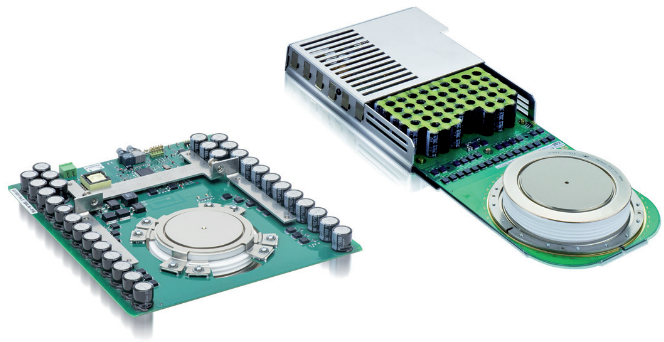
IGCT – integrated gate-commutated thyristors

ABB Semiconductors' IGCTs are now 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.



The IGCT is a gate-controlled turn-off switch which turns off like a transistor but conducts like a thyristor with the lowest conduction losses. Figure 1 shows turn-off at 3000 A.
GCTs are the only high power semiconductors to be supplied already integrated into their gate units. The user thus only needs to connect the device to a 28 – 40 V power supply and an optical fibre for on/off control. Because of the topology in which it is used, the IGCT produces negligible turn-on losses. This, together with its low conduction losses, enables operation at higher frequencies than formerly obtained by high power semiconductors.

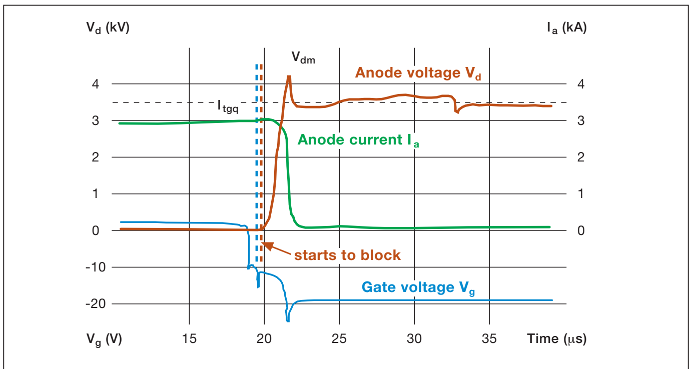


Fig. 1 IGCT turn-off exhibits same waveform and losses (E_{off}) as transistor

As can be seen in table 1, IGCTs are available as reverse conducting (RC), reverse blocking (symmetrical) and asymmetric devices. The low losses allow hard-switched operating frequencies of up to 600 Hz for 6.5 kV devices and 1 kHz for 4.5 kV devices in the steady state and over 5 kHz in burst mode.

Figure 2 illustrates the basic IGCT VSI topology. It can be seen that diode commutation is controlled by the inductance L. The free-wheel circuit of figure 2 minimizes the turn-on energy in the semiconductor by storing it in L. The inductance is the most logical fault limitation technique in the event of catastrophic failure since, as opposed to resistors and fuses, it has the benefit of "already being there". The press-pack construction of the IGCT, combined with the inductance, makes the system resistant to explosion, even when the device's surge rating is exceeded.

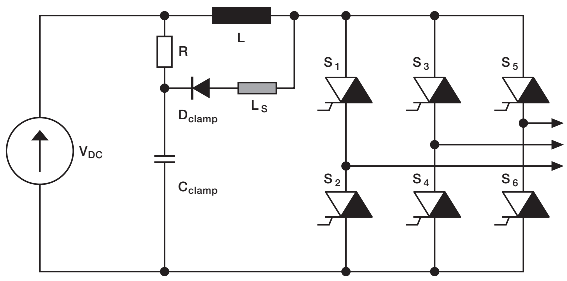


Fig. 2 Basic IGCT inverter circuit

Turn-off dv/dt is also not gate-controlled, but programmed at the device manufacturing stage by anode design and lifetime engineering. The absence of dv/dt and di/dt control functionality simplifies the gate-unit design and allows a high degree of standardisation. Some sixty publications exist on the use of IGCTs in many applications. These can be downloaded from the ABB Website **www.abb.com/semiconductors**. Table 2 summarises the essential documents relating to the application of IGCTs.

Applications

The integrated gate-commutated thyristor is the power switching device of choice for demanding high-power applications such as:

- MVD (Medium Voltage Drives)
- Marine drives
- Co-generation
- Wind power converters
- STATCOMs
- DVRs (Dynamic Voltage Restorers)
- BESS (Battery Energy Storage Systems)
- SSB (Solid State Breakers)
- DC traction line boosters
- Traction power compensators
- Interties

Outlook

The expansion of power electronics into the new fields of energy management, renewable energy sources and co-generation is driving semiconductor requirements towards higher frequency, higher voltage and higher efficiency while increasing demands for reliability and lower costs.

The IGCT is capable of still higher currents, voltages and frequencies without series or parallel connection and the first products are introduced as “High Power Technology” devices, see table 1. This latest family of IGCTs exhibit up to 30 % higher turn-off capability than standard devices.

Currently in development are technologies to increase the rated temperature for a number of devices and to increase the current rating with larger silicon diameters.

Within 10 years of its introduction, the IGCT has established itself as the power device of choice for high power at high voltage by meeting the demands of a growing power electronic market. Single inverters of over 15 MVA can now be realised without series or parallel connection achieving the highest inverter power densities in the industry.

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Product range

Type	Reverse conducting		Asymmetric	Reverse blocking
Si Ø / V_{DRM}	91 mm	140 mm	91 mm	
4.5 kV	2200 A	[4] 8000 A	[1] 4000 A	
4.5 kV			[2] 4000 A	
4.5 kV			[3] 3600 A (HPT)	
4.5 kV			5000 A (HPT)	
5.5 kV	1800 A		3600 A (HPT)	
6.5 kV			3800 A (HPT)	1100 A

Table 1 Product range

Legend: [1] standard [2] low on-state [3] low turn-off losses [4] projected for 2016

Documentation

Document title	Document number
Applying IGCT gate units	5SYA2031
Applying IGCTs	5SYA2032
Recommendations regarding mechanical clamping of press-pack high power semiconductors	5SYA2036
Failure rates of IGCTs due to cosmic rays	5SYA2046
Field measurements on high power press-pack semiconductors	5SYA2048
Voltage ratings of high power semiconductors	5SYA2051
Specification of environmental class for pressure contact IGCTs - OPERATION	5SZK9107
Specification of environmental class for pressure contact IGCTs - STORAGE	5SZK9109
Specification of environmental class for pressure contact IGCTs - TRANSPORTATION	5SZK9110

Table 2

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