
HITACHI
Inspire the Next
IGBT for
AUTOMOTIVE
VEHICLES
-PEOPLE
-FORUMS
-MAIL
-SHOP
-BUY
Made by
Hitachi Power Semiconductor Device Ltd

Hitachi Motivation – Social Innovation

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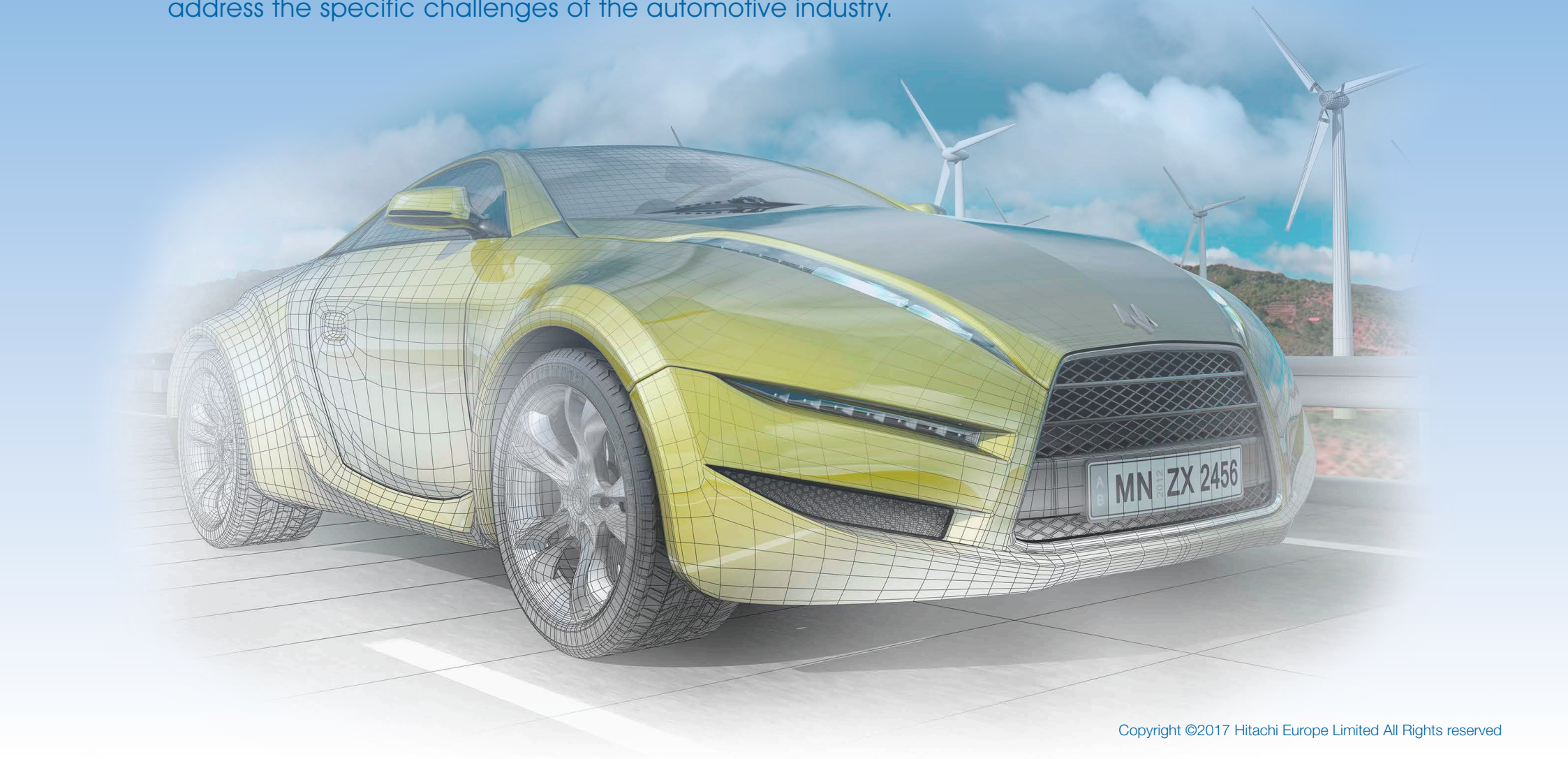
Hitachi has a long history of providing high reliability power modules with worldwide proven lifetimes for locomotive traction.

We draw on this experience to offer a range of standardised power modules for Electric and Hybrid-Electric Vehicles that address the specific challenges of the automotive industry.



OEM Motivation

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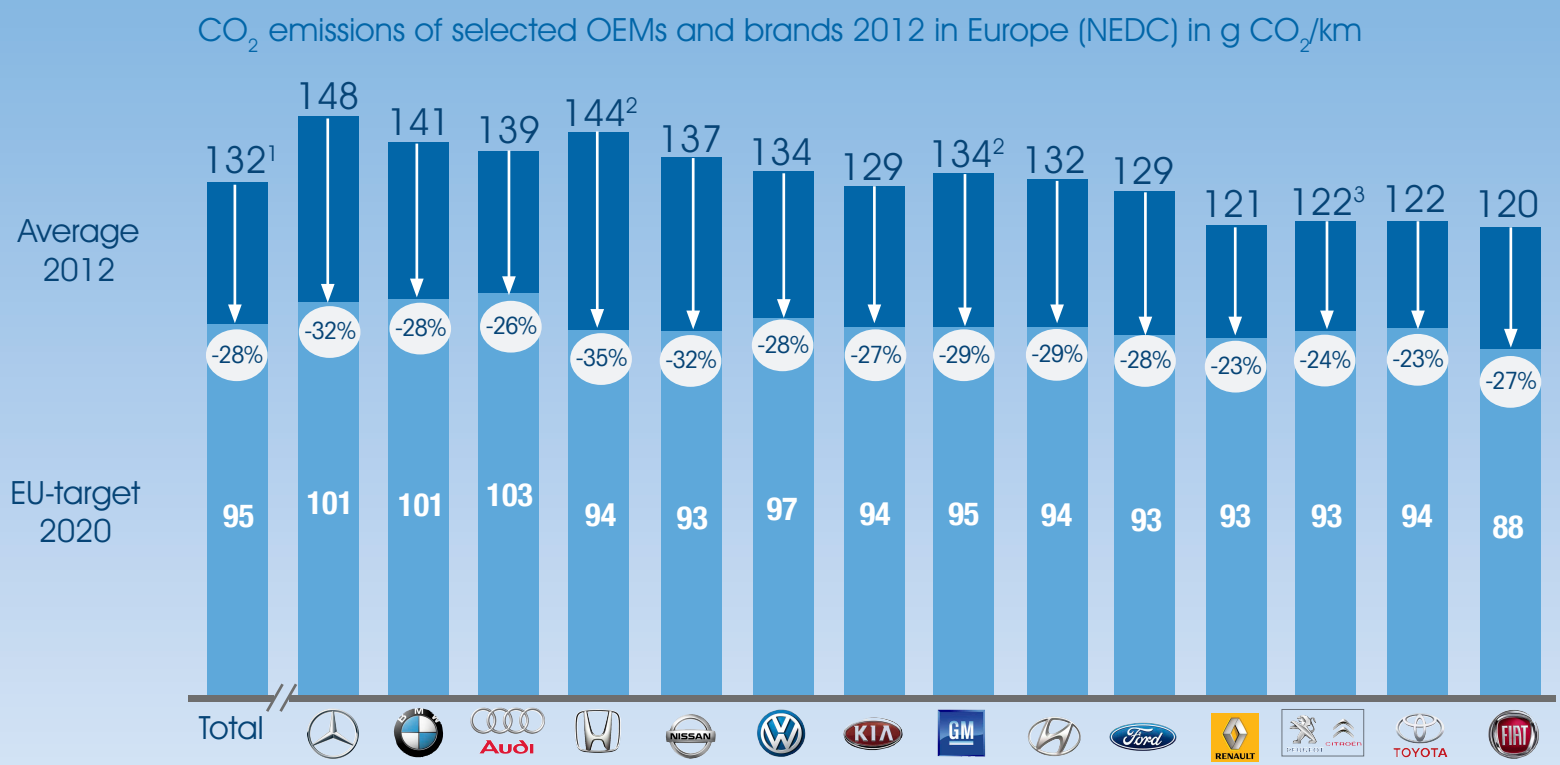
28% reduction in average vehicle CO2 emissions required by EU 2012-2020



1.Average of top 20 brands
2.Data from 2011:2012 numbers not officially published yet
3.Average of Peugeot 121.2 and Citreon 122.0 and average difference Peugeot -7.3 and Citreon -3.4

SOURCE: European Commission : Press search

Awareness of the worlds environmental challenges is increasing and the determination of society to limit the damage growing but the need for personal mobility remains as important as ever. The key to addressing this challenge is the reduction in CO2 emissions from vehicles and across the world vehicle manufacturers are working towards ever more efficient and less polluting vehicles. Electric and Hybrid-Electric vehicles will be central to achieving ongoing reduced emissions and meeting ever more stringent government regulations.

Hitachi is driving innovation and efficiency at the core of the electric vehicle with our range of Automotive Power Modules for Electric and Hybrid Electric vehicles. Bringing advanced technologies and continuous enhancements Hitachi power modules offer high efficiency, compact and optimised power conversion for the next generation of low emission vehicles.

Japanese Quality - Worldwide Support

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Japanese design and manufacturing

Local support, delivered worldwide

Distributed manufacturing locations
for security of supply

Hitachi is committed to supplying the highest quality products delivering dependable performance in demanding applications. We have a long history of producing reliable and high performance power modules, developed and manufactured to the highest quality standards in Japan and backed up by a worldwide network providing sales and technical support locally to you. Distributed manufacturing locations and a robust business continuity plan ensure we can meet customer demands whatever happens.

Wide Experience of EV and HEV Markets

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Hitachi's e-mobility traction business, previously focussed on the passenger & freight traction markets, was expanded into the automotive sectorfrom the beginning of the millennium. Hitachi power modules have been adopted globally by automotive manufacturers for the European, Asia-Pacific and North American markets.

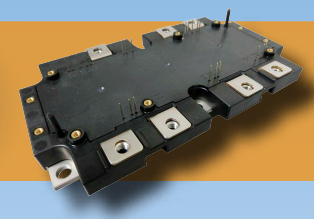
Hitachi has a long history of providing high reliability power modules with proven lifetime for locomotive traction in Japan and Europe. We draw on this experience to offer a range of power modules for Electric and Hybrid-Electric Vehicles that address the specific challenges of the automotive industry.

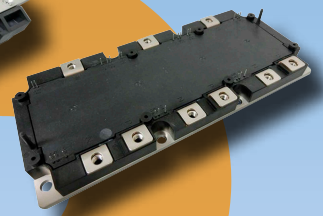
2000

Hitachi has a long history in traction in Japan and Europe with high reliability and proven life time

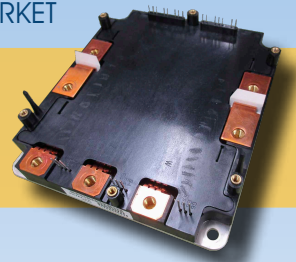
With 90+ years experience in electric locomotion

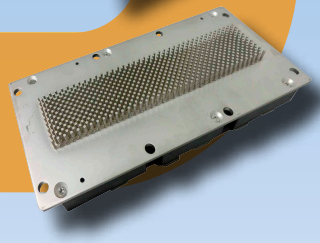
JAPAN /USA MARKET



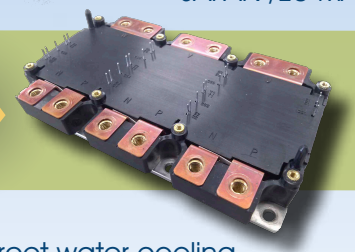


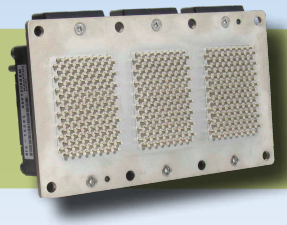
USA MARKET





JAPAN /EU MARKET





2016

Direct water cooling technology has been applied and continuously improved.

Consolidated to a standard part for EV.

Special Requirements on IGBT Power Module in EV Powertrain

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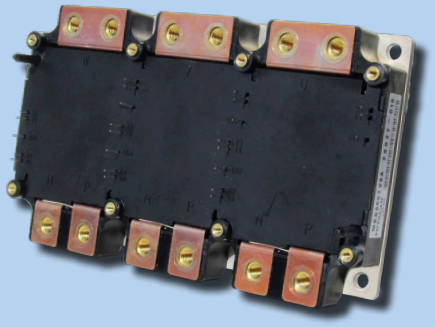
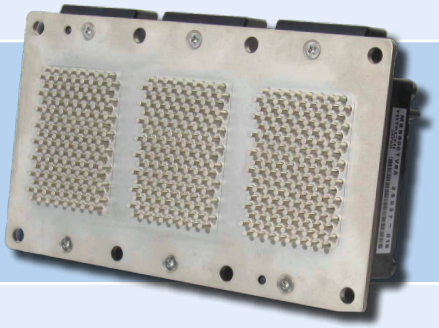
The automotive industry has a unique set of design constraints. Hitachi power modules help to address each of these by offering a wide operating range, high reliability, optimised compact standardised packages and competitive pricing.

Requirements	Hitachi Advantage
Wide operating range: Operating current Battery voltage Carrier frequency Power factor Modulation ratio Coolant temperature Coolant flow rate etc	Low conduction loss (Vce(sat), VF) Low switching loss High temperature operation (Tj) Low thermal resistance Low module inductance etc.
Module condition checking	On-chip temperature sensing or current sensing Vce sensing for short-circuit
High reliability and quality	Strict routine test of RBSOA, RRSOA, SCSOA for all arms Full Chip traceability Full routine test of all datasheet parameters Advanced packaging technologies Robust environmental and reliability type testing
Small package, auxiliary terminal compatibility	Optimization of device, package, etc.
Lower system development costs	Based on standardised mechanical outline irrespective of Voltage Class or Ampere rating.





Traceability for IGBT Module

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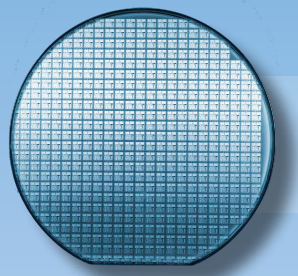
As part of Hitachi's commitment to the best quality and reliability our standard production process includes complete traceability from finished power module right back to the chips location on the wafer.



Lot ,Wafer No.
Chip location

Dicing

Chip test

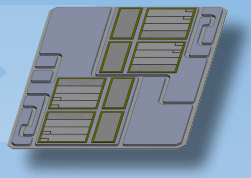
Chip tray No

Test Results
Lot, wafer, location,
tray No.

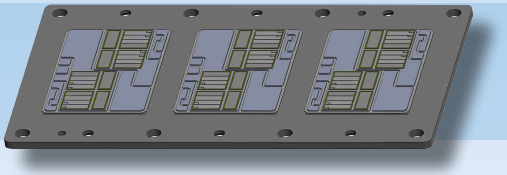
Class selection of
Vce(sat) and VF

Chip tray No

Test Results
Lot, wafer, location,
tray, class No.

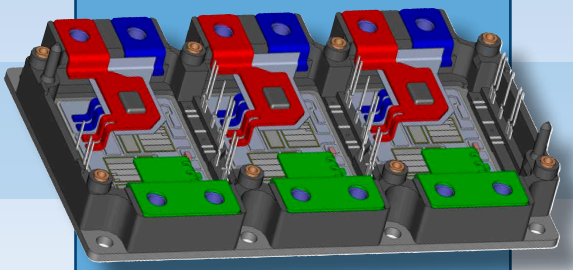


Chip mount, Wire bond,
Case assembling, etc.

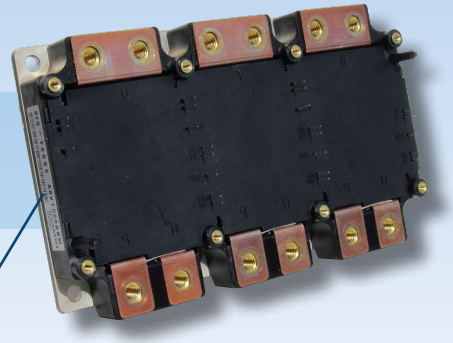


Same class chips on the **DBS**
DBS :**D**ie **B**ond **S**ubstrate

Routine test



Test Results
Lot, wafer, location,
tray, class, serial No.



Name and serial No.
plus 2D code

Reliability Test Methods for EV IGBT Module

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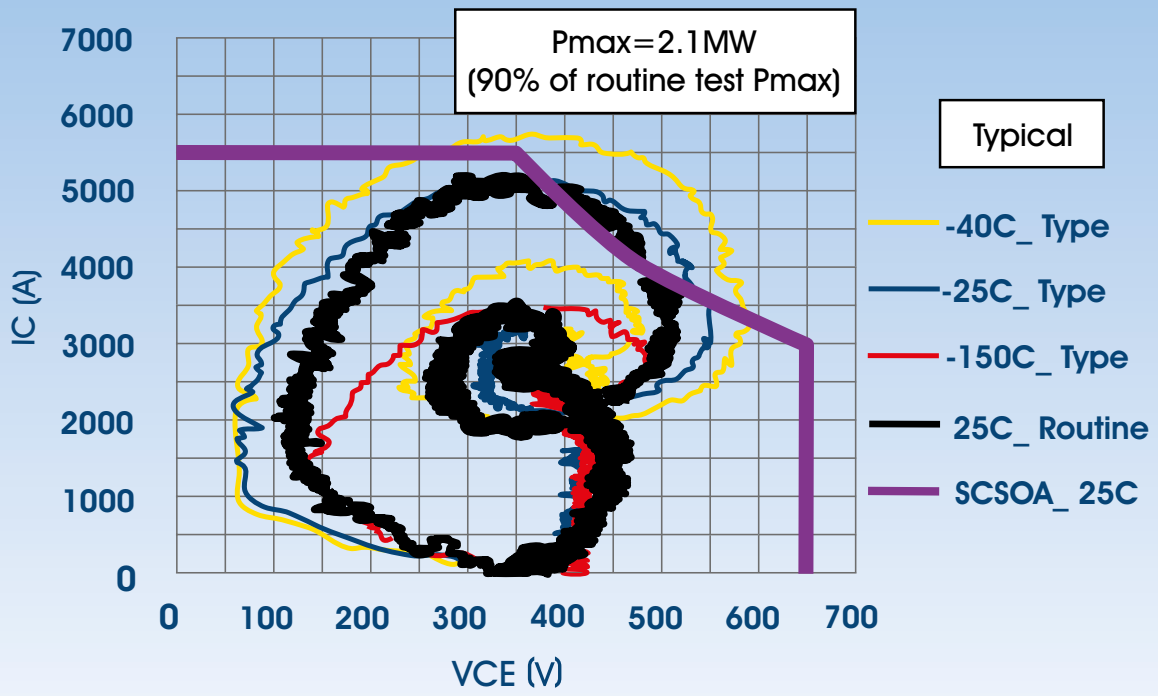
'To ensure optimum performance and the highest reliability, Hitachi routinely tests every module against datasheet parameters, in addition to rigorous environmental and reliability type testing during product development.'

100% routine test of all datasheet parameters on every module

Strict routine test of RBSOA, RRSOA, SCSOA



Rigorous reliability and environmental type testing:

No.	Type of Test
Environmental Function	High temperature storage
	Low temperature storage
	Temperature cycling
	High humidity
Mechanical Function	Mechanical shock
	Mechanical vibration
	Screw torque (Main terminal / mounting)
Electrical Function	Power cycling
	Intermitting operation life
	Applied DC voltage
	Applied AC voltage

Important Features

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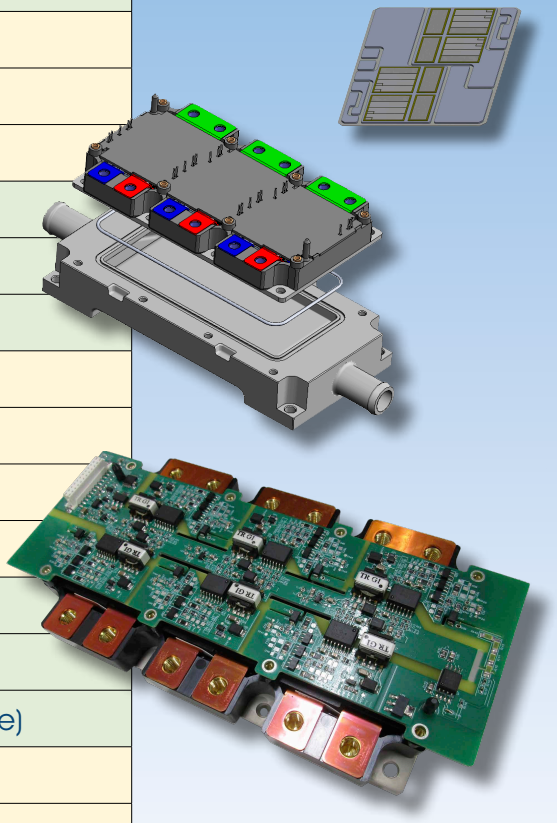
Key features	Hitachi Advantage
Switching losses	•Advanced Chip technologies - SiC Diodes and MOSFET
	•Option for soft switching – low EMI, easy design in
	•Option for fast hard switching for minimum loss switching
	•Trade off for best application implimentation field reliability
Cooling	•Advanced packaging technologies and future developments:
	- Direct Water Cooling
	- Unique advanced copper sintering
Size and weight	•Advanced chip technologies
	•Advanced packaging technologies
	•High current density modules
High Tj max	•Advanced packaging and Chip technologies
	•New bonding
	•SiC
	•Unique advanced copper sintering
Life time	•Proven lifetime and reliability
	•Robust testing and quality control
	•Unique advanced copper sintering (up to 10x increase in power cycle life)
Easy design in	•Global support base
	•Evaluation Kits available

We apply and continuously enhance advanced technologies to deliver the best possible performance and give our customers the edge in a challenging marketplace.



Module Family

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Hitachi offers a standardised package designed for Electric Vehicles providing:

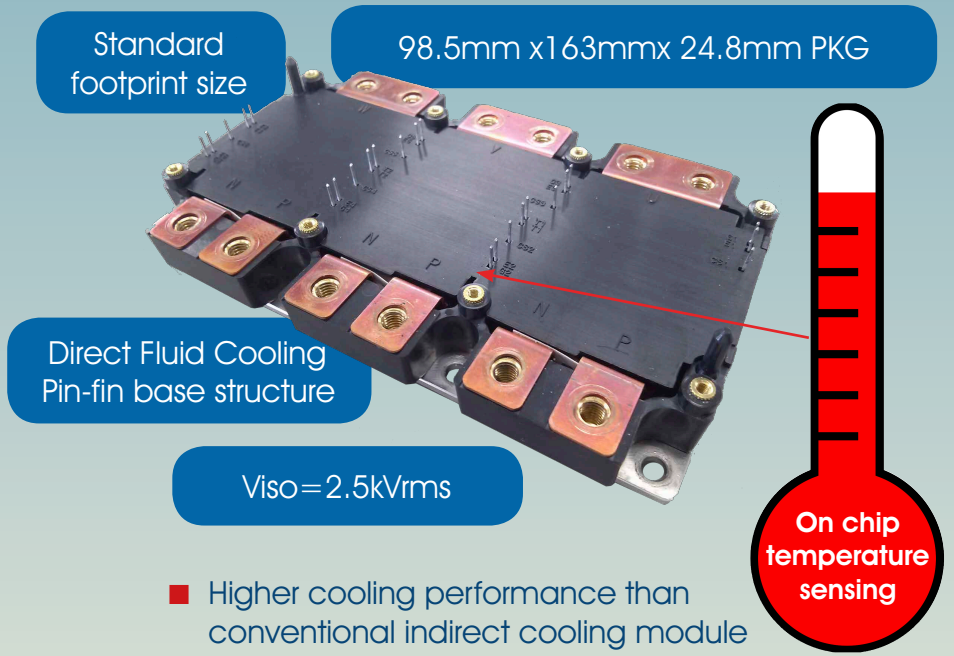
- 6-in-1 IGBTs for 3 phase converters
- Direct water cooling for optimum cooling performance
- small form factor for compact and lightweight converter designs
- On chip IGBT temperature sensors for accurate temperature information

The product family uses the same module package while offering a variety of voltage and current options to meet future Electric Vehicle designs utilising higher battery voltages.

Advanced innovations will be brought to the EV module to further improve performance including Silicon Carbide chips for reduced losses and higher power density and advanced copper sintering for improved cooling performance.

6 in1 module

Direct fluid cooling module with pin-fin base for EV/HEV



- Higher cooling performance than conventional indirect cooling module
- Compact and stable sealing structure, thermal grease free

Same module package, progression of power options

2016
650V/600A

2017
650V/800A
On chip temperature sensor upper and lower side

2020
600-1200V SiC
Low loss & high Current density

Direct Water Cooling

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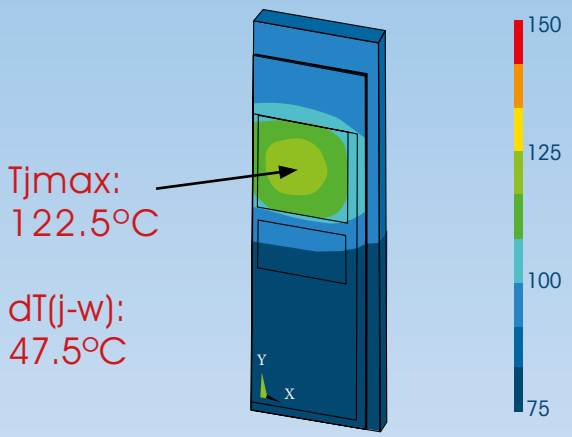
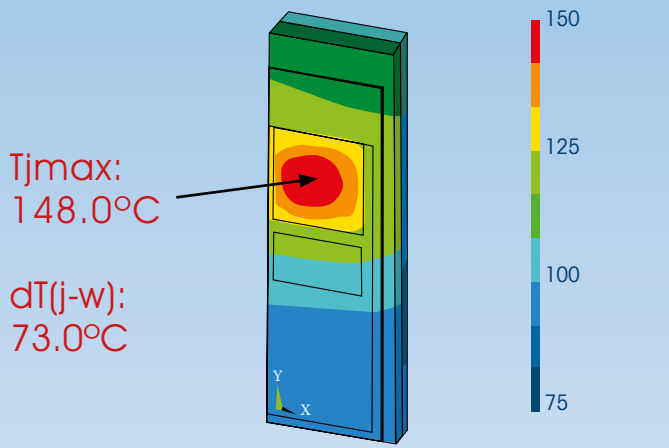
Our EV module utilises direct water cooling with pin-fin base for enhanced cooling performance, improved thermal fatigue capability and ease of assembly

- Higher cooling performance thermal impedance could be reduced by 35%.
- Higher thermal fatigue capability.

Assumptions: Powered 250W per IGBT Die, Water Temp 75°C

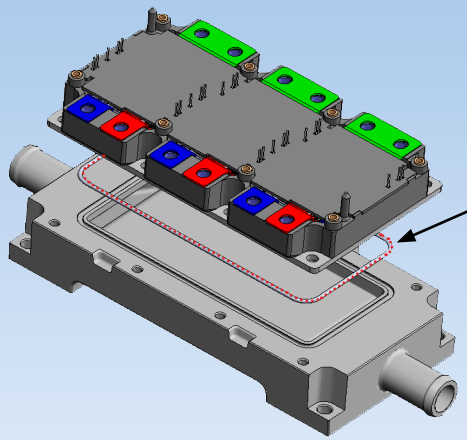


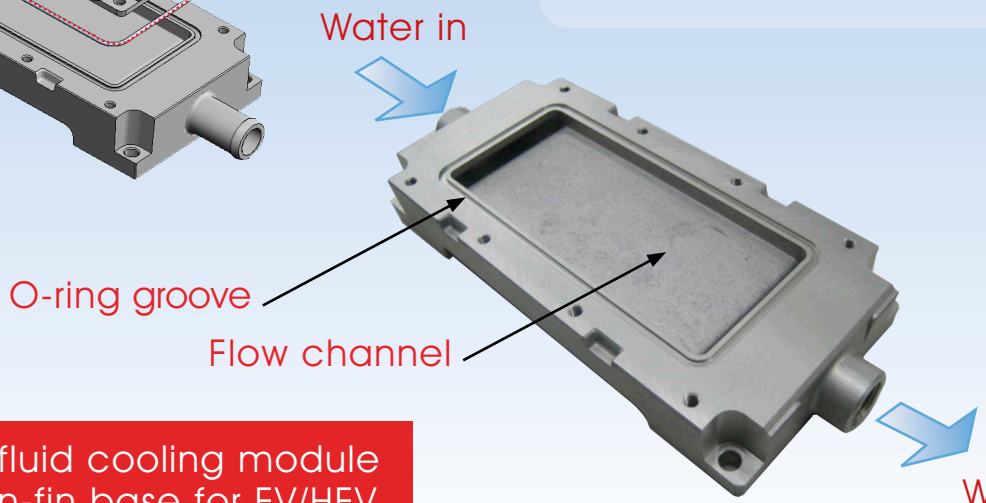
New Direct Fluid Cooling Structure



Conventional indirect Fluid Cooling Structure

Improvement of Cooling Performance is approx. 35%





Direct fluid cooling module with pin-fin base for EV/HEV

- Keep stable performance
  - No grease assembly process is required.
  - No thermal fatigue lifetime influence from grease.
  - Uniform temperature across the module can be obtained.
  - → longer lifetime
- Easy assembly
  - No need to care about paste thickness uniformity

Evaluation Kits for EV IGBT Module

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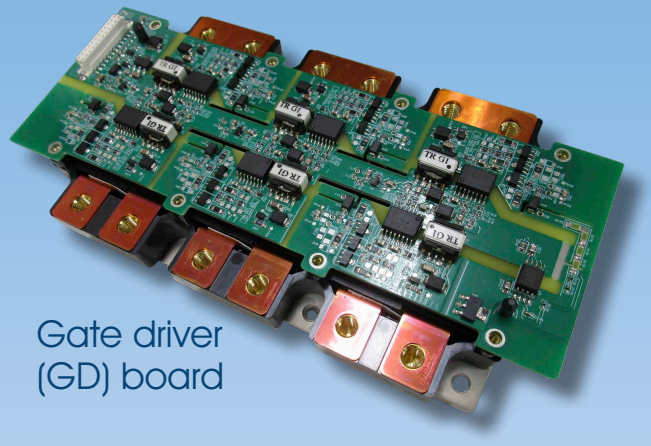
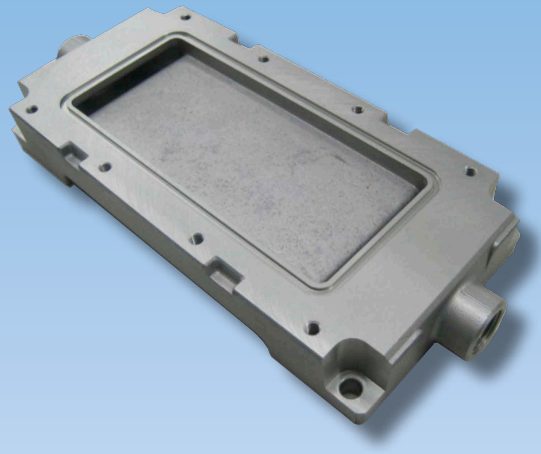
Hitachi makes evaluation of our EV module easy so you can see the benefits. We combine local support worldwide with a comprehensive evaluation kit making initial testing straightforward.

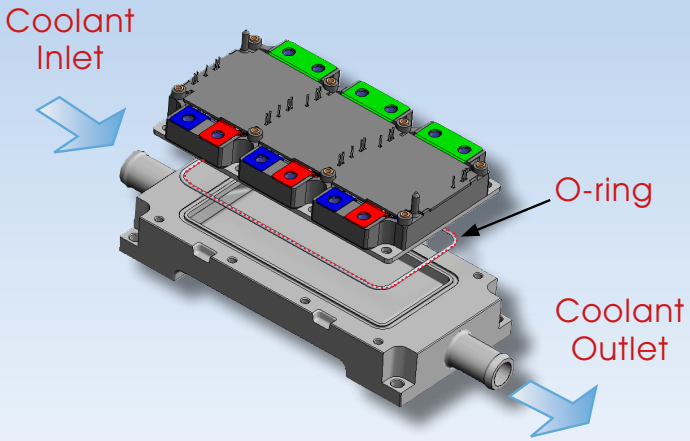


Gate driver
(GD) board



GD Type	IGBT Type
K150811	MBB600TV6A
K160205	MBB800TW6A
(Under design)	1200V/400A/6in1

DC linked capacitor available for
MBB600TV6A and MBB800TW6A



Water cooling jacket available for
MBB600TV6A and MBB800TW6A

Features

- Optical isolation
- DC-DC power supply
- Temperature sensing
- Short-circuit IGBT protection with soft-shutdown
- UVLO(Under Voltage Lock-Out)
- Miller clamp sinking
- PN voltage sensing

Advanced Chip Technologies IGBT Chip Structure

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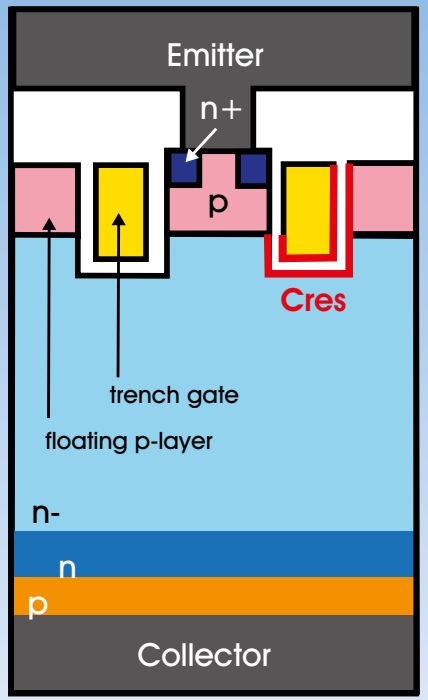
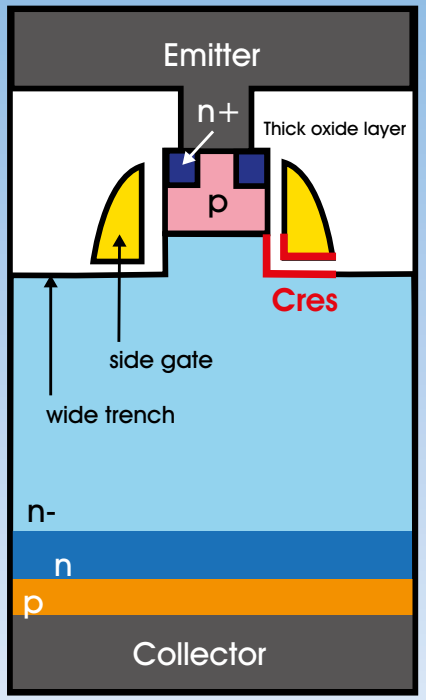
As a technology leader in power devices we are continually bringing innovations and advanced technology to our products. Our novel patented Hitachi side wall gate IGBTs are being applied to our 1200V class and next generation 650V/750V class giving improved gate control and short circuit durability.



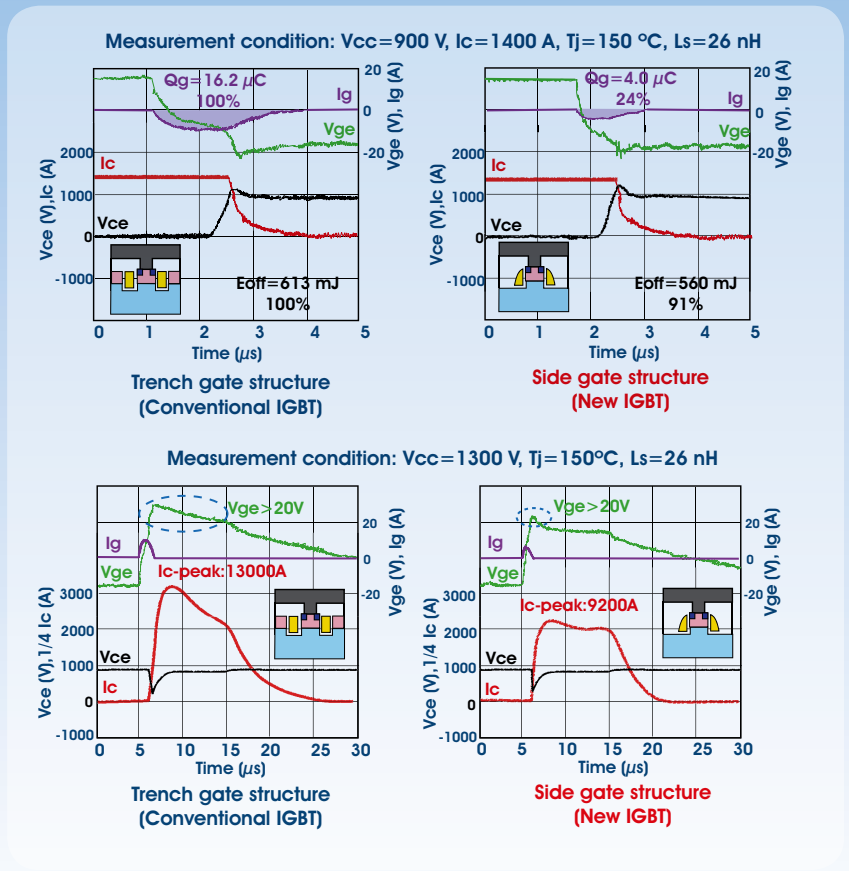
Trench gate structure
(conventional)
650V/600A
MBB600TV6A



Side gate structure
(New concept)
650V/800A
MBB800TW6A
1200V / 400A module

Benefits of new side gate structure:

- Low reverse transfer capacitance (Cres)
- Reduced Gate Charge (Qg) by 76%
- Reduced turn off loss (Eoff) by 9%
- Reduced gate voltage (Vge) peak at turn on and short circuit
- Improved Short circuit performance – Reduced collector current (Ic) peak giving improved durability



Advanced packaging technology

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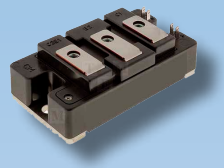
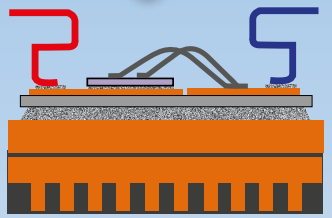
Our advanced packaging technologies developed alongside traction applications bring big improvements in performance to deliver a step change in performance and lifetime. Super low module inductance improves switching performance and reduces voltage overshoots allowing higher safety margins, increased operating voltages or reduced switching losses through faster switching. Advanced Copper Sintering lowers thermal impedance by 50% giving a typical 25% and up to 40% increase in output power for the same module footprint and same chip technology. Lifetime is drastically improved with a ten fold increase in power cycling life.

Future modules will offer double sided direct water cooling for optimum thermal management, module performance and lifetime

Double sided direct water cooling

Past (Silicon)

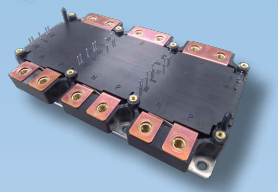


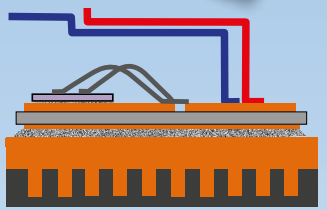


Schemetic cross section

Technology
Indirect cool
Terminal solder
Bending terminal

Present (Silicon)

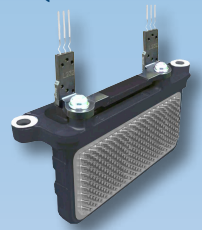


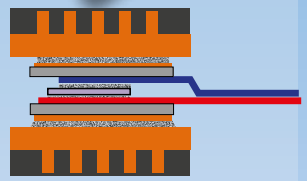


Schemetic cross section

Technology
Single side direct
Metal bond terminal Anti
parallel strip PN

Future (Silcon Carbide)



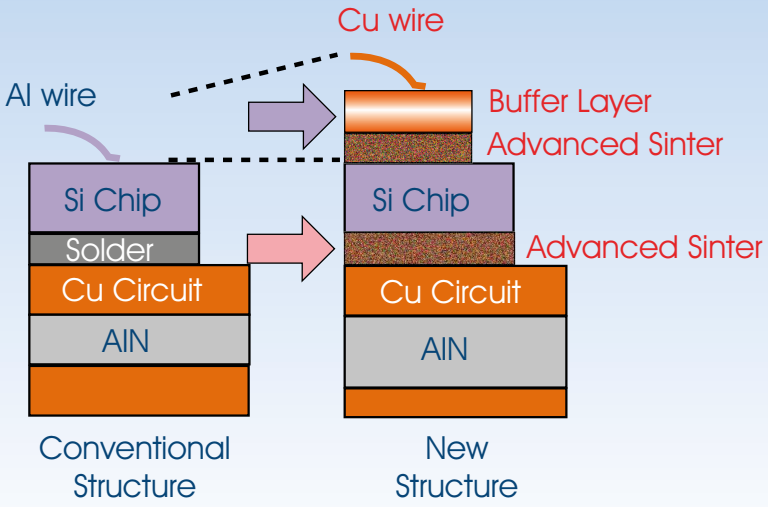


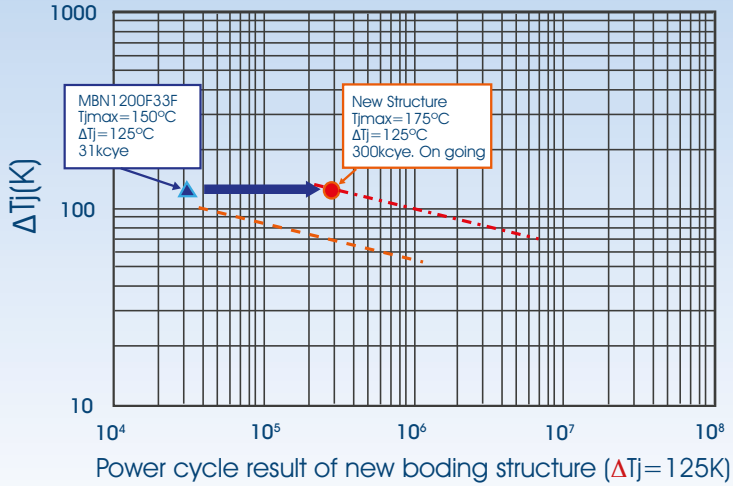
Schemetic cross section

Technology
Both side direct
Direct emitter bond
Advanced sintering
SIC MOS+SBD

Advanced Copper Sintering and New bonding

10X increase in power cycle life
Thermal Resistance decreases by >30%, corresponding to invertor output increase of ≈25%.





Silicon Carbide (SiC)

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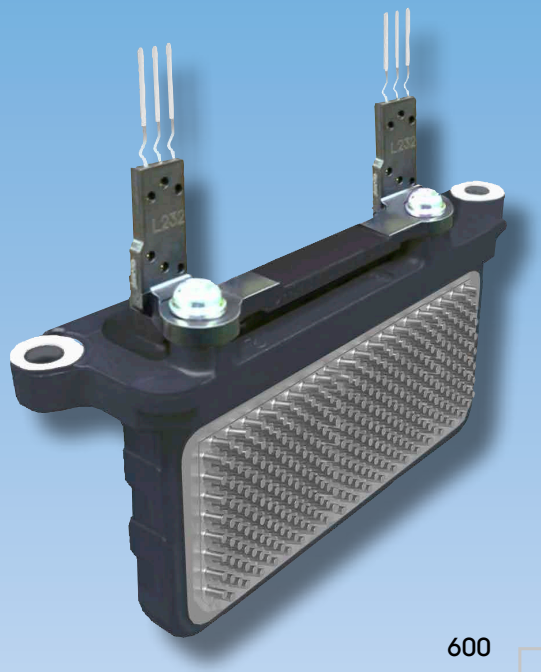
SiC Hybrid Module

Silicon IGBT combined with Silicon Carbide Schottky Barrier Diodes

Hitachi is developing a full range of Silicon Carbide devices to provide high efficiency switching, higher power density, higher temperature operation and increased output power for a wide range of markets. For EV applications SiC devices will be available in standard packages providing an easy design progression from Silicon devices allowing designers to realise the benefits of SiC more quickly.

Hitachi has a wide range of capabilities and technology to maximise the benefits of wide band gap devices including low inductance packages and advanced bonding for improved cooling and higher temperature operation.

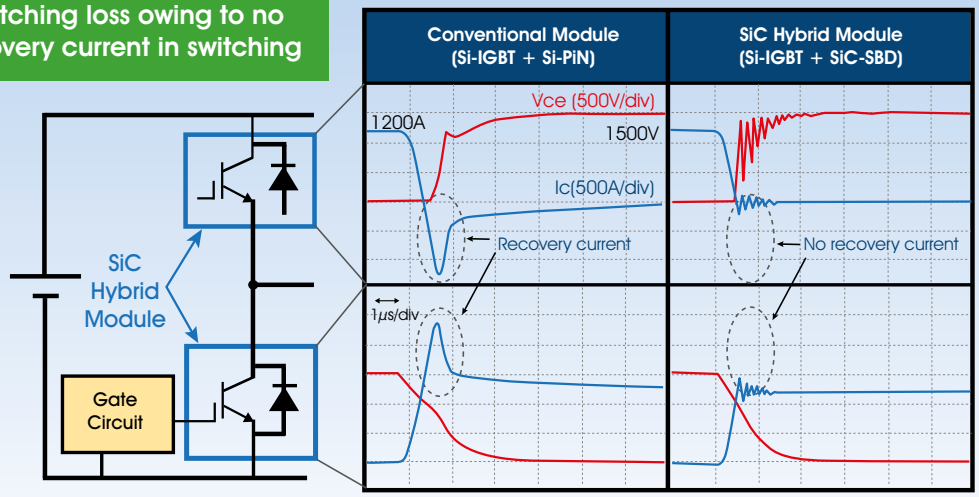


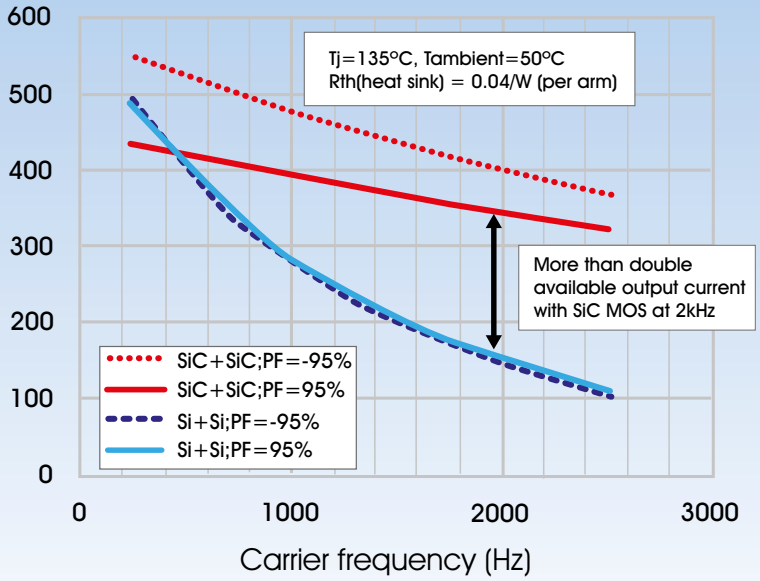
Full SiC Module
Silicon Carbide MOSFETs

Benefits:

- Significant reduction in switching losses, higher temperature operation, higher power density
- Better efficiency, reduced cooling requirement, smaller package, reduced weight, increased frequency of operation

Possible reduction by 50% of switching loss owing to no recovery current in switching





Automotive module capability

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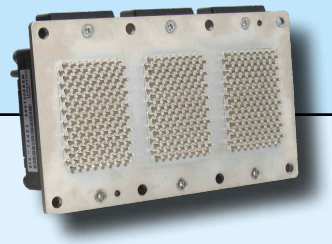
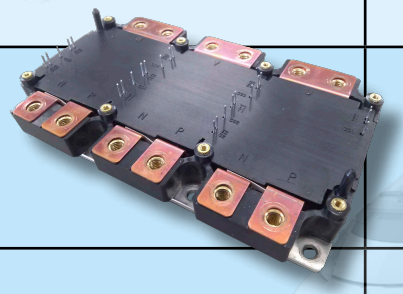
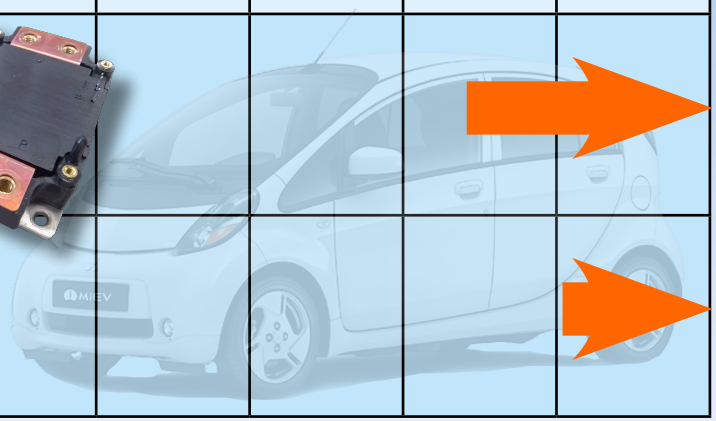
Collector Emitter Voltage / Collector Current	IGBT Chip Type	2016	2017	2018	2019
650V/600A MBB600TV6A	Trench HiGT	→	→	→	→
650V/800A MBB800TW6A	Trench HiGT Temperature sensor on IGBT chip		→	→	→
1200V/400A	Advanced Trench HiGT Temperature sensor on IGBT chip			→	→
750V/800A MBB800TX7A	(Side wall gate, upper and lower arm on chip temp sense)				→







The Hitachi EV module roadmap provides a standard package with a progression of power options to meet the diverse requirements of the EV market including capability for higher DC voltages and in the future the introduction of SiC modules.

360° Care

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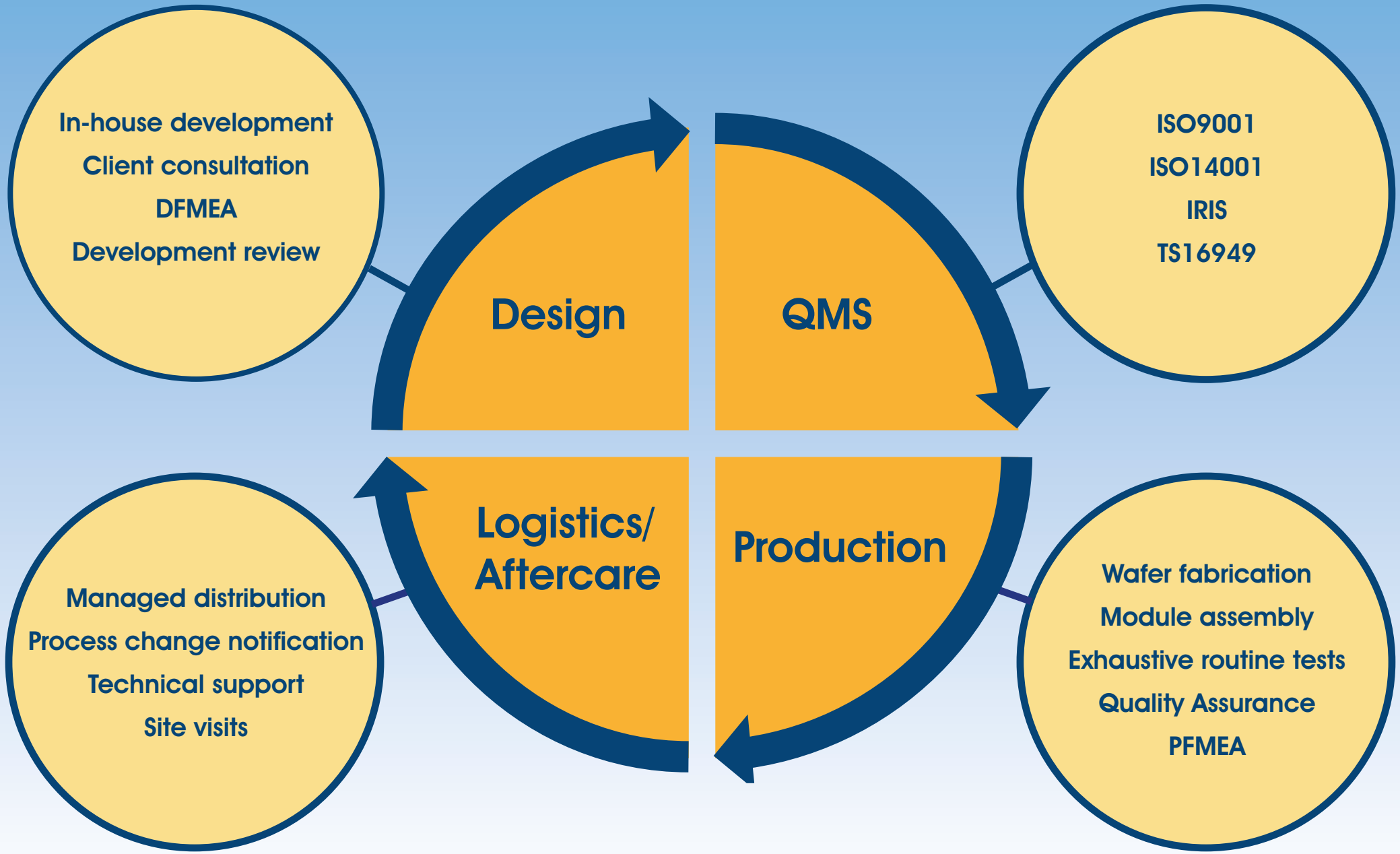

Summary and Conclusion

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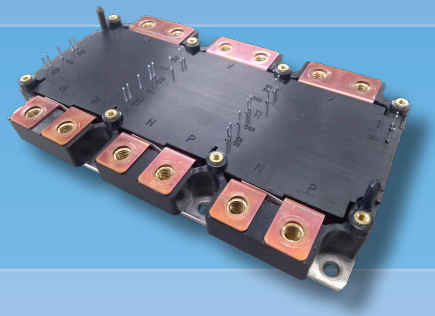
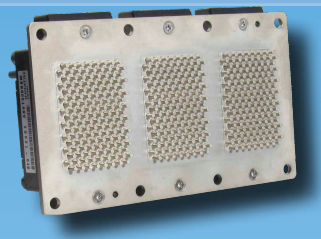
Committed Partner for EV

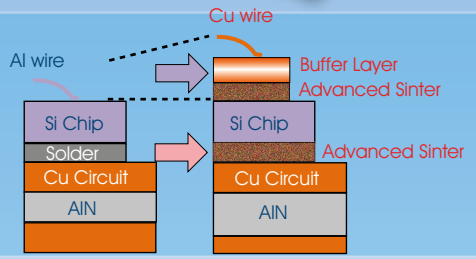
- Leader in power semiconductor device
- EV module experience in the US, Japan and the EU market
- High quality assurance

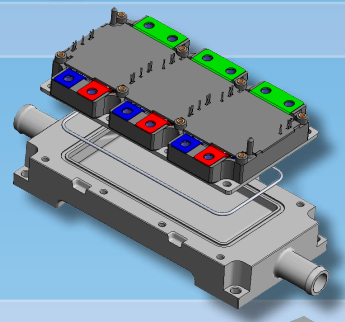




Leading Edge Technologies

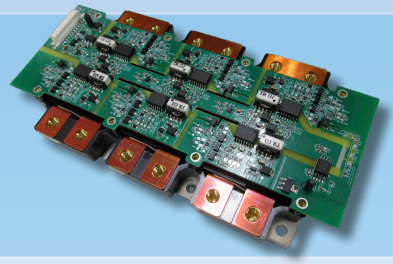
- Advanced device and packaging for high current density, high reliability, easy switching control without oscillation, on-chip sensing, etc.





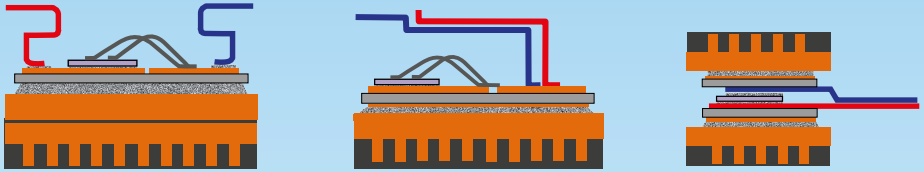
Application Support

- Evaluation kits (gate driver board, capacitor, cooling jacket, etc.)
- Worldwide service and support
- Collaboration with Hitachi Research Laboratory, Hitachi group, etc.



Looking Ahead – Future proof your investments

- Next generation Si and SiC device and packaging technologies (double-side cooling, advanced sintering, new bonding, etc.)



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