

V_{DRM}	=	4500 V
I_{TGQM}	=	3600 A
I_{TSM}	=	$20.0 \cdot 10^3$ A
V_{T0}	=	1.24 V
r_T	=	0.51 m Ω
V_{DC}	=	2800 V

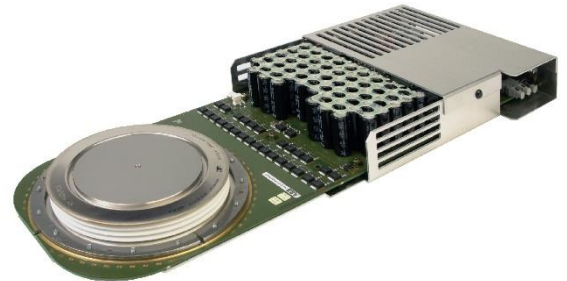
Reverse Conducting Integrated Gate-Commutated Thyristor

5SHX 36L4521

Preliminary

Doc. No. 5SYA1256-01 Apr. 19

- High snubberless turn-off rating
- Optimized for low on-state losses
- High electromagnetic immunity
- Simple control interface with status feedback
- AC or DC supply voltage



Blocking

Maximum rated values ¹⁾

Parameter	Symbol	Conditions	min	typ	max	Unit
Repetitive peak off-state voltage	V_{DRM}	Gate Unit energized			4500	V
Permanent DC voltage for 100 FIT failure rate of RC-GCT	V_{DC}	Ambient cosmic radiation at sea level in open air Gate Unit energized			2800	V

Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
Repetitive peak off-state current	I_{DRM}	$V_D = V_{DRM}$, Gate Unit energized			50	mA

Mechanical data

Maximum rated values ¹⁾

Parameter	Symbol	Conditions	min	typ	max	Unit
Mounting force	F_M		38	41	44	kN

Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
Pole-piece diameter	D_p	± 0.1 mm		85		mm
Housing thickness	H	clamped $F_m = 41$ kN	25.3		25.7	mm
Weight	m				3	kg
Surface creepage distance	D_s	Anode to Gate	33			mm
Air strike distance	D_a	Anode to Gate	10			mm
Length	l	± 1.0 mm		439		mm
Height	h	± 1.0 mm		41		mm
Width IGCT	w	± 1.0 mm		173		mm

1) Maximum rated values indicate limits beyond which damage to the device may occur

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GCT Data

On-state

Maximum rated values ¹⁾

Parameter	Symbol	Conditions	min	typ	max	Unit
Average on-state current	$I_{T(AV)M}$	Half sine wave, $T_c = 85\text{ °C}$, $T_{vj} = 125\text{ °C}$			1280	A
RMS on-state current	$I_{T(RMS)}$				2010	A
Peak non-repetitive surge current	I_{TSM}	$t_p = 3\text{ ms}$, $T_{vj} = 125\text{ °C}$ sine half wave			TBD	A
Limiting load integral	I^2t	$V_D = V_R = 0\text{ V}$, after surge			TBD	A ² s
Peak non-repetitive surge current	I_{TSM}	$t_p = 10\text{ ms}$, $T_{vj} = 125\text{ °C}$ sine half wave			$20.0 \cdot 10^3$	A
Limiting load integral	I^2t	$V_D = V_R = 0\text{ V}$, after surge			$2.00 \cdot 10^6$	A ² s
Critical rate of rise of onstate current	$di_T/dt_{(cr)}$	For higher di_T/dt and current lower than 100 A, an external retrigger puls is required.			100	A/ μ s

Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
On-state voltage	V_T	$I_T = 1500\text{ A}$, $T_{vj} = 125\text{ °C}$	1.60	1.80	2.00	V
Threshold voltage	$V_{(T0)}$	$I_T = 500\text{ A} - 3000\text{ A}$, $T_{vj} = 125\text{ °C}$		1.14	1.24	V
Slope resistance	r_T				0.44	0.51

Turn-on switching

Maximum rated values ¹⁾

Parameter	Symbol	Conditions	min	typ	max	Unit
Critical rate of rise of on-state current	di/dt_{crit}	$f = 0 - 160\text{ Hz}$, $T_{vj} = 125\text{ °C}$ $I_T = 3600\text{ A}$, $I_{TM} \leq \text{TBD A}$, $V_D = 2800\text{ V}$			1000	A/ μ s

Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
Turn-on delay time	$t_{d(on)}$	$T_{vj} = 125\text{ °C}$			5	μ s
Turn-on delay time status feedback	$t_{d(on) SF}$	$V_D = 2800\text{ V}$, $I_T = 1500\text{ A}$ $di/dt = V_D / L_i$, $L_i = 3\text{ }\mu\text{H}$			7	μ s
Rise time	t_r	$C_{CL} = 10\text{ }\mu\text{F}$, $L_{CL} = 250\text{ nH}$, $D_{CL} = D_{FWD} = 5\text{SDF } 08\text{H}6005$			2	μ s
Turn-on energy per pulse	E_{on}				1.40	J

Turn-off switching

Maximum rated values ¹⁾

Parameter	Symbol	Conditions	min	typ	max	Unit
Controllable turn-off current	I_{TGQM}	$V_{DM} \leq V_{DRM}$, $T_{vj} = 125\text{ °C}$ $V_D = 2800\text{ V}$, $R_s = 0.6\text{ }\Omega$, $C_{CL} = 10\text{ }\mu\text{F}$, $L_{CL} \leq 250\text{ nH}$, $D_{CL} = D_{FWD} = 5\text{SDF } 08\text{H}6005$			3600	A

Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
Turn-off delay time	$t_{d(off)}$	$V_D = 2500\text{ V}$, $T_{vj} = 125\text{ °C}$ $V_{DM} \leq V_{DRM}$, $I_{TGQ} = 1500\text{ A}$			10	μ s
Turn-off delay time status feedback	$t_{d(off) SF}$	$L_i = 3\text{ }\mu\text{H}$			7	μ s
Turn-off energy per pulse	E_{off}	$C_{CL} = 10\text{ }\mu\text{F}$, $L_{CL} = 250\text{ nH}$, $R_s = 0.6\text{ }\Omega$ $D_{CL} = D_{FWD} = 5\text{SDF } 08\text{H}6005$		8.70		J
Turn-off delay time	$t_{d(off)}$	$V_D = 2800\text{ V}$, $T_{vj} = 125\text{ °C}$ $V_{DM} \leq V_{DRM}$, $I_{TGQ} = 1500\text{ A}$			9	μ s
Turn-off delay time status feedback	$t_{d(off) SF}$	$L_i = 3\text{ }\mu\text{H}$			7	μ s
Turn-off energy per pulse	E_{off}	$C_{CL} = 10\text{ }\mu\text{F}$, $L_{CL} = 250\text{ nH}$, $R_s = 0.6\text{ }\Omega$ $D_{CL} = D_{FWD} = 5\text{SDF } 08\text{H}6005$		9.50	12.0	J

Diode Data

On-state

Maximum rated values ¹⁾

Parameter	Symbol	Conditions	min	typ	max	Unit
Average on-state current	$I_{F(AV)M}$	Half sine wave, $T_C = 85\text{ °C}$, $T_{vj} = 125\text{ °C}$			910	A
RMS on-state current	$I_{F(RMS)}$				1420	A
Peak non-repetitive surge current	I_{FSM}	$t_p = 3\text{ ms}$, $T_{vj} = 125\text{ °C}$ $V_D = V_R = 0\text{ V}$			TBD	A
Limiting load integral	I^2t				TBD	A ² s
Peak non-repetitive surge current	I_{FSM}	$t_p = 10\text{ ms}$, $T_{vj} = 125\text{ °C}$ $V_D = V_R = 0\text{ V}$			$20.0 \cdot 10^3$	A
Limiting load integral	I^2t				$2.00 \cdot 10^6$	A ² s

Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
On-state voltage	V_F	$I_T = 1500\text{ A}$, $T_{vj} = 125\text{ °C}$	2.20	2.40	2.60	V
Threshold voltage	$V_{(F0)}$	$T_{vj} = 125\text{ °C}$ $I_T = 500\text{ A} - 3000\text{ A}$		1.32	1.46	V
Slope resistance	r_F				0.72	0.76

Turn-on

Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
Peak forward recovery voltage	V_{FRM}	$di_F/dt = 2000\text{ A}/\mu\text{s}$, $T_{vj} = 125\text{ °C}$			230	V
		$di_F/dt = 500\text{ A}/\mu\text{s}$, $T_{vj} = 125\text{ °C}$			95	V

Turn-off

Maximum rated values ¹⁾

Parameter	Symbol	Conditions	min	typ	max	Unit
Decay rate on-state current	$di/dt_{(cr)}$	$I_{FM} = 3600\text{ A}$, $T_{vj} = 125\text{ °C}$ $V_D = 2800\text{ V}$			1000	A/ μs

Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
Reverse recovery current	I_{RM}	$T_{vj} = 125\text{ °C}$, $I_{FM} = 1500\text{ A}$, $V_D = 2500\text{ V}$, $-di_F/dt = V_D / L_i$, $L_{CL} = 250\text{ nH}$, $C_{CL} = 10\text{ }\mu\text{F}$, $R_s = 0.6\text{ }\Omega$, $D_{CL} = D_{FWD} = 5\text{SDF } 08\text{H}6005$			1500	A
Reverse recovery charge	Q_{rr}				4080	μC
Turn-off energy	E_{rec}				9.00	J
Reverse recovery current	I_{RM}	$T_{vj} = 125\text{ °C}$, $I_{FM} = 1500\text{ A}$, $V_D = 2800\text{ V}$, $-di_F/dt = V_D / L_i$, $L_{CL} = 250\text{ nH}$, $C_{CL} = 10\text{ }\mu\text{F}$, $R_s = 0.6\text{ }\Omega$, $D_{CL} = D_{FWD} = 5\text{SDF } 08\text{H}6005$			1600	A
Reverse recovery charge	Q_{rr}				4220	μC
Turn-off energy	E_{rec}				10.3	15.0

Gate Unit Data

Power supply

Maximum rated values ¹⁾

Parameter	Symbol	Conditions	min	typ	max	Unit
Gate Unit voltage (Connector X1)	$V_{Gin\ RMS}$	AC square wave amplitude (15 kHz - 100 kHz) or DC voltage. No galvanic isolation to power circuit.	28		40	V
Min. current needed to power up the Gate Unit	$I_{Gin\ Min}$	Rectified average current see application note 5SYA 2031	2			A
Gate Unit power consumption	$P_{Gin\ Max}$				130	W

Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
Internal current limitation	$I_{Gin\ Max}$	Rectified average current limited by the Gate Unit			8	A

Optical control input/output

Maximum rated values ¹⁾

Parameter	Symbol	Conditions	min	typ	max	Unit
CS On-time	t_{on}	CS: Command signal	40			μ s
CS Off-time	t_{off}		40			μ s

Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
Optical input power	$P_{on\ CS}$	CS: Command signal SF: Status feedback	-15		-1	dBm
Optical noise power	$P_{off\ CS}$		-45			dBm
Optical output power	$P_{on\ SF}$	Valid for 1mm plastic optical fiber (POF)	-19		-1	dBm
Optical noise power	$P_{off\ SF}$		-50			dBm
Pulse width threshold	t_{GLITCH}	Max. pulse width without response			400	ns
External retrigger pulse width	t_{retrig}		700		1100	ns

Connectors ²⁾

Parameter	Symbol	Description
Gate Unit power connector	X1	AMP: MTA-156, Part Number 641210-5 ³⁾
LWL receiver for command signal	CS	Avago, Type HFBR-2521Z ⁴⁾
LWL transmitter for status feedback	SF	Avago, Type HFBR-1528Z ⁴⁾

2) Do not disconnect or connect fiber optic cables while light is on.

3) AMP, www.amp.com

4) Avago Technologies, www.avagotech.com

Visual feedback

Parameter	Symbol	Description	Color
Gate OFF	LED1	"Light" when GCT is off	(green)
Gate ON	LED2	"Light" when gate-current is flowing	(yellow)
Fault	LED3	"Light" when not ready / Failure	(red)
Power supply voltage OK	LED4	"Light" when power supply is within specified range	(green)

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Thermal

Maximum rated values ¹⁾

Parameter	Symbol	Conditions	min	typ	max	Unit
Junction operating temperature	T _{vj}		0		125	°C
Storage temperature range	T _{stg}		-40		60	°C
Ambient operational temperature	T _a		0		50	°C

Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
Thermal resistance junction-to-case of GCT	R _{th(j-c)}	Double side cooled, no heat flow between GCT and Diode part			11	K/kW
Thermal resistance case-to-heatsink of GCT	R _{th(c-h)}				5.1	K/kW
Thermal resistance junction-to-case of Diode	R _{th(j-c)}				14	K/kW
Thermal resistance case-to-heatsink of Diode	R _{th(c-h)}				7.2	K/kW

Analytical function for transient thermal impedance:

$$Z_{thJC}(t) = \sum_{i=1}^n R_i(1 - e^{-t/\tau_i})$$

GCT

i	1	2	3	4
R _i (K/kW)	6.295	2.912	1.545	0.257
τ _i (s)	0.5551	0.1201	0.0079	0.0079

Diode

i	1	2	3	4
(K/kW)	9.100	3.072	1.418	0.406
τ _i (s)	0.5434	0.1146	0.0078	0.0063

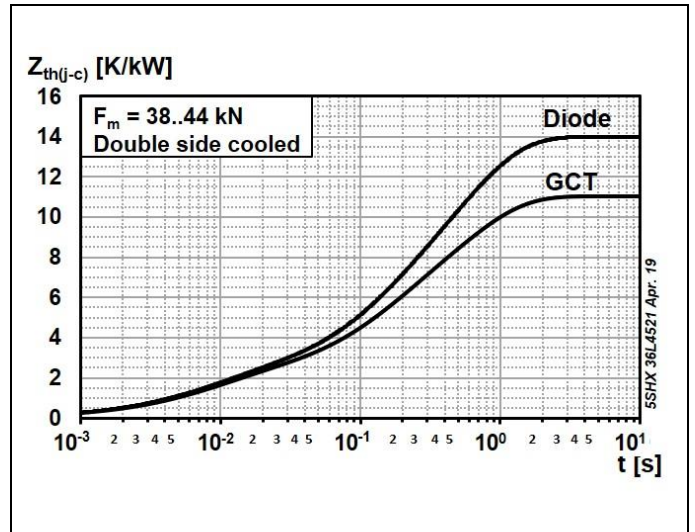


Fig. 1 Transient thermal impedance (junction-to-case) vs. time (max. values)

Max. Turn-off current for Lifetime operation

- calculated lifetime of on-board capacitors 20 years
- with slightly forced air cooling (air velocity > 0.5 m/s)
- strong air cooling allows for increased ambient temperature

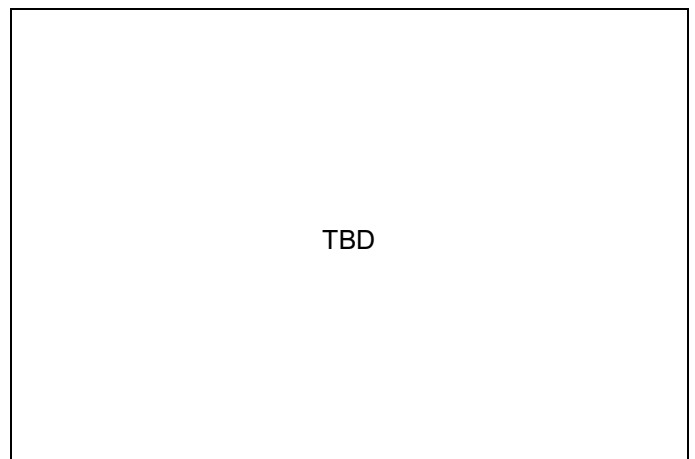


Fig. 2 Max. turn-off current vs. frequency for lifetime operation

GCT Part

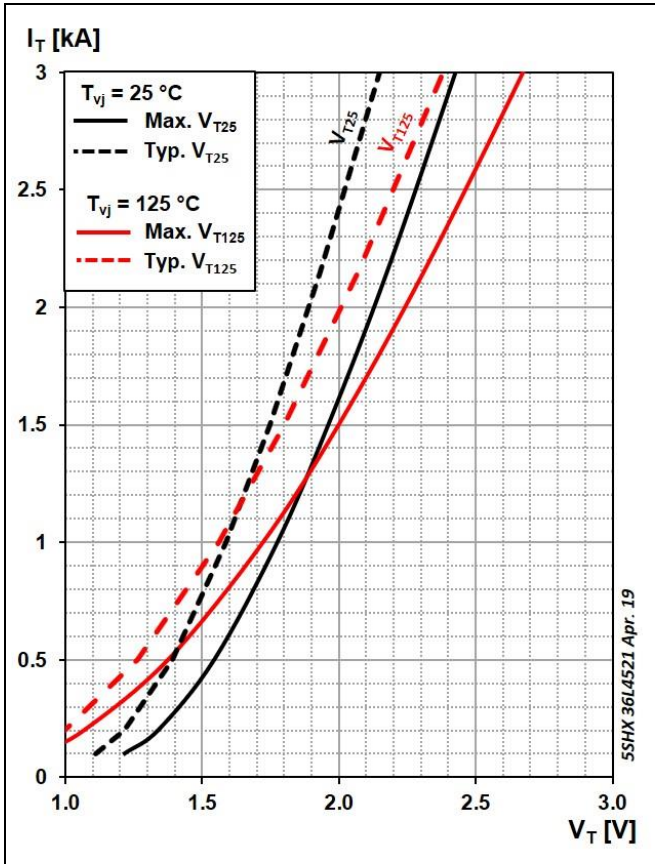


Fig. 3 GCT on-state voltage characteristics

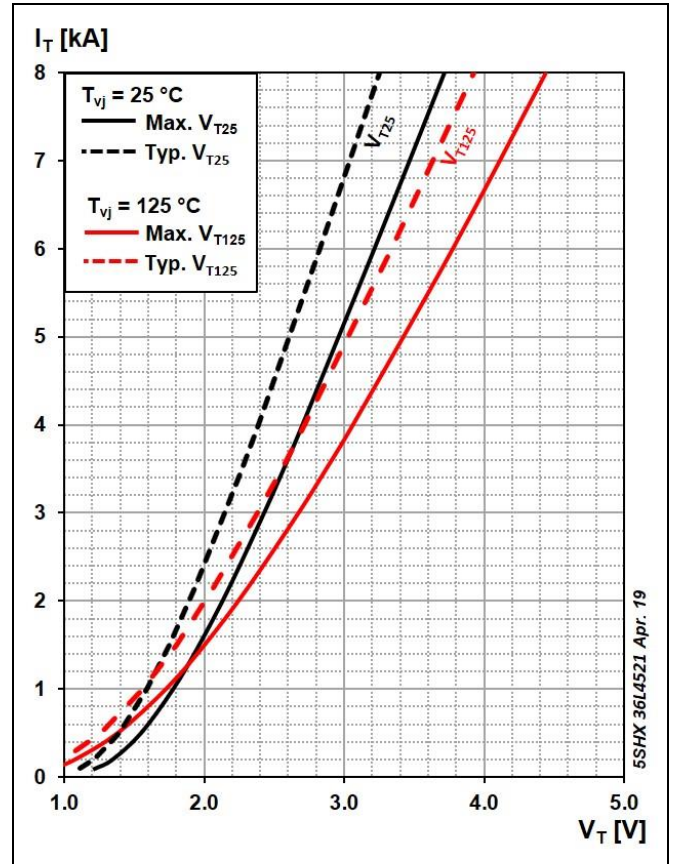


Fig. 4 GCT on-state voltage characteristics

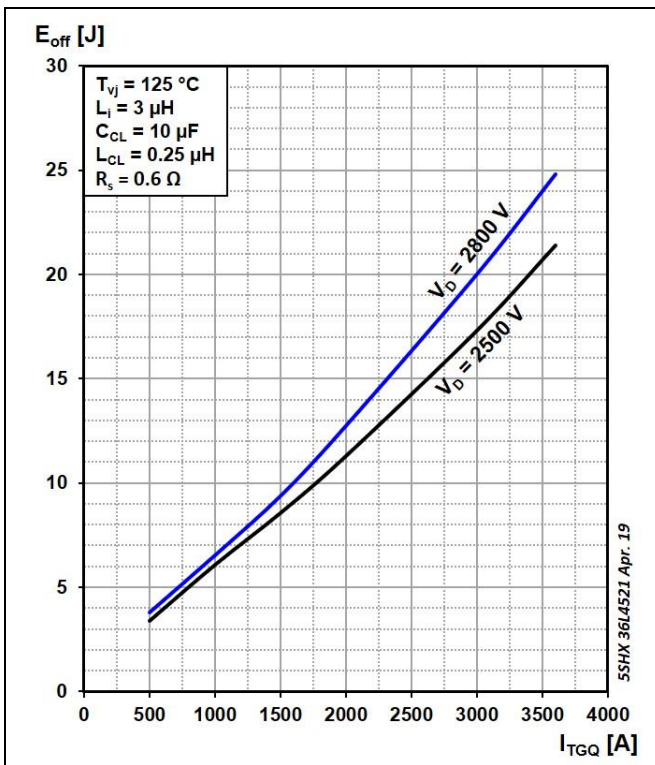


Fig. 5 GCT turn-off energy per pulse vs. turn-off current (typical values)

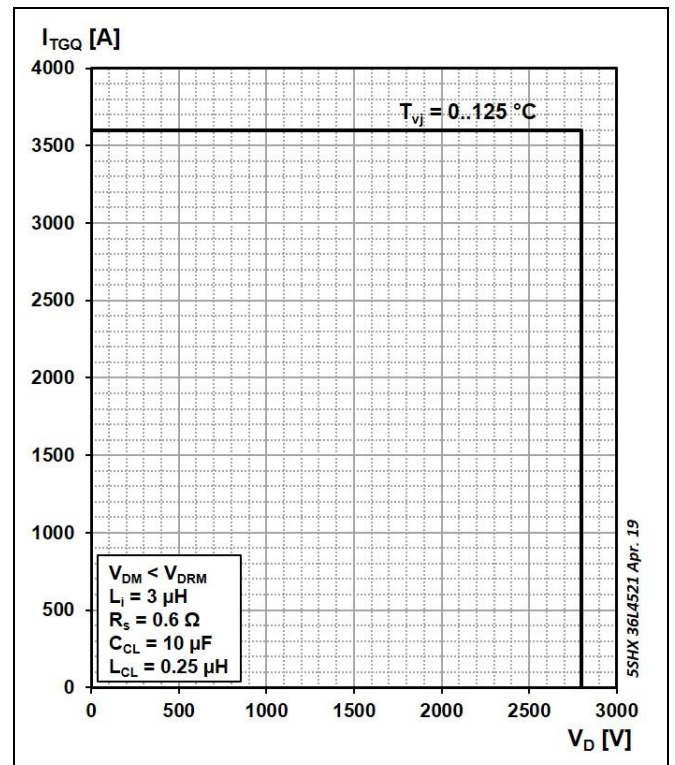


Fig. 6 Safe Operating Area

Diode Part

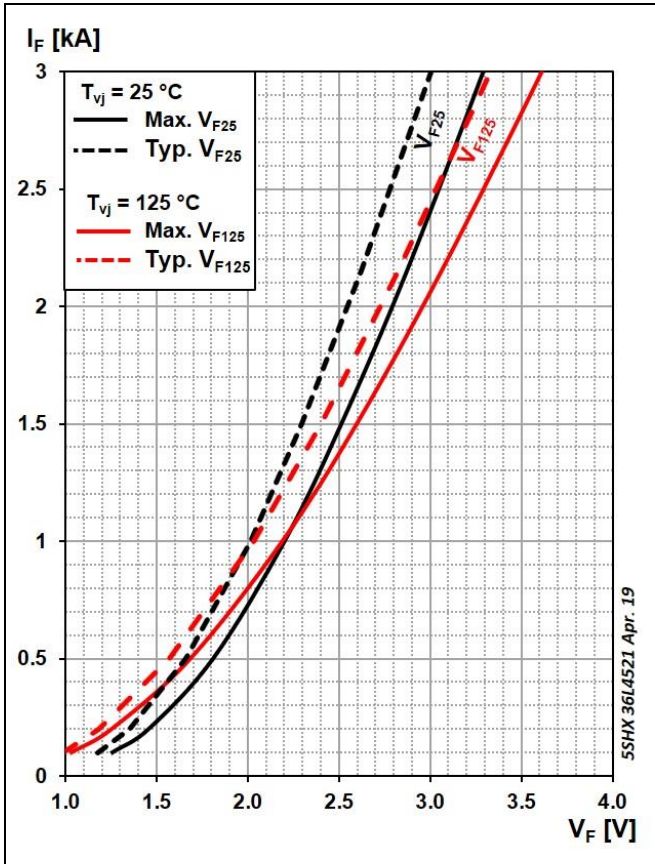


Fig. 7 Diode on-state voltage characteristics

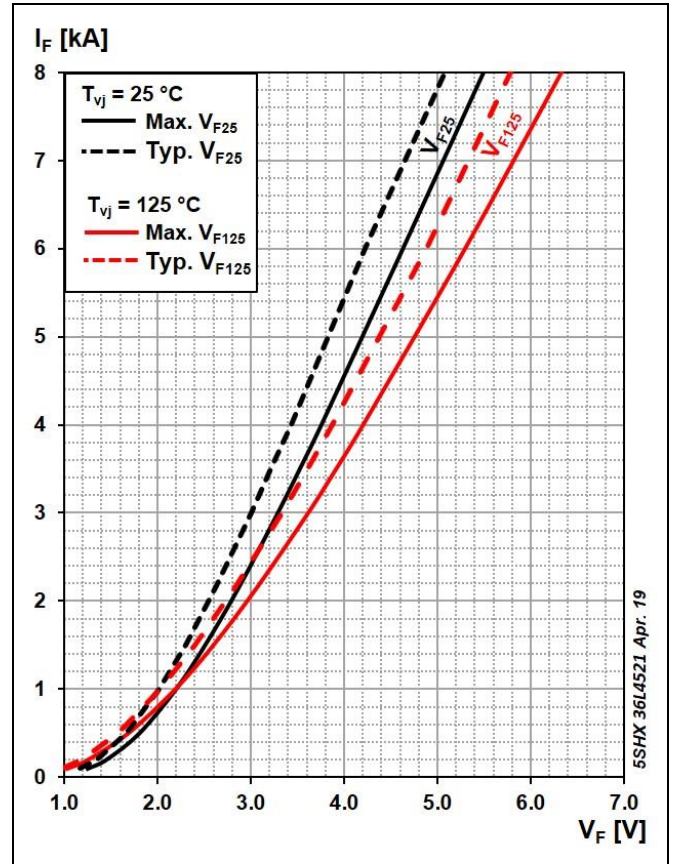


Fig. 8 Diode on-state voltage characteristics

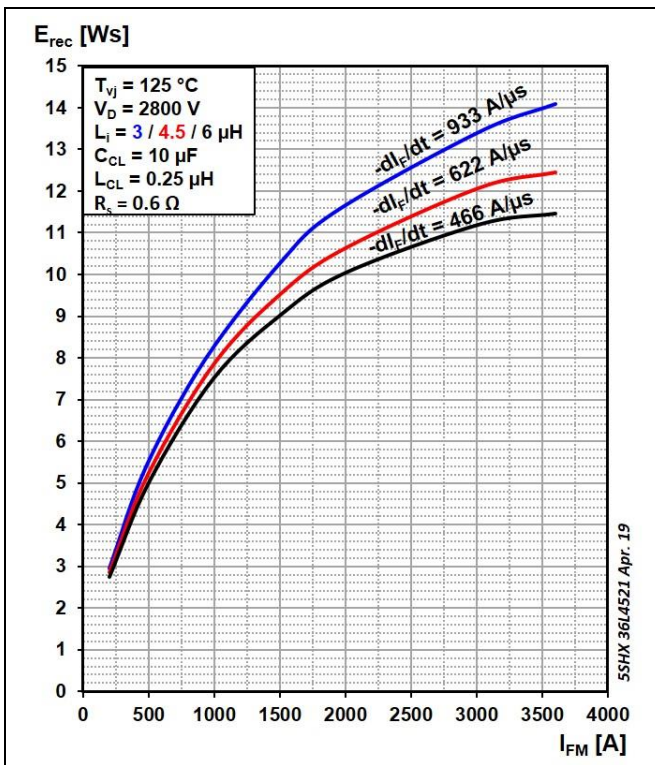


Fig. 9 Upper scatter range of Turn-off energy per pulse vs. turn-off current (typical values)

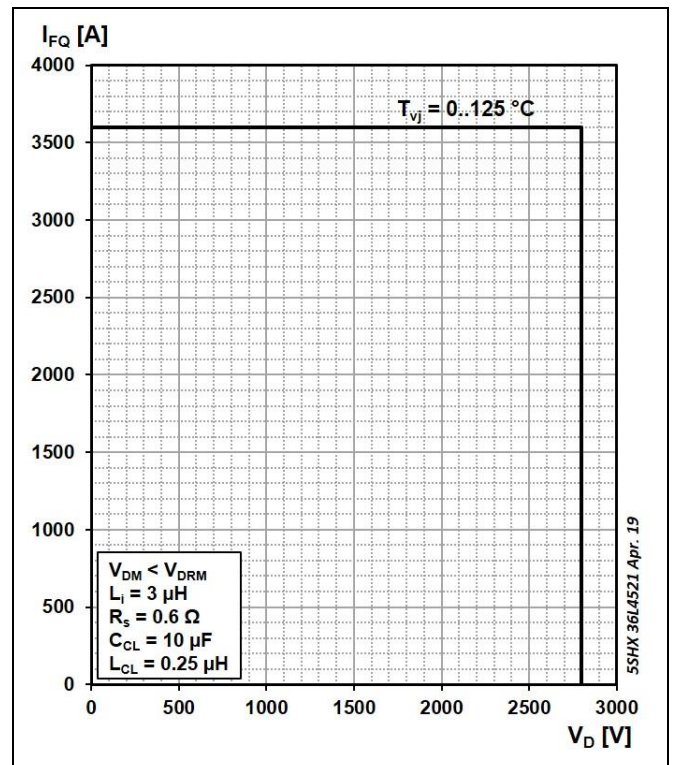


Fig. 10 Diode Safe Operating Area

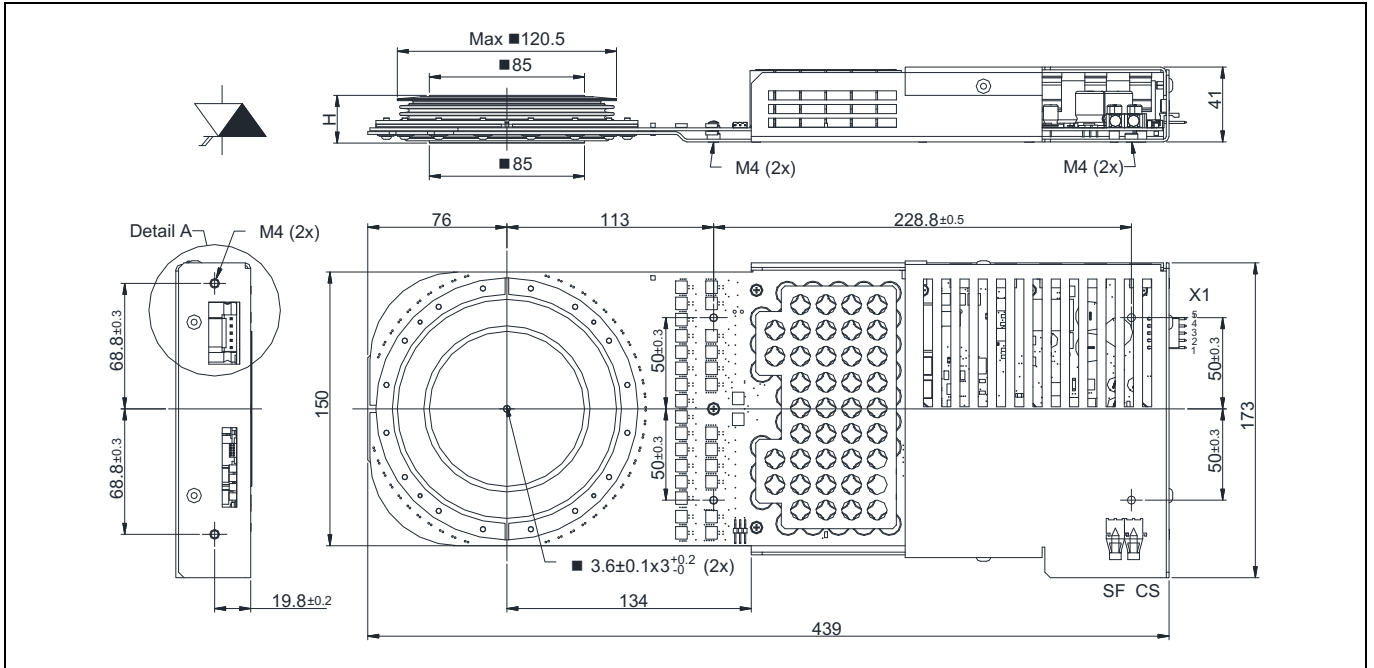


Fig. 11 Outline drawing; all dimensions are in millimeters and represent nominal values unless stated otherwise.

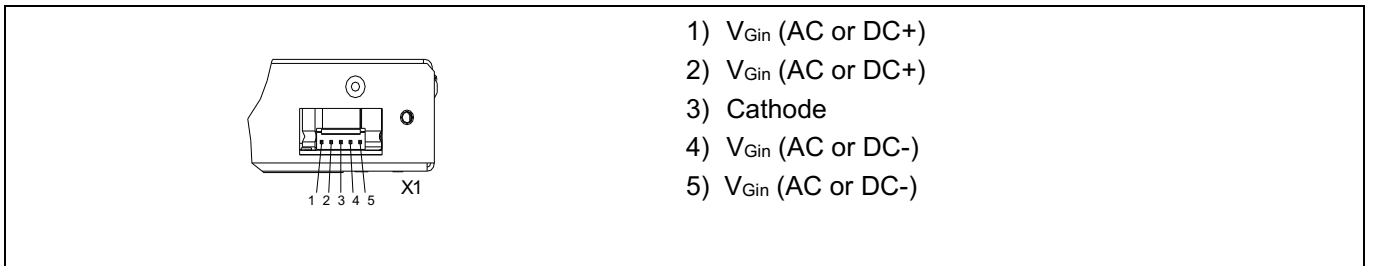


Fig. 12 Detail A: pin out of supply connector X1

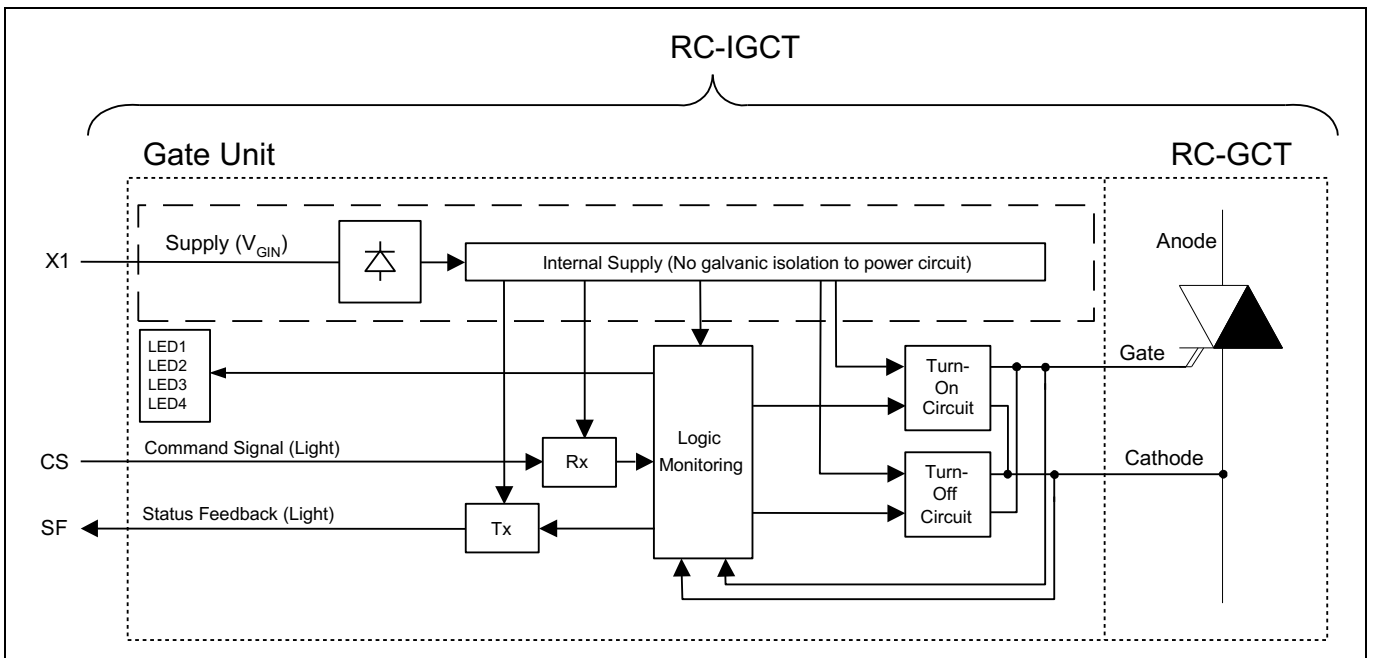


Fig. 13 Block diagram

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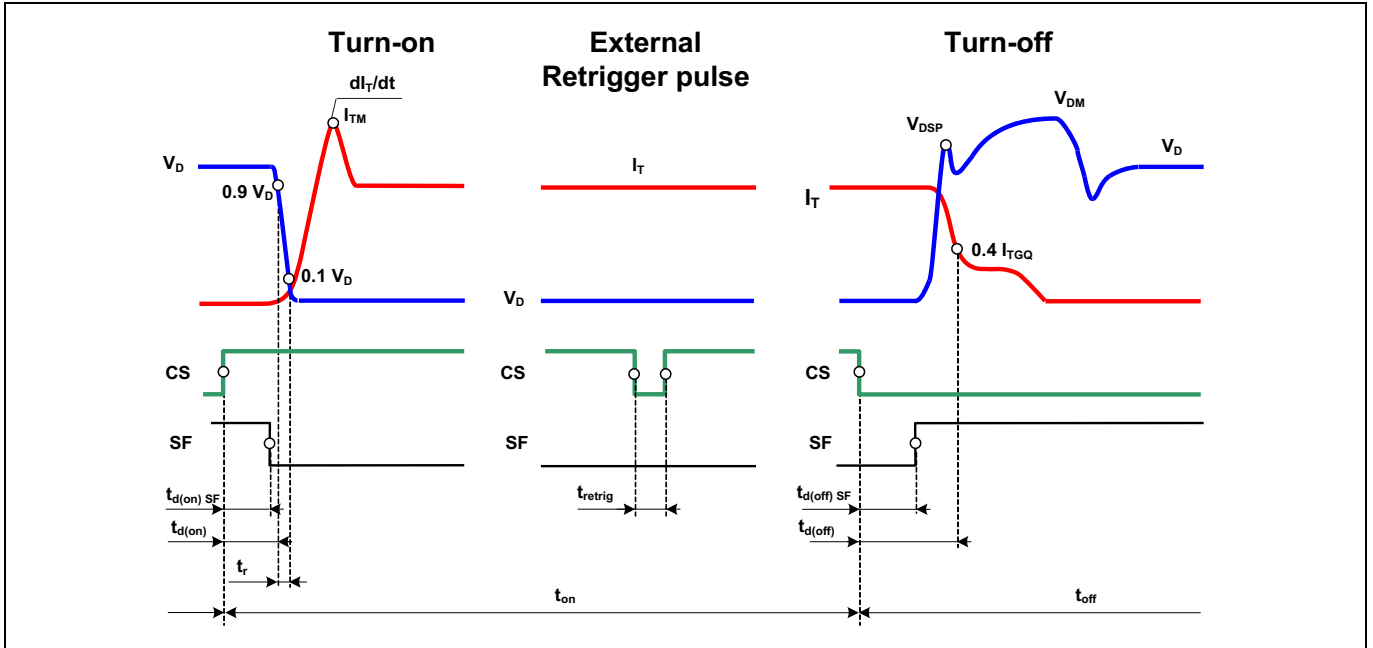


Fig. 14 General current and voltage waveforms with IGCT-specific symbols

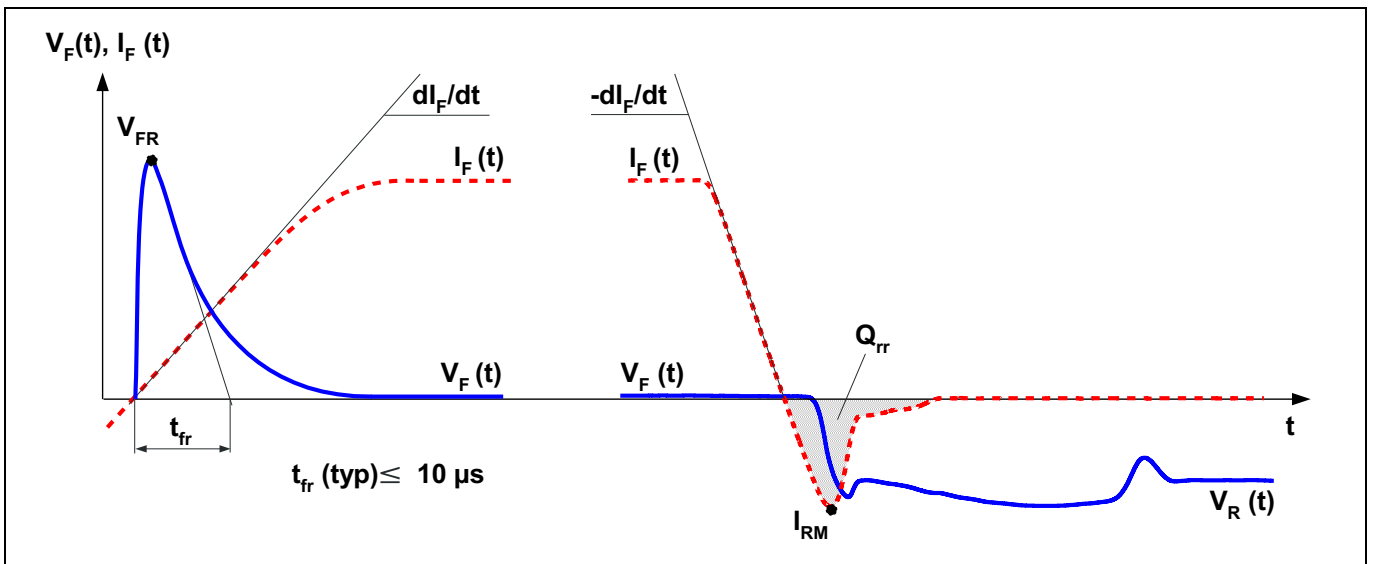


Fig. 15 General current and voltage waveforms with Diode-specific symbols