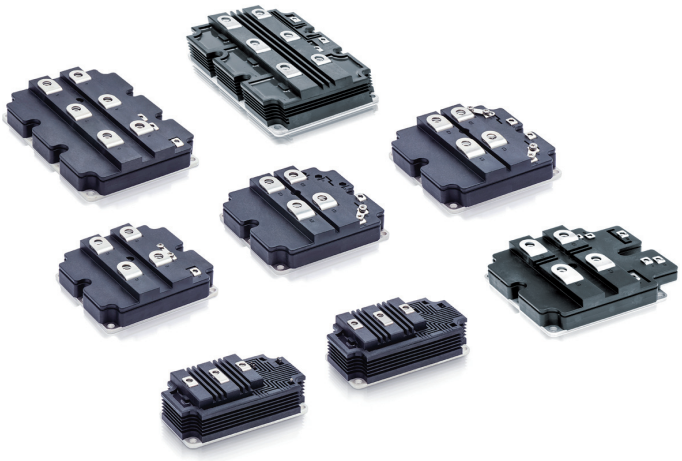
HiPak IGBT modules

ABB Semiconductors' HiPak modules are a family of highpower IGBTs in industry standard housings using the popular 190 x 140 mm, 130 x 140 mm and 140 x 70 mm footprints.
HiPak modules are the perfect match for demanding highpower applications such as traction, T & D, renewable energy (wind, solar) and industrial drives.



ABB's HiPak modules are available in three standard isolation voltages (4, 6 and 10.2 kV_{RMS}) and a variety of circuit configurations. These modules exclusively use Aluminium Silicon Carbide (AlSiC) base-plate material and Aluminium Nitride (AlN) isolation with low thermal resistance. This specific material combination offers an excellent power cycling performance thanks to its matched thermal expansion coefficients (CTE). All HiPak modules feature ABB's advanced *Soft Punch Through* (SPT and SPT^+) chip technology, which combines low-losses with soft-switching performance and record-breaking Safe Operating Area (SOA).

In keeping with ABB's reputation for offering high power semiconductors of exceptionally high reliability, the HiPak SPT chips have been optimized for reliable operation under harsh conditions. This has been achieved through smooth switching characteristics – and through rugged operation (high SOA) as this translates into operational safety margins for the equipment.

Furthermore, the SPT^+ chipsets (IGBT and diode) at 1700 V and 3300 V blocking voltages have been improved to operate at higher junction temperatures up to 150 °C in the HiPak modules .

Table 1 on the next page shows the current HiPak product portfolio. Modules designated "HV" have isolation voltages of up to 10.2 kV_{RMS}. Standard types have isolation voltages of up to 6 kV_{RMS}, depending on V_{CES} rating.

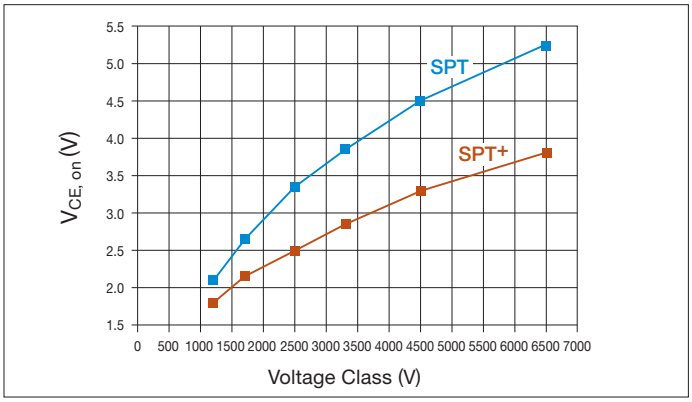
HiPak product portfolio

Part number	Voltage V_{CES} (V)	Current I_C (A)	Configuration	Footprint	Package
1.7 kV					
5SND 0800M170100	1700	2 x 800	Dual IGBT	130 x 140	HiPak1
5SNE 0800M170100	1700	800	Chopper	130 x 140	HiPak1
5SNA 1600N170100	1700	1600	Single IGBT	130 x 140	HiPak1
5SNA 1800E170100	1700	1800	Single IGBT	190 x 140	HiPak2
5SNA 2400E170100	1700	2400	Single IGBT	190 x 140	HiPak2
5SNA 2400E170305*	1700	2400	Single IGBT	190 x 140	HiPak2
5SNA 2000J170300*	1700	2000	Single IGBT	190 x 140	HiPak1 HV
5SLA 2000J170300*	1700	2000	Single Diode	190 x 140	HiPak1 HV
5SNA 3600E170300*	1700	3600	Single IGBT	190 x 140	HiPak2
5SLA 3600E170300*	1700	3600	Single diode	190 x 140	HiPak2
2.5 kV					
5SNA 1500E250300*#	2500	1500	Single IGBT	190 x 140	HiPak2
3.3 kV					
5SNG 0250P330305*	3300	2 x 250	Half bridge	140 x 70	HiPak0 HV
5SLG 0500P330300*	3300	2 x 500	Diode bridge	140 x 70	HiPak0 HV
5SND 0500N330300*	3300	2 x 500	Dual IGBT	130 X 160	HiPak1
5SNA 0800N330100	3300	800	Single IGBT	130 x 140	HiPak1
5SNE 0800E330100	3300	800	Chopper	190 x 140	HiPak2
5SNA 1000N330300*	3300	1000	Single IGBT	130 x 140	HiPak1
5SLD 1000N330300*	3300	2 x 1000	Dual diode	130 x 140	HiPak1
5SLD 1200J330100	3300	2 x 1200	Dual diode	130 x 140	HiPak1 HV
5SNA 1200E330100	3300	1200	Single IGBT	190 x 140	HiPak2
5SNA 1200G330100	3300	1200	Single IGBT	190 x 140	HiPak2 HV
5SNA 1500E330305*	3300	1500	Single IGBT	190 x 140	HiPak2
4.5 kV					
5SNG 0150P450300	4500	2 x 150	Half Bridge	140 x 70	HiPak0 HV
5SLG 0600P450300	4500	2 x 600	Diode bridge	140 x 70	HiPak0 HV
5SLD 0650J450300	4500	2 x 650	Dual diode	130 x 140	HiPak1 HV
5SNA 0650J450300	4500	650	Single IGBT	130 x 140	HiPak1 HV
5SNA 0800J450300	4500	800	Single IGBT	130 x 140	HiPak1 HV
5SLD 1200J450350	4500	2 x 1200	Dual diode	130 x 140	HiPak1 HV
5SNA 1200G450300	4500	1200	Single IGBT	190 x 140	HiPak2 HV
5SNA 1200G450350+	4500	1200	Single IGBT	190 x 140	HiPak2 HV
6.5 kV					
5SNA 0400J650100	6500	400	Single IGBT	130 x 140	HiPak1 HV
5SNA 0500J650300	6500	500	Single IGBT	130 x 140	HiPak1 HV
5SLD 0600J650100	6500	2 x 600	Dual diode	130 x 140	HiPak1 HV
5SNA 0600G650100	6500	600	Single IGBT	190 x 140	HiPak2 HV
5SNA 0750G650300	6500	750	Single IGBT	190 x 140	HiPak2 HV

Table 1 * T_{VJ} (operational) up to 150 °C + 10.2 kV_{RMS} Isolation # Contact factory

SPT technology

SPT is a well-established planar IGBT technology covering the range of 1200 V to 6500 V. It is characterized by smooth switching waveforms and exceptional robustness which is of particular importance at higher voltages and currents where stray inductances are not easily minimized.



SPT+ technology

SPT+ retains all the features of the SPT technology but reduces $V_{CE\ SAT}$ by up to 30 % according to the curve of figure 1 – an achievement previously believed to be possible only with trench technology.

Fig. 1 $V_{ce(sat)}$ for different IGBT cell technologies on SPT silicon at 125 °C. (current density of SPT range, same E_{off})

High ruggedness at 6500 V

In the case of the new 6500 V SPT$^+$ IGBT the on-state losses exhibit a reduction of approximately 30 % when compared to the standard SPT device. This, in combination with the improved ruggedness of the SPT$^+$ IGBT has enabled an increase in the current rating from 600 A for the standard 6500 V HiPak up to 750 A for the new SPT$^+$ version.

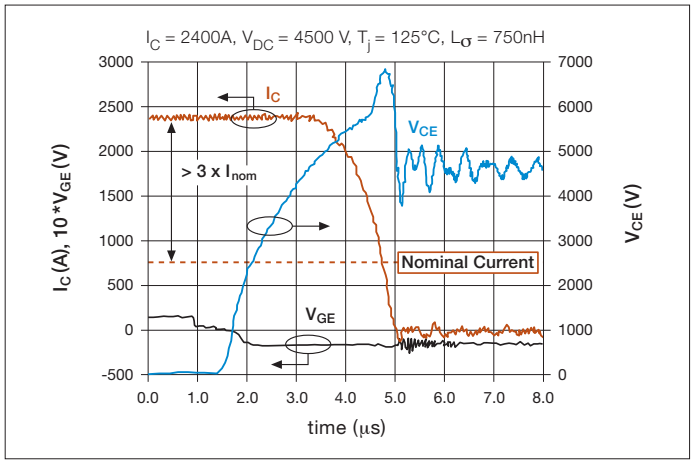


Fig. 2 6500 V SPT$^+$ IGBT turn-off under SOA conditions measured at module level, P_{poff} = 11.7 MW

Figure 2 shows the extremely high turn-off ruggedness of the 6500 V SPT$^+$ IGBT setting a new benchmark for this voltage class. A current of 2400 A – which corresponds to more than three times the nominal current – was switched-off against a DC-link voltage of 4500 V at a junction temperature of 125 °C. The stray inductance in this case was 750 nH, which is more than double the value that can be expected in the targeted application environment and shows that the specified SOA can be fulfilled with margin.

150 °C operation

ABB recently upgraded the 1700 V and 3300 V SPT$^+$ chipsets to be operational in HiPak modules at junction temperatures up to 150 °C. For the IGBT, this is achieved by improved device structures combined with new termination designs. This has resulted in excellent blocking characteristic and low reverse currents, which guarantee stable operation at 1700 V and 3300 V up to temperatures above 150 °C.
On the diode side, the plasma has been shaped for low forward-voltage drop and soft reverse-recovery by using both local and uniform lifetime control. The local lifetime control is obtained by proton (H+) irradiation. The use of hydrogen particles has reduced the 150 °C leakage current by a factor of three when compared with the previous SPT diode platform.

Figure 3 shows the RBSOA test on the 3600 A 1700 V HiPak2 module where a current of 10500 A is turned off at a DC-link voltage of 1300 V, proving the ruggedness of the SPT$^+$ IGBT-design when paralleled in the HiPak2 module.

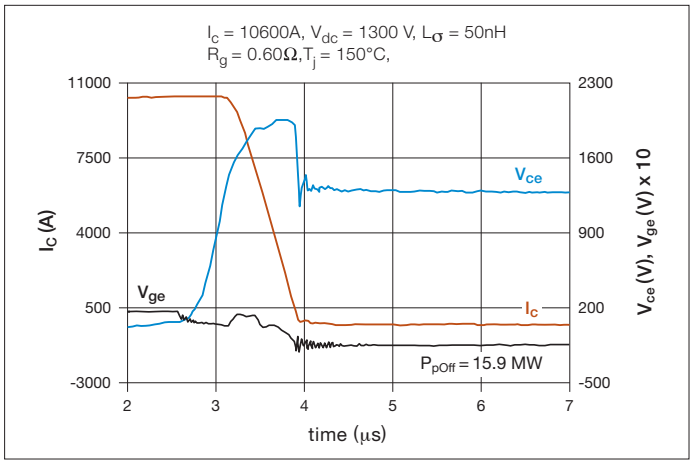


Fig. 3 3600 A / 1700 V HiPak RBSOA measured at T_j = 150 °C with active clamp

The buffer and anode designs used in the SPT$^+$ IGBT have been optimized in order to obtain a high short-circuit SOA capability, even at gate voltages exceeding the guaranteed gate drive voltage of 15 V.

Increased reliability with improved HiPak

As of late 2013 an improved HiPak construction has been rolled out. During Q1 2014 all E, M and N housings will benefit from the new design.
The improved HiPak modules will be a direct 1:1 replacement with identical electrical and thermal characteristics. The principal electro-mechanical layout remains unchanged. The improvements are realized by the following design features:

Epoxy-less housing construction:

The case temperature rating will be increased to $T_{C, max}$ = 150 °C. The new package now complies with the latest fire and smoke requirements: NFF 16-101/102 I3 – F2 and CEN TS 45545 HL2 cat. R23 required for traction applications.

New internal auxiliary connections:

The internal solder connections between the gate-print and the substrate will be substituted by standard aluminium wire bonding. This well established technology allows for higher reliability and offers a redundant double wire connection (figure 4).

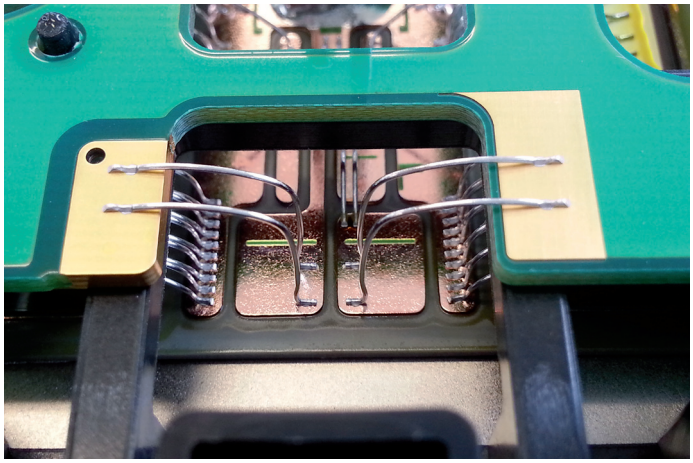


Fig. 4 New redundant aluminium wire-bond connection of gate and auxiliary emitter

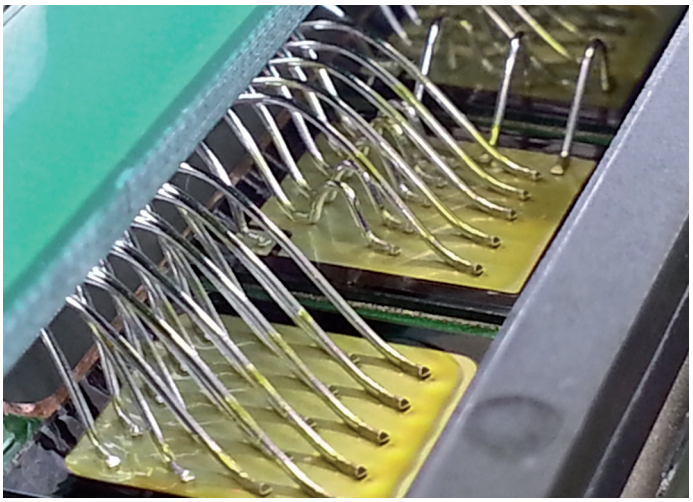


Fig. 5 Stich-bond layout and improved bonding parameters boost the power cycling capability

Terminal Foot:
The main terminals offer an improved solder foot with specifically designed spacers in order to achieve a homogenous solder layer thickness. This allows for an improved temperature cycling performance.

Wire-Bonding:
The emitter side wire-bonding parameters have been improved and so called stich-bonds (figure 5) are used. This results in an improvement of factor 4 in IOL (target 2 Mcycles $\Delta T = 60$ K, $T_{vj,\,max} = 150$ °C).

The new design has been qualified with all the relevant tests: shock and vibration, temperature cycling, IOL and THB. During 2015, the improvements will be made available for the high-voltage housings (G, J and P).

Documentation

Device datasheets are available on ABB's website **www.abb.com/semiconductors**. Additional documentation required for the reliable application of HiPak modules is available on the same site. See summary in table 2 below.

Document title	Document number
Mounting Instructions for HiPak modules	5SYA2039
Paralleling of IGBT modules	5SYA2098
Thermal design and temperature rating of IGBT modules	5SYA2093
Failure Rates of HiPak modules due to cosmic rays	5SYA2042
Load-Cycle capability of HiPaks	5SYA2043
Thermal runaway during blocking	5SYA2045
Applying IGBTs	5SYA2053
Surge currents for IGBT diodes	5SYA2058
Specification of environmental class for HiPak – OPERATION (Traction)	5SZK9120
Specification of environmental class for HiPak – STORAGE	5SZK9111
Specification of environmental class for HiPak – TRANSPORTATION	5SZK9112
Specification of environmental class for HiPak – OPERATION (Industry)	5SZK9113

Table 2 Principal applications documents

Summary

As illustrated above, ABB's HiPak family of IGBT modules continues to set new standards of robustness for high reliability applications. Robustness translates to higher operating safety margins and allows low gate drive resistance at turn-off which, in turn, allows lower turn-off losses.
SPT chip technology with its smooth switching behavior, allows users the greatest freedom of design by not imposing dv/dt or peak-voltage restrictions at turn-off. The new SPT$^+$ technology allows further loss reductions without compromizing any of the existing features of SPT. Further improvements on the cell design allow chipsets to operate at junction temperatures up to 150 °C.

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