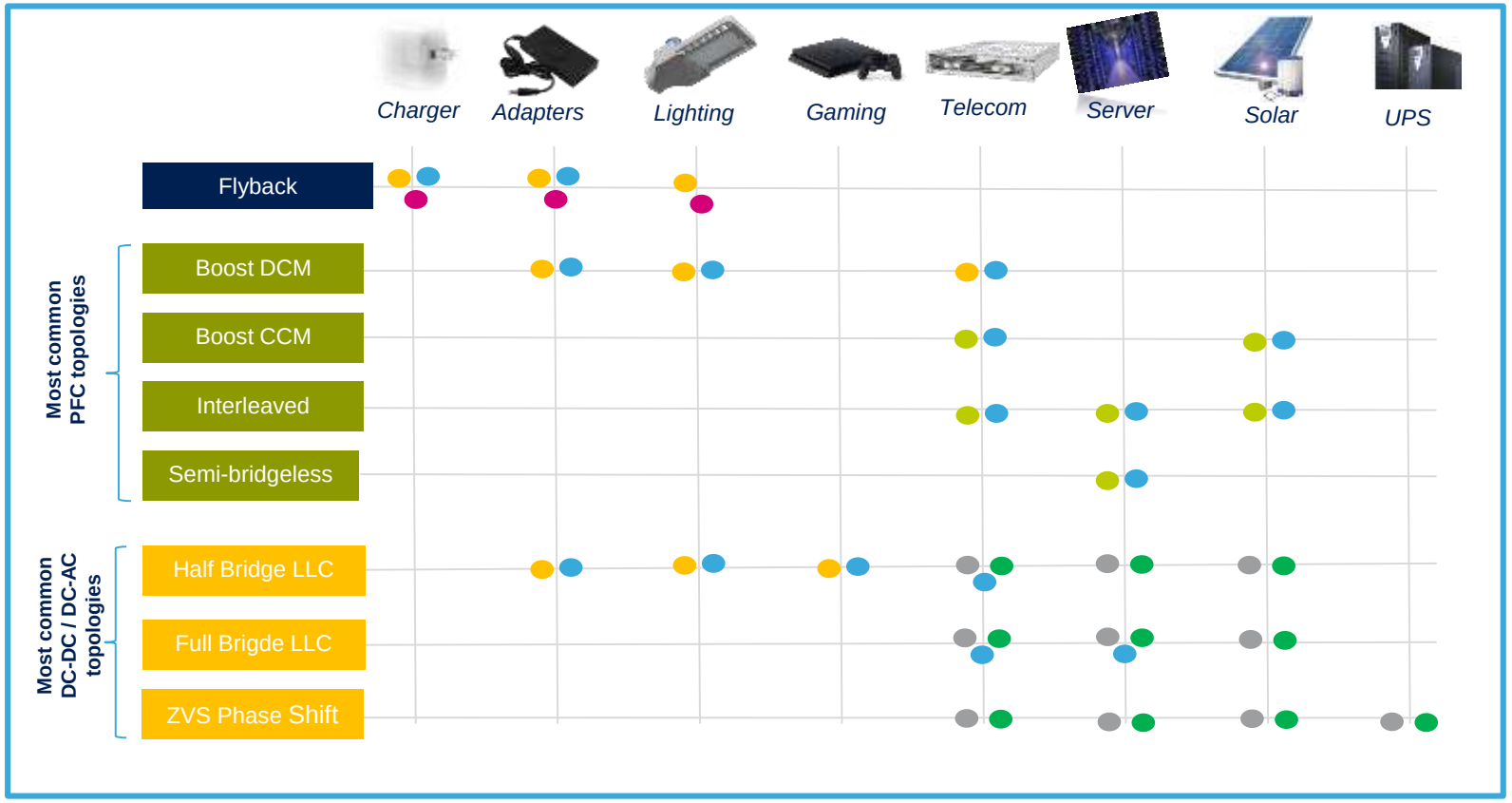
M6
- ***MDmesh™ M6***
  - ✓ *600V*

DM2
- ***MDmesh™ DM2***
  - ✓ *400V – 650V*

DM6
- ***MDmesh™ DM6***
  - ✓ *600V – 650V*

Aux Power Supply

K5
- ***MDmesh™ K5***
  - ✓ *800V – 1500V*



- Technologies tailored for application
- Complete product range (250V → 1500V)
- Multiple package options (SMD and Through hole)


TO-220


PowerFLAT™ 8x8 HV

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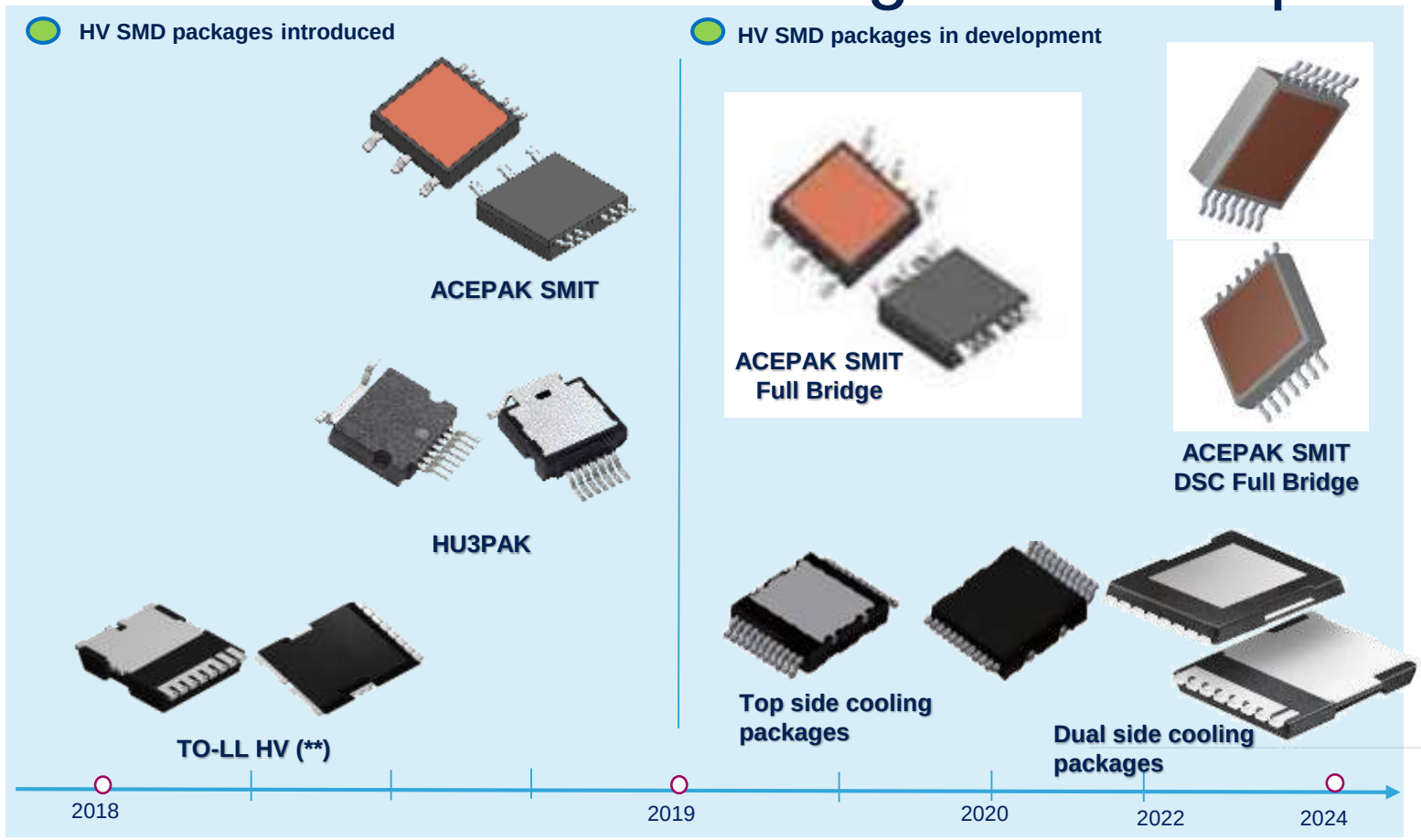
HV Power MOSFET

Package Roadmap

HV SMD existing packages

- ISOTOP ®
- PowerFLAT™ 8x8 HV
- D2PAK
- H2PAK
- PowerFLAT™ 5x6 VHV
- PowerFLAT™ 5x6 HV
- DPAK
- PowerFLAT™ 3.3x3.3 HV
- PowerFLAT™ 5x6
- PowerFLAT™ 5x5
- SOT223-2L
- DIP-8



Under feasibility study

Version: HV 19.05.1

(**) HV single island (with source kelvin contact)

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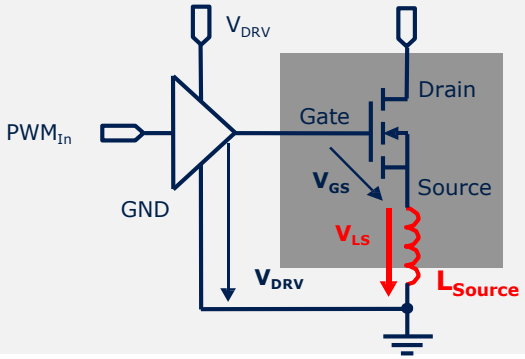
TO-LL

Features and Benefits

Features

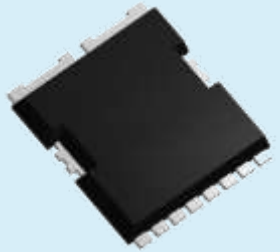
- 30% Reduced Space on Board vs D2PAK
- Added kelvin source
- Reduced thickness (2.3mm)
- High creepage (distance 2.7mm)

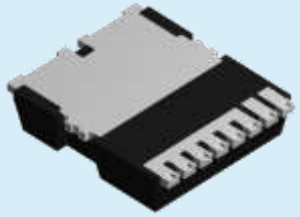
Parasitic source inductance



current variation generates an overvoltage that decreases the efficiency due to slow down of transient

Top view





Bottom view

HV single island with kelvin source contact

Benefits

- Increased Power Density

  (M6/DM6 600V 75mOhm, M9 600V 28mOhm, M9 650V 33mOhm)
- Improvement in Turn on / Turn off efficiency
- Compact Telecom SMPS solution
- MOSFET BVdss from 600V up to 850V

Application analysis

TO220 vs. TO-LL

1000W PFC

80mΩ 600V MDmesh M6 same die size

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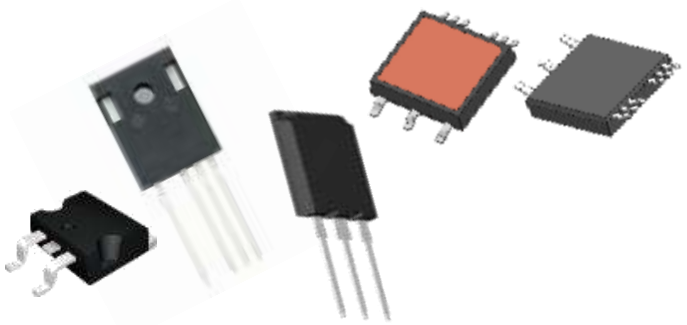
IGBT & IPM

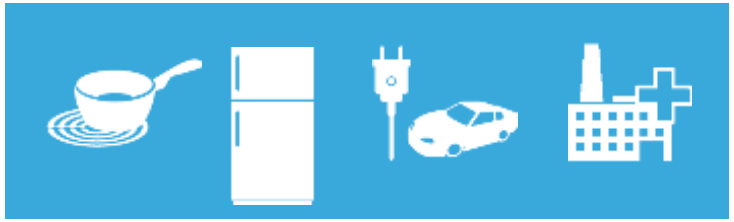
Power Product Portfolio

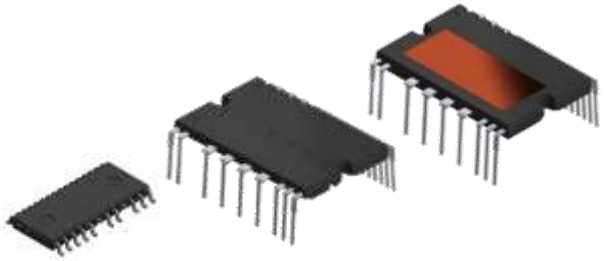
From Discrete to Power Modules, ST leads the innovation



Discrete packages

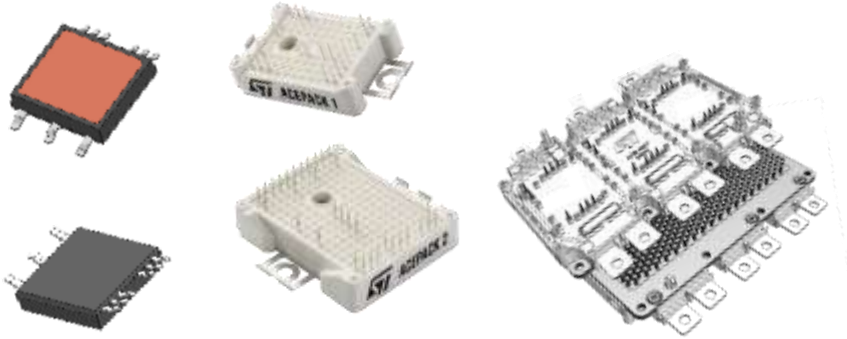
Typical power: 10 W to 5 kW





SLLIMM™ IPM

Typical power: 20 W to 3 kW



ACEPACK™ Power Modules

Typical power: 3 to 300 kW

Ideal solutions for

Industrial & Robotic Drives, Home Appliances, Welding, Pumps, Fans & Blowers, Air Conditioning, and EV

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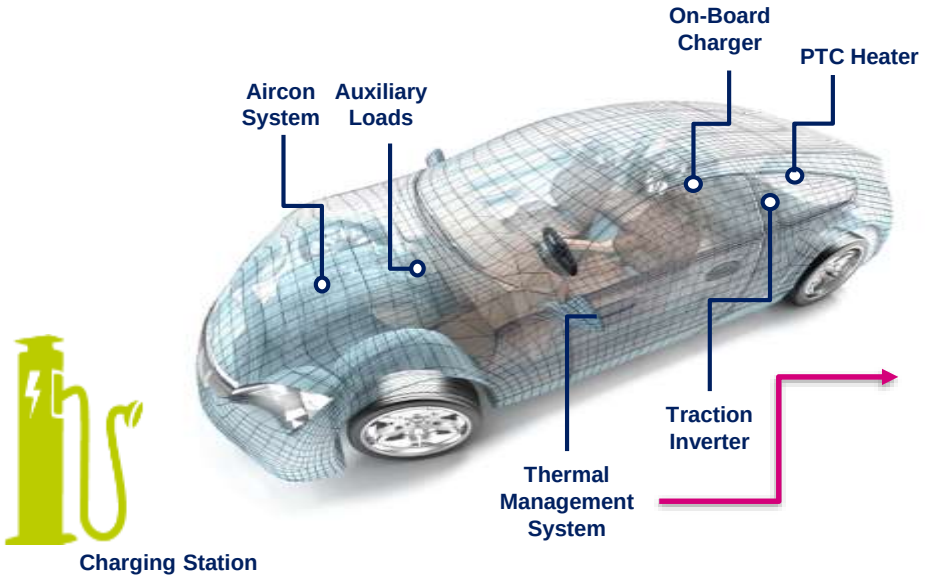
IGBT Application Focus

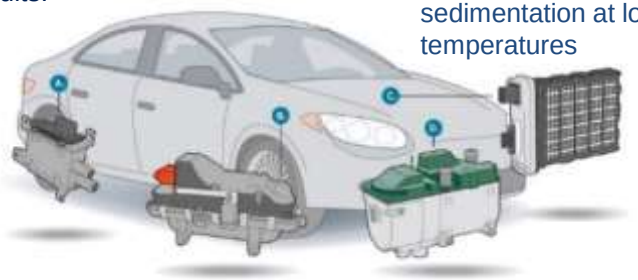


A. Battery Heater
Battery energy ensured by heating management event at cold temperatures

B. Water Heater
Can be integrated with existing cooling water circuits.

C. Air Heater
Enable the passenger compartment to warm up quickly

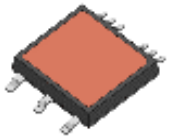
D. Fuel Heater
Warms up fuel to prevent sedimentation at low temperatures



Broad range offer

TO247 3 Long-Lead | *TO247 4L Long-Lead* | *MAX247 Long-Lead* | *H2PAK-2* | *HiPower*

HU3PAK | *Bare die*



ACEPACK SMIT (SMD – Top side cooling)

SLLIMM 2nd (FM, DBC, Nano)
For Aircon System

ST offer

NM2 Series (750V) – in development	**Inverter Traction,**
M Series (650V) **MS Series (1200V)**	**PTC Heater and Air-conditioning system**
HB & HB2 series (650V) **V series (600V) with SiC diode copack** **H series (1200V)**	**On Board Charger , DC/DC Charging Station**

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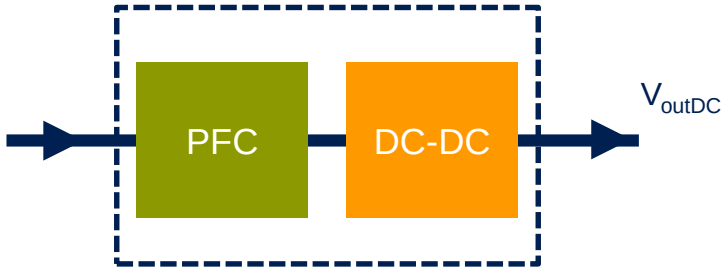
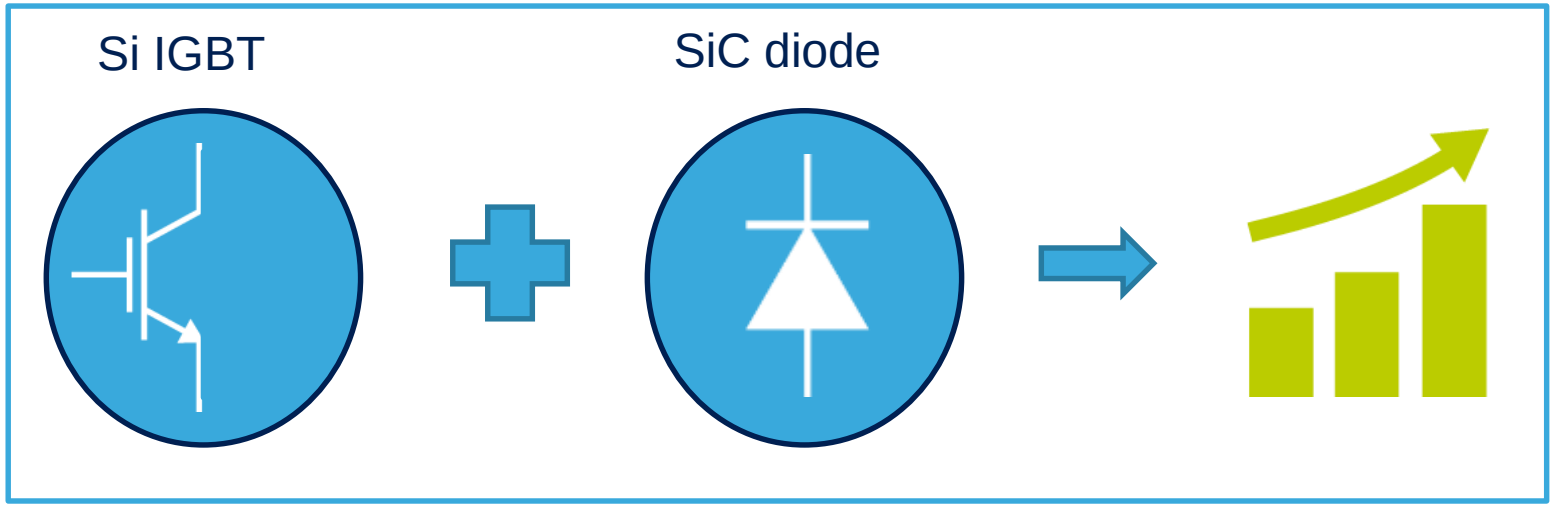
IGBT + SiC Solution

OBC & DC-DC in (H)EV CAR

600V series with SiC co-packed diode

Main power stages block diagram





STGWA60V60DWFAG

Designed for automotive applications in DC-DC converters and totem pole PFC

- Maximum junction temperature : T_J = 175 °C
- $V_{CE(sat)}$ = 1.85 V (typ.) @ I_C = 60A
- Silicon Carbide diode with no-reverse recovery charge is co-packaged in freewheeling configuration

Optimum compromise between conduction and switching losses to maximize the efficiency of very high frequency converters.

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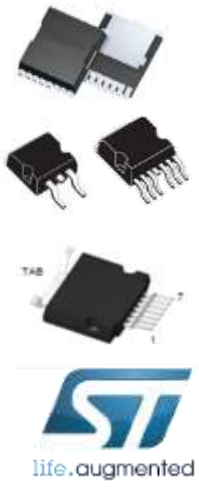
IGBT: 650V M Series

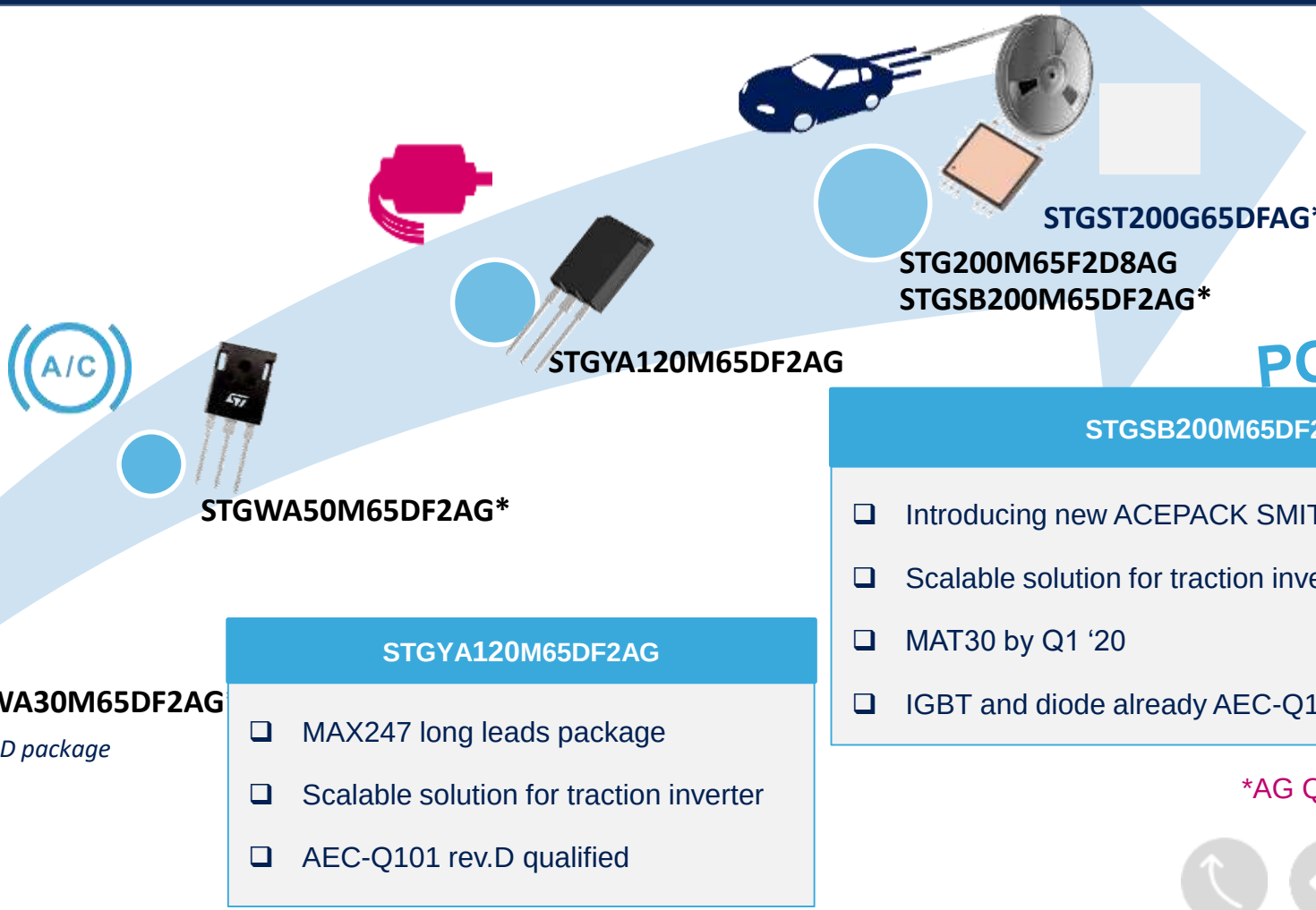
Automotive-grade Devices

Increasing Power Range Coverage

STGWA30M65DF2AG
STGWA50M65DF2AG

- TO-247 long leads package
- Suitable for AirCon and PTC heaters
- AEC-Q101 rev.D qualified by:
  - 30A: Q1 ‘20
  - 50A: Q1 ‘20





Feasible in discrete SMD package

STGYA120M65DF2AG

- MAX247 long leads package
- Scalable solution for traction inverter
- AEC-Q101 rev.D qualified

STGSB200M65DF2AG

- Introducing new ACEPACK SMIT power module
- Scalable solution for traction inverter
- MAT30 by Q1 ‘20
- IGBT and diode already AEC-Q101 rev.D certified

*AG Qualification on-going

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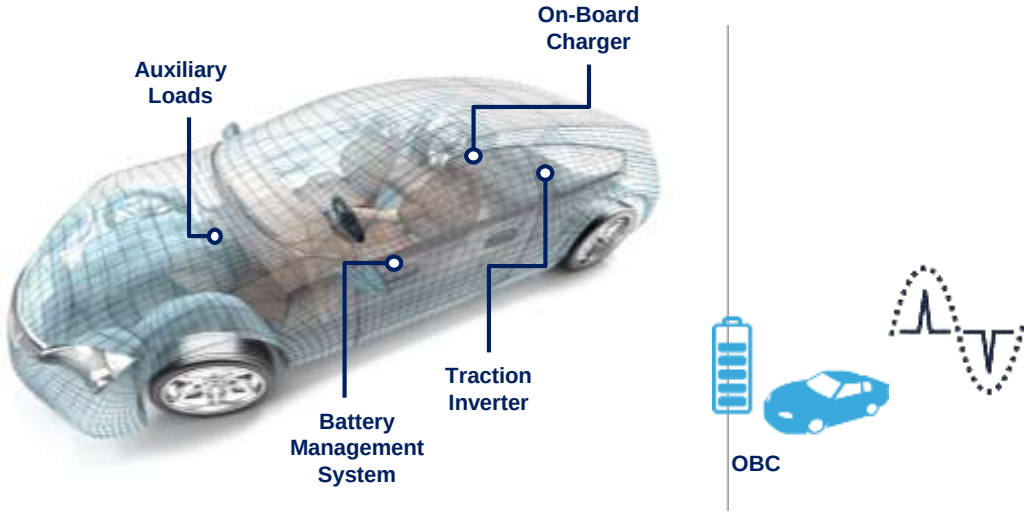
Discrete IGBTs

On-Board Chargers and Charging Stations



Package offer

TO-247 Long Lead

TO247-4 Long Lead

H2PAK-2

HB series product portfolio

STGH30H60DFB-2AG

STGH30H65FB-2AG

STGH30H65DFB-2AG

H2PAK-2

30A 650V HB series product portfolio:

- **Z2PAK-2 package for improve creepage/clearance**
- **Available with and without co-packaged diode**
- **To be used in PFC/boost and DC/DC portion**
- **AEC-Q101 qualification during Q1 2020**

New 650V HB2 series product benefits:

- **Automotive eligible**
- **Improved gate charge for faster switching**
- **Improved efficiency in final application**

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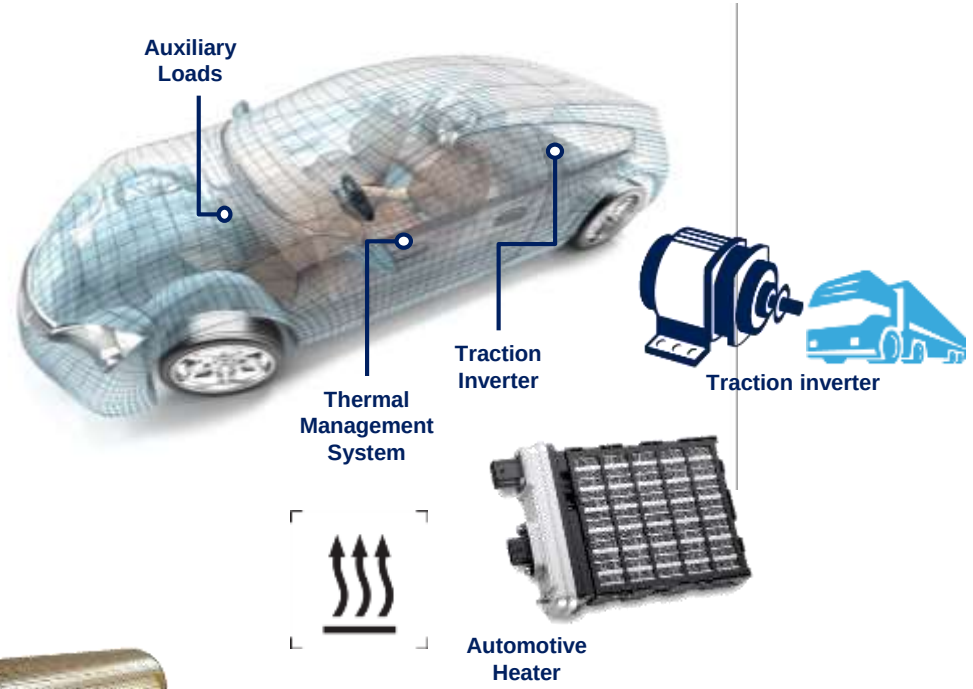
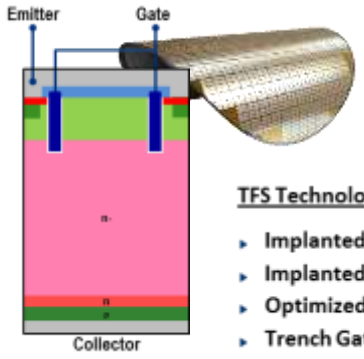
1200V Automotive Grade MS Series

Discrete IGBTs





TFS Technology Milestones

- Implanted Back Emitter
- Implanted Field Stop
- Optimized P-N-P BJT
- Trench Gate
- Thin wafer thickness

TFS Technology Benefits

- Lower E_{OFF} due to improved minority carrier recombination
- High switching robustness (Large RBSOA)
- Lower $V_{CE(sat)}$
- Lower R_{TH}

(*)In development

ST offer

GWA40MS120(D)F4AG(*)

- To be used as first technological test vehicle
- 25A and 15A in roadmap

TO-247 Long Lead

1200V "MS" series main targets:

- 175°C of max operating junction temperature (TJ)
- Min 5µs of short circuit rating at start T_J of 150°C, V_{BUS} = 800V, V_{GE}=15V
- 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 for easier paralleling
- Thin IGBT die for a better thermal resistance
- Tailored for traction inverter and thermal management systems.

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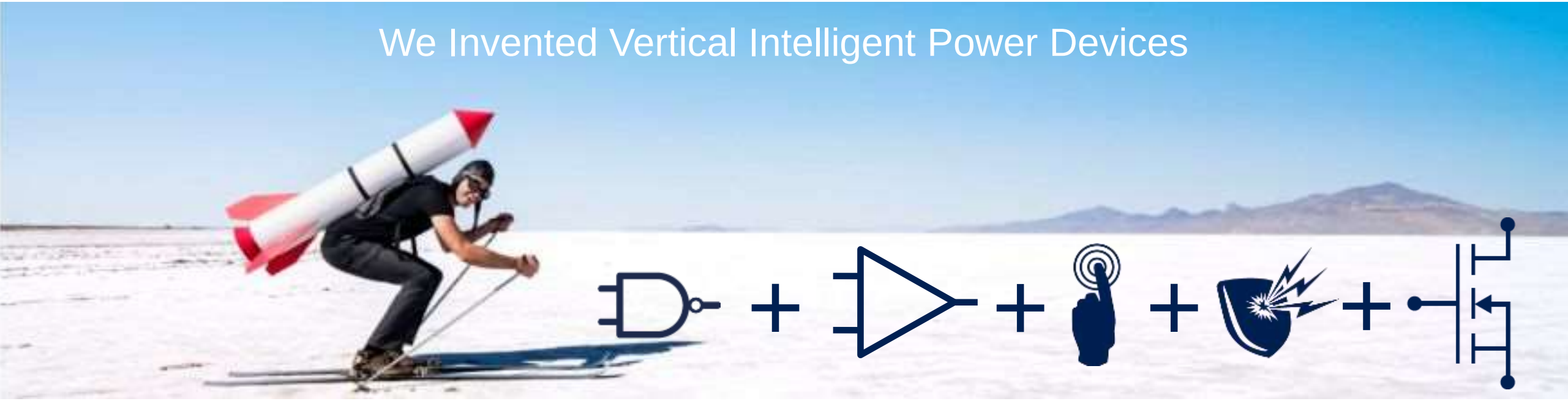
VIPower®

Inventors by Nature



VIPower®

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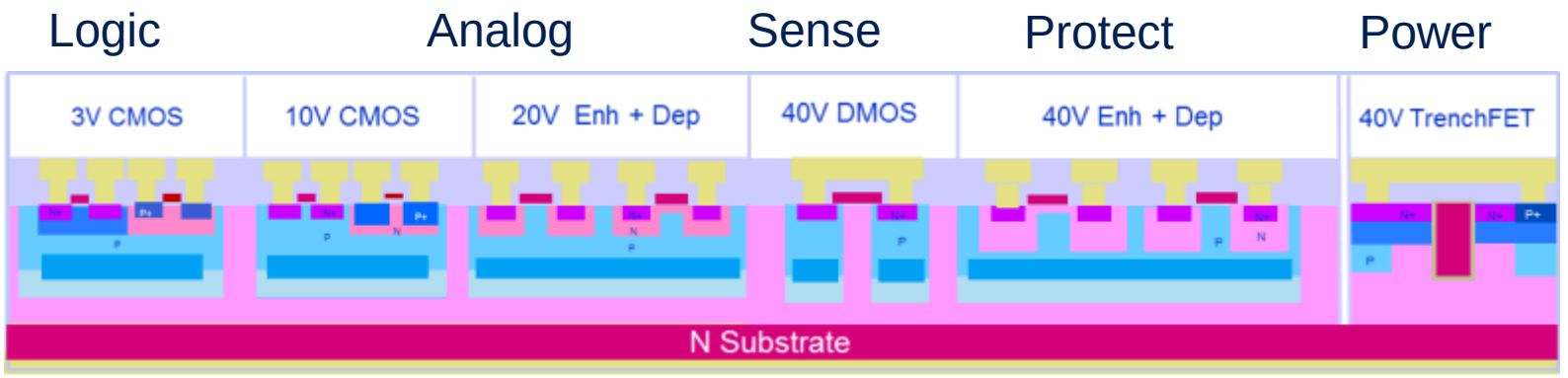

VIPower® M0-7/M0-7E

High Side Drivers Portfolio Overview

VIPower® M0-7 / M0-7E

VIPower® Zero

Four output channels

VNQ7E110AJ

VNQ7140AJ | VNQ7050AJ | VNQ7040AY

Two output channels

VND7E070AJ | VND7E040AJ | VND7E025AJ

VND7140AJ (*) | VND7050AJ (*) | VND7040AJ | VND7030AJ | VND7020AJ | VND7012AY | VND7004AY

One output channel

VN7E010AJ | VN7007ALH | VN7004CLH | VN7003ALH (*)

VN7140AJ | VN7050AJ | VN7040AJ | VN7020AJ | VN7016AJ | VN7010AJ | VN7008AJ | VN7007AH | VN7004CH | VN7003AH (*)

VN7140AS (*) | VN7050AS | VN7040AS

On-state resistance

140mΩ	50mΩ	40mΩ	30mΩ	20mΩ	16mΩ	12mΩ	10mΩ	8mΩ	7mΩ	4mΩ	3mΩ
2.5A	4A	4.5A	5A	6A	7A	9A	9.5A	10A	13A	17A	20A

PSSO-36 | PSSO-16 | Octapak | SO-8 | M0-7E series (PSSO-16)

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(*) Cold cranking capability on specific part numbers in PSSO-12

M0-9 SPI High Side Drivers

Welcome to Digital Current Sense

- Worlds first family of power HSDs with **Digital Current Sense**
- The **best current sense accuracy** ever reached in a High Side Driver
- The first with **Integrated PWM generation** and **sampling synchronization unit**
- Footprints up to **42% smaller** than the best competitor

Applications

Product line

QFN32L 6x6

4 channels	6 channels
VN9D5D20F	VN9D30Q100F
VN9D7D20F	VN9T25T70F
	VN9Q25D70F
	VN9E30F

M0-9 Standard High Side Drivers

Lower $R_{DS(on)}$, Smaller Packages

- M0-9 Standard further extends the largest family of HSDs in the market
- Full **pin-to-pin** and SW compatible with M0-7
- The **best current sense accuracy** ever reached in a High Side Driver
- Incorporated **self turn on** in reverse battery conditions

VIPower HSDs

Applications

Product line

PowerSSO-16

1 channels	2 channels	4 channels
VN9004AJ	VND9800AJ	VNQ9025AJ
VN9006AJ	VND9012AJ	VNQ9080AJ
VN9008AJ	VND9016AJ	
VN9012AJ	VND9025AJ	
VN9016AJ		

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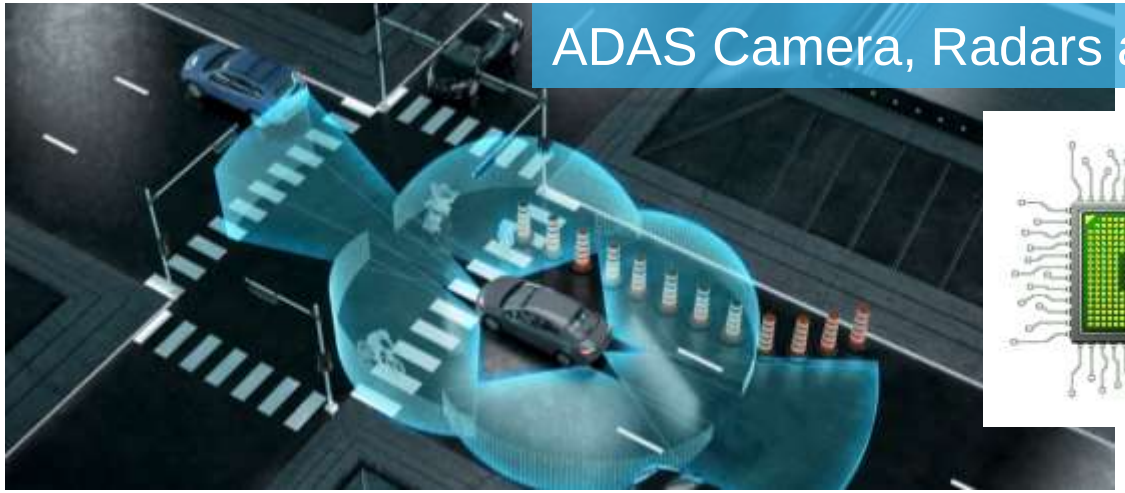
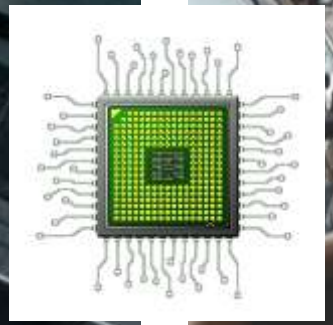
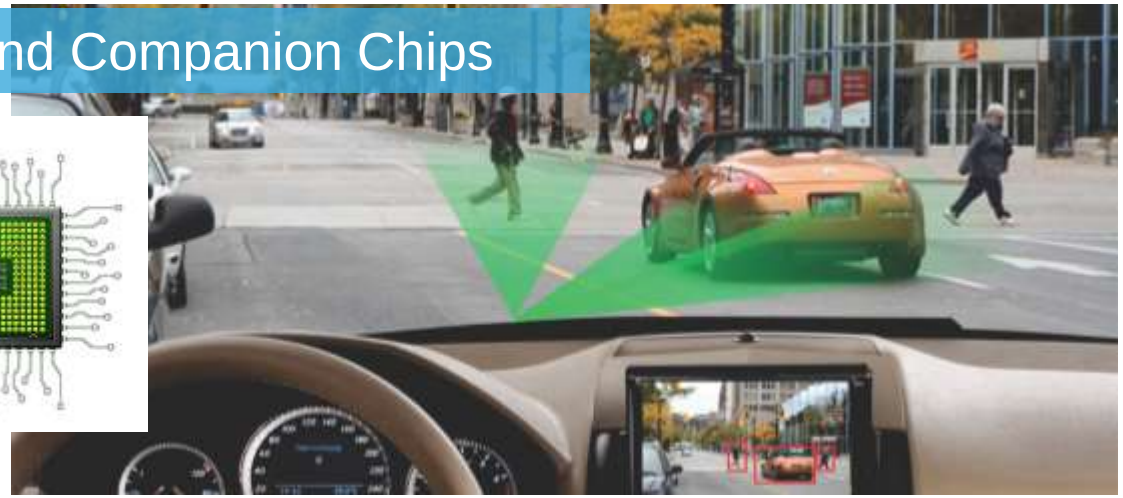
Power Management Focus



ADAS Camera, Radars and Companion Chips





USB Power Delivery

Infotainment

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Infotainment and ADAS Power Supply

Product Roadmap

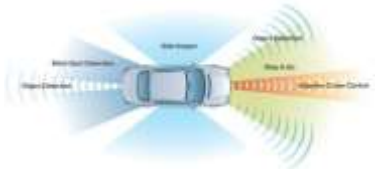
L5963

Dual monolithic switching regulator with LDO and HSD (3A x 2 + 250mA)

2016

ADAS L5965

Multiple power management for automotive **vision and radar** systems ISO26262



2018

L5964

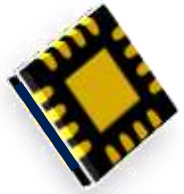
Dual monolithic switching regulator with LDO and **watchdog, reset** (3.5A x 2 or 7A + 250mA)

2019

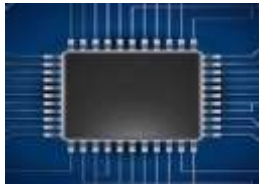
NEW ADAS PMIC

Second generation ADAS PMIC

2020



Multiple power management for automotive **cameras** (ADAS) Targeting QFN flip-chip package



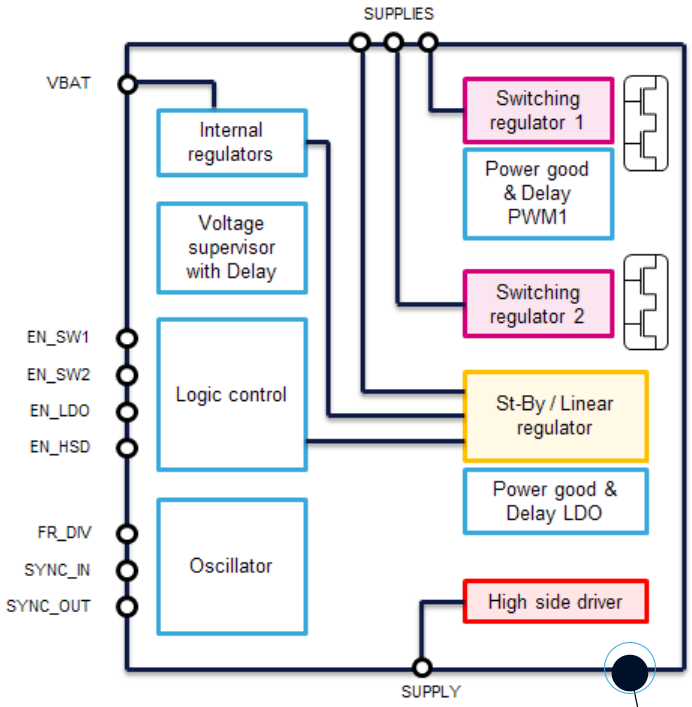
ASICs
Adopting all IPs developed for ADAS PMICs

Multiple buck-boost power management for Audio and USB Type-C power delivery

Type-C

L5963

Dual Monolithic Switching Regulator with LDO and HSD



Compatible to battery voltage or post regulator
Output V adjustable by ext R partitioning @ 2.5A
250kHz free run – Sync till 2.0 MHz

Compatible to battery voltage or post regulator
Output V adjustable by ext R partitioning @ 3.0A
250kHz free run – Sync till 2.0 MHz

Compatible to battery voltage
Always supplied to guarantee backup function
Adjustable V by ext R partitioning @ 250mA

500mA max load capability

MAIN FEATURES

- Compact solution in a small package
- Every regulator is battery compatible
- High switching frequency, up to 2MHz
- High current capability, up to 3A
- Extremely low quiescent current in st-by (25uA typ)
- Possibility of synchronization
- Voltage monitoring and power goods
- 180° phase shift between dc-dc

BENEFITS

- Use of just a single device with 3 outputs
- Flexibility
- High integration level
- Small external components
- Master slave configuration and customized power up sequences without any external control
- Low EMI emissions
- Automotive qualified AEC Q100

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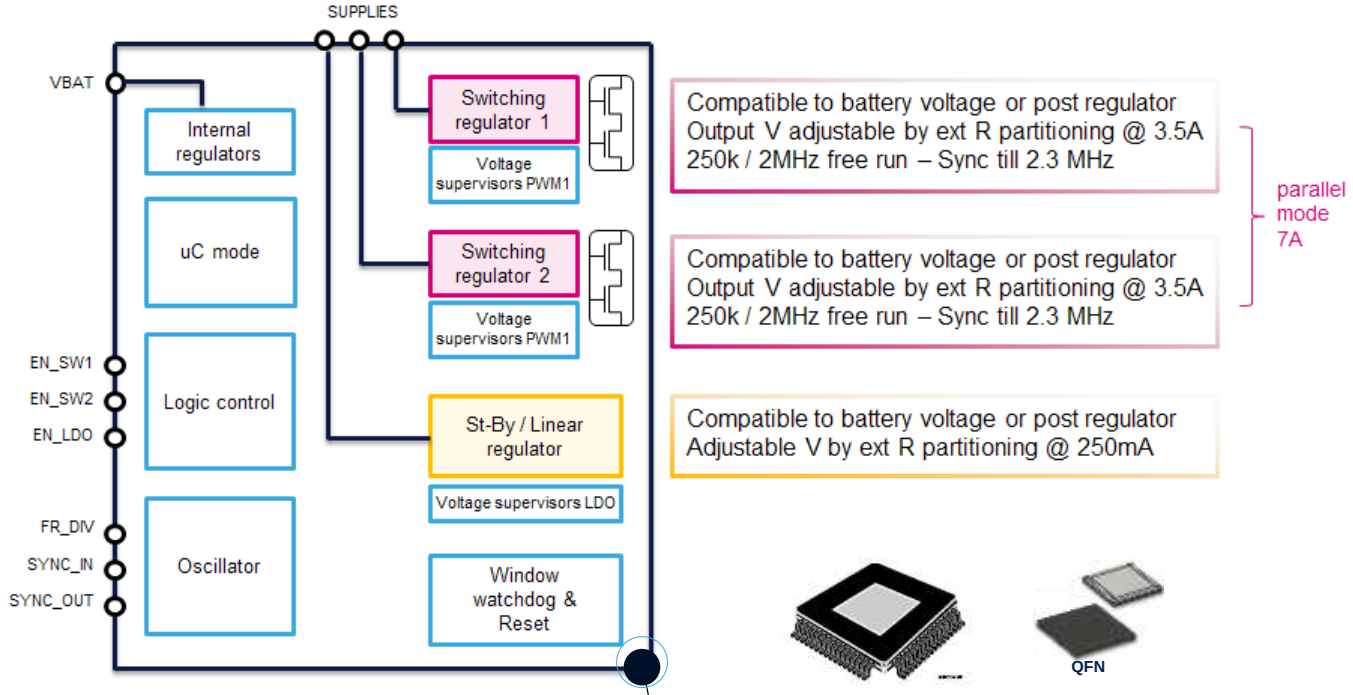
L5964

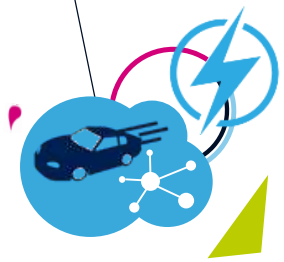
Dual Switching Regulator with LDO and UC Power Mgmt



LQFP64 (exposed pad up)

QFN

Samples and demo boards available



MAIN FEATURES

- Compact solution in a small package
- Current mode
- Every regulator is battery compatible
- High switching frequency, up to 2.3MHz
- High current capability, up to 7A multi-phase
- Possibility of synchronization
- Voltage supervisors and power goods
- Phase shift between regulators
- Microcontroller management

BENEFITS

- Few external components
- Flexibility of use and high integration level
- Internal oscillator or external synch
- Use of small inductors
- Can be used as high current pre-regulator
- Master slave configuration and customized power up sequences without any external control
- Low EMI emissions
- Automotive qualified AEC Q100

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L5965

PMIC for Cameras and Radars

L5965 is a multiple voltage regulator including pre and post regulators, 7 output voltages with the target to supply ADAS systems and to be compatible to ST ICs:

- Vision processors (EyeQ3, EyeQ4, … (Vision-System-on-Chip))
- Radar sensors (STRADA431 - 24GHz Transceiver, …)
- Microcontrollers (SPC58NE84E7, SPC58NE84C3 - 32bit microcontroller for automotive ASIL-D applications, …)

An SPI interface is present

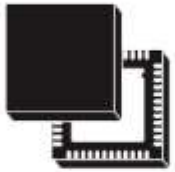
OTP for programming

Designed with reference to

CERTIFIED FUNCTIONAL SAFETY JQA

Certification for Products
in accordance with
ISO 26262

VFQFPN-48



VFQFPN-48 (7x7x1.0mm)
Very Fine Quad Flat Package No lead

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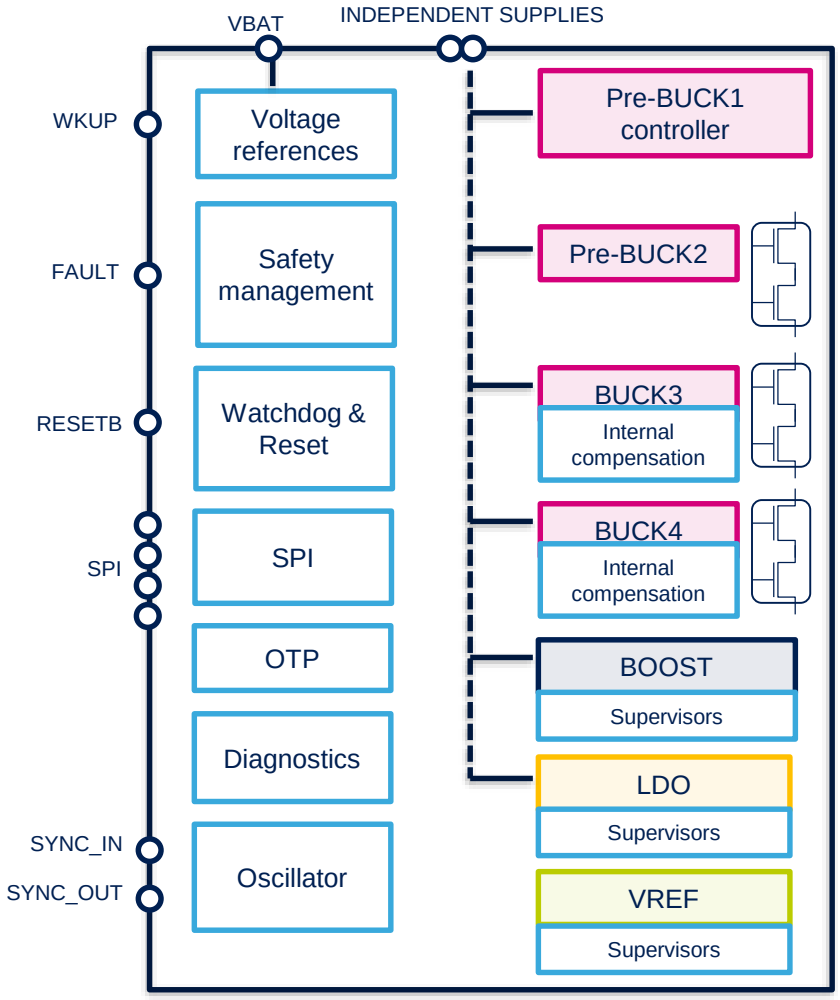
L5965

Multiple Power Mgmt for Vision and Radar Systems



Buck pre/post controller compatible to battery V
5-3.8-3.3-1.8-1.2-1.1-1.0-0.8 V @ 0.4 MHz

Buck pre/post regulator compatible to battery V
5.0-3.6-3.3-1.5-1.35-1.2-1.1-1.0 V @ 1-2 A ● 0.4 - 2.4 MHz

Buck post regulator compatible to 5.5V max
3.3-2.5-2.3-2.0-1.8-1.35-1.2-1.0 V @ 1.2 A ● 2.4 MHz

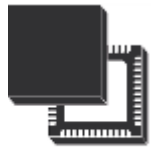
Buck post regulator compatible to 5.5V max
3.3-1.8-1.35-1.3-1.25-1.2-1.12-1.1 V @ 0.9 A ● 2.4 MHz

Boost post regulator compatible to 5.5V max
7 – 5 V @ 0.3 A ● 2.4 MHz

Linear post regulator compatible to 5.5V max
5-3.3-2.8-2.5-1.8-1.3-1.25-1.2 V @ 300/600 mA

Internally connected to the battery
4.1 - 3.3 – 2.5 – 1.8 V @ 20 mA

OTP programmable!



VFQFPN

Samples and demo boards available

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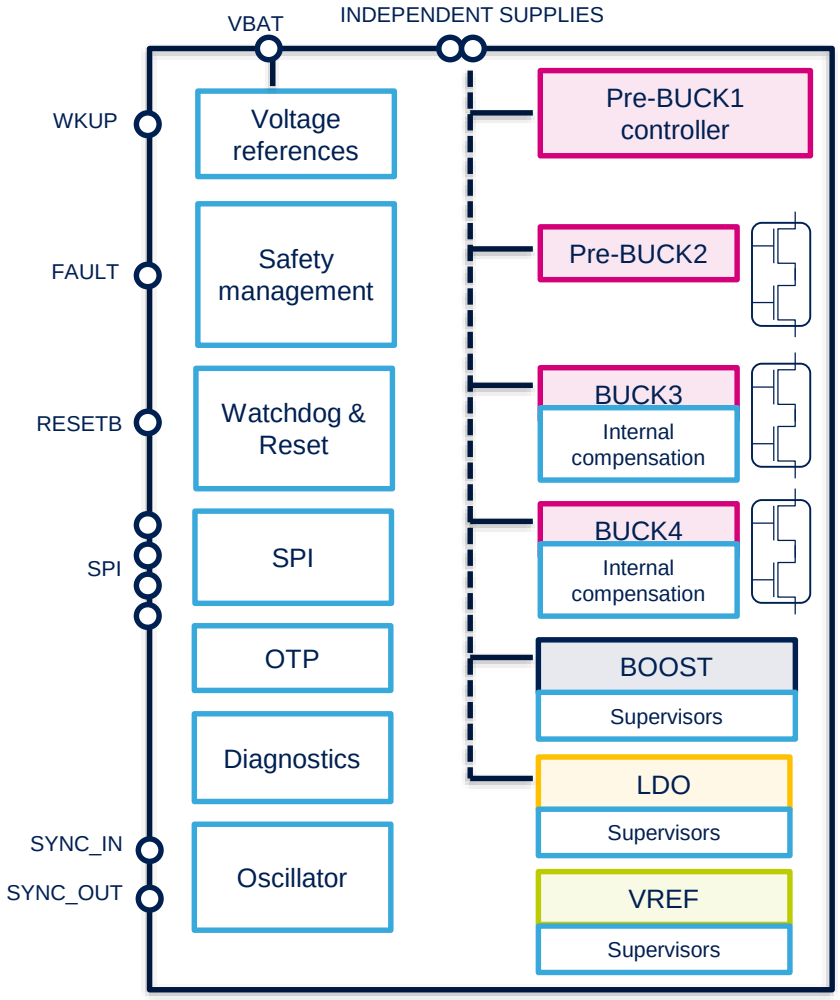
L5965

Start/Stop Operation Overview

VBAT1 & VBAT2 UV Thresholds:
5.3/5.8/6.3V (decreasing)
5.5/6/6.5V (increasing)
Triggers UV warning on SPI

Power on Reset Thresholds:
3/3.4/3.8V (rising)
2.8/3.2/3.6V (falling)
Triggers SHUTDOWN state



Buck pre/post controller compatible to battery V
5-3.8-3.3-1.8-1.2-1.1-1.0-0.8 V @ 0.4 MHz

Input range: 4V to 32V
+/- 2.5% regulation

Buck pre/post regulator compatible to battery V
5.0-3.6-3.3-1.5-1.35-1.2-1.1-1.0 V @ 1-2 A ● 0.4 - 2.4 MHz

Input range: 3.3V to 32V
+/- 2.5% regulation
190mOhm HS (hot)

Buck post regulator compatible to 5.5V max
3.3-2.5-2.3-2.0-1.8-1.35-1.2-1.0 V @ 1.2 A ● 2.4 MHz

Input range: 3V to 5.5V
+/- 2.5% regulation
250mOhm HS (hot)

Buck post regulator compatible to 5.5V max
3.3-1.8-1.35-1.3-1.25-1.2-1.12-1.1 V @ 0.9 A ● 2.4 MHz

Input range: 3V to 5.5V
+/- 2.5% regulation
250mOhm HS (hot)

Boost post regulator compatible to 5.5V max
7 – 5 V @ 0.3 A ● 2.4 MHz

Input range: 3V to 5.5V
+/- 2.5% regulation

Linear post regulator compatible to 5.5V max
5-3.3-2.8-2.5-1.8-1.3-1.25-1.2 V @ 300/600 mA

Input range: 1.8V to 6V
+/- 2.5% regulation

Internally connected to the battery
4.1 - 3.3 – 2.5 – 1.8 V @ 20 mA

Can be adjusted to 5V out
1% regulation

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L5965

Main Features

- ✓ Designed with reference to ISO26262
- ✓ Switching frequencies up to 2.4MHz
- ✓ Output voltages and power-up sequence selectable with OTP to reduce the use of external components
- ✓ Output voltage monitors for UV/OV detection and Power Good ‘s
- ✓ SPI interface for programming and diagnostics
- ✓ Fault pin
- ✓ Independent supply pins

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ISO26262 - ASIL Compliance

ISO26262 ASIL compliance

- VIN/VOUT monitors
- Two independent Band-gaps: one for reference and one for monitor
- Ground loss monitors
- Internal compensation network and resistor divider
- Digital BIST on internal logic
- Analog BIST:
  - Voltage comparator toggle
  - Temperature comparators toggle
  - Reset assertion check
- Fault pin to Microcontroller

OTP programmable parameters

- BUCK1 output values
- BUCK2 output values
- BUCK2 current limit value
- BUCK2 free running frequency
- BUCK3 output values
- BUCK4 output values
- LDO output values
- LDO output current limitation
- BOOST output voltage
- VREF output voltage
- Main BUCK selection (to decide which regulator between BUCK1 and BUCK2 is the main pre-regulator)
- Power-up sequence

Second Generation ADAS PMIC

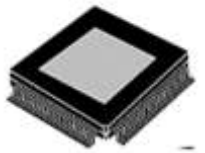
- Pre Buck1 controller, OTP V, battery compatible
- Buck2 controller OTP V
- Buck3 converter OTP V, 3A
- Buck4 converter OTP V, 3A
- Buck5 converter OTP V, 1.25A
- Boost converter / controller
- LDO1 OTP V, 0.75A
- LDO2 OTP V, 0.75A
- LDO3 OTP V, 0.75A
- LDO4 OTP V, 0.75A
- LDO5 OTP V, 0.75A
- LDO6 OTP V, 0.25A
- LDO7 OTP V, 0.25A
- FD CAN interface, SPI, protections, OTP, safety

Powerful power management IC offering a full set of features to support applications that need to fulfill functional safety requirements as defined by Automotive Safety Integrity Level (ASIL) A-B-C-D.

Evolution of L5965 with improved functionalities, higher current capability, higher number of power rails and controller, higher voltage precision.

Complete programmability by OTP

ST has all IPs to provide PMICs for ADAS and, in general, for the automotive environment



TQFP128L
(Exposed pad up)

- First engineering samples in H1’19
- Final samples in H2 2020
- Production H2 2021

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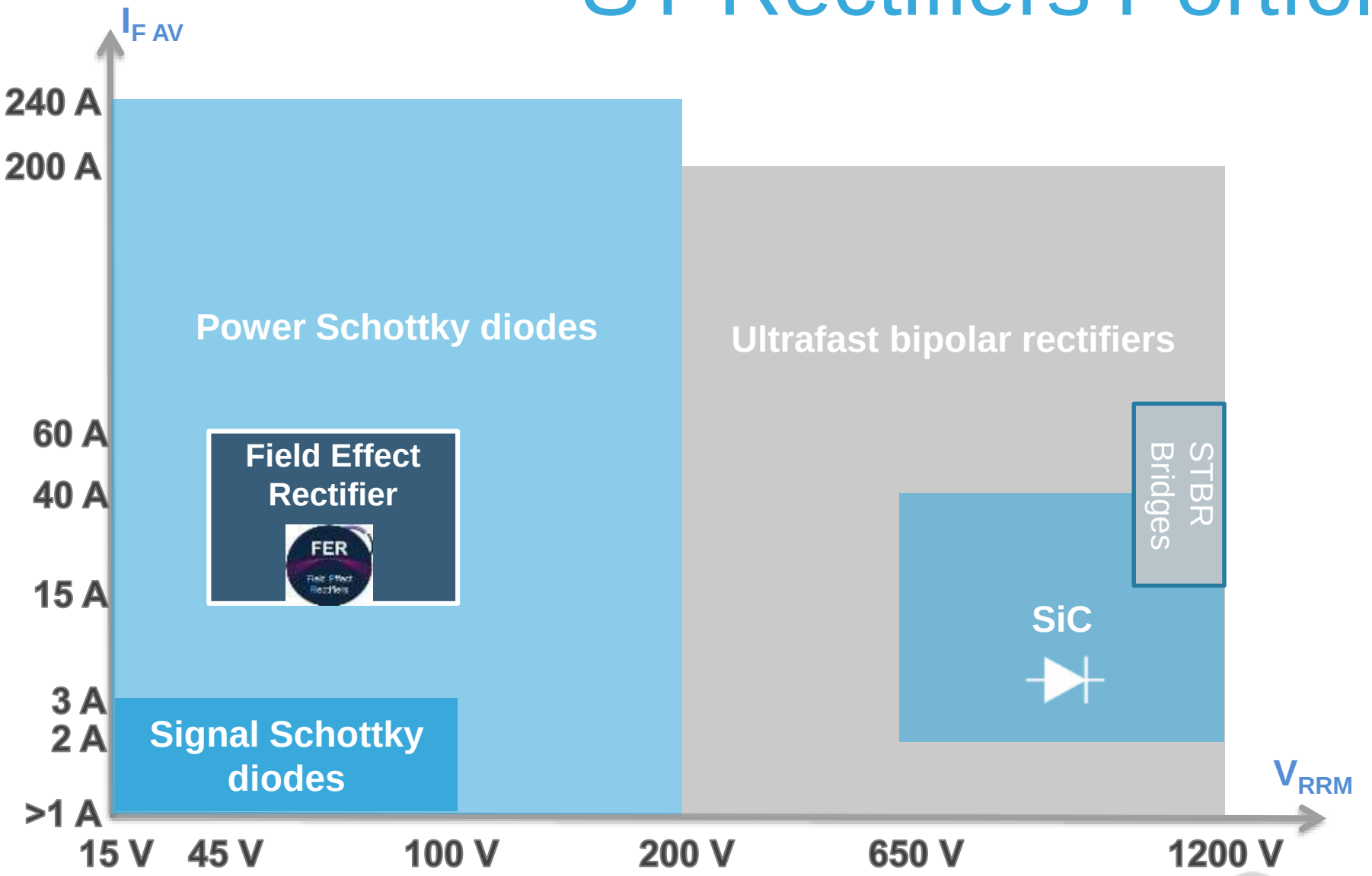
ST Rectifiers Portfolio



Automotive Rectifiers Main Features

Power Schottky Rectifiers

- Planar Power Schottky technology
- Lowest V_F with “L” series
- Optimized V_F/I_R trade-off (H, M series)
- Avalanche specification
- Tj max = 175°C

Ultra Fast Rectifiers

- Planar Ultra Fast technology
- Lowest Q_{RR} with “R” series
- Tuned for all applications (L, R & S, ST series)
- Tj max = 175°C

Very High Efficiency

- FERD **technology***
  - Power integration
  - PowerFlat 5x6
  - TO-277A
  - Best in class V_F/I_R
  - “U” & “M” series
- SiC **technology**
  - Get the highest efficiency on the market
  - Downsize your global system

Environment & Quality

- Lead Free components
- RoHS compliant
- Halogen free resin
- PPAP capable
- AEC-Q101 compliant

4 pillars to drive innovation and leadership

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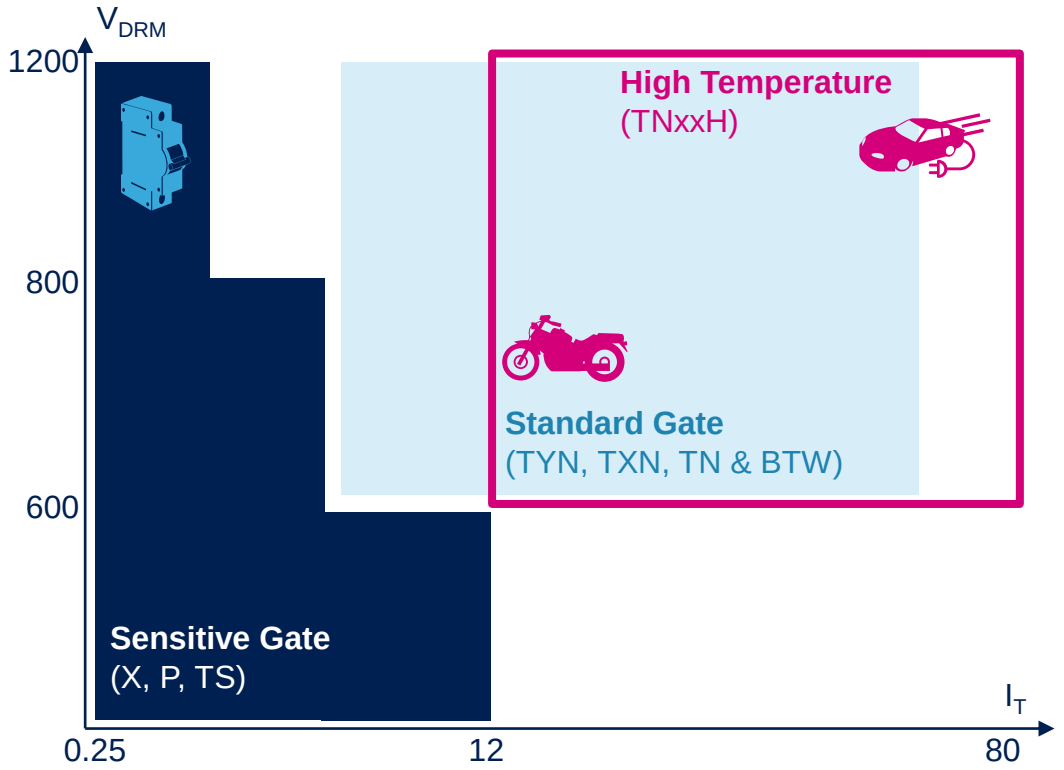
* In development for Automotive

SCR Thyristor Portfolio

The most innovative SCR portfolio

Bidirectional Blocking



- **V_{DRM}: 400 to 1200 V**
- **I_{TRMS}: 0.25 to 80 A**
- **I_{GT}: 5 µA to 50 mA**
- **T_J: 125°C & 150°C**

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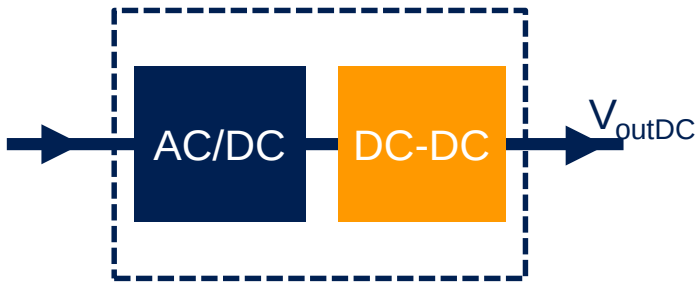
Diodes and SCR in OBC

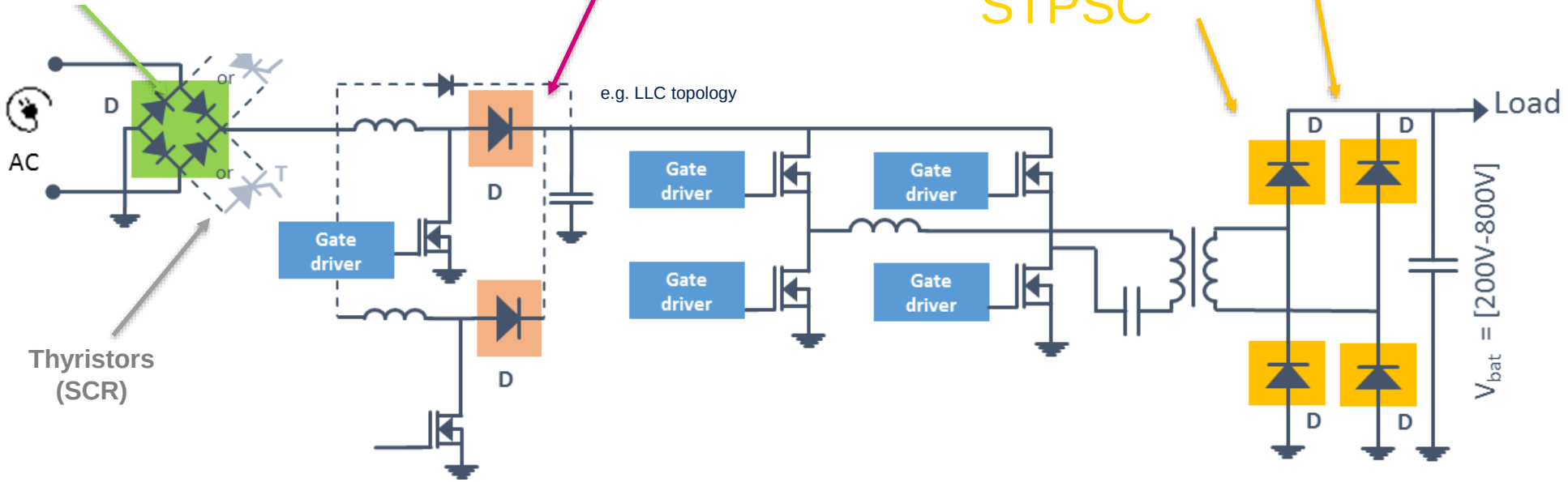
Bridge and Bridgeless



Bridge Rectifiers
STBR

SiC Diodes
STPSC

SiC Diodes
Rapid Quiet Rectifiers
STTH-RQ
STPSC



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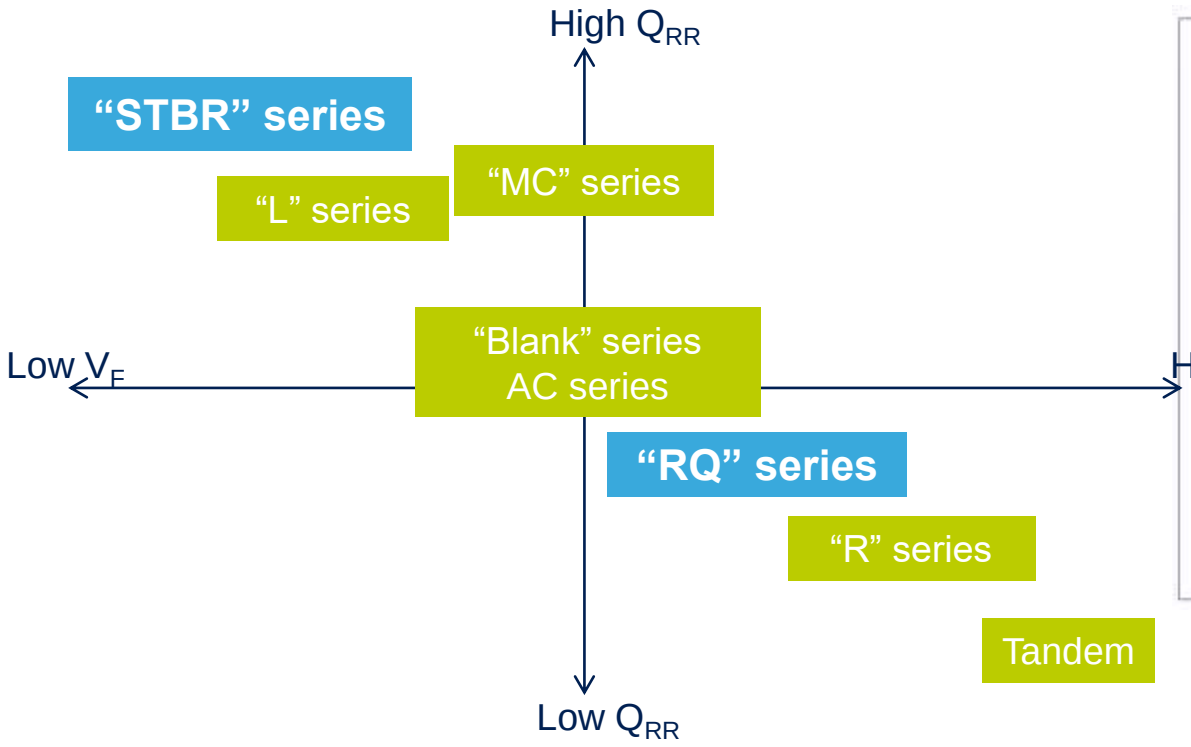
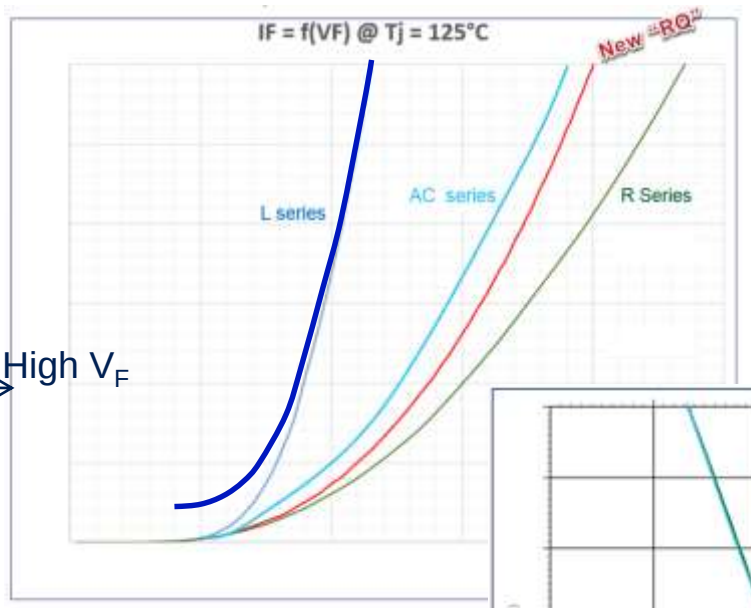
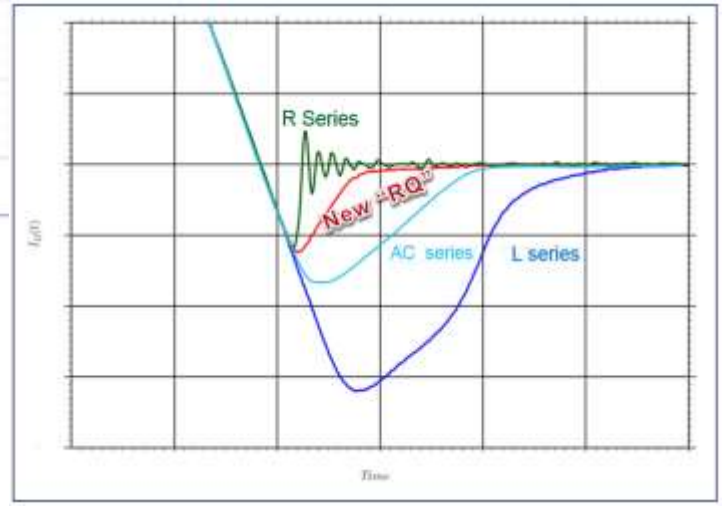
Ultrafast Rectifiers

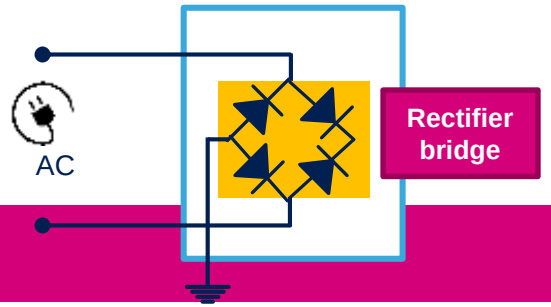
STBR & STTHxxRQ Series

Ultrafast STTHxx series: 200V to 1200V & 1A to 200A







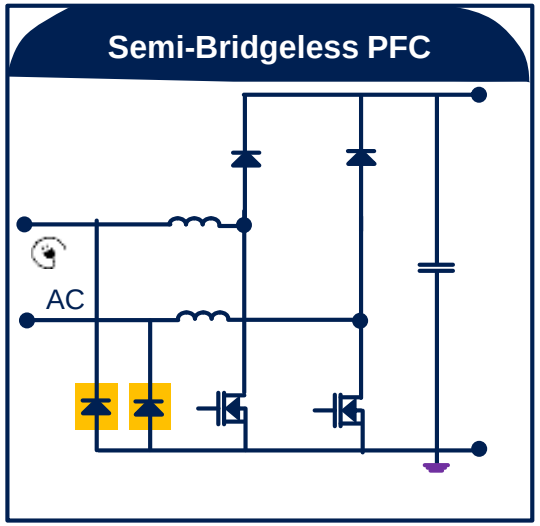


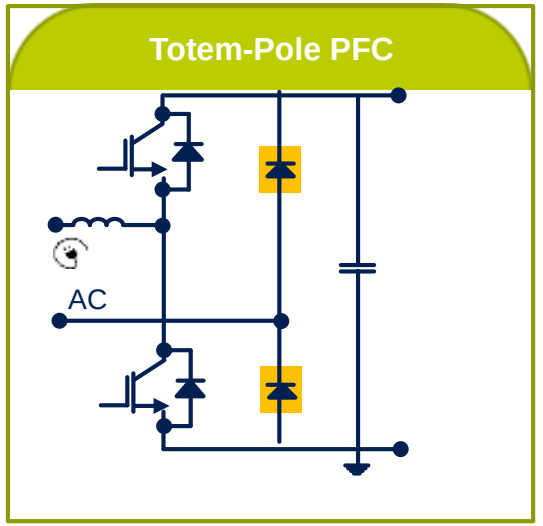
STBR Performance

Improved in IFSM & VF

STBR also suits PFC configurations

	STBR3012W	STTH3010W
V_{RRM}	**1200 V**	**1000 V**
Package	DO247	DO247/D2PAK
T_{jmax}	175 °C	175 °C
$I_{F(AV)}$	30 A	30 A
I_{FSM} **(half-sin 10ms)**	**300 A**	180 A
$V_{F(typ)}$ **(15A,150°C)**	**0.83 V**	1.12 V
$V_{F(typ)}$ **(30A,150°C)**	**0.95 V**	1.3 V
$I_{R(max)}$ **(V_{RRM} ,150°C)**	100 µA	100 µA





Ideal for on-board chargers (OBC) & charging stations

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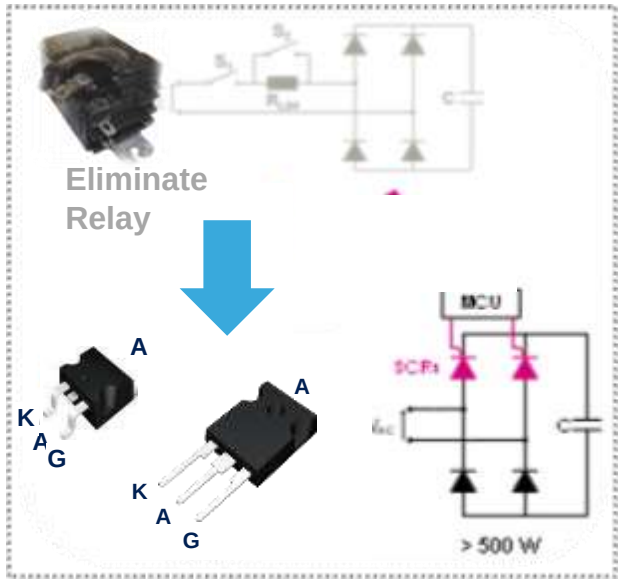
AG Thyristors for EV Charging

In-rush current limiting SCR for OBC

Features	TN5050H	TN3050H
V_{DRM} / V_{RRM}	1,200 V over T_J range	
Max T_J	-40°C to +150°C	
V_{DSM} / V_{RSM}	1300 V	1400 V
I_{TRMS} (T_C=125°C)	80 A	30 A
I_{TSM} (10ms,25°C)	580 A	300 A
V_{TO} (150°C)	0.88V	0.88V
R_D (150°C)	6 mΩ	14 mΩ
I_{GT} (25°C)	10 to 50 mA	10 to 50 mA
dV/dt (800V-150°C)	1 kV/µs	



Design Value

- AEC-Q101 PPAP Available on request
- High switching life expectancy
- Enable system to resist 6kV surge
- High speed power up / line drop recovery

A smart way to turn on your system

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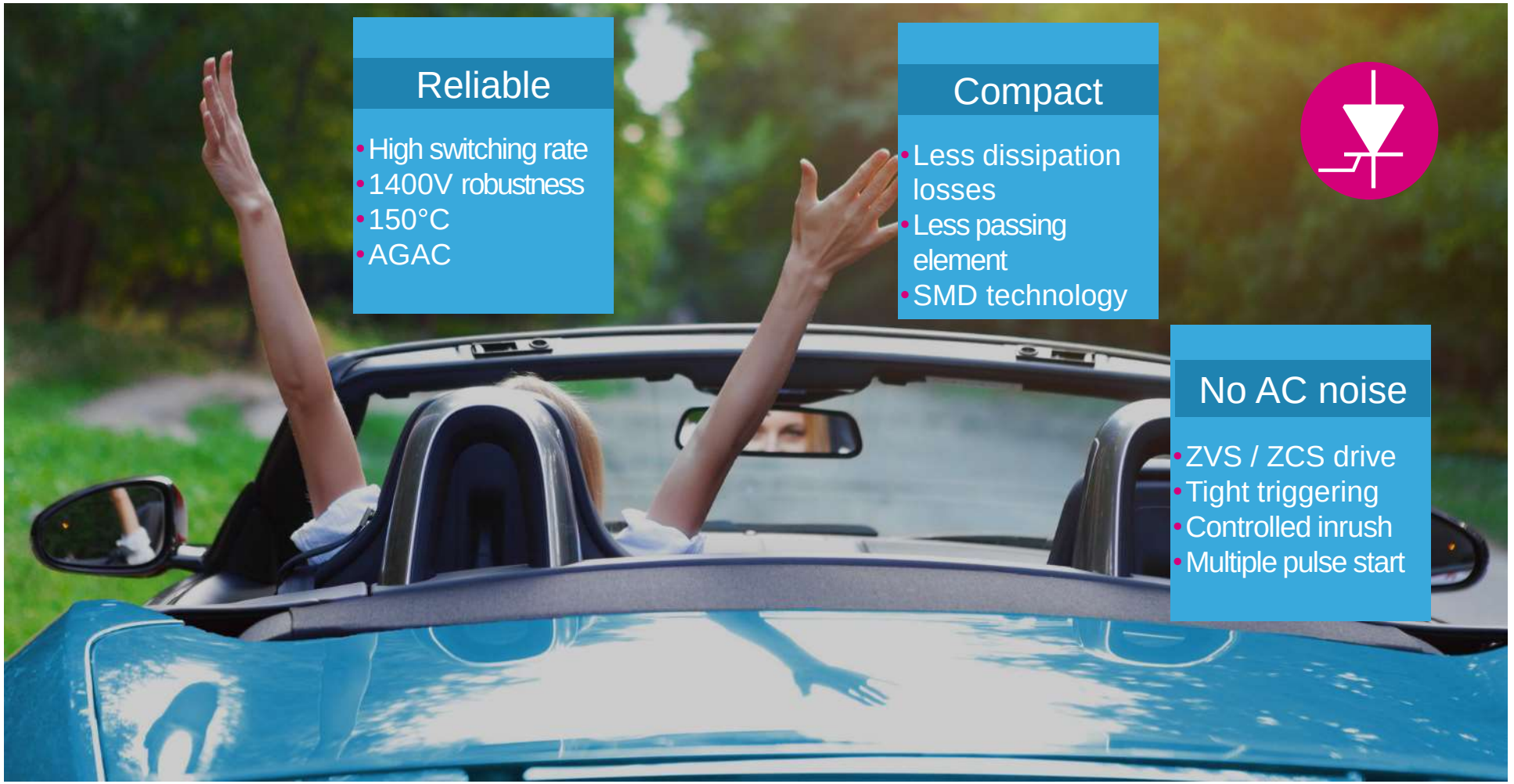
SCR in OBC



Reliable

- High switching rate
- 1400V robustness
- 150°C
- AGAC

Compact

- Less dissipation losses
- Less passing element
- SMD technology

No AC noise

- ZVS / ZCS drive
- Tight triggering
- Controlled inrush
- Multiple pulse start

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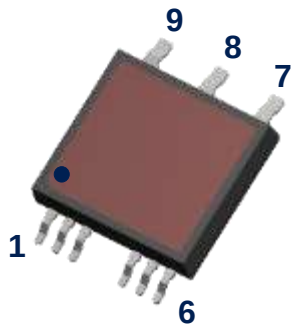
Innovation in Power Conversion

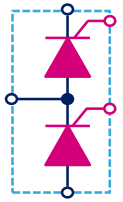
Surface Mount Insulated Top Side Cooling Package

- 1200V SCR , Rectifier and SiC
- High Junction Temperature
- 20 A to 120 A RMS operating current
- Surface Mount
- Isolated Top side cooled

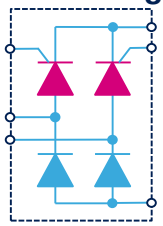


- 3-phase AC Line EMI-compliant
- Improved Reliability
- Large range / Integration
- Automated process
- Converter stack over heat sink

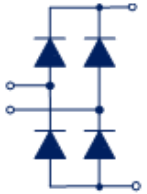
SCR Bridge Leg



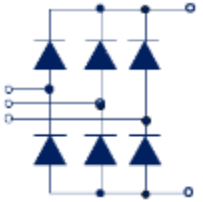
Mixed Bridge



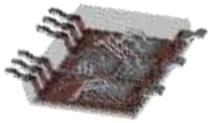
STTH Bridge



STPSC Bridge



Automotive certified



2500V isolation, High creepage

Propose disruptive integration with ST latest technologies - High Tj SCR, HV Diode, FET, IGBT – and Best in class SiC

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Integrated and Isolated Drivers

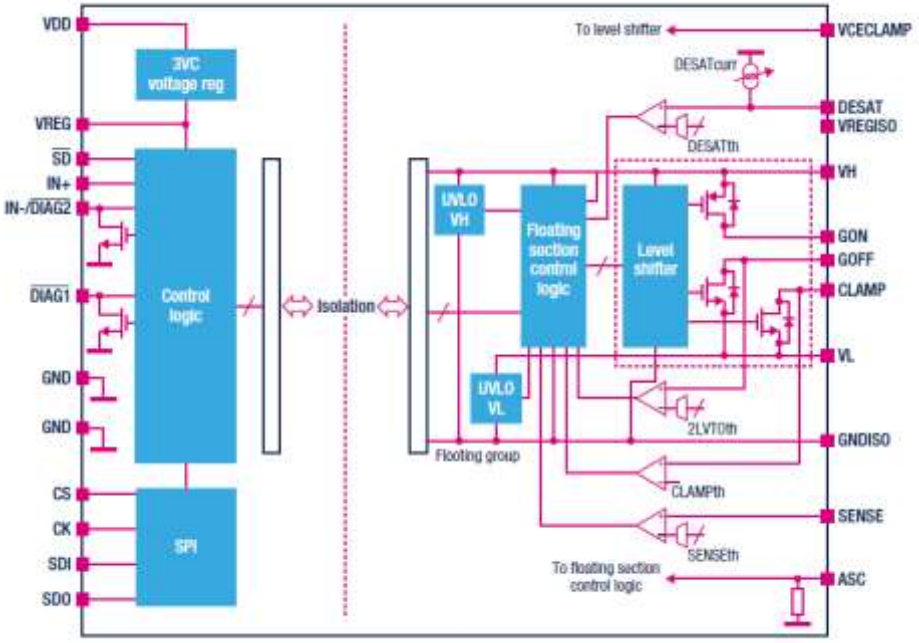
PTS Products

STGAP

Galvanically Isolated Drivers

Integrated Magnetic Coupling

Outstanding robustness, noise immunity and design flexibility



STGAP1AS

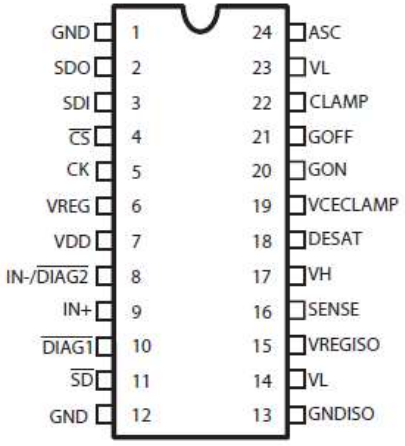
Galvanic separation between input and control stage from high current gate driving and diagnostics

Inductive coupling transfers the logic signal across the isolation for the highest signal integrity and fast propagation

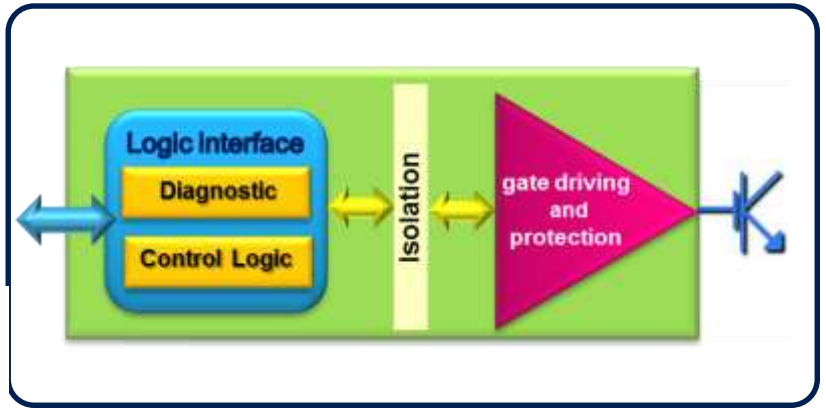
STGAP1AS

Advanced Isolated Gate Driver

Advanced single driver perfect for High-End applications



SO24W



Main Features

- SPI Interface
- SiC Driver
- 4kV Isolation Voltage
- 5 A sink/source current
- Fully protected – Advanced features

Now in production **AEC-Q100 grade 1 Qualified**
Wide operating range (-40°C -125°C)

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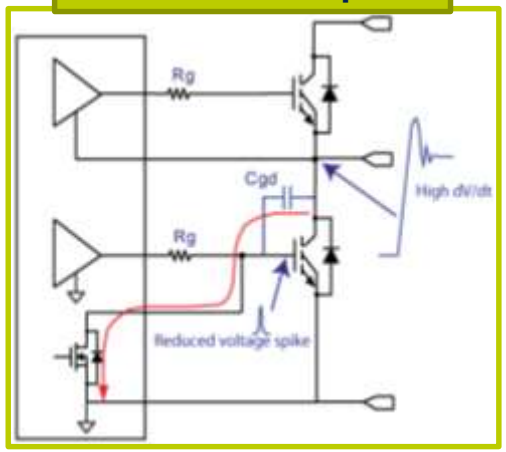
GapDRIVE

Gate Driving State of the Art

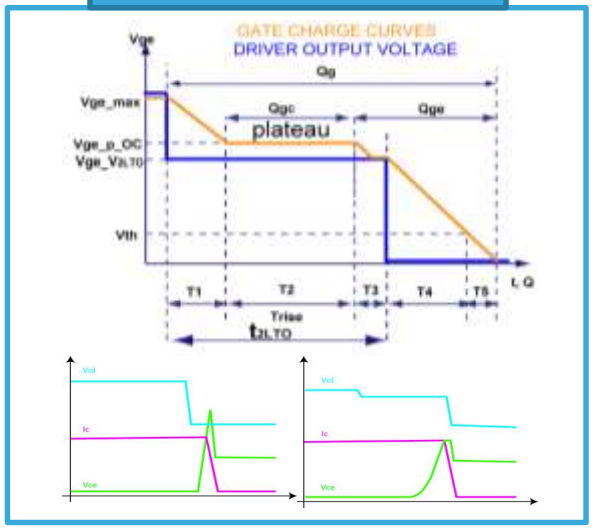
Miller Clamp



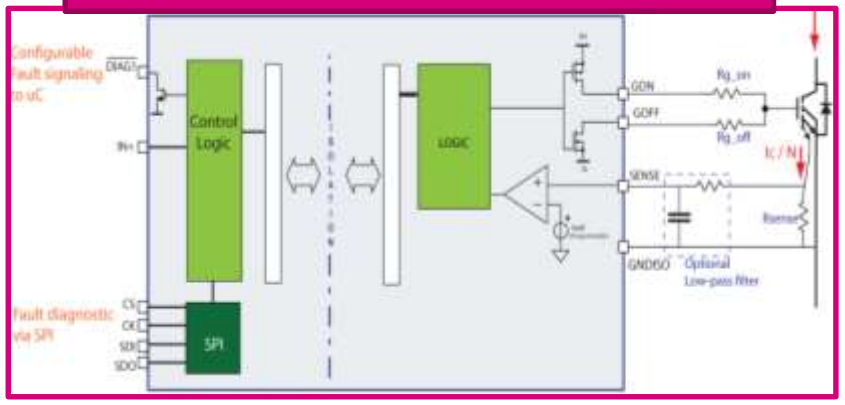
Advanced features

- Negative drive ability
- 30 V, ±5 A gate drive ability
- Advanced SPI diagnostic
- SPI parameter configuration
- Supply UVLO & OVLO
- Overtemperature protection
- Dedicated Diagnostic pins
- 3.3/5V CMOS/TTL inputs

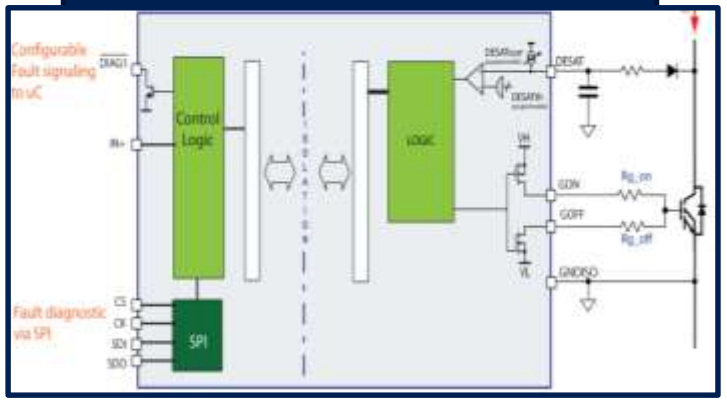
2 Level TurnOff



Overcurrent Protection



Desaturation Protection



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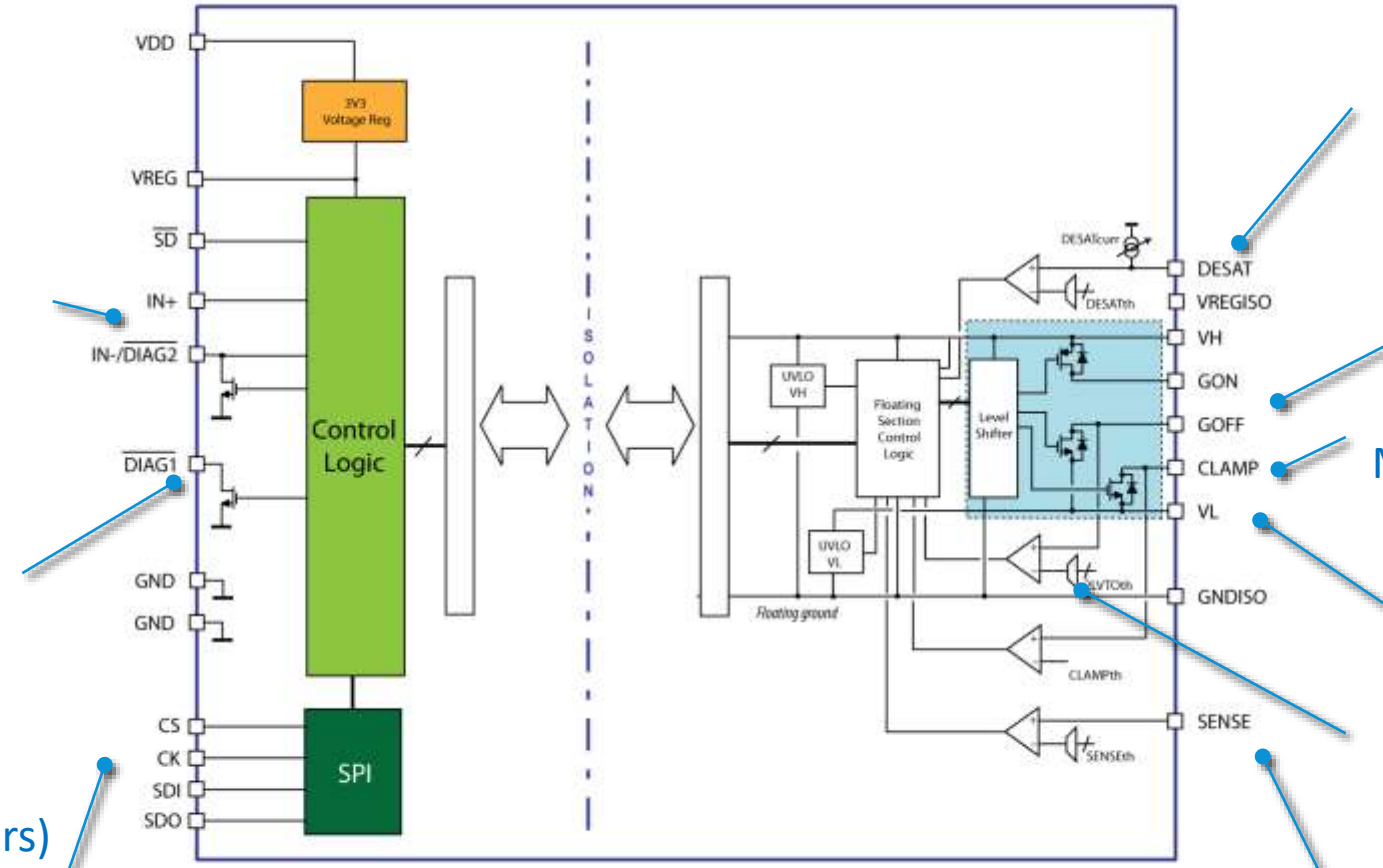
STGAP1AS

Automotive Galvanically Isolated Single Gate Driver

Single / Dual input

General fault indication

- Configuration (parameters)
- Extended diagnostic



Desaturation protection

Separate source / sink pins

Miller clamp on dedicated pin

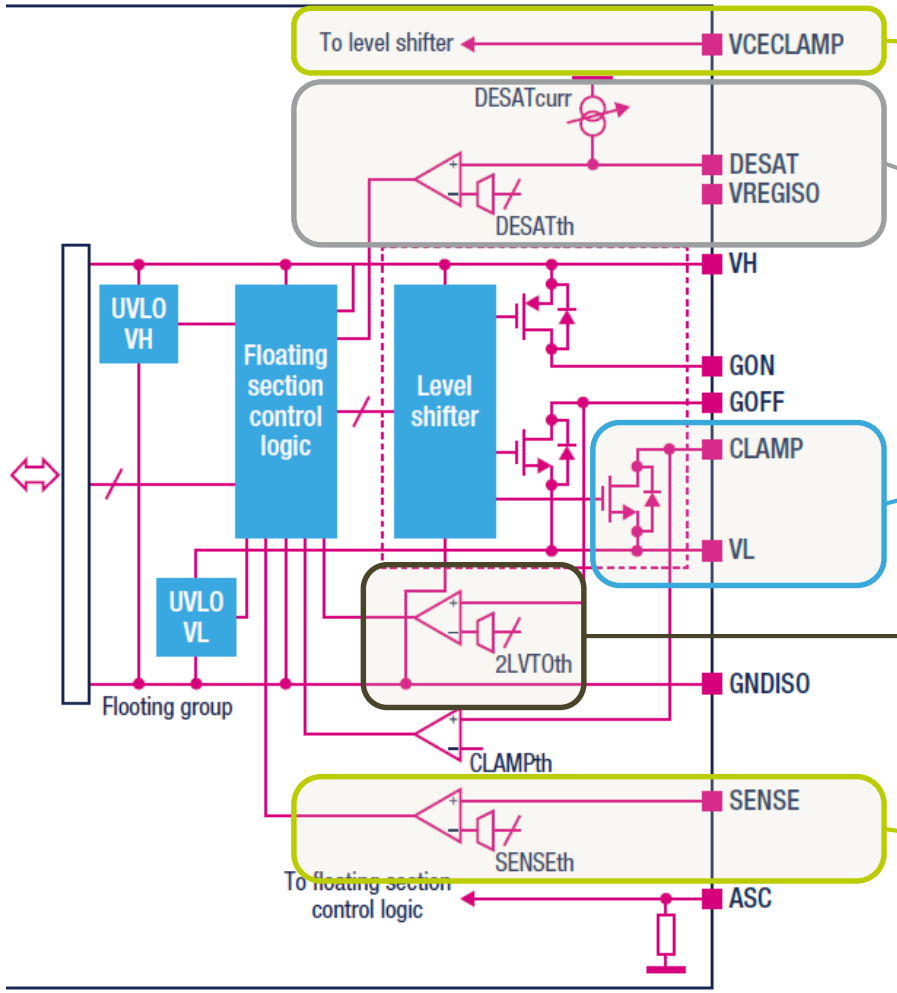
Negative voltage allowed

Programmable 2 level turn-off

Sense for over-current protection

SO24W Package

Output Stage Features

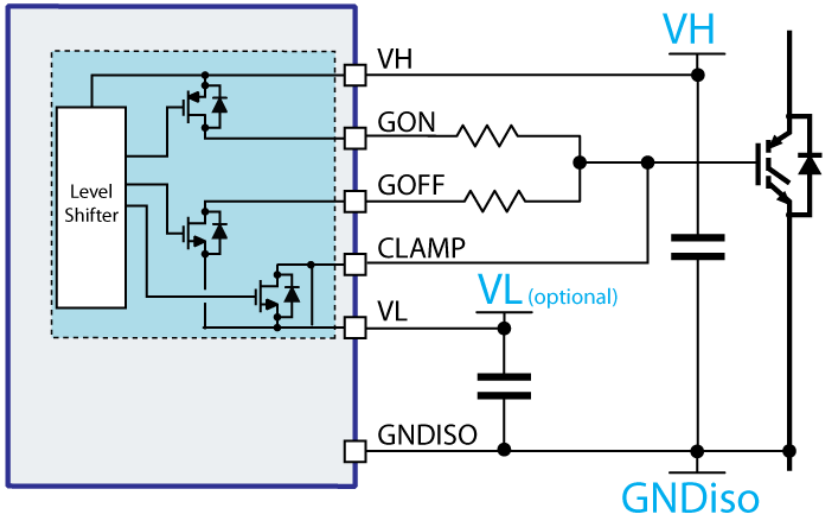


- V_{CE} active clamping protection
  - Prevent transistor break-down
- Programmable desaturation detection
  - Recognize short-circuit
- Active Miller Clamp function
  - Avoid induced turn-on phenomenon
- Configurable 2-level turn-off
  - Limit overvoltage spikes during turn-off at high currents
- Comparator with programmable reference
  - Overcurrent protection sensing

Embedded features save external components, increasing reliability and ensuring better performances

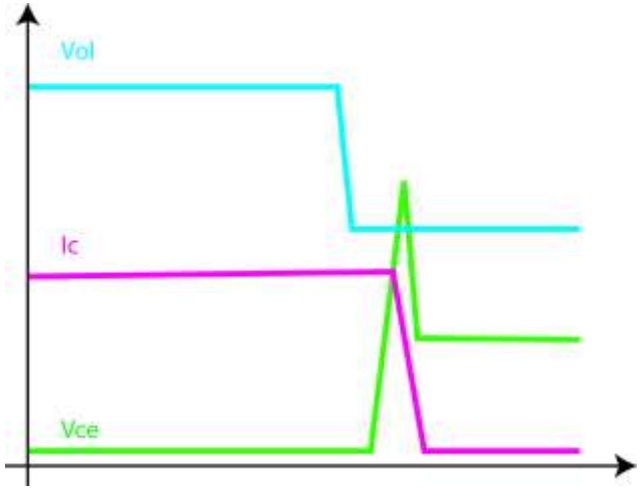
Driving Stage

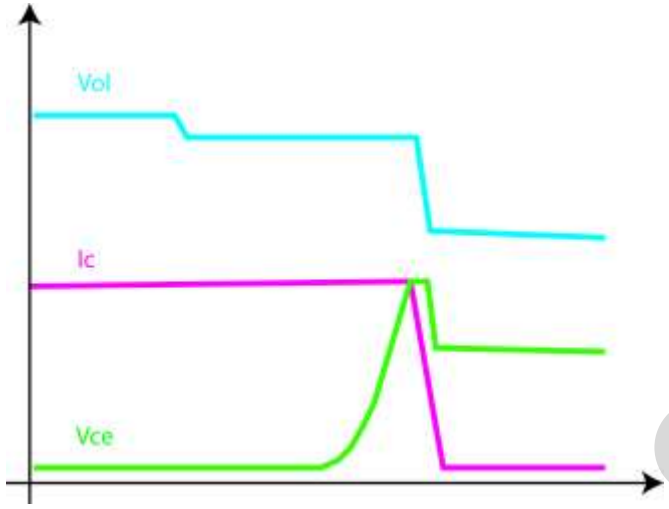
- Operative **positive supply** voltage up to **36 V**
  - Operative range for gapDRIVE positive supply is 4.5 V ≤ VH ≤ 36 V
  - Suitable to drive devices requiring high Vgs such as SiC MOSFETs
- Operative **negative supply** voltage down to **-10 V**
  - Operative range for gapDRIVE optional negative supply:
    -10 V ≤ VL ≤ 0 V
  - Operative range of overall power supply for gapDRIVE:
    VH - VL ≤ 36 V
- ***High gate driving current*** capability
  - gapDRIVE **current capability is ±5 A** Typ @ 25 °C
  - Higher current capability can hardly be achieved in insulated ICs due to power dissipation limitations: exposed pad packages cannot be used, due to creepage requirements.
- ***Separate turn-on and turn-off pins***
  - Easy gate driving tuning



2 Level Turn-Off in GapDRIVE

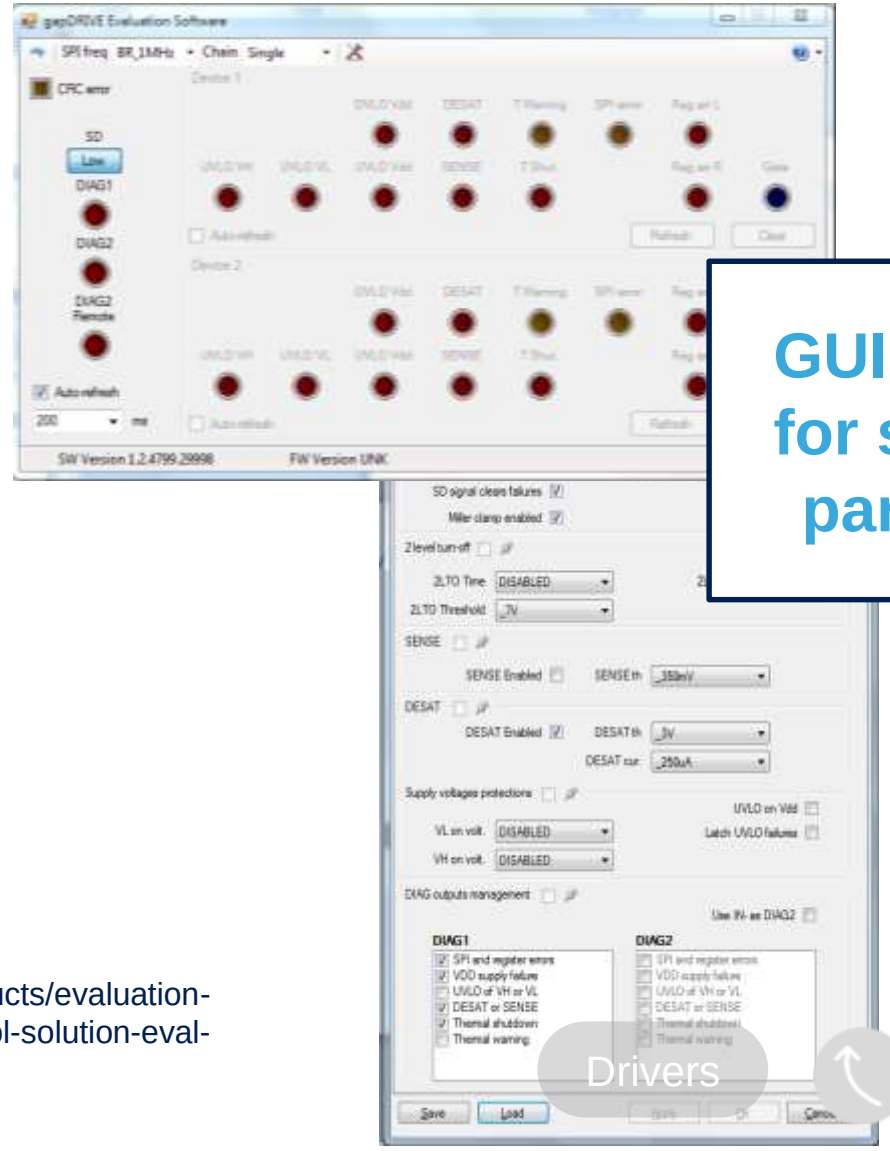
- 2LTO protects power switches from V_{CE} overvoltage spikes during turn-of in case of overcurrent conditions
- 2LTO can be programmed to occur:
  - At each cycle (like in TD350)
  - **Only after a DESAT or Over Current Event**
  - Never (disabled)
- Both 2LTO **voltage** and **duration** are **programmable** via SPI
- 2LTO offers advantages over *Soft Turn-off* since it only slows down the turn-off speed for the minimum time necessary to avoid overvoltages, thus limiting the duration of the high-voltage high-current overstressing condition





STGAP1AS Evalboard

EVALSTGAP1AS



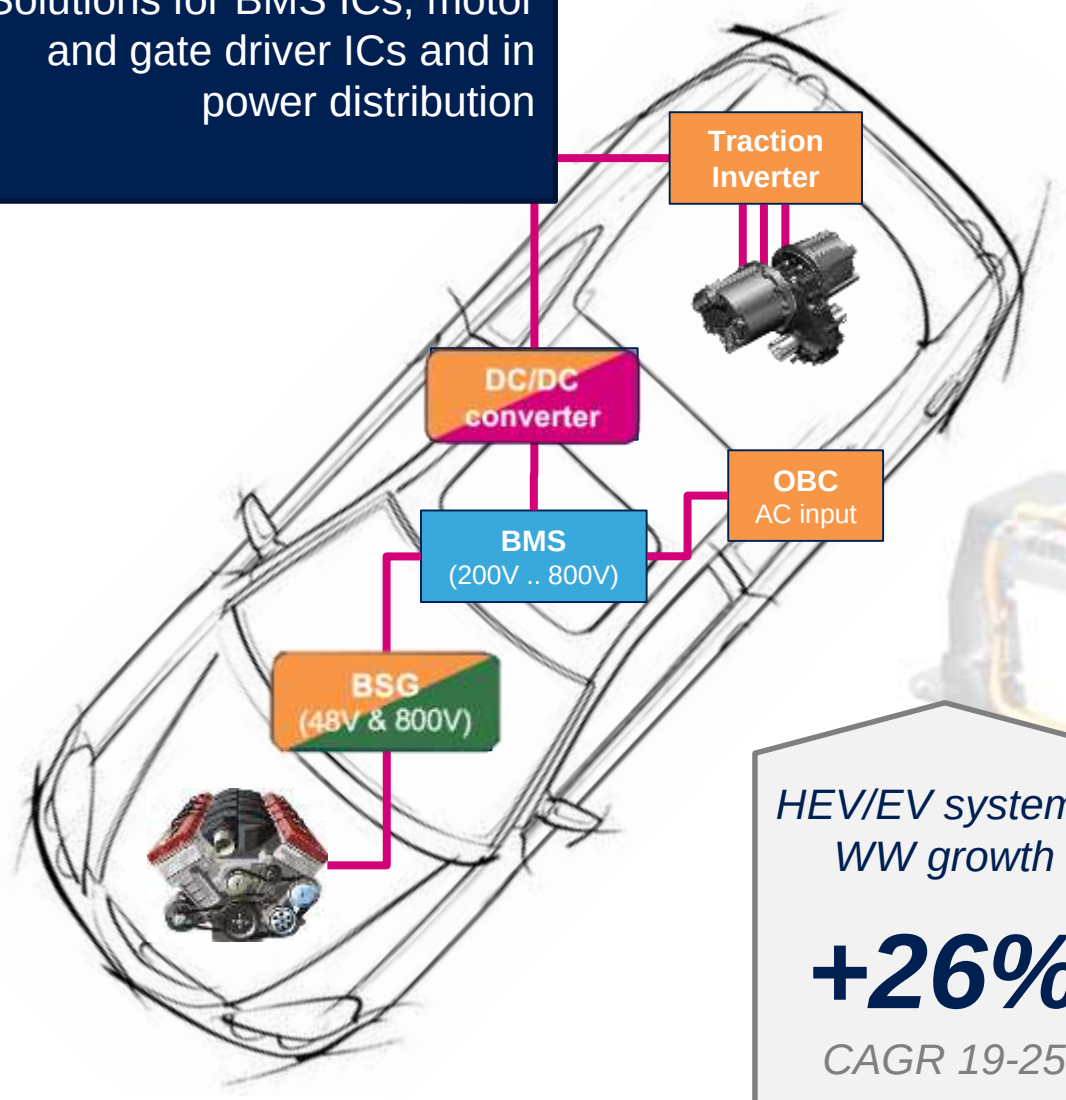
GUI available for setting all parameters

http://www.st.com/content/st_com/en/products/evaluation-tools/solution-evaluation-tools/motor-control-solution-eval-boards/evalstgap1as.html

Car Electrification

PTS Product Roadmap

Solutions for BMS ICs, motor and gate driver ICs and in power distribution



HEV/EV systems WW growth

+26%

CAGR 19-25

BMS IC	BLDC pre driver 12V-48V	IGBT/SiC gate driving	Power distribution
ASIC BCD6s TQFP100EP 10 cells + I_sense	**L9907** BCD6 TQFP64EP BLDC 48V	**L9501** BCD6s HV/9sL SO20 Dual gate drv	**L9788** BCD9sL TQFP100EP Uchip w/ HV relay drv
ASIC BCD8sAUTO TQFP64EP 12 cells	ASIC BCD8sAUTO TQFP48EP BLDC 48V	**L9502B** BCD6s HV/9sL SO24 Single gate drv	**L9305** BCD9sL PSSO36 HV relay CC drv
L9963 BCD9sL TQFP64EP 14 cells	**L9908** BCD9sL TQFP48EP BLDC 48V	**L9502** BCD6s HV/9sL SO28 Single gate drv	**L9660** BCD5 LQFP64 4ch Squib driver
L9963T BCD9sL SO16N BMS XCVR		**L9966** BCD9sL TQFP48EP Flexible sensor IF	
L9963S, L9962, L9965			
BMS SoC			

Drivers

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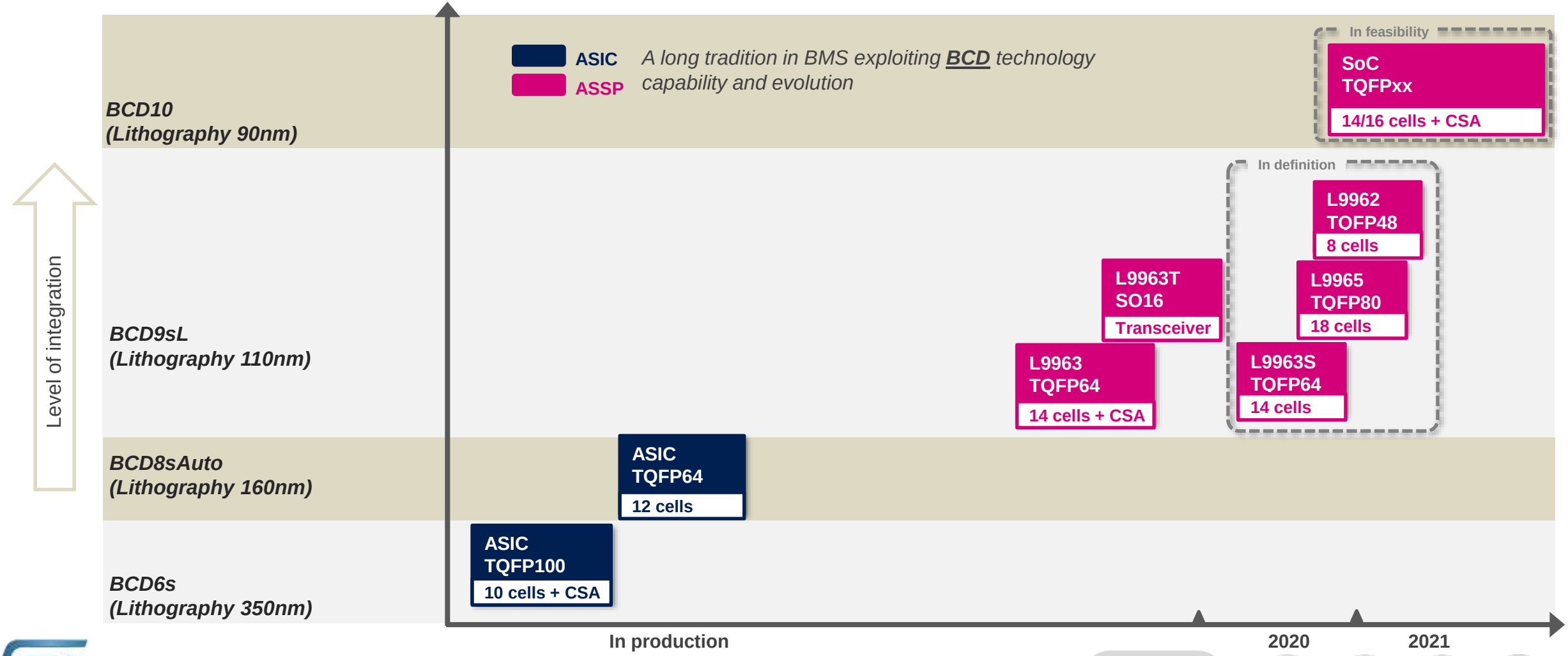
Battery Management System

Product Roadmap



L9763: Pioneer of BMS Devices

GM **Chevrolet-Volt**

LG Chem

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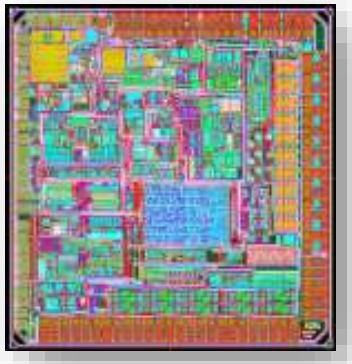
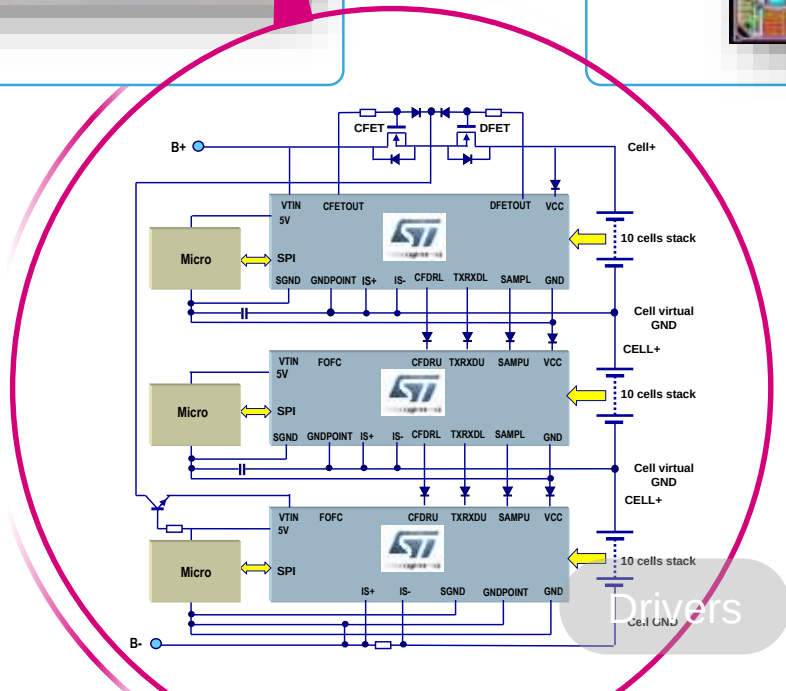


L9763

- First generation ST BMS IC
- BCD6s technology & TQFP100 package
- Managing up to 10 cells stack
- Passive balancing (configurable internal/external switches)
- Battery pack current sensing
- Vertical interface for modules communication



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Drivers

BMS Experience

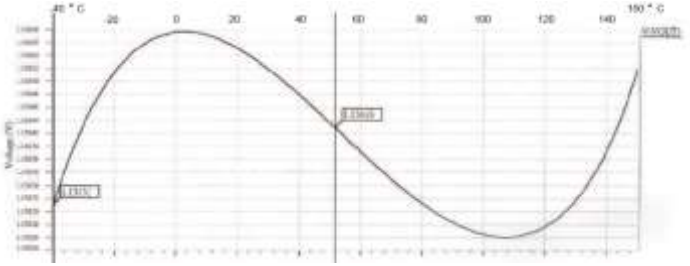
Leadership in semiconductor for **BMS**

First BMS development started in 2008

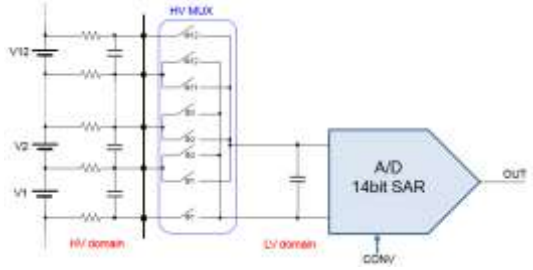
First BMS in mass production since 2011

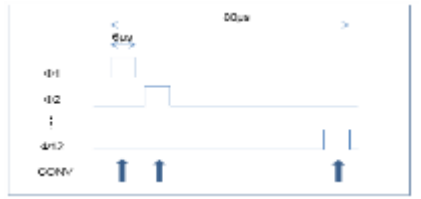
Internal reference accuracy performance < 0.1%

Logarithmic compensated bandgap

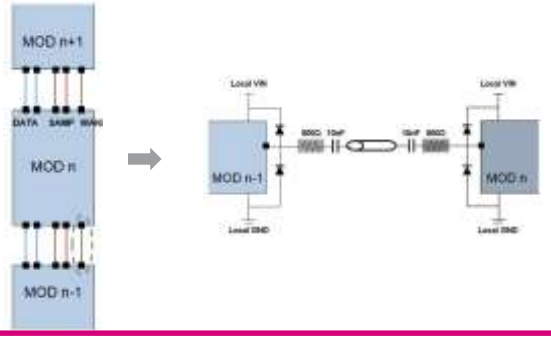


HV A/D converter 14bit, 80us to convert 12 cells





Integrated vertical interface for modules stack communications



- Max speed up to 500 kB/s
- Differential data & sampling lines
- Single ended functionality in case of short
- AC coupling to withstand short circuit fault

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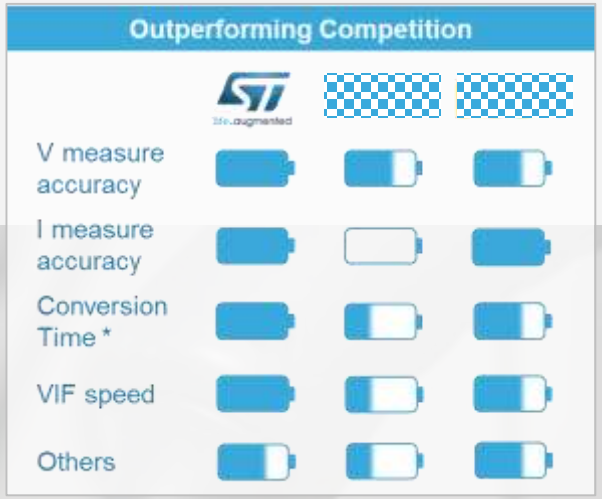
TQFP64

L9963 – Stonehenge

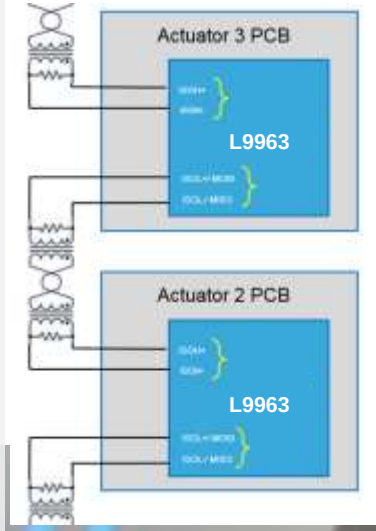
Battery Management IC for EV/HEV

- Up to 14 cells monitoring and balancing
- 16-bit Σ-Δ ADC for cell voltage monitoring
- 18-bit Σ-Δ ADC for battery current monitoring
- Internal balancing FET up to 200mA
- Configurable for external FET balancing
- Vertical interface up to 3Mbps

- ISO26262 Ready for ASIL D systems
- Cell total conversion error 2mV
- Current sense error 0.5%
- Real simultaneous conversion of 14 cells: total conversion is done in 300us.



ISO 26262



Production Q4 2019

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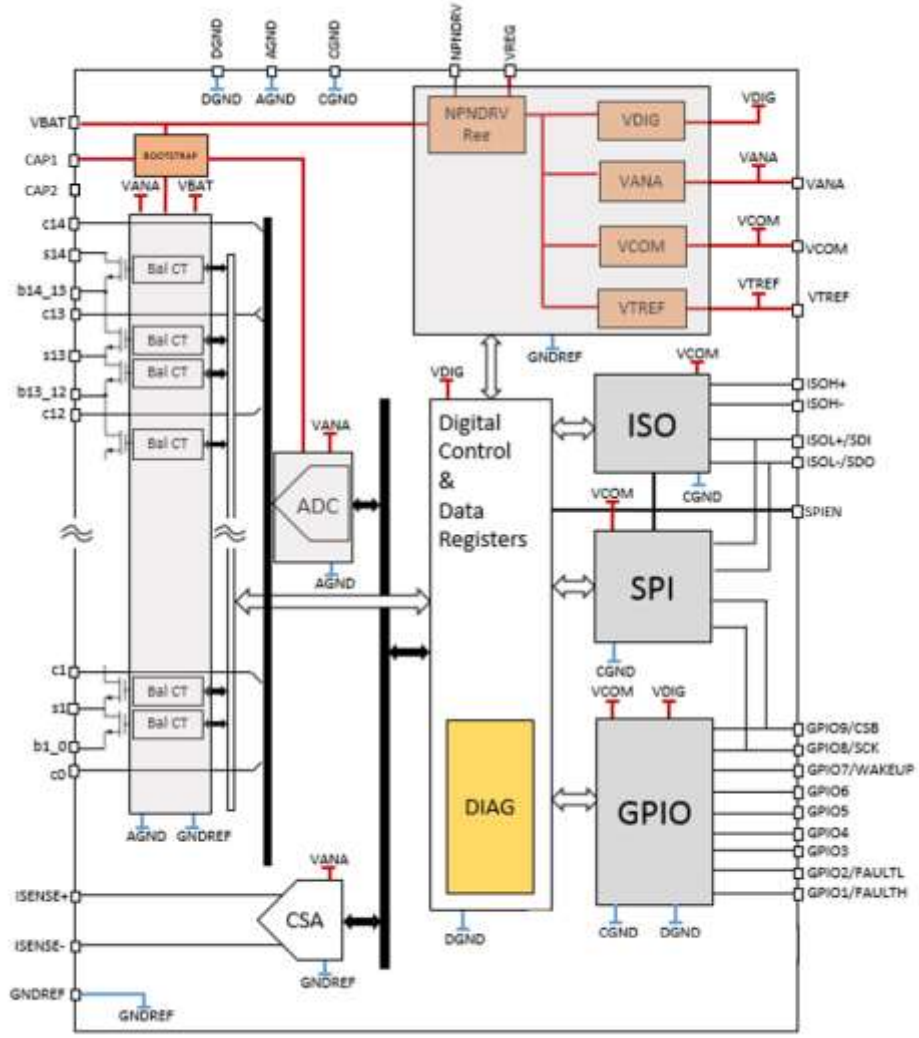
Drivers

L9963 Main Features

Features

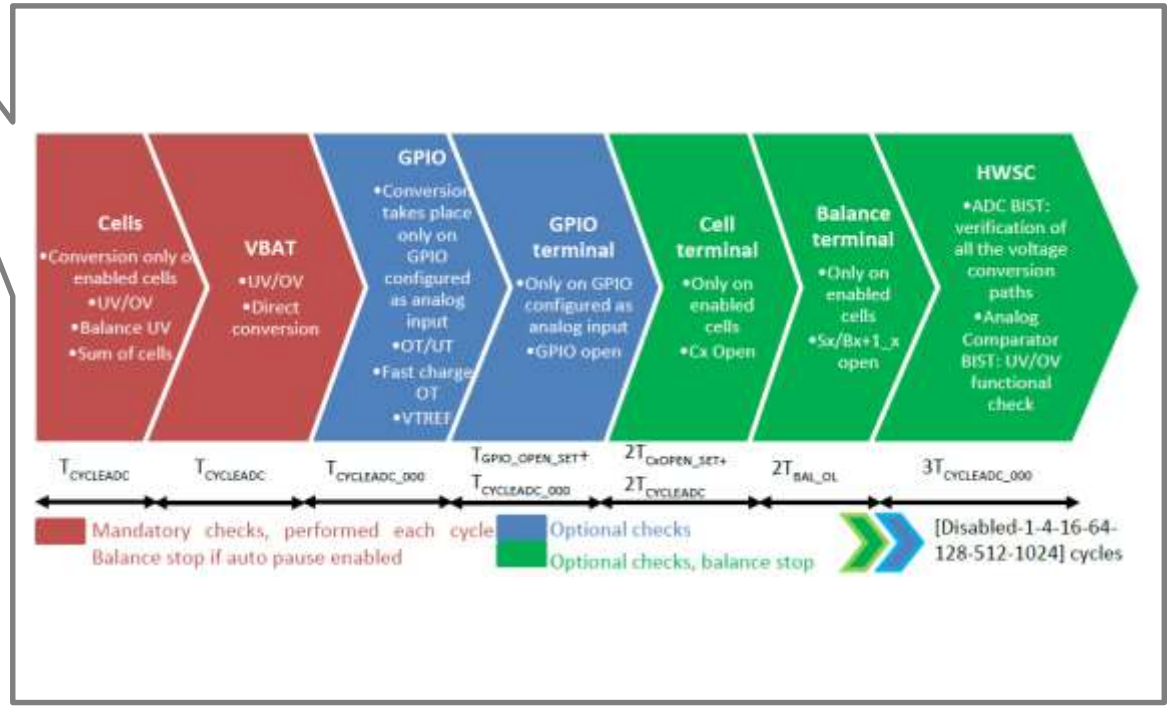
- Measures 4 to 14 cells in series
- Synchronized High-precision cell voltage and current measurement within ±1500A range with Coulomb counter included
- 8 programmable filtering options for cell and battery stack voltage conversion
- 16-bit voltage measurement with maximum error of **±2mV** in whole operating temperature range
- 2.66mbps isolated serial communication and 5Mbps SPI are integrated for daisy-chained connection
- Maximum 200 mA passive internal balance for single cell in both normal and sleep-balancing mode. If balance is enabled on more cells, the maximum current of each single cell is reduced according to power dissipation
- Two balancing modes: Manual and Timed mode
- Supports both internal and external balancing
- Single or multiple channel cell balancing simultaneously
- -40°C/200°C temperature measurement range with support for NTC monitoring
- 9 General purpose I/O (7 out of 9 can be used for NTC)
- Engineered for **ISO26262** compliant system, **ASIL-D** capable
- Passes 200 mA Bulk Current Injection (BCI) test



L9963 Advanced Features

1. Measures 4 to 14 cells in series, supporting also busbar connection without altering cell results.

2. Intelligent diagnostic routine providing automatic failure validation. Redundant fault notification through both SPI Global Status Word (GSW) and dedicated FAULT line.

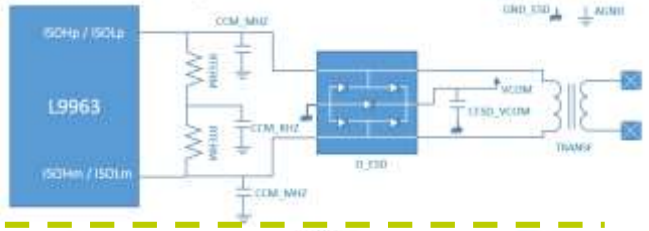


3. 2.66 Mbps isolated serial communication with regenerative buffer, supporting long cables and dual access ring.

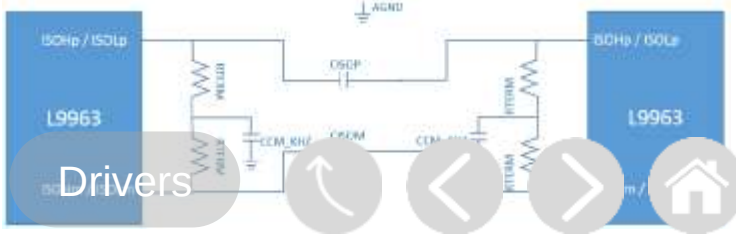
4. Robust hot-plug performance. No Zeners needed in parallel to the cells.

Fast cells conversion & acquisition
15 x L9963 = <u>210 cells → < 10ms</u>

Distributed BMS



Centralized BMS



Drivers

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Hot Plug Protection

4

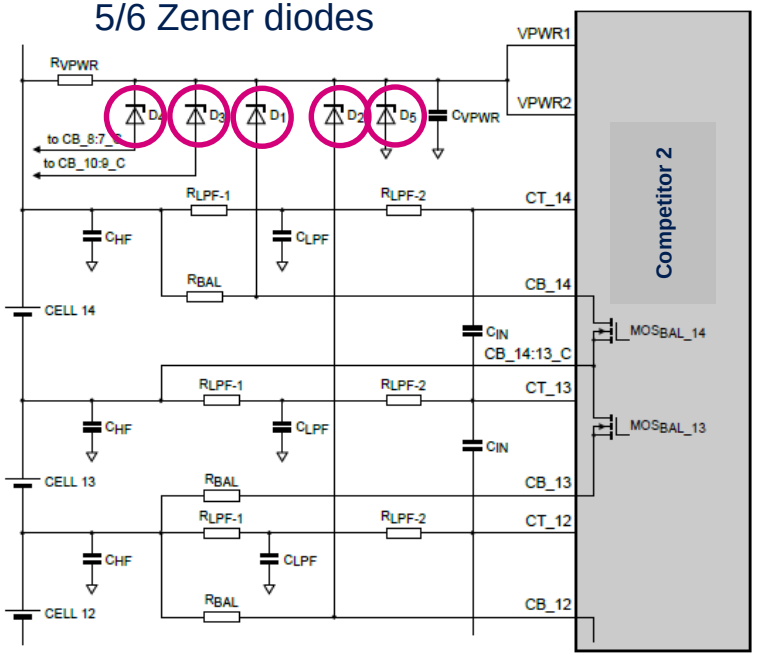
Hot plug is a critical condition for AFE

The majority of the AFE devices requires a large number of external components to withstand hot plug.

L9963 has an intrinsic robustness to hot plug and only in some very critical cases few limited external components are needed

Generic AFE protection net

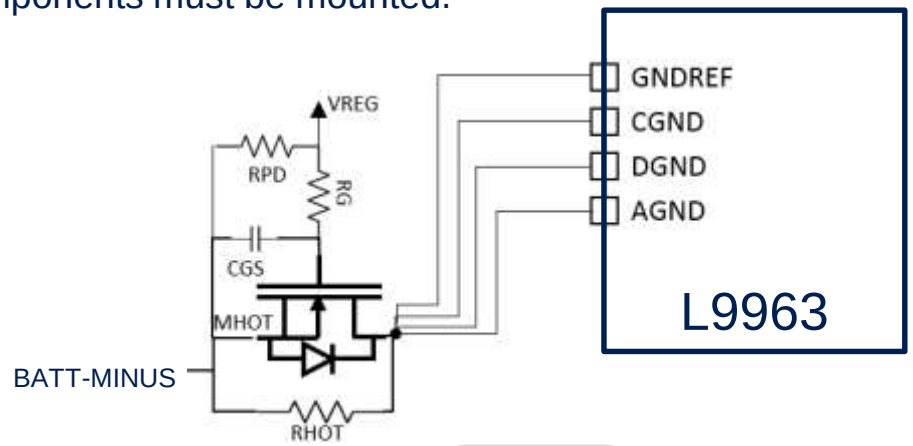
5/6 Zener diodes



L9963 can safety handle hot plug if:

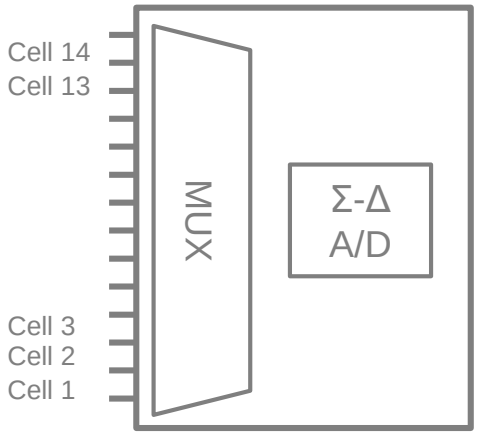
- The recommended components and configurations for cell voltage sensing and balancing are used
- AMR is not violated

In case the above conditions are not met, few additional external components must be mounted.

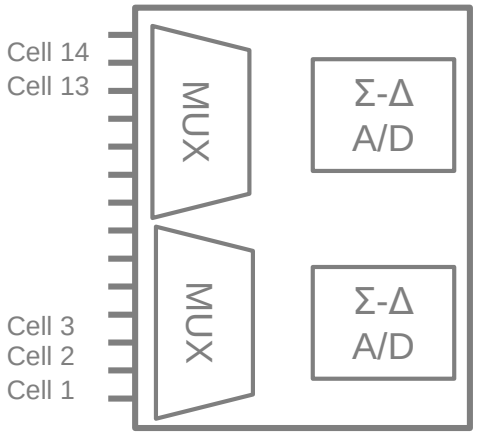


L9963 Mastering Cell Monitoring

Competitor 1

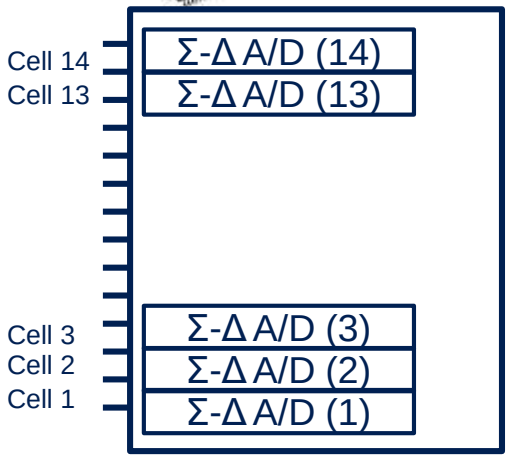


Competitor 2



- Differently from the competition L9963 uses **14 Σ-Δ ADC converter**.
- Each cell has is dedicated converter.
- Adjacent converters use independent power supplies and references.

L9963



+ Performance

1. Long filtering time on the Σ-Δ ADC converter without impacting the synchronization of the cell voltage reading.
2. Less than 2 us desynchronization between samples of a 800V battery pack.

+ Safety

3. Fully redundant conversion path using the adjacent Σ-Δ ADC converter for each cell.
4. Advanced limp home functionality: in case of ADC failure the related cell can be converted with the adjacent Σ-Δ ADC converter.

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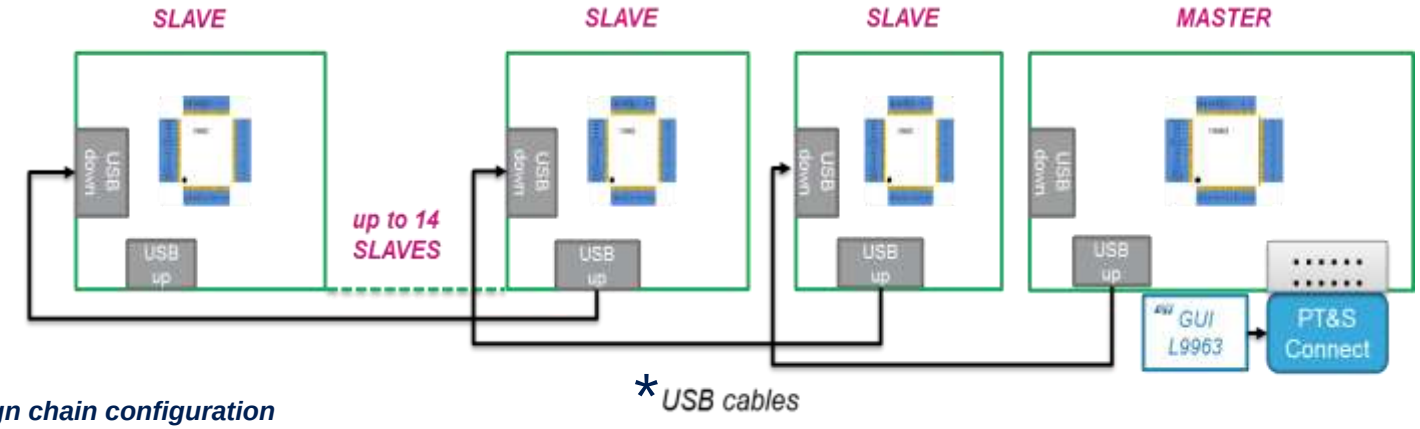
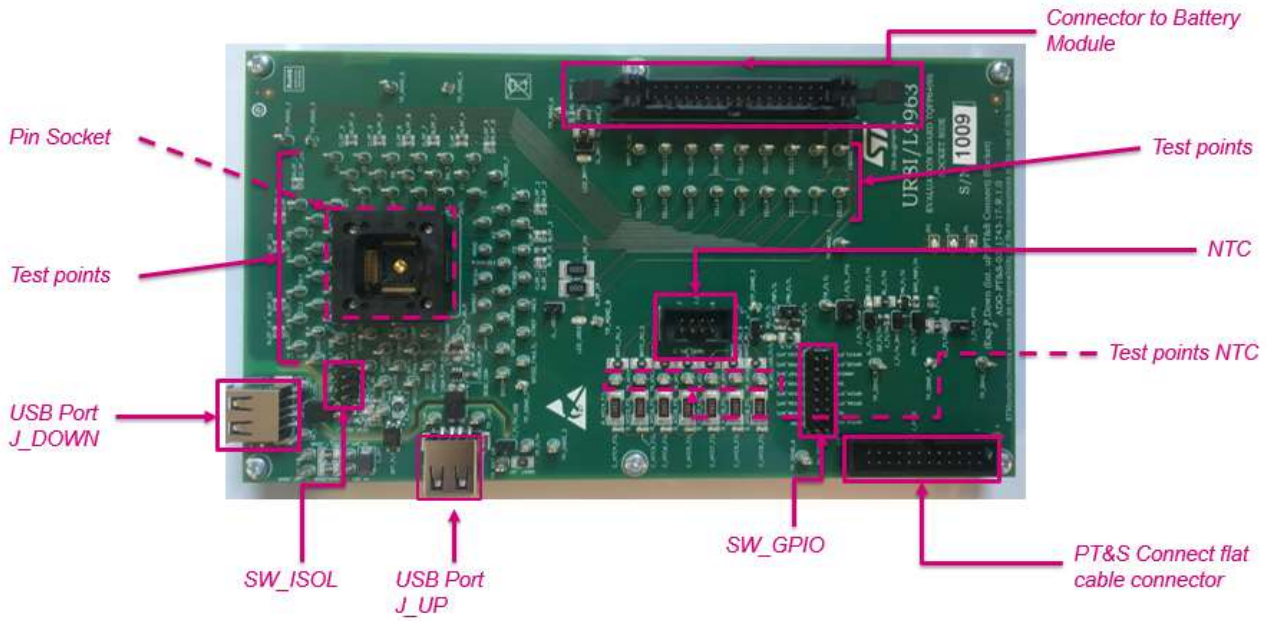
L9963 Evaluation Kit



Design chain configuration

Evaluation kit

- ✓ Datasheet
- ✓ Final silicon samples
- ✓ Demo board + PT&S connector
- ✓ GUI
- ✓ Safety Manual



* *Transformer VIF uses USB connector*

SO16

L9963T

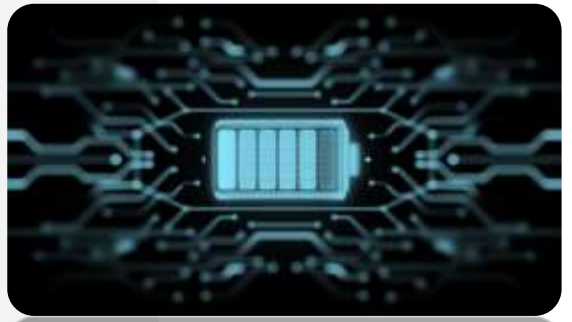
Isolated Transceiver for BMS

Transformer isolated communication interface

Up to 2.66 Mbps

3.3V and 5V compatible logic threshold

- Isolated SPI interface
- L9963 companion transceiver for BMS application
- Automotive EV application
- Robust conducted and radiated immunity performance
- ISO262622, ready for ASIL D system



Ready for sampling m/o 2019
Production b/o 2020

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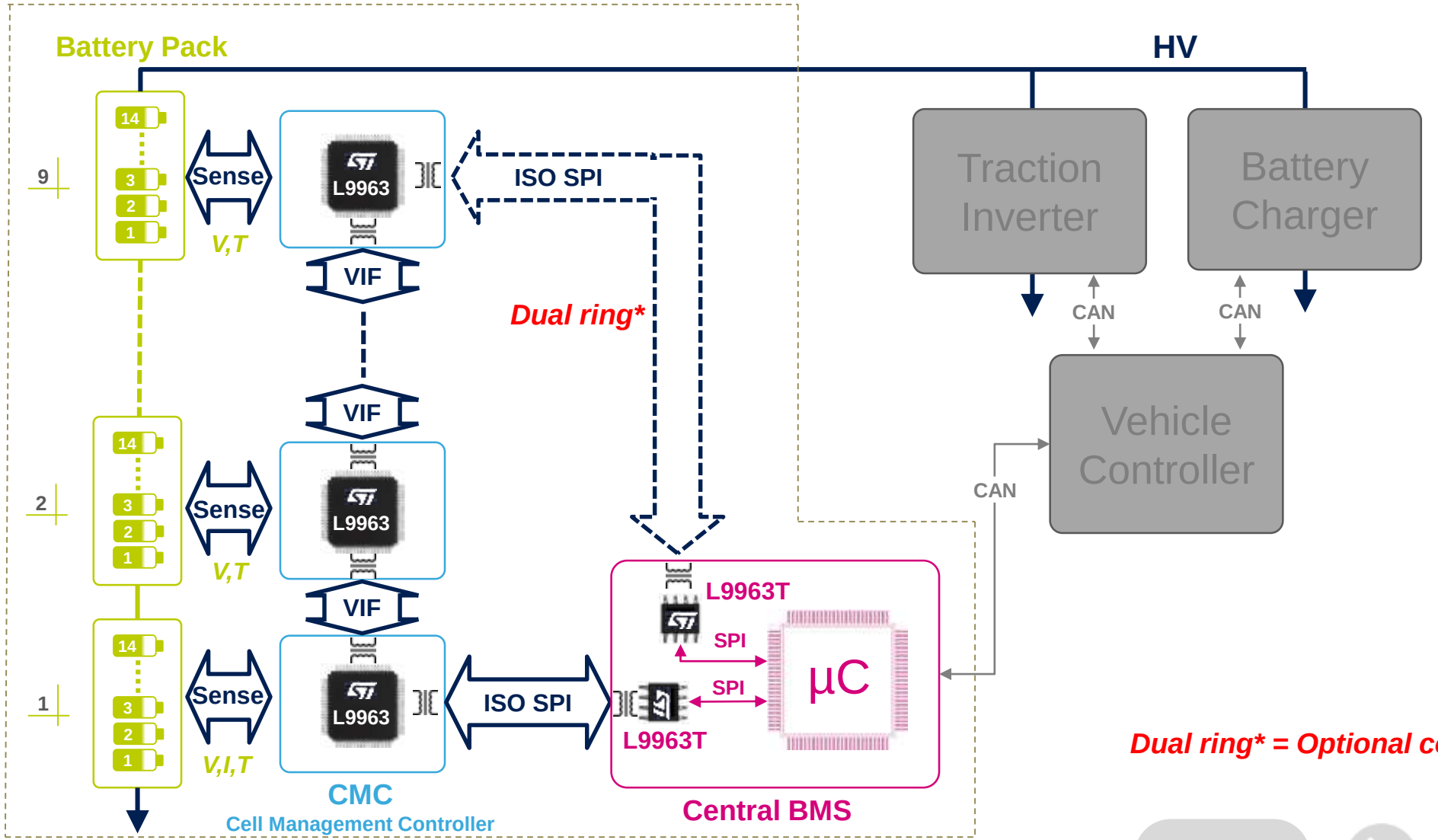
L9963 & L9963T – System Overview



Dual ring = Optional configuration*

V,I,T = Voltage, Current and Temperature sense

BMS Complete Line-up

L9963

QUALIFIED

14 cells
1 current sense

TQFP64EP

L9963T

AVAILABLE Q1/20

Isolated
transceiver

SO16

L9963S

IN DEFINITION

14 cells

TQFP64EP

L9962

IN DEFINITION

8 cells

TQFP48EP

L9965

IN DEFINITION

18 cells

TAFP80EP

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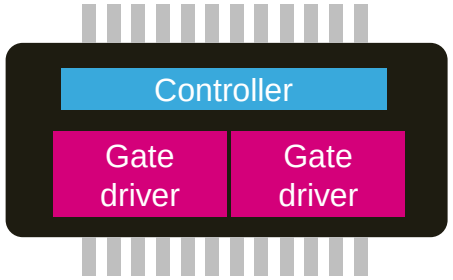
Car Electrification

IGBT / SiC Isolated Gate Driver Family

Scalable offer from single to dual gate drivers, from low to high content

Twin isolated Gate Driver (6kV) for OBC, DC/DC, BSG

Family L9501

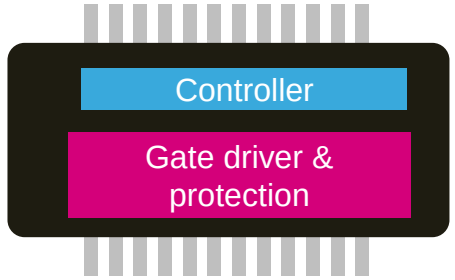


SO20

Single isolated Gate Driver (6kV) for TRACTION

With protection, diagnostics and communication

Family L9502



SO24 / SO28

Automotive qualification
ISO26262 compliancy

SUSTAINABLE TECHNOLOGY by ST

BCD9sL

BCD6s with Galvanic capacitive isolation

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L9501 Family Overview

L9501 Base blocks

- **Dual gate driver**
- **Automotive** AEC-Q100 Grade 1 — AEC-Q100
- **Functional Safety** ISO 26262 — ISO 26262
- **Galvanic Isolation** 6kV
- **Input supply** VDD 3.3V to 20V
- **AMR VH-VL** 40V
- **Current capability** Isink 4A, Isource 4A
- **Protection** UV & TSD

Automotive qualification
ISO26262 compliancy

L9501 configurations

L9501 Flyback voltage 23V Miller clamp	**L9501D** Flyback voltage 23V Desaturation
L9501L Flyback voltage 18V Miller clamp	**L9501DL** Flyback voltage 18V Desaturation
L9501B Miller clamp	**L9501DB** Desaturation

L9502 Family Overview

AEC-Q100

ISO 26262

L9502	L9502B
Single gate driver	**Single gate driver**
Automotive AEC-Q100 Grade 1	**Automotive** AEC-Q100 Grade 1
Functional Safety ISO 26262 ASIL D	**Functional Safety** ISO 26262 ASIL D
Galvanic Isolation 6kV	**Galvanic Isolation** 6kV
Input supply VDD 3.3V to 20V	**Input supply** VDD 3.3V to 20V
Flyback voltage Configurable	
AMR VH-VL 40V	**AMR VH-VL** 40V
Current capability Isink 15A, Isource 15A	**Current capability** Isink 15A, Isource 15A
HV ADC	**HV ADC**
IGBT/SiC Temperature Sense	**IGBT/SiC Temperature Sense**
IGBT/SiC Current Sense	**IGBT/SiC Current Sense**
Miller clamp + DESAT	**Miller clamp + DESAT**
SPI Diagnostic & Protection	**SPI** Diagnostic & Protection

ASIL Ready

Automotive qualification
ISO26262 compliancy

SUSTAINABLE TECHNOLOGY by ST

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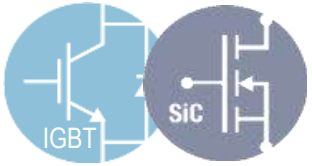
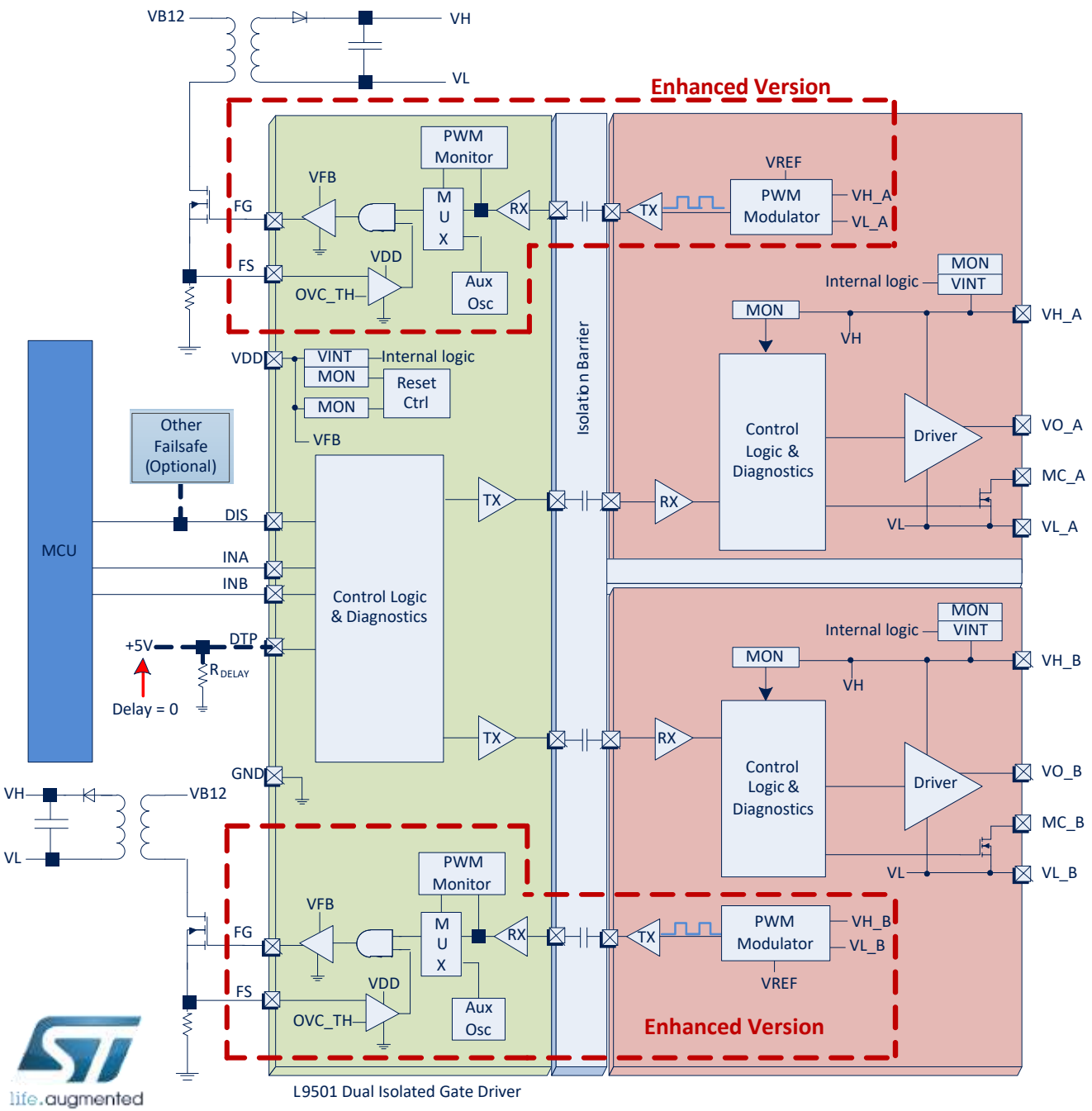
L9501 Gate Driver

OBC, BSG, DC/DC

General Overview

- Dual channel isolated gate driver
- AEC-Q100 Grade 1 qualified
- 6kV peak galvanic isolation
- CMTI > 100V/ns
- 4 A sink/source current capability
- Active miller clamp
- VH-VL 40V capable
- Pulse width distortion < 10ns; delay < 100ns
- Programmable dead time through DT pin
- LV and HV under voltage protection
- Thermal protection
- 2 flyback
  - LS pre-driver and controller
  - Regulated voltage 23V
  - 156kHz switching frequency
  - Current limitation protection
  - Max/Min duty cycle protection





L9501 Dual Isolated Gate Driver

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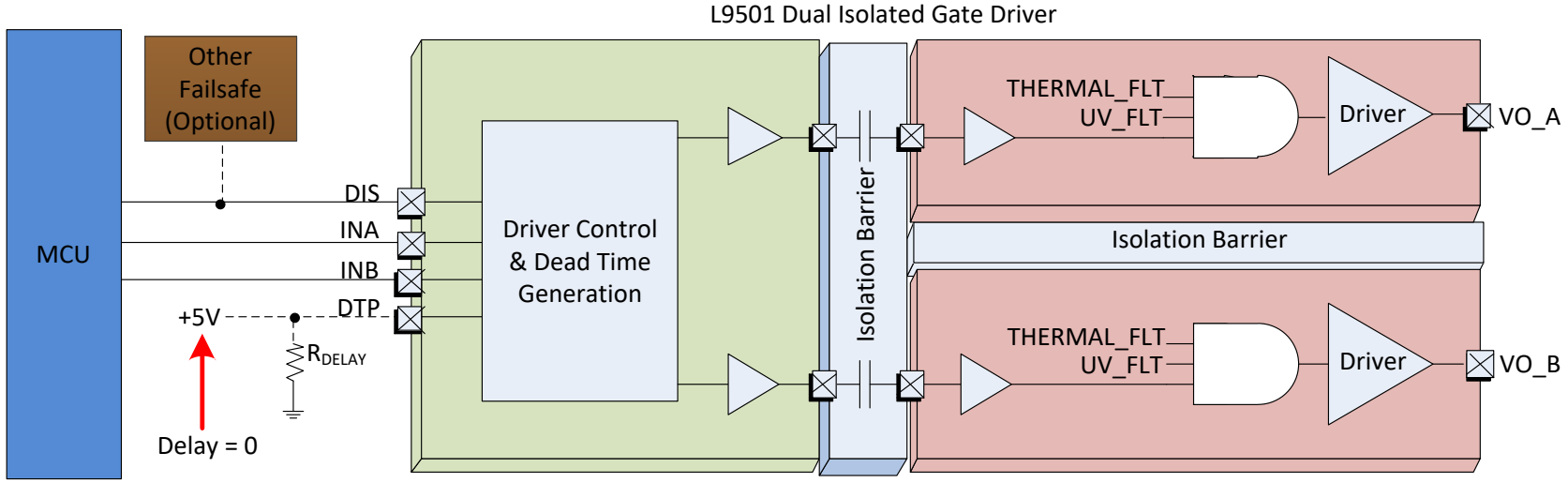
L9501 Gate Driver

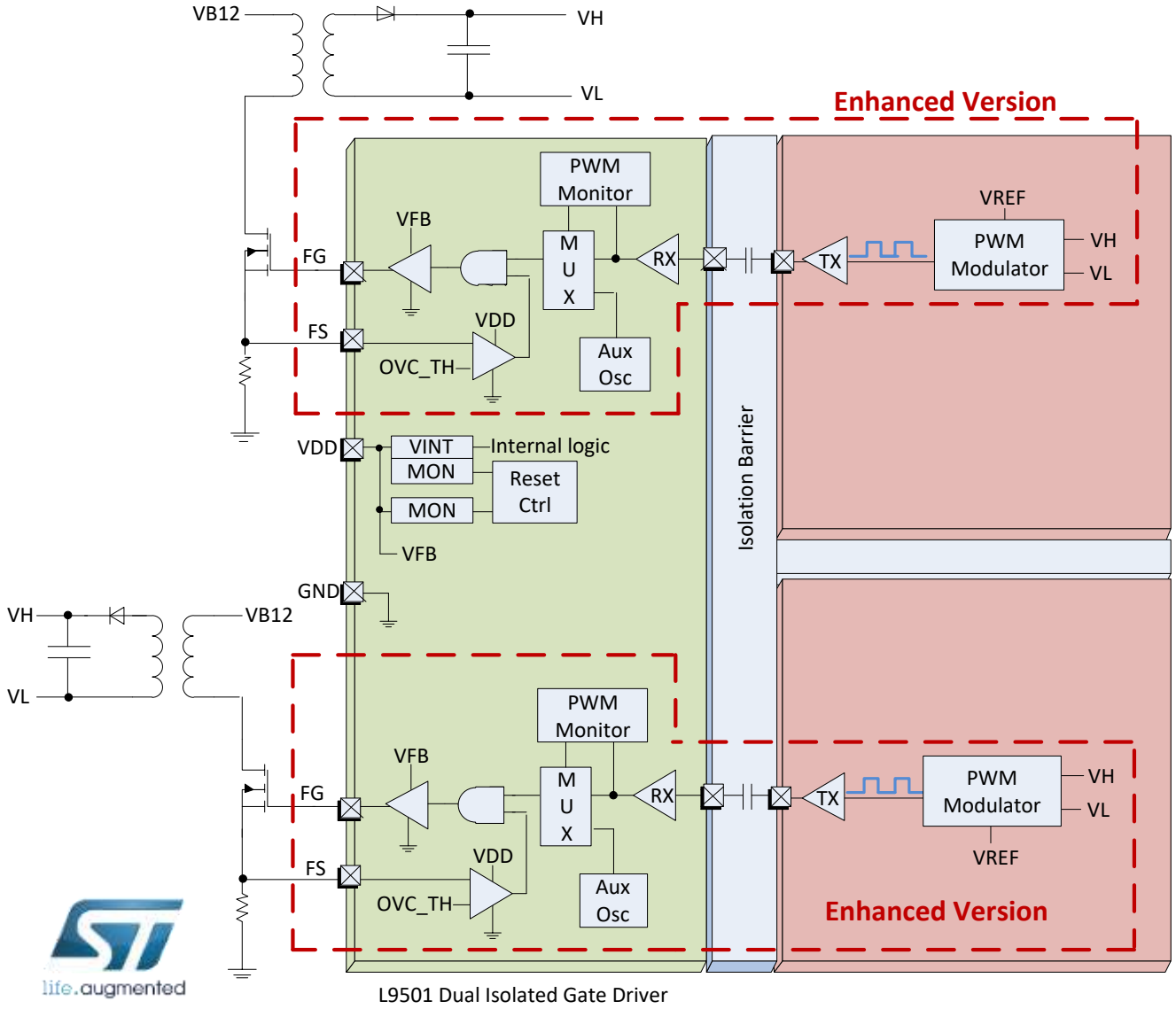
Output Control



- Driver A & B are isolated from each other and the low voltage control interface
- Driver A & B are controlled thru their respective inputs (INx)
  - Drivers can be disabled using the “DIS” pin on low voltage side or by faults in the high voltage side, thermal and under voltage
  - “DIS” function can be by an independent failsafe monitoring device or driven directly from the MCU
  - Transition delays between drivers A & B is set by the DTP pin (Dead Time Protection) using an external resistor or direct connection to +5V for no delay.
- Thermal and under voltage faults in the high voltage domain are independent per each driver stage.
- In low voltage domain, VDD & VINT 3.3V under voltage faults drives output low (SAFE_OFF)

L9501 Gate Driver

Flyback Controller



L9501 Dual Isolated Gate Driver

- Flyback Controller Function
  - Dual flyback circuits, independently controlled
  - Provides isolated HV domain voltage from LV domain
  - PWM modulator senses VH-VL voltage and adapts PWM control signal
    - PWM frequency is 156KHz, nominal
    - Minimum and maximum duty cycles are internally limited
  - Auxiliary oscillator provides startup PWM to begin HV domain power-up sequence, oscillators are independent
  - Overcurrent protection disables gate drive for the remainder of the PWM cycle
  - In low voltage domain, VDD & VINT 3.3V under voltage faults disable FG output drivers

SUSTAINABLE TECHNOLOGY by ST

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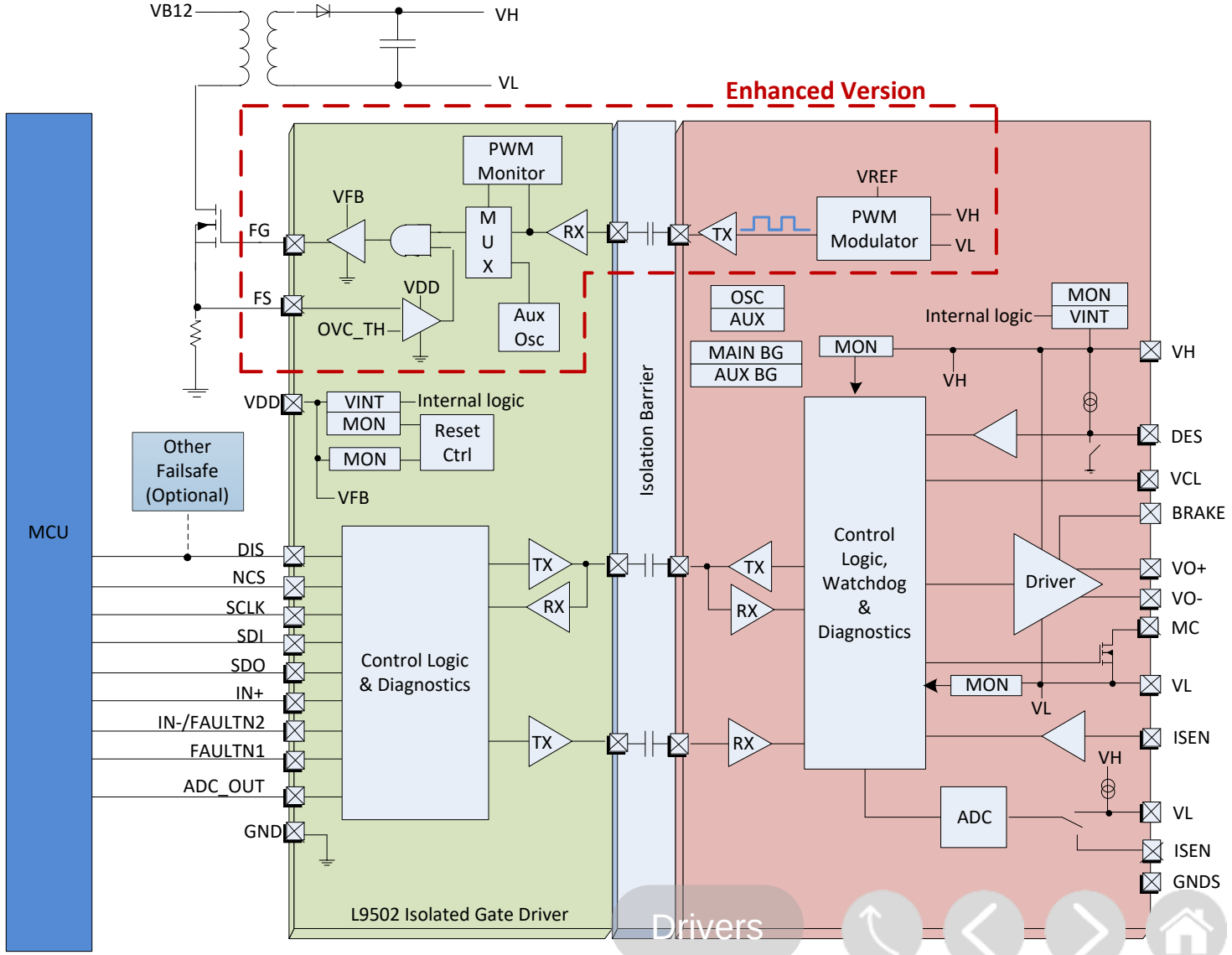
L9502 Isolated Gate Driver

Traction Inverter Basic & Enhanced

Automotive qualification
ISO26262 compliancy

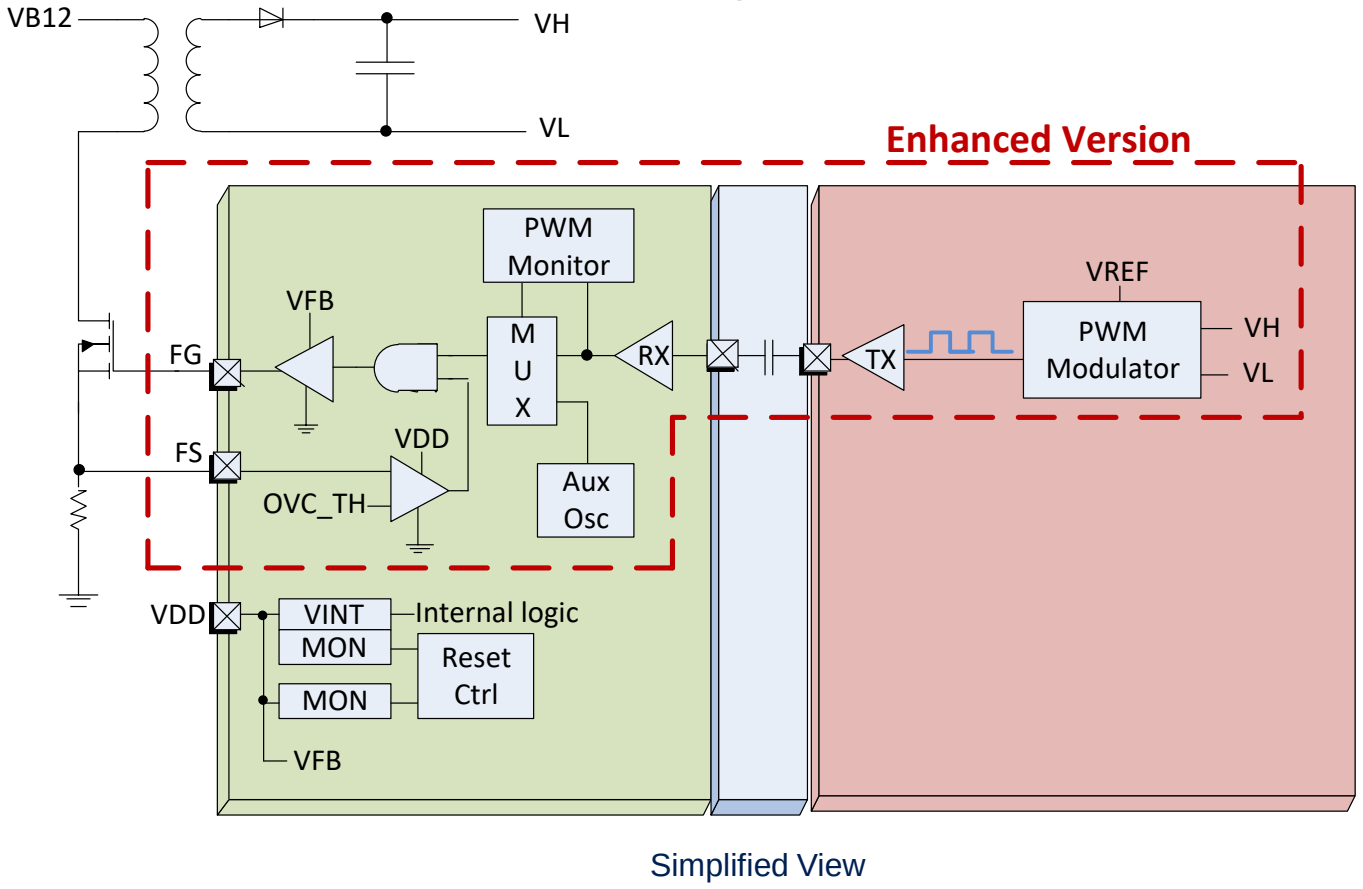
Device Overview

- Single channel isolated gate driver
- AEC-Q100 Grade 1 qualified
- ISO 26262, ready for ASIL D systems
- 6kV galvanic isolation
- CMTI > 100V/ns
- 10 A min, 15A typical sink/source current
- Miller clamp
- VH-VL 40V capable
- Pulse width distortion < 10ns; delay < 100ns
- Full diagnostic and programmability through SPI
- Overcurrent protection
- 4 channel A/D converter
- ***Flyback (Enhanced Version)***
  - *LS pre-driver and controller*
  - *SPI programmable regulated voltage*
  - *156kHz switching frequency*
  - *Current limitation & over current protection*
  - *Min/Max duty cycle protection*



L9502 Isolated Gate Driver

Flyback Controller



Simplified View

- Flyback Controller Function
  - Provides isolated HV domain voltage from LV domain
  - PWM modulator senses VH-VL voltage and adapts PWM control signal
    - PWM frequency is 156KHz, nominal
    - Minimum and maximum duty cycles are internally limited
  - Auxiliary oscillator provides startup PWM to begin HV domain power-up sequence
  - Current limit protection disables gate drive after 4 consecutive PWM cycles, requires SPI fault reset to restart
  - In low voltage domain, VDD & VINT 3.3V under voltage faults disable FG output driver

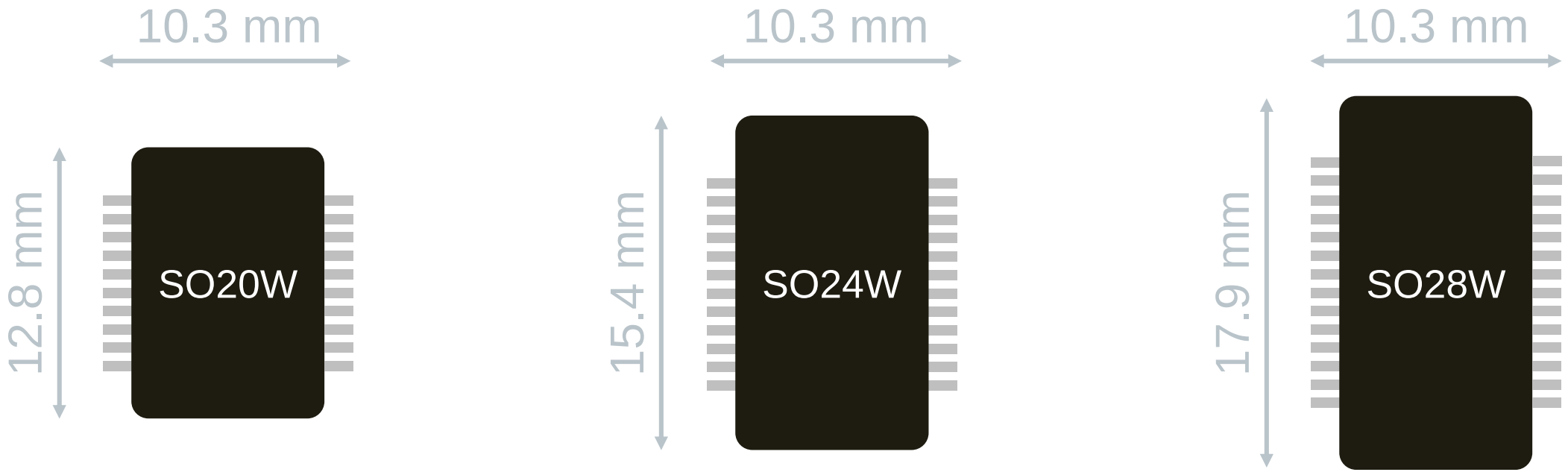
IGBT SiC

Automotive qualification
ISO26262 compliancy

ASIL Ready

SUSTAINABLE TECHNOLOGY by ST

Packages



L9501
Dual gate driver ENHANCED

L9502B
Single gate driver BASIC for Traction

L9502
Single gate driver ENHANCED for Traction

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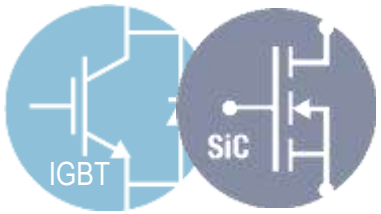

Automotive qualification
ISO26262 compliancy

Schedule

First silicon	*Final silicon*	*PPAP*
Q4 2019	***Q2 2020***	***Q2 2021***

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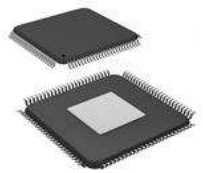
TQFP64EP



L9907

BLDC Pre-driver IC

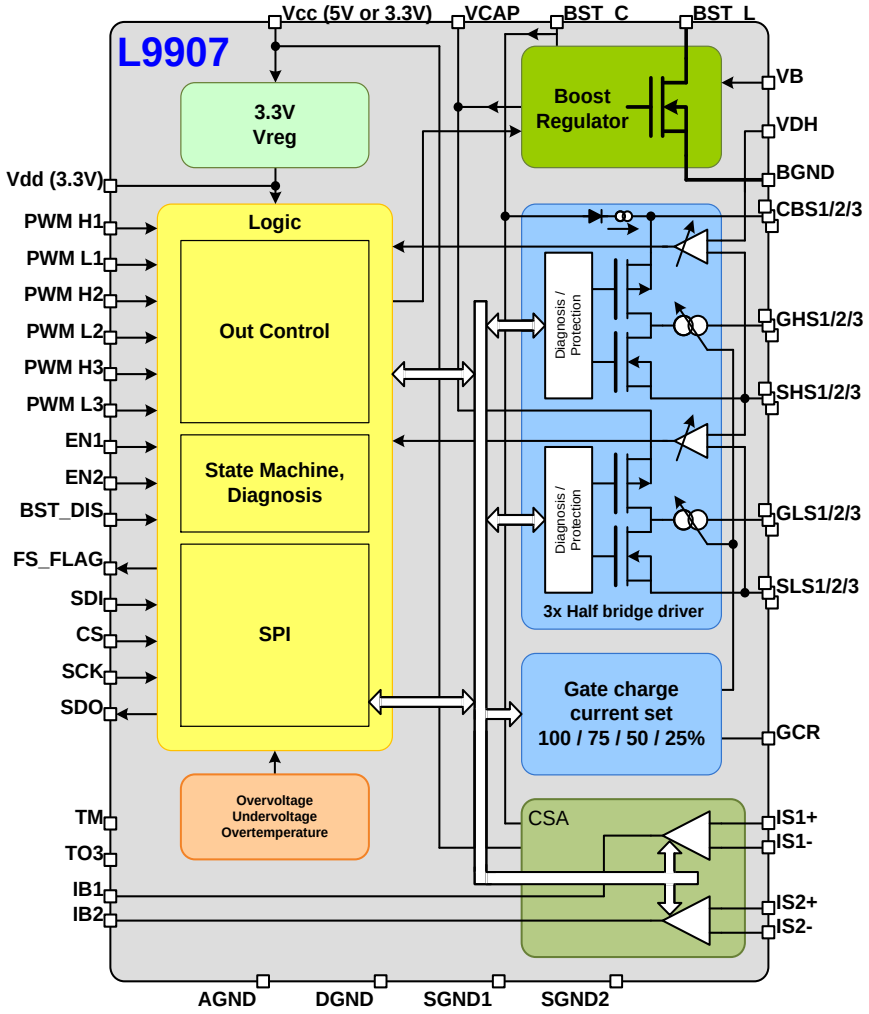
Key Highlight

- ISO26262 systems compatible
- Wide range of system compatibility (12v / 24v/ 48v)
- 2 independent floating CSAs
- MOSFET HS Driver pins robustness at -7V
- Double switch-off path
- Fault pin

Availability

- In production

Block Diagram



Technical information

- Supply Voltage from 5V to 54V
- Supply current consumption < 5 uA
- Driver compatible up to 75V
- 3.3V and 5V compatible
- Full Rdson down to 5V
- 3 Channel Low & High Side Drivers
  - PWM operation up to 30 kHz
  - Output internally clamped to 70V
  - Output current 1A peak
  - Source connection to each Mosfet
  - Independent driving control
- 2-differential current sense amplifier with programmable gain
- Full diagnosis by 10-bit SPI
- programmability on: dead time with a fixed minimum value, Drain-Source monitoring, programmable over-voltage shut-down, programmable gain for operational amplifier
- Thermal Shutdown

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TQFP48EP

L9908 - Stelvio

Brushless Motor Pre-driver IC

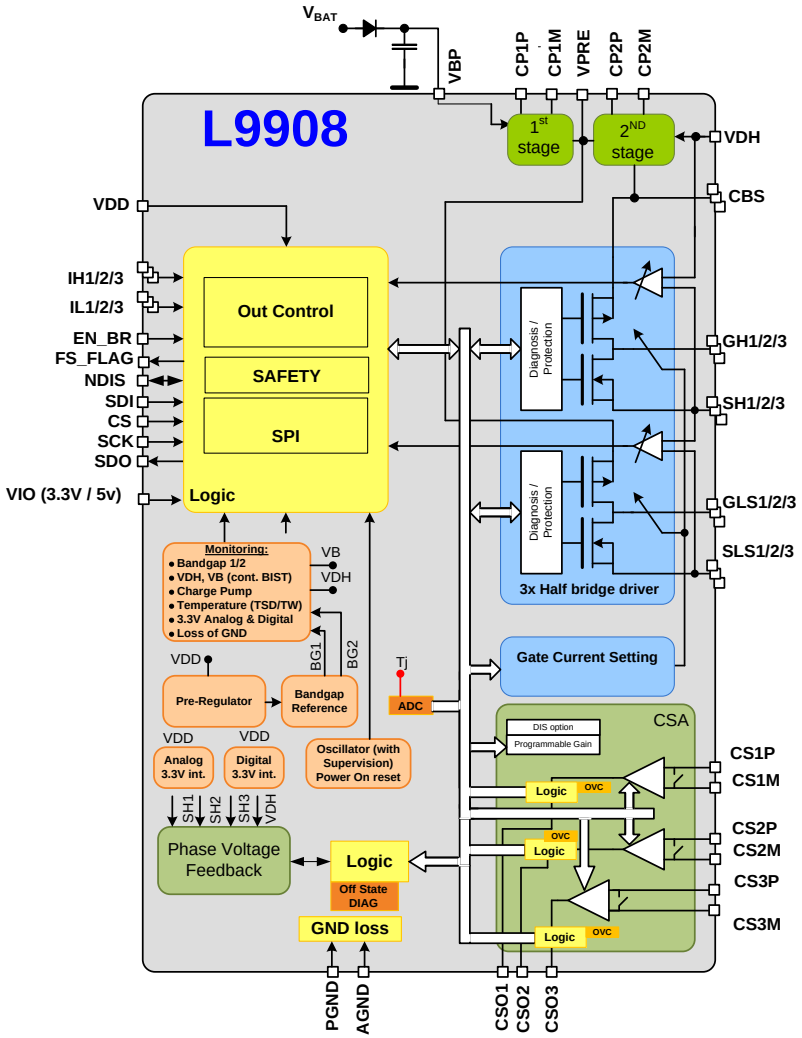
Key Highlight

- Full ISO26262 compliant, ASIL-D systems ready
- Wide range of system compatibility (12v / 24v/ 48v)
- 3 independent low-side CSAs
- Smart logic for current acquisition and processing
- MOSFET HS Driver pins robustness at -14V
- AEC-Q100 Grade 0

Availability

- ES available e/o Q4’18
- PPAP end Q4 ’19

Block Diagram



Technical information

- VDH Motor Supply Voltage from 4.5V to 75V
- Digital I/O compatible 3.3V and 5V logic
- 3 Channel Low & High Side pre-drivers
  - typ PWM operation 20 kHz, max Qg 300nC
  - Single source/sink current (typ 2.2A peak)
  - Source connection to each Mosfet
- 3-differential low-side current sense amplifier with programmable gain and smart logic for current measurement
- Full diagnosis by 32-bit SPI, 10MHZ with 5-bit CRC and WD
- programmability on: dead time with a fixed minimum value, Drain-Source monitoring, over-voltage shut-down
- OFF state diagnostics
- Two safety disable path (EN_BR, NDIS)
- Thermal Shutdown

Drivers

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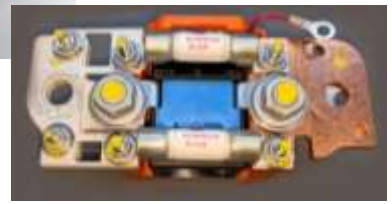
Powertrain Electrification

Power Distribution

Vehicle Control Units (VCU)
and
Battery Cut-off Systems

are required in modern electric car designs



ST contributes with:

- Integrated Uchip with on/off drivers for HV relays → **L9788**
- Current control driver IC for HV relays → **L9305**
- Integrated Uchip with squib drivers for battey cut-off applications → **L9678**
- Squib driver ICs for battery cut-off applications → **L9654, L9660, L9679E**

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Powertrain Electrification

Power Distribution

Investigation on L9788 in VCU application

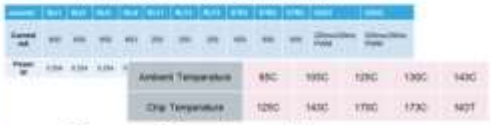
Bench Test

- Confirm the effectiveness of driving high voltage contact relay through O2 and Pre-driver Channel.

TE EVC500 waveform

Thermal Test

- Verified the dynamic performance of L9788 in managing the inrush current of high voltage relay.



Thermal test result

Functional Safety Analyze

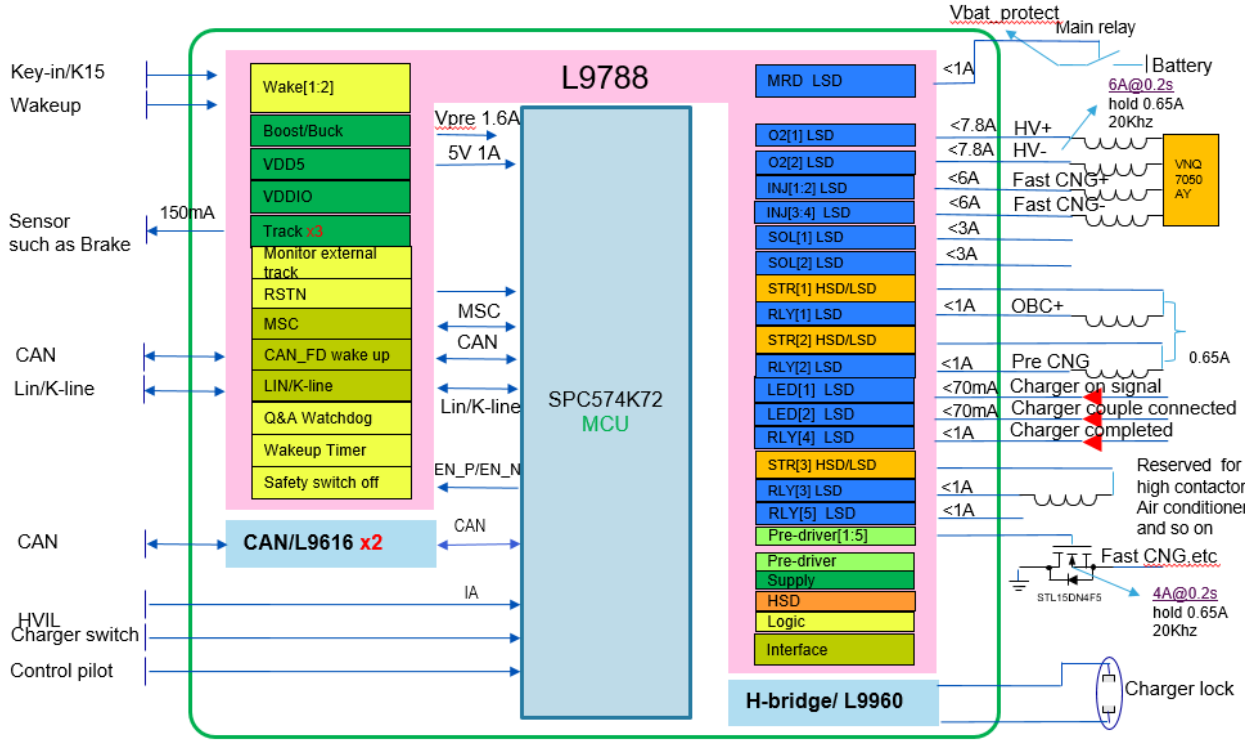
- Analyzed on safety requirement to L9788 for VCU application.

VCU Safety Requirement

VCU Demo Kit

- Developed the dynamic demo for VCU with K2 + L9788 kit solution

VCU Demo Kit



TQFP100EP

L9788

4-cylinder Uchip for Engine Management

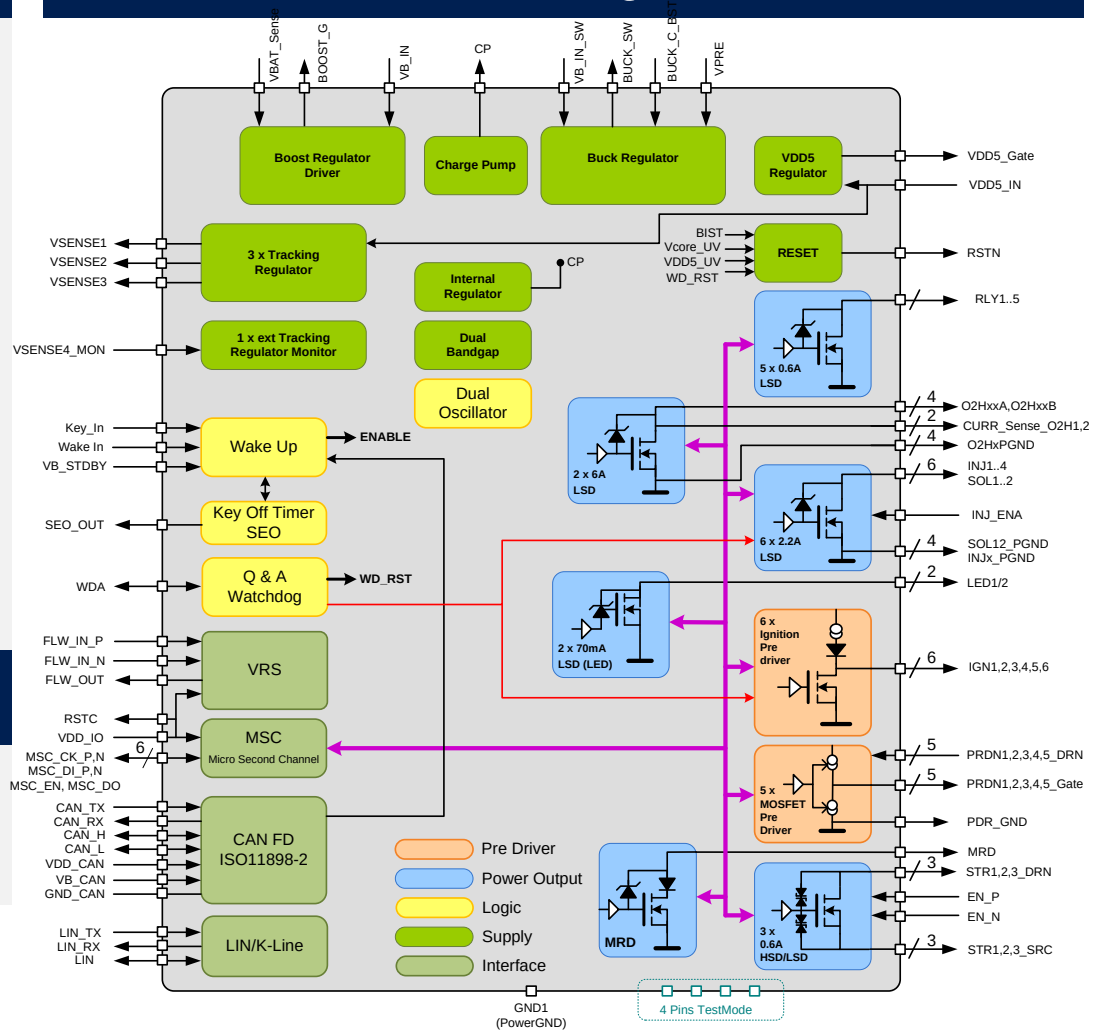
Key Highlight

- ISO26262 systems compatible
- Dimensioned for mid-end platforms (regulator currents and load driver energy)
- Boost - Buck topology for low battery functionality for Start/Stop systems
- Ready for 6 cylinders system extension

Availability

- In production

Block Diagram



Technical information

- Supply section:
  - Boost regulator with ext. MOS
  - Buck pre-regulator with int. MOS and ext. Diode
  - 5V linear reg. with ext. MOS
  - 3x 5V tracking regulator
- 16 low side drivers with full diagnostic (Main Relay Driver incl.)
- 3 HS/LS configurable drivers with full diagnostic
- 6 IGN pre-driver with full diagnostic
- 3 pre-drivers for low side n-channel MOS
- MSC, VRS, K-Line/LIN interfaces
- CAN-FD transceiver
- Query/Answer WD for output drivers switch off and µC reset
- 5V/3.3V IO compatibility
- Low stand-by current consumption
- Stand-by memory

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Drivers

PSSO36

TQFP48EP

L9305 - Stonemountain

4 Channel Current Controlled Valve Driver

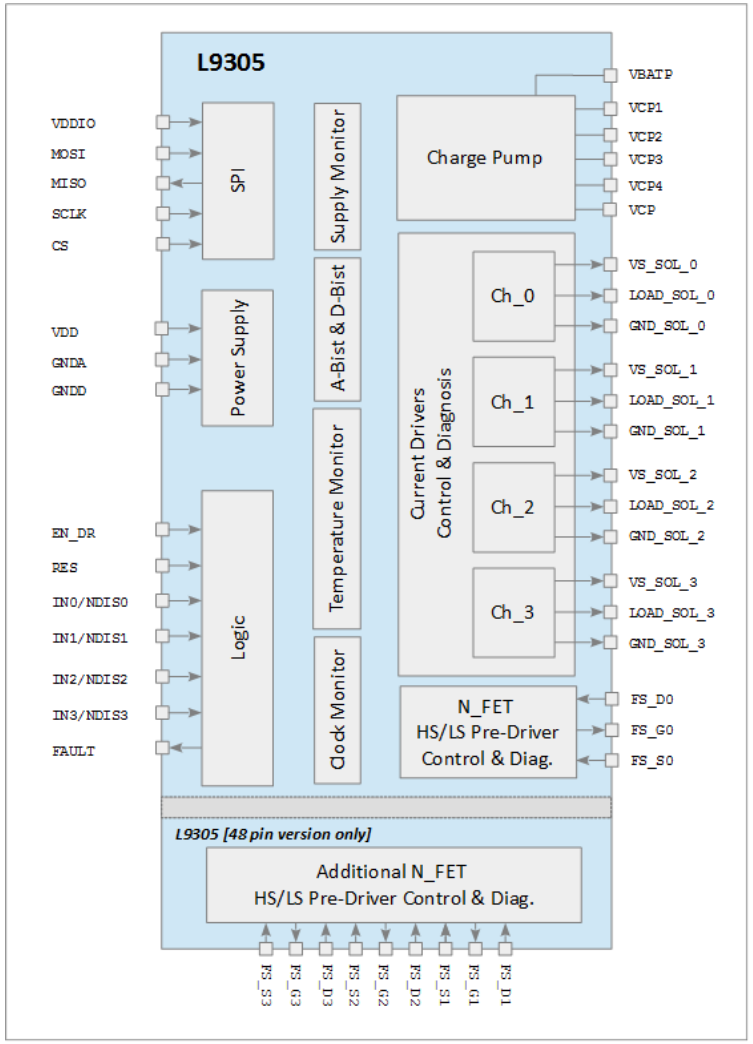
Key Highlight

- 3mA accuracy and Internal sensing I path immune to aging
- No ECU final line calibration needed
- Redundancy of the whole I regulation path
- Real time echo of the regulated current availble on SPI register
- Programmable triangular & square dither
- Full ISO26262 compliant, ASIL-D systems ready

Availability

- In production

Block Diagram



Technical information

- 4 independent LSD/HSD current controlled drivers
  - Integrated Current Sense Path
  - Current Accuracy (in normal range)
    - ± 3mA in 0 to 1.2A range
    - ± 1% in 1.2A to 1.5A range
  - Current Accuracy (in extended range)
    - ± 20mA in 0 to 0.5A range
    - ± 4% in 0.5A to 2A range
  - Max Driver RDSON 400mΩ @ 175 ° C
  - 13 bit Current Set-point Resolution
  - Variable and Fixed Frequency Current Control Algorithm
  - Programmable Dither Function
  - Selectable Driver Slew Rate Control
- 1 or 4 Fail safe pre-drivers with VDS monitoring
- Redundant Safe Enable Path
- Advanced Diagnosis and Monitoring
- Temperature Sensor and Monitoring
- 32 bit SPI (5 bit CRC)

ST Protection and IPAD Range for Automotive Applications

TVS

ISO 16750
ISO 7637-2
IEC 61000-4-5

Standard SMD

400W – 7KW
6V up to 82V V_{BR}
& Tj max 150°C

New Flat SMD

6V up to 188V V_{BR}
& Tj max 175°C

ESD

ISO 10605
IEC 61000-4-2
ISO 7637-3

ESD 1, 2, 4, 5 lines

0.3pF - 100pF
5V - 37V V_{BR}
150°C

175°C for ESDCAN

ASIP

ISO 10605
IEC 61000-4-2
ISO 7637-3
CISPR-25

R, L, C integrated in silicon or glass

5V - 37V V_{BR}

EMI and CM

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AG TVS Roadmap

Standard package TVS

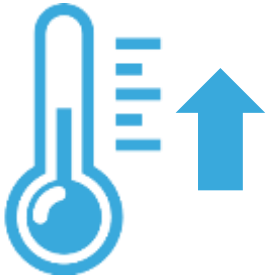
Flat TVS

Compatible with standard DO-xxx

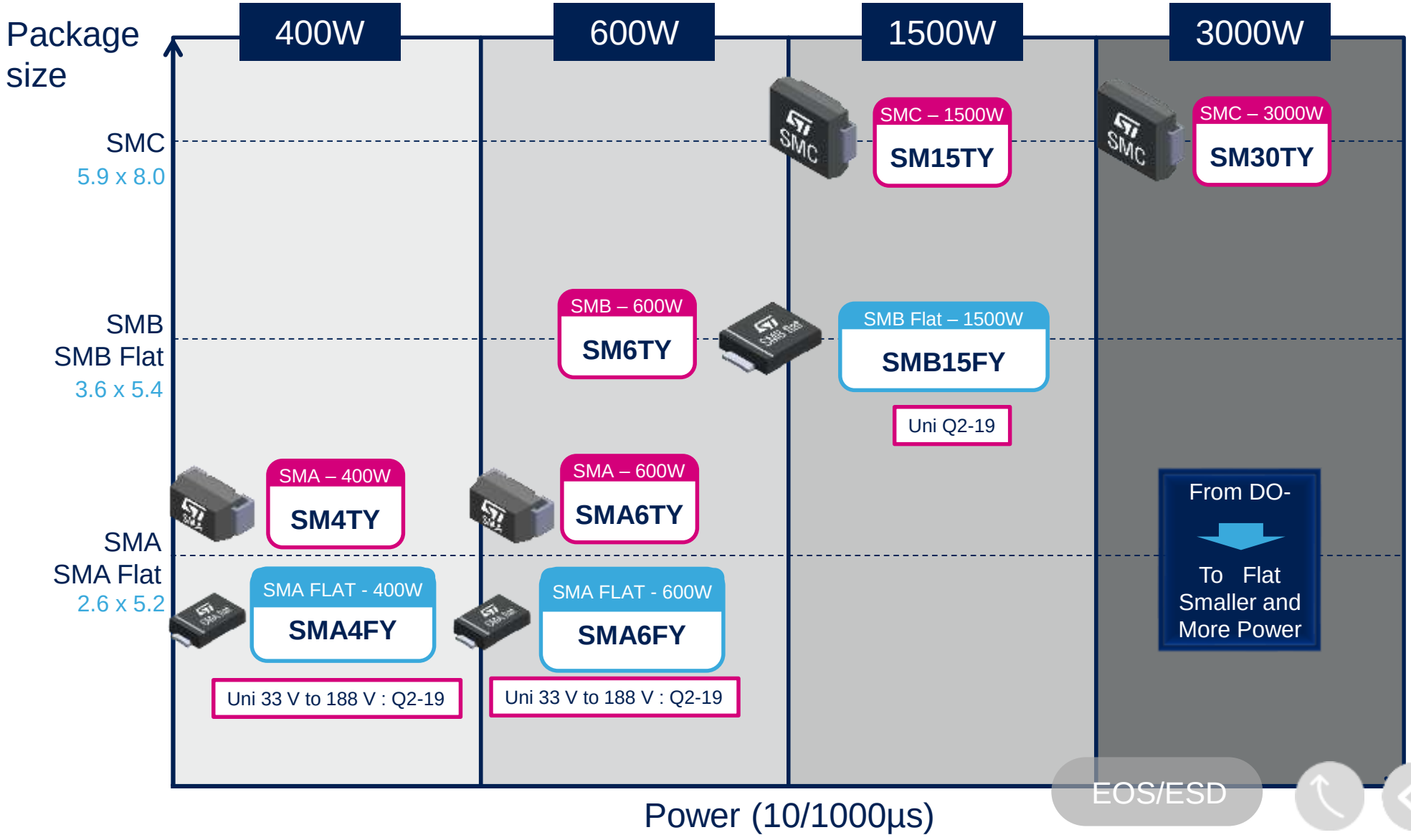
Better Choice

More Power

Smaller and Higher Tj

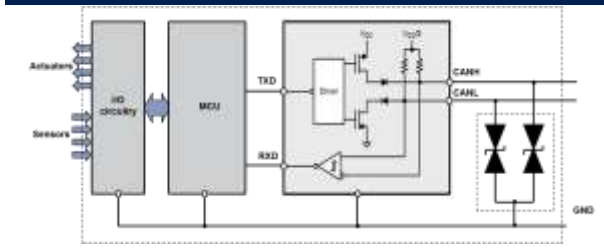


Automotive Grade TVS Protection



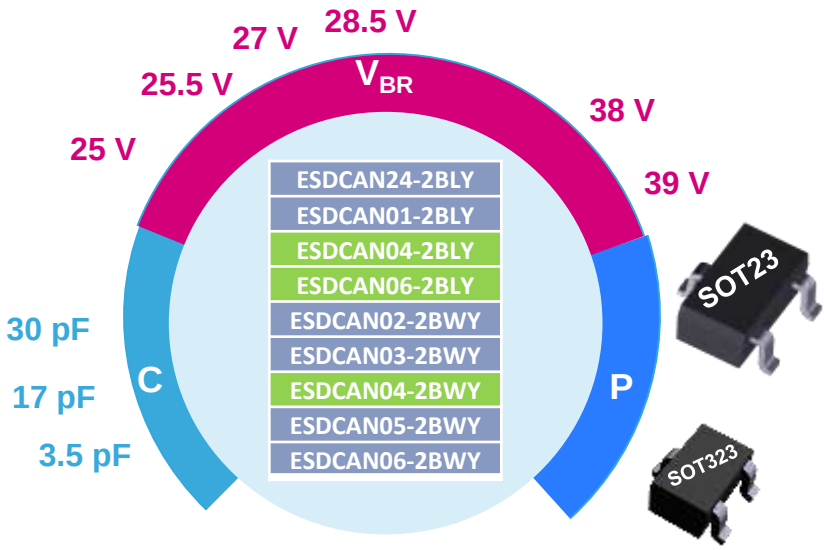
ESDCAN Portfolio Summary

100 % fulfilled with the widest CAN protection range on the market



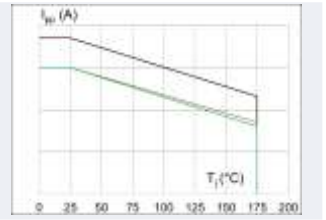
Protocol compliance

- CAN: up to 1Mb/s
- CAN-FD: up to 8 Mb/s
- Flexray: up to 10 Mb/s



Tough environment

→ Able to work up to 175 °C



Compatibility

12 V systems
→ V_{BR} >24 V

24 V systems
→ V_{BR} > 36 V

ISO 16750-2

Reverse connection
→ bidirectional

ISO 16750-2

Jump start
→ V_{BR} > 24 and 36 V

ISO 10605 IEC 61000-4-2

ESD compliance

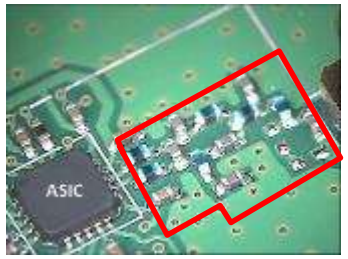
→ Up to 30 kV contact
→ Up to 30 kV air

ISO 7637-3

→ Rated with automotive pulse

IPAD™ Technology Platform

Integration Enablers for ASIP



Tunable Capacitors

High Density Decoupling Capacitors

Low Loss RF Capacitors

HIGH DENSITY RESISTOR

High Precision Resistors

Ipad / Ipd

Silicon **Glass**

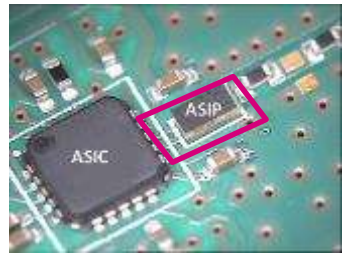
ESD Diodes

High Q Inductors

High Surge TVS

System In Package

Chip Scale Package
Plastic Packages



Protection and Filtering ICs

for Digital Automotive Solutions

ETHERNET

HSP011-2BM6Y

Miniaturized 2 wires high speed protection in µQFN wettable flanks

1

3

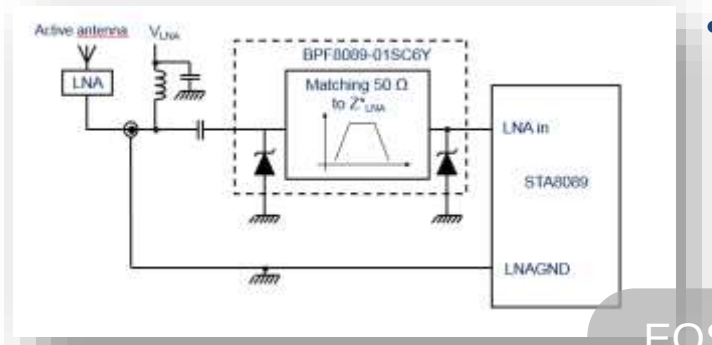
TELEMATICS

High density discretes integration around IC : **ASIP**

- **V2X : ECMF4-2459A6M10Y**
  ESD protection + Common Mode Filtering integration.

  Avoid antenna desense and secure communication.

- **GNSS : BPF8089**
  ESD protection and Filter integration around GNSS circuit.



USB POWER DELIVERY

2

HSP151-2BW3Y

HSP181-2W3Y

High efficiency protection for high speed ports
Voltage compatible with short to battery

EOS/ESD

Body Smart Power

VREGs/
PMICs

Door Zone

Door Locks

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Voltage Regulators

BCD4S BCD5S BIPOLAR	Vo = 5V
BCD9SL	Conf. for 8 fixed Vo

Feature Set

L99VR02XP
Com.Mat. Wk 15 ‘21

L99VR01J
Com.Mat. Wk 11 ’20

L99VR02J
Com.Mat. Wk 02 ‘21

L99VR01S
Com.Mat. TBD

L5150

L5300

L4993
L4979

L4988

L4995

L5050SD

L5050S

L4949

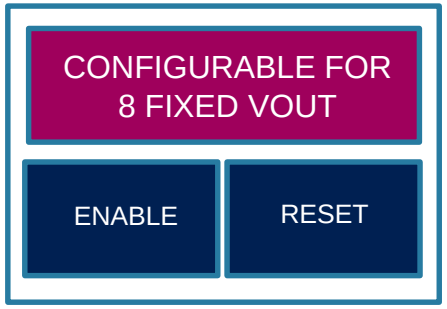
50 | 100 | 150 | 200 | 250 | 300 | 500

Output current (mA)

BSP

VREGs – New Product Line-up

L99VR01S



SO-8

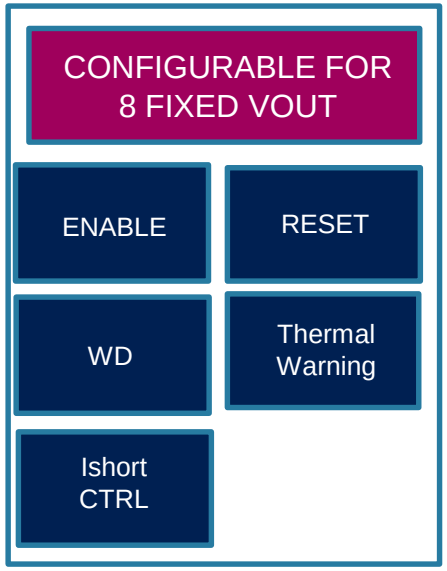
200 mA

L99VR01J

POWERSSO-12

200 mA

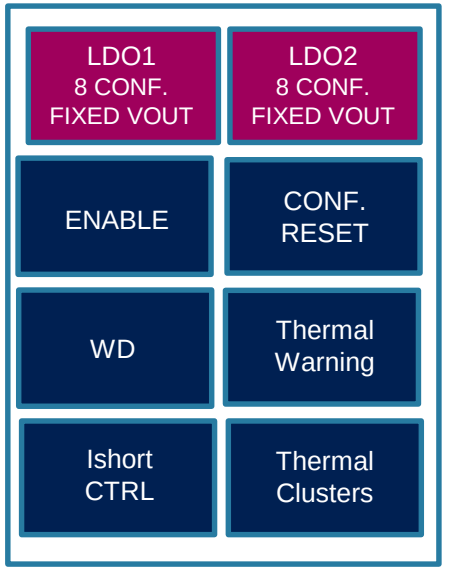
L99VR02J



POWERSSO-12

500 mA

L99VR02XP



POWERSSO-36

2x250 mA

Output Current

BSP

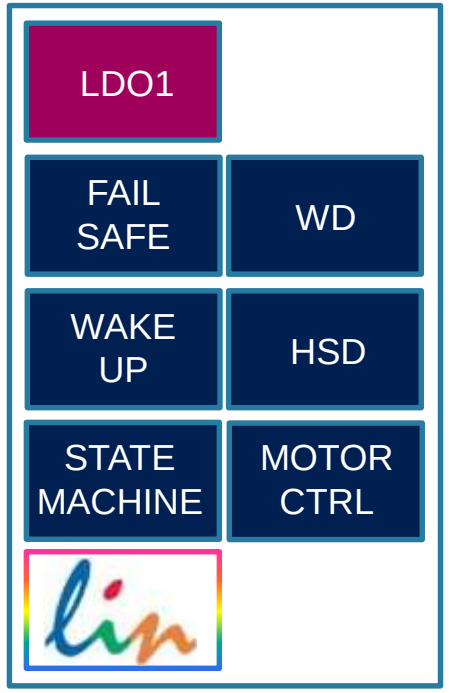
Automotive Power Management ICs

Portfolio Review

Power Management Line up

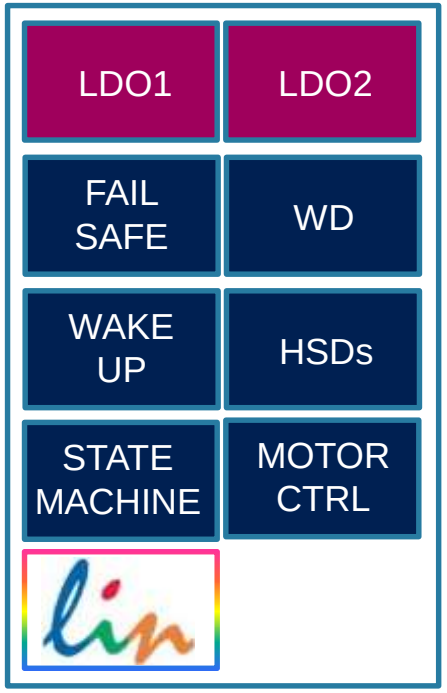
L99PM60J

Motor Control, LIN, Vreg, HSDs



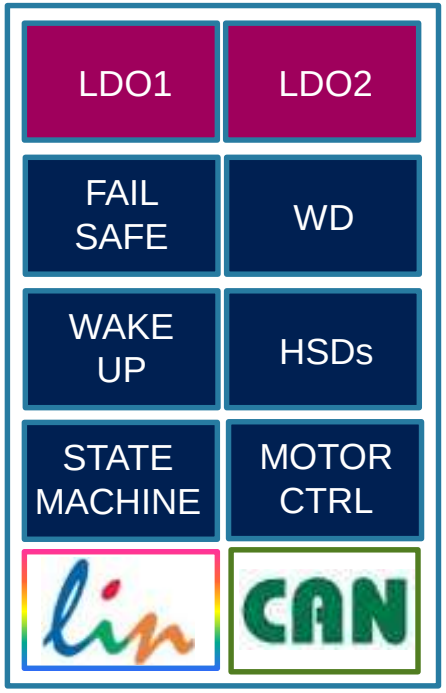
L9952GXP

Motor Control, LIN, Vregs, HSDs Wakeup, Op amps, etc



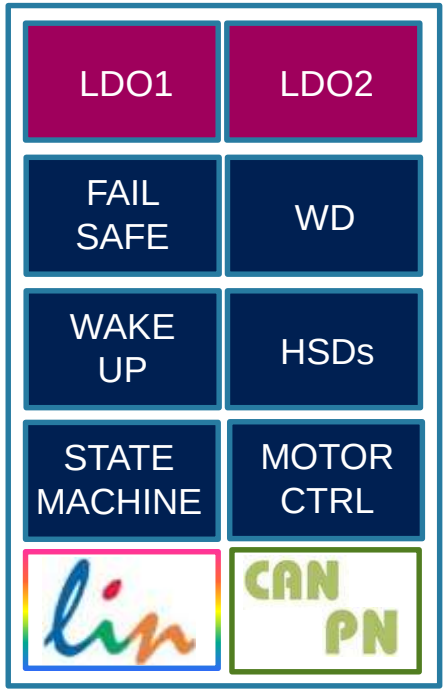
L99PM62GXP

Motor Control, LIN, CAN, Vregs, HSDs Wakeup, Op amps, etc



L99PM72GXP

Motor Control, LIN, CAN-PN, Vregs, HSDs, Wakeup, Op amps, etc



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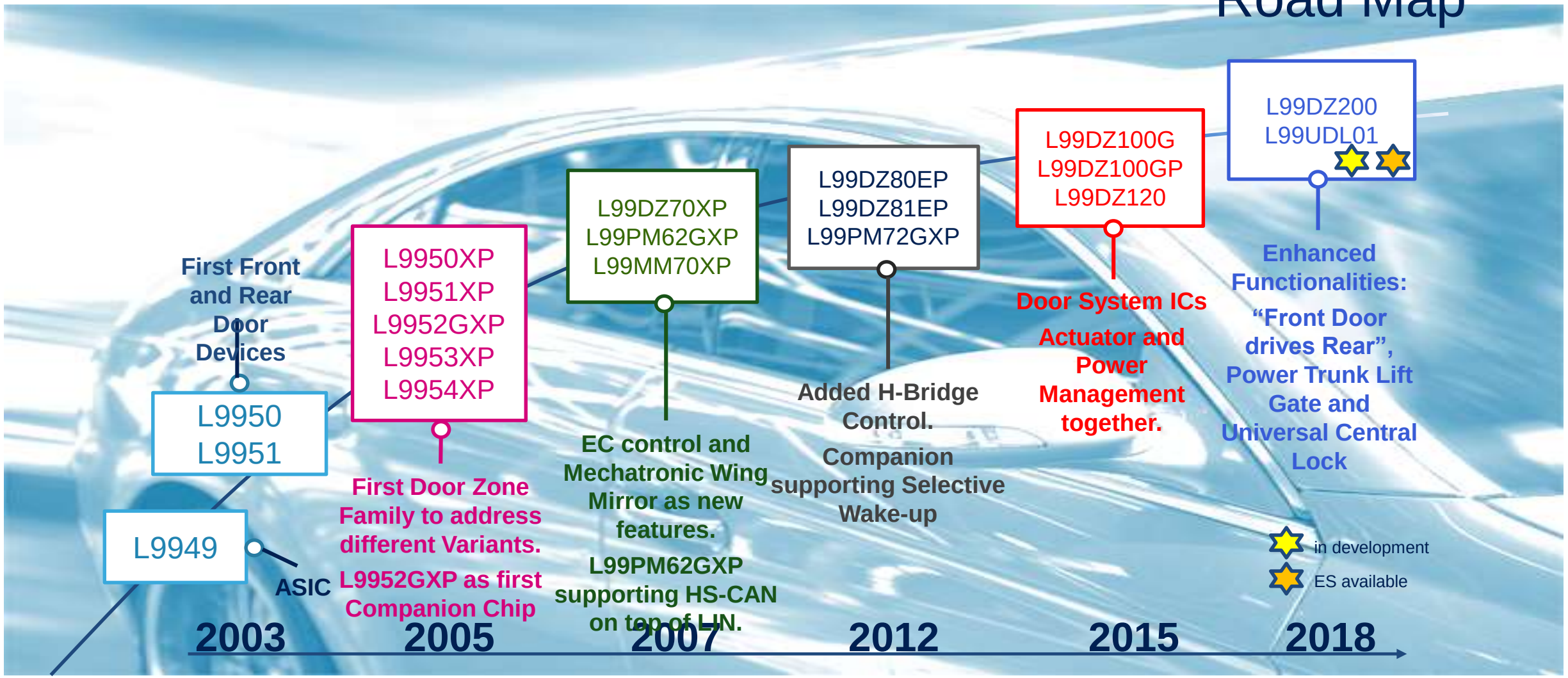
BSP

Door Zone

Road Map



Door Zone

L99DZxxx Roadmap

L99DZ100GP (Front Door)

Power window, door-lock, door lights

Mirror heater, adjust, fold and EC control

CAN PN

LIN

L99DZ1xx family members are 100% HW and SW compatible to support a customer platform development

L99DZ100G (Front Door)

Power window, door-lock, door lights

Mirror heater, adjust, fold and EC control

CAN

LIN

L99DZ120 (Rear Door)

Power window, door-lock, door lights

LIN

In Development

L99DZ200 (Front Drives Rear)

Dual H-bridge gate drivers, door lights

Mirror heater, adjust, fold and EC control

CAN

Front-drives-Rear Power Trunk Lift Gate

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Door Lock

L99UDL01 Door Lock IC

Charge Pump

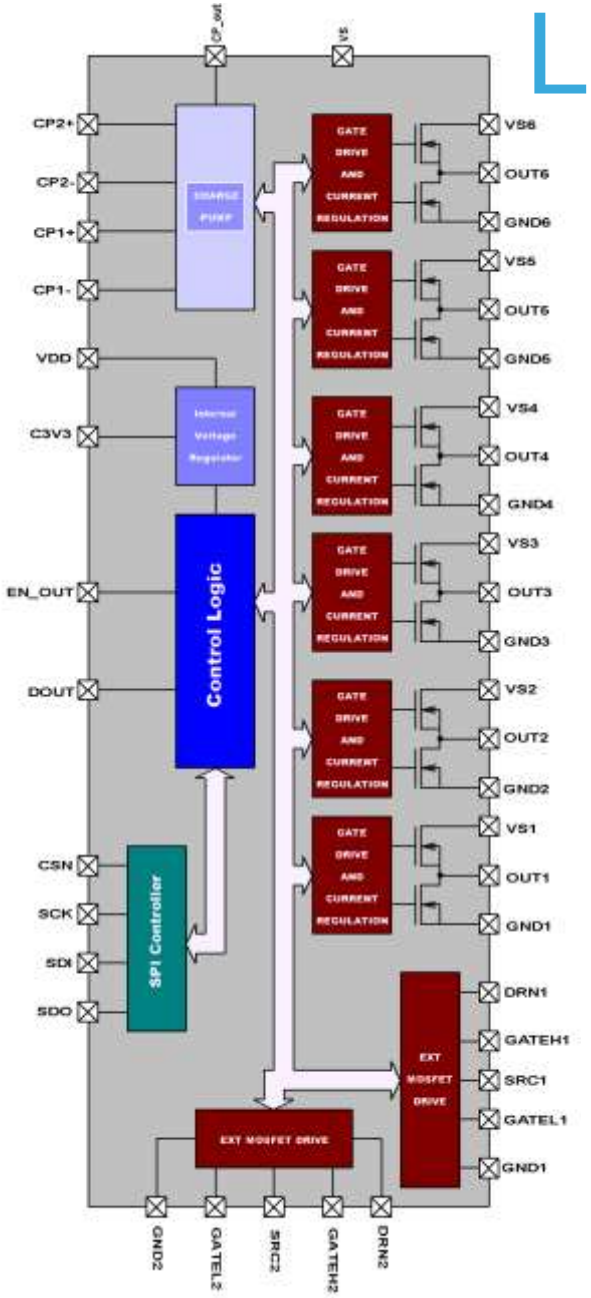
- 2 Stage
- 5 pins

Control logic

- Fully programmable

SPI I/O

- 16 bit
- 17 registers



6 Half Bridges

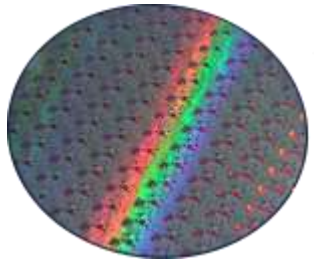
- Power Stage: 90 mΩ per FET
- Current regulation loops for each HSD and each LSD
- Mechanism for paralleling up to 2x3 outputs

External MosFET Control

- Flexible loading
- Programmable V_{DS} monitor

Package:

Power-TQFP64L



Process:

BCD8S Auto

BSP

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General Purpose Analog for Automotive

A long history of Automotive general purpose products

- DC-DC converters
- LED Drivers
- LDOs
- Voltage Reference
- Op Amps, Comp, current sense
- Interfaces
- Reset and supervisors
- Automotive Standard Logics

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Automotive Op Amps/Comparators

Product Highlights

TSZ18x series Zero Drift Amplifiers	• Very low offset 25µV max • Very low drift in Temperature 0.1µV/°C • Excellent Speed/power ratio 3MHz /1mA
TSX7x Series Precision 16V Amplifiers	• Very low offset 200µV max • Very low drift in Temperature 2.5µV/°C • Energy efficient
TSB7x series Low Power 36V Amplifier	• 6MHz / 22 MHz GBP • 300 µV max input offset Voltage • Operating from 2.7V to 36V
LM290xH series Grade 0 (150°C)	• SO/TSSOP/MiniSO packages • High Temperature guarantee • Op-Amps and Comparators
TSX370x/TSX339/TSX393 Open drain Comparators	• 16V CMOS Dual & Quad series • MicroPower 5µA max • DFN8 2x2mm & QFN16 3x3mm

Automotive

O2 sensor

Current measurement

Steering angle sensor

Resistance temperature detector

Gear box

Engine control

Breaking system