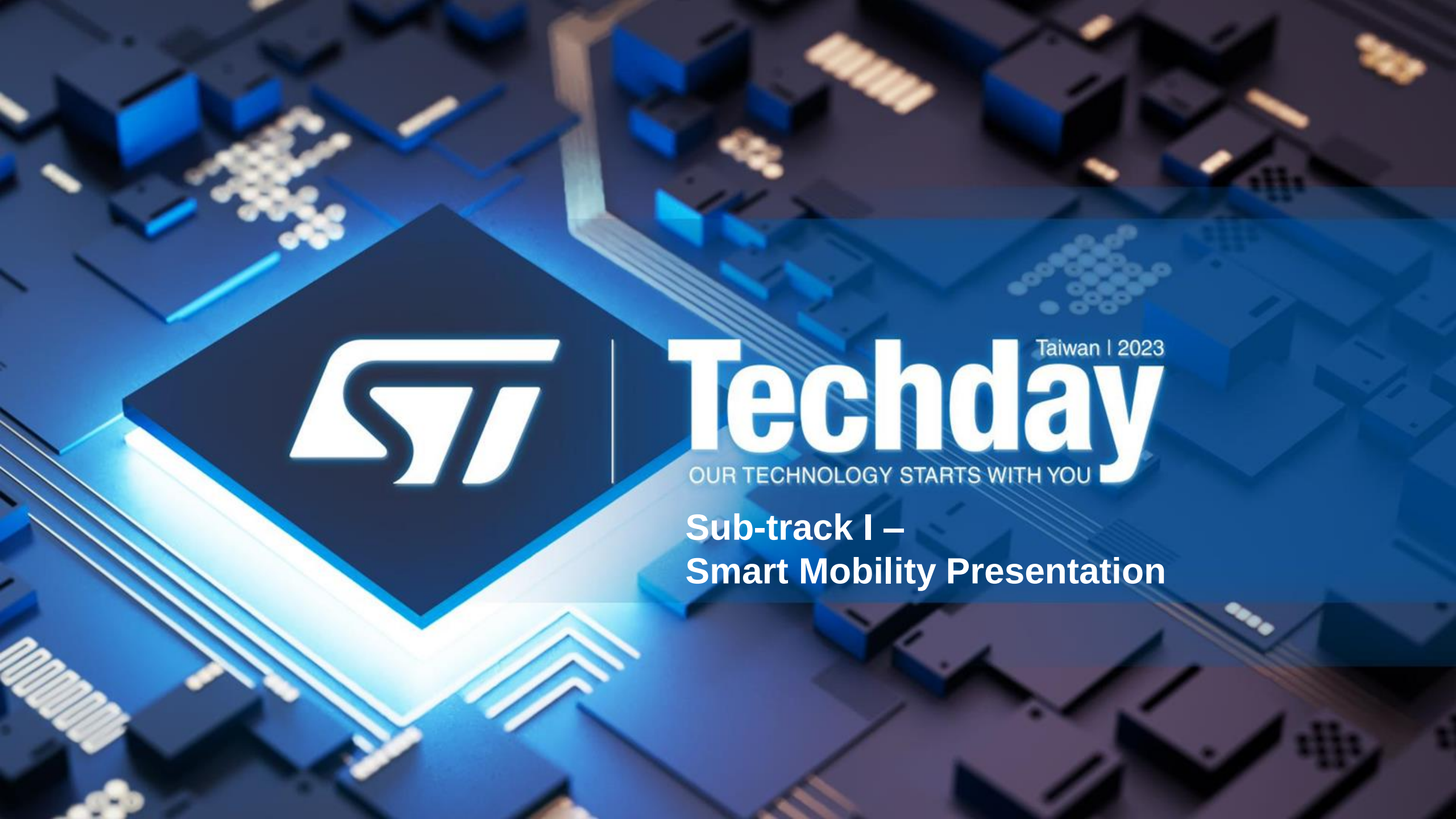

Sub-track I –
Smart Mobility Presentation

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ST’s power discrete solutions improve performance and density in new energy vehicles

Alvin Chen

STMicroelectronics

SiC MOSFET
technology & product roadmap

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Silicon carbide MOSFET technology executive strategy

Technology Roadmap

Planar

2014: Gen1
- **1200 V** (0 to 300 kHz)
- **1700 V** (0 to 300 kHz)
- 20 V driving voltage

2018: Gen2
- **650 V** (0 to 500 kHz)
- **1200 V** (0 to 500 kHz)
- 18 V driving voltage

2020: Gen3
- **750 V** (0 to 500 kHz)
- **1200 V** (0 to 500 kHz)
- 18 V* driving voltage

2023: Gen4
- **750 V** (0 to 1 MHz)
- **1200 V** (0 to 1 MHz)
- 15 V* driving voltage

Continuous scale-down
[Ron x area]

x2 shrinkage

x4 shrinkage

x5 shrinkage

No Planar

2025: Gen 5
Radical innovation

Product Status

Planar

Gen1	**In full production**
Gen2	**In full production**
3rd Gen	**Technology qualified in Q4 2020**
4th Gen	**In development** Expected introduction in 2023

No Planar

Feasibility and simulation results in **2022**

* Suggested for best performance

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STPOWER SiC MOSFET positioning vs. product family & package

Breakdown Voltage

650V	750V / 900V	1200V	1700V

Series

G2	G3	G3	G1	G2	G3	G1

On-state resistance

18 mOhm to 55 mOhm	14 to 55 mOhm	11 mOhm (750) 12 mOhm (1200)	52 mOhm to 520 mOhm	25 mOhm to 75 mOhm	8 to 69 mOhm	1 Ohm and 65 mOhm

Package	PowerFLAT 8x8 STD & DSC	H2PAK-7L	HU3PAK	ACEPAK SMIT	HiP-247 (3 & 4 leads)	STPAK	Bare Dice
							
	Surface Mounting				Through-Hole	Special Package Solutions	

HV MOSFET
technology & product roadmap

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High-voltage power MOSFET for automotive

Technology roadmap

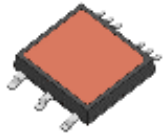
DM2 → DM6 → DM9 — Higher power level and better efficiency

K5 → K6 — Sole source for very high voltage SJ MOSFET

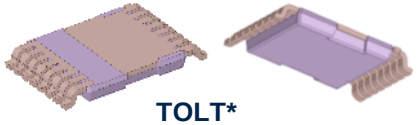
M5 → M9 — Increasing high power density and compactness system

Advanced packaging

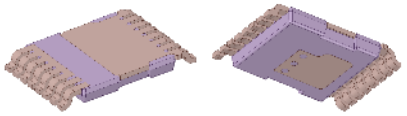
HU3PAK



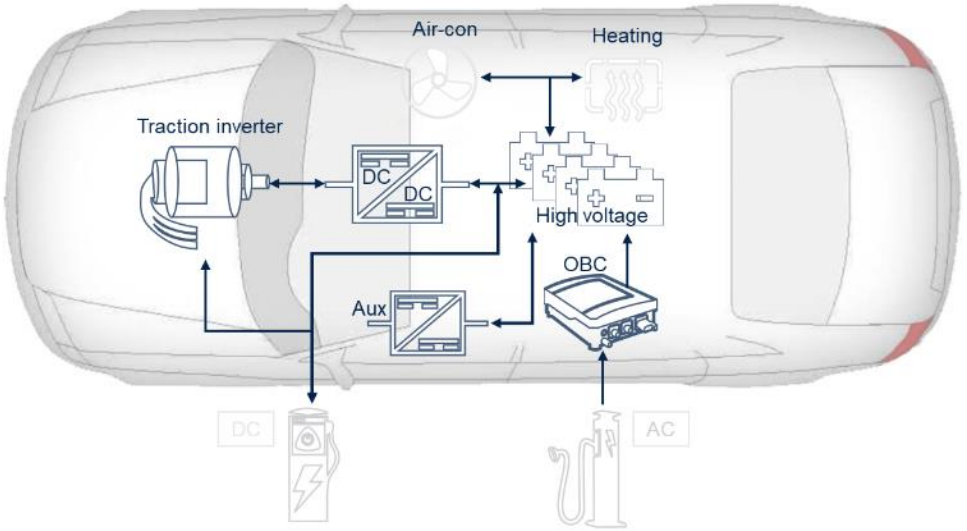
ACEPACK SMIT



TOLT*



TOLT DSC*



OBC **DC-DC Converter**	MDmesh DM2, DM6, DM9* (SOP Q4'23)
Battery Management System	MDmesh DM6, MDmesh K5 MDmesh K6* (SOP Q1'24)
Aux for Traction inverter	MDmesh K5

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*Under development

High-voltage silicon MOSFET M9 – the next step forward

The most complete product portfolio for high power and efficiency systems

- Best $R_{DS(on)}$ **x area**
- Step forward for **both hard and soft switching**
- **DM9 FAST diode** embedded version available
- **Wider** product portfolio

Why choose M9/DM9?

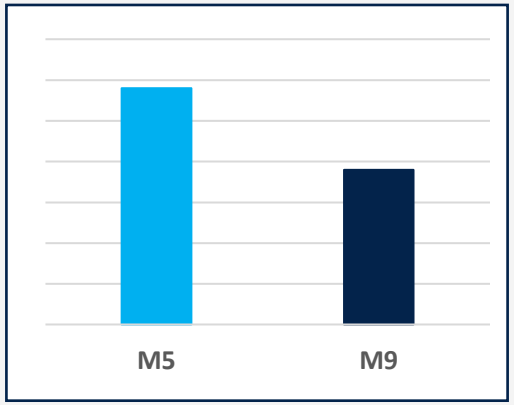
- **Only one technology** for hard (PFC) and soft switching (LLC)
- **Higher power level** and **better efficiency** maintaining same package
- **Increasing power density** providing smaller package
- **Improved system ruggedness** applying new production processes
- **Better electrical parameters**, giving more safety to the system

ST's Si MOSFET: the insurance in the high voltage power switches scenario

MDmesh M9 / DM9 main features

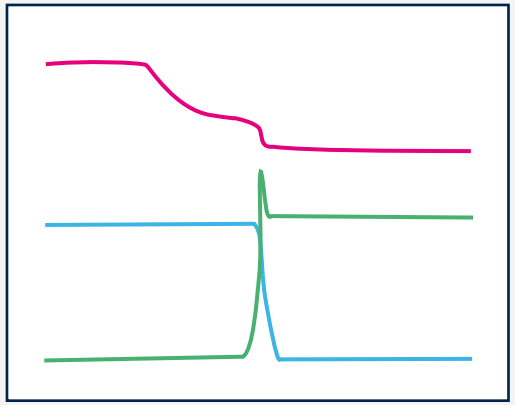
$R_{ds(ON)}$

- Very low $R_{ds(ON)}$ per area
- Suitable for Hard switching topologies
- Best choice for Resonant high power density system



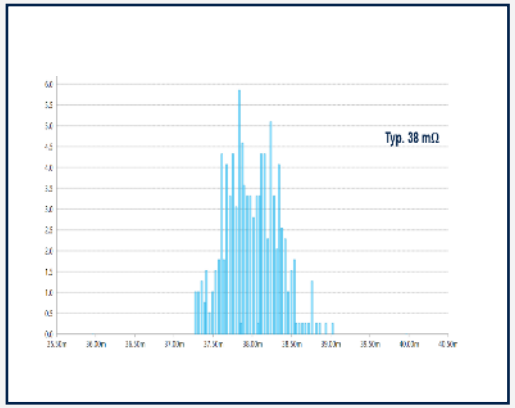
Power losses

- Reducing switching energy losses
- Reducing switching time
- Increasing switching frequency



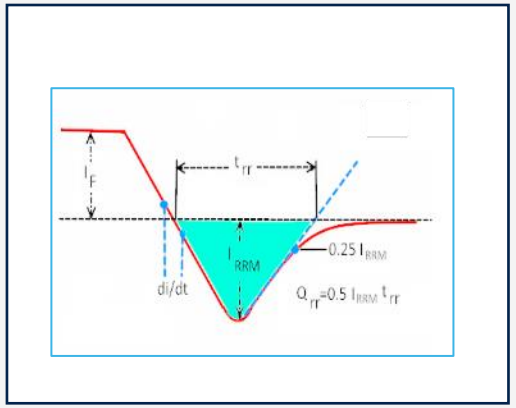
Process

- Reduced BVdss spread <70V
- Reduced Vth spread <1V
- Ruggedness (UIS test)



Robustness

- Static dv/dt up to 120V/ns
- Dynamic dv/dt up to 50V/ns (M9)
- Dynamic dv/dt up to 120V/ns (DM9)



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Rectifier technology & product roadmap

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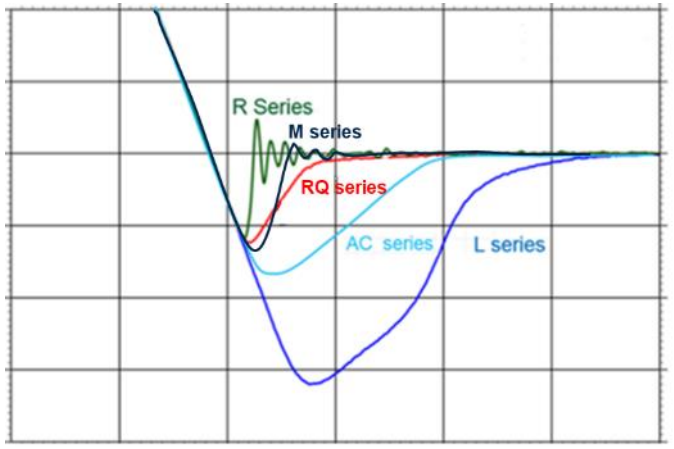
Leadership in power management
DFD* rectifier footprint in multiple markets

High-voltage diodes

> 200V

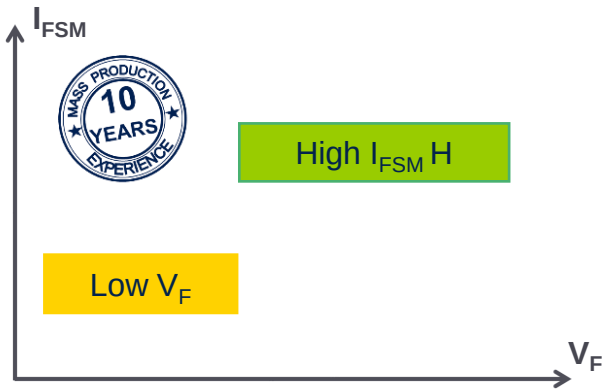
STTH series
STBR series



SiC diodes

650V & 1200V

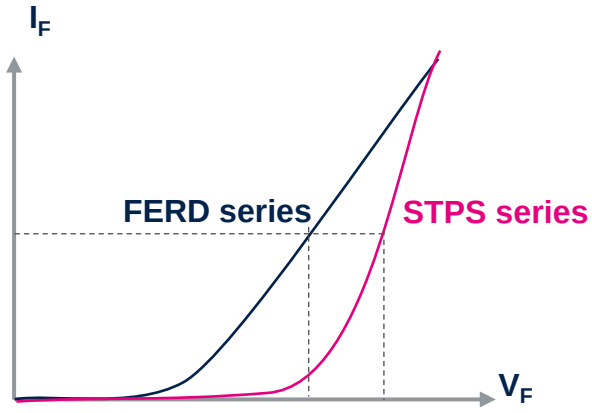
STPSC series



Low-voltage diodes

< 200V

FERD series
STPS series
STPST series



✓ AEC-Q101 = Y suffix in part numbers
✓ PPAP capable

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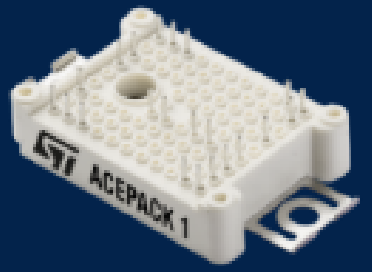
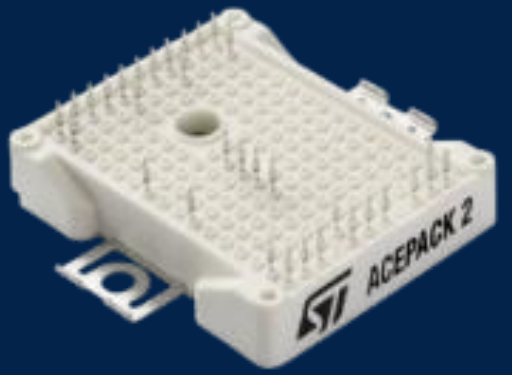
* DFD = Discrete & Filter Division

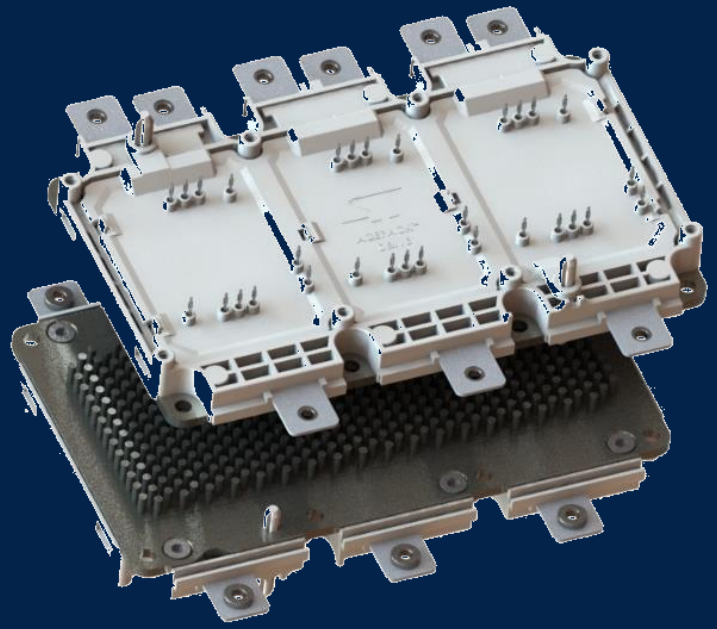
Power module solution

ACEPACK 1 & 2

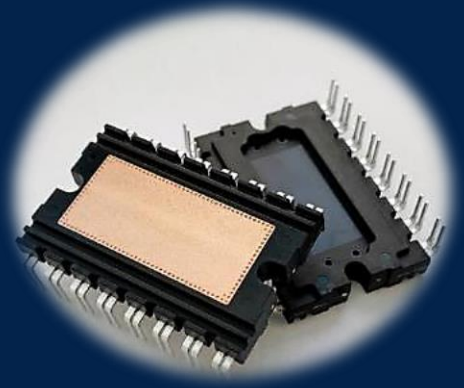




ACEPACK DRIVE



ACEPACK DMT-32



Dual in line, molded, through-hole 32-pin power modules

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Power module segmentation and strategy

Market Segment	H(EV) & Ecosystem: Traction 	H(EV) & Ecosystem: OBC & Other mechatronic platforms 
Key factors for growth	▪ **Car electrification mega-trend due to CO_2 worldwide reduction programs** ▪ **Maximize production capacity of ACEPACK DRIVE** SiC MOSFET: the “commodity” power module solution adopted by majority of car makers for the current and next Platform.	▪ **Car electrification** market is expanding ▪ Use of new high efficiency topologies/solutions for an increasing miniaturization of the system ▪ Not only light EV but also truck, van and fuel cell vehicles requiring higher power ▪ Bi-directionality is requested
Products	▪ **ACEPACK DRIVE** SiC MOSFET & IGBT+Diode ▪ **Customized Transfer Molded Modules (TMM)** for + 2026 platforms Full SiC, IGBT + Diode & Hybrid ▪ **Complete Power Box** with advanced technique for interconnection to the cooler	▪ **ACEPACK DMT-32**: compact and slim power module tailored for car OBC, DC-DC and auxiliaries: 650V/1200V SiC MOSFET based ▪ **ACEPACK 1 & 2**: to enabling DC-DC and auxiliary systems for higher power like for truck, van and fuel cell systems.

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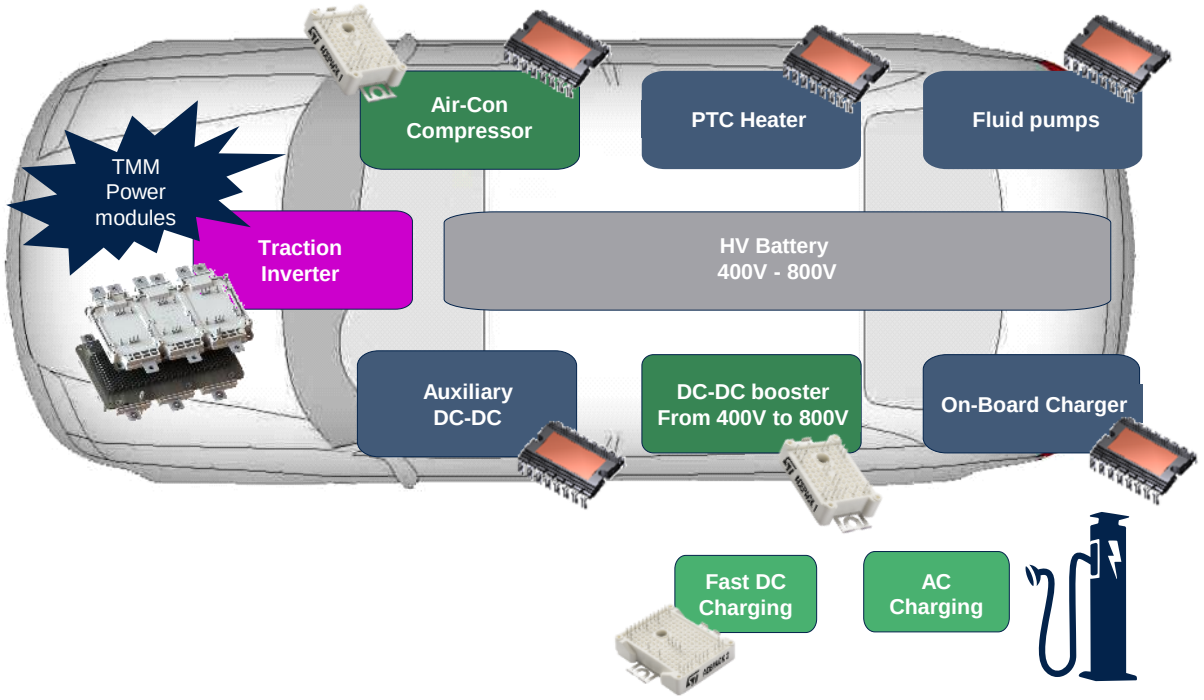
Automotive application focus: OBC, DC-DC, and traction inverter

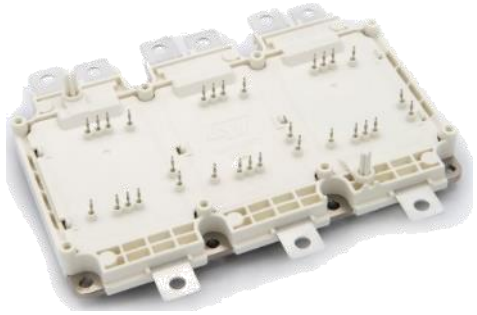


Power modules approach main benefits:

- lower occupation → Increased power density
- Easy of cooling system design
- Improved manufacturability: from IMS to PCB
- Improved stray inductance and parasitic components

Applications

ACEPACK* power module package options

ACEPACK options	Package design	Key features	Configurations	Applications
ACEPACK 1 3kW to 15kW ACEPACK 2 10kW to 30kW		• Silicon 100% produced and controlled by ST (SiC MOSFET, IGBT, and diodes) • Compact design and cost-effective system approach for a plug & play system solution • Configuration flexibility • 2500Vrms electrical isolation	• CIB • Six-pack • Three level boost • Four-pack • Half-bridge	
ACEPACK DMT 32 2kW to 10kW		• Silicon 100% produced and controlled by ST (SiC, MOSFET and diodes) • Electrically insulated • Top-side cooling • Dual-in-line molded through-hole • 3kVrms electrical isolation	• Four-pack • Six-pack • Totem pole	
ACEPACK DRIVE 120kW to 300kW		• 750 - 1200V SiC MOSFET-based switch • Improved light load performance for extended EV driving ranges • Active metal bonding (AMB) substrate for enhanced thermal dissipation • Different bus bar configuration options • Extremely low energies dissipation • Direct cooled Cu baseplate with pin fins	• Six-pack	

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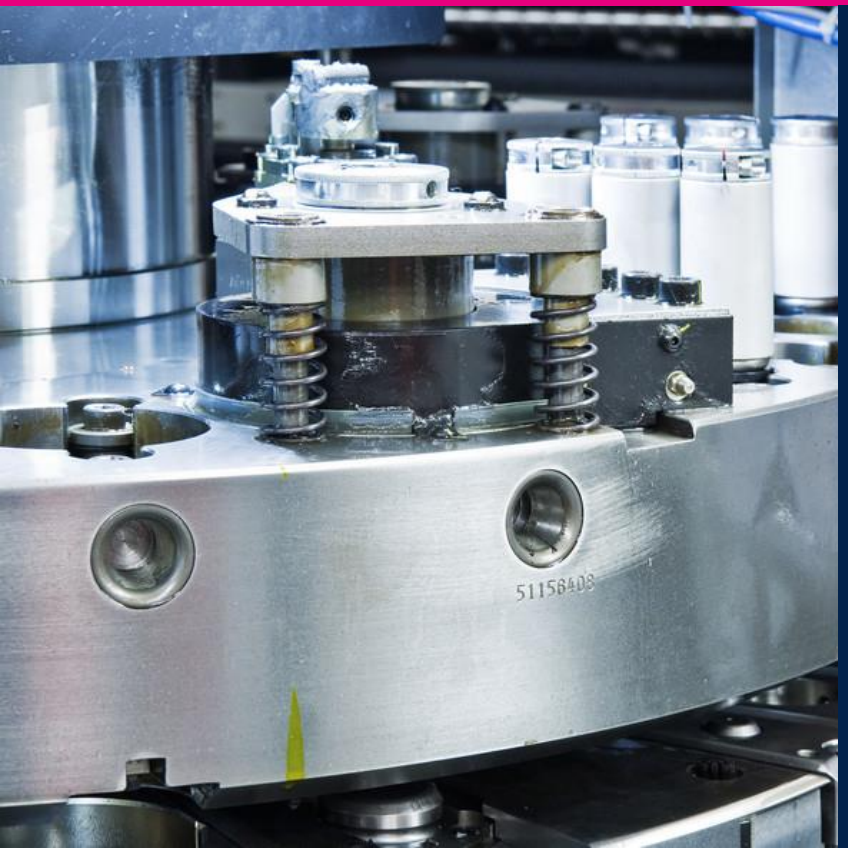
ACEPACK 1 and ACEPACK 2 key benefits

Industrial drives, motor control, UPS, automotive EV ecosystems and DC-DC converter



ACEPACK 1 & 2

33.8 x 48 mm

48 x 56.7 mm

- Press fit and solder pin options for configuration flexibility
- Up to 1200V breakdown voltage
- Integrated screw clamps
- All power switches in a module including NTC
- Several current ratings available
- Several configuration options (CIB, six-pack, half-bridge etc..)
- Low stray inductance
- High reliability and robustness, lower power-side board occupation
- Compact design and cost-effective system approach
- Very high-power density

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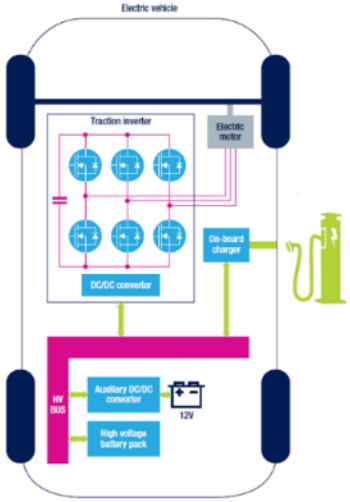
ACEPACK DMT-32
automotive grade power module

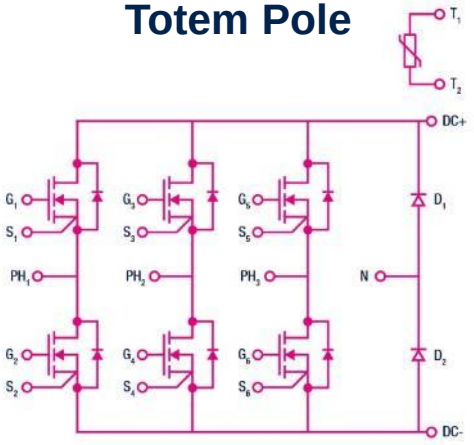
DMT-32: Dual in-line Molded Through-hole 32 pin module



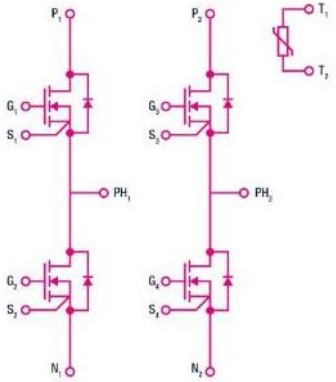
New Power Modules family suitable for OBC, DC-DC and auxiliary applications (*):

- SiC MOSFET Gen2 and Gen3 power switches used in different configurations: Four pack, Six pack, Totem Pole
- Suitable to cover several sub-function up to 22kW of power range
- SOP: Q4’23(**)

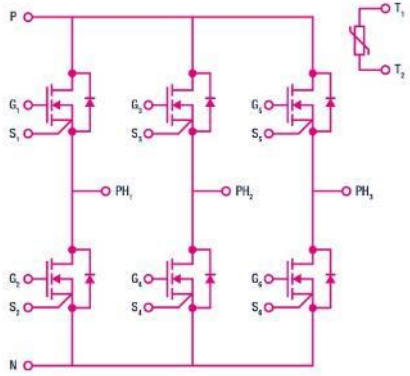
Totem Pole



Four Pack



Six Pack



In-Line

Package Size:
44x32x6mm

Zig-Zag

NEW

Package Size:
44x37.9x6mm

(*) Auxiliary application as: fluid pumps and HVAC and climate control for BEV/HEV; (**) depending on configuration

Direct liquid cooled high-performance power module

Traction inverter for (H)EV, trucks, and buses

Main traction inverter

Press fit connections for high reliable and long-lasting connection

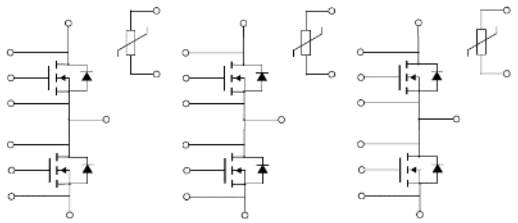
AQG-324 qualified

Pin-fin base plate for direct liquid cooling

Dedicated NTC for each single substrate

Best-in-class $R_{DS(on)}$

ACEPACK DRIVE
based on
SiC MOSFET Gen 3
1200V & 750V



Internal layout optimized for minimized stray inductance

High reliability and robustness: dice sintered to substrate for SiC-based power modules

Different bus bar available to fit welding or screwing connection methods

AMB substrates for better thermal management for SiC-based power modules

Extremely high-power density

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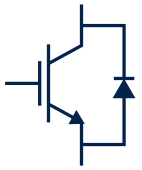
ACEPACK DRIVE for 400V battery

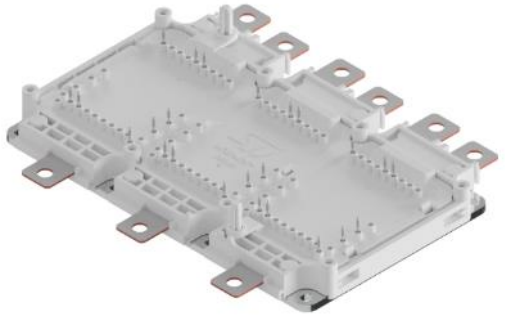
IGBT & diode based | **SiC MOSFET based**

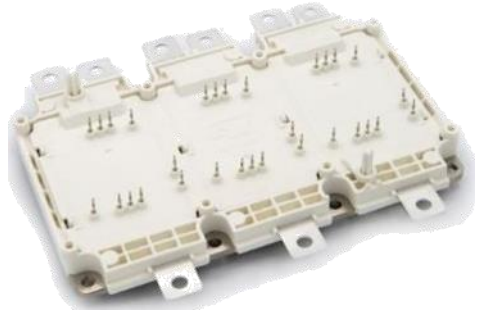


120kW | **150kW** | **180kW** | **175kW** | **220kW** | **Power**(3)

ADP46075W3

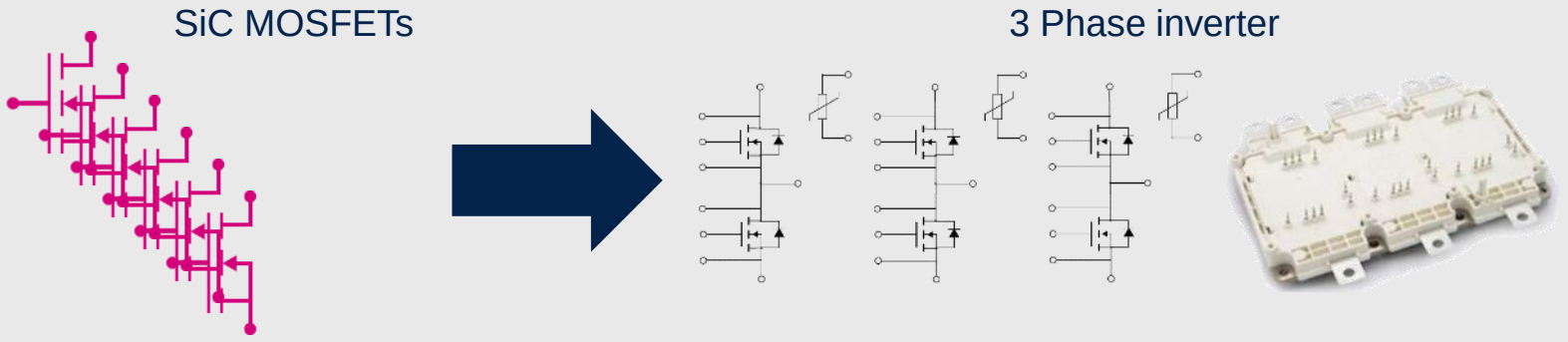
ADP61075W3





ACEPACK DRIVE for 800V battery

Gen3 SiC MOSFETs: Tailored for high-power traction inverters

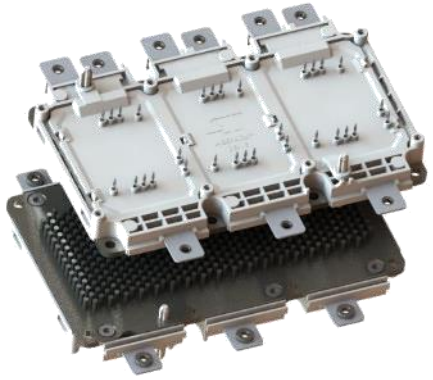


180kW	230kW	300kW	Power(1)
ADP280120W3	ADP360120W3	ADP480120W3	

1. Power level coming from simulation, system power depending on inverter design and mission profile

ACEPACK DRIVE
SiC-based product portfolio in full production

ACEPACK DRIVE: Full Gen3 SiC MOSFETs



Part number	SiC technology	BV	$R_{DS(on)typ}$ @ 25°C (per switch)	$R_{DS(on)typ}$ @ 175°C (per switch)	Max peak power indication(1)
ADP480120W3(-L)	Gen 3	1200V	1.90 mΩ	3.35 mΩ	300 kW
ADP360120W3			2.55 mΩ	4.25 mΩ	230 kW
ADP280120W3			3.80 mΩ	6.50 mΩ	180 kW
ADP61075W3(-L)		750V	1.20 mΩ	1.95 mΩ	220 kW
ADP46075W3			1.60 mΩ	2.60 mΩ	175 kW

www.st.com/en/power-modules-and-ipm/acepack-drive/products.html

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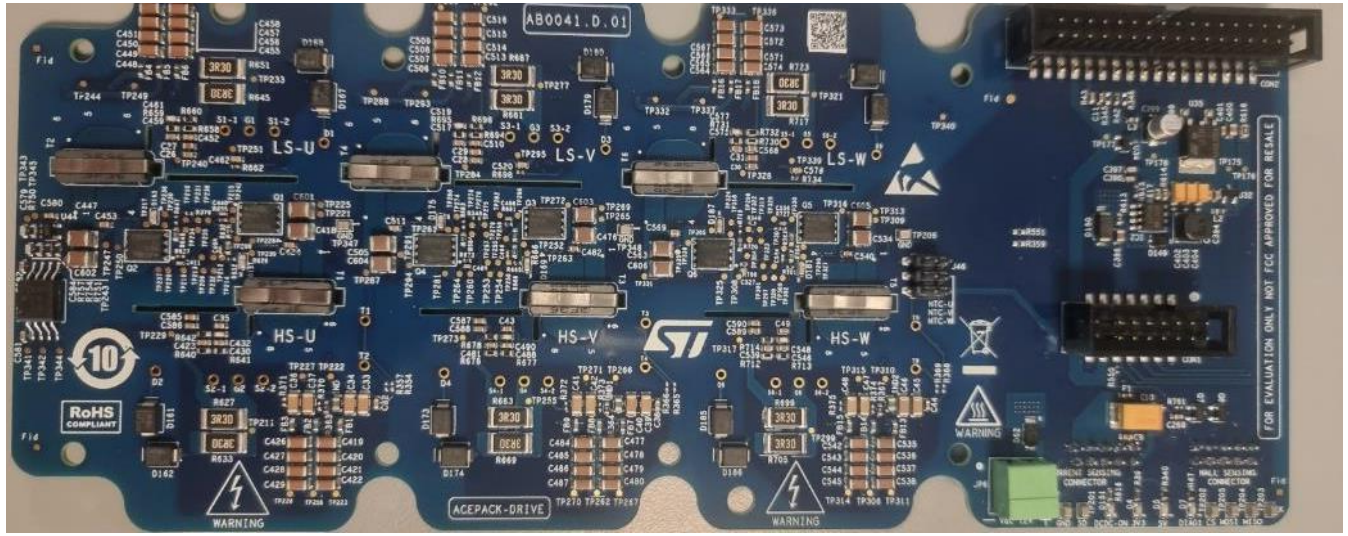
1. Power level coming from simulation, system power depending on inverter design and mission profile

STEVAL-APD02ACB eval board for SiC-based devices

STEVAL-APD02ACB is fully compatible with ACEPACK DRIVE power press fit pins and requires a dedicated pressing tool to mount it



Proof of Concept available for ACEPACK DRIVE SiC devices only.

SiC-based ACEPACK DRIVE

New STEVAL with full ASIL/D will be available by end of this year: validation running

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Thank you