

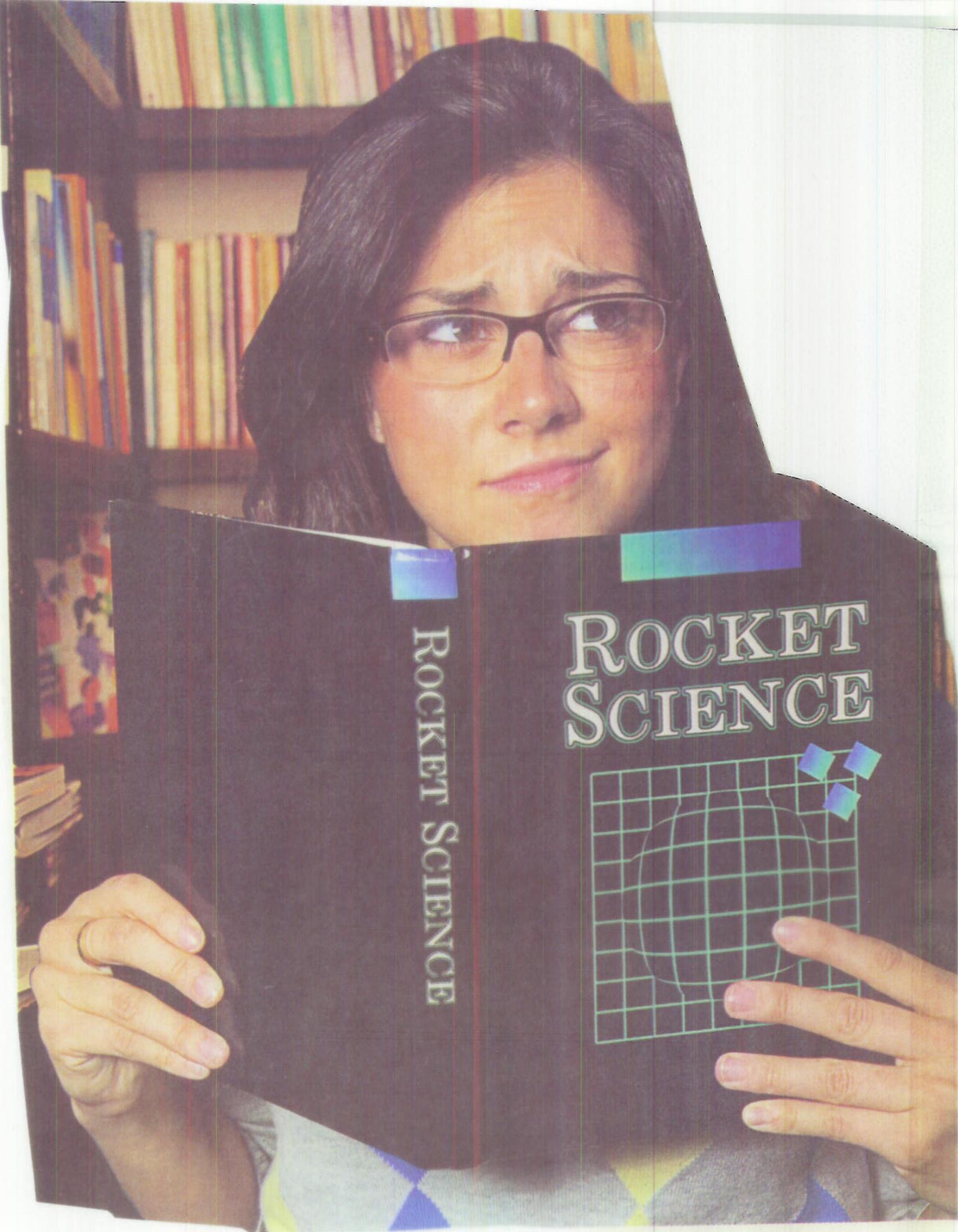
Thyristors : High Power Devices

- High Power device design :
 - Transistor Structure (rugged turn off capabilities)
 - Thyristor Structure (low conduction losses)
- Devices developed along these lines

Thyristors	Transistors
<ul style="list-style-type: none"> • GTO (Gate turn-off thyristors) • MCT (MOS-controlled thyristors) • FCT (Field-controlled thyristors) • MTO (MOS-turn off thyristor) • EST (Emitter switched thyristors) • IGTT (Insulated gate turn off thyristors) • GCT (Gate Commutated Thyristors) • IGCT (Integrated Gate commutated Thyristors) 	<ul style="list-style-type: none"> • Bipolar Transistors • Darlington transistor) • MOSFETs' • IGBT (Integrated gate Bipolar transistor)

GCT's

- Dominance of thyristor structures :
 - Inherent ability to conduct larger currents with minimal losses
- Contenders for High Power Applications :
 - GTO's (Thyristor) : Cumbersome snubbers required
 - IGBT's (Transistor) : Inherently high losses
- GCT's :
Semiconductor based on GTO structure
Gate Circuit has low inductance that enables cathode emitter to shut off "instantaneously"



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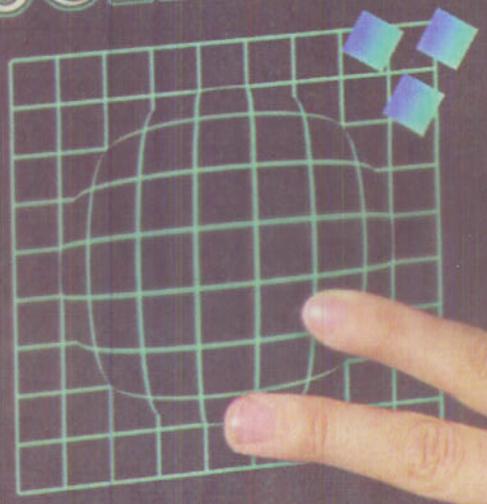


Fig 4.144 pg 91

The MOS-Controlled Thyristor (MCT)

Device with uncertain future. } GTO with MOS Input

- Still an emerging device, but some devices are commercially available
- p-type device
- A latching SCR, with added built-in MOSFETs to assist the turn-on and turn-off processes
- Small feature size, highly interdigitated, modern fabrication

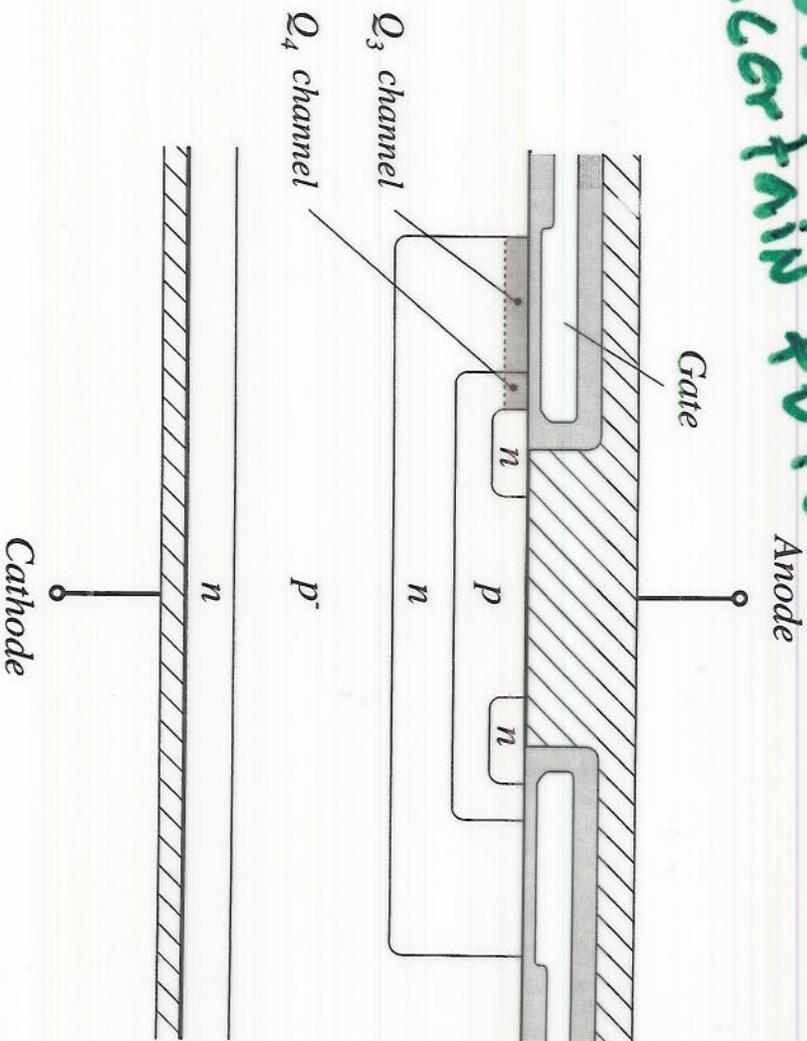
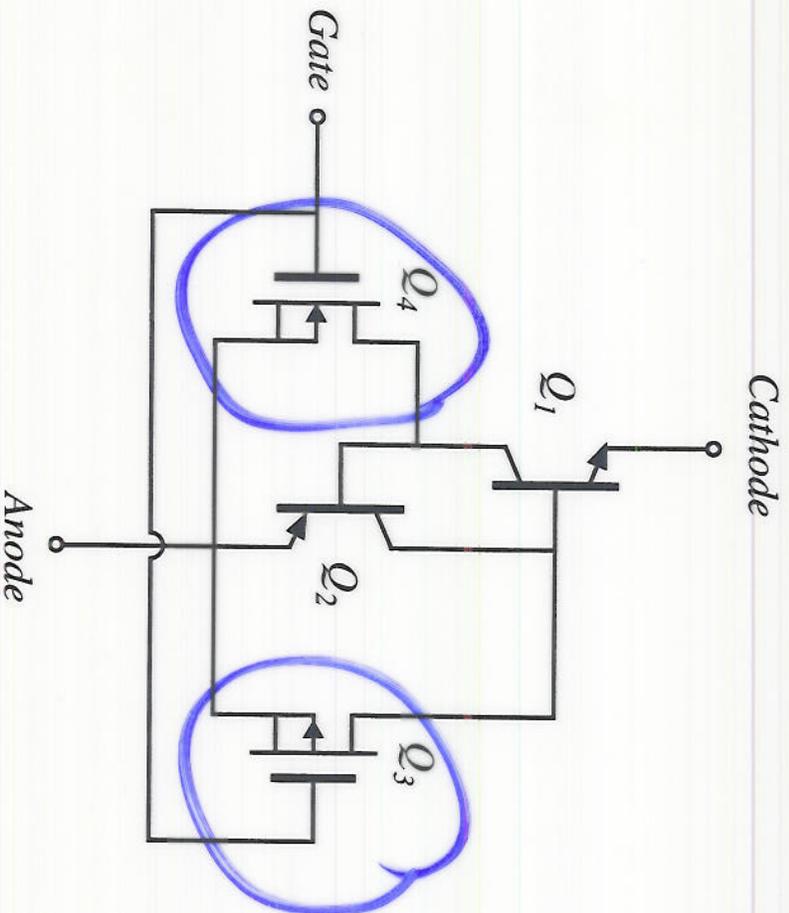


Fig 4.45 99 92

The MCT: equivalent circuit

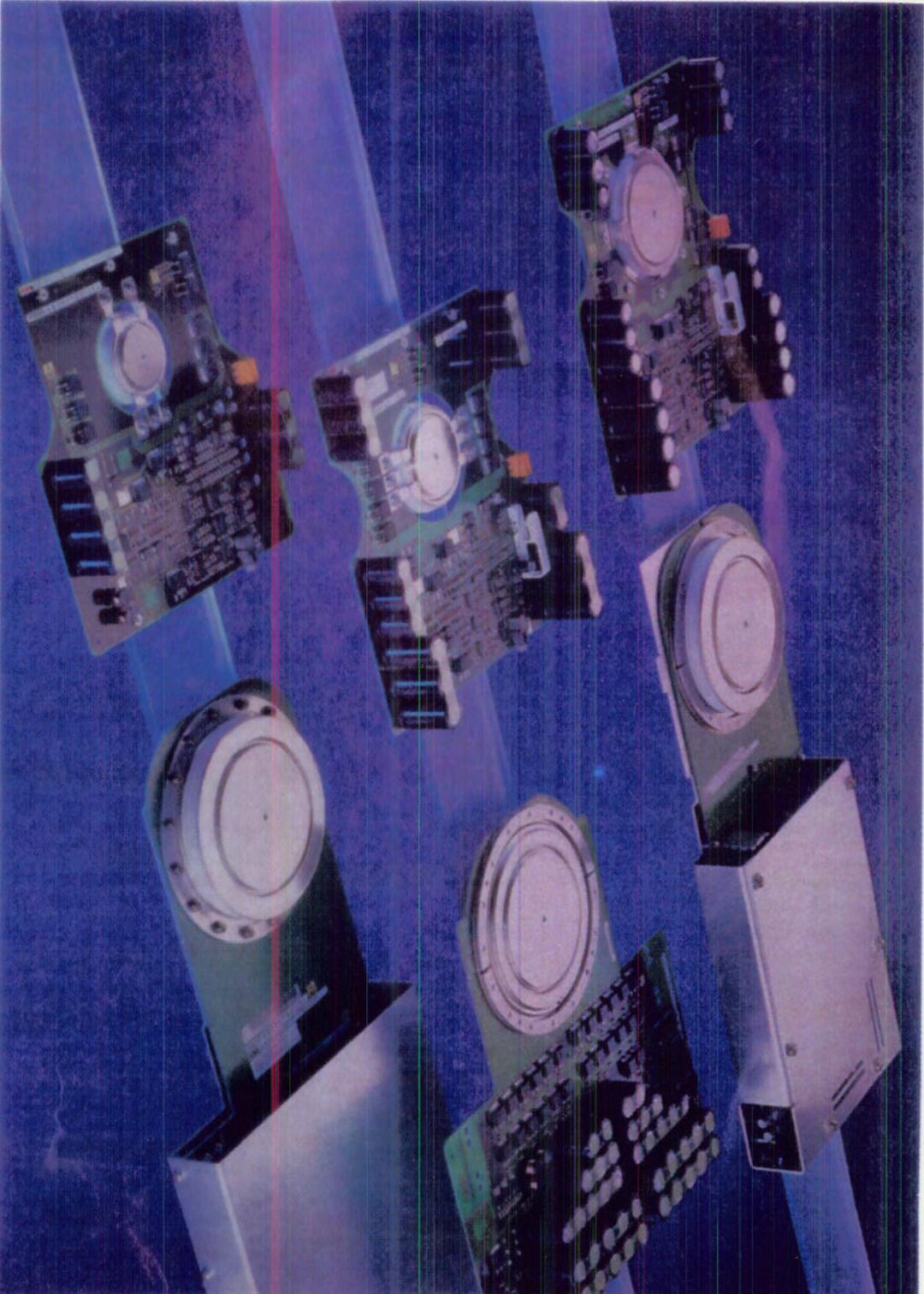


- Negative gate-anode voltage turns p-channel MOSFET Q_3 on, causing Q_1 and Q_2 to latch ON
- Positive gate-anode voltage turns n-channel MOSFET Q_4 on, reverse-biasing the base-emitter junction of Q_2 and turning off the device
- Maximum current that can be interrupted is limited by the on-resistance of Q_4



and 6 kV, 250 - 4000 A

Symmetric, Symmetric
Reverse Conducting Types



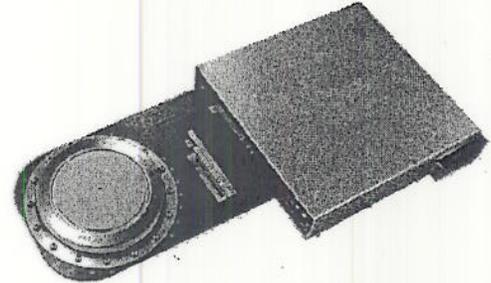
V_{DRM}	=	4500 V
I_{TGQM}	=	4000 A
I_{TSM}	=	32 kA
V_{T0}	=	1.40 V
r_T	=	0.325 m Ω
V_{DClink}	=	2800 V

Asymmetric Integrated Gate-Commutated Thyristor

5SHY 35L4503

Doc. No. 5SYA1228-01 Jan. 01

- Highest snubberless turn-off rating
- Suitable for series connection
- Fast response ($t_{don} < 3 \mu s$, $t_{doff} < 6 \mu s$)
- High reliability
- Very high EMI immunity
- Simple fibre optic control interface and status feedback
- Cosmic radiation withstand rating



Blocking

V_{DRM}	Repetitive peak off-state voltage	4500 V	$V_{GR} \geq 2V$
I_{DRM}	Repetitive peak off-state current	≤ 50 mA	$V_D = V_{DRM}$ $V_{GR} \geq 2V$
V_{DClink}	Permanent DC voltage for 100 FIT failure rate	2800 V	Ambient cosmic radiation at sea level in open air.

Mechanical data (see Fig. 8)

F_m	Mounting force	min.	36 kN	
		max.	44 kN	
D_p	Pole-piece diameter		85 mm	± 0.1 mm
H	Housing thickness		26 mm	± 0.5 mm
m	Weight IGCT		3.30 kg	
D_s	Surface creepage distance	\geq	33 mm	Anode to Gate
D_a	Air strike distance	\geq	13 mm	Anode to Gate
l	Length IGCT		451 mm	± 1.0 mm
h	Height IGCT		40 mm	± 1.0 mm
w	Width IGCT		213 mm	± 1.0 mm

ABB Semiconductors AG reserves the right to change specifications without notice.

GCT Data

On-state (see Fig. 2, 3, 4)

I_{TAVM}	Max. average on-state current	1345 A	Half sine wave, $T_C = 85\text{ }^\circ\text{C}$		
I_{TRMS}	Max. RMS on-state current	2110 A			
I_{TSM}	Max. peak non-repetitive surge current	32 kA	$t_p =$	10 ms	$T_j = 125\text{ }^\circ\text{C}$ After surge: $V_D = V_R = 0\text{V}$
		47 kA	$t_p =$	1 ms	
I^2t	Limiting load integral	$5.1 \cdot 10^6\text{ A}^2\text{s}$	$t_p =$	10 ms	
		$1.1 \cdot 10^6\text{ A}^2\text{s}$	$t_p =$	1 ms	
V_T	On-state voltage	$\leq 2.70\text{ V}$	$I_T =$	4000 A	$T_j = 125\text{ }^\circ\text{C}$
V_{T0}	Threshold voltage	1.40 V	$I_T =$	1000 - 4000 A	
r_T	Slope resistance	0.325 m Ω			

Turn-on switching

di/dt_{crit}	Max. rate of rise of on-state current	1000 A/ μs	$f = 500\text{ Hz}$	$T_j = 125\text{ }^\circ\text{C}$
			$I_T = 4000\text{ A}$	$V_D = 2500\text{ V}$
t_{don}	Turn-on delay time	$\leq 3\text{ }\mu\text{s}$	$V_D = 2500\text{ V}$	$T_j = 125\text{ }^\circ\text{C}$
t_r	Rise time	$\leq 1\text{ }\mu\text{s}$	$I_T = 4000\text{ A}$	
$t_{on(min)}$	Min. on-time	10 μs	$R_s = 0.8\text{ }\Omega$	$L_i = 2.2\text{ }\mu\text{H}$
E_{on}	Turn-on energy per pulse	$\leq 1.5\text{ J}$	$C_{CL} = 6.0\text{ }\mu\text{F}$	$L_{CL} = 0.3\text{ }\mu\text{H}$

Turn-off switching (see Fig. 5, 6)

I_{TGQM}	Max. controllable turn-off current	4000 A	$V_{DM} \leq V_{DRM}$	$T_j = 125\text{ }^\circ\text{C}$
			$V_D = 2500\text{ V}$	$L_{CL} = 0.3\text{ }\mu\text{H}$
t_{doff}	Turn-off delay time	$\leq 6.0\text{ }\mu\text{s}$	$V_D = 2500\text{ V}$	$V_{DM} \leq V_{DRM}$
t_f	Fall time	$\leq 1.0\text{ }\mu\text{s}$	$T_j = 125\text{ }^\circ\text{C}$	$R_s = 0.8\text{ }\Omega$
$t_{off(min)}$	Min. off-time	10 μs	$I_{TGQ} = 4000\text{ A}$	$L_i = 2.2\text{ }\mu\text{H}$
E_{off}	Turn-off energy per pulse	$\leq 19.5\text{ J}$	$C_{CL} = 6.0\text{ }\mu\text{F}$	$L_{CL} = 0.3\text{ }\mu\text{H}$

Gate Unit

Power supply (see Fig. 7 to 9)			
V_{GDC}	Gate Unit voltage	$20 \pm 0.5 V_{DC}$	Without galvanic isolation to power circuit.
P_{Gin}	Gate Unit power consumption	$\leq 52 W$	$f_s = 500 Hz$, $I_{TQG,AV} = 1000 A$, $\delta = 0.5$
X1	Gate Unit power connector	AMP, Type 640389-4, MTA 156, friction lock, right angle ^{Note 1}	
Optical control input/output (see Fig. 8 to 10)			
$P_{on CS}$	Optical input power	$> -21 dBm$	Valid for 1mm plastic optical fibre (POF)
$P_{off CS}$	Optical noise power	$< -40 dBm$	
$P_{on SF}$	Optical output power	$> -19 dBm$	
$P_{off SF}$	Optical noise power	$< -50 dBm$	
t_{GLITCH}	Pulse width threshold	$\leq 300 ns$	Max. pulse width without response
CS	Receiver for command signal	Agilent, Type HFBR-2528 ^{Note 2}	
SF	Transmitter for status feedback	Agilent, Type HFBR-1528 ^{Note 2}	

Note 1: AMP, www.amp.com

Note 2: Agilent Technologies, www.semiconductor.agilent.com