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High-voltage power MOSFETs: the latest technologies and trends for your automotive applications

STMicroelectronics

High voltage MOSFET trends and technologies for your automotive applications

High voltage power MOSFET market challenges

STPOWER MOSFET High-voltage family overview

Find the best fit for your automotive applications

STPOWER advanced packaging technology overview

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High voltage power MOSFET in automotive

Market challenges

- Higher power efficiency needing tailored technology
- More compact systems requiring new package solutions

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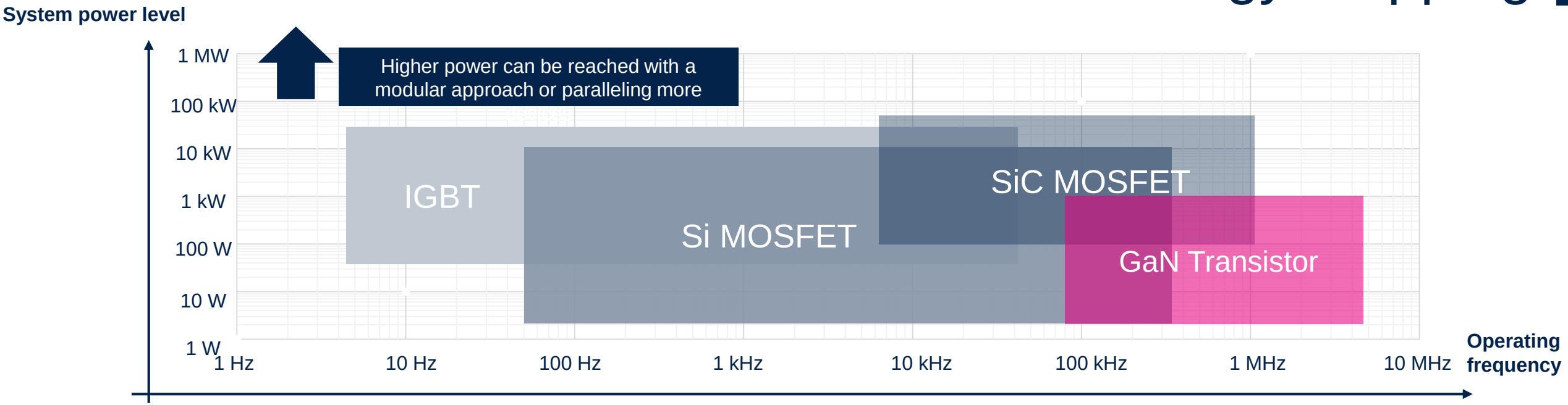
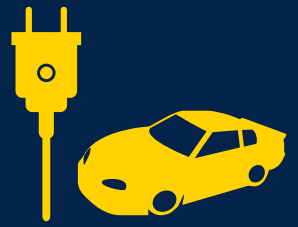
High Voltage power transistor technology mapping



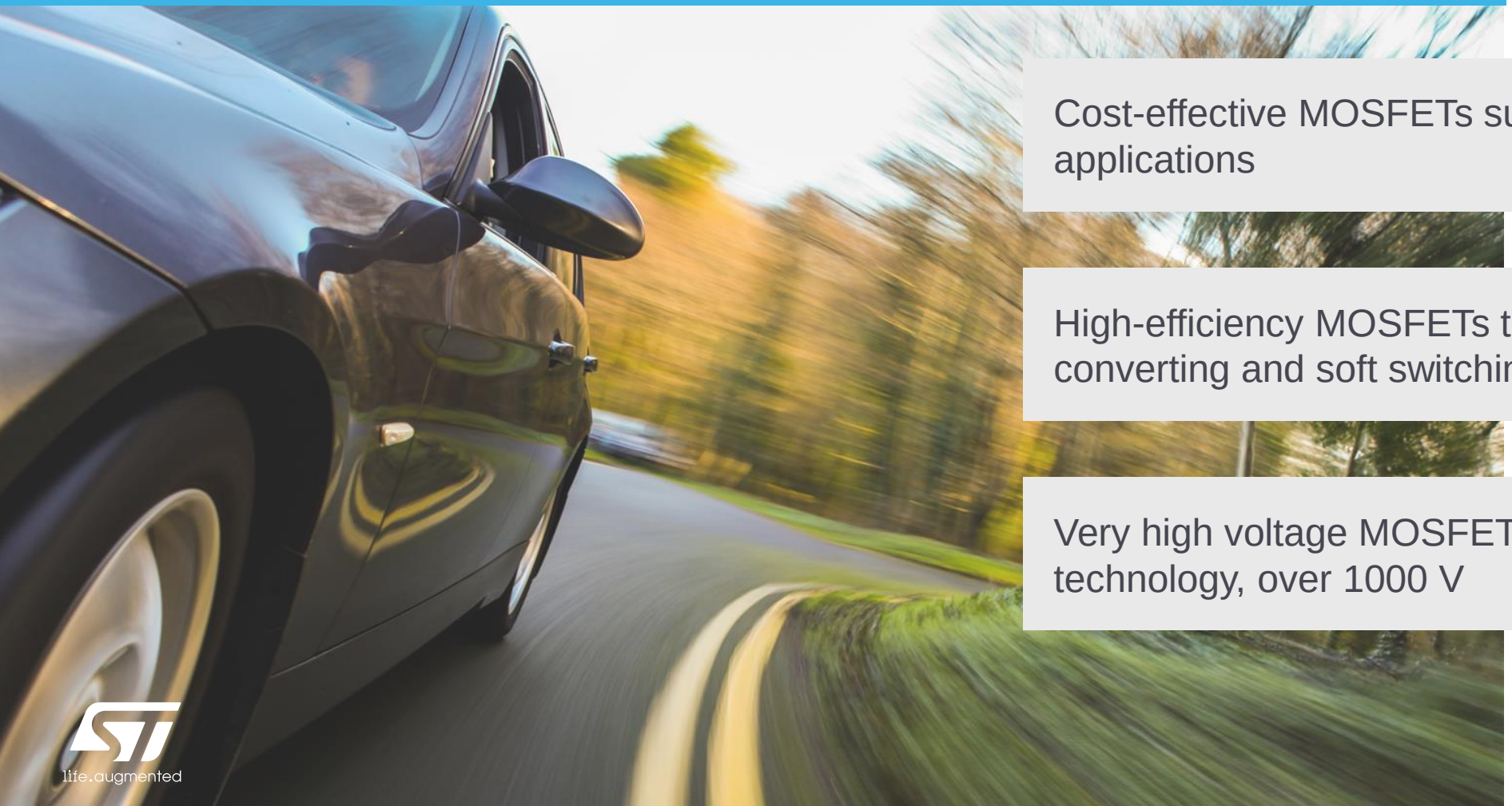
Technology	Features	Preferred for (some examples)
Si HV MOSFET	Medium-high power, high voltage, up to several kw, high frequency	SMPS, server and telecom, DC/DC, low power motor control, OBC, charging station
IGBT	Very high power, high voltage, medium frequency up to 50 kHz	HV motor control, H.A., UPS, welding, induction heating, main traction
SiC MOSFET	Very high power, high voltage, high frequency, high temperature ratings	High power DC/DC, UPS, charging station, main traction inverters, OBC
GaN Transistor	Very high frequency, over 80 kHz, medium-high power up to several kW	SMPS, Telecom Power, DC/DC, OBC, PV inverters, LiDAR

High voltage power MOSFET automotive market landscape

Market Focus	Growth Drivers	Key Applications
 **AUTOMOTIVE**	• Environment: worldwide program to reduce CO_2 emissions • Electro-mobility transformation • Smaller and lighter power units • Better system efficiency	• DC-DC converter • On Board Charger • Auxiliary DC/DC converter • Breakers • Charging Station

STPOWER MOSFET high voltage family

A comprehensive product range for every need



Cost-effective MOSFETs suitable for broad power applications

High-efficiency MOSFETs to enable resonant converting and soft switching applications

Very high voltage MOSFETs super-junction technology, over 1000 V

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STPOWER MOSFET high voltage family overview

The most complete product portfolio for automotive high-power systems

MDmesh* M2/DM2 **400 V, 500 V, 600 V, 650 V**	The best **cost/performance** trade-off **, suitable** for a broad range of power applications
MDmesh M6/DM6 **600 V, 650 V, 700 V**	The **right** super-junction for high efficiency: **enabler** for resonant converters and soft switch applications
MDmesh M5 **550 V, 650 V**	The perfect option for outstanding **$R_{DS(on)}$** , **compact solution, enabler** of high-power PFC
MDmesh K5/DK5 **800 V, 850 V, 900 V, 950 V, 1050 V, 1200 V, 1500 V, 1700 V**	The **industry's first** super-junction technology over 1000 V **suitable for very high voltage range**

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STPOWER MOSFET series positioning by applications

Breakdown Voltage

600V	650V	800V – 1700V

MDmesh* series

M2	M6	DM2	DM6	M5	DM2	DM6	K5

Focus Topology

Flyback, PFC/LLC resonant conv.	Flyback, PFC/LLC high efficiency	HB / FB, ZVS, LLC	HB / FB, ZVS, LLC high efficiency	High-end-power PFC and hard switching topologies	HB / FB, ZVS, LLC high power level	HB / FB, ZVS, LLC high power level high efficiency	Flyback topology

Focus Applications

Charger adapters, LED lighting, Medical	Server, 5G, Consumer, Adapters, Solar, Medical	Solar, Server, Telecom SMPS, Electric Vehicles, Charging, Medical	LED driver, LED lighting, auxiliary SMPS, EV-Car, Medical

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STPOWER MOSFET technologies for automotive applications

The best fit for your automotive applications

MDmesh* M5

- One of the industry's lowest $R_{DS(on)}$
- Targeted for high efficiency in high-power applications
- Smaller form factor for final system & high switching speed

MDmesh M6/DM6

- The latest series for HV MOSFET (600 V – 650 V – 700 V)
- Improved efficiency at light load conditions
- With fast diode embedded (DM6 series)

MDmesh K5

- The most complete series for very high voltages
- Targeted for Flyback topologies
- AG available

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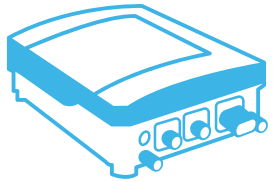
STPOWER MOSFET technologies for automotive applications

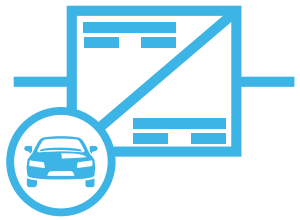
HV MOSFETs Discrete



On Board Charger and BMS

- MDmesh* M5/M2/M6 (600 V, 650 V)
- MDmesh DM2/DM6 (600 V, 650 V)
- MDmesh K5 (800 V, 1200 V)

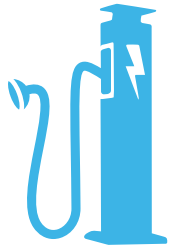
- In hard switching to target higher power density.
- Optimized switching characteristics with very low turn-off sw. losses
- Allows to operates with very high voltage range



DC/DC Converter

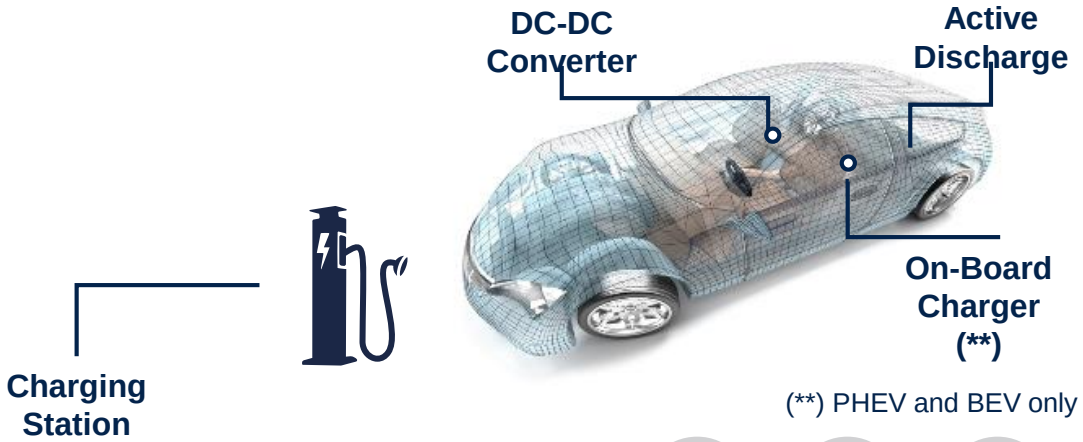
- MDmesh M5 (650 V)
- MDmesh DM2/DM6 (600 V, 650 V)

- In hard switching to target higher power density.
- Permits to reduce the conduction ad switching losses and target higher power efficiency especially at low load.



Charging Station

- MDmesh M5 (650 V)
- MDmesh DM2/DM6 (600 V, 650 V)



(**) PHEV and BEV only

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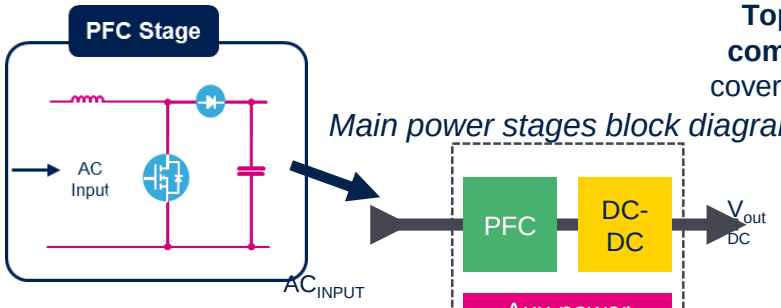
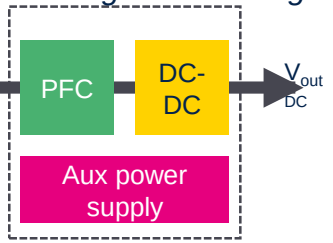
STPOWER MOSFET MDmesh* M5 leading technology for high power PFC

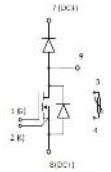
Ideal solution for high power level

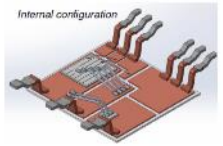


Top Side cooling package and **compacted topology** proposal to cover more efficient system/topology

Main power stages block diagram







650V

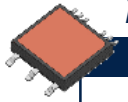
STB43N65M5
$R_{DS(on)}$= 0.063Ω

(Samples Available Full prod. July '20)

650V

STB46N65M5AG
$R_{DS(on)}$= 0.080Ω

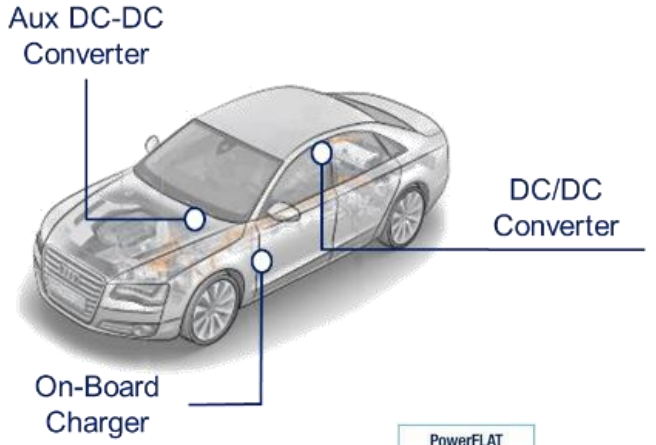
(Samples Dec'20 Full prod. June '21)



650V

SB49N65M5AG
$R_{DS(on)}$= 0.049Ω

- One of the industry's lowest $R_{DS(on)}$
- Targeted for high efficiency in High power Applications
- Smaller form factor for final system
- High switching speed



Targets high power density and enables compact systems thanks to low on-state losses per silicon area combined to low Q_g in a wide range of packages

Technology:
SJ MOSFET 550 V ÷ 650 V
(Enabler for High Power PFC)

Complete Product portfolio in a wide package's offer

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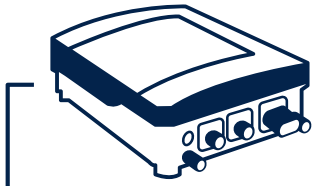
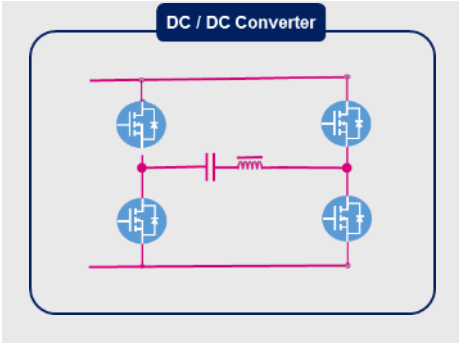
STPOWER MOSFET MDmesh* M6/DM6 latest step-up super-junction technology

Ideal solution for resonant converter at 600 V and 650 V



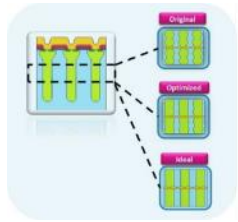
On-Board Charger

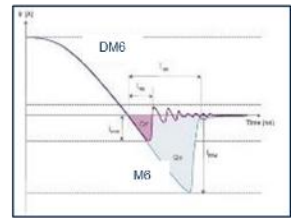


Charging station

650V	650V	650V	600V
STB30N65DM6AG	STWA46N65DM6AG	STWA68N65DM6AG	SD42N60DM6AG
$R_{DS(on)}$= 0.110Ω	$R_{DS(on)}$= 0.0630Ω	$R_{DS(on)}$= 0.039Ω	$R_{DS(on)}$= 0.042Ω
	(Samples May'20 Full prod. Nov '20)	*(Samples May'20 Full prod. Nov '20)*	*(Samples Dec'20 Full prod. June '21)*

- The latest series for HV MOSFET (600V - 650V - 700V)
- Targeted for ZVS & LLC bridge topologies
- Improved efficiency at light load conditions
- With fast diode embedded

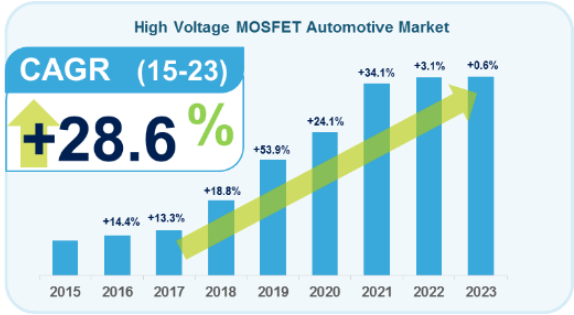




Tailored for resonant topologies

Reduces switching losses and offers an excellent $R_{DS(on)}$ thus enhancing end-application performance saving energy to achieve climate goals

Technology:
SJ MOSFET 600 V ÷ 700 V
(Ideal for resonant topologies)



600V - 650V - 700V MDmesh M6:
the right HV power MOSFET for high efficiency topologies

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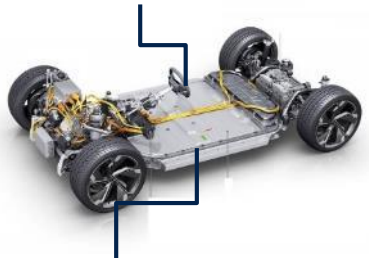
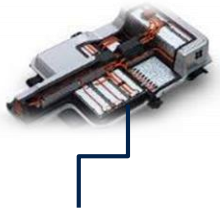
STPOWER MOSFET MDmesh* K5 very high voltage super-junction technology

Leader in Very High Voltage with K5 series

On-Board Charger



Aux DC-DC Converter



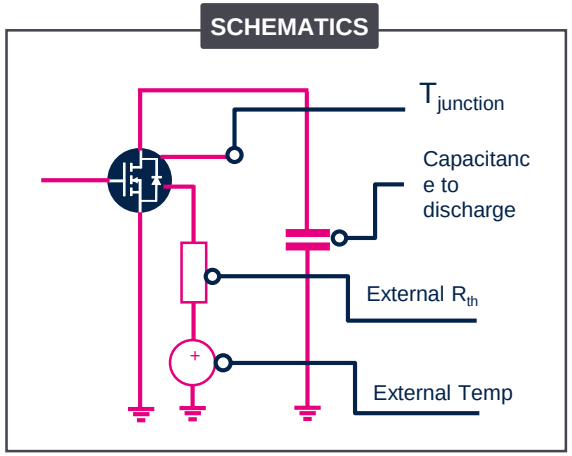
BMS

Charging station

950V	950V	1200V	1200V
STD3N95K5	STW22N95K5	STH2N120K5-2AG	STH13N120K5-2AG
$R_{DS(on)}$= 5Ω	$R_{DS(on)}$= 0.330Ω	$R_{DS(on)}$= 10Ω	$R_{DS(on)}$= 0.690Ω

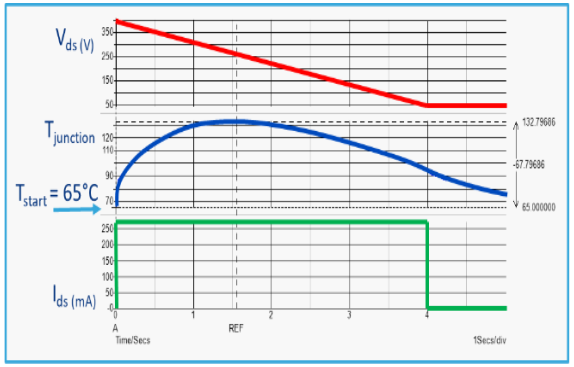
- The most complete series for VHV MOSFET (from 800V till 1500V)
- Targeted for Flyback topologies
- AG available

SCHEMATICS



Operates at a very high voltage range. $R_{DS(on)}$ and BV_{dss} are the right mix to reach a highly efficient and compact solution when running at very high voltage.

Technology:
SJ MOSFET 800V ÷ 1700V
(Ideal for flyback topologies)



Complete Product Portfolio

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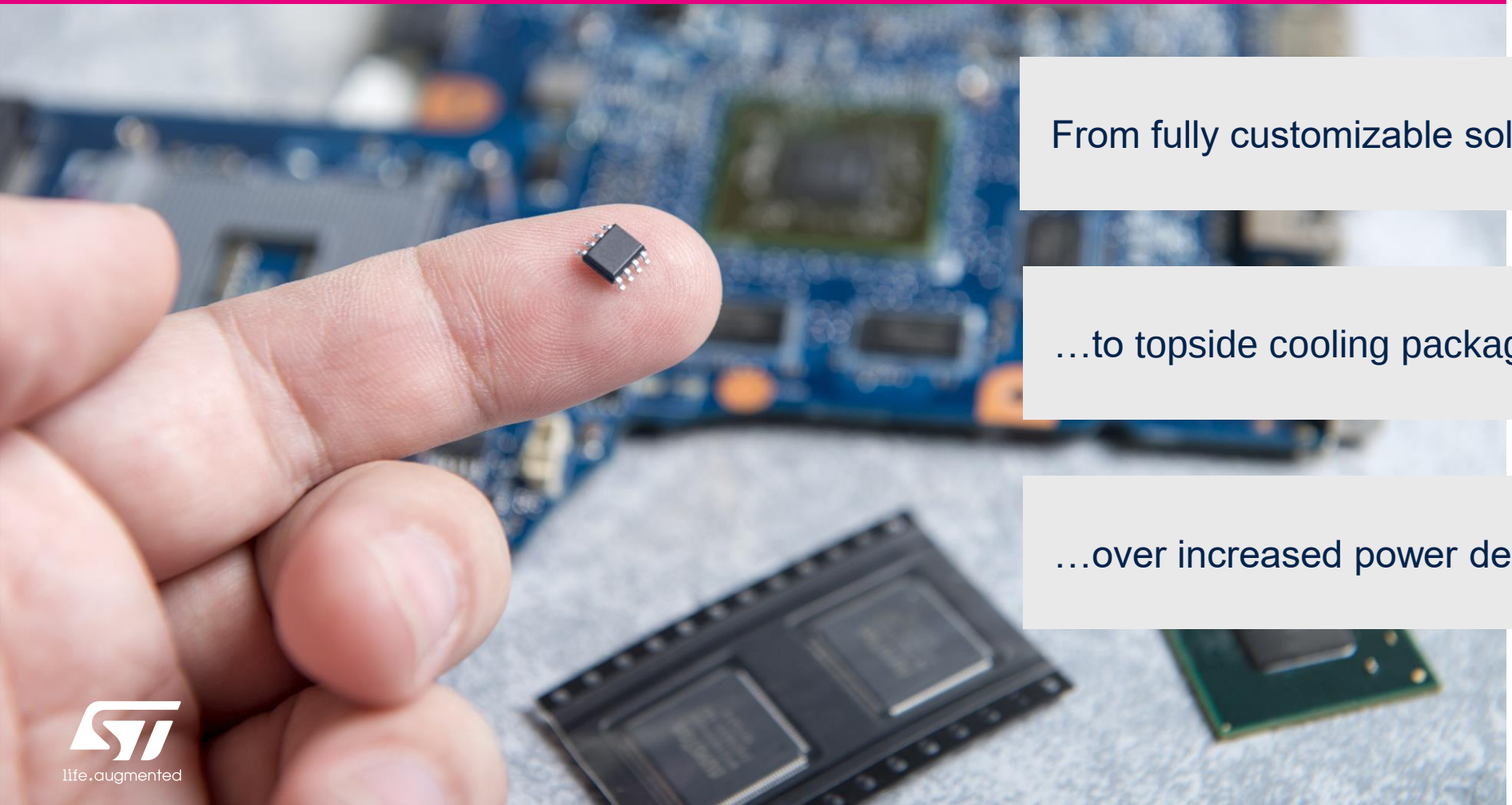
STPOWER advanced packaging technology overview

A wide variety of packages available



From fully customizable solutions…

…to topside cooling packages

…over increased power density.

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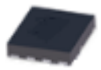
Advanced packaging technologies

SMD

PowerFLAT



3.3x3.3 HV ***5x6 HV*** ***5x6 VHV***

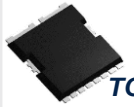
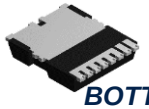



5x5 HV ***8x8 HV***

- 3.3x3.3
  - Space Saving vs. SOT223
- 5x5
  - Customized solutions
- 5x6
  Higher creepage for Very High Voltage
- 8x8 (HV)
  - Space Saving vs. D2PAK
  - Higher efficiency
  - Kelvin pin option available

SOT223-2

TO-LL

TOP view ***BOTTOM view***

- Compactnesss
- Higher power density
- Reliability at high V_{DSS} rating

H2PAK


H2PAK ***H2PAK-7***

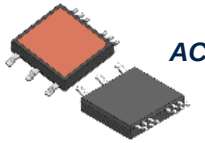
- Designed for Automotive
- Higher insulation voltage (higher creepage)
- Available for 1200V series
- Available with 7 pins

HU3PAK*


BOTTOM view ***TOP view***

- Top side cooling package
- Higher creepage distance
- Very high thermal dissipation
- Kelvin source pin enables higher efficiency

ACEPACK* SMIT



ACEPACK SMIT

- Top side cooling package
- Dice chips on Direct Bond Copper (DBC) substrate
- 2500Vrms electrical isolation

Keys advantages

- Increase Power Density
- Reduce parasitic effects
- Target higher efficiency level

Through Hole (TO247-4)


Standard ***Long Lead***

Kelvin Pin (versus 3L solution)

- Lower Switching losses
- Higher efficiency
- Available in Long Lead option
- Higher insulation voltage (higher creepage)

STPOWER ACEPACK* SMIT general overview

Package Features

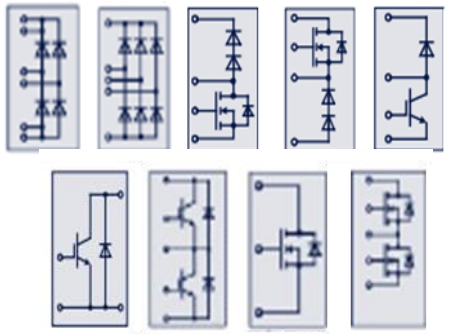
- **2500 Vrms** electrical isolation
- **SMD** assembly
- total footprint 32.7 x 22.5mm
- Top side cooling
- Dice chips on **Direct Bond Copper (DBC) substrate**
- Low thermal resistance
- Reduced parasitic inductance and capacitance

Technology and Flexibility

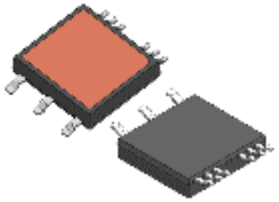
Suitable for several switch technologies:

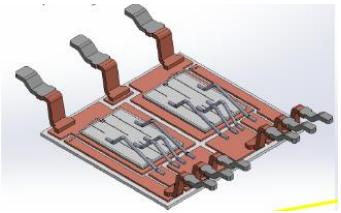
- IGBT
- HV Power MOSFET (Si & SiC based)
- Diode (Si & SiC based)

Several topologies



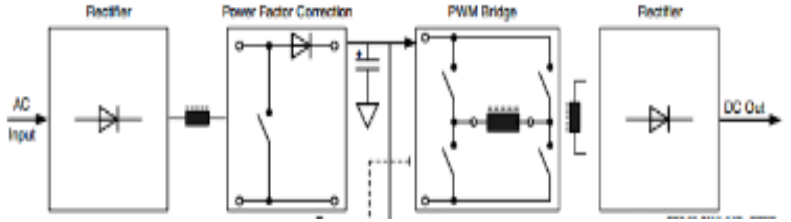
Top Side Cooling





Modularity

Ideal to build a complete system



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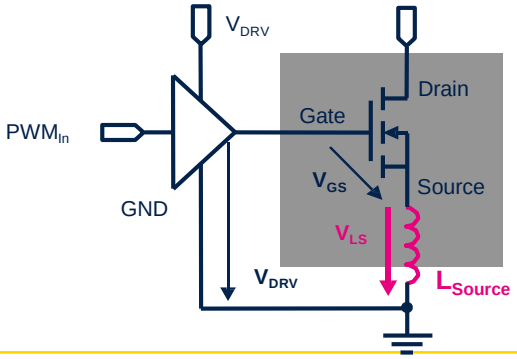
TO-LL features and benefits

Features

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

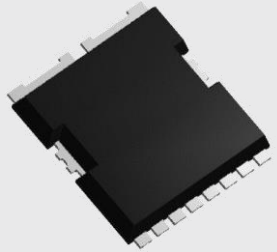
Parasitic source inductance

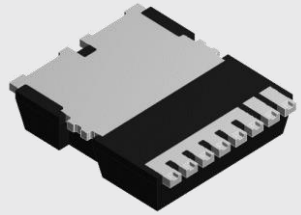


current variation generates an overvoltage that decreases the efficiency due to slow down of transient

30% Saved board area compared to D2PAK

Top view





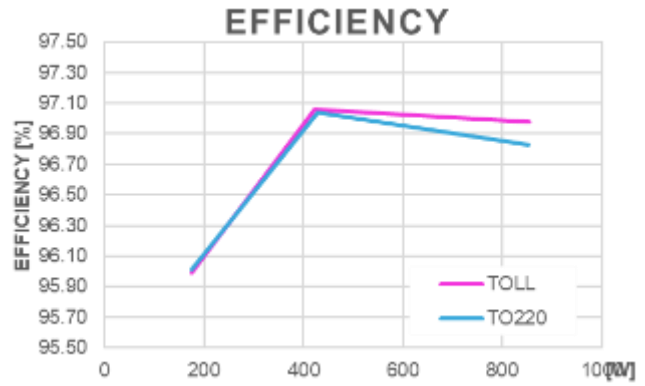
Bottom view

HV single island with kelvin source contact

Benefits

- Increased Power Density
  - (MDmesh* M6 600V 80mΩ, 99mΩ, 125mΩ)
  - (MDmesh M9 600V 28mOhm, MDmesh M9 650V 33mOhm)
- Improvement in Turn on / Turn off efficiency
- Compact Telecom SMPS solution
- MOSFET BVdss from 600V up to 850V

Application analysis



1000W PFC

TO-220 vs. TO-LL

80mΩ 600V MDmesh* M6 same die size

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Thank you

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