VEHICLE & TRANSPORTATION TECHNOLOGY INNOVATION MEETINGS

VISHAY
The DNA of tech.™

Evolution in Vishay Power Modules for E-mobility

Solutions for high voltage and low voltage applications

Claudio Damilano

Director of Marketing - Vishay Power Modules

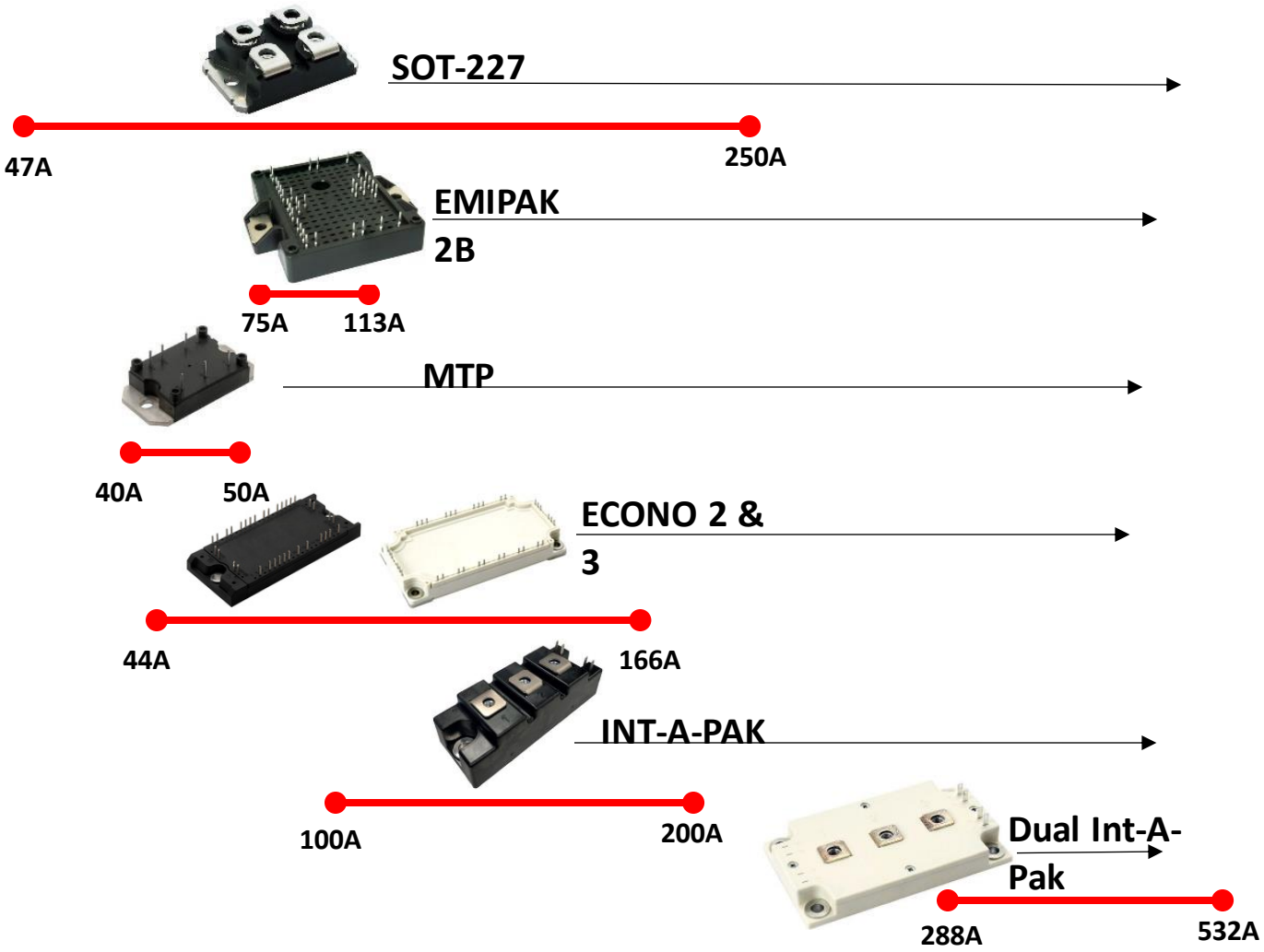
Vishay Semiconductor Italiana – brief history highlights

- In this location since 1969 (International Rectifier)
- Start of the Fab activities with Schottky planar products in 1995 on 4’’
- Start of the ultrafast diodes Fred Pt production in 2001 on 5’’
- Start of the IGBT modules assembly in 2003
- Start of the Trench (submicron) fab in 2005
- Vishay site (Vishay Semiconductor Italiana) since 2007
- Opening of the Characterization Lab at Turin Polytechnic in 2007
- OHSAS 18001 certification of the location in 2011
- Start of production of modules for automotive (electric cars) in 2011
- Ultrafast product families converted to 6’’ in 2014
- Fab production fully converted to 6’’ in 2016
- Opening of the Application Lab (ALPS) at Turin Polytechnic in 2017
- Power Modules sub division is created in 2020
- BG2 Plant for power modules production opens in 2022

VISHAY – POWER MODULEs HQ - BORGARO SITE

Power modules – Industrial Legacy

- **IGBT Modules**

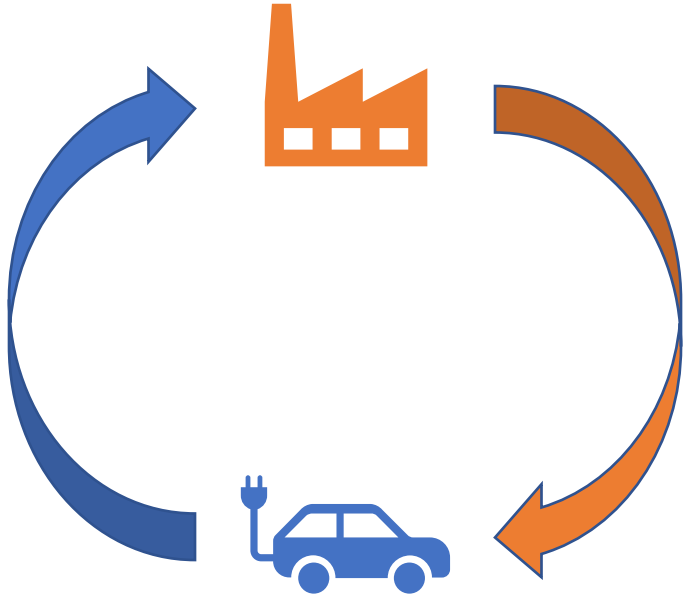


Configuration	Blocking Voltage
Single switch (also with AP Diodes) Low and High Sides choppers	600V to 1200V
3-levels half bridge inverter stage	600V
Full & Half bridge configurations	600V to 2000V
4-pack configuration	1200V
Half-bridge	650V
Half-bridge	600V

THE VIRTUOUS CIRCLE

RELIABILITY

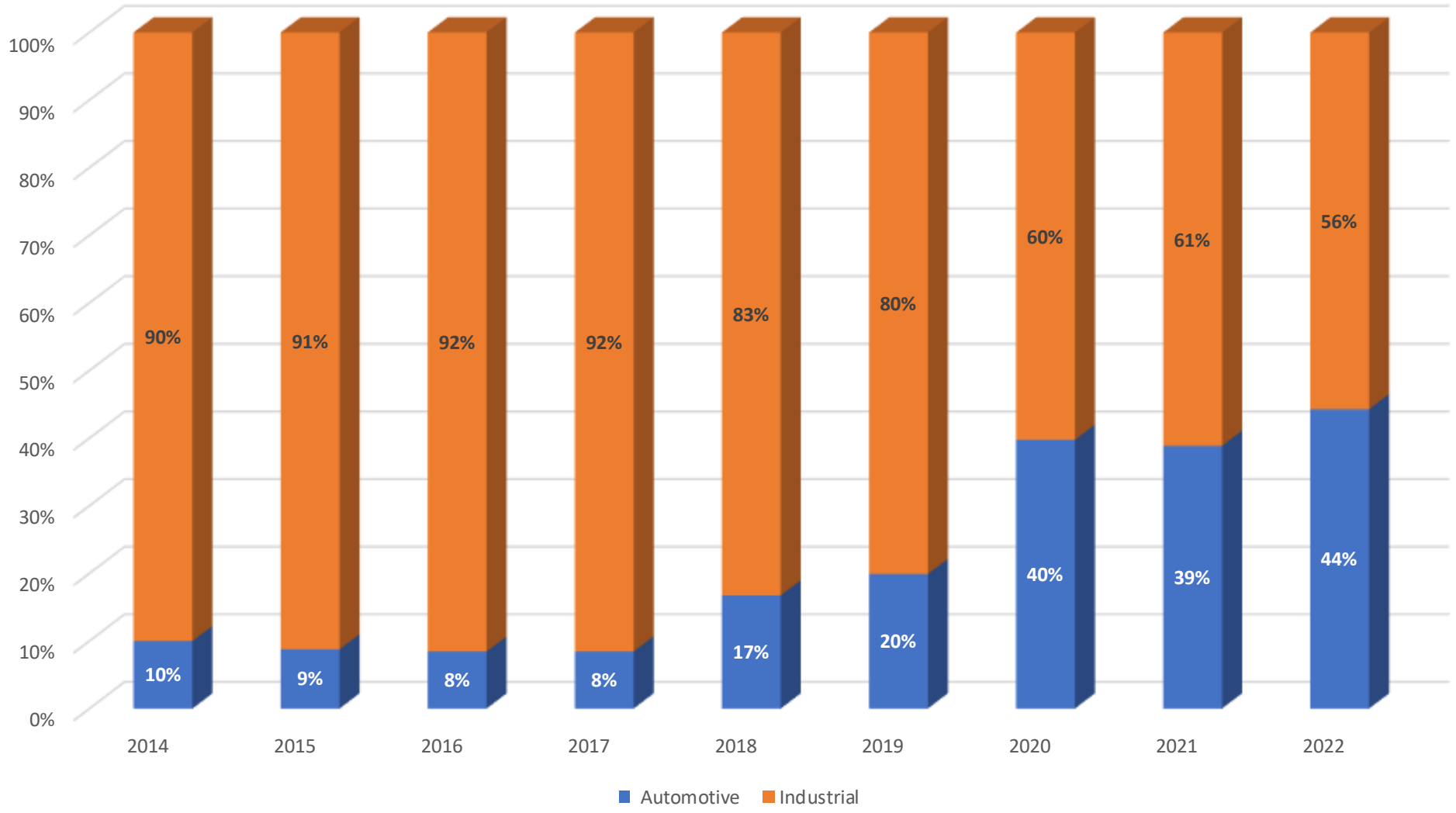
SCALABILITY



POWER

EXPERIENCE

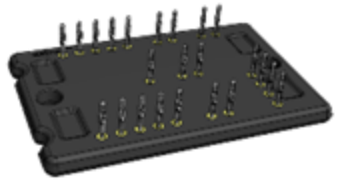
REVENUE SHARE



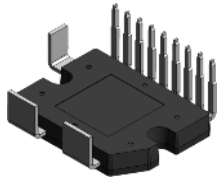
FOCUS POWER MODULES PRESENT AND FUTURE

- AUTOMOTIVE: OBC & 48V LS-EV

- EMIPAK-1B - STD OBC modules – time to market (STD OTS product, AQG-324)
- NEW TRANSFER MOLD SOLUTIONs



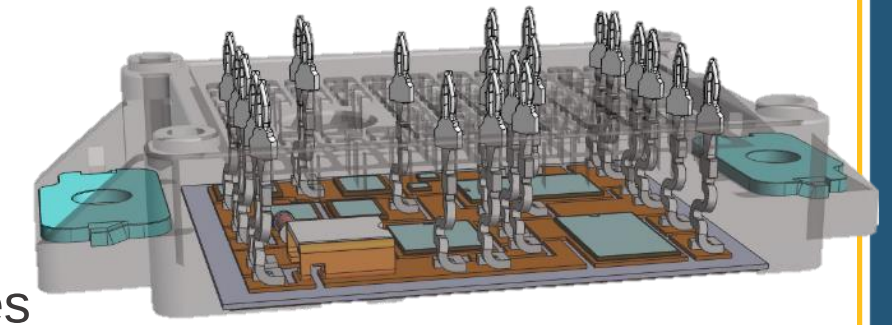
- MAC2PAK – 11kW and 22kW SiC Mosfet based OBC solutions



- FLATPAK-HC0– 80V - 190A Phase leg & Battery disconnect
- FLATPAK-HC1– 80V – 300A Phase leg & Battery disconnect

BENEFIT OF VISHAY POWER EMIPAK-xB MODULES

- POWER DENSITY vs DISCRETE
- AQG-324 Ready for automotive applications
- Press-fit pins: easy to assemble and long lasting
- Solder-pins: optional, compatibility with legacy technologies
- Low Rth DBC, high voltage insulation
- Complex circuits fit in small form factor, low pin count and low stray inductance
- Data Matrix code on case for simple identification on production floor
- Isolation voltage tested up to 3500V



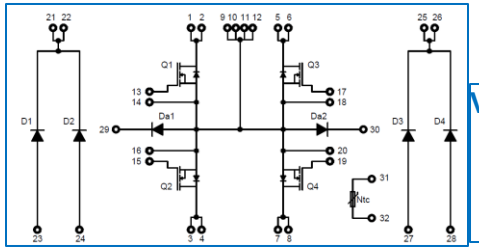
EMIPAK 1B
48 x 34mm

EMIPAK 2B
48 x 57mm

NEW PRODUCTS in EMIPAK-1B

EMIPAK-1B

RELEASED



VS-ENZ025C60N - PFC 7.4kW nominal power

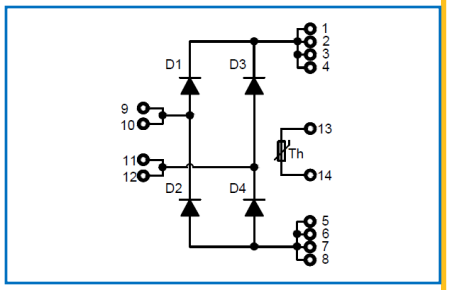
2x interleaved Bridgless PFC (4x channels) w/flexible current sensing options

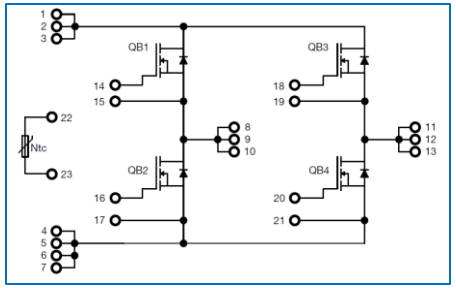
600V 4x 56 mOhm Mosfets, 4x 10A SiC Diodes, 2x low VF diodes, NTC

VS-ENW30S120T - Rectifier 7.4kW nominal power

SiC Diodes H-bridge for LLC or Phase shift converter output rectification

1200V 4x 30A SiC Diodes, NTC





VS-ENY050C60 – for DC/DC 3 to 7.4kW nominal power

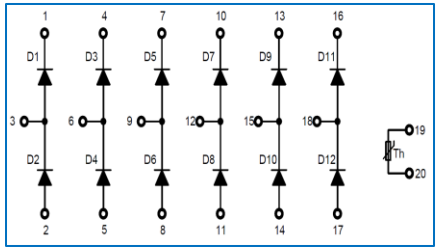
Mosfet H-bridge for LLC or Phase shift converter

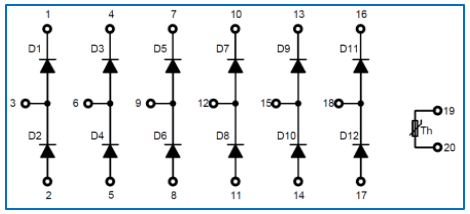
600V 4x 37 mOhm Mosfets feat. fast body diodes, NTC

VS-ENV020F65U: ULTRAFAST BRIDGE

HF Output Rectification w/ flexible configuration (1x1Φ or 3x1Φ)

12x 20A 650V FRED G2 U-type (G5 H-type option), NTC





VS-ENV020M120M: MULTI-BRIDGE - 11kW

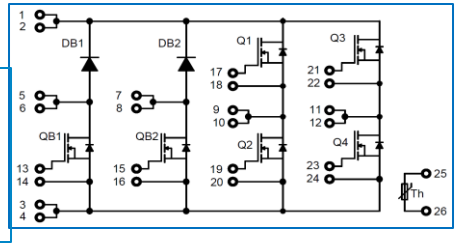
AC Line Input Rectification w/ flexible configuration (1x1Φ or 3x1Φ)

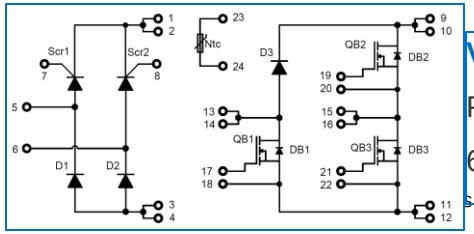
12x 20A 1200V MOAT Input Rectifiers, NTC

VS-ENK025C65S: PFC - 3.6kW

Bridged* Interleaved (or B/less PFC) + H-Bridge for LLC or FBPS

650V 6x 63 mOhm Mosfets, 2x 10A SiC Diodes, NTC





VS-ENM040M60P: ONE-MODULE SOLUTION - 3.6kW

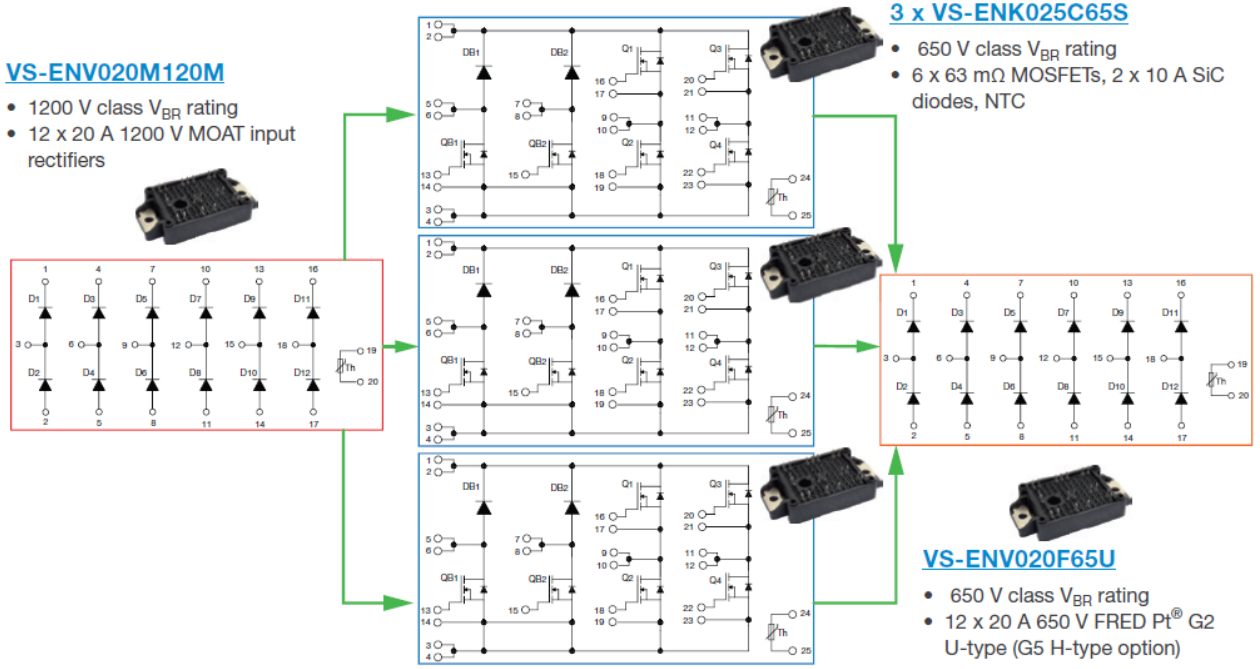
PFC w/soft start control + Half-Bridge for LLC converter

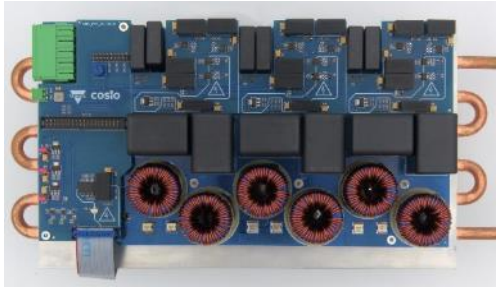
600V 40A Input bridge + 33 mOhm Mosfets + 30A SiC Boost diode, NTC

AQG324

AQG-324 Modular and Compact solution for On-Board Chargers

- BUILD ELABORATE ARCHITECTURES WITH A FEW BUILDING BLOCKS

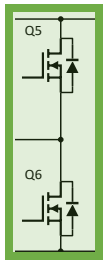
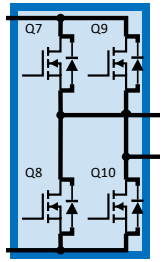
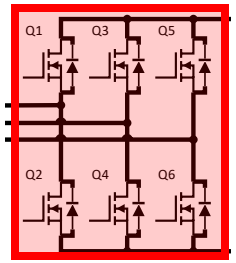
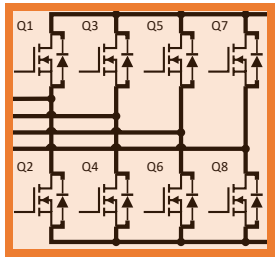
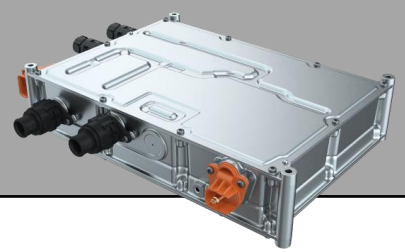




[VS-ENV020M120M](#)
[VS-ENK025C65S](#)
[VS-ENV020F65U](#)
[VS-ENZ025C60N](#)
[VS-ENY050C60](#)
[VS-ENW30S120T](#)
[VS-ENM040M60P](#)

EMIPAK PLATFORM

1200V SiC MOSFETs – TYP CONFIGURATIONS

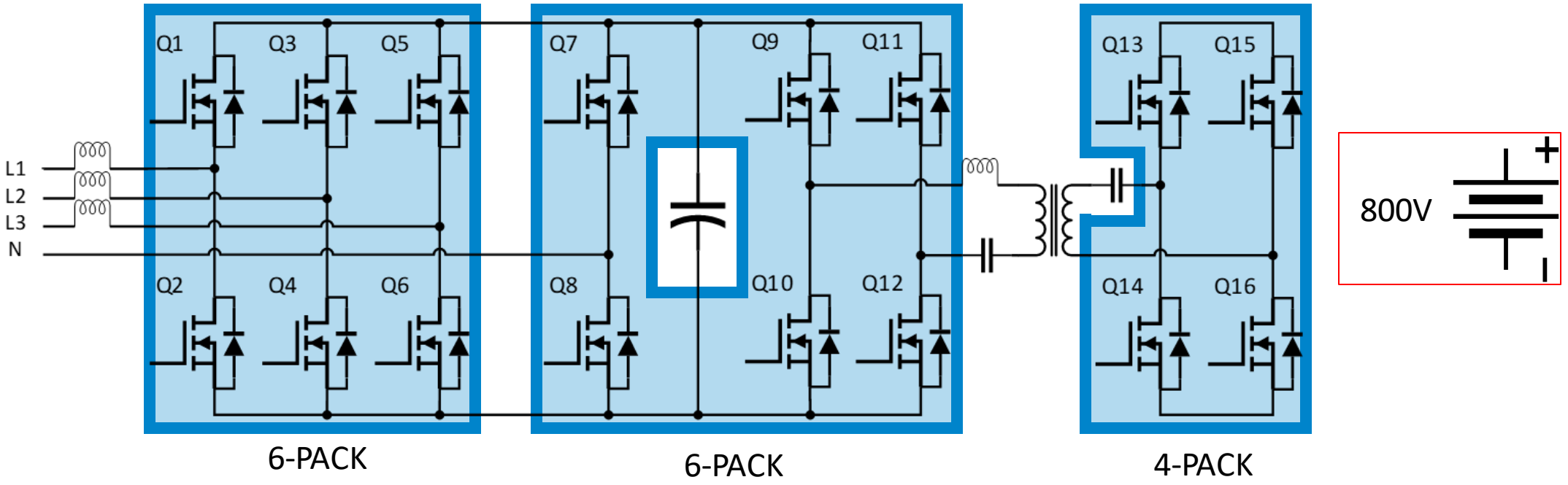
	 2-PACK	 4-PACK	 6-PACK	 8-PACK
	10mΩ		*60/80mΩ*	
	6mΩ			

SiC MOSFET

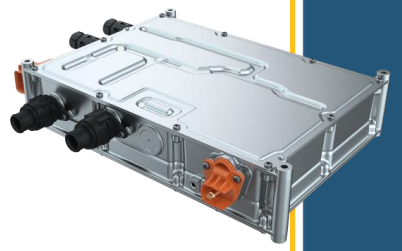
11 kW OBC – BIDIRECTIONAL DESIGN

SiC MOSFET

EMIPAK 1B VERSION



1200V SiC MOSFET

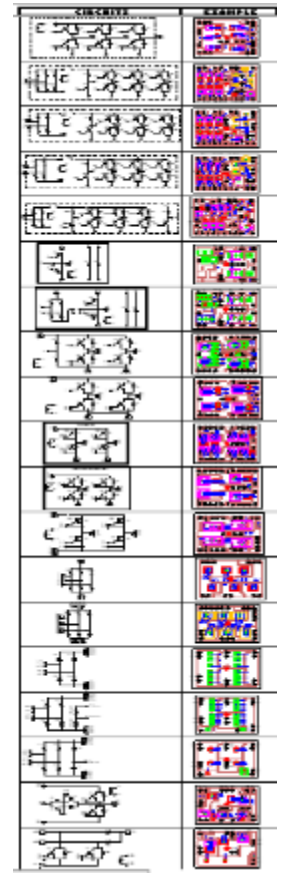


FLEXIBILITY & CUSTOMIZATION: MAJOR ADVANTAGES of MODULES

EMIPAK 1B

MAACPAK

- *Form Factor:* Modules can be designed to optimize layout
- *Power Density:* Modules offer a more compact and easy mounting solution
- *Additional Functionality:* *Vishay can offer additional integration to* customer, integrating active and passive components such as Shunt, Thermistor, Capacitor, gate resistors in their own modules.
- *Lower Risk:* power management and silicon tested and guaranteed
- *Application specific:* optimized and tailored to customer's needs, advantage vs customer's competitors using standard solutions from open market

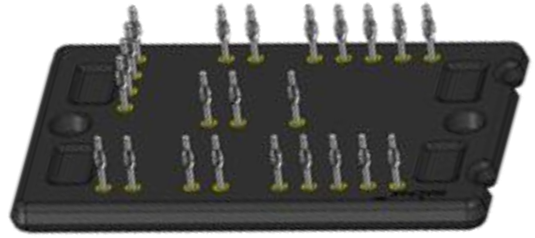


EVOLUTION OF OBC POWER MODULE PACKAGEs

2008

2016

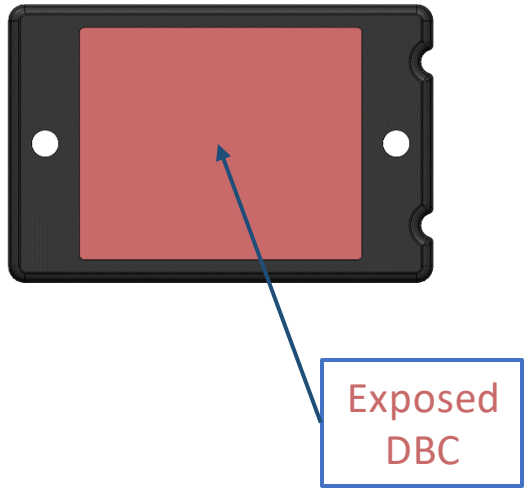
2024

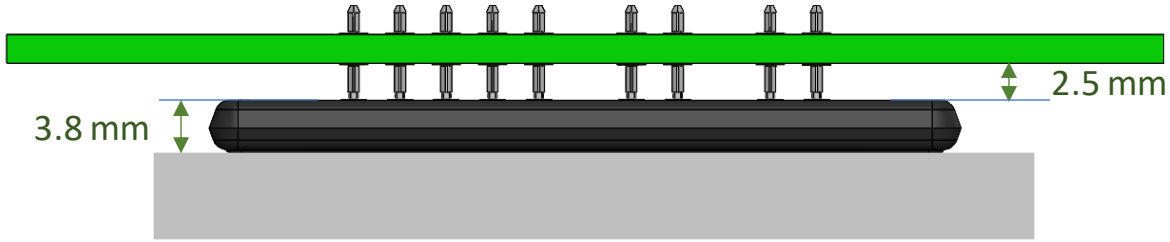


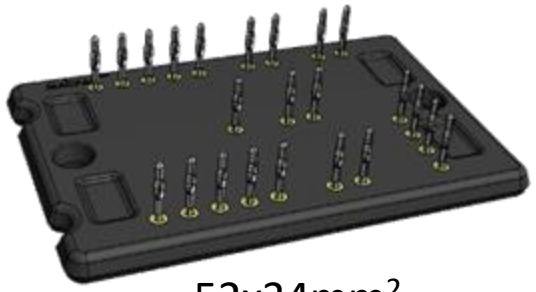
MTP	EMIPAK-1B	MA²CPAK
SOLDER PIN	PRESSFIT PIN	PRESSFIT PIN
COPPER BASE	DBC EXPOSED	ISOLATION EXPOSED
2-PARTS BOX + GEL	SINGLE BOX + GEL	TRANSFER MOLD
INDUSTRIAL PART w/EXTENDED QUALIFICATION TESTS	INDUSTRIAL STANDARD w/DESIGN FOR EXTRA AUTO-REL	DESIGNED FOR AQG324
16 mm HEIGHT	12 mm HEIGHT	6.3 mm HEIGHT

MA2CPAK – TRASFER MOLD TECHNOLOGY

- AQG-324 QUALIFIED – AUTOMOTIVE APPLICATIONs READY
- PRESSFIT PINS – EASY ASSEMBLY
- PINOUT & INT. LAYOUT - DESIGN FLEXIBILITY
- RUGGED TRANSFER MOLD CONSTRUCTION
- LOW RTH – HIGH PERFORMANCE
- LATEST SEMICONDUCTOR TECHNOLOGIES – HIGH EFFICIENCY
- REDUCED STRAY INDUCTANCE vs LEGACY SOLUTIONS







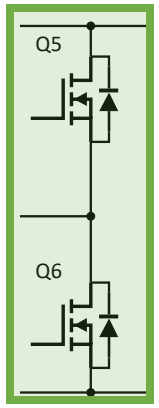
52x34mm^2

PRODUCT RANGE: SiC 1200V PLATFORM

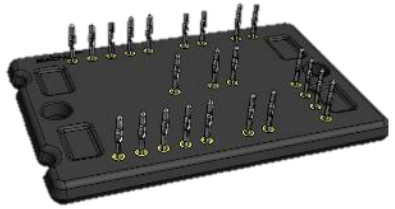
SiC MOSFET

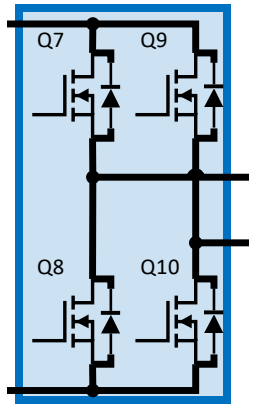
AQG324

1200V SiC MOSFETs – TYP CONFIGURATIONS

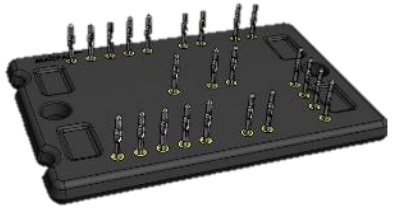


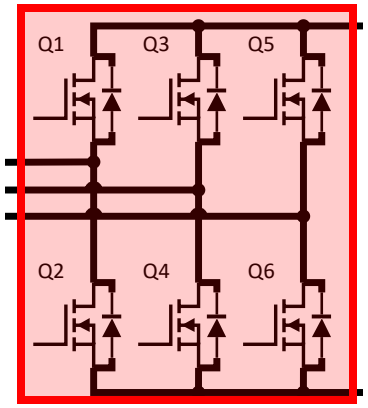
2-PACK
10mΩ



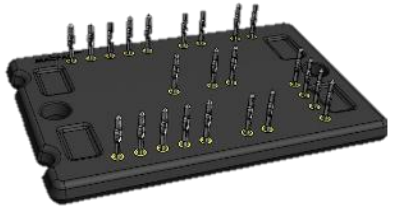


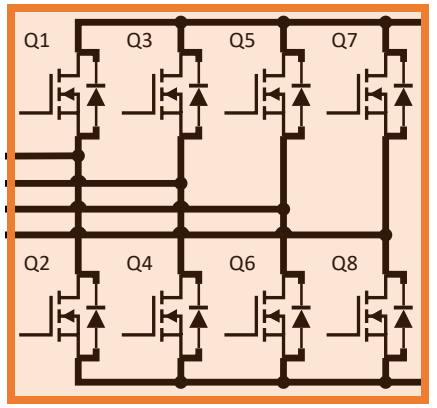
4-PACK
20mΩ



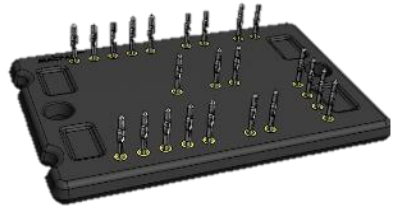


6-PACK
40mΩ





8-PACK
60mΩ



VISHAY
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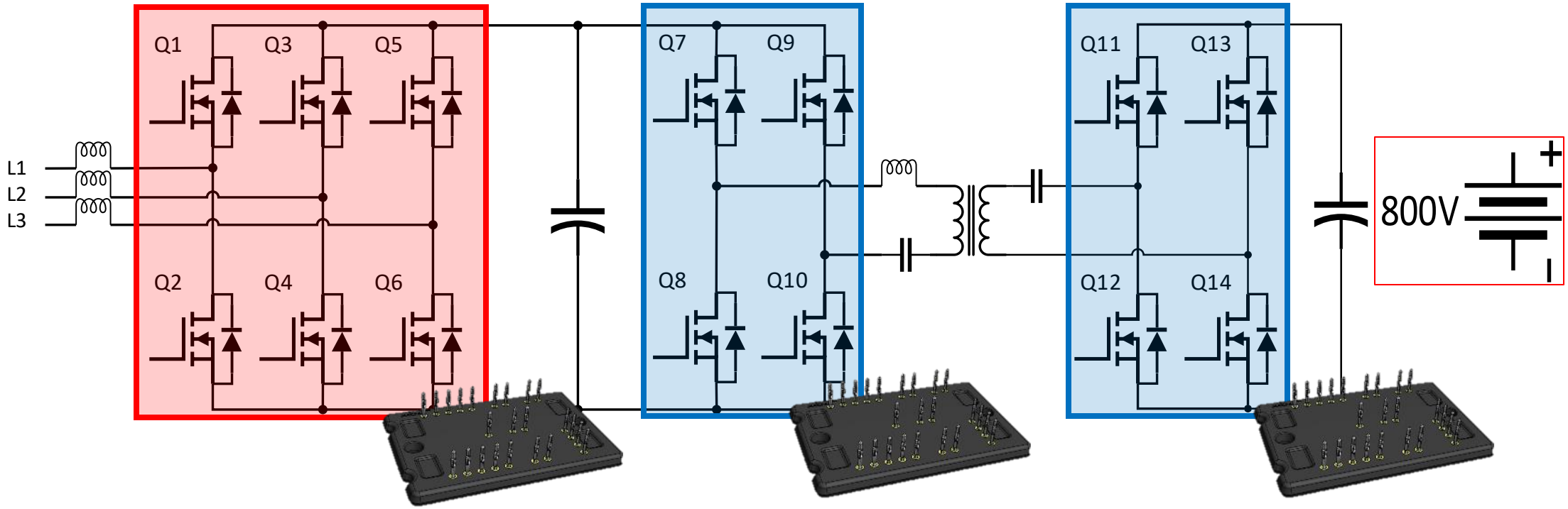
11kW OBC – SiC 1200V PLATFORM

BIDIRECTIONAL TOPOLOGY



VS-MPX020P120
PFC
6-PACK
1200V 80mΩ SiC MOSFET

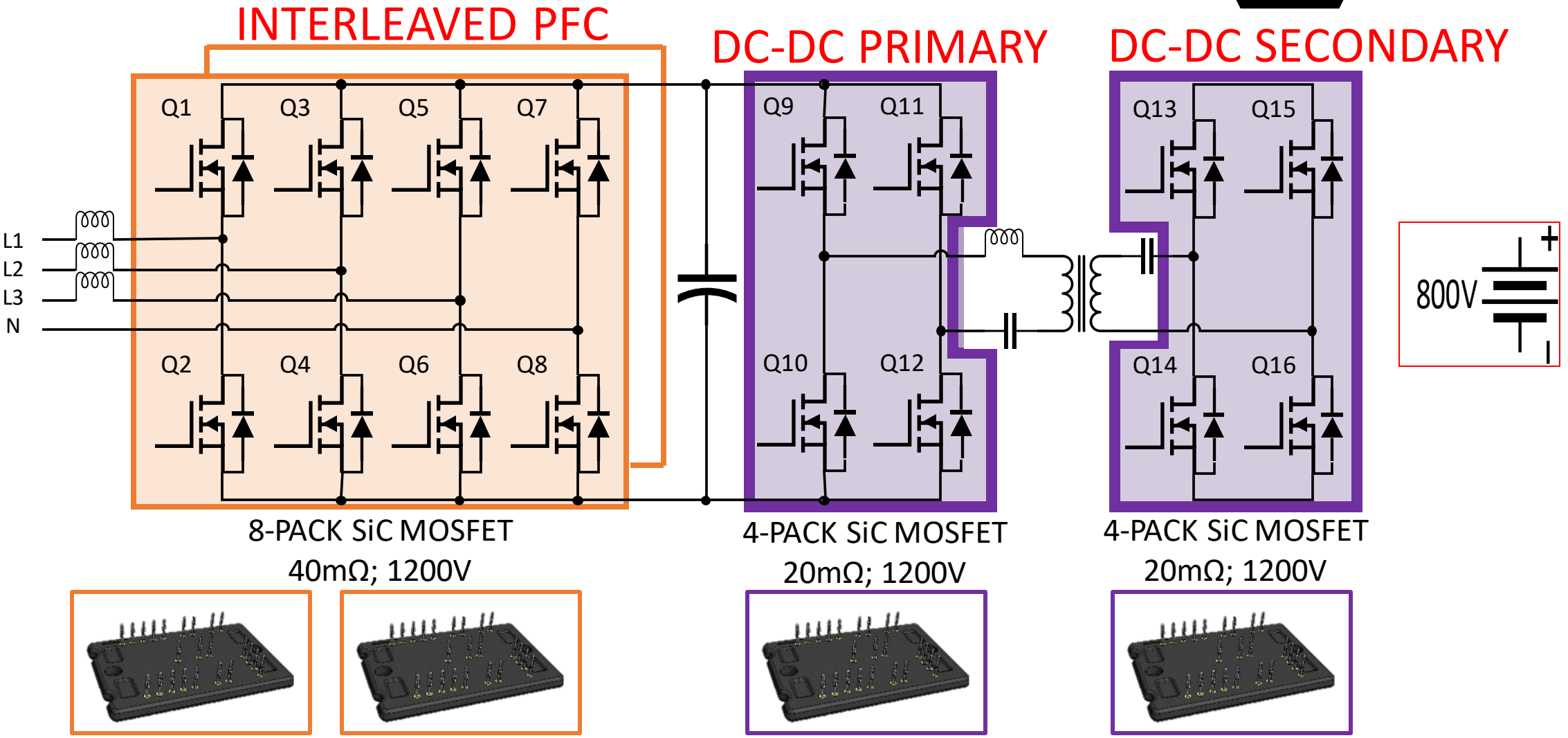
VS-MPY040P120
DC/DC PRIMARY STAGE
4-PACK
1200V 40mΩ SiC MOSFET

VS-MPY040P120
DC/DC SECONDARY STAGE S.R.
4-PACK
1200V 40mΩ SiC MOSFET

22kW BIDIRECTIONAL:

SiC MOSFET

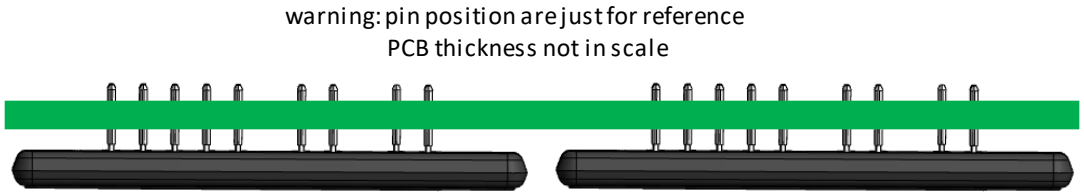
AQG324

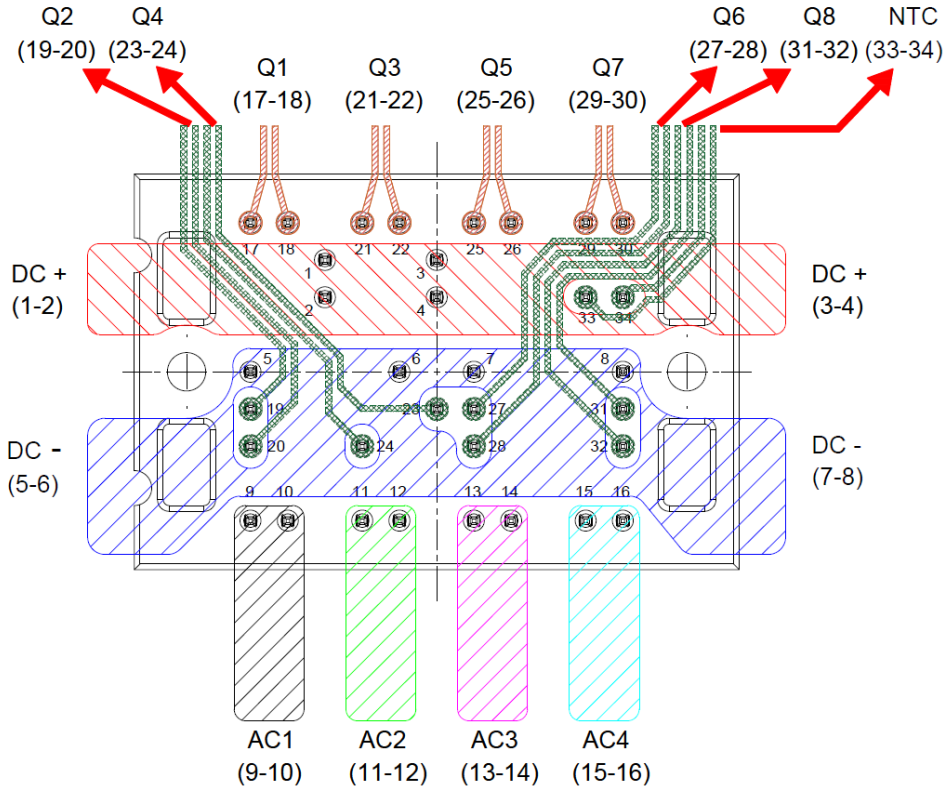


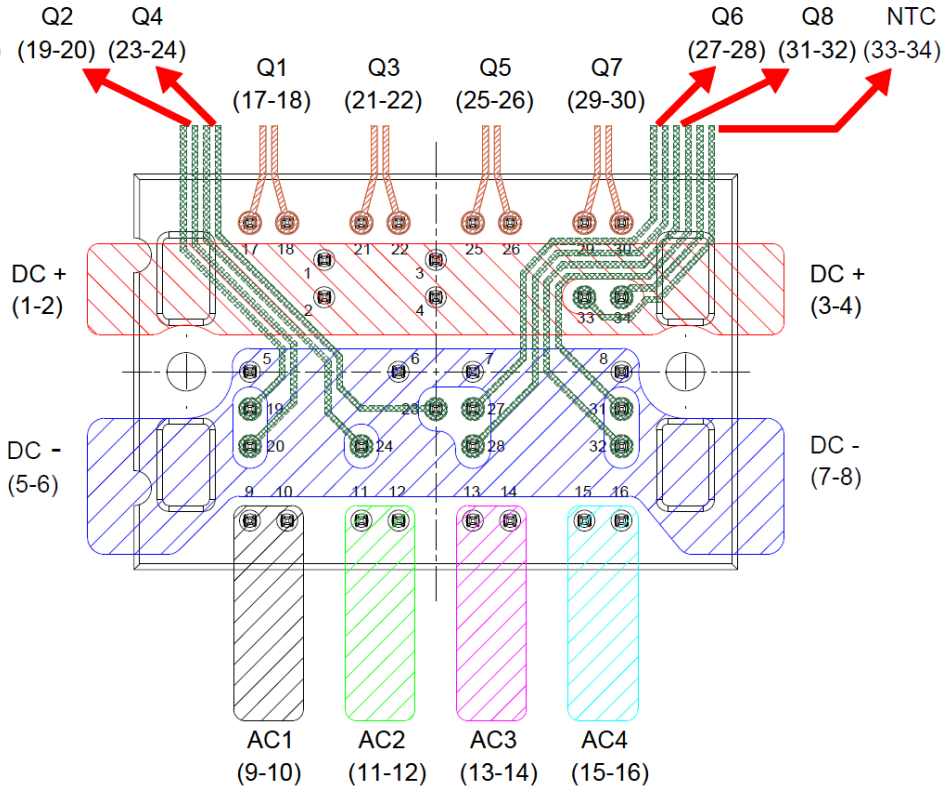
8-PACK MODULE: MAACPAK

PCB CONNECTIONS EXAMPLE

OPTIMIZED FOR PCB LAYOUT



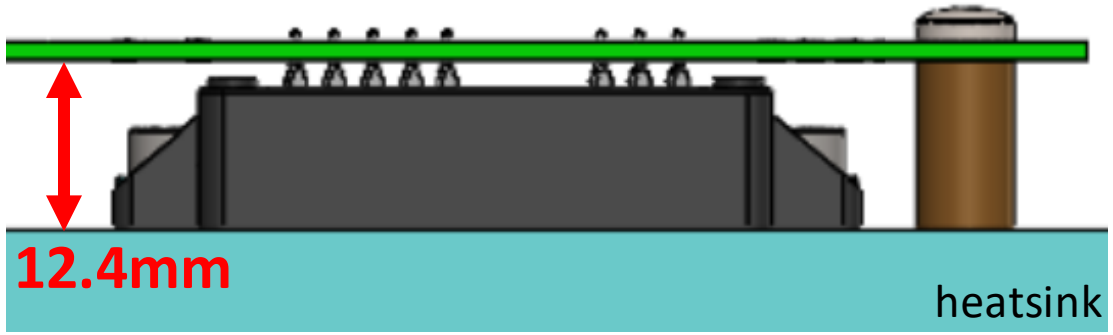


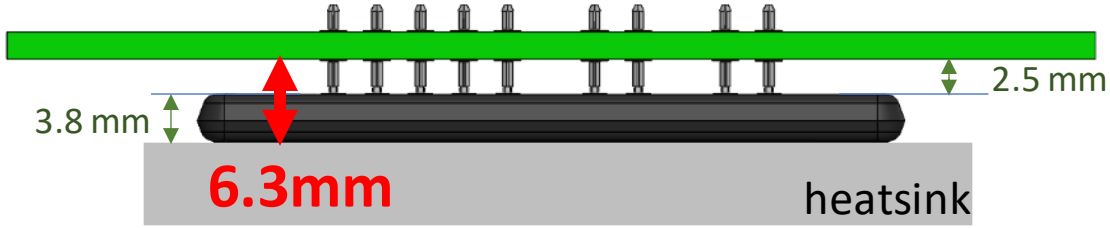


MECHANICAL MOUNTING

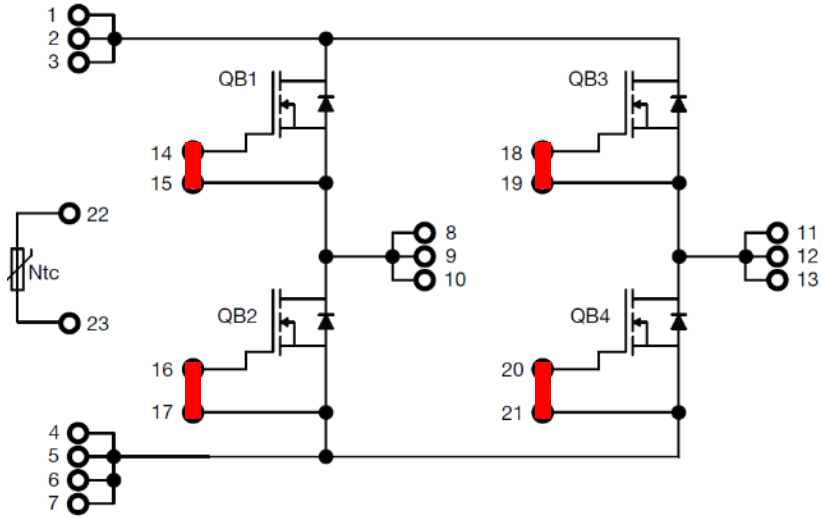
PCB TO HEATSINK DISTANCE

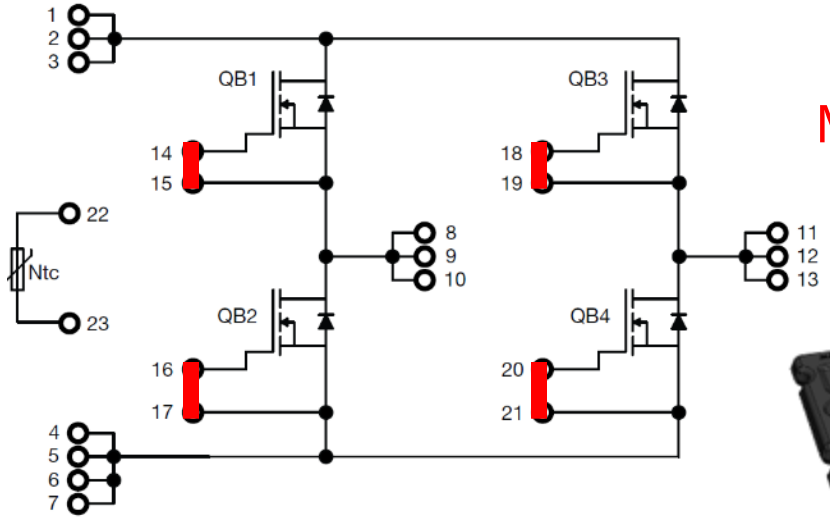
ALMOST **50%** PCB to HEATSINK DISTANCE REDUCTION



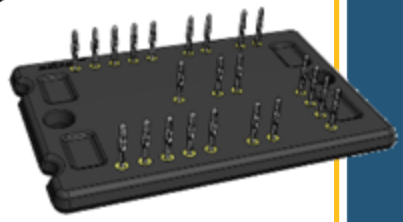


EMIPAK 1B





MAACPAK



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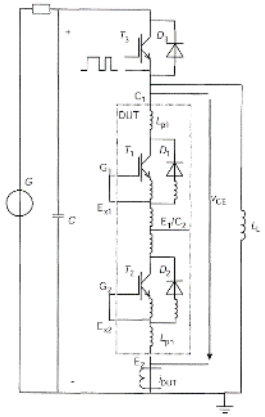
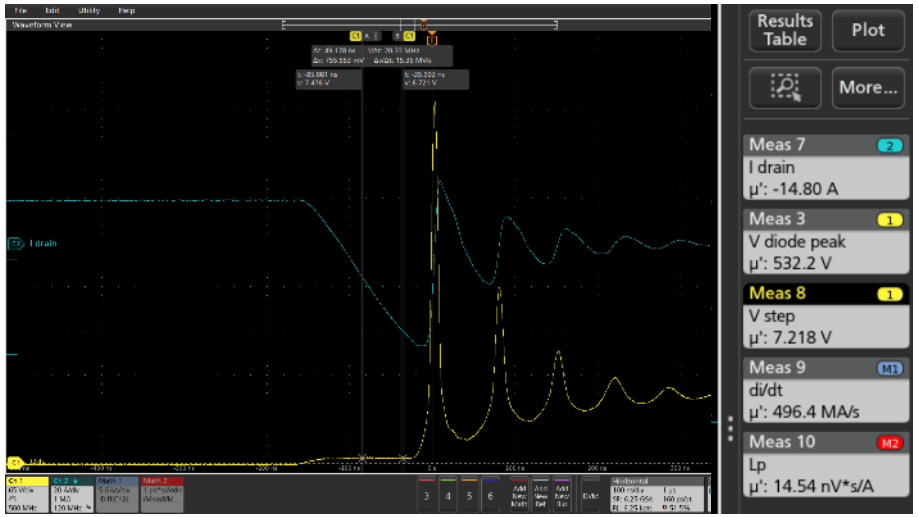
IEC 60747-15 – Parasitic Inductance measurement

CIRCUIT DIAGRAM & WAVEFORMS



EMIPAK 1B

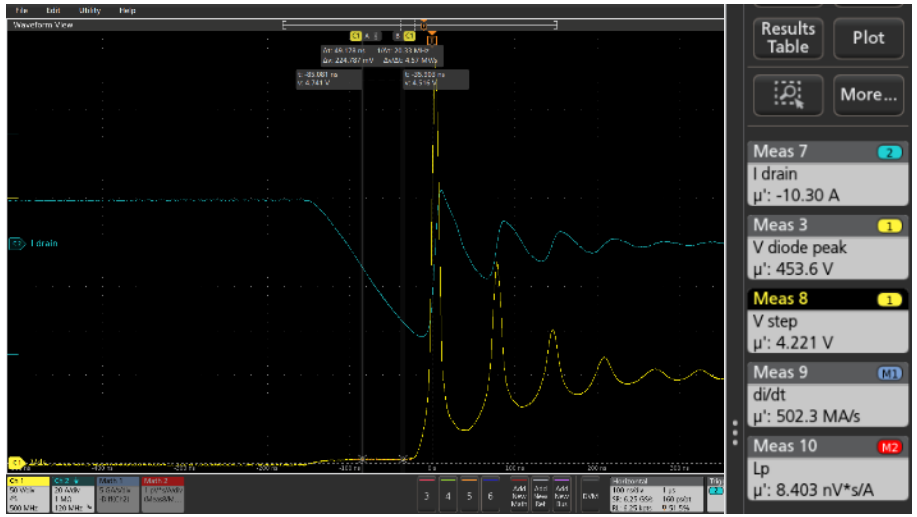


$$-\frac{di_F}{dt} = 496\ A/\mu s$$

$$V_{STEP} = 7.2\ V$$

$$L_{STRAY} = 14.5\ nH$$

MAACPAK

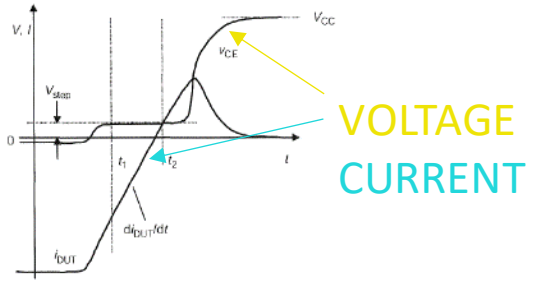


$$-\frac{di_F}{dt} = 502\ A/\mu s$$

$$V_{STEP} = 4.2\ V$$

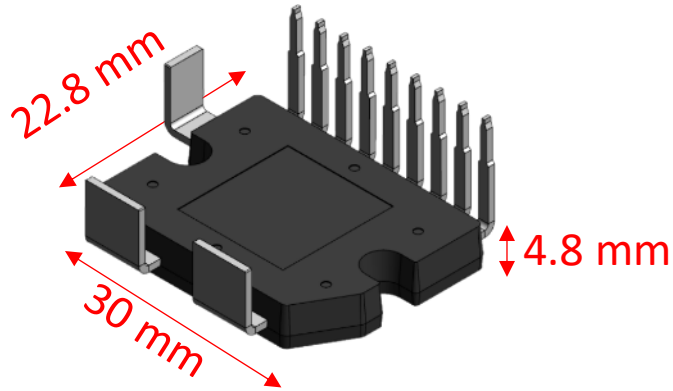
$$L_{STRAY} = 8.4\ nH$$

ALMOST **50% LESS**
PARASITIC INDUCTANCE

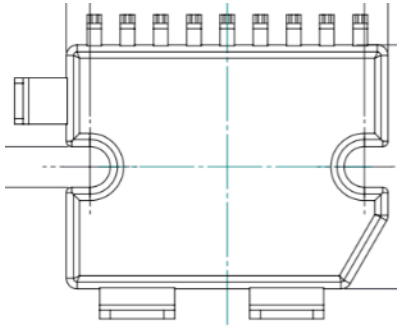


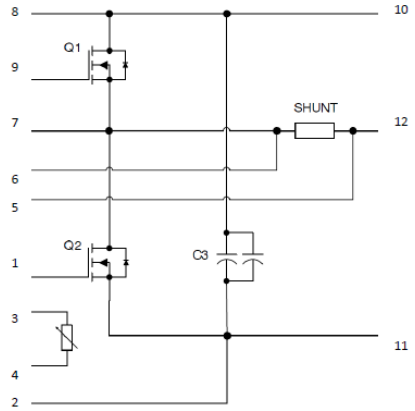
FLATPACK HC0: 3 - 6kW+

FLATPAK – HC0



- LOW CURRENT PINS COUNT 10
- HIGH (100-200) CURRENT PINS COUNT 3
- 80V Si Mosfets, (HVM, IGBTs, SiC Mosfets)
- Target application : 48V 3-6kW inverter LS-EV, Boost Inverter 3x or 6x – 48V BRM
- Driver Product
  - Phase leg, 80V Mosfets, 0.7 mOHM





THANK YOU