

$V_{DRM}$	=	4500 V
$I_{TGQM}$	=	3600 A
$I_{TSM}$	=	15.0·10 <sup>3</sup> A
$V_{T0}$	=	1.59 V
$r_T$	=	0.74 mΩ
$V_{DC}$	=	2800 V

# Reverse Conducting Integrated Gate-Commutated Thyristor

## 5SHX 36L4520

### Preliminary

Doc. No. 5SYA1255-01 Apr. 19

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



## Blocking

*Maximum rated values <sup>1)</sup>*

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			100	mA

## Mechanical data

*Maximum rated values <sup>1)</sup>*

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 <sup>1)</sup>

Parameter	Symbol	Conditions	min	typ	max	Unit
Average on-state current	$I_{T(AV)M}$	Half sine wave, $T_c = 85\text{ °C}$ , $T_{vj} = 125\text{ °C}$			1040	A
RMS on-state current	$I_{T(RMS)}$				1640	A
Peak non-repetitive surge current	$I_{TSM}$	$t_p = 3\text{ ms}$ , $T_{vj} = 125\text{ °C}$ sine half wave			$22.0 \cdot 10^3$	A
Limiting load integral	$I^2t$	$V_D = V_R = 0\text{ V}$ , after surge			$726 \cdot 10^3$	A <sup>2</sup> s
Peak non-repetitive surge current	$I_{TSM}$	$t_p = 10\text{ ms}$ , $T_{vj} = 125\text{ °C}$ sine half wave			$15.0 \cdot 10^3$	A
Limiting load integral	$I^2t$	$V_D = V_R = 0\text{ V}$ , after surge			$1.12 \cdot 10^6$	A <sup>2</sup> 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/ $\mu$ s

#### Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
On-state voltage	$V_T$	$I_T = 1500\text{ A}$ , $T_{vj} = 125\text{ °C}$	2.20	2.45	2.70	V
Threshold voltage	$V_{(T0)}$	$I_T = 500\text{ A} - 3000\text{ A}$ , $T_{vj} = 125\text{ °C}$		1.46	1.59	V
Slope resistance	$r_T$				0.66	0.74

### Turn-on switching

#### Maximum rated values <sup>1)</sup>

Parameter	Symbol	Conditions	min	typ	max	Unit
Critical rate of rise of on-state current	$di/dt_{crit}$	$f = 0 - 500\text{ Hz}$ , $T_{vj} = 125\text{ °C}$ $I_T = 3600\text{ A}$ , $I_{TM} \leq \text{TBD A}$ , $V_D = 2800\text{ V}$			1000	A/ $\mu$ s

#### Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
Turn-on delay time	$t_{d(on)}$	$T_{vj} = 125\text{ °C}$			5	$\mu$ 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	$\mu$ 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	$\mu$ s
Turn-on energy per pulse	$E_{on}$				1.40	J

### Turn-off switching

#### Maximum rated values <sup>1)</sup>

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

#### Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
Turn-off delay time	$t_{d(off)}$	$V_D = 2500\text{ V}$ , $T_{vj} = 125\text{ °C}$ $V_{DM} \leq V_{DRM}$ , $I_{TGQ} = 1500\text{ A}$			8	$\mu$ s
Turn-off delay time status feedback	$t_{d(off) SF}$	$L_i = 3\text{ }\mu\text{H}$			7	$\mu$ s
Turn-off energy per pulse	$E_{off}$	$C_{CL} = 10\text{ }\mu\text{F}$ , $L_{CL} = 250\text{ nH}$ , $R_s = 0.6\text{ }\Omega$ $D_{CL} = D_{FWD} = 5\text{SDF } 08\text{H}6005$		5.23		J
Turn-off delay time	$t_{d(off)}$	$V_D = 2800\text{ V}$ , $T_{vj} = 125\text{ °C}$ $V_{DM} \leq V_{DRM}$ , $I_{TGQ} = 1500\text{ A}$			8	$\mu$ s
Turn-off delay time status feedback	$t_{d(off) SF}$	$L_i = 3\text{ }\mu\text{H}$			7	$\mu$ s
Turn-off energy per pulse	$E_{off}$	$C_{CL} = 10\text{ }\mu\text{F}$ , $L_{CL} = 250\text{ nH}$ , $R_s = 0.6\text{ }\Omega$ $D_{CL} = D_{FWD} = 5\text{SDF } 08\text{H}6005$		6.00	8.50	J

## Diode Data

### On-state

#### Maximum rated values <sup>1)</sup>

Parameter	Symbol	Conditions	min	typ	max	Unit
Average on-state current	$I_{F(AV)M}$	Half sine wave, $T_C = 85\text{ °C}$ , $T_{vj} = 125\text{ °C}$			730	A
RMS on-state current	$I_{F(RMS)}$				1140	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 <sup>2</sup> s
Peak non-repetitive surge current	$I_{FSM}$	$t_p = 10\text{ ms}$ , $T_{vj} = 125\text{ °C}$ $V_D = V_R = 0\text{ V}$			TBD	A
Limiting load integral	$I^2t$				TBD	A <sup>2</sup> s

#### Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
On-state voltage	$V_F$	$I_T = 1500\text{ A}$ , $T_{vj} = 125\text{ °C}$	2.80	3.23	3.60	V
Threshold voltage	$V_{(F0)}$	$T_{vj} = 125\text{ °C}$ $I_T = 500\text{ A} - 3000\text{ A}$		1.73	1.88	V
Slope resistance	$r_F$				1.00	1.15

### 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 <sup>1)</sup>

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/ $\mu\text{s}$

#### Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
Reverse recovery current	$I_{RM}$	$T_{vj} = 125\text{ °C}$ , $I_{FM} = 1500\text{ A}$ , $V_D = 2500\text{ V}$ , $-di_F/dt = V_D / L_i$ , $L_{CL} = 250\text{ nH}$ , $C_{CL} = 10\text{ }\mu\text{F}$ , $R_s = 0.6\text{ }\Omega$ , $D_{CL} = D_{FWD} = 5\text{SDF } 08\text{H}6005$			1400	A
Reverse recovery charge	$Q_{rr}$				2180	$\mu\text{C}$
Turn-off energy	$E_{rec}$				4.30	J
Reverse recovery current	$I_{RM}$	$T_{vj} = 125\text{ °C}$ , $I_{FM} = 1500\text{ A}$ , $V_D = 2800\text{ V}$ , $-di_F/dt = V_D / L_i$ , $L_{CL} = 250\text{ nH}$ , $C_{CL} = 10\text{ }\mu\text{F}$ , $R_s = 0.6\text{ }\Omega$ , $D_{CL} = D_{FWD} = 5\text{SDF } 08\text{H}6005$			1500	A
Reverse recovery charge	$Q_{rr}$				2280	$\mu\text{C}$
Turn-off energy	$E_{rec}$				5.00	8.00

# Gate Unit Data

## Power supply

Maximum rated values <sup>1)</sup>

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 <sup>1)</sup>

Parameter	Symbol	Conditions	min	typ	max	Unit
CS On-time	$t_{on}$	CS: Command signal	40			$\mu$ s
CS Off-time	$t_{off}$		40			$\mu$ 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 <sup>2)</sup>

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

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

3) AMP, [www.amp.com](http://www.amp.com)

4) Avago Technologies, [www.avagotech.com](http://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 <sup>1)</sup>

Parameter	Symbol	Conditions	min	typ	max	Unit
Junction operating temperature	T <sub>vj</sub>		0		125	°C
Storage temperature range	T <sub>stg</sub>		-40		60	°C
Ambient operational temperature	T <sub>a</sub>		0		50	°C

## Characteristic values

Parameter	Symbol	Conditions	min	typ	max	Unit
Thermal resistance junction-to-case of GCT	R <sub>th(j-c)</sub>	Double side cooled, no heat flow between GCT and Diode part			11	K/kW
Thermal resistance case-to-heatsink of GCT	R <sub>th(c-h)</sub>				5.1	K/kW
Thermal resistance junction-to-case of Diode	R <sub>th(j-c)</sub>				14	K/kW
Thermal resistance case-to-heatsink of Diode	R <sub>th(c-h)</sub>				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 <sub>i</sub> (K/kW)	6.295	2.912	1.545	0.257
τ <sub>i</sub> (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 <sub>i</sub> (s)	0.5434	0.1146	0.0078	0.0063

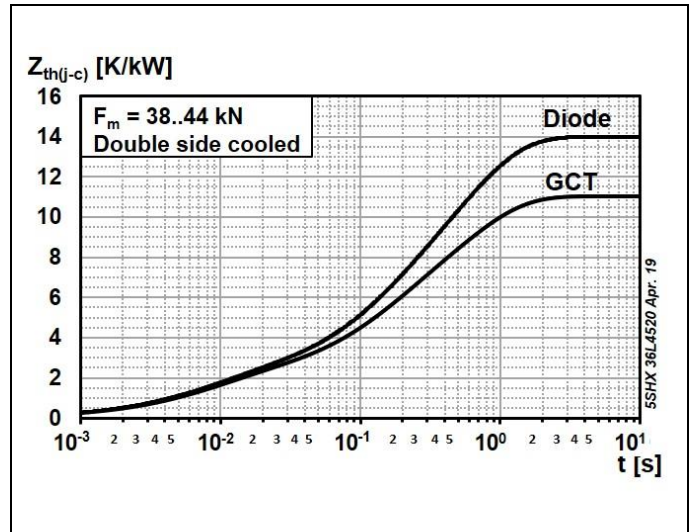


Fig. 1 Transient thermal impedance (junction-to-case) vs. time (max. values)

## 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

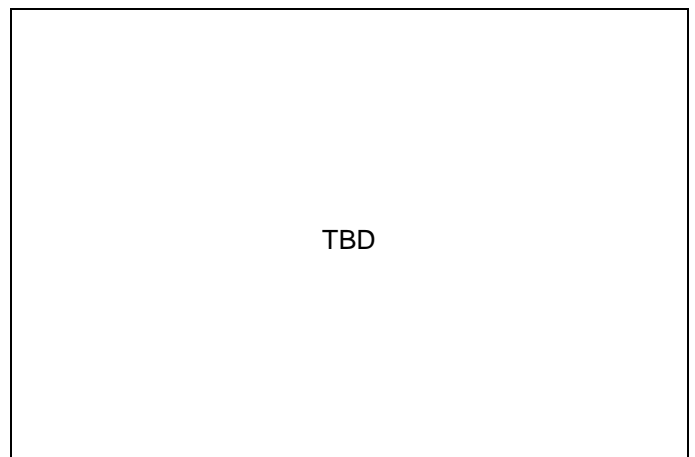


Fig. 2 Max. turn-off current vs. frequency for lifetime operation

# GCT Part

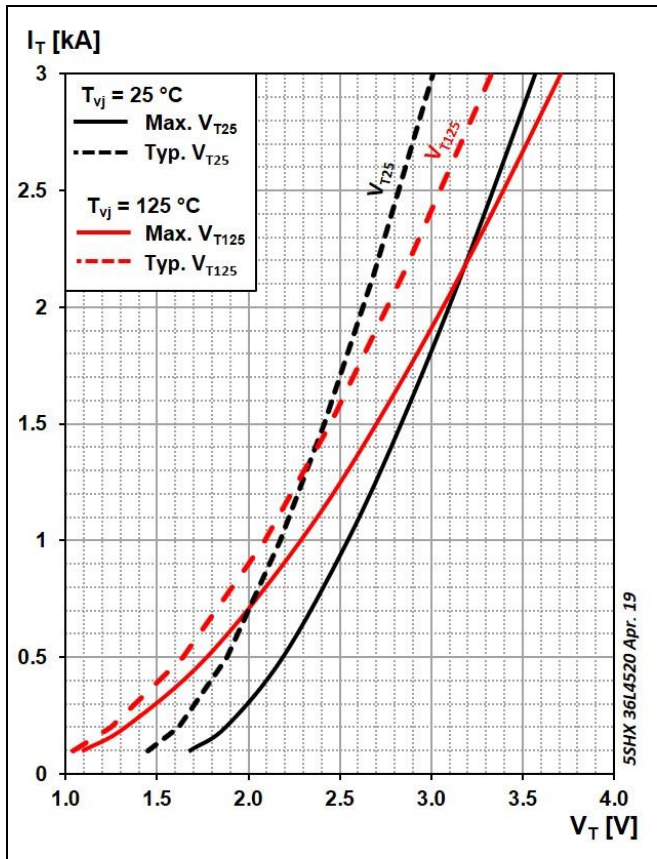


Fig. 3 GCT on-state voltage characteristics

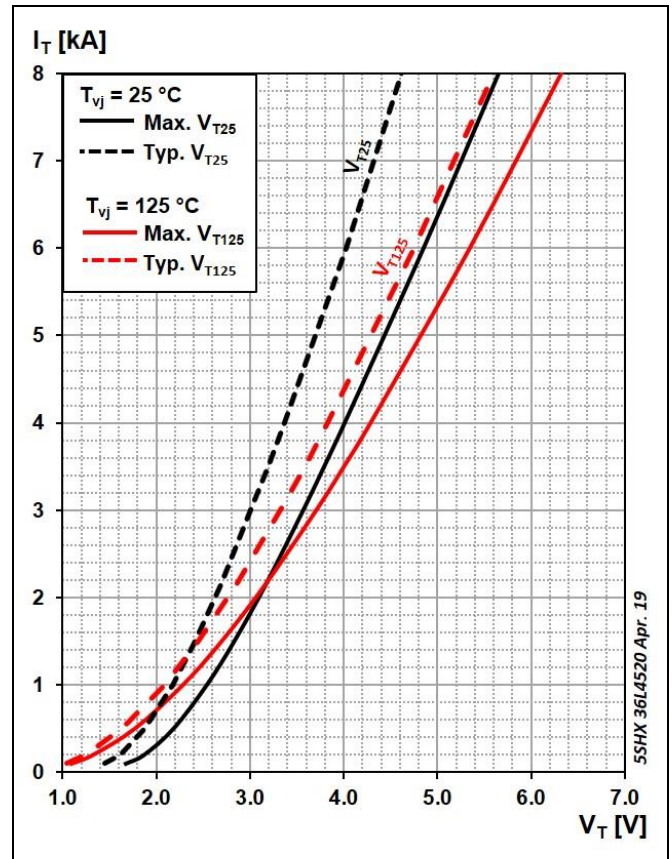


Fig. 4 GCT on-state voltage characteristics

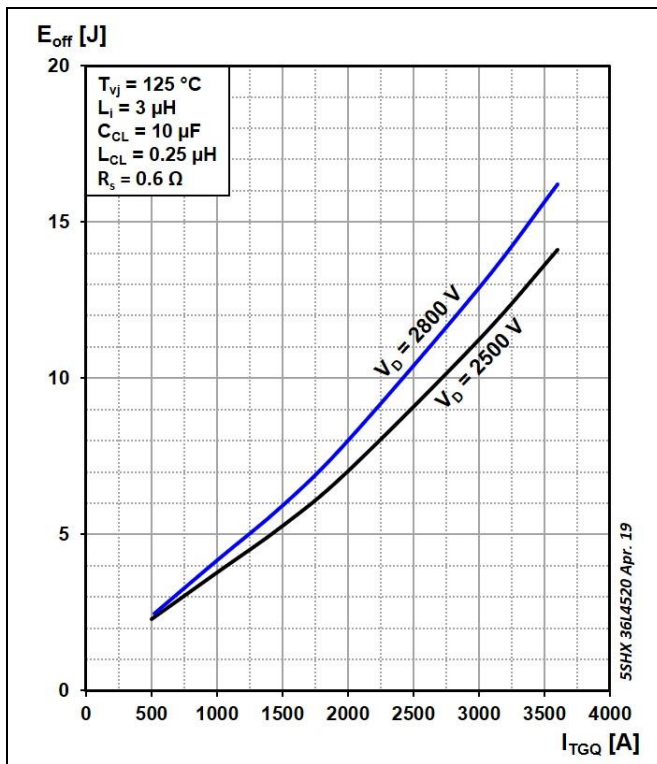


Fig. 5 GCT turn-off energy per pulse vs. turn-off current (typical values)

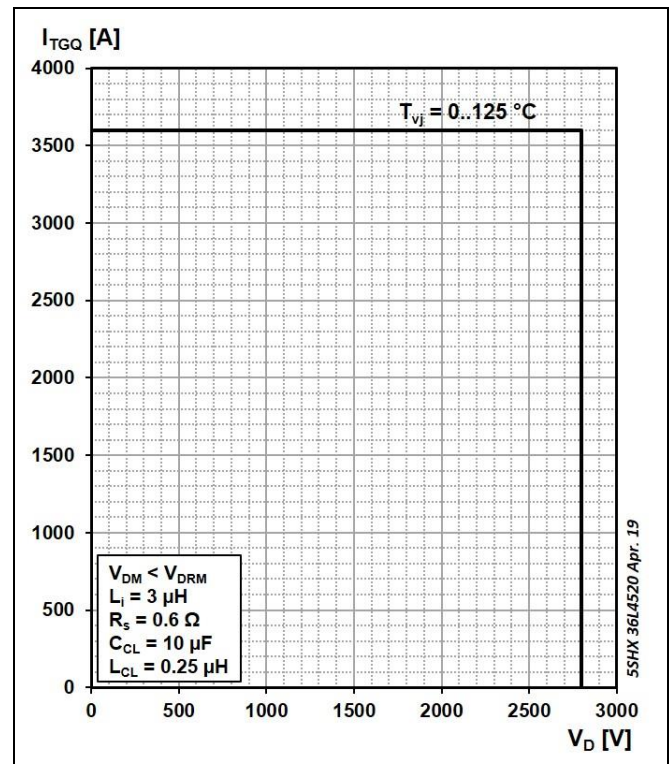


Fig. 6 Safe Operating Area, single pulse



# Diode Part

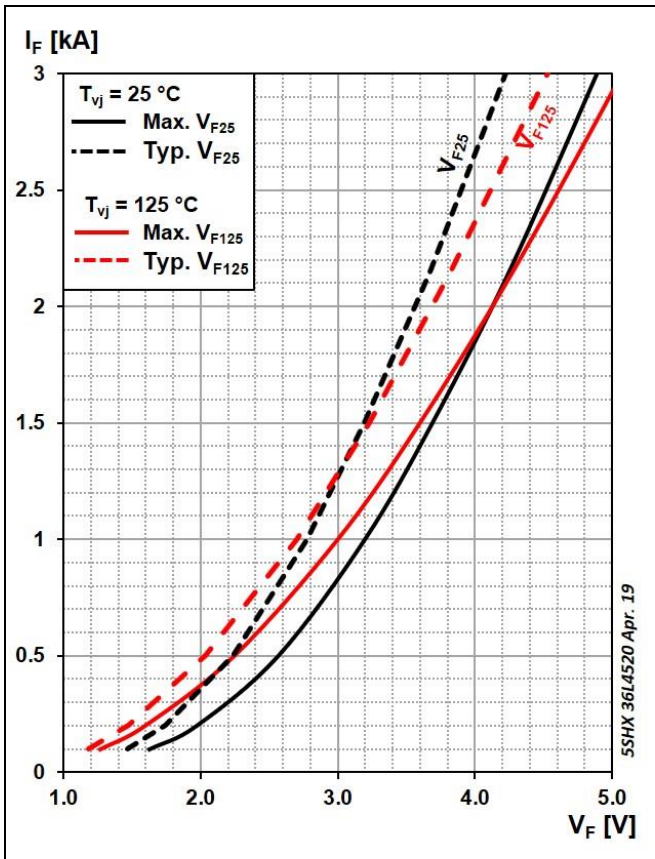


Fig. 7 Diode on-state voltage characteristics

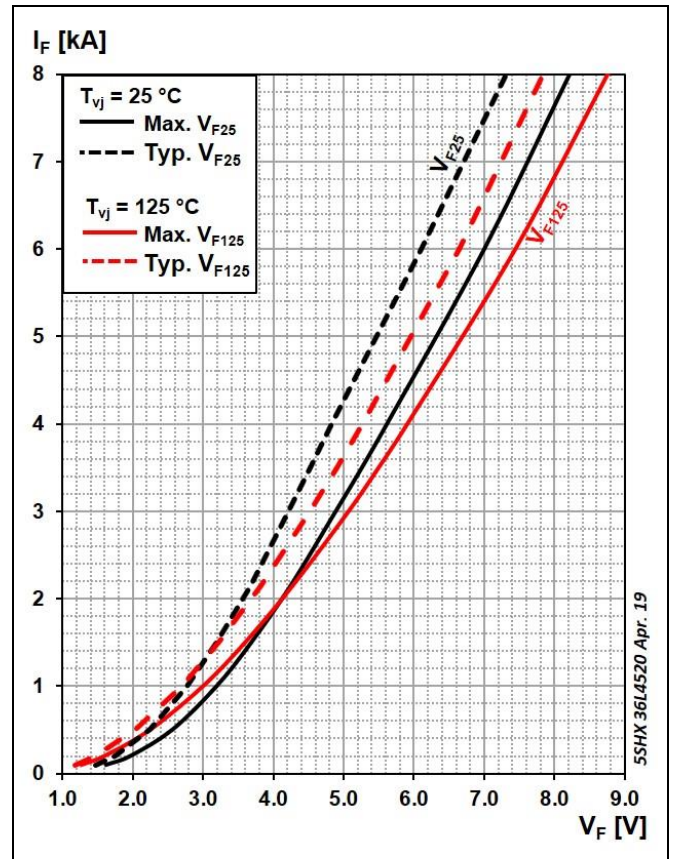


Fig. 8 Diode on-state voltage characteristics

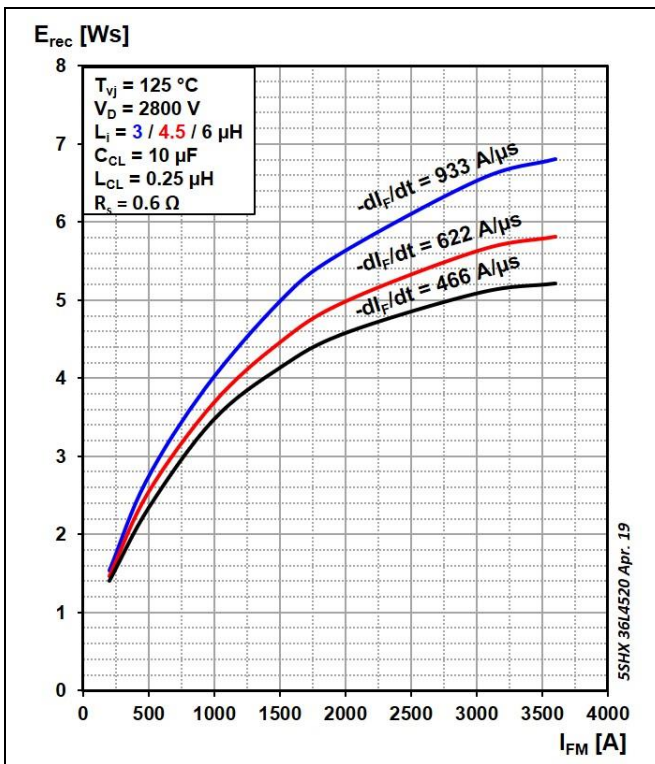


Fig. 9 Upper scatter range of Turn-off energy per pulse vs. turn-off current (typical values)

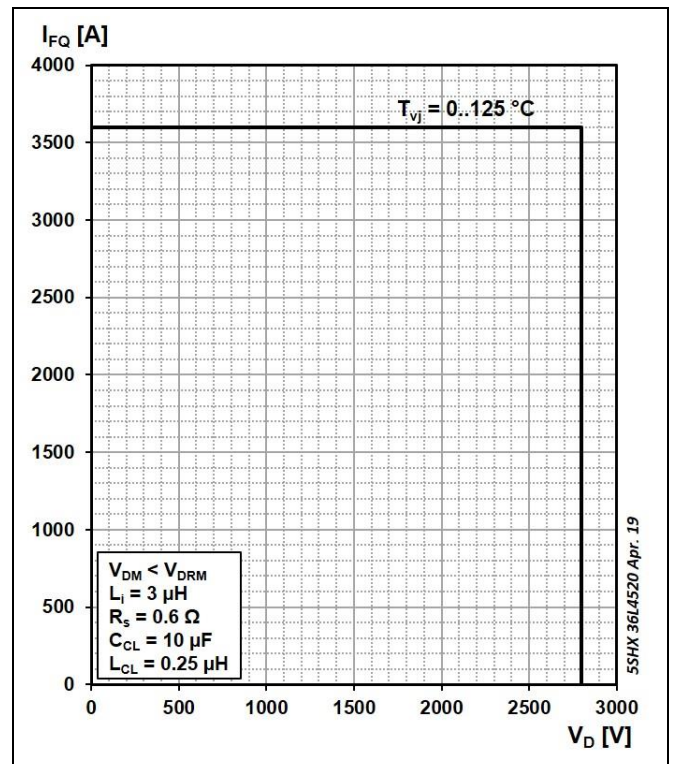
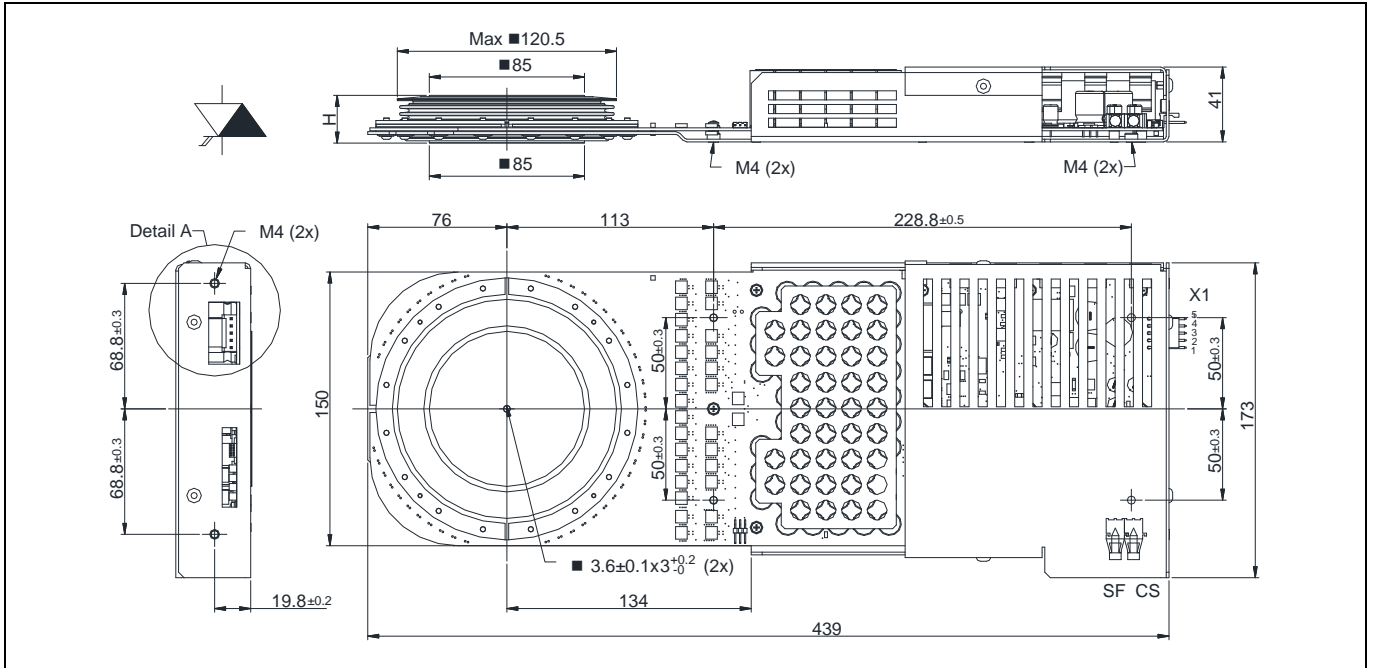
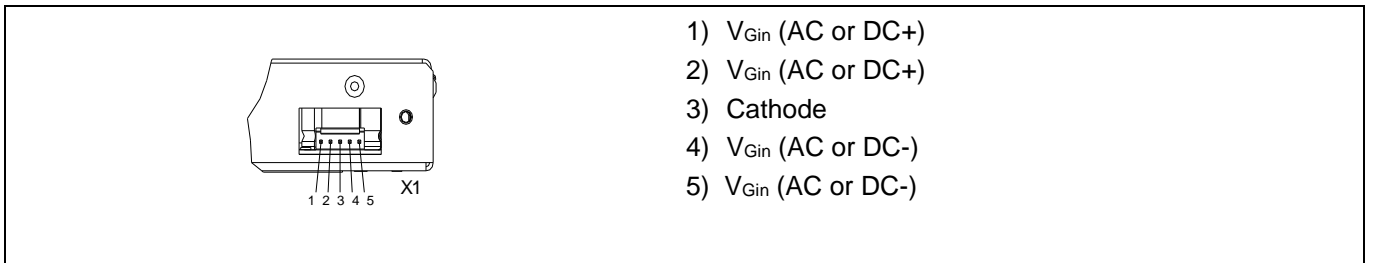


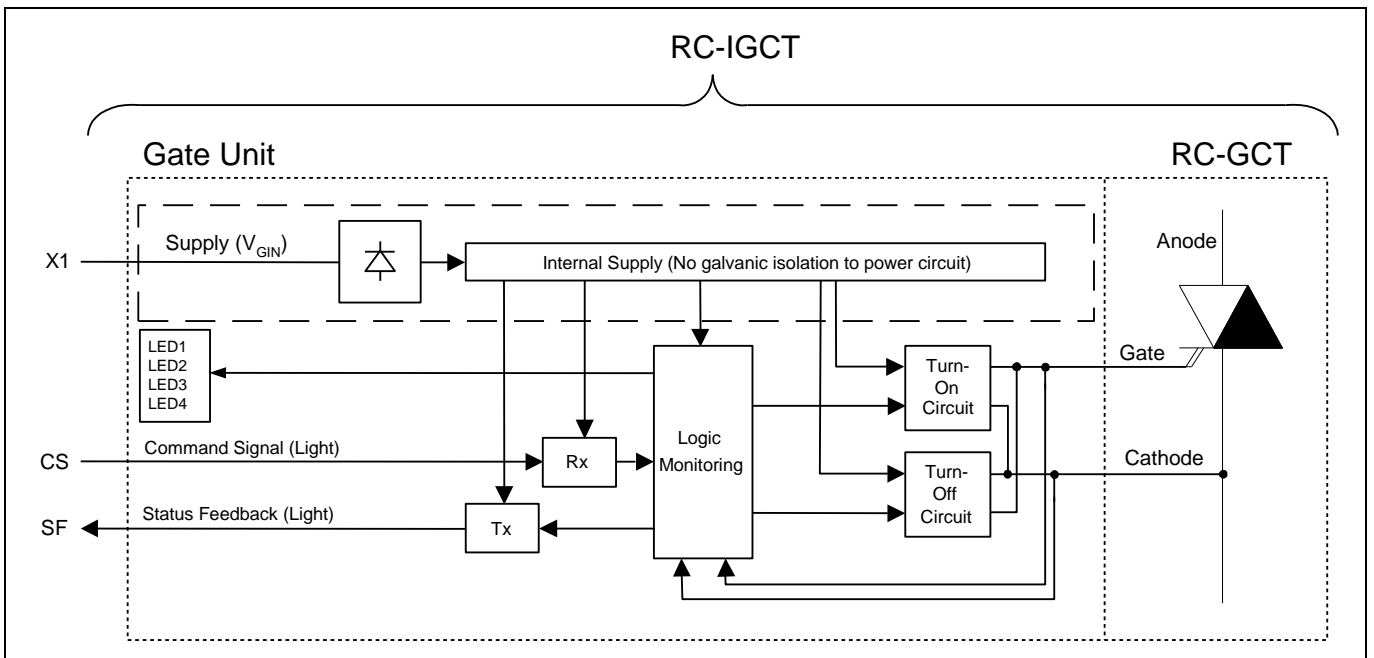
Fig. 10 Diode Safe Operating Area, single pulse



**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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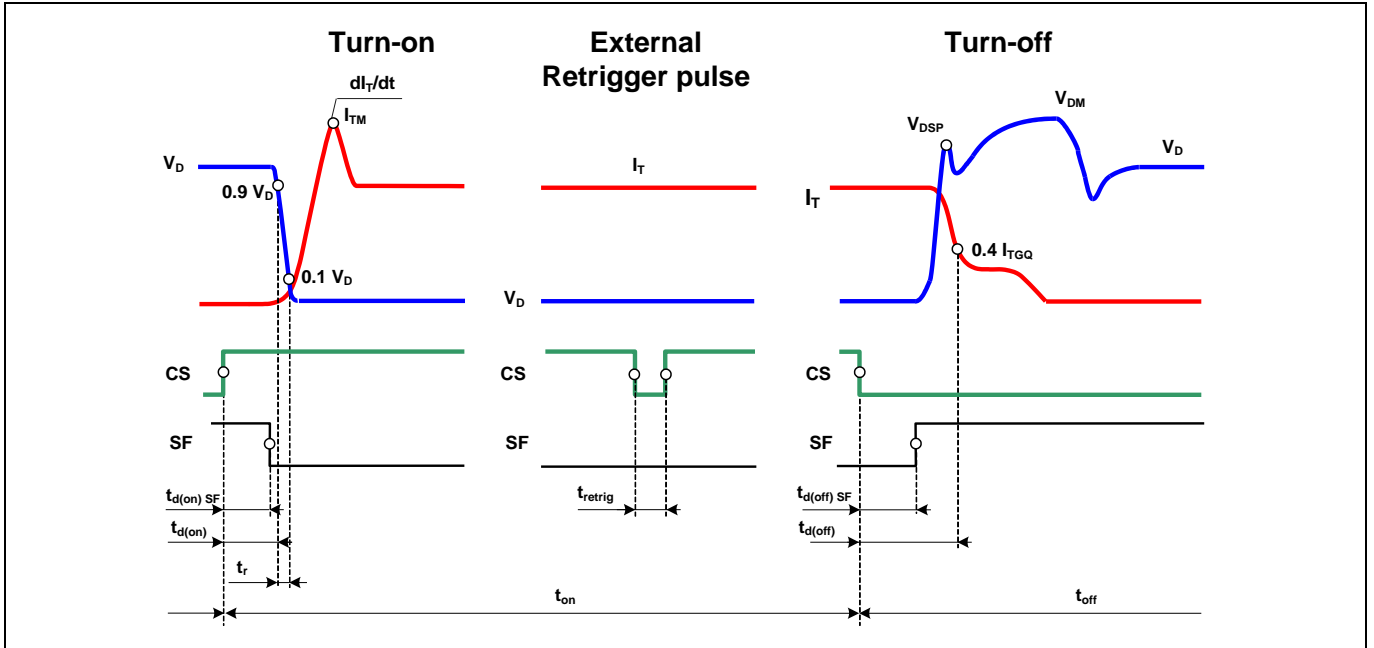


Fig. 14 General current and voltage waveforms with IGCT-specific symbols

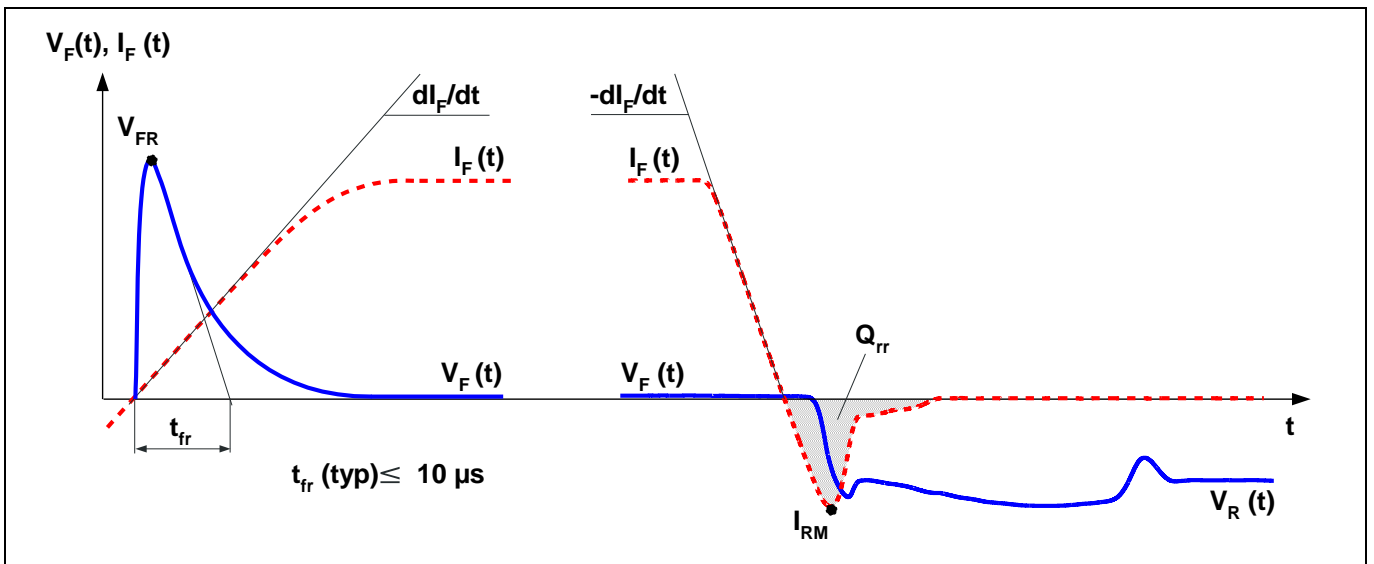


Fig. 15 General current and voltage waveforms with Diode-specific symbols

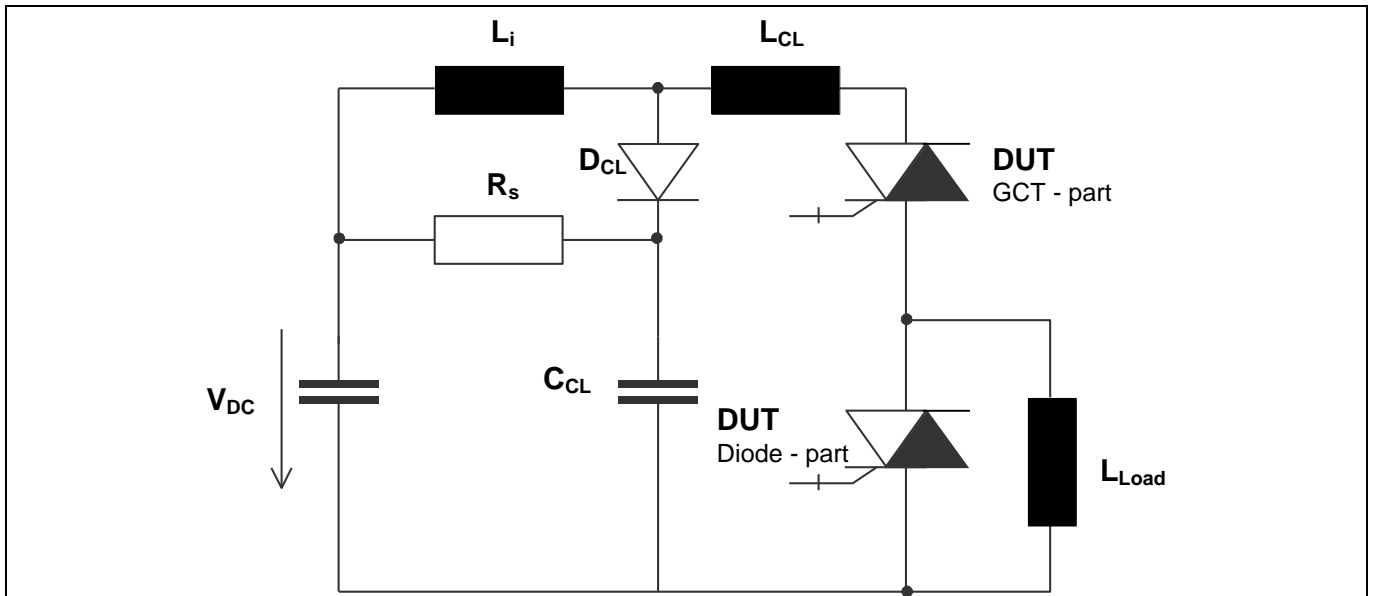


Fig. 16 Test circuit

## Related documents:

5SYA 2031	Applying IGCT Gate Units
5SYA 2032	Applying IGCTs
5SYA 2036	Recommendations regarding mechanical clamping of Press Pack High Power Semiconductors
5SYA 2046	Failure rates of IGCTs due to cosmic rays
5SYA 2048	Field measurements on High Power Press Pack Semiconductors
5SYA 2051	Voltage ratings of high power semiconductors
5SZK 9107	Specification of environmental class for pressure contact IGCTs, OPERATION available on request, please contact factory
5SZK 9109	Specification of environmental class for pressure contact IGCTs, STORAGE available on request, please contact factory
5SZK 9110	Specification of environmental class for pressure contact IGCTs, TRANSPORTATION available on request, please contact factory

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