

# Next Generation Power Discretetes and Packages

Technology Overview



Silicon MOSFETs



Wide Bandgap Transistors - SiC



Wide Bandgap Transistors - GaN



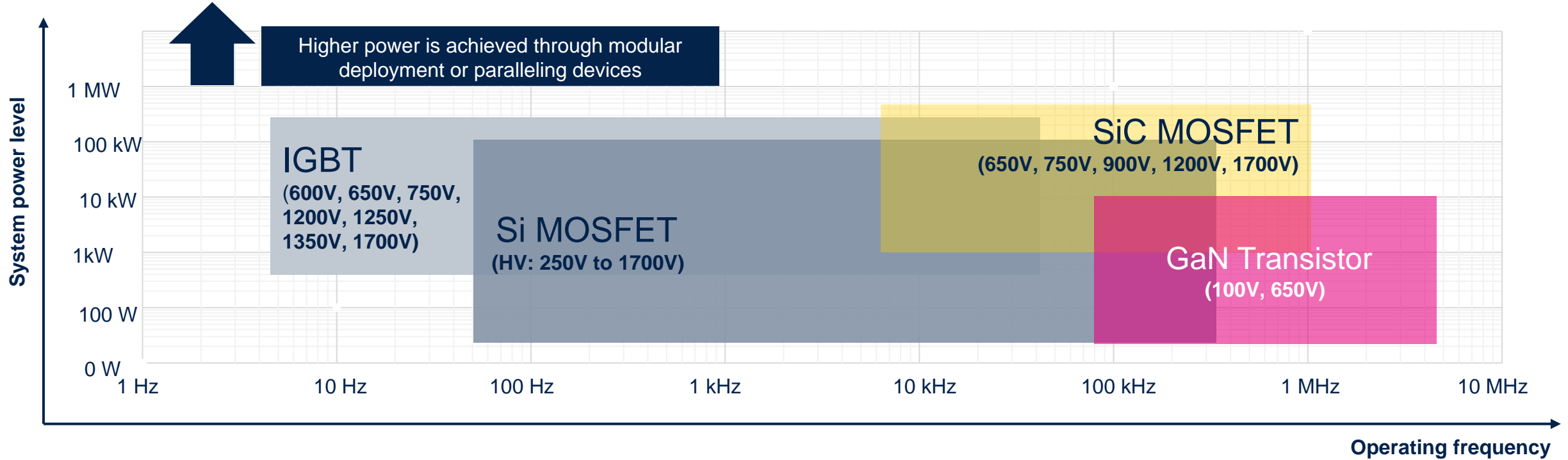
IGBTs and IPM



Power Modules



# Silicon and Wide-bandgap Power Technology Positioning



Technology	Features	Ideal for
<b>Si HV MOSFET</b> (>200V)	Medium-high power up to several kW, high voltage, high frequency	SMPS, server and telecom, DC/DC, low-power motor control, OBC, charging station, ...
<b>IGBT</b>	Very high power, high voltage, medium frequency up to 50 kHz	HV motor control, H.A., UPS, welding, induction heating, main traction, ...
<b>SiC MOSFET</b>	Very high power, high voltage, high frequency, high temperature	High power DC/DC, UPS, charging station, main traction inverters, OBC, ...
<b>GaN Transistor</b>	Medium-high power up to several kW, very high frequency > 80 kHz	SMPS, Telecom Power, DC/DC, OBC, PV inverters, LiDAR, ...



# High-voltage Silicon MOSFETs

**MDmesh: the most complete product portfolio for industrial & multisegment systems**

	<b>M2/DM2</b>	Balanced cost & performance for a broad range of power applications	400 V, 500 V, 600 V, 650 V
	<b>M6/DM6</b>	Superjunction technology for high efficiency in resonant converters and soft-switching applications	600 V, 650 V
	<b>M5</b>	Outstanding $R_{DS(on)}$ in high-power PFC and compact solutions	550 V, 650 V
<b>New</b>	<b>M9/DM9</b>	Enables higher power density and efficiency	250 V, 600 V, 650 V
	<b>K5/DK5</b>	First superjunction technology > 1000 V for very high voltage applications	800 V, 900 V, 950 V, 1050 V, 1200 V, 1500 V, 1700 V
<b>New</b>	<b>K6</b>	Industry's lowest $R_{DS(on)}$ in the very high voltage market. Suitable for very high voltage range	800 V, 950 V, 1050 V, 1200 V, 1500 V, 1700 V





# STPOWER High Voltage Silicon MOSFETs

## M9/DM9 – The Next Step Forward

The most complete product portfolio for high power and efficiency systems



- Best FOM  $R_{DS(on)} \times Q_g$  in the market
- Step forward in **hard switching and soft switching**
- **DM9 FAST diode** embedded version available
- **Wider** product portfolio

### Why choosing M9/DM9?

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





# 800 – 950 V MDmesh K6 Series

## MDmesh K6 superjunction MOSFETs for very-high-voltage applications

**Perfect** for LED lighting applications and auxiliary SMPS based on flyback topology.

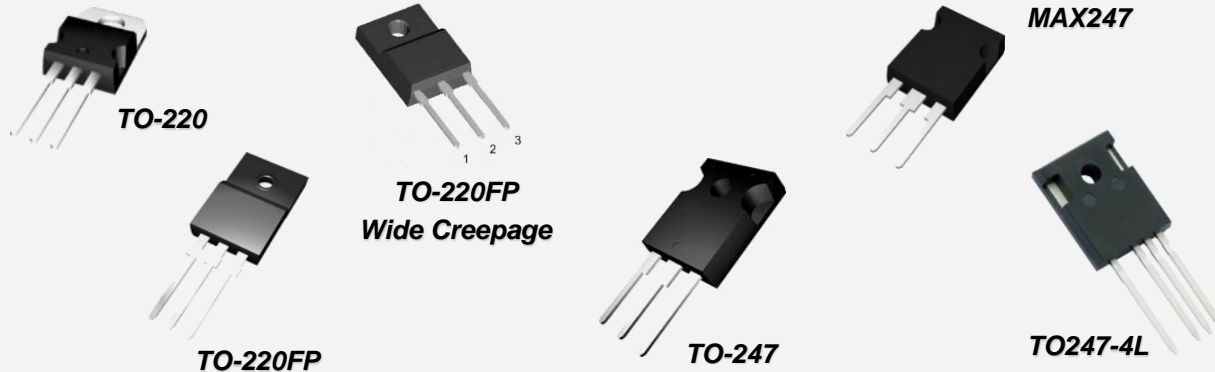
**Industry's** best  $R_{DS(on)}$  for 800 V voltage range, enables designers to increase the power density system for more compactness solution

Lighting applications  
Auxiliary SMPS and e-metering



# High Voltage Power MOSFET Packages

## Through Hole

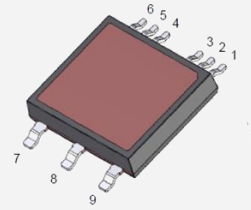


## SMD



## ACEPACK SMIT package

- Top side cooling package
- Several topologies can be realized
- Very high thermal dissipation
- Kelvin source pin enables higher efficiency
- Automotive graded



## HU3PAK package

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



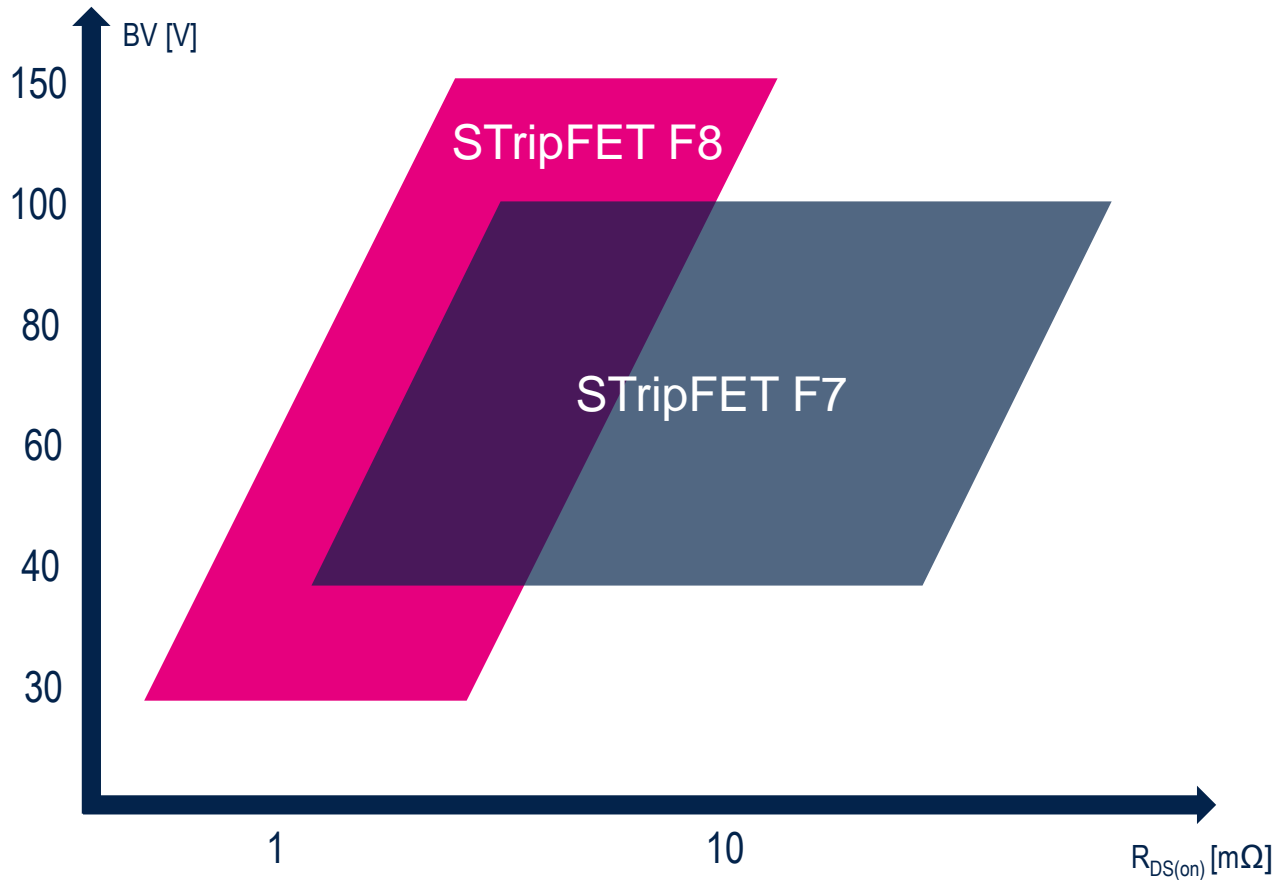
## TO-LL package

- Compactness
- Higher power density
- Reliability at high VDSS rating
- Kelvin source pin enables higher efficiency
- High creepage (distance 2.7 mm)



# New STripFET F8 for Low Voltage Silicon MOSFETs

F8 technology enabling **efficiency** and **power density**



STripFET F8 coverage vs. STripFET F7

## STripFET™ F8 Value proposition

Enhance competitiveness in 12V and 48V systems: improvement up to **-35%**  $R_{DS(on)}$  x Area, and new packages

Excellent  $R_{DS(on)}$  performance in all the breakdown voltage ranges

New **sub- $m\Omega$**  devices at 40V in PowerFLAT 5x6 mm package

Extend the breakdown voltage range from 40V - 100V (F7) to **30V - 150V (F8)**

# Automotive and Industrial Applications For SiC MOSFET

- Global CO2 emission reduction
- Smaller and lighter power unit form factor
- Better inverter efficiency
- Extra mileage / lower battery cost

## Car electrification

Traction inverter

On-board charger

DC/DC converter



## High-end industrial

Better efficiency

Smaller form factor

Lower TCO vs. silicon

- Solar inverter
- Energy storage
- Power supply
- Charging station
- Welding
- Drives





# SiC MOSFET Series

## High voltage and fast switching for high density applications

**Gen1**

Optimized  $R_{DS(on)}$  and  $T_j$  for motor drive applications

1200 V – 1700 V

**Gen2**

Balanced  $R_{DS(on)}$  and  $Q_g$  for a broad range of automotive & industrial applications

650 V, 1200 V, 2200 V

**New**

**Gen3**

Ultrafast series optimizing  $R_{DS(on)}$  vs.  $Q_g$  trade off for very high frequency applications and automotive grade qualified

650 V, 750 V, 900 V, 1200 V

**SiC VHV**  
**2200 V\***

**Very high voltage SiC** extends the advantages of SiC technology to higher voltage ranges

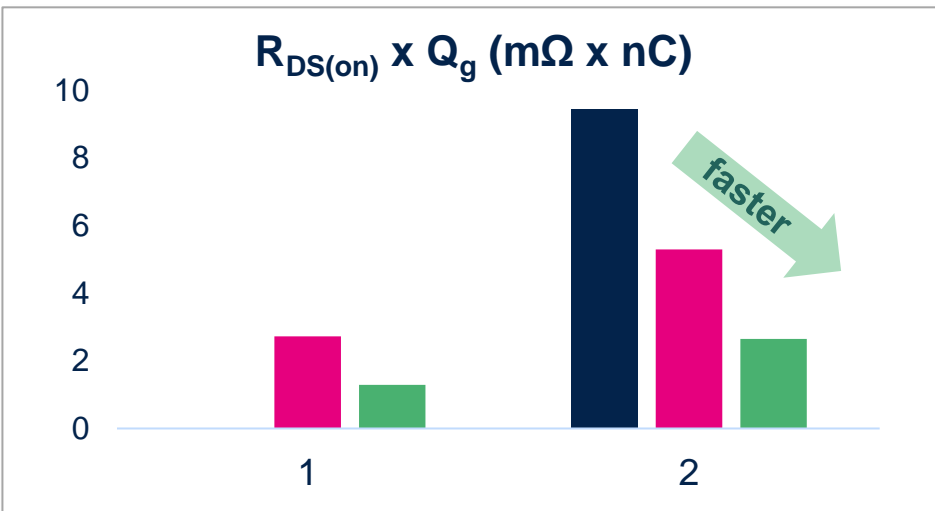
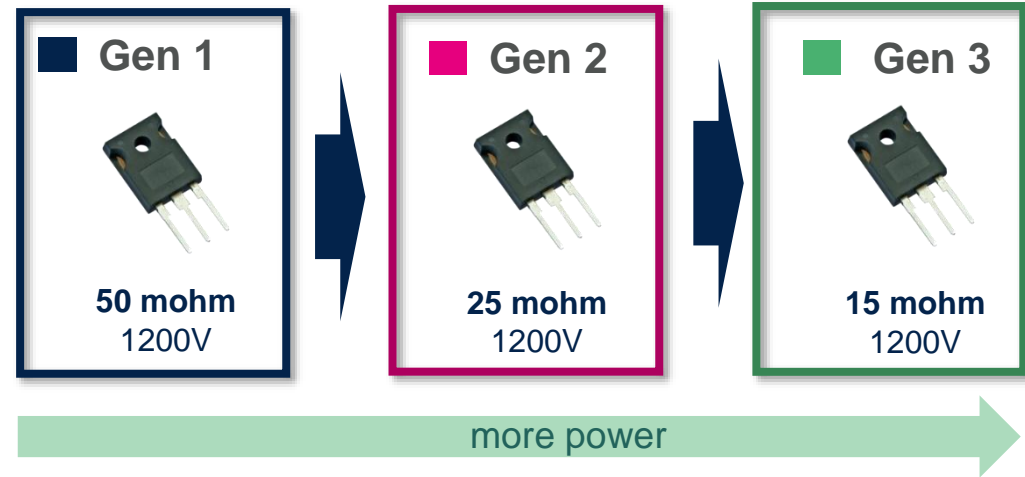
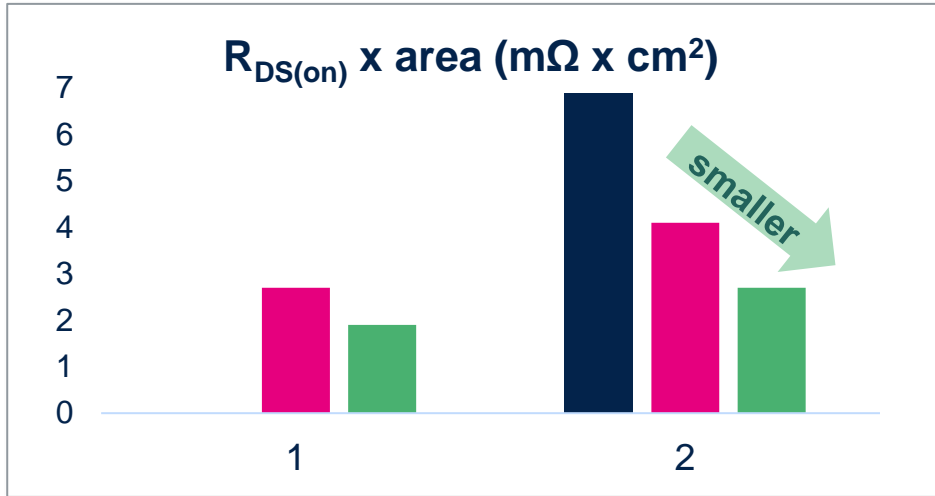
2200 V

\* industrial grade



# SiC MOSFET Advances In Technology

## Figure of Merits

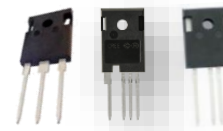
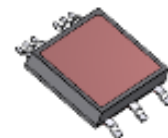
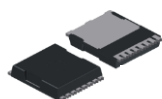


### Improvement over MOSFET generations

- **Lower  $R_{DS(on)} \times \text{Area}$ :**
  - ✓ For a discrete MOSFET, it enables lower  $R_{DS(on)}$  for a given chip size or smaller chip size for a given  $R_{DS(on)}$ , higher current capability, lower conduction losses.
  - ✓ For a power module, it means higher power achievable with the same form factor.
- **Lower  $R_{DS(on)} \times Q_g$ :**
  - ✓ Lower switching losses and higher frequency (reduced board size).

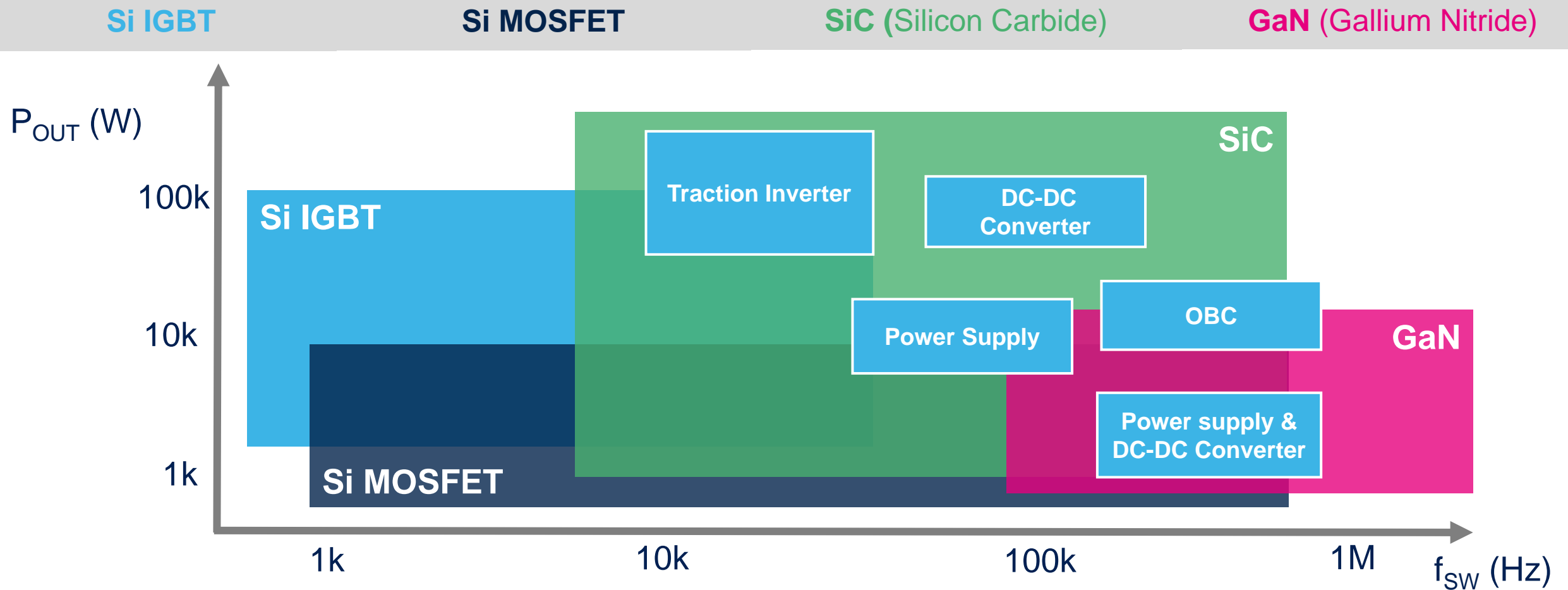
# SiC MOSFET Package Technologies

PowerFLAT 8x8 STD & DSC	TO-LL	H2PAK-7L	HU3PAK	ACEPACK SMIT	HiP247 (3, 4, long leads)	STPAK	Bare Die
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Surface mounting					Through-hole	Special package solutions	
<ul style="list-style-type: none"> <li>Industrial domain</li> <li>Very Thin (&lt; 1mm)</li> <li>Well accepted in power conversion</li> <li>Dual side cooling option</li> <li>Leadless</li> </ul>	<ul style="list-style-type: none"> <li>Industrial domain</li> <li>2.4mm(max) thickness</li> <li>Good Rthj-a performance</li> <li>Leadless</li> <li>Kelvin source for optimized driving</li> <li>Good thermal dissipation</li> </ul>	<ul style="list-style-type: none"> <li>Automotive qualified at 175°C</li> <li>Kelvin Source for optimized driving</li> <li>High runner for Automotive customers</li> </ul>	<ul style="list-style-type: none"> <li>Automotive qualified at 175°C</li> <li>Top side cooling</li> <li>Kelvin Source for optimized driving</li> <li>Very good thermal dissipation</li> <li>Specifically designed for OBC, DC-DC Converter</li> </ul>	<ul style="list-style-type: none"> <li>Automotive qualified at 175°C</li> <li>Isolated Top side cooling</li> <li>Suitable for different configurations (HB, dual-die, etc.)</li> <li>High Power</li> <li>Modular Approach</li> </ul>	<ul style="list-style-type: none"> <li>Automotive qualified at 200°C</li> <li>Very common Industry standard</li> <li>Kelvin Source option for optimized driving</li> <li>High creepage version (1200V and 1700V) in development</li> </ul>	<ul style="list-style-type: none"> <li>Automotive qualified at 200°C</li> <li>Unique solution for traction inverter</li> <li>Very High thermal dissipation efficiency</li> <li>Sense pin for optimized driving</li> <li>Multi-sintered package</li> </ul>	<ul style="list-style-type: none"> <li>WLBI &amp; KGD</li> <li>T&amp;R or RWF options</li> <li>Compliant with the most stringent Automotive Quality Requirements</li> </ul>

# Power Semiconductors Positioning vs. Key Applications



**SiC MOSFET is the best technology so far for high voltage, high frequency, and high power system applications.**

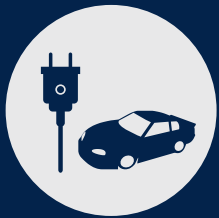
# The Main Trends In PowerGaN

## Electrification at the center of the mobility revolution

Smart Mobility



### Applications



- Traction inverters
- DC-DC converters
- On-board chargers
- Wireless chargers

## Maximizing efficiency and consolidating renewable energy generation

Power & Energy



### Applications



- SMPS and LED lighting
- 5G & datacenter power supplies
- Solar and energy storage
- Charging stations
- Motor control and appliances

# Focus product: SGT65R65AL

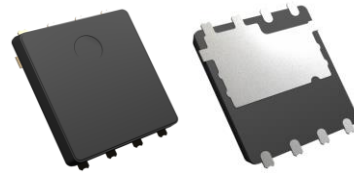
## p-GaN G-HEMT™ transistor – 49 mΩ

### Product attributes

- Typ 49 mΩ effective  $R_{DS(on)}$  @ 25°C
- 650 V DC, 750 V peak
- 25A DC
- 85 pF  $C_{oss}$
- 3 pF  $C_{rss}$
- 1.8 V threshold voltage
- 5.4 nC gate charge
- 0 nC reverse recovery charge

### PowerFLAT 5x6 HV

- 1 mm max thickness
- Fixed form factor
- Kelvin source for optimized driving
- Easy to drop in vs standard solution
- Well accepted in power conversion
- Industrial qualification



### Applications

- Game console PSU
- Adapters
- LED lighting



# Focus product: SGT120R65AL

## p-GaN G-HEMT™ transistor – 75 mΩ

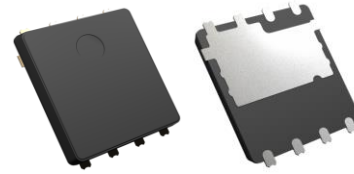


### Product Attributes

- Typ 75 mΩ Effective RDS(on) @ 25°C
- 650V DC, 750 V peak
- 15A DC
- 50 pF Coss
- 0.9 pF Crss
- 1.8V Threshold Voltage
- 3 nC Gate Charge
- 0 nC Reverse Recovery Charge

### PowerFLAT 5x6 HV

- 1mm max thickness
- Fixed form factor
- Kelvin Source for optimized driving
- Easy to drop in vs standard solution
- Well accepted in power conversion
- Industrial qualification



### Applications

- Game console PSU
- Adapters
- LED lighting

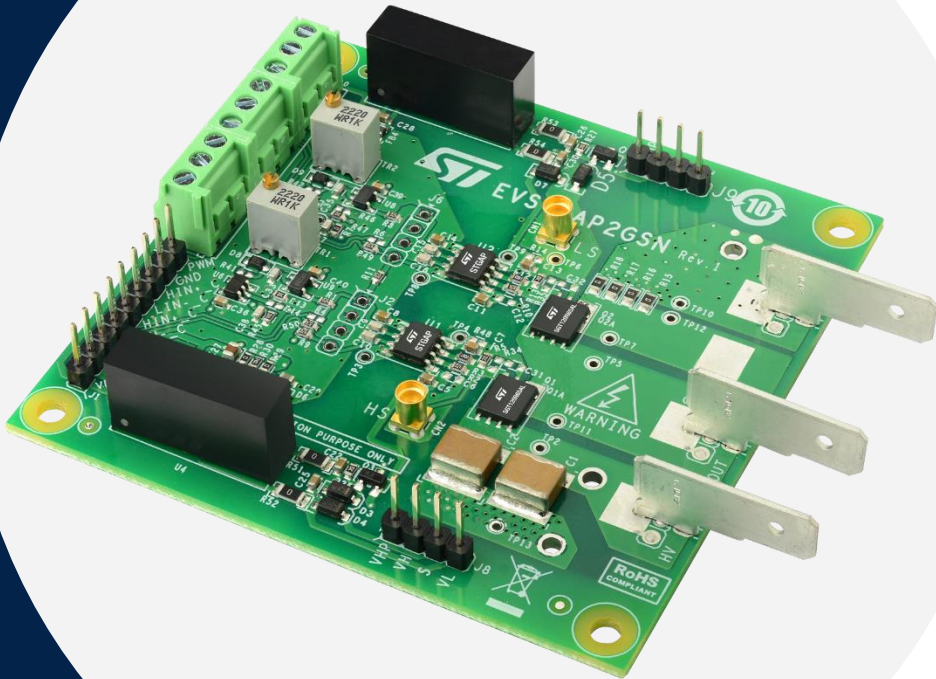


# Gate driver for G-HEMT™ devices

## What to know about G-HEMT™ (p-GaN)

### G-HEMT™

- p-GaN is a true enhancement-mode normally off device
- Voltage driven. Driver charges/discharges  $C_{ISS}$
- Max  $V_{GS}$  ratings = -10 V, 7V
- Driving Voltage = 5 - 6 V
- Negative driving voltage (i.e. -3V) can be used to improve immunity to gate ringing/cross conduction and turn-off losses
- Easy slew rate control by  $R_g$
- Kelvin pin to reduce common source inductance (CSI) effect
- Much lower  $Q_g$  than other technologies: lower drive loss
- No DC gate drive current required





# Advantages of GaN

	Characteristics	Features	Benefits
Material properties	Wide bandgap (3.4 eV)	High critical electric Field $E_{cr}$	Shorter drift region for the same BV (cost reduction)
		Low intrinsic carrier concentration ( $n_i = 1.9 \times 10^{-10}$ )	Lower leakage current
	Piezo polarization nature (high channel concentration without intentional doping)	High electron mobility in the channel up to 2000 $\text{cm}^2/\text{Vs}$	<ul style="list-style-type: none"> <li>Lower on-state resistance</li> <li>Lower conduction losses</li> <li>Higher system efficiency</li> </ul>
Technology properties	Heterostructure based device	High electron mobility in the channel up to 2000 $\text{cm}^2/\text{Vs}$	Enabler for high frequency hard switching applications reducing the size of the passive components (cost reduction of the system)
		Fast switching	
	Possibility to grow GaN on Si substrate	Cheaper technology compared to SiC or Diamond	Cost reduction of the system



# Trench Gate Field IGBTs Series Positioning

## Breakdown Voltage

600V		650V				1200V		1250V	1350V	1700V
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## Current

4 to 20 A	20 to 80 A	4 to 200 A	20 to 80 A	15 to 100A	20 to 50 A	40 A	8 to 75 A	15 to 75 A	20 A, 30 A	25 A, 35 A	50 A bare die
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## Switching frequency

8 to 30 kHz	50 to 100 kHz	2 to 20 kHz	16 to 60 kHz			2 to 20 kHz		20 to 100 kHz	16 to 60 kHz		2 to 20 kHz
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## IGBT series

H	★ V	★ M	★ HB	★ HB2	IH	★ MS	M	H	IH	IH2	M
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## Focus Applications

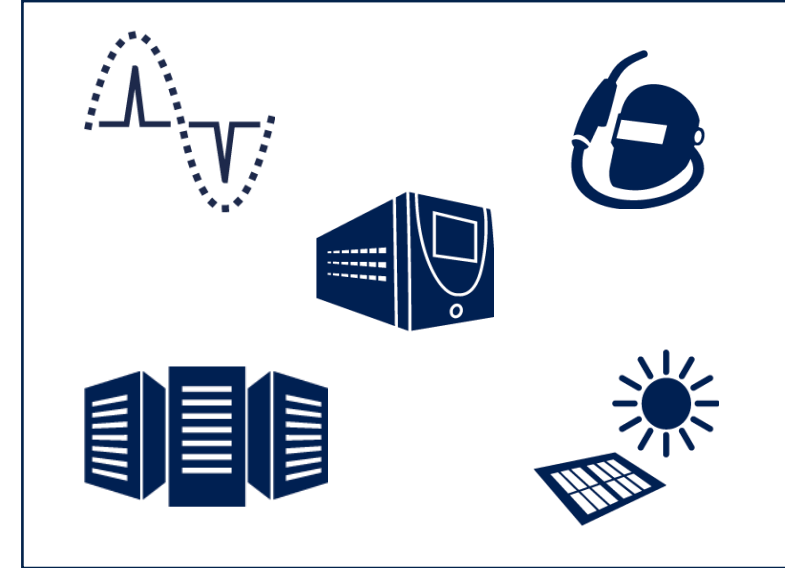
Home appliances	Welding, PFC, Solar, UPS, Charger	Industrial motor control, automotive traction inverter, GPI, Air-Con	PFC, Solar, UPS, Charger, Welding and soft switching	Induction heating, microwave and soft switching	Motor Control, Aux loads, PTC heaters, Battery thermal mgmt	Industrial motor control, GPI, Air-Con	PFC, Welding, Solar, UPS, Charger	Induction heating, microwave and soft switching	Industrial motor control, GPI, Windmill
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- ★ AEC-Q101 rev. D qualified
- ★ AG Qualification on-going



# Trench Field Stop IGBTs

## High Switching Frequency Conversion



### 600V V series

- $V_{CESAT}$  : 1.8 V - 1.85 V
- Current capability: 20A to 80A in discrete pkg
- Available also in bare die
- W or W/O co-pack fast diode
- $T_J$  max = 175°C

**STGWA60V60DWFAG**

First Hybrid IGBT  
with SiC diode  
Available in production

### 650V HB series

- $V_{CESAT}$  : 1.6 V - 1.65 V
- Current capability: 20A to 80A in discrete pkg
- Available also in bare die
- W or W/O co-pack fast diode
- $T_J$  max = 175°C

### 650V HB2 series

- Low  $V_{CESAT}$  : 1.55 - 1.65 V
- Current capability: 15 to 100A in discrete pkg
- Available also in bare die
- Different diode options
- $T_J$  max = 175°C

**HB2 series in TO-247-4**  
50, 75, 100A Available in production

### 1200V H series

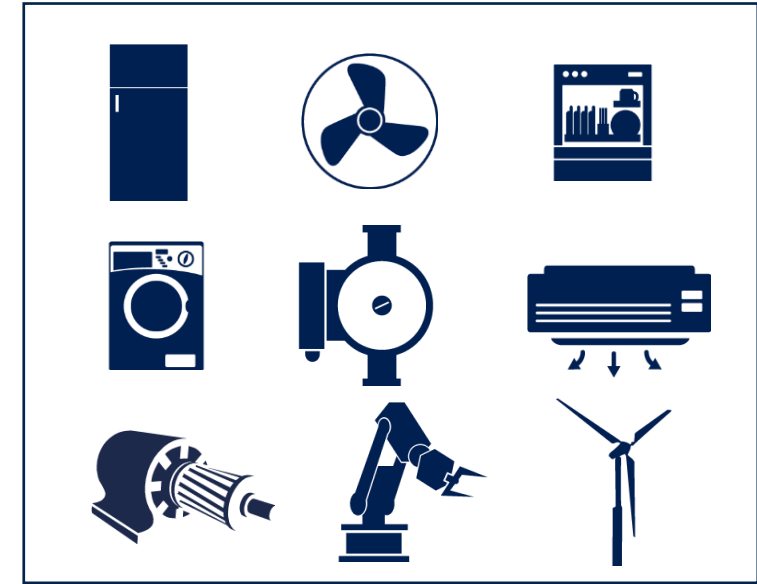
- $V_{CESAT}$  : 2.1 V
- Current capability: 15 to 75A in discrete package
- Available also in bare die
- $t_{SC}$  of 5  $\mu$ s at  $T_J = 150^\circ\text{C}$ ,  $V_{CC} \leq 600\text{V}$
- $T_J$  max = 175°C

**STGYA50H120DF2**  
**STGYA75H120DF2**

NEW

# Trench Field Stop IGBTs

## The Right Solution For Motor Control



### 600V H series

- Low  $V_{CESAT}$  : 1.5 V-1.6 V
- Current capability: 4A(\*) to 20A in discrete pkg
- Available also in bare die
- $t_{SC}$  of 5 us at  $T_J=25^{\circ}C$ ,  $V_{CC} \leq 360V$
- $T_J \text{ max} = 175^{\circ}C$

STGD4H60DF  
Available

NEW

### 650V M series

- Low  $V_{CESAT}$  : 1.55 V - 1.65 V
- Current capability: 4A to 200A in discrete pkg
- Available also in bare die
- $t_{SC}$  of 6  $\mu s$  at  $T_J= 150^{\circ}C$ ,  $V_{CC} \leq 400V$
- $T_J \text{ max} = 175^{\circ}C$

### 1200V M series

- $V_{CESAT}$  : 1.85 V
- Current capability: 8 to 50A in discrete pkg
- Available also in bare die
- $t_{SC}$  of 10  $\mu s$  at  $T_J= 150^{\circ}C$ ,  $V_{CC} \leq 600V$
- $T_J \text{ max} = 175^{\circ}C$

STGYA50M120DF3  
Available

NEW

### 1700V M series

- $V_{CESAT}$  : 2 V
- Current capability: 50A Available only in bare die (D7,D8)
- $t_{SC}$  of 10  $\mu s$  at  $T_J= 125^{\circ}C$ ,  $V_{CC} \leq 1000V$
- $T_J \text{ max} = 150^{\circ}C$

STG50M170F3D7/D8  
Available

NEW



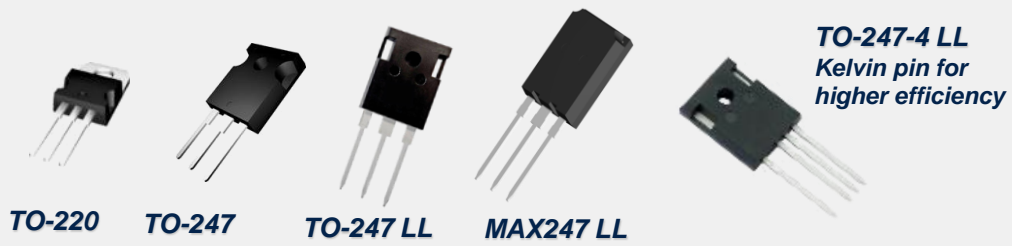
life.augmented



# Package Overview for Discrete IGBT

Through-Hole package

Production

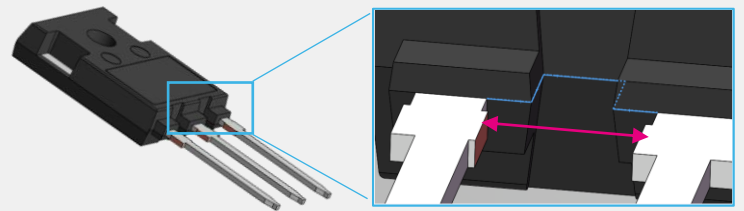


Wide package portfolio to address the market needs



Development

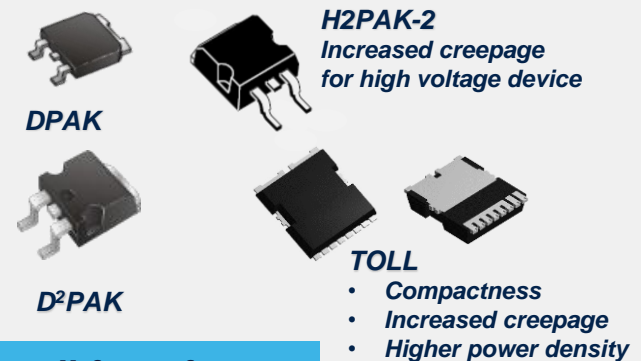
Isolated option



- TO-247 HC & HCI
- Easy replace of STD TO-247 long leads
  - Higher Creepage and clearance for extended Vrms
  - Isolated option ( $\leq 3.5\text{kV/s}$ ) with  $\text{Al}_2\text{O}_3$  substrate for high thermal dissipation

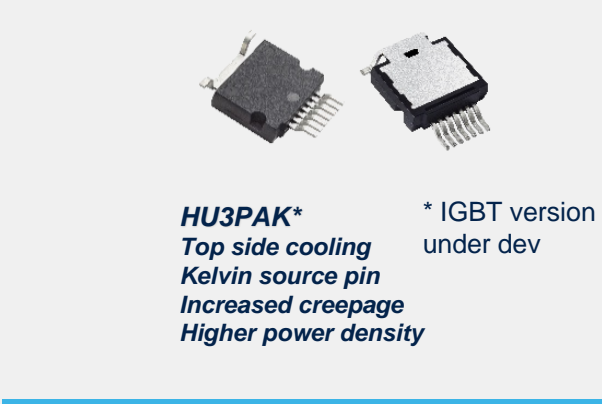
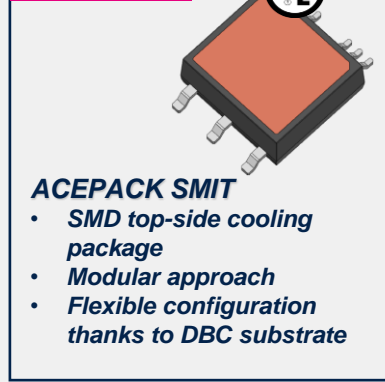
Higher safety in harsh environment

SMD package



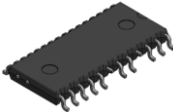

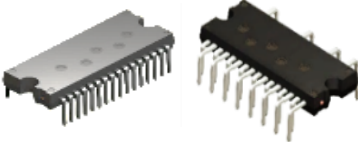


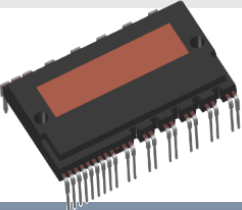
Small form factor for space saving

Isolated



Compactness and performance

# SLLIMM: Small Low-Loss Intelligent Molded Module

SLLIMM nano			SLLIMM 2 <sup>nd</sup> series		NEW SLLIMM HP
SMD	TH	2 <sup>nd</sup> series TH	Full molded	DBC	
600 V IGBT 500 V MOSFET 1 up to 3 A		600 V IGBT 600 V <b>SJ MOSFET</b> 3 up to 8 A	600 V IGBT 8 up to 15 A	600 V IGBT 600 V <b>SJ MOSFET</b> 12 up to 35 A	IGBT 650 V, 50 A 1200 V, 10 A
					
<b>NSDIP-26L</b> 12.45 x 29.15 x 3.10 mm	<b>NDIP-26L</b> 12.45 x 29.15 x 3.10 mm	<b>N2DIP-26L</b> 12.45 x 32.15 x 4.10 mm	<b>SDIP2F-26L</b> 24 x 38 x 3.5 mm	<b>SDIP2B-26L</b> 24 x 38 x 3.5 mm	<b>SDIPHP-30L</b> 31 x 52 x 5.6 mm

10 to 600 W

300 W to 3 kW

3 to 7 kW





# ACEPACK\* Power Module Package Options

## ACEPACK options

## Package design

## Key features

## Configurations

## Applications

**ACEPACK 1**  
3kW to 15kW



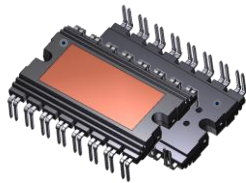
33.8 x 48 mm

**ACEPACK 2**  
10kW to 30kW



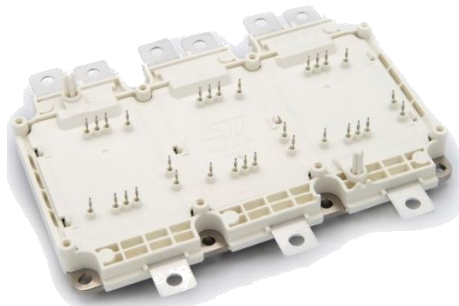
48 x 56.7 mm

**ACEPACK DMT-32**  
2kW to 10kW  
*Under development*



44x32x6 mm

**ACEPACK DRIVE**  
120kW to 300kW



- 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

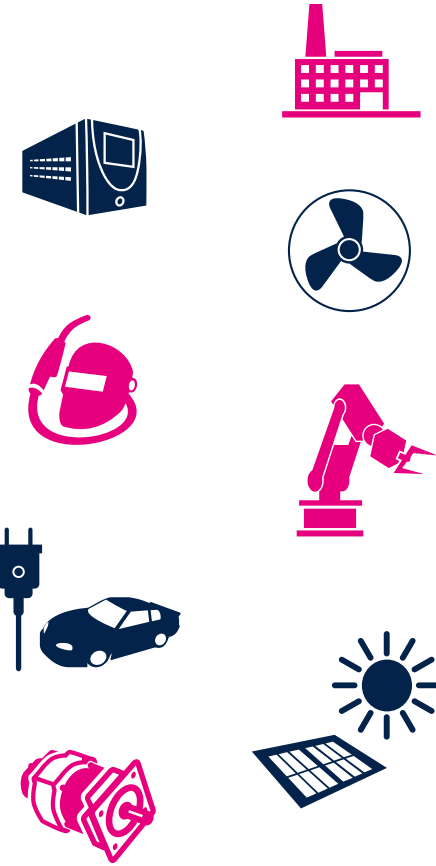
- Silicon 100% produced and controlled by ST (SiC, MOSFET, IGBT, and diodes)
- Electrically insulated
- Top-side cooling
- Dual-in-line molded through-hole

- 750 - 1200V SiC MOSFET-based switch
- Improved light load performance for extended EV driving ranges
- Active metal bonding (AMB) substrate for enhanced thermal dissipation
- 3 different bus bar configuration options
- Extremely low energies dissipation
- Direct cooled Cu baseplate with pin fins

- CIB
- SixPack
- Three level boost
- FourPack
- Half bridge

- FourPack
- SixPack
- Totem pole

- SixPack



\* is a registered and/or unregistered trademark of STMicroelectronics International NV or its affiliates in the EU and/or elsewhere.



# Focus on ACEPACK 1-2

## ACEPACK 1

33.8 x 48 mm

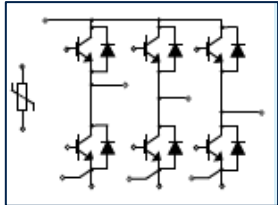


## ACEPACK 2

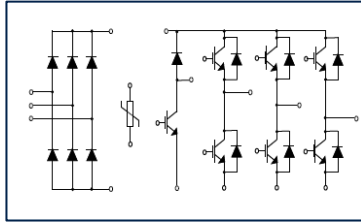
48 x 56.7 mm



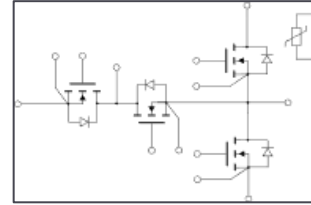
### Main Standard Configuration



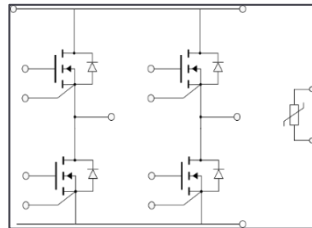
Six pack



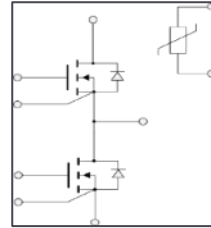
Converter Inverter  
Brake (CIB)



Three Level T-type



FourPack



Half Bridge

ACEPACK standard solutions with IGBT and diodes

ACEPACK standard solutions with SiC

ACEPACK Customized solutions with SiC or IGBT



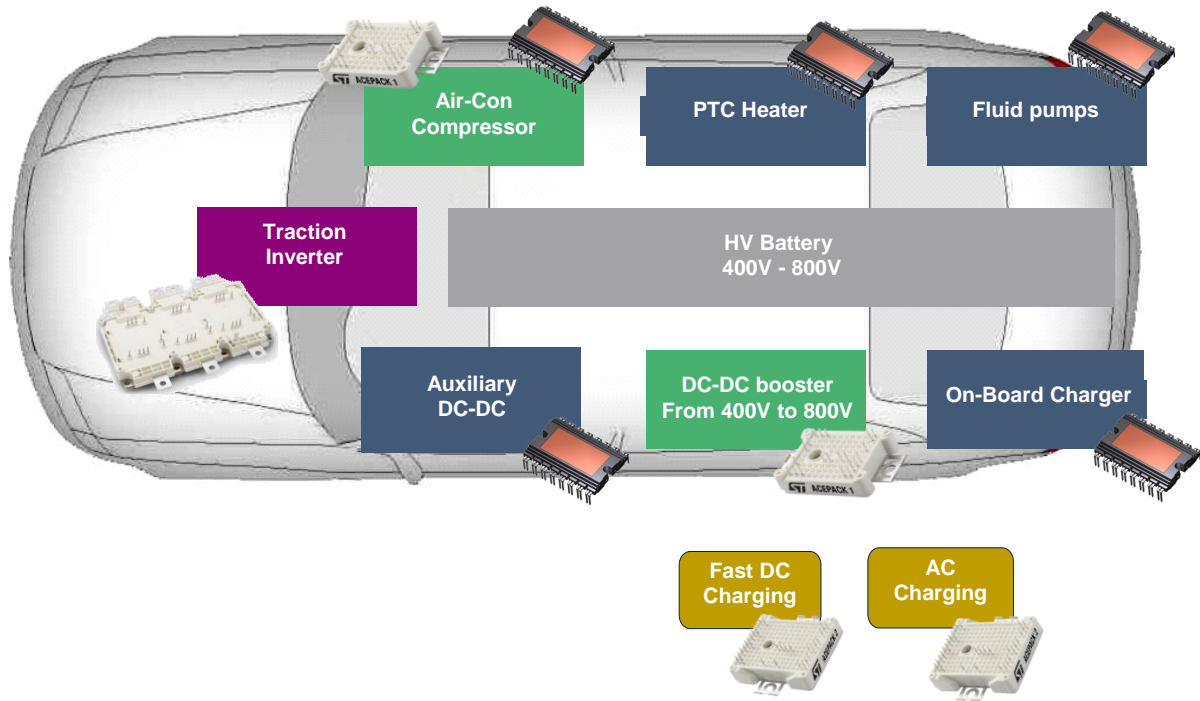
Combining semiconductor and package technologies for multiple design topologies tailored to customers' needs

- Several configurations (CIB, Six-pack, half bridge, FourPack, Three Level T-type)
- High reliability and robustness, miniaturized power sideboard space
- Simplified and stable screwing
- Compact design and cost-effective system approach
- Very high-power density



# Electric Vehicles Blocks Addressed By STPOWER Transistors

## Power modules applications diagram



DMT-32 Domain

AirCon  
E-compressor

SixPack  
3 – 10kW

On-board charger

TotemPole, FouPack  
7 – 22kW

DC-DC converter

FourPack  
4 – 10kW

Fluid Pumps

SixPack  
3 – 5kW

