



Product catalog 2017

Power semiconductors

ABB

Contents

Introduction	
This is ABB Semiconductors	5
Applications	6
SEMIS – Semiconductor simulation tool	8
Product outlook	10
IGBT dies and modules	
IGBT and diode dies	12
Medium-power IGBT modules	16
High-power IGBT and diode modules	18
Diode, thyristor, IGCT and GTO press-packs	
Diodes	28
Thyristors	42
Integrated gate-commutated thyristors (IGCTs)	54
Gate turn-off thyristors (GTOs)	58
Silicon surge voltage suppressors	62
Test systems	64
Further information	
Certificates	66
REACH Declaration	69
Documentation	70
Perpetual innovation	72
Part numbering structure	74
Symbols	78
Worldwide distributors	80



This is ABB Semiconductors



ABB's success story in power electronics began more than 100 years ago with the production of mercury-arc rectifiers in Switzerland. Over the past 60 years, ABB has played a pivotal part in the development of power semiconductors and their applications.

ABB is a leading supplier of power semiconductors with production facilities in Lenzburg, Switzerland, and Prague, Czech Republic, as well as a research laboratory for wide bandgap semiconductors in Baden-Dättwil, Switzerland.

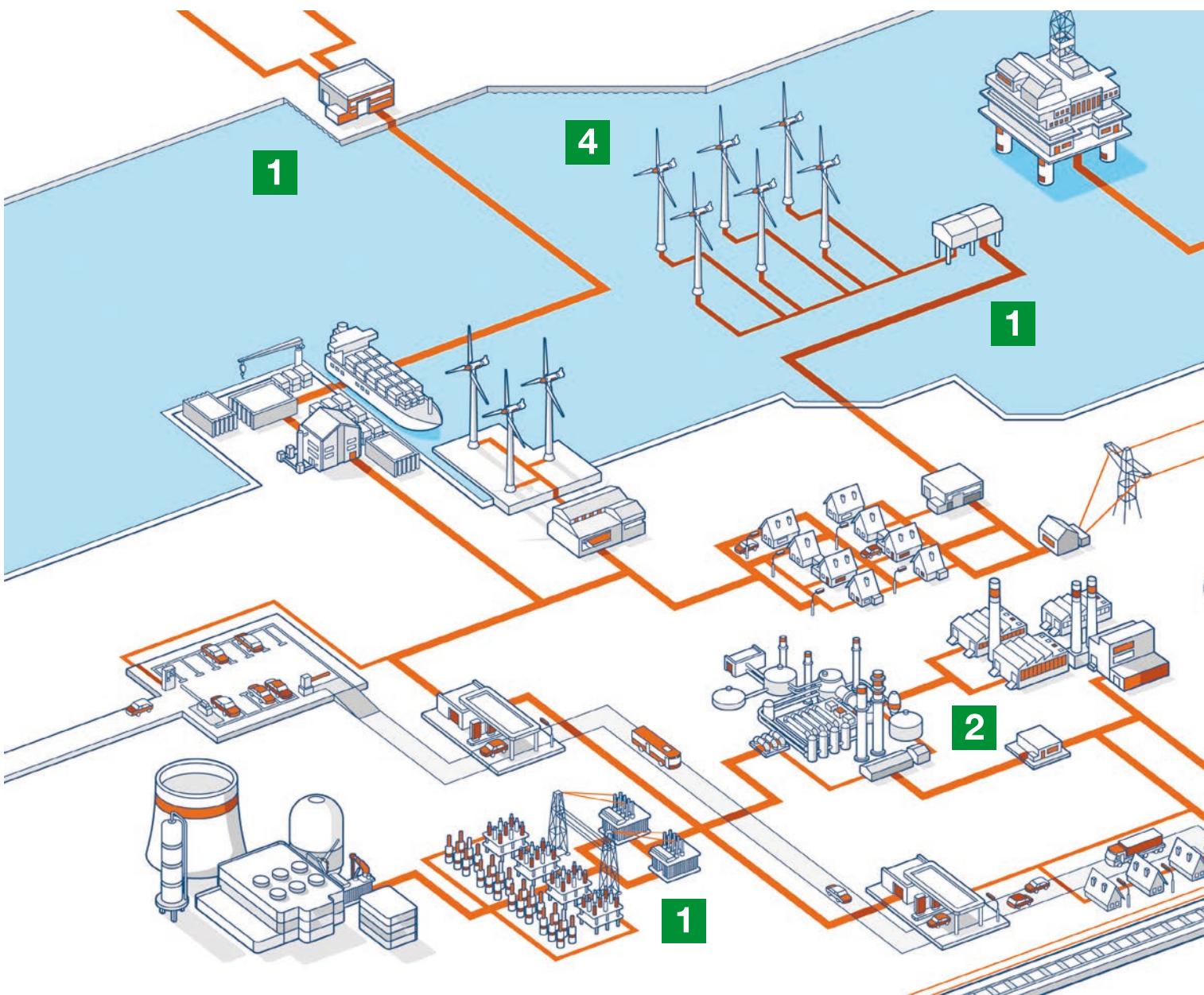
Exceeding quality requirements, guaranteeing reliability expectations and perpetual pioneering are our distinctions.

This product catalog provides an overview of ABB's full range of power semiconductors.

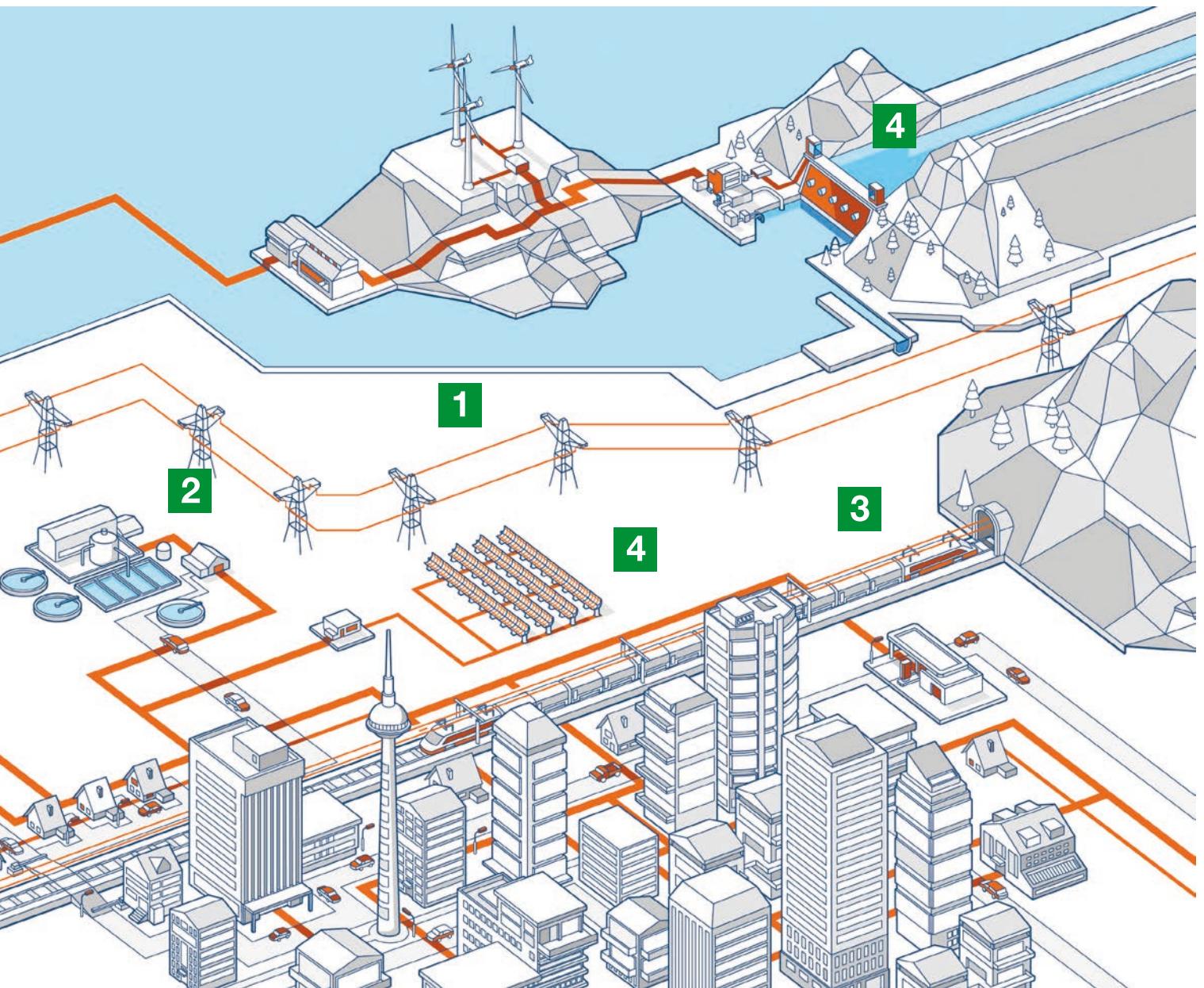
Additionally, a compilation of broad background information on our portfolio can be found in our product brochure.

For more information please contact us or visit
www.abb.com/semiconductors.

Applications



ABB's power semiconductors are key components in a variety of demanding applications in markets like power transmission & distribution, industrial, transportation and renewable energy. Customers rely on ABB's high quality power semiconductor products and use them in applications in power ranges from 50 kW to 10 GW.

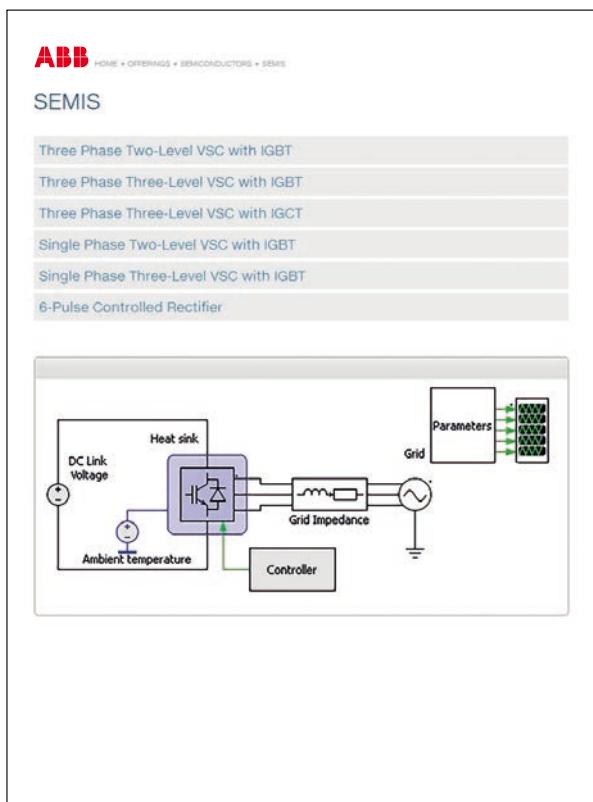


- 1** Power transmission and distribution (HVDC, FACTS, STATCOM and others)
- 2** Industry (medium and low-voltage drives, soft starters, UPSs, high-power rectifiers, excitation systems and others)
- 3** Transportation (main and auxiliary drives, trackside power supply)
- 4** Renewable energy (converters for pumped hydro, wind turbines and solar)

SEMIS - Semiconductor simulation tool

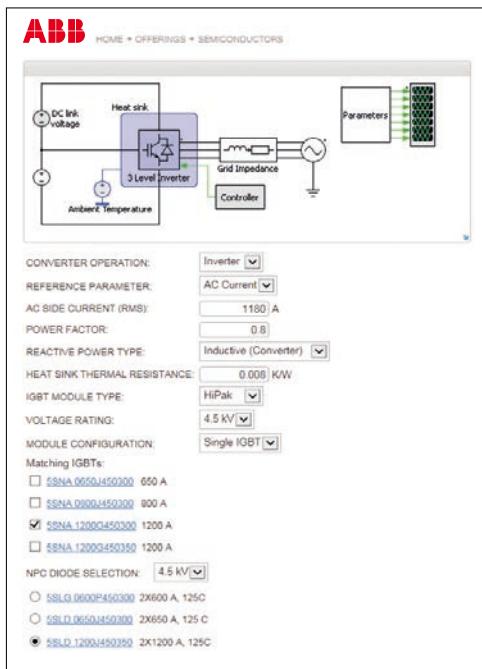
ABB's Semiconductor Simulation tool SEMIS is a web-based application, intended to assist engineers at an early design phase in selecting the semiconductor device best fitting their application with respect to thermal losses. For a system designer it serves as a practical way to choose the appropriate semiconductor device, according to the parameters of the application, without having to spend too much time and effort.

A variety of commonly met industrial converter topologies are available for simulation at ABB Semiconductors' website.



SEMIS offers a user friendly interface for parameter set up and provides a comprehensive steady state analysis for the selected ABB semiconductor products. Simulation results are obtained in both graphical and arithmetical form. Time based graphs such as semiconductor current, output voltage, output current and junction temperatures are presented. The arithmetical results are listed in tables and among others indicate the estimated semiconductor switching and conduction losses, as well as the junction temperature. Input and output values for voltage and current are also available. Multiple device selection and simultaneous simulation for the same conditions are possible for direct product comparison.

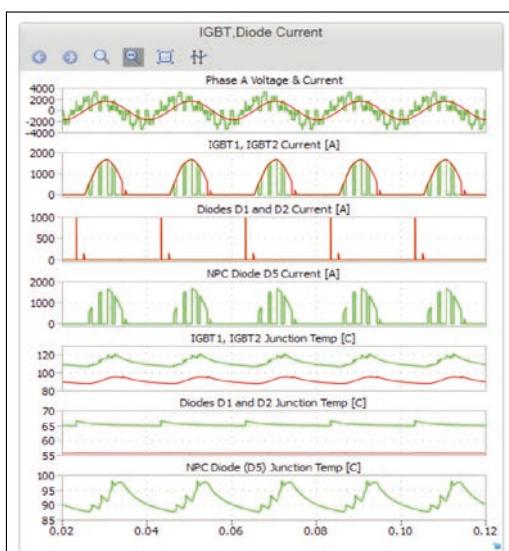
Using SEMIS is very easy. Go to our website (www.abb.com/semiconductors) and click on the *Simulation tool SEMIS* tile under 'Links and downloads'. The user is directed to the available topologies section. As soon as the desired topology is chosen, specific input parameters can be selected such as load power, power factor, heat sink thermal resistance.



SEMIS then lists the suitable ABB products according to the input parameters. Once the user defines the Semiconductor(s) of choice then the simulation may start.

SEMIS simulation results are time based graphs and tables with arithmetic values. The semiconductor losses are analytically calculated as switching and conduction losses. They are also presented on converter level, accounting for the total losses on all devices. Having the input power also available in the results, SEMIS calculates the total semiconductor losses as percentage of the absorbed power from the converter. This way, the user gets an indication of the impact of the semiconductor selection in the overall efficiency of the converter. The semiconductor virtual junction temperature T_{VJ} is another parameter included in the results allowing for assessing the thermal limits of operation. If permissible limits of product operation are exceeded, alert messages are generated.

As SEMIS is based on the PLECS simulation software, the devices' thermal models (in XML format) are available for download from our website, allowing PLECS users the flexibility to simulate ABB products accurately based on manufacturer's data, on their own.



Device Losses & Temperatures					
	Switching	Conduction	Combined Losses	Avg.Junction Temperature ($T_{J,Avg}$)	
IGBT1	1.674 kW	1.031 kW	2.705 kW	115 °C	
IGBT2	173.51 W	1.768 kW	1.941 kW	92 °C	
D1	80.39 W	5.43 W	85.81 W	66 °C	
D2	0 W	5.43 W	5.43 W	56 °C	
NPC D5	324.12 W	825.69 W	1.150 kW	93 °C	
Converter Losses	13.02 kW	22.18 kW	35.20 kW		
% Losses				0.87 %	

Converter AC Parameters					
	Real Power	Reactive Power	Phase Voltage (RMS)	Phase Current (RMS)	Output Frequency
	4003 kW	2999 kVAR	1.414 kV	1.179 kA	50 Hz

DC Parameters & Control Parameters				
	DC Power	DC Voltage	Switching Frequency	Modulation Index
	4038 kW	2 500 kV	450 Hz	0.80

Product outlook

Innovation and quality are key for success. It is our mission to drive innovation in power semiconductor technology together with our customers and to add value through best performance and quality. We are pushing to be the best and most forward-looking performer in our markets when it's about reliability.

ABB Semiconductors' vast range of power semiconductors for industrial, traction, power generation & distribution and renewable energy markets will be expanded soon with the following new products:

LinPak IGBT modules

For the first time, a high-power highly reliable IGBT module becomes available that addresses long sought customer requirements such as low overall stray inductance, high flexibility and highest current densities. The already presented 1,700 V, 2 x 1,000 A module is ready for mass production in Q1/17. The 3,300 V, 2 x 450 A module in the same package becomes available for mass production in the first half of 2017. The lineup will be expanded to higher voltages in the coming years.

Target ratings LinPak

	Availability	Rating	Configuration	V_{CEsat} (V) typ. 125 °C	V_F (V) typ. 125 °C
	AISiC (LV) MP	1700 V / 2 x 1000 A	Phase leg	2.55	1.75
	AISiC (LV) Samples now, MP Q2/17	3300 V / 2 x 450 A	Phase leg	3.10	2.25
	AISiC (HV)	4500 V / 2 x 350 A	Phase leg		
	AISiC (HV)	6500 V / 2 x 250 A	Phase leg		

LoPak1 medium-power phase leg IGBT modules

Following ABB's product expansion into the medium-power segment, we will add a new industry standard phase leg module to our portfolio. The LoPak1 is a low profile, low inductive module that features the latest low loss 1,700 V SPT++ chip-set and 175 °C junction operation temperature setting a new benchmark in the industry. This allows customers to use more converter output power per rated module amps yielding in a significant financial benefit.

Target ratings LoPak1

	Availability	Rating	Configuration	V_{CEsat} (V) typ. 125 °C	V_F (V) typ. 125 °C
	Samples now, MP Q3/17	1700 V / 2 x 450 A	Phase leg	2.55	1.75
	Samples now, MP Q3/17	1700 V / 2 x 300 A	Phase leg	2.55	1.75
	Samples now, MP Q3/17	1700 V / 2 x 225 A	Phase leg	2.55	1.75

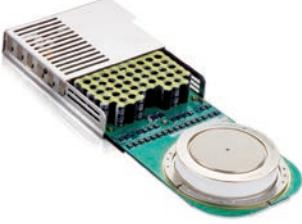
Reverse conducting IGCT platform

A new product platform for reverse conducting IGCTs in two voltage levels, 4,500 V and 6,500 V was developed and is currently in sampling stage.

The devices are optimized for applications such as industrial medium-voltage drives (MVD), wind-power converters, STATCOMs, power quality and railway interties.

The main advantages of this new product platform are the very low on-state losses provided by the thyristor structure, the negligible turn-on losses in the semiconductor and the high reliability of the devices.

The HPT⁺ IGCT cell leads to an increased performance at high junction temperatures. Changes to the package led to a great reduction of the thermal resistance as well as the inherent capacity for handling surge currents.

	Availability	Voltage (V_{DRM})	Current (I_{TQGM})	Housing
	Samples available now, MP Q3/17	4500 V	3000 A	L
	Samples available now, MP Q3/17	6500 V	2200 A	L

High-voltage high-power thyristor

ABB releases a new product of its next generation high-power high-voltage thyristor product line. Latest thyristor technology features have been applied with focus on increased surge current, loss reduction, increased junction temperature and highest reliability.

The device is addressing demanding high-end applications such as pumped hydro, drives, HVDC and SVC.

	Availability	Voltage (V_{DRM})	Current (I_{TAVM})	Housing
	Samples available now, MP Q3/17	8500 V	3300 A	U

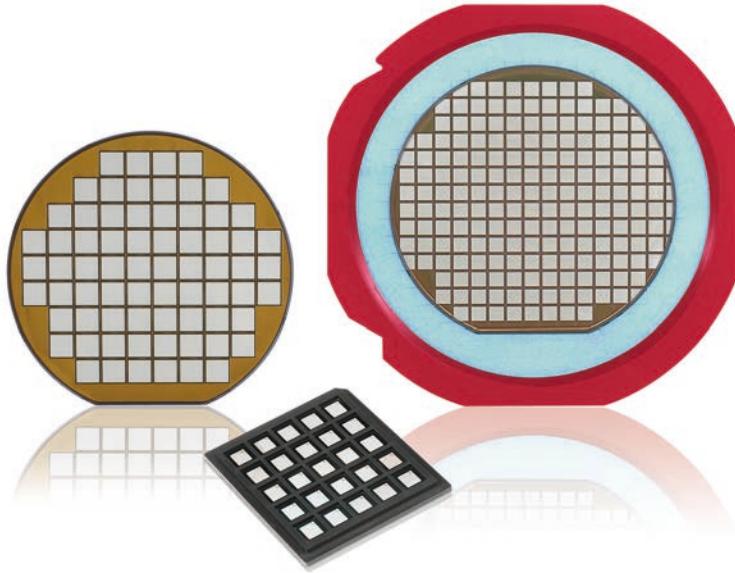
IGBT and diode dies

When looking for chipsets featuring highest switching performance, ruggedness and reliability, ABB's IGBT chips with accompanying diodes are certainly the preferred choice.

ABB Semiconductors' SPT (Soft Punch Through) chipsets and their improved versions with lower losses (SPT+ and SPT++) are available at 1,200 V and 1,700 V. They feature highest output power per rated ampere due to a moderate chip shrinkage and thus larger die area compared to others.

Typical applications for 1,200 V are power converters for industrial drives, solar energy, battery backup systems (UPS) and electrical vehicles. Applications for 1,700 V also include industrial power conversion & drives, wind turbines and traction converters.

ABB's 1,700 V SPT++ chipset is the world's first 1,700 V chipset that offers an operational junction temperature of up to 175 °C. This allows the module designer to increase the power density of the IGBT modules significantly.



Diode dies

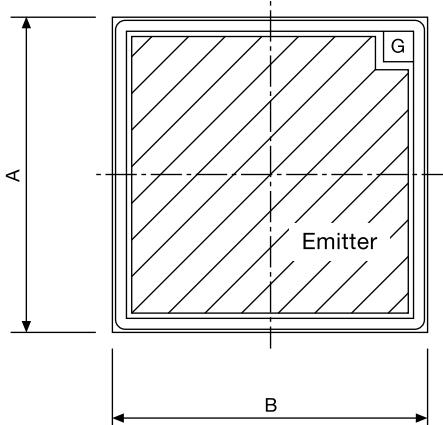
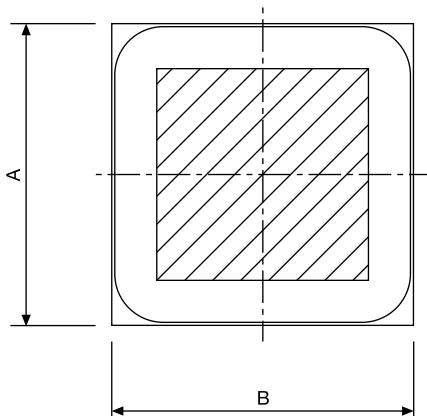
Part number	Type	Size A x B mm	Thickness μm	V_{PRM} (V)	I_F (A)	V_F (V) typ. 125 °C	Max. dies per wafer (W) or tray (T)
1.2 kV							
5SLY 76E1200							
5SLY 86E1200	SPT ⁺	6.3 x 6.3	350	1200	50	1.85	361 (W)
5SLY 76F1200							
5SLY 86F1200	SPT ⁺	7.4 x 7.4	350	1200	75	1.85	257 (W)
5SLY 76G1200							
5SLY 86G1200	SPT ⁺	8.4 x 8.4	350	1200	100	1.85	198 (W)
5SLY 76J1200							
5SLY 86J1200	SPT ⁺	10.0 x 10.0	350	1200	150	1.85	137 (W)
1.7 kV							
5SLZ 76E1700 New	SPT ⁺⁺ /FSA	6.6 x 6.6	370	1700	50	1.75	326 (W)
5SLY 86E1700	SPT ⁺	6.6 x 6.6	390	1700	50	2.1	326 (W)
5SLZ 76F1700 New	SPT ⁺⁺ /FSA	7.7 x 7.7	370	1700	75	1.75	237 (W)
5SLY 86F1700	SPT ⁺	7.7 x 7.7	390	1700	75	2.1	237 (W)
5SLY 86G1700	SPT ⁺	8.6 x 8.6	390	1700	100	2.1	188 (W)
5SLZ 86J1700	SPT ⁺⁺ /FSA	10.2 x 10.2	370	1700	150	1.75	131 (W)
5SLY 86J1700	SPT ⁺	10.2 x 10.2	390	1700	150	2.1	131 (W)
5SLY 86M1700							69 (W)
5SLY 12M1700	SPT ⁺	13.6 x 13.6	390	1700	300	2.1	25 (T)

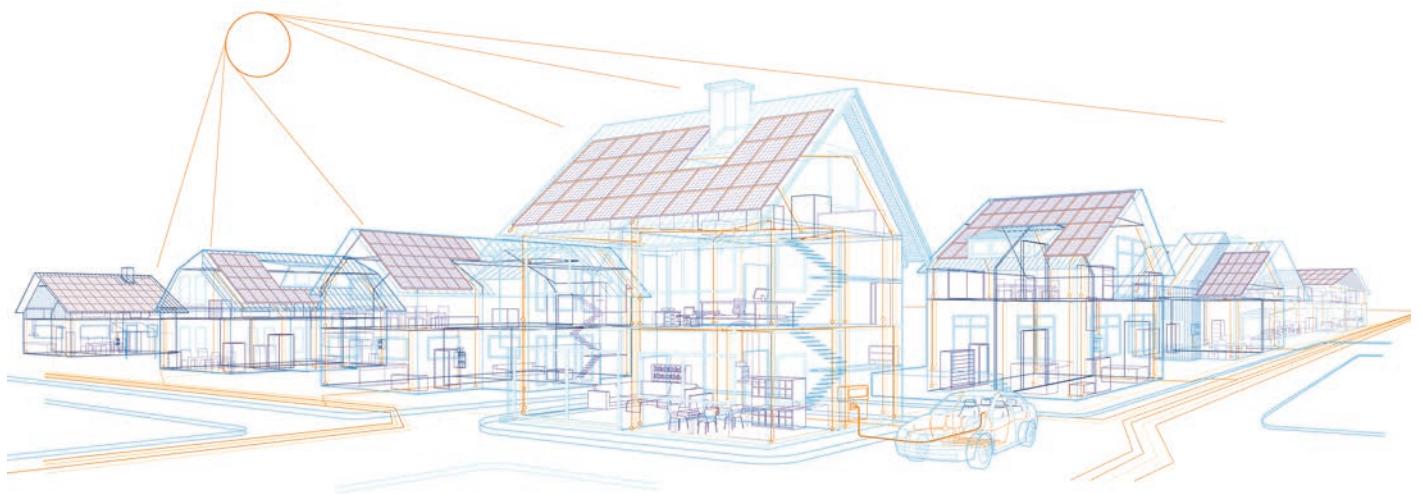
IGBT dies

Part number	Type	Size A x B mm	Thickness μm	V_{CES} (V)	I_c (A)	I_{CM} (A)	V_{CESat} (V) typ. 125 °C	Max. dies per wafer (W) or tray (T)
1.2 kV								
5SMY 76H1280								
5SMY 86H1280	SPT ⁺	9.1 x 9.1	140	1200	57	114	2.1	166 (W)
5SMY 76J1280								
5SMY 86J1280	SPT ⁺	10.2 x 10.2	140	1200	75	150	2.1	130 (W)
5SMY 76K1280								
5SMY 86K1280	SPT ⁺	11.2 x 11.9	140	1200	100	200	2.1	98 (W)
5SMY 76M1280								
5SMY 86M1280	SPT ⁺	13.5 x 13.5	140	1200	150	300	2.2	71 (W)
1.7 kV								
5SMY 86G1721	SPT ⁺	8.6 x 8.6	209	1700	50	100	3.0	186 (W)
5SMY 86J1721	SPT ⁺	10.1 x 10.1	209	1700	75	150	3.0	132 (W)
5SMY 76J1730 New								
5SMY 86J1730	SPT ⁺	10.1 x 10.1	190	1700	75	150	2.55	132 (W)
5SMY 86K1721	SPT ⁺	11.4 x 11.4	209	1700	100	200	3.0	102 (W)
5SMY 76K1730 New								
5SMY 86K1730	SPT ⁺⁺	11.4 x 11.4	190	1700	100	200	2.55	102 (W)
5SMY 86L1731 New	SPT ⁺⁺	7.4 x 19.9	190	1700	120	240	2.7	86 (W)
5SMY 86M1721	SPT ⁺	13.6 x 13.6	209	1700	150	300	3.0	69 (W)
5SMY 86M1730	SPT ⁺⁺	13.6 x 13.6	190	1700	150	300	2.55	69 (W)
5SMY 86M1731	SPT ⁺⁺	13.9 x 14.0	190	1700	160	320	2.55	66 (W)

Please refer to page 73 for part numbering structure.

IGBT dies





Medium-power IGBT modules

ABB enhances its successful IGBT module range into the medium-power segment. Starting with the 62Pak, ABB brings the proven high quality and reliability of the HiPak modules to the 62 mm module range.

ABB's 62Pak modules have an advanced packaging technology that leverages the performance of the latest silicon technology:

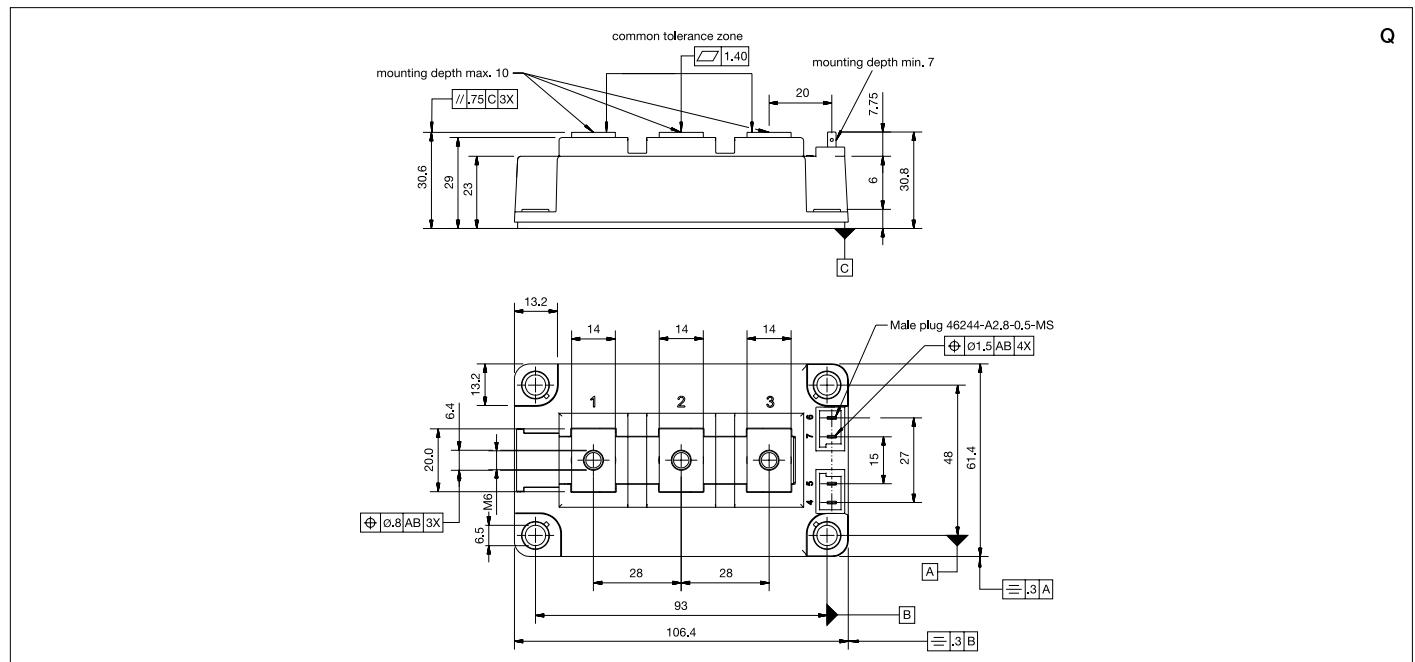
- 1,700 V SPT++ fast switching IGBT / diode chipset with lowest switching losses
- Full 175 °C operation temperature with full square SOA
- Best-in-class temperature cycling performance of bond-wire chip connection
- Standard package allowing drop-in replacement



Part number <i>T_v</i> (operational) up to 175°C	Voltage V _{CES} (V)	Current I _C (A)	Configuration *	V _{CESat} (V) typ. 125°C	V _F (V) typ. 125°C	Housing
1.7 kV						
5SNG 0150Q170300	1700	2 x 150	(5) - Phase leg IGBT	2.55	1.75	Q
5SNG 0200Q170300	1700	2 x 200	(5) - Phase leg IGBT	2.55	1.75	Q
5SNG 0300Q170300	1700	2 x 300	(5) - Phase leg IGBT	2.55	1.75	Q

Please refer to page 73 for part numbering structure.

* Configurations on page 24



Dimensions in mm

High-power IGBT and diode modules

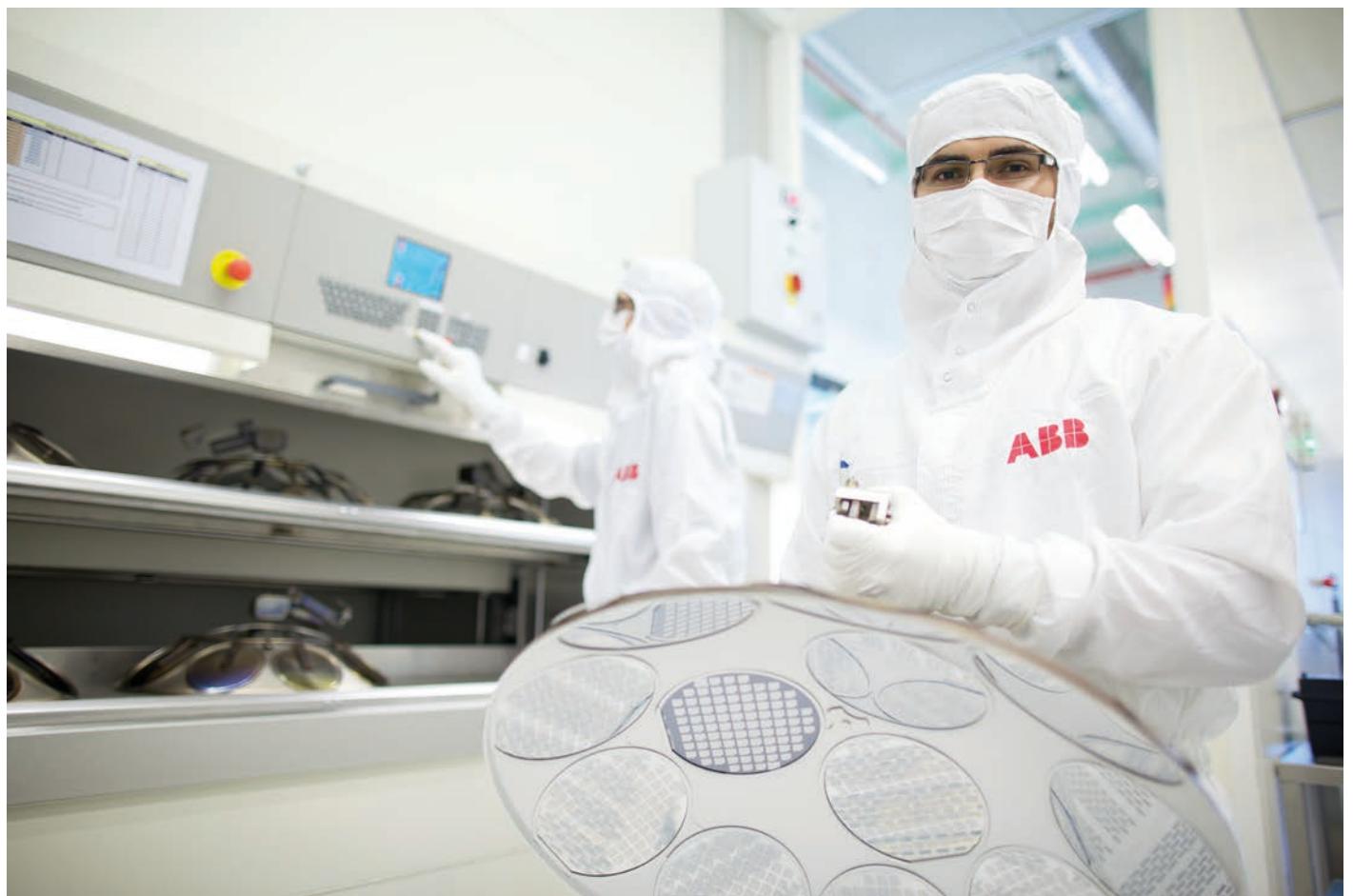
ABB offers two categories of high-power IGBT and diode modules: Insulated and press-pack modules.

Insulated modules consist of the new innovative, low inductive phase leg LinPak and the well-established HiPak lineup with more than 15 years of successful track record.

Press-pack modules are a range of pressure contact IGBT modules also known as StakPak. StakPaks are ABB's flagship with record power ratings up to 4,500 V and 3,000 A.

ABB's high-power IGBT and diode module families are:

- LinPak IGBT modules → page 20
- HiPak IGBT and diode modules → page 22
- StakPak IGBT press-pack modules → page 26



LinPak IGBT modules

The LinPak is a new innovative solution for all power conversion applications. It enables the design of converters with lowest overall inductance, thus fast low switching loss chipsets can be used for the first time also in high-current applications. These applications include amongst others traction, converters for wind turbines or other renewables, industrial drives, as well as power electronics for FACTS applications. In addition, the LinPak allows very easy parallel connection, thus the current rating of the inverters can be scaled up with just one article number. This makes the supply chain and initial device design-in efforts significantly more efficient.

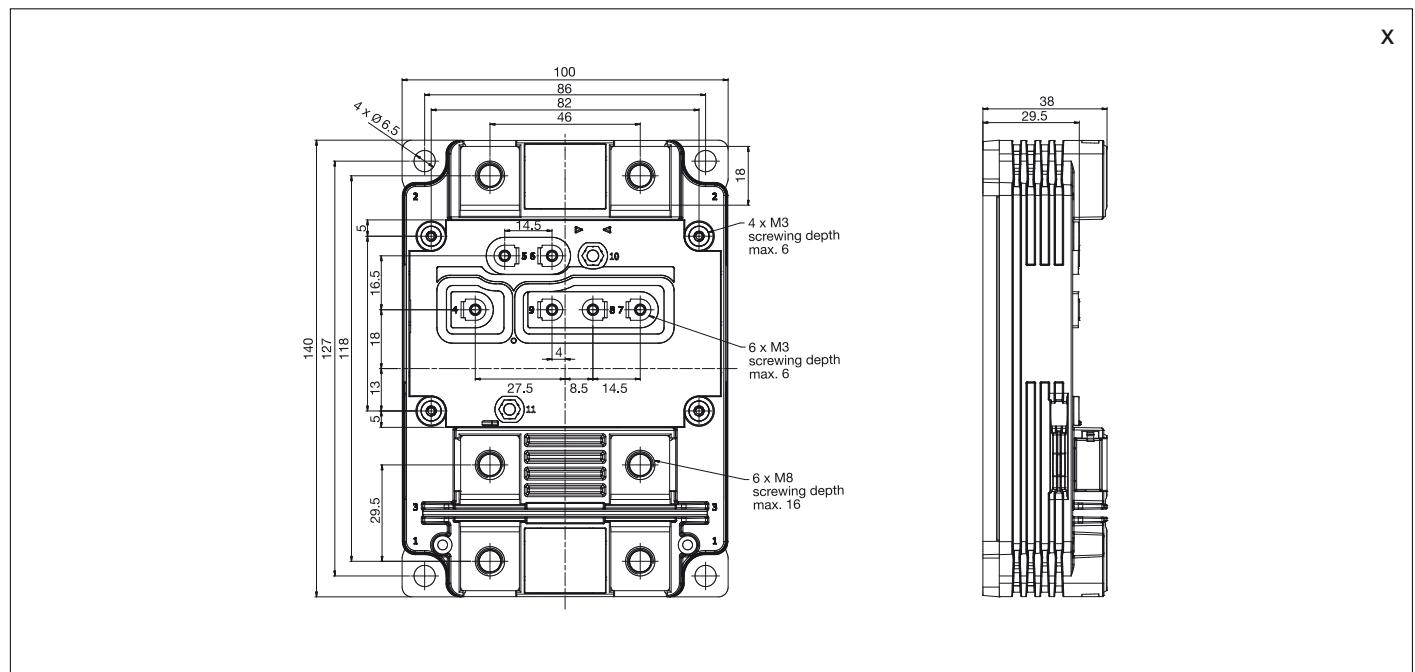
ABB's LinPak modules feature lowest switching losses and excellent robustness thanks to its low inductance. The first product is available as a 1,700 V device, further products with 3,300 V and above will follow soon.



Part number	Voltage V_{CES} (V)	Current I_c (A)	Configuration	V_{CESat} (V) typ. 125°C	V_F (V) typ. 125°C	Housing
T_{vj} (operational) up to 175°C						
1.7 kV						
5SNG 1000X170300	1700	2 x 1000	(5) – Phase leg IGBT	2.55	1.75	X

Please refer to page 73 for part numbering structure.

* Configurations on page 24



Dimensions in mm

HiPak IGBT and diode modules

Demanding high-power applications such as traction inverters, medium-voltage drives, wind turbine converters, HVDC or FACTS are looking for the highest reliability IGBT modules. ABB's HiPak family of IGBT modules is the best fit to demanding applications, continuing to set new standards of robustness.

ABB's HiPak IGBT modules are available from 1,700 V to 6,500 V in various configurations. They all feature low losses combined with soft-switching performance and record-breaking Safe Operating Area (SOA).



Part number	Voltage V_{CES} (V)	Current I_c (A)	Configuration	V_{CESat} (V) typ. 125°C	V_F (V) typ. 125°C	Housing
T_{vj} (operational) up to 125°C						
1.7 kV						
5SND 0800M170100	1700	2 x 800	(3) – Dual IGBT	2.6	1.7	M
5SNE 0800M170100	1700	800	(2) – Chopper	2.6	1.7	M
5SNA 1600N170100	1700	1600	(1) – Single IGBT	2.6	1.7	N1
5SNA 1800E170100	1700	1800	(1) – Single IGBT	2.6	1.7	E
5SNA 2400E170100 *	1700	2400	(1) – Single IGBT	2.6	1.7	E
3.3 kV						
5SNE 0800E330100	3300	800	(2) – Chopper	3.8	2.35	E
5SNA 0800N330100	3300	800	(1) – Single IGBT	3.8	2.35	N1
5SLD 1200J330100	3300	2 x 1200	(4) – Dual Diode	-	2.35	J
5SNA 1200E330100	3300	1200	(1) – Single IGBT	3.8	2.35	E
5SNA 1200G330100	3300	1200	(1) – Single IGBT	3.85	2.35	G
T_{vj} (operational) up to 150°C						
1.7 kV						
5SNA 2400E170305	1700	2400	(1) – Single IGBT	2.4	1.67	E
5SNA 3600E170300	1700	3600	(1) – Single IGBT	3.0	1.95	E
5SLA 3600E170300	1700	3600	(6) – Single Diode	-	1.95	E
2.5 kV						
5SNA 1500E250300	2500	1500	(1) – Single IGBT	2.5	2.0	E
3.3 kV						
5SNG 0250P330305	3300	2 x 250	(5) – Phase leg IGBT	3.1	2.25	P
5SLG 0500P330300	3300	2 x 500	(7) – Phase leg Diode	-	2.25	P
5SND 0500N330300	3300	2 x 500	(3) – Dual IGBT	3.1	2.25	N2
5SLD 1000N330300	3300	2 x 1000	(4) – Dual Diode	-	2.25	N1
5SNA 1000N330300	3300	1000	(1) – Single IGBT	3.1	2.25	N1
5SNA 1500E330305	3300	1500	(1) – Single IGBT	3.1	2.25	E

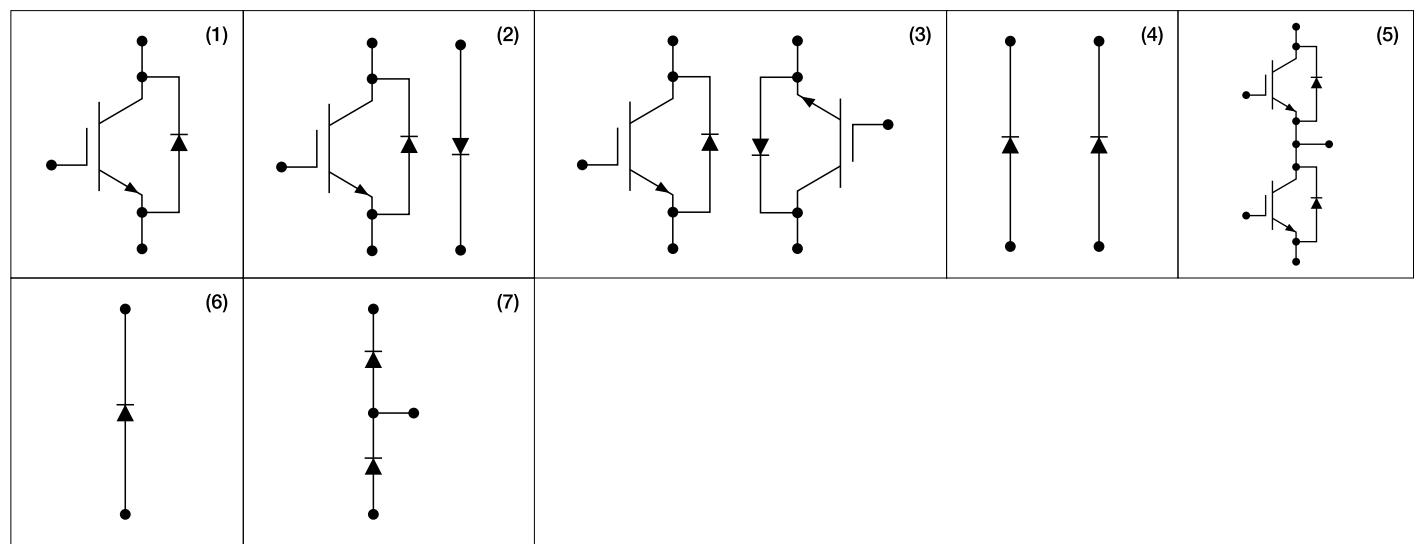
* not for new designs

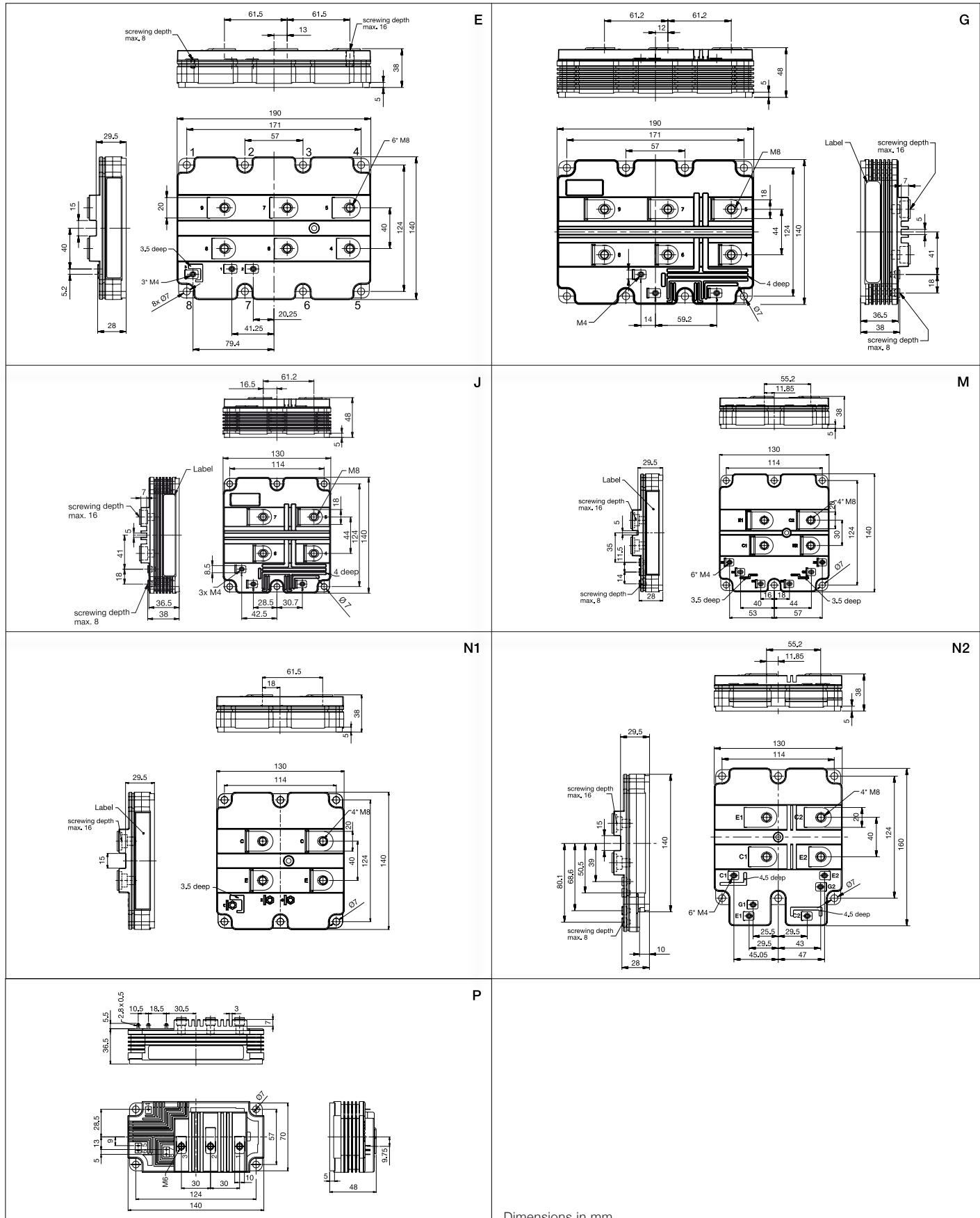
Please refer to page 73 for part numbering structure.

Part number	Voltage V_{CES} (V)	Current I_C (A)	Configuration	V_{CESat} (V) typ. 125°C	V_F (V) typ. 125°C	Housing
T_{vj} (operational) up to 125°C						
4.5 kV						
5SNG 0150P450300	4500	2 x 150	(5) – Phase leg IGBT	3.5	3.45	P
5SLG 0600P450300	4500	2 x 600	(7) – Phase leg Diode	-	3.5	P
5SLD 0650J450300	4500	2 x 650	(4) – Dual Diode	-	3.4	J
5SNA 0650J450300	4500	650	(1) – Single IGBT	3.7	3.4	J
5SNA 0800J450300	4500	800	(1) – Single IGBT	3.55	3.5	J
5SLD 1200J450350	4500	2 x 1200	(4) – Dual Diode	-	3.5	J
5SNA 1200G450300	4500	1200	(1) – Single IGBT	3.55	3.5	G
5SNA 1200G450350	4500	1200	(1) – Single IGBT	3.55	3.5	G
6.5 kV						
5SNA 0400J650100	6500	400	(1) – Single IGBT	5.4	3.4	J
5SNA 0500J650300	6500	500	(1) – Single IGBT	3.9	3.4	J
5SLD 0600J650100	6500	2 x 600	(4) – Dual Diode	-	3.4	J
5SNA 0600G650100	6500	600	(1) – Single IGBT	5.4	3.4	G
5SNA 0750G650300	6500	750	(1) – Single IGBT	3.9	3.4	G

Please refer to page 73 for part numbering structure.

Configurations





Dimensions in mm

StakPak IGBT press-pack modules

To enhance reliability and reduce cost in systems that require redundancy and series-connected IGBT modules, one should consider using ABB's StakPaks.

ABB's StakPak family uses a well proven concept in IGBT press-pack technology that:

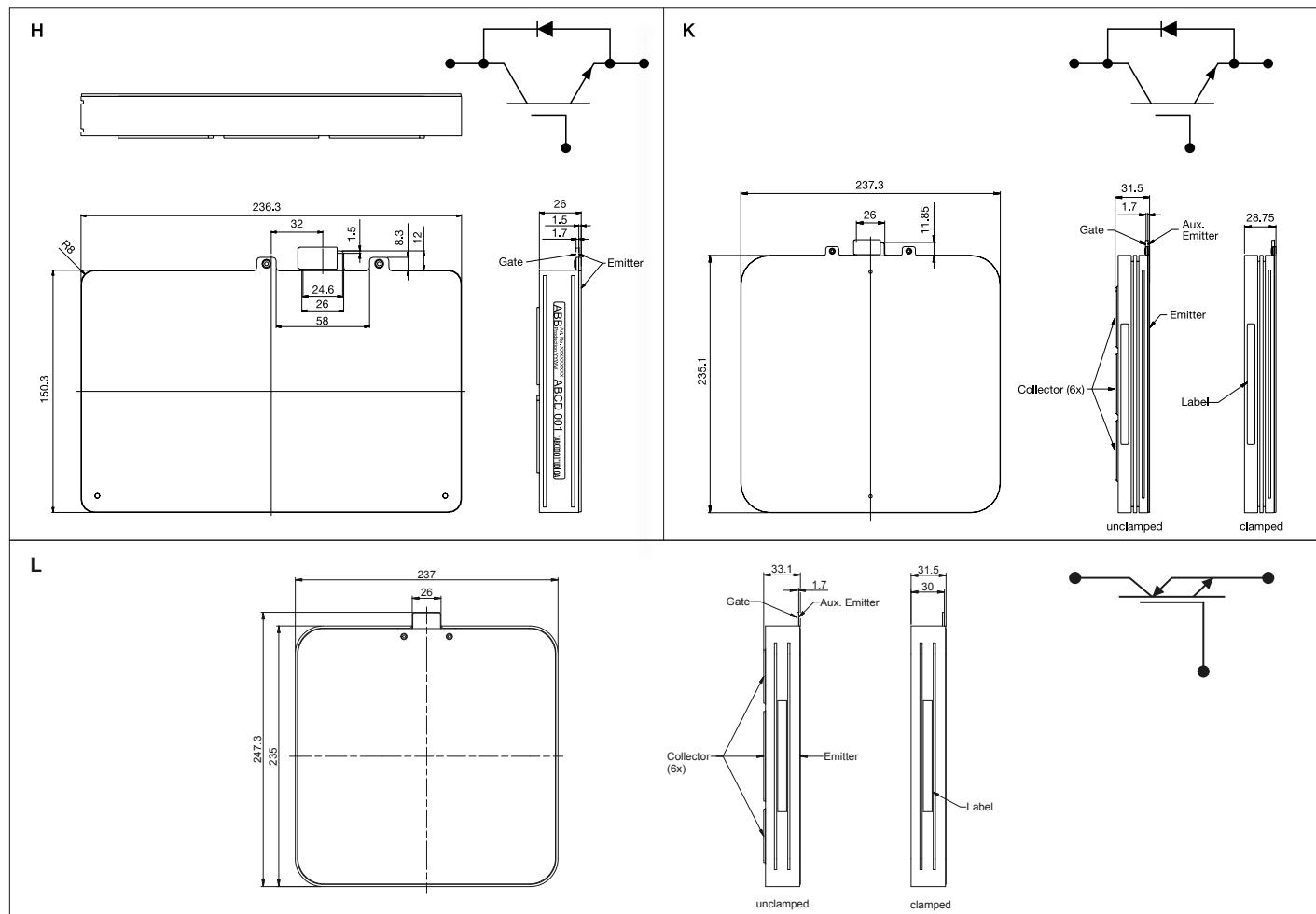
- allows for easy mechanical and electrical series connection
- allows for easy stack design thanks to high tolerance for inhomogeneous mounting pressure
- guarantees a uniform chip pressure in multiple-device stacks
- provides a stable shorted state in case of failure
- long-term short-circuit failure mode (SCFM) available

ABB Semiconductors' StakPak IGBT modules are therefore a perfect match for applications like HVDC, FACTS, breakers and pulsed power.



Part number	Voltage V_{CES} (V)	Current I_C (A)	V_{CEsat} (V) typ. 125°C	V_F (V) typ. 125°C	IGBT-to-diode ratio	Housings	SCFM rating
5SNR 10H2501 *	2500	1000	2.7	1.9	2:1	H	Yes
5SNR 13H2501 *	2500	1300	2.7	1.9	2:1	H	Yes
5SNR 20H2501 *	2500	2000	2.7	1.9	2:1	H	Yes
5SNA 1300K450300	4500	1300	3.4	2.3	1:1	K	Yes
5SNA 2000K450300	4500	2000	3.4	2.4	1:1	K	Yes
5SNA 2000K451300	4500	2000	3.5	3.0	2:1	K	Yes
5SNA 2000K452300 **	4500	2000	3.5	3.0	2:1	K	No
5SNA 3000K452300	4500	3000	3.5	3.0	2:1	K	No
5SJA 3000L450300 **	4500	3000	3.13	2.5	1:1 (BiGT)	L	No

* not for new designs / ** contact factory / Please refer to page 73 for part numbering structure.



Dimensions in mm

Diodes

Diodes are used in a number of different applications. Each of these applications sets different requirements on the diodes' characteristics. Inverter applications ask for fast recovery diodes with soft-switching characteristics, high-current rectifiers demand diodes with low on-state losses, medium-power rectifiers benefit from diodes with avalanche capability and welding rectifiers require highest current in the smallest package.

ABB offers four press-pack diode families that meet these requirements:

- Fast recovery diodes → page 30
- Standard rectifier diodes → page 34
- Avalanche diodes → page 36
- Welding diodes → page 38



Fast recovery diodes

ABB Semiconductors' comprehensive family of fast recovery diodes is optimized for enhanced Safe Operating Area (SOA) and controlled (soft) turn-off recovery. This makes these diodes very well suited for all converter applications.

ABB has a long history in producing high-power fast recovery diodes for applications such as Voltage Source Inverters (VSIs), Current Source Inverters (CSIs) and snubbers. The diodes are typically used in combination with IGCTs and GTOs as free-wheeling, snubber and clamp diodes, thus enabling full IGCT and GTO performance.

ABB particularly developed L-housing fast recovery diodes to optimally match IGBT and IEGT applications where a dI/dt of up to 5 kA/ μ s is required.

Fast recovery diode recommendations for various applications can be found in the ABB application note *Applying fast recovery diodes*. The latest version is available at www.abb.com/semiconductors.



GTO free-wheeling diodes

Part number	V_{RRM}	V_{DC}	I_{FAVM}	I_{FSM}		V_{F0}	r_F	I_{rr}	Q_{rr}	T_{VJM}	R_{thJC}	R_{thCH}	F_m	Housing					
	$T_c = 85^\circ\text{C}$		1ms	10ms	T_{VJM}		di/dt=80 A/ μs												
	V	V	A	kA	kA	V	m Ω	A	μC										
5SDF 13H4501	4500	2800	1200	60.0	25.0	1.30	0.48	800 *	3000 *	125	12	3	40	H1					
5SDF 10H6004	6000	3800	1100	44.0	18.0	1.50	0.60	1000	6000	125	12	3	40	H1					

* at di/dt = 300A/ μs

Drawings see page 36f.

Please refer to page 75 for part numbering structure.

Snubber diodes

Part number	V _{RRM}	V _{DC}	I _{FAVM}	I _{FSM}	V _{F0}	r _F	I _{rr}	Q _{rr}	T _{VJM}	R _{thJC}	R _{thCH}	F _m	Housing	
			T _C =85°C		1ms	10ms	T _{VJM}		di/dt=100 A/μs		T _{VJM}			
			V	V	A	kA	kA	V	mΩ	A	μC	°C	K/kW	K/kW
5SDF 05D2501	2500	1100	490	27.0	8.5	1.40	0.50	250	900	125	40	8	11	D
5SDF 03D4501	4500	2400	320	12.0	5.0	2.00	1.50	200	1000	125	40	8	11	D
5SDF 07H4501	4500	2400	900	40.0	16.0	1.80	0.90	260	1700	125	12	3	40	H1
5SDF 02D6002	6000	3000	250	11.4	3.6	2.50	2.50	260	2000	125	40	8	11	D

IGBT diodes

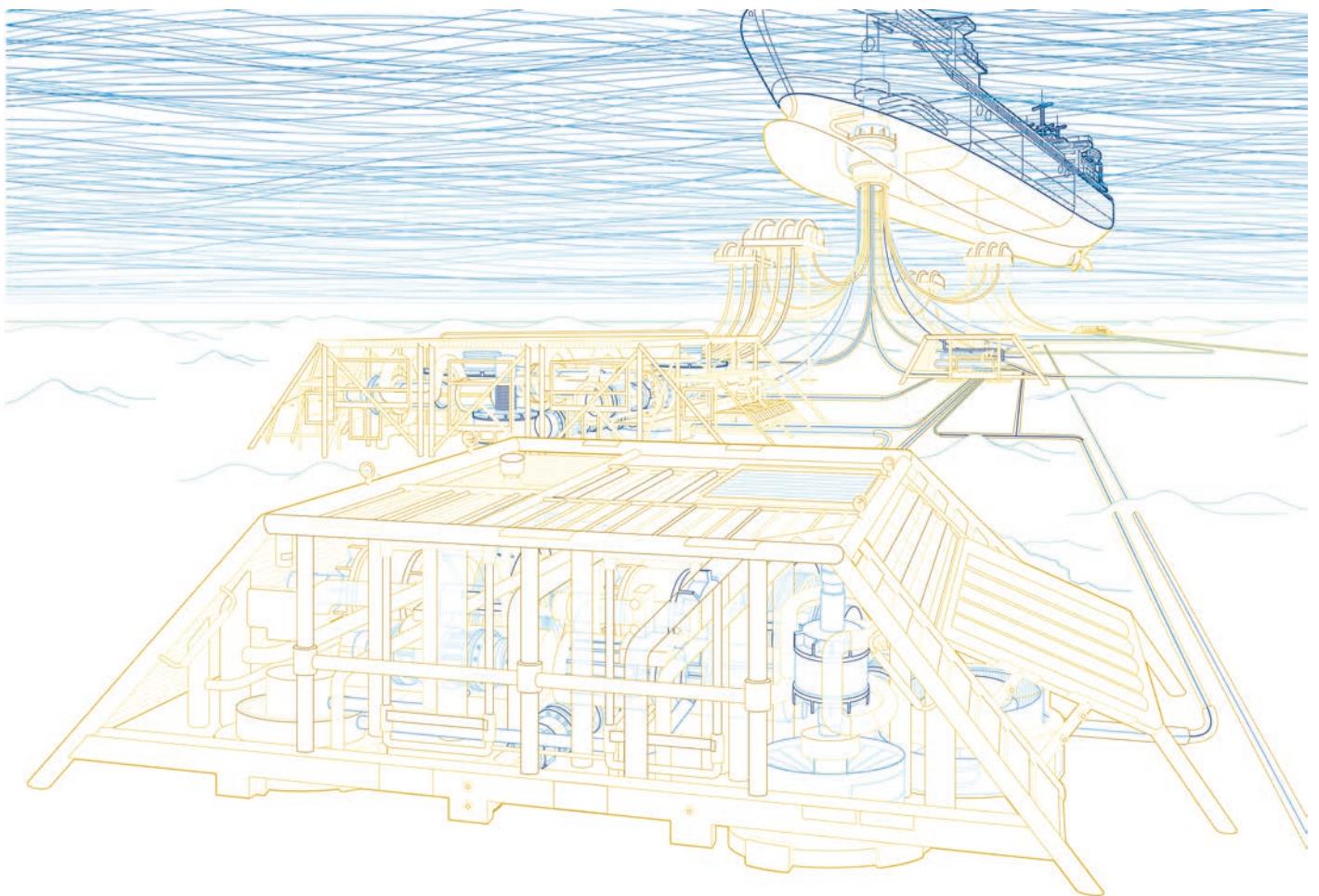
Part number	V _{RRM}	V _{DC}	I _{FAVM}	I _{FSM}	V _{F0}	r _F	I _{rr}	Q _{rr}	T _{VJM}	R _{thJC}	R _{thCH}	F _m	Housing	
			T _C =70°C		10ms	T _{VJM}	di/dt=5000 A/μs		T _{VJM}					
			V	V	A	kA	V	mΩ	A	μC	°C	K/kW	K/kW	kN
5SDF 20L4521	4500	2800	1950	45.0	1.70	0.80	3600	5300	140	6	3	40	L3	
5SDF 28L4521	4500	2800	2620	56.0	1.10	0.47	3700	10100	140	6	3	40	L3	

IGCT diodes

Part number	V _{RRM}	V _{DC}	I _{FAVM}	I _{FSM}	V _{F0}	r _F	I _{rr}	di/dt	T _{VJM}	R _{thJC}	R _{thCH}	F _m	Housing	
			T _C =70°C		1ms	10ms	T _{VJM}	max.		T _{VJM}				
			V	V	A	kA	kA	V	mΩ	A	A/μs	°C	K/kW	K/kW
5SDF 03D4502	4500	2800	275	10.0	5.0	2.15	2.80	355	300	115	40	8	16	D
5SDF 05F4502	4500	2800	435	32.0	16.0	2.42	2.10	610	430	115	17	5	20	F
5SDF 10H4503	4500	2800	1100	47.0	20.0	1.75	0.88	1520	600	125	12	3	40	H1
5SDF 20L4520	4500	2800	1950	-	45.0	1.70	0.80	2400	1200	140	6	3	40	L3
5SDF 28L4520	4500	2800	2620	-	56.0	1.10	0.47	2800	1000	140	6	3	40	L3
5SDF 02D6004	5500	3300	175	8.0	3.0	3.35	7.20	300	220	115	40	8	16	D
5SDF 04F6004	5500	3300	380	22.0	10.0	2.70	2.80	600	340	115	22	5	20	F
5SDF 08H6005	5500	3300	585	40.0	18.0	4.50	1.30	900	440	115	12	3	40	H1

Drawings see page 36f.

Please refer to page 75 for part numbering structure.



Standard rectifier & avalanche diodes

ABB's two families of high-power rectifier diodes – standard rectifier diodes and avalanche diodes – are well-known for their outstanding reliability and excellent nominal and surge current capabilities.

The **standard rectifier diodes** are optimized for line frequency and low on-state losses. Their main applications are rectifiers for large AC drives, aluminum smelting and other metal refining as well as trackside supply.

The **avalanche diodes** are self-protected against transient over-voltages, offer reduced snubber requirements and feature maximum avalanche power dissipation. They are frequently used for input rectifiers in traction converters or high-voltage power rectifiers.

For safe and easy parallel or series connection, both types of diodes are available in groups of similar V_F or Q_{rr} , respectively.



Standard recovery diodes

Part number	V_{RSM}	V_{RRM}	I_{FAVM}	I_{FSM}	V_{T0}	r_T	T_{VJM}	R_{thJC}	R_{thCH}	F_m	Housing	
			10ms		T_{VJM}							
	V	V	A	kA	V	$m\Omega$	$^{\circ}C$	K/kW	K/kW	kN		
5SDD 70H2000	2000	2000	7030	65.0	0.861	0.046	190	8.0	2.5	50	H2	
5SDD 65H2400	2400	2400	6520	59.0	0.870	0.057	190	8.0	2.5	50	H2	
5SDD 51L2800	2800	2000	5380	65.0	0.770	0.082	175	8.0	3.0	70	L1	
5SDD 60N2800	2800	2000	6830	87.0	0.800	0.050	160	5.7	1.0	90	N	
5SDD 60Q2800	2800	2000	7385	87.0	0.800	0.050	160	5.0	1.0	90	Q	
5SDD 11T2800	2800	2800	1285	15.0	0.933	0.242	160	32.0	8.0	10	T1	
5SDD 11D2800	2800	2800	1285	15.0	0.933	0.242	160	32.0	8.0	10	D	
5SDD 24F2800	2800	2800	2600	30.0	0.906	0.135	160	15.0	4.0	22	F	
5SDD 48H3200	3200	3200	4710	61.0	0.992	0.067	160	8.0	2.5	50	H2	
5SDD 54N4000	4000	3600	5200	85.0	0.800	0.086	150	5.7	1.0	90	N	
5SDD 40H4000	4000	4000	3847	46.0	0.900	0.133	160	8.0	2.5	50	H2	
5SDD 08D5000	5000	5000	1028	12.0	0.894	0.487	160	32.0	8.0	10	D	
5SDD 08T5000	5000	5000	1028	12.0	0.894	0.487	160	32.0	8.0	10	T1	
5SDD 20F5000	5000	5000	1978	24.0	0.940	0.284	160	15.0	4.0	22	F	
5SDD 38H5000	5000	5000	3814	45.0	0.903	0.136	160	8.0	2.5	50	H2	
5SDD 36K5000	5000	5000	3638	45.0	0.903	0.136	160	9.2	2.5	50	K	
5SDD 33L5500	5500	5000	3480	46.0	0.940	0.147	150	7.0	1.5	70	L1	
5SDD 50N5500	5500	5000	4570	73.0	0.800	0.107	150	5.7	1.0	90	N	
5SDD 06D6000	6000	6000	662	10.5	1.066	0.778	150	42.0	8.0	11	D	
5SDD 10F6000	6000	6000	1363	17.5	1.015	0.407	150	20.0	5.0	22	F	
5SDD 14F6000	6000	6000	1363	17.5	1.015	0.407	150	20.0	5.0	22	F	
5SDD 31H6000	6000	6000	3246	40.0	0.894	0.166	150	8.0	2.5	50	H2	
5SDD 50N6000	6000	6000	4210	71.2	0.800	0.134	150	5.7	1.0	90	N New	

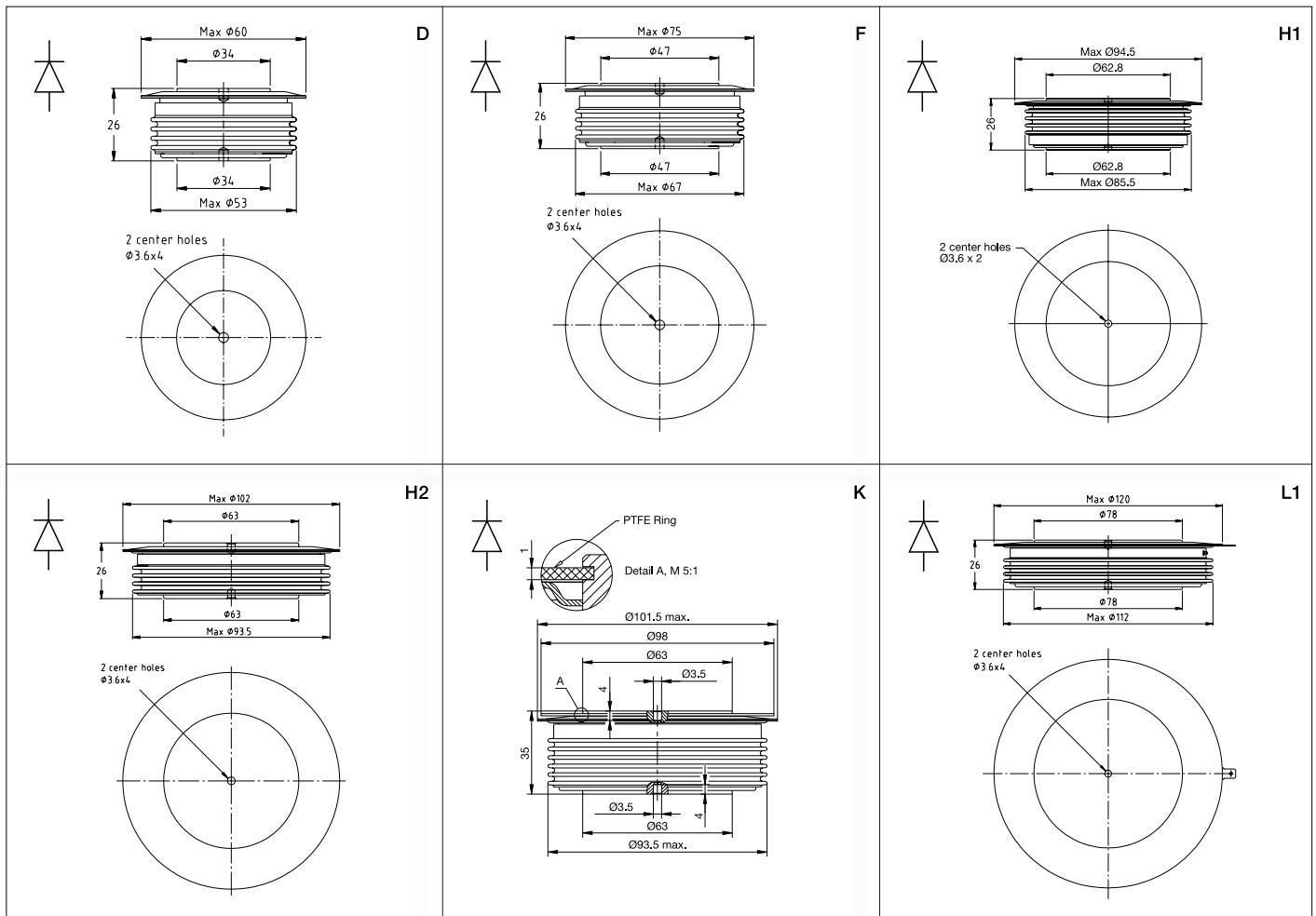
Drawings see page 36f.

Please refer to page 75 for part numbering structure.

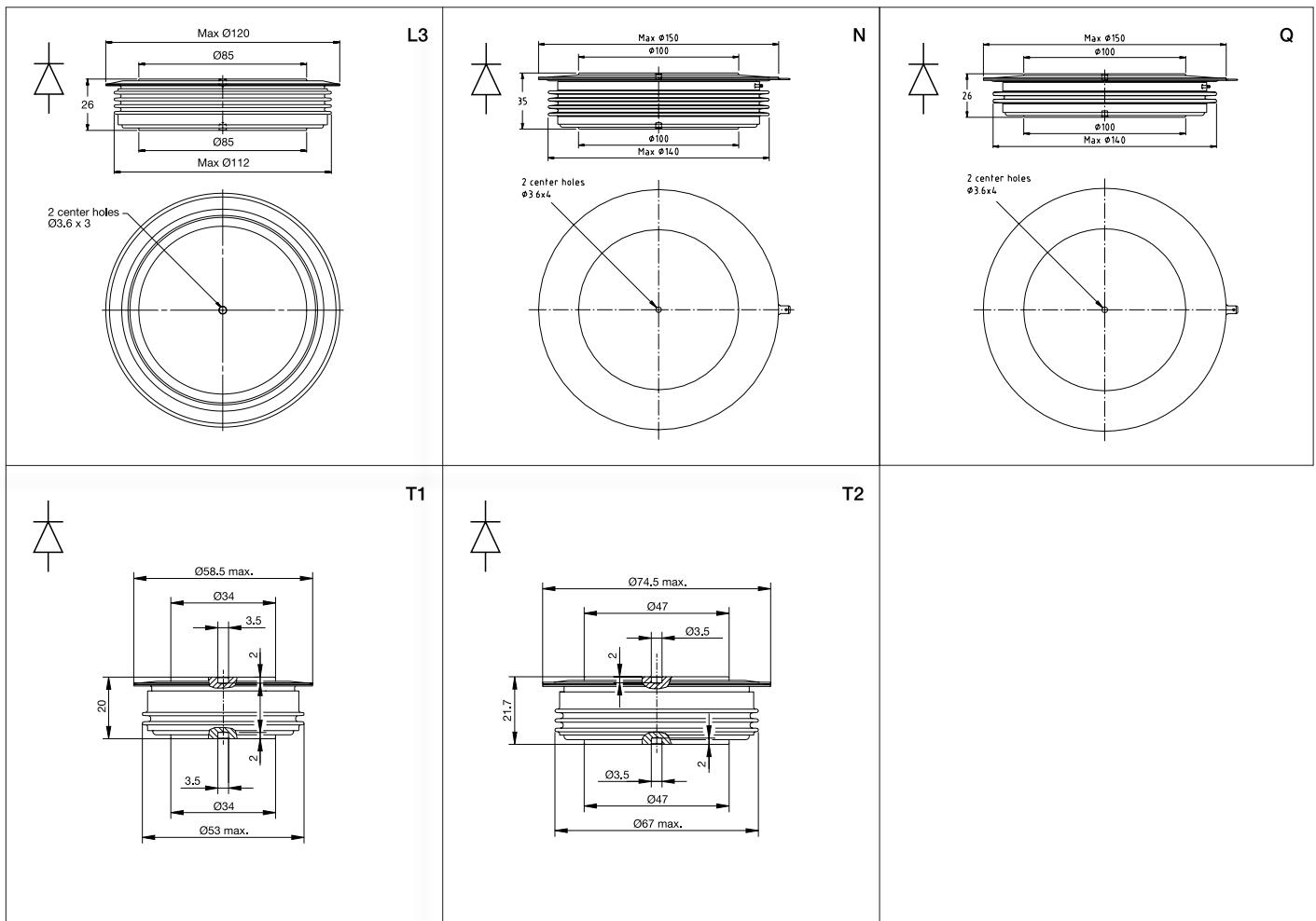
Avalanche diodes

Part number	V_{RRM}	I_{FAVM}	I_{FSM}	V_{FO}	r_F	P_{RSM} 20μs	T_{VJM}	R_{thJC}	R_{thCH}	F_m	Housing
		$T_c = 85^\circ\text{C}$	10ms	T_{VJM}							
		V	A	kA	V	mΩ	kW	°C	K/kW	K/kW	kN
5SDA 11D1702	1700	1310	15.0	0.74	0.25	50	160	40	10	11	D
5SDA 27F2002	2000	2700	31.0	0.79	0.09	100	160	20	5	22	F
5SDA 10D2303	2300	1140	13.5	0.83	0.30	50	160	40	10	11	D
5SDA 24F2303	2300	2350	29.0	0.84	0.13	75	160	20	5	22	F
5SDA 09D2604	2600	1020	11.5	0.87	0.39	50	160	40	10	11	D
5SDA 08D3205	3200	910	9.2	0.93	0.52	50	160	40	10	11	D
5SDA 21F3204	3200	2110	26.0	0.89	0.17	75	160	20	5	22	F
5SDA 07D3806	3800	790	7.6	1.01	0.72	50	160	40	10	11	D
5SDA 16F3806	3800	1620	20.5	1.03	0.32	50	160	20	5	22	F
5SDA 06D5007	5000	690	7.0	1.10	1.01	50	160	40	10	11	D
5SDA 14F5007	5000	1410	17.5	1.13	0.44	50	160	20	5	22	F

Please refer to page 75 for part numbering structure.



Dimensions in mm



Dimensions in mm

Welding diodes

Almost every second car driving in Europe has been fabricated using ABB welding diodes, as most of the major welding equipment manufacturers rely on ABB's quality, reliability and performance.

ABB's comprehensive product range offers medium frequency (up to 2 kHz) and high frequency (up to 10 kHz) welding diodes. They all feature very low on-state voltage and very low thermal resistance. In addition, they are available in light package, thin and hermetically sealed ceramic housings or even housing-less, another welcomed feature for equipment that is mounted directly on robot arms.



Medium frequency

Part number	V_{RRM}	V_{Fmin}	V_{Fmax}	I_{FAVM}	I_{FSM}	V_{F0}	r_F	T_{VJM}	R_{thJC}	R_{thCH}	F_m	Housing
	$T_j = 25^\circ\text{C}$, $I_F = 5000 \text{ A}$		$T_c = 85^\circ\text{C}$	10ms	T_{VJM}	T_{VJM}						
	V	V	V	A	kA	V	mΩ	°C	K/kW	K/kW	kN	
5SDD 71X0200	200	-	1.05	7110	55	0.74	0.026	170	10.0	5.0	22	X
5SDD 71B0200	200	-	1.05	7110	55	0.74	0.026	170	10.0	5.0	22	B
5SDD 0120C0200	200	-	0.92 *	11000	85	0.75	0.020	170	6.0	3.0	36	C
5SDD 71X0400	400	0.97	1.02	7110	55	0.74	0.026	170	10.0	5.0	22	X
5SDD 71B0400	400	-	1.05	7110	55	0.74	0.026	170	10.0	5.0	22	B
5SDD 0120C0400	400	0.83 *	0.88 *	11350	85	0.74	0.018	170	6.0	3.0	36	C
5SDD 92Z0401	400	-	1.03 *	9250	60	0.78	0.031	180	5.6	3.6	22	Z1
5SDD 0105Z0401	400	-	1.01 *	10502	70	0.812	0.026	180	5.0	2.5	30	Z2
5SDD 0135Z0401	400	-	0.92 *	13500	85	0.758	0.021	180	3.9	2.6	35	Z3

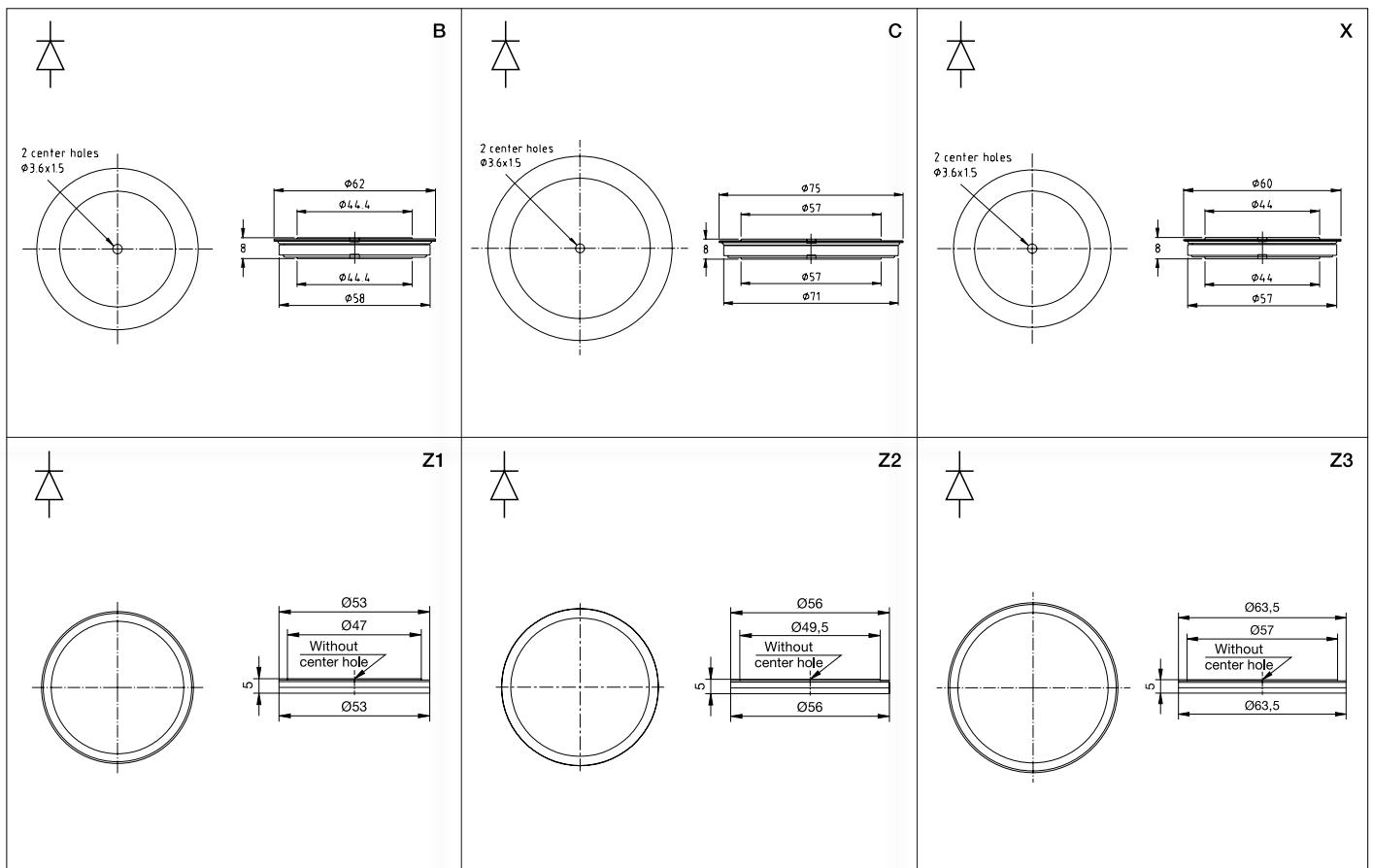
* at 8000 A, T_{VJM}

High frequency

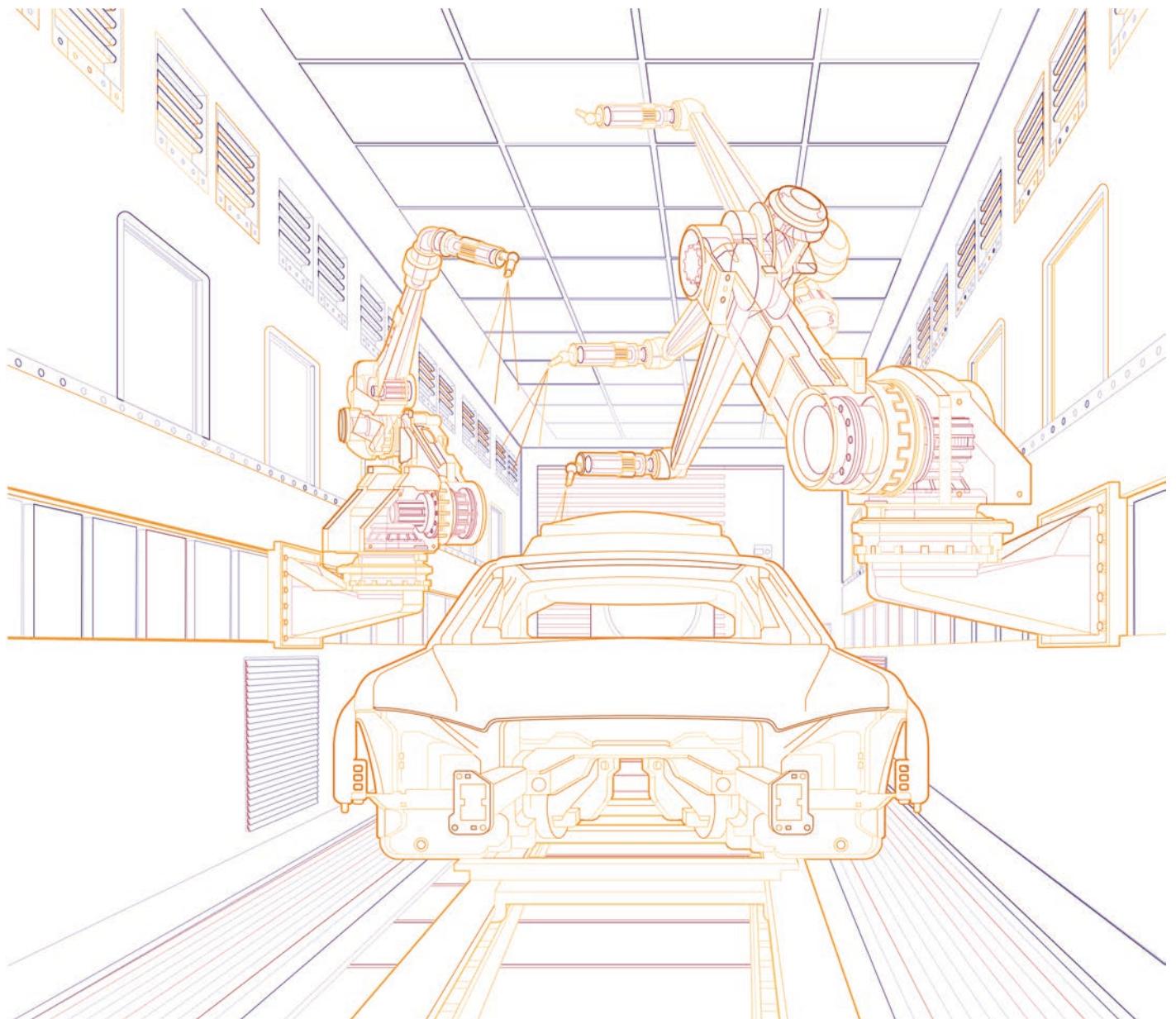
Part number	V_{RRM}	V_{Fmax}	I_{FAVM}	I_{FSM}	V_{F0}	r_F	Q_{rr}	T_{VJM}	R_{thJC}	R_{thCH}	F_m	Housing
	T_{VJM}		$T_c = 85^\circ\text{C}$	10ms	T_{VJM}	T_{VJM}	T_{VJM}					
	V	V	A	kA	V	mΩ	μC	°C	K/kW	K/kW	kN	
5SDF 63B0400	400	1.14	6266	44	0.96	0.036	180	190	10.0	5.0	22	B
5SDF 63X0400	400	1.14	6266	44	0.96	0.036	180	190	10.0	5.0	22	X
5SDF 90Z0401	400	1.13	9041	48	0.98	0.032	200	190	5.6	3.6	22	Z1
5SDF 0102C0400	400	1.14 *	10159	70	0.98	0.022	300	190	6.0	3.0	35	C
5SDF 0103Z0401	400	1.20 *	10266	54	1.00	0.027	230	190	5.0	2.5	30	Z2
5SDF 0131Z0401	400	1.14 *	13058	70	0.98	0.022	300	190	3.9	2.6	35	Z3

* at 8000 A

Please refer to page 75 for part numbering structure.



Dimensions in mm



Thyristors

High-power thyristors are used in applications ranging from 100 kW soft starters up to HVDC stations rated above 10 GW. Besides commonly being used at line frequency, they are also found in the kilohertz range applications like induction heating. Such applications can take advantage from devices where multiple functionalities are integrated in a single housing, like the integration of a diode and a thyristor or two antiparallel thyristors.

ABB offers the following thyristor families:

- Phase control thyristors (PCTs) → page 44
- Bi-directionally controlled thyristors (BCTs) → page 48
- Reverse conducting thyristors (RCTs) → page 50



Phase control thyristors – PCTs

ABB Semiconductors' phase control thyristor has been the backbone of the high-power electronics industry since its introduction almost 50 years ago and has set benchmark reliability records over many years.

The field of PCT applications ranges from kW DC drives and MW rated line commutated frequency converters to GW converters for HVDC transmission.

ABB was the first company to introduce 6“ thyristor products and offers the most complete range of high-power thyristors. New thyristor products continue to be developed with focus on minimizing overall losses and maximizing the power rating of the device.

Applications using two antiparallel thyristors can take advantage of ABB's innovative bi-directionally controlled thyristors (BCTs) that incorporate two antiparallel thyristors in a single housing (see page 48).

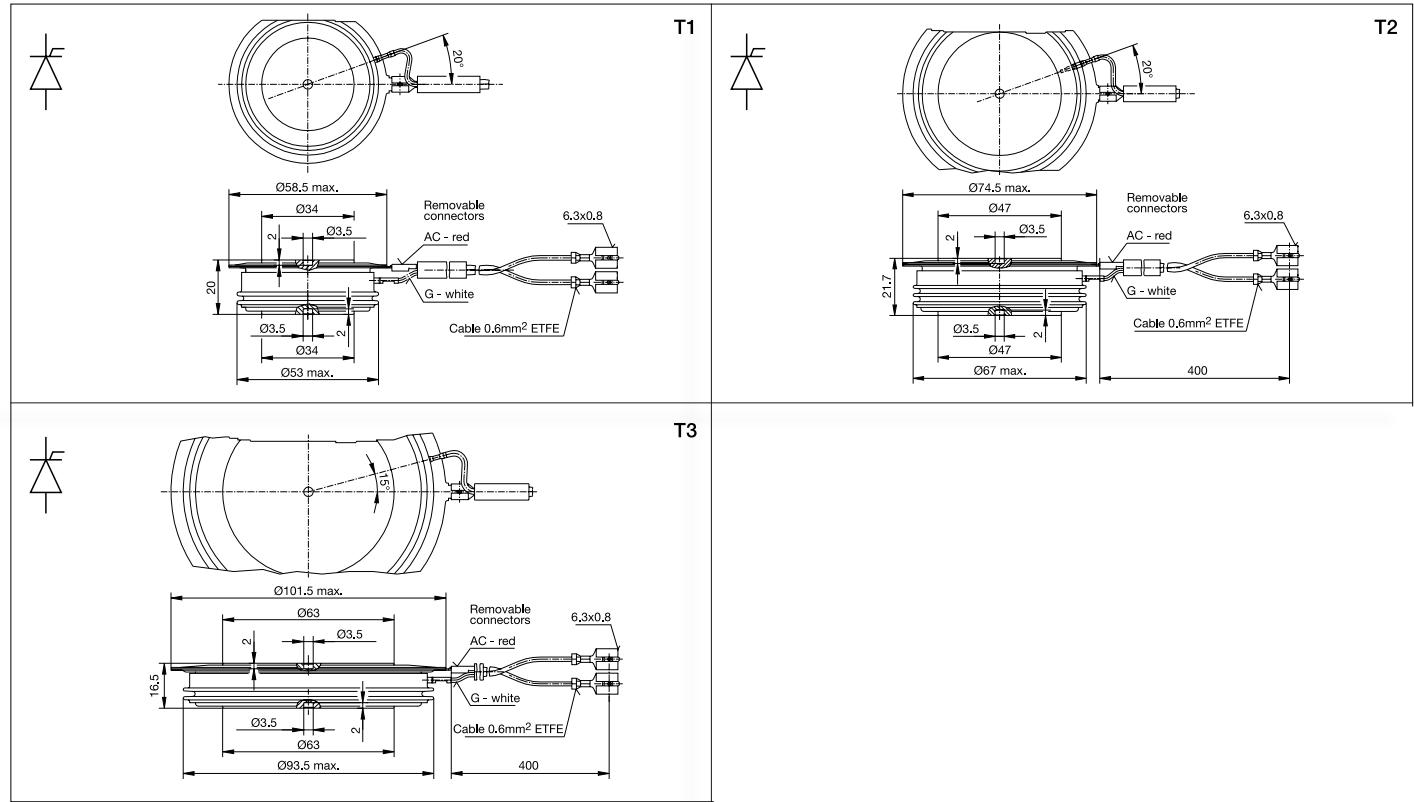


Part number	V_{DRM}, V_{RRM}	I_{TAVM}	I_{TSM}	V_{T0}	r_T	T_{VJM}	R_{thJC}	R_{thCH}	F_m	Housing
	T_{VJM}	$T_c = 70^\circ\text{C}$	10ms T_{VJM}	T_{VJM}						
	V	A	kA	V	mΩ	°C	K/kW	K/kW	kN	
5STP 10D1601	1600	969	15.0	0.93	0.302	125	32.0	10.0	10	D
5STP 10T1600	1600	969	15.0	0.93	0.302	125	32.0	10.0	10	T1
5STP 20F1601	1600	1901	27.3	0.95	0.152	125	16.0	4.0	22	F
5STP 20T1600	1600	1956	27.3	0.95	0.152	125	15.5	4.0	22	T2
5STP 34H1601	1600	3370	49.0	0.94	0.066	125	10.0	3.0	50	H
5STP 34T1600	1600	3370	49.0	0.94	0.066	125	10.0	3.0	50	T3
5STP 07D1800	1800	730	9.0	0.80	0.540	125	36.0	7.5	10	D
5STP 09D1801	1800	932	13.7	0.94	0.341	125	32.0	10.0	10	D
5STP 18F1800	1800	1660	21.0	0.83	0.230	125	17.0	4.0	22	F
5STP 18F1801	1800	1825	26.2	0.97	0.170	125	16.0	4.0	22	F
5STP 30H1801	1800	3108	47.0	0.98	0.081	125	10.0	3.0	50	H
5STP 42L1800	1800	4170	64.0	0.85	0.082	125	7.0	1.5	70	L
5STP 50Q1800	1800	6100	94.0	0.90	0.050	125	5.0	1.0	90	Q
5STP 09D2201	2200	863	12.0	0.98	0.414	125	32.0	10.0	10	D
5STP 17F2201	2200	1702	25.5	0.99	0.206	125	16.0	4.0	22	F
5STP 17T2200	2200	1743	25.5	0.99	0.206	125	15.5	4.0	22	T2
5STP 29H2201	2200	2855	45.0	1.00	0.107	125	10.0	3.0	50	H
5STP 06D2800	2800	620	8.8	0.92	0.780	125	36.0	7.5	10	D
5STP 08D2801	2800	792	10.6	1.06	0.492	125	32.0	10.0	10	D
5STP 08T2800	2800	792	10.6	1.06	0.492	125	32.0	10.0	10	T1
5STP 15T2800	2800	1589	23.6	1.02	0.265	125	15.5	4.0	22	T2
5STP 16F2800	2800	1400	18.0	0.82	0.370	125	17.0	4.0	22	F
5STP 16F2801	2800	1554	23.6	1.02	0.265	125	16.0	4.0	22	F
5STP 27H2801	2800	2670	43.0	1.04	0.127	125	10.0	3.0	50	H
5STP 33L2800	2800	3740	65.5	0.95	0.100	125	7.0	1.5	70	L

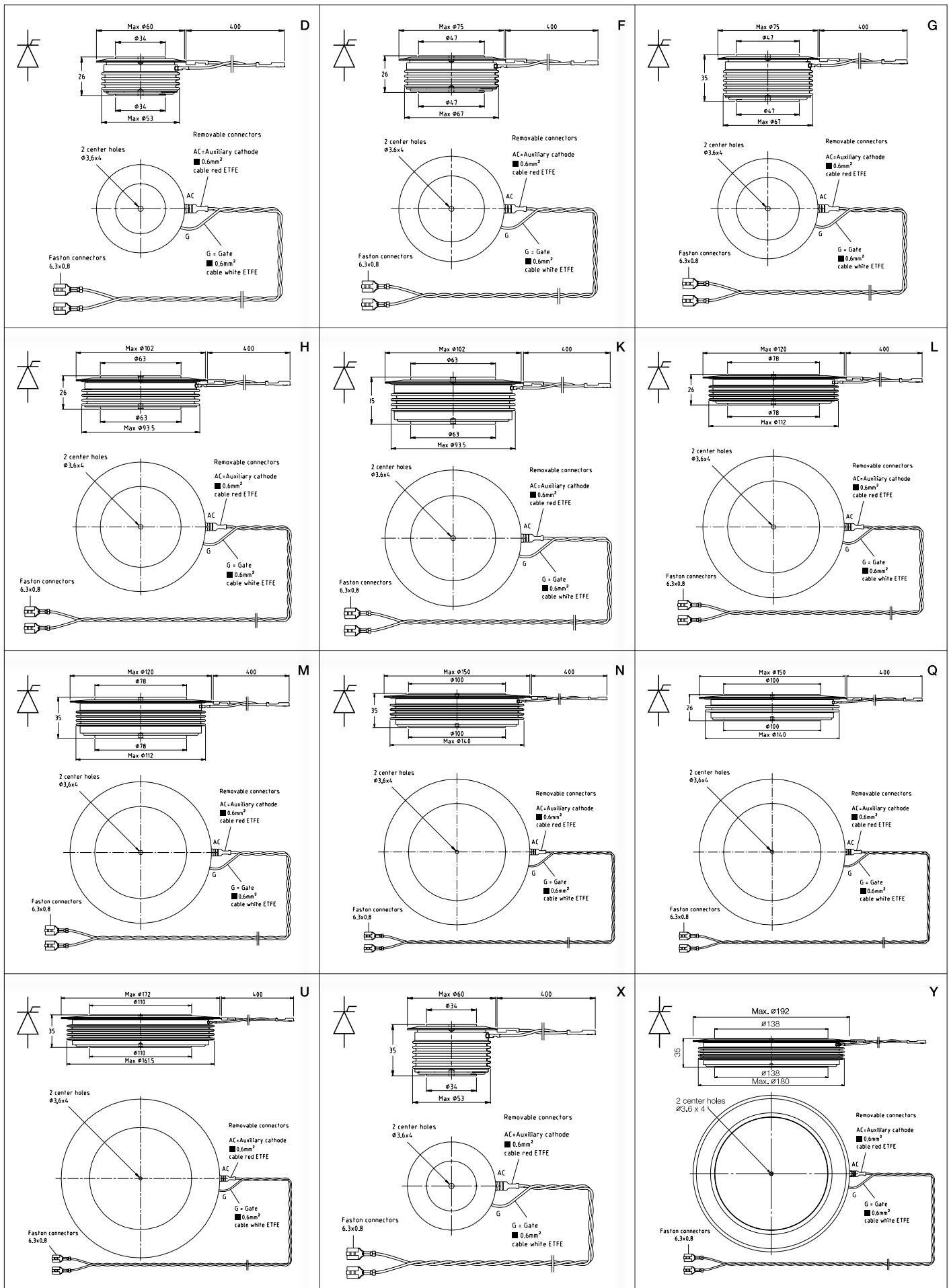
Please refer to page 74 for part numbering structure.

Part number	V_{DRM}, V_{RRM}	I_{TAVM}	I_{TSM}	V_{T_0}	r_T	T_{VJM}	R_{thJC}	R_{thCH}	F_m	Housing
	T_{VJM}	$T_c = 70^\circ\text{C}$	10ms	T_{VJM}						
	V	A	kA	V	mΩ	°C	K/kW	K/kW	kN	
5STP 45N2800	2800	5080	77.0	0.86	0.070	125	5.7	1.0	90	N
5STP 45Q2800	2800	5490	77.0	0.86	0.070	125	5.0	1.0	90	Q
5STP 04D4200	4200	470	7.1	1.00	1.500	125	36.0	7.5	10	D
5STP 12F4200	4200	1150	17.3	0.95	0.575	125	17.0	4.0	22	F
5STP 21H4200	4200	2192	32.0	1.25	0.191	125	10.0	3.0	50	H
5STP 28L4200	4200	3170	54.0	0.97	0.158	125	7.0	1.5	70	L
5STP 38N4200	4200	3960	64.5	0.95	0.130	125	5.7	1.0	90	N
5STP 38Q4200	4200	4275	64.5	0.95	0.130	125	5.0	1.0	90	Q
5STP 04D5200	5200	440	6.1	1.20	1.600	125	36.0	7.5	10	D
5STP 17H5200	5200	1975	34.0	1.02	0.320	125	10.0	2.0	50	H
5STP 25L5200	5200	2760	50.5	1.00	0.225	125	7.0	1.5	70	L
5STP 25M5200	5200	2540	50.5	1.00	0.225	125	9.0	1.5	70	M
5STP 34N5200	5200	3600	63.0	1.03	0.160	125	5.7	1.0	90	N
5STP 34Q5200	5200	3875	63.0	1.03	0.160	125	5.0	1.0	90	Q
5STP 52U5200	5200	5120	99.0	1.04	0.115	125	4.0	0.8	135	U
5STP 03D6500	6500	380	4.7	1.20	2.300	125	36.0	7.5	10	D
5STP 03X6500	6500	350	4.7	1.20	2.300	125	45.0	7.5	10	X
5STP 08F6500	6500	830	15.1	1.24	1.015	125	17.0	4.0	22	F
5STP 08G6500	6500	720	15.1	1.24	1.015	125	22.0	4.0	22	G
5STP 12K6500	6500	1370	31.5	1.18	0.632	125	11.0	2.0	50	K
5STP 18M6500	6500	1800	47.5	1.20	0.430	125	9.0	1.5	70	M
5STP 26N6500	6500	2810	65.0	1.12	0.290	125	5.7	1.0	90	N
5STP 42U6500	6500	4250	86.0	1.24	0.162	125	4.0	0.8	135	U
5STP 48Y7200 * New	7200	4840	92.0	1.06	0.115	110	3.0	0.6	190	Y
5STP 45Y8500 * New	8500	4240	90.0	1.10	0.160	110	3.0	0.6	190	Y
5STP 27N8500 * New	8500	2450	64.0	1.09	0.420	125	5.7	1.0	90	N
5STP 27Q8500 * New	8500	2630	64.0	1.09	0.420	125	5.0	1.0	90	Q

* Contact factory / Please refer to page 74 for part numbering structure.



Dimensions in mm



Dimensions in mm

Bi-directionally controlled thyristors – BCTs

Improved volume consumption and reduced part count for SVC, 4-quadrant DC-drive or soft starter equipment in the magnitude of 25 percent compared with equally rated PCT-solutions are possible with ABB's BCTs – without jeopardizing reliability and performance.

ABB's innovative bi-directionally controlled thyristor (BCT) features two monolithically integrated antiparallel thyristors in a single housing. The two thyristor halves are individually triggered and have a separation region enabling the design of high-voltage devices with the dynamic capability of discrete devices.

The BCT is designed, manufactured and tested using the same philosophy, technology and equipment as the well-established PCT (page 44), thus reaching the same levels of performance and reliability.

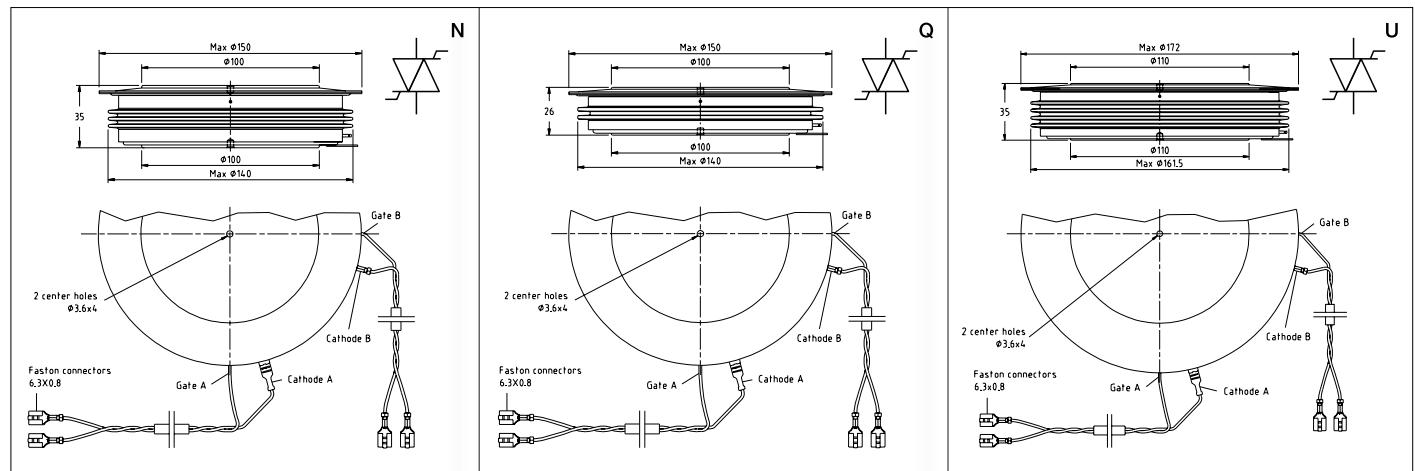
A table of replacement of PCTs by BCTs is given in the BCT application note which can be found at www.abb.com/semiconductors.



Part number	V_{RM}	V_{RMS}^*	I_{TAVM}	I_{TSM}	V_{TO}	r_T	T_{VJM}	R_{thJC}	R_{thCH}	F_m	Housing
	T_{VJM}	$T_c = 70^\circ\text{C}$	$T_c = 70^\circ\text{C}$	10ms	T_{VJM}						
	V	A	A	kA	V	mΩ	°C	K/kW	K/kW	kN	
5STB 24N2800	2800	5400	2430	43.0	0.85	0.160	125	11.4	2.0	90	N
5STB 24Q2800	2800	5840	2630	43.0	0.85	0.160	125	10.0	2.0	90	Q
5STB 18N4200	4200	4260	1920	32.0	0.96	0.285	125	11.4	2.0	90	N
5STB 17N5200	5200	4000	1800	29.0	1.02	0.320	125	11.4	2.0	90	N
5STB 25U5200	5200	4400	1980	42.0	1.06	0.219	110	8.5	1.6	135	U
5STB 13N6500	6500	3120	1405	22.0	1.20	0.600	125	11.4	2.0	90	N
5STB 18U6500	6500	3510	1580	29.7	1.20	0.458	110	8.5	1.6	135	U

* AC full-wave

Please refer to page 74 for part numbering structure.



Dimensions in mm

Reverse conducting thyristors

ABB's reverse conducting thyristors feature optimized and very short turn-on and turn-off time, large critical rates of on-state current rise, high surge current ratings and a wide operating temperature range.

These thyristors feature a monolithically integrated free-wheeling diode and are typically used in DC chopper drives, pulse power and other fast switching applications.

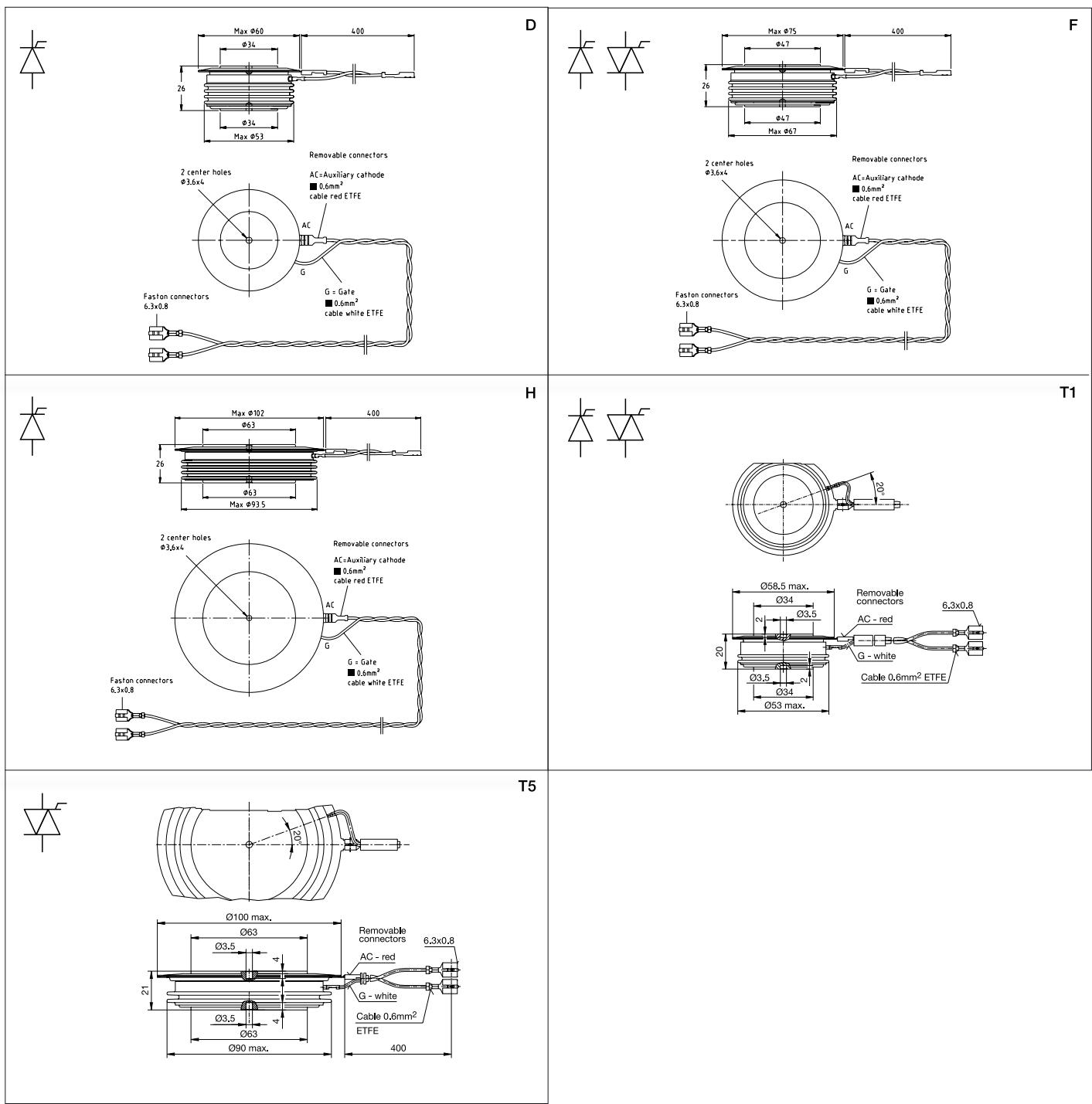
They are also available as spare and replacement parts.



Reverse conducting fast thyristors

Part number	V_{DRM}	I_{TAVM}/I_{FAVM}	I_{TSM}/I_{FSM}	V_{TO}/V_{F0}	r_T/r_F	t_q	T_{VJM}	R_{thJC}	R_{thCH}	F_m	Housing
	$T_c = 70^\circ\text{C}$	10ms T_{VJM}	T_{VJM}								
	V	A	kA	V	mΩ	μs	°C	K/kW	K/kW	kN	
5STR 03T2040 FST	2000	360	5.0	1.55	1.010	40.0	125	55	10	10	T1
Diode part		223	3.5	1.34	2.100	4.0	125	98	-	-	
5STR 10T2520 FST	2500	857	14.0	2.04	0.321	20.0	125	20	3	30	T5
Diode part		388	6.0	1.49	1.066	4.0	125	50	-	-	

Please refer to page 74 for part numbering structure.



Dimensions in mm

Integrated gate-commutated thyristors – IGCTs

Within 15 years of its introduction, the IGCT has established itself as the semiconductor of choice for high-power frequency converters by meeting the requirements of today's demanding applications.

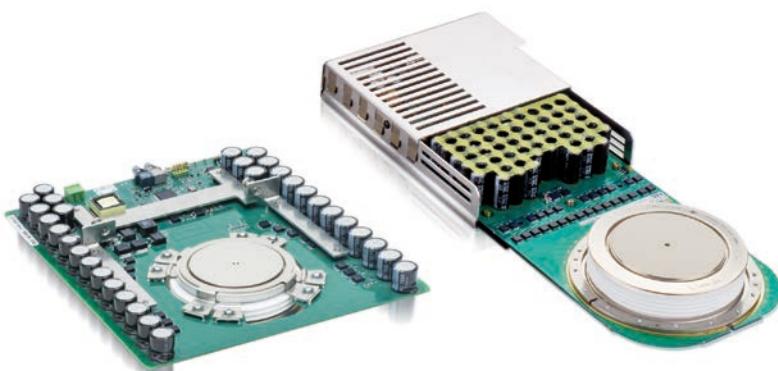
ABB Semiconductors' IGCTs are used in a multitude of applications due to their versatility, efficiency and cost-effectiveness. With their low on-state voltage, they achieve the lowest running costs by reaching inverter efficiencies of 99.6 percent and more.

Single inverters of over 15 MVA can be realised without series or parallel connection, thus achieving the highest inverter power densities in the industry.

The number of applications featuring IGCTs is manifold: medium-voltage drives (MVDs), marine drives, co-generation, wind power converters and STATCOMs, to name just a few.

The latest record performance using IGCTs was achieved with the world's most powerful frequency converter (100 MVA) for variable speed pumped hydropower application that ABB has installed to the Grimsel 2 power plant in the Swiss Alps.

ABB's most recent IGCT development is the 6,500 V reverse blocking (RB) IGCT. This symmetrical IGCT is optimized for the current source inverter technology in medium-voltage drive and breaker applications.



Asymmetric IGCTs

Part number	V_{DRM}	V_{DC}	V_{RRM}	I_{TGQM}	I_{TAVM}	I_{TSM}		V_T	V_{T0}	r_T	T_{VJM}	R_{thJC}	R_{thCH}	F_m	V_{GIN}	Outline
					$T_c = 85^\circ C$		3ms	10ms	4000A	T_{VJM}						
	V	V	V	A	A	kA	kA	V	V	mΩ	°C	K/kW	K/kW	kN	V	
5SHY 35L4520	4500	2800	17	4000	1700	50	32	2.70	1.40	0.33	125	8.5	3	40	28-40	Fig. 1
5SHY 35L4521	4500	2800	17	4000	1700	50	32	2.70	1.40	0.33	125	8.5	3	40	28-40	Fig. 1
5SHY 35L4522	4500	2800	17	4000	2100	56	35	2.00	1.15	0.21	125	8.5	3	40	28-40	Fig. 1
5SHY 40L4511	4500	2800	17	3600	1430	39	28	3.50	1.70	0.45	125	8.5	3	40	28-40	Fig. 1
5SHY 55L4500	4500	2800	17	5000	1870	50	33	2.35	1.22	0.28	125	8.5	3	40	28-40	Fig. 1
5SHY 50L5500	5500	3300	17	3600	1290	40	26	4.10	1.66	0.62	125	8.5	3	40	28-40	Fig. 1
5SHY 42L6500	6500	4000	17	3800	1290	40	26	4.10	1.88	0.56	125	8.5	3	40	28-40	Fig. 1

- optimized for snubberless turn-off
- contact factory for series connection

Reverse blocking IGCTs

Part number	V_{DRM}	V_{RRM}	I_{TGQM}	I_{TAVM}	V_T	V_{T0}	r_T	T_{VJM}	R_{thJC}	F_m	V_{GIN}	Outline
					$T_c = 85^\circ C$		800A	T_{VJM}				
	V	V	A	A	V	V	mΩ	°C	K/kW	kN	V	
5SHZ 11H6500	6500	6500	1100	490	5.87	2.92	3.69	125	14	20	19-21	Fig. 2

Reverse conducting IGCTs

Part number	V_{DRM}	V_{DC}	I_{TGQM}	I_{TAVM} / I_{FAVM}	I_{TSM} / I_{FSM}	V_T / V_F	V_{T0} / V_{F0}	r_T / r_F	di/dt	I_{rr}	T_{VJM}	R_{thJC}	F_m	V_{GIN}	Outline
					$T_c = 85^\circ C$		10ms	I_{TGQM}	T_{VJM}	max.					
	V	V	A	A	kA	V	V	mΩ	A/μs	A	°C	K/kW	kN	V	
5SHX 26L4520 GCT	4500	2800	2200	1010		17.0	2.95	1.80	0.53				13		
Diode part				390		10.6	5.40	2.70	1.24	650	900	125	26	44	28-40
5SHX 19L6020 GCT	5500	3300	1800	840		18.0	3.45	1.90	0.90				13		
Diode part				340		7.7	6.40	2.70	2.23	510	780	125	26	44	28-40

- monolithically integrated free-wheeling diode optimized for snubberless turn-off
Please refer to page 74 for part numbering structure.

Fig. 1

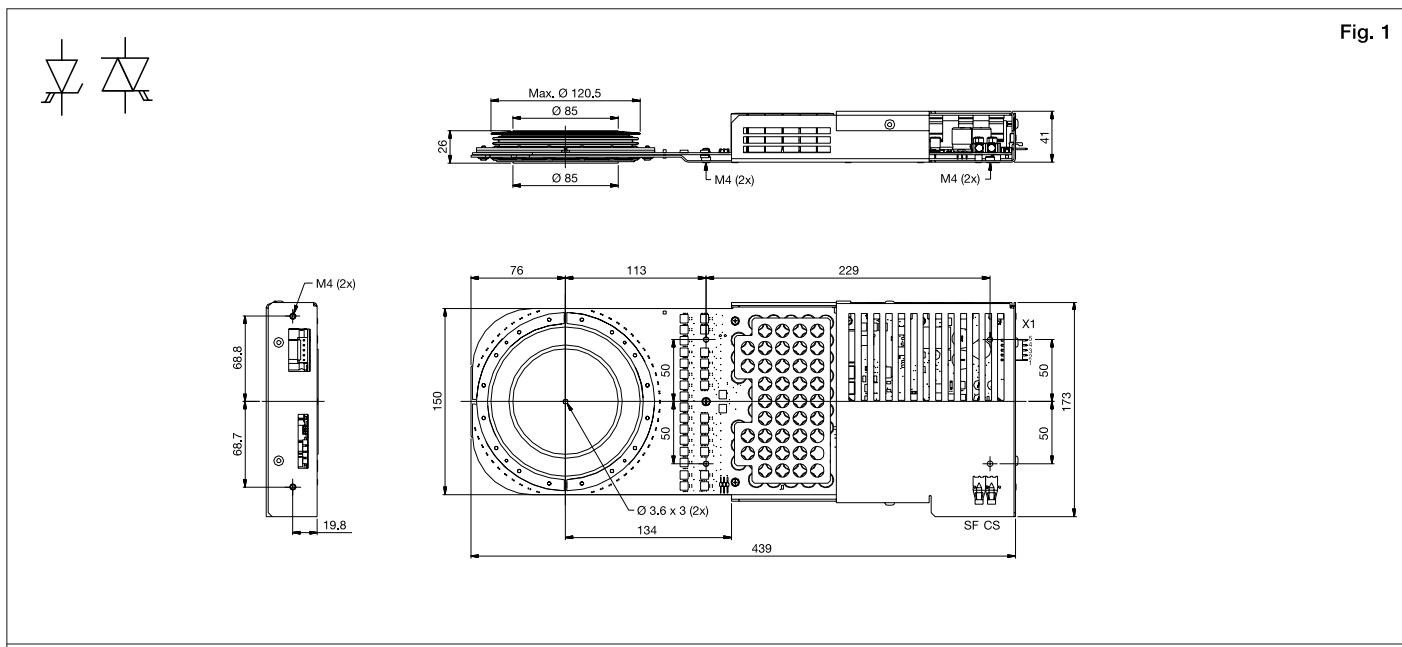
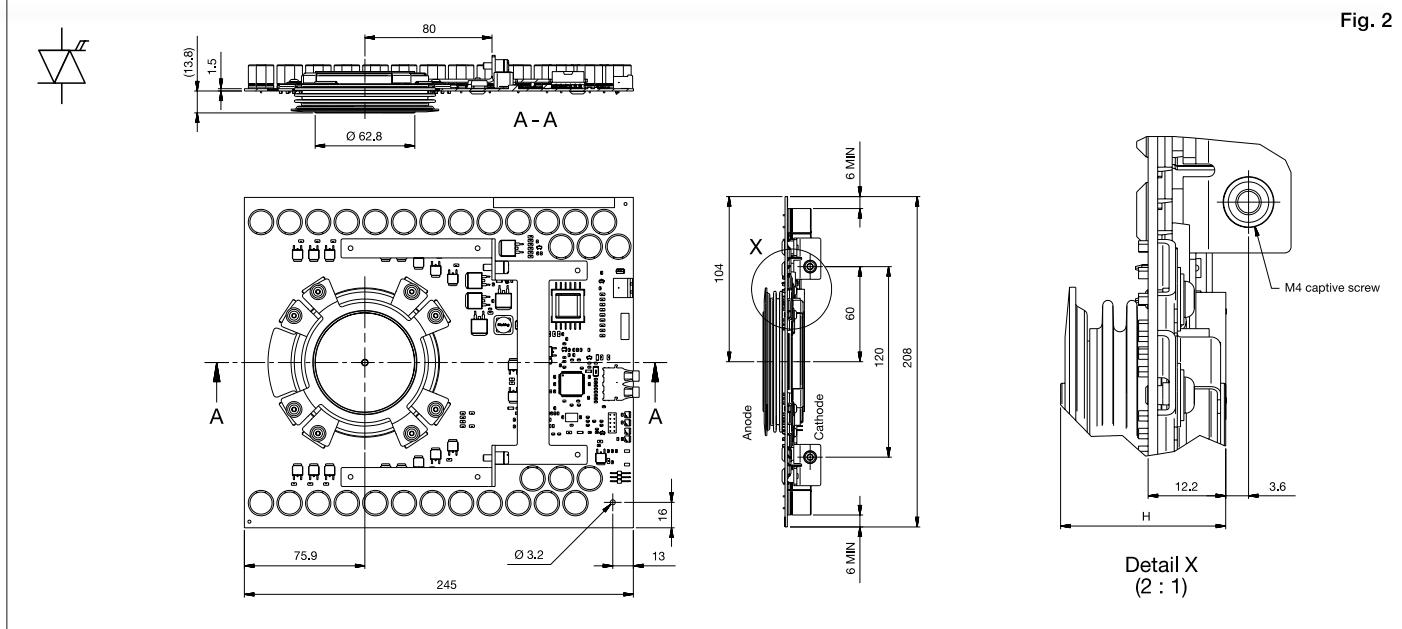


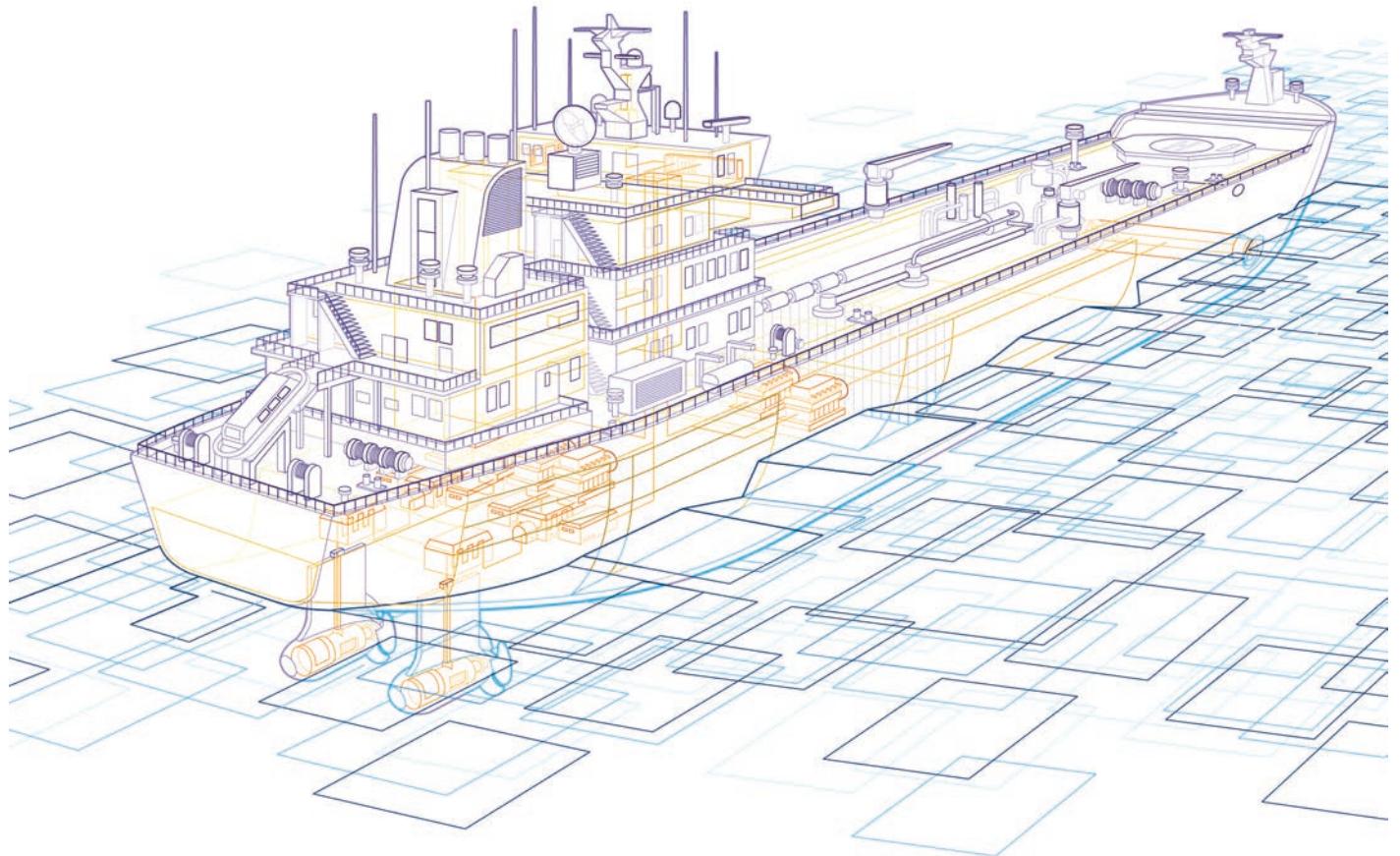
Fig. 2



Dimensions in mm

Fast recovery diode recommendation

For all asymmetric and reverse conducting IGCTs, ABB offers matching free-wheeling, neutral point (NPC) and clamp diodes. The actual choice of the diode depends on the specific application. Please see application note 5SYA 2064, Applying fast recovery diodes, on www.abb.com/semiconductors.



Gate turn-off thyristors – GTOs

One might be assuming that the rapid advance of the IGBT would spell an equally rapid end to the GTO era. The demand for these devices, however, is still strong today.

ABB offers a broad portfolio of asymmetric GTOs with proven field reliability in various traction and industrial applications.

Asymmetric GTOs are divided in two categories: fine pattern and standard. Fine pattern GTOs with buffer layer have exceptionally low on-state and dynamic losses and are optimized for fast switching.



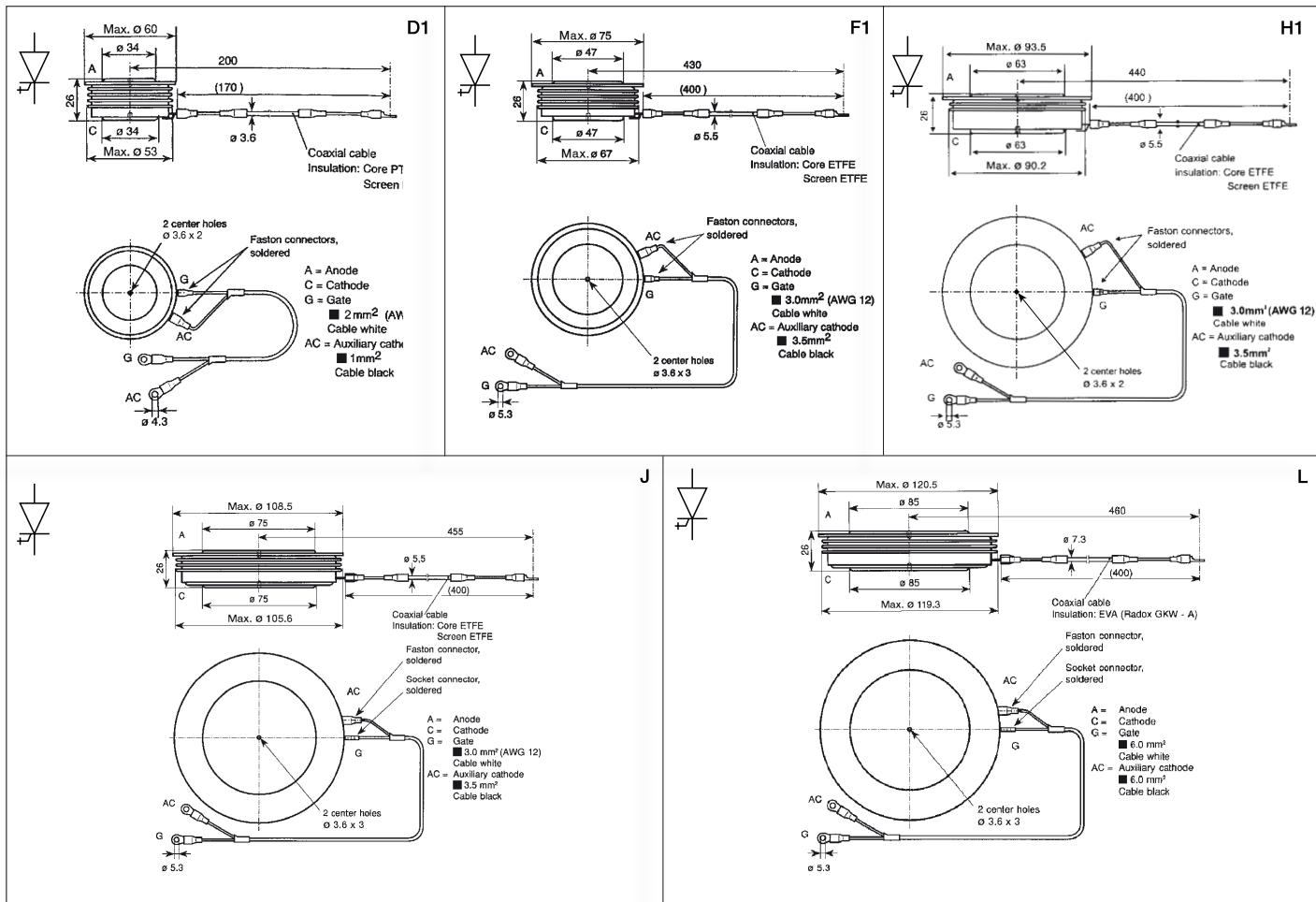
Asymmetric GTOs

Part number	V_{DRM}	V_{DC}	V_{RRM}	I_{TGQM} at C_S	I_{TAVM}	I_{TSM}	V_T	V_{T0}	r_T	T_{VJM}	R_{thJC}	R_{thCH}	F_m	Housing	
	V	V	V	A	μF	A	kA	V	V	$m\Omega$	$^\circ C$	K/kW	K/kW	kN	
5SGA 15P2502	2500	1400	17	1500	3	570	10.0	2.80	1.45	0.90	125	27	8	15	F1
5SGA 20H2501	2500	1400	17	2000	4	830	16.0	2.80	1.66	0.57	125	17	5	20	H1
5SGA 25H2501	2500	1400	17	2500	6	830	16.0	3.10	1.66	0.57	125	17	5	20	H1
5SGA 30J2501	2500	1400	17	3000	5	1300	30.0	2.50	1.50	0.33	125	12	3	40	J
5SGA 06D4502	4500	2800	17	600	1	210	3.0	4.00	1.90	3.50	125	50	8	11	D1
5SGA 20H4502	4500	2200	17	2000	4	710	13.0	3.50	1.80	0.85	125	17	5	20	H1
5SGA 30J4502	4500	2800	17	3000	6	930	24.0	4.00	2.20	0.60	125	12	3	40	J
5SGA 40L4501	4500	2800	17	4000	6	1000	25.0	4.40	2.10	0.58	125	11	3	40	L

Asymmetric fine pattern GTOs with buffer layer

5SGF 30J4502	4500	3000	17	3000	3	960	24.0	3.90	1.80	0.70	125	12	3	33	J
5SGF 40L4502	4500	2800	17	4000	6	1180	25.0	3.80	1.20	0.65	125	11	3	40	L

Please refer to page 74 for part numbering structure.

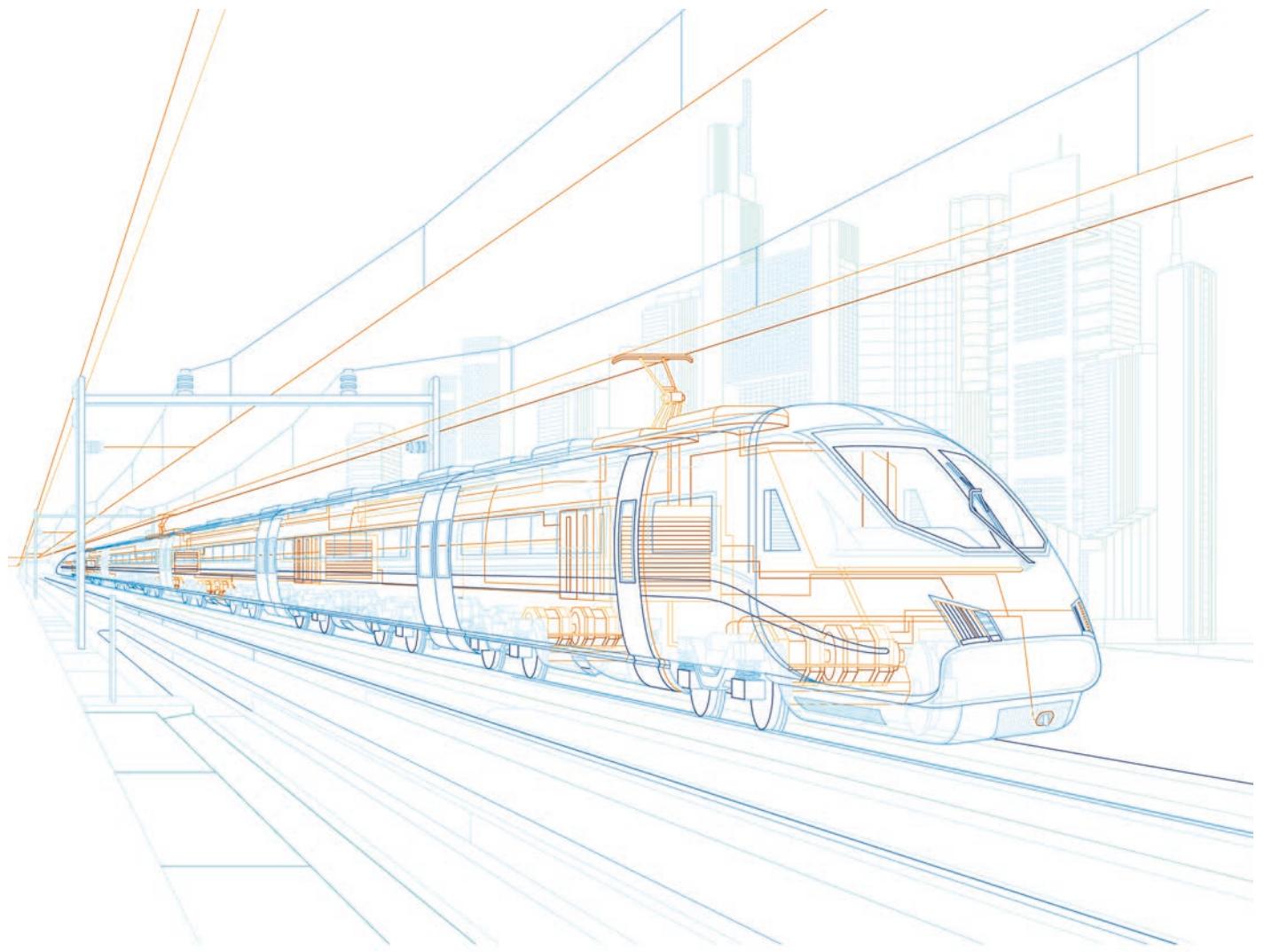


Dimensions in mm

Fast recovery diode recommendation

For all GTO types, ABB offers matching free-wheeling and snubber diodes.

The actual choice of the diode depends on the specific application. Please see application note 5SYA 2064, Applying fast recovery diodes, on www.abb.com/semiconductors.



Silicon surge voltage suppressors

ABB's power semiconductor devices exhibit impressive robustness against inadmissibly over-voltages. In certain applications, however, silicon surge voltage suppressors are still used today as they protect for example power thyristors against small and medium power surges (eg 200 kW over 10 µs) and thus allow the use of thyristors with lower voltage capability and much smaller snubber circuits.

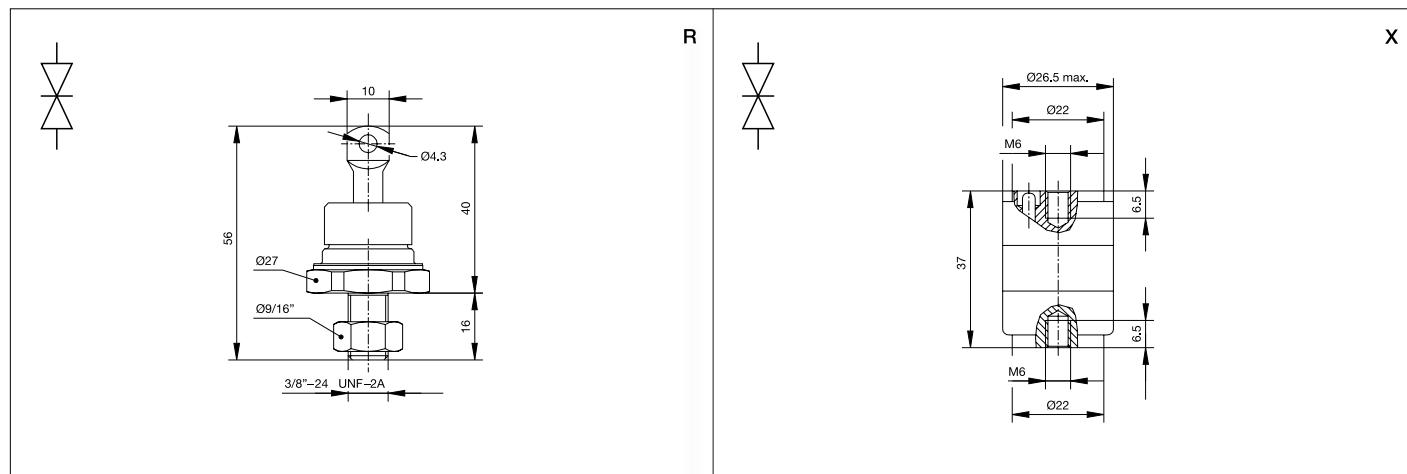
ABB Semiconductors' silicon surge voltage suppressors feature symmetric blocking characteristics with avalanche breakdown capability and offer an effective protection against repetitive and non-repetitive over-voltages. Several types of surge voltage suppressors are available as spare and replacement parts.



Part number ** = $V_R/100V$	V_R $T_{VJ} = 60^\circ\text{C}$	Tolerance $T_{VJ} = 60^\circ\text{C}$	I _{RM} for base width				T_{VJM}	R_{thJH}	Housing	
			10μs	100μs	1ms	10ms				
			V	V	A	A	A	°C	K/kW	
5SSA 50R**00	500, 600	±60	500	135	33	7.5	125	600	R	
5SSA 38R**00	700, 800	±60	380	100	25	4.5	125	600	R	
5SSA 30R**00	900, 1000	±60	300	80	21	4.0	125	600	R	
5SSA 26R**00	1100, 1200	±60	260	67	18	3.6	125	600	R	
5SSA 23R**00	1300, 1400	±60	230	58	15	3.4	125	600	R	
5SSA 20P**00	1500, 1600	±60	200	50	13	3.0	125	600	R	
5SSB 50X**00	450, 550	±50	500	135	33	7.5	125	500	X	
5SSB 38X**00	650, 750	±50	380	100	25	4.5	125	500	X	
5SSB 30X**00	850, 950	±50	300	80	21	4.0	125	500	X	
5SSB 26X**00	1050, 1150	±50	260	67	18	3.6	125	500	X	
5SSB 23X**00	1250, 1350	±50	230	58	15	3.4	125	500	X	
5SSB 20X**00	1450, 1550	±50	200	50	13	3.0	125	500	X	
5SSB 30X**00	1650, 1750, 1850, 1950	±50	300	80	21	4.0	125	250	X	
5SSB 26X**00	2050, 2150, 2250, 2350	±50	260	67	18	3.6	125	250	X	
5SSB 23X**00	2450, 2550, 2650, 2750	±50	230	58	15	3.4	125	250	X	
5SSB 20X**00	2850, 2950	±50	200	50	13	3.0	125	250	X	

** = $V_R/100V$

Please refer to page 75 for part numbering structure.



Test systems for high-power semiconductors

ABB Semiconductors is well known as one of the leading suppliers of power semiconductors. Good to know that ABB Semiconductors also designs, manufactures and offers CE compliant customized power semiconductor test systems.

More than 30 years of experience and proximity to semiconductor development, production and application enable ABB to offer test systems for various environments like research & development, laboratory, production or failure analysis. Highest quality assurance, safe handling, as well as remote or on-site service capability are guaranteed.

High-power semiconductor test systems

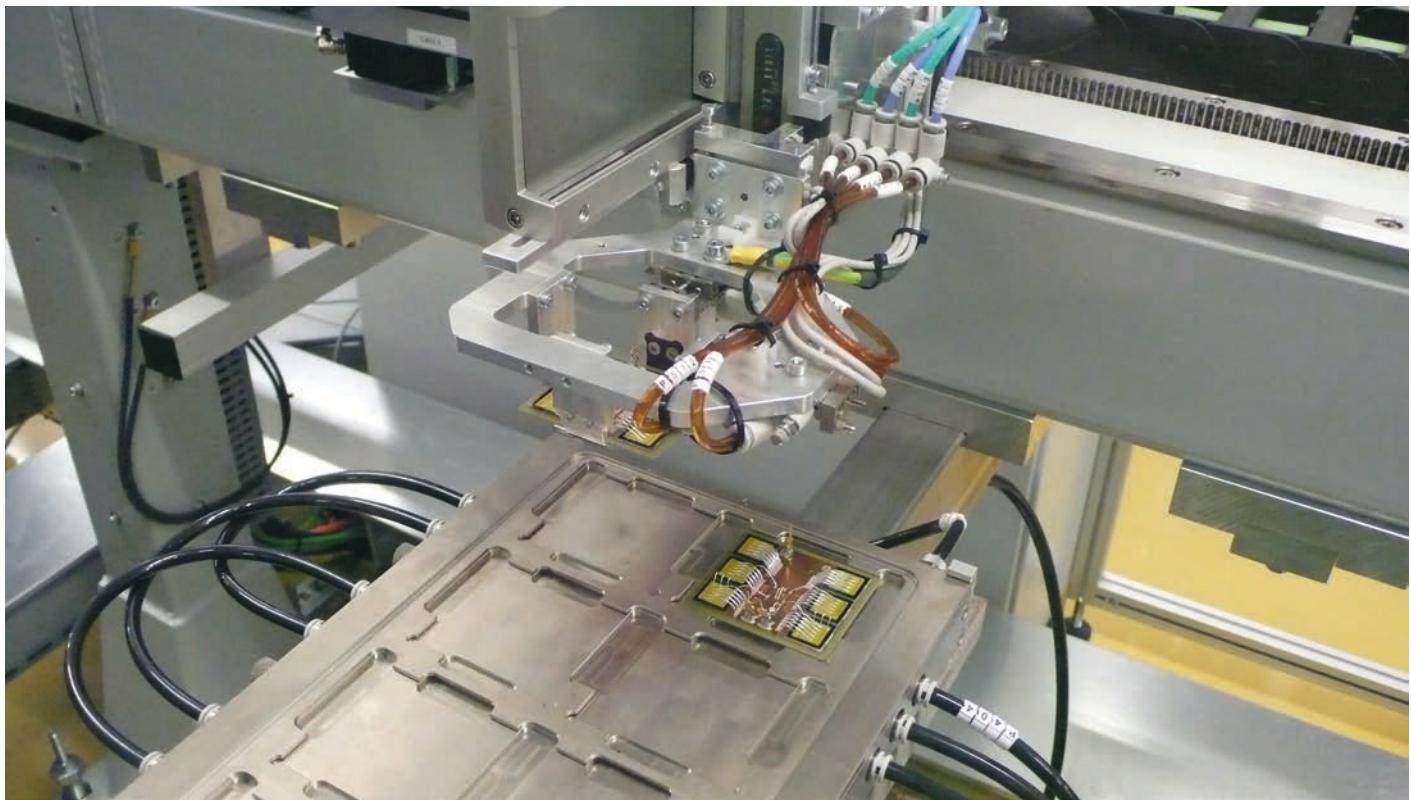
ABB offers static and dynamic production test systems for most types of power semiconductor devices like diodes, PCTs, BCTs, GTOs, IGCTs and IGBTs. They can handle dies, substrates, submodules, modules, wafers and press pack devices. Also reliability test systems for high temperature reverse bias, intermittent operating life or surge current tests are available. Auxiliary tester parts include clamping, capacitor discharge, pre-heating, data acquisition and parameter extraction units as well as programmable IGBT and thyristor gate units.

Parameters

The ABB test systems cover the range of up to 14 kV and 10 kA and use configurable stray inductances down to 60 nH. During testing, the clamped device under test (DUT) can be precisely heated up to 200 °C for production systems or cooled down to -40 °C in an environmental chamber for engineering systems. The clamping units can handle devices up to 240 mm in diameter and can apply a clamping force of up to 240 kN.

Automation

Our test systems are designed for easy integration into automated handling equipment. The test system's software is compatible to commercial control systems such as manufacturing execution systems (MES) and computer-aided quality assurance (CAQ).



	Blocking voltage AC or DC	Gate characteristics	On-state, forward voltage	Reverse recovery charge	Critical dV/dt	Circuit-commutated turn-off time	$V_{cesat} / V_{pinch-off}$	Turn-on / turn-off
Bipolar test systems								
Thyristor and diode static / dynamic	X	X	X	X	X	X		
Gate turn-off thyristor and diode static	X	X	X					X
Gate turn-off thyristor and diode dynamic	X			X				X
IGBT test systems								
IGBT and diode dies static	X	X					X	
IGBT and diode substrates static / dynamic	X	X		X			X	X
IGBT and diode modules static	X	X					X	
IGBT and diode modules dynamic				X				X
Baseplates flatness								

Reliability test systems

- High temperature reverse bias
- Intermittent operating life
- Surge current

Auxiliary unit

- Clamping unit
- Capacitor discharge unit
- Pre-heating unit
- Programmable IGBT and thyristor gate units
- Data acquisition and parameter extraction units

Further information

Certificates

ABB is committed to the highest ethical, environmental and business standards.

ABB has been awarded the ISO certifications for manufacturing, design and development of high-power semiconductor devices and modules (ISO 9001, 14001 and OHSAS 18001).

ABB Switzerland Ltd., Semiconductors, is also certified according to IRIS Revision 02 which is a globally recognized standard unique to the railway sector for the evaluation of management systems. It complements the internationally recognized ISO 9001 quality standard introducing rail specific requirements.



- IQNet -

THE INTERNATIONAL CERTIFICATION NETWORK

CERTIFICATE

IQNet and CQS
hereby certify that the organization

ABB s.r.o.
Vyskočilova 1561/4a, 140 00 Praha 4, Czech Republic
ABB s.r.o., Local product group Semiconductors
Novodvorská 1768/138a, 142 21 Praha 4, Czech Republic

for the following processes

Design, development and manufacturing of:
 • silicon single crystals, wafers and special products
 • high power semiconductor devices and modules

has implemented and maintains a

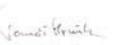
Quality Management System

which fulfills the requirements of the following standard

ISO 9001 : 2015

Issued on: 2016 - 08 - 15
Validity date: 2019 - 08 - 14

Registration Number: CZ - 2157/2016

AENOR Spain AFNOR Certification France ABB-Vancker International Belgium APCER Portugal CCC Cyprus CISQ Italy CCC China CQM China CGS Czech Republic Co-Cert Croatia DQS Holding GmbH Germany FCAV Brazil FONDONORMA Venezuela ICOTEC Colombia IMQ-Mexico Inspecta Certification Ireland INTECO Costa Rica IRAM Argentina JQA Japan KFQ Korea MBTTEC Greece MSZT Hungary Netas AS Norway NSAI Ireland PCBC Poland Quality Austria Austria KK Russia MTSSTT Turkey QIQUA Hungary SGS Switzerland SGS International Malaysia SQS Switzerland SRAC Romania TEST St Petersburg Russia TSB Turkey YUQS Serbia
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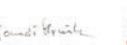
Environmental Management System

which fulfills the requirements of the following standard

ISO 14001 : 2015

Issued on: 2016 - 08 - 15
Validity date: 2019 - 08 - 14

Registration Number: CZ - 169/2016

AENOR Spain AFNOR Certification France ABB-Vancker International Belgium APCER Portugal CCC Cyprus CISQ Italy CCC China CQM China CGS Czech Republic Co-Cert Croatia DQS Holding GmbH Germany FCAV Brazil FONDONORMA Venezuela ICOTEC Colombia IMQ-Mexico Inspecta Certification Ireland INTECO Costa Rica IRAM Argentina JQA Japan KFQ Korea MBTTEC Greece MSZT Hungary Netas AS Norway NSAI Ireland PCBC Poland Quality Austria Austria KK Russia MTSSTT Turkey QIQUA Hungary SGS Switzerland SGS International Malaysia SQS Switzerland SRAC Romania TEST St Petersburg Russia TSB Turkey YUQS Serbia
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 • high power semiconductor devices and modules

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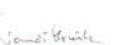
Occupational Health and Safety

which fulfills the requirements of the following standard

BS OHSAS 18001 : 2007

Issued on: 2016 - 08 - 15
Validity date: 2019 - 08 - 14

Registration Number: CZ - 170/2016

AENOR Spain AFNOR Certification France ABB-Vancker International Belgium APCER Portugal CCC Cyprus CISQ Italy CCC China CQM China CGS Czech Republic Co-Cert Croatia DQS Holding GmbH Germany FCAV Brazil FONDONORMA Venezuela ICOTEC Colombia IMQ-Mexico Inspecta Certification Ireland INTECO Costa Rica IRAM Argentina JQA Japan KFQ Korea MBTTEC Greece MSZT Hungary Netas AS Norway NSAI Ireland PCBC Poland Quality Austria Austria KK Russia MTSSTT Turkey QIQUA Hungary SGS Switzerland SGS International Malaysia SQS Switzerland SRAC Romania TEST St Petersburg Russia TSB Turkey YUQS Serbia
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Further information REACH Declaration



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To whom it may concern

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Reference No. 5SYS 5623-01
Page 1/1
Date December 1st, 2016

Declaration regarding the REACH-Regulation

With reference to the Regulation (EC) N° 1907/2006, issued by the European Union for the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH), please be aware that:

- during normal and reasonably foreseeable conditions of use, products and related accessories, which are articles according to REACH, manufactured by ABB Switzerland Ltd., Semiconductors and/or ABB s.r.o., Czech Republic do not intentionally release any substance or preparation (mixtures);
- ABB Switzerland Ltd., Semiconductors and/or ABB s.r.o., Czech Republic continuously assess their products for content of Substances of Very High Concern (SVHC), as included in the "Candidate List" by the European Chemicals Agency (ECHA);
- ABB Switzerland Ltd., Semiconductors and/or ABB s.r.o., Czech Republic continuously undertake communications throughout their supply chain in order to collect information about suppliers' compliance with REACH Regulation.

According to our current best knowledge all devices of the entire product portfolio manufactured by ABB Switzerland Ltd., Semiconductors and/or ABB s.r.o., Czech Republic do not contain SVHC substances exceeding 0.1% w/w.

Relevant for our chip customers only: the dicing tape (film) as carrier for bare die products contains the following substance in concentration above the 0.1% w/w limit:

- Bis (2-ethylhexyl)phthalate (DEHP), CAS 117-81-7, EC 204-211-0.

In the event we discover that any SVHC is present above the reporting threshold, we will inform you according to the requirements of the REACH directive.

Yours sincerely,
ABB Switzerland Ltd. - Semiconductors

Dr. Jürgen Bernauer
Manager Product Group Semiconductors

Mojmir Balous
Local Product Group Manager

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Further information

Documentation

IGBT dies and modules

Document title	Document number
Mounting instructions for StakPaks	5SYA 2037
Mounting instructions for HiPak modules	5SYA 2039
Failure rates of HiPak modules due to cosmic rays	5SYA 2042
Load-cycling capability of HiPak IGBT modules	5SYA 2043
Thermal runaway during blocking	5SYA 2045
Voltage ratings of high-power semiconductors	5SYA 2051
Applying IGBTs	5SYA 2053
IGBT diode safe operating area	5SYA 2057
Surge currents for IGBT diodes	5SYA 2058
Applying IGBT and diode dies	5SYA 2059
Thermal design and temperature ratings of IGBT modules	5SYA 2093
Paralleling of IGBT modules	5SYA 2098
Mounting Instructions for 62Pak	5SYA 2106

Diodes

Document title	Document number
High-current rectifier diodes for welding applications	5SYA 2013
Design of RC snubbers for phase control applications	5SYA 2020
High-power rectifier diodes	5SYA 2029
Mechanical clamping of press-pack high-power semiconductors	5SYA 2036
Field measurements on high-power press-pack semiconductors	5SYA 2048
Voltage ratings of high-power semiconductors	5SYA 2051
Failure rates of fast recovery diodes due to cosmic rays	5SYA 2061
Applying fast recovery diodes	5SYA 2064
Parameter selection of high-power semiconductor for series and parallel connection	5SYA 2091

Thyristors

Document title	Document number
Bi-directionally controlled thyristors	5SYA 2006
Design of RC snubbers for phase control applications	5SYA 2020
Gate-drive recommendations for phase control and bi-directionally controlled thyristors	5SYA 2034
Mechanical clamping of press-pack high-power semiconductors	5SYA 2036
Field measurements on high-power press-pack semiconductors	5SYA 2048
Voltage definitions for phase control and bi-directionally controlled thyristors	5SYA 2049
Voltage ratings of high-power semiconductors	5SYA 2051
Switching losses for phase control and bi-directionally controlled thyristors	5SYA 2055
Parameter selection of high-power semiconductor for series and parallel connection	5SYA 2091
Surge currents for phase control thyristors	5SYA 2102

IGCTs

Document title	Document number
Applying IGCT gate units	5SYA 2031
Applying IGCTs	5SYA 2032
Mechanical clamping of press-pack high-power semiconductors	5SYA 2036
Failure rates of IGCTs due to cosmic rays	5SYA 2046
Field measurements on high-power press-pack semiconductors	5SYA 2048
Voltage ratings of high-power semiconductors	5SYA 2051

GTOs

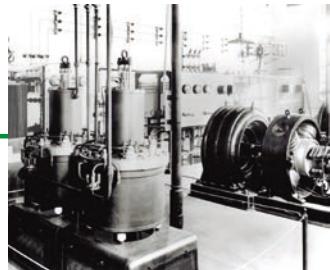
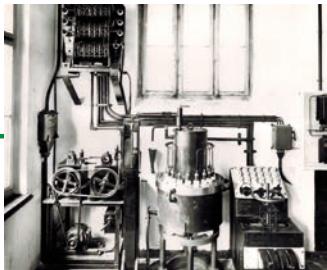
Document title	Document number
Mechanical clamping of press-pack high-power semiconductors	5SYA 2036
Field measurements on high-power press-pack semiconductors	5SYA 2048
Voltage ratings of high-power semiconductors	5SYA 2051

Environmental specifications

Document title	Document number
Storage of diodes, PCTs, GTOs	5SZK 9104
Transport of diodes, PCTs and GTOs	5SZK 9105
Operation of pressure contact IGCTs	5SZK 9107
Storage of IGCTs	5SZK 9109
Transport of IGCTs	5SZK 9110
Storage of HiPaks	5SZK 9111
Transport of HiPaks	5SZK 9112
Operation of industry HiPaks	5SZK 9113
Handling, packing and storage conditions for sawn wafer dies and bare dies	5SZK 9114
Operation of industry press-pack diodes, PCTs and GTOs	5SZK 9115
Operation of traction press-pack diodes, PCTs and GTOs	5SZK 9116
Operation of traction HiPaks	5SZK 9120

Further information

Perpetual innovation



1913

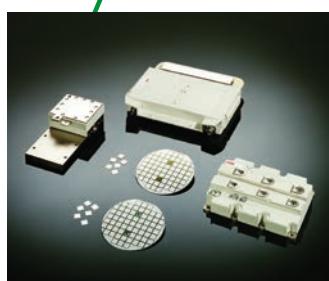
BBC begins development and production of mercury-arc rectifiers

1915

BBC mercury-arc rectifiers used in the Limmattal tramline Zurich – Dietikon, Switzerland

1938

First locomotive using multi-anode mercury-arc rectifiers from BBC Mannheim, Germany



1998

Opening of ABB production facility for BiMOS in Lenzburg, Switzerland



1996

ABB begins production of IGCT in Lenzburg, Switzerland



1988

ASEA (Sweden) and BBC (Switzerland) merge to form ABB (Asea Brown Boveri)

2010

Inauguration of expanded production facility at ABB Semiconductors in Lenzburg, Switzerland



2012

Successful design and development of ABB's hybrid HVDC breaker





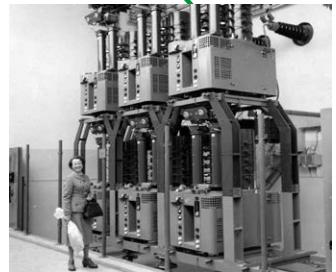
1939

First HVDC transmission line
(pilot installation) Wettingen –
Zurich, Switzerland



1954

BBC develops the first
germanium diode



1954

First commercial HVDC
transmission line connecting
Gotland island with the
Swedish mainland (ASEA)



1981

Inauguration of BBC high
power semiconductor factory
in Lenzburg, Switzerland

1964

First locomotive using BBC
silicon diodes (RE 4/4 Series
161, BLS)

2014

Inauguration of ABB's new
power electronics advanced
research lab in Dättwil,
Switzerland



2016

62Pak - Medium-power IGBT
modules and BiGT StakPak



Further information

Part numbering structure

IGBT and diode dies

Product group _____

5SM = IGBT
5SL = Diode

Technology _____

X = SPT / Y = SPT+ and SPT++ / Z = Enhanced trench / FSA, FCE diode

Type _____

76 = unsawn wafer die / 86 = sawn wafer die
12 = picked die (waffle pack)

Die size in mm² _____

E = 36.00 – 48.99	K = 121.00 – 143.99
F = 49.00 – 63.99	L = 144.00 – 168.99
G = 64.00 – 80.99	M = 169.00 – 195.99
H = 81.00 – 99.99	
J = 100.00 – 120.99	

Blocking voltage (V/100) _____

Version number _____

5SM Y 86 M 12 80

IGBT and diode modules

Product group _____

5SJA = BiGT module
5SLA = Single diode module
5SLD = Dual diode module
5SLG = Phase leg diode modules
5SNA = Single IGBT module / IGBT press-pack
5SND = Dual IGBT module
5SNE = Low side chopper
5SNG = Phase leg IGBT module
5SNR = IGBT press-pack

Nominal collector current rating (A) _____

Package _____

E = HiPak2, 40 mm	M = HiPak1, 30 mm
G = HiPak2 HV, 44 mm	N1 & 2 = HiPak1, 40 mm
H = Press-pack standard	P = HiPak0
J = HiPak1 HV, 44 mm	Q = 62Pak
K = Press-pack	R = LoPak1
L = Press-pack	S = LoPak3
	X = LinPak

Blocking voltage (V/100) _____

Package variation _____

0 = standard

Technology variation _____

1 = SPT / 3 = SPT+ and SPT++

Version number _____

5SND 0800 M 17 0 1 00

IGCT

Product group _____

5SHX = Reverse conducting IGCT
5SHY = Asymmetric IGCT
5SHZ = Reverse blocking IGCT

Max. turn-off current (I/100) _____

Housing _____

Blocking voltage (V/100) _____

Version number _____

5SHY 35 L 45 20

GTO

Product group _____

5SGA = Asymmetric GTO
5SGF = Fine pattern GTO

Max. turn-off current (I/100) _____

Housing _____

Blocking voltage (V/100) _____

Version number _____

5SGA 20 H 25 01

Phase control thyristors

Product group _____

5STP = Phase control thyristor
5STB = Bi-directionally controlled thyristor

Average on-state current (I/100) _____

Housing _____

Blocking voltage (V/100) _____

Version number _____

5STP 26 N 65 00

Reverse conducting thyristors

Product group _____

5STR = Reverse conducting

Average on-state current (I/100) _____

Housing _____

Blocking voltage (V/100) _____

Version number or t_q _____

5STR 10 T 25 20

Diodes

Product group _____
5SDA = Avalanche rectifier diode
5SDD = Rectifier diode
5SDF = Fast recovery diode

Average on-state current (I/100) _____

Housing _____

Blocking voltage (V/100) _____

Version number _____

5SDA 14 F 50 07

Surge voltage suppressors

Product group _____
5SSA = Standard
5SSB = Press-pack

Pulsed current (I/10) _____

Housing _____

Blocking voltage (V/100) _____

Version number _____

5SSA 50 R 06 00

Further information

Symbols

Symbol	Description
C_s	Snubber capacitance
di/dt_{max}	Maximum rate of rise or decline of on-state current
dV/dt	Maximum rate of rise of off-state voltage
F_m	Mounting force
I_c	DC collector current
I_{CM}	Peak collector current
I_F	Diode nominal mean forward current
I_{FAVM}	Max. average forward current (180° sine wave)
I_{FSM}	Max. surge peak forward current for a 180° sine wave; no voltage reapplied after surge
I_{RM}	Max. peak avalanche current for a single 180° sine wave pulse
I_{RMS}	Max. rms on-state current (AC full wave)
I_{rr}	Max. (typ. for IGBT diode) reverse recovery current
I_T	Forward current
I_{TAVM}	Max. average on-state current (180° sine wave)
I_{TGOM}	Max. turn-off current
I_{TSM}	Max. surge peak on-state current for a 180° sine wave; no voltage reapplied after surge
P_{RSM}	Max. surge avalanche power dissipation (single pulse)
Q_{rr}	Max. reverse recovery charge
r_F	Forward slope resistance
r_T	On-state slope resistance
R_{thCH}	Thermal resistance case to heatsink
R_{thJC}	Thermal resistance junction to case
R_{thJH}	Thermal resistance junction to heatsink
T_c	Case temperature
t_q	Turn-off time
T_{VJ}	Junction temperature
T_{VJM}	Max. junction temperature

Symbol	Description
V_{CES}	IGBT collector-emitter voltage
V_{CEsat}	Collector-emitter saturation voltage
V_{DC}	Max. DC voltage rating for 100 FIT, 100 percent duty
V_{DRM}	Max. repetitive peak forward blocking voltage
V_F	Forward voltage drop
V_{F0}	Forward threshold voltage
V_{Fmax}	Max. forward voltage drop
V_{Fmin}	Min. forward voltage drop
V_{GIN}	Input voltage of IGCT gate drive
V_R	Symmetrical peak avalanche voltage at a sinusoidal current pulse with 20 A peak, 10 μ s pulse width and 60 °C junction temperature
V_{RM}	Max. repetitive peak blocking voltage
V_{RRM}	Max. repetitive peak reverse blocking voltage
V_{RSM}	Max. surge peak reverse blocking voltage
V_T	On-state voltage drop
V_{TO}	On-state threshold voltage

Further information

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