

|                      |   |                    |
|----------------------|---|--------------------|
| $V_{\text{DRM}}$     | = | 4500 V             |
| $I_{\text{TGQM}}$    | = | 2200 A             |
| $I_{\text{TSM}}$     | = | $17 \times 10^3$ A |
| $V_{\text{(T0)}}$    | = | 1.8 V              |
| $r_{\text{T}}$       | = | 0.533 mW           |
| $V_{\text{DC-link}}$ | = | 2800 V             |

# Reverse Conducting Integrated Gate-Commutated Thyristor 5SHX 26L4510

Doc. No. 5SYA1230-03 Aug 07

- High snubberless turn-off rating
- Optimized for medium frequency (<1 kHz) and low turn-off losses
- High reliability
- High electromagnetic immunity
- Simple control interface with status feedback
- AC or DC supply voltage
- Contact factory for series connection



## Blocking

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

| Parameter   | Symbol               | Conditions   | min | typ | max  | Unit |
|---|----------------------|--|-----|-----|------|------|
| Repetitive peak off-state voltage                       | $V_{\text{DRM}}$     | Gate Unit energized  |     |     | 4500 | V    |
| Permanent DC voltage for 100 FIT failure rate of RC-GCT | $V_{\text{DC-link}}$ | 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 | $I_{\text{DRM}}$ | $V_{\text{D}} = V_{\text{DRM}}$ , Gate Unit energized |     |     | 50  | mA   |

## Mechanical data (see Fig. 20, 21)

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

| Parameter      | Symbol         | Conditions | min | typ | max | Unit |
|----------------|----------------|------------|-----|-----|-----|------|
| Mounting force | $F_{\text{m}}$ |            | 42  | 44  | 46  | kN   |

*Characteristic values*

| Parameter                 | Symbol         | Conditions    | min  | typ | max  | Unit |
|---------------------------|----------------|---------------|------|-----|------|------|
| Pole-piece diameter       | $D_{\text{p}}$ | $\pm 0.1$ mm  |      | 85  |      | mm   |
| Housing thickness         | H              |               | 25.3 |     | 25.8 | mm   |
| Weight                    | m              |               |      |     | 2.9  | kg   |
| Surface creepage distance | $D_{\text{s}}$ | Anode to Gate | 33   |     |      | mm   |
| Air strike distance       | $D_{\text{a}}$ | Anode to Gate | 10   |     |      | mm   |
| Length                    | l              | $\pm 1.0$ mm  |      | 439 |      | mm   |
| Height                    | h              | $\pm 1.0$ mm  |      | 40  |      | mm   |
| Width IGCT                | w              | $\pm 1.0$ mm  |      | 173 |      | mm   |

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

ABB Switzerland Ltd, Semiconductors reserves the right to change specifications without notice.



## GCT Data

### On-state (see Fig. 3 to 6, 23)

**Maximum rated values** Note 1

| Parameter                                       | Symbol         | Conditions  | min | typ | max                | Unit             |
|---|----------------|---|-----|-----|--------------------|------------------|
| Max. average on-state current                   | $I_{T(AV)M}$   | Half sine wave, $T_C = 85\text{ °C}$ ,<br>Double side cooled                                      |     |     | 1010               | A                |
| Max. RMS on-state current                       | $I_{T(RMS)}$   |   |     |     | 1590               | A                |
| Max. peak non-repetitive surge on-state current | $I_{TSM}$      | $t_p = 10\text{ ms}$ , $T_j = 125\text{ °C}$ , sine wave<br>after surge: $V_D = V_R = 0\text{ V}$ |     |     | $17 \times 10^3$   | A                |
| Limiting load integral                          | $I^2t$         |   |     |     | $1.45 \times 10^6$ | A <sup>2</sup> s |
| Max. peak non-repetitive surge on-state current | $I_{TSM}$      | $t_p = 3\text{ ms}$ , $T_j = 125\text{ °C}$ , sine wave<br>after surge: $V_D = V_R = 0\text{ V}$  |     |     | $25 \times 10^3$   | A                |
| Limiting load integral                          | $I^2t$         |   |     |     | $938 \times 10^3$  | A <sup>2</sup> s |
| Critical rate of rise of on-state current       | $di_T/dt_{cr}$ | For higher $di_T/dt$ and current lower than 100 A an external retrigger pulse is required.        |     |     | 100                | A/ $\mu$ s       |

#### Characteristic values

| Parameter         | Symbol     | Conditions                                    | min | typ | max   | Unit       |
|-------------------|------------|---|-----|-----|-------|------------|
| On-state voltage  | $V_T$      | $I_T = 2200\text{ A}$ , $T_j = 125\text{ °C}$ | 2.3 | 2.6 | 2.95  | V          |
| Threshold voltage | $V_{(T0)}$ | $T_j = 125\text{ °C}$                         |     |     | 1.8   | V          |
| Slope resistance  | $r_T$      | $I_T = 400 \dots 3000\text{ A}$               |     |     | 0.533 | m $\Omega$ |

### Turn-on switching (see Fig. 23, 25)

**Maximum rated values** Note 1

| Parameter                                 | Symbol         | Conditions   | min | typ | max | Unit       |
|---|----------------|--|-----|-----|-----|------------|
| Critical rate of rise of on-state current | $di_T/dt_{cr}$ | $f = 0.500\text{ Hz}$ , $T_j = 125\text{ °C}$ ,<br>$I_T = 2200\text{ A}$ , $V_D = 2800\text{ V}$ |     |     | 650 | A/ $\mu$ s |

#### Characteristic values

| Parameter                          | Symbol       | Conditions   | min | typ | max  | Unit    |
|------------------------------------|--------------|--|-----|-----|------|---------|
| Turn-on delay time                 | $t_{don}$    | $V_D = 2800\text{ V}$ , $T_j = 125\text{ °C}$<br>$I_T = 2200\text{ A}$ , $di/dt = V_D / L_i$<br>$L_i = 5\text{ }\mu\text{H}$<br>$C_{CL} = 10\text{ }\mu\text{F}$ , $L_{CL} = 0.3\text{ }\mu\text{H}$ |     |     | 3.5  | $\mu$ s |
| Turn-on delay time status feedback | $t_{don SF}$ |  |     |     | 7    | $\mu$ s |
| Rise time                          | $t_r$        |  |     |     | 1    | $\mu$ s |
| Turn-on energy per pulse           | $E_{on}$     |  |     |     | 0.85 | J       |

### Turn-off switching (see Fig. 7, 8, 23, 25)

**Maximum rated values** Note 1

| Parameter                          | Symbol     | Conditions   | min | typ | max  | Unit |
|------------------------------------|------------|--|-----|-----|------|------|
| Max. controllable turn-off current | $I_{TGQM}$ | $V_{DM} \leq V_{DRM}$ , $T_j = 125\text{ °C}$ ,<br>$V_D = 2800\text{ V}$ , $R_S = 0.65\text{ }\Omega$ ,<br>$C_{CL} = 10\text{ }\mu\text{F}$ , $L_{CL} \leq 0.3\text{ }\mu\text{H}$ |     |     | 2200 | A    |
| Max. controllable turn-off current | $I_{TGQM}$ | $V_{DM} \leq V_{DRM}$ , $T_j = 125\text{ °C}$ ,<br>$V_D = 3200\text{ V}$ , $R_S = 0.65\text{ }\Omega$ ,<br>$C_{CL} = 10\text{ }\mu\text{F}$ , $L_{CL} \leq 0.3\text{ }\mu\text{H}$ |     |     | 1100 | A    |

#### Characteristic values

| Parameter                           | Symbol        | Conditions  | min | typ | max | Unit    |
|-------------------------------------|---------------|---|-----|-----|-----|---------|
| Turn-off delay time                 | $t_{doff}$    | $V_D = 2800\text{ V}$ , $T_j = 125\text{ °C}$<br>$V_{DM} \leq V_{DRM}$ , $R_S = 0.65\text{ }\Omega$<br>$I_{TGQ} = 2200\text{ A}$ , $L_i = 5\text{ }\mu\text{H}$<br>$C_{CL} = 10\text{ }\mu\text{F}$ , $L_{CL} = 0.3\text{ }\mu\text{H}$ , |     |     | 7   | $\mu$ s |
| Turn-off delay time status feedback | $t_{doff SF}$ |   |     |     | 7   | $\mu$ s |
| Turn-off energy per pulse           | $E_{off}$     |   |     |     | 7.8 | J       |

## Diode Data

**On-state** (see Fig. 9 to 12, 24, 25)

**Maximum rated values** Note 1

| Parameter                              | Symbol       | Conditions   | min | typ | max                 | Unit             |
|--|--------------|--|-----|-----|---------------------|------------------|
| Max. average on-state current          | $I_{F(AV)M}$ | Half sine wave, $T_C = 85\text{ °C}$                                 |     |     | 390                 | A                |
| Max. RMS on-state current              | $I_{F(RMS)}$ |  |     |     | 620                 | A                |
| Max. peak non-repetitive surge current | $I_{FSM}$    | $t_p = 10\text{ ms}$ , $T_{vj} = 125\text{ °C}$ , $V_R = 0\text{ V}$ |     |     | $10.6 \times 10^3$  | A                |
| Limiting load integral                 | $I^2t$       |  |     |     | $561.8 \times 10^3$ | A <sup>2</sup> s |
| Max. peak non-repetitive surge current | $I_{FSM}$    | $t_p = 3\text{ ms}$ , $T_{vj} = 125\text{ °C}$ , $V_R = 0\text{ V}$  |     |     | $14.3 \times 10^3$  | A                |
| Limiting load integral                 | $I^2t$       |  |     |     | $306.7 \times 10^3$ | A <sup>2</sup> s |

**Characteristic values**

| Parameter         | Symbol     | Conditions                                       | min  | typ  | max  | Unit |
|-------------------|------------|--|------|------|------|------|
| On-state voltage  | $V_F$      | $I_F = 2200\text{ A}$ , $T_{vj} = 125\text{ °C}$ | 3.54 | 4.25 | 5.4  | V    |
| Threshold voltage | $V_{(F0)}$ | $T_{vj} = 125\text{ °C}$                         |      |      | 2.7  | V    |
| Slope resistance  | $r_F$      | $I_F = 400\text{...}3000\text{ A}$               |      |      | 1.24 | mΩ   |

**Turn-on** (see Fig. 24, 25)

**Characteristic values**

| Parameter                     | Symbol    | Conditions   | min | typ | max | Unit |
|-------------------------------|-----------|--|-----|-----|-----|------|
| Peak forward recovery voltage | $V_{FRM}$ | $di_F/dt = 650\text{ A}/\mu\text{s}$ , $T_{vj} = 125\text{ °C}$  |     |     | 80  | V    |
|                               |           | $di_F/dt = 3000\text{ A}/\mu\text{s}$ , $T_{vj} = 125\text{ °C}$ |     |     | 250 | V    |

**Turn-off** (see Fig. 13 to 17, 24, 25)

**Maximum rated values** Note 1

| Parameter                           | Symbol         | Conditions  | min | typ | max | Unit             |
|-------------------------------------|----------------|---|-----|-----|-----|------------------|
| Max. decay rate of on-state current | $di/dt_{crit}$ | $I_{FM} = 2200\text{ A}$ , $T_{vj} = 125\text{ °C}$<br>$V_{DClink} = 2800\text{ V}$ |     |     | 650 | A/ $\mu\text{s}$ |
| Max. decay rate of on-state current | $di/dt_{crit}$ | $I_{FM} = 3200\text{ A}$ , $T_{vj} = 125\text{ °C}$<br>$V_{DClink} = 2800\text{ V}$ |     |     | 650 | A/ $\mu\text{s}$ |

**Characteristic values**

| Parameter                | Symbol   | Conditions   | min | typ | max  | Unit          |
|--------------------------|----------|--|-----|-----|------|---------------|
| Reverse recovery current | $I_{RM}$ | $I_{FM} = 2200\text{ A}$ , $V_{DC-Link} = 2800\text{ V}$<br>$-di_F/dt = 650\text{ A}/\mu\text{s}$ , $L_{CL} = 300\text{ nH}$ |     |     | 900  | A             |
| Reverse recovery charge  | $Q_{rr}$ | $C_{CL} = 10\text{ }\mu\text{F}$ , $R_S = 0.8\text{ }\Omega$ ,   |     |     | 2800 | $\mu\text{C}$ |
| Turn-off energy          | $E_{rr}$ | $T_{vj} = 125\text{ °C}$ , $D_{CL} = 5\text{SDF } 10\text{H}4520$  |     | 2.7 | 4    | J             |

## Gate Unit Data

### Power supply (see Fig. 18, 19)

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

| Parameter                                     | Symbol        | Conditions  | min | typ | max | Unit |
|---|---------------|---|-----|-----|-----|------|
| Gate Unit voltage<br>(Connector X1)           | $V_{GIN,RMS}$ | AC square wave amplitude (15 kHz - 100kHz) 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  | 2.1 |     |     | A    |
| Gate Unit power consumption                   | $P_{GIN Max}$ |   |     |     | 100 | 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 <sup>2)</sup> (see Fig. 23)

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

| Parameter     | Symbol    | Conditions | min | typ | max | Unit    |
|---------------|-----------|------------|-----|-----|-----|---------|
| Min. on-time  | $t_{on}$  |            | 40  |     |     | $\mu s$ |
| Min. 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<br>SF: Status feedback<br>Valid for 1mm plastic optical fiber (POF) | -15 |     | -1   | dBm  |
| Optical noise power            | $P_{off CS}$ |  |     |     | -45  | dBm  |
| Optical output power           | $P_{on SF}$  |  |     |     | -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 | $t_{retrig}$ |  | 600 |     | 1100 | ns   |

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

### Connectors <sup>2)</sup> (see Fig. 20 to 22)

| 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-2528 <sup>4)</sup>              |
| LWL transmitter for status feedback | SF     | Avago, Type HFBR-1528 <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 (see Fig. 22)

| 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)  |

# Thermal

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

| 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   | $R_{th(jc)}$ | Double side cooled                      |     |     | 12.6 | K/kW |
| Thermal resistance case-to-heatsink of GCT   | $R_{th(ch)}$ | No heat flow between GCT and Diode part |     |     | 4.2  | K/kW |
| Thermal resistance junction-to-case of Diode | $R_{th(jc)}$ | Double side cooled                      |     |     | 26   | K/kW |
| Thermal resistance case-to-heatsink of Diode | $R_{th(ch)}$ | No heat flow between GCT and Diode part |     |     | 10.4 | 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      |
|-------------|--------|--------|--------|--------|
| $R_i(K/kW)$ | 8.769  | 1.909  | 1.218  | 0.699  |
| $\tau_i(s)$ | 0.5407 | 0.0792 | 0.0091 | 0.0025 |

### Diode

| i           | 1      | 2      | 3      | 4      |
|-------------|--------|--------|--------|--------|
| $R_i(K/kW)$ | 17.057 | 5.007  | 2.498  | 1.439  |
| $\tau_i(s)$ | 0.5460 | 0.0829 | 0.0089 | 0.0023 |

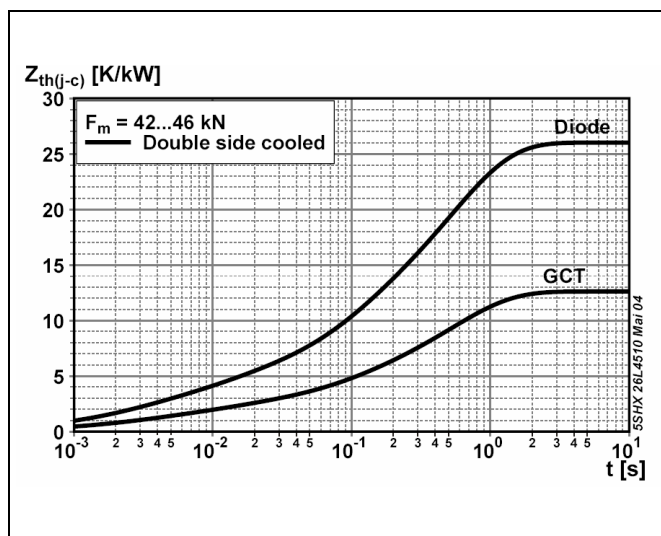


Fig. 1 Transient thermal impedance (junction-to-case) vs. time (max. values)

### 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

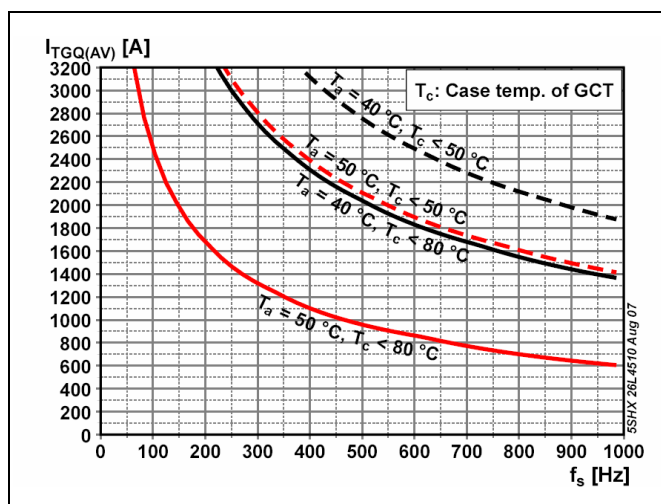


Fig. 2 Max. turn-off current vs. frequency for lifetime operation

### GCT Part

Max. on-state characteristic model:

$$V_{T25} = A_{T25} + B_{T25} \cdot I_T + C_{T25} \cdot \ln(I_T + 1) + D_{T25} \cdot \sqrt{I_T}$$

Valid for  $i_T = 300 - 15000$  A

| A <sub>25</sub>        | B <sub>25</sub>        | C <sub>25</sub>        | D <sub>25</sub> |
|------------------------|------------------------|------------------------|-----------------|
| $-79.1 \times 10^{-3}$ | $272.3 \times 10^{-6}$ | $296.9 \times 10^{-3}$ | 0.0             |

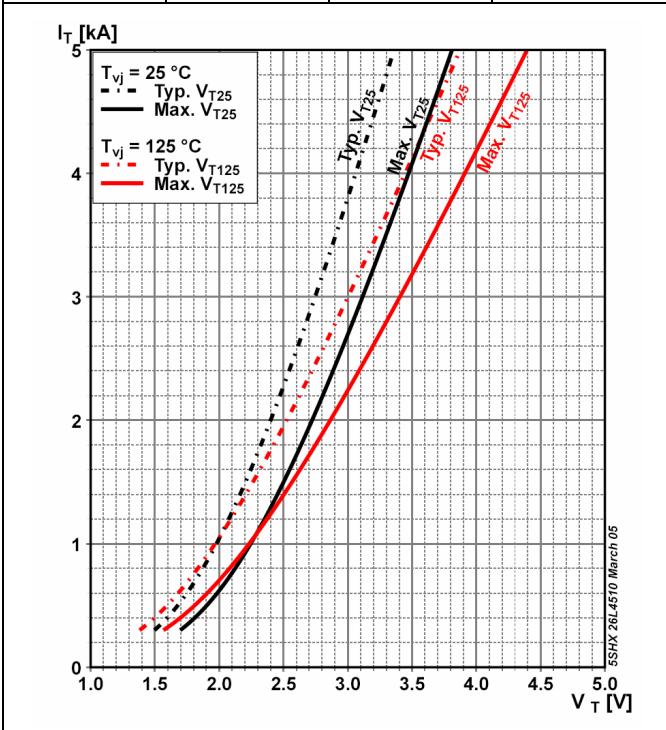


Fig. 3 GCT on-state voltage characteristics

Max. on-state characteristic model:

$$V_{T125} = A_{T125} + B_{T125} \cdot I_T + C_{T125} \cdot \ln(I_T + 1) + D_{T125} \cdot \sqrt{I_T}$$

Valid for  $i_T = 300 - 15000$  A

| A <sub>125</sub>        | B <sub>125</sub>       | C <sub>125</sub>       | D <sub>125</sub> |
|-------------------------|------------------------|------------------------|------------------|
| $-342.7 \times 10^{-3}$ | $414.9 \times 10^{-6}$ | $312.7 \times 10^{-3}$ | 0.0              |

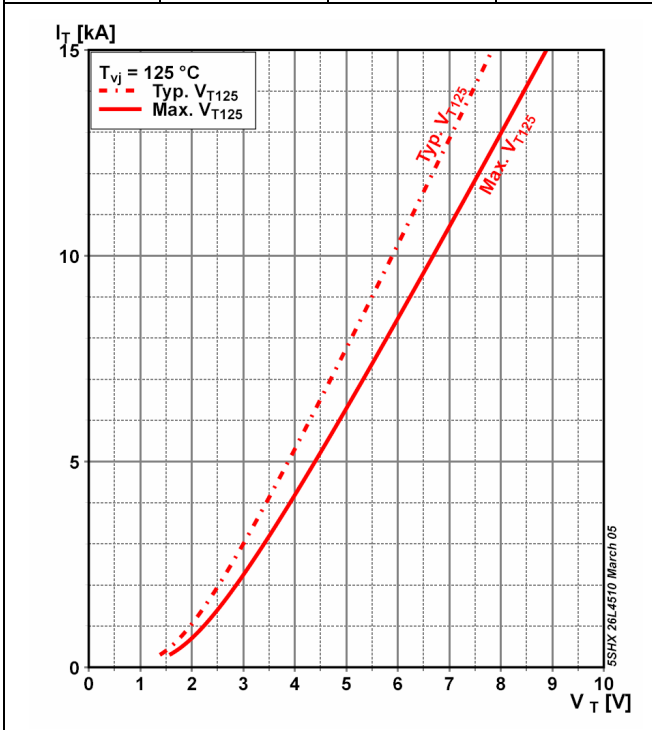


Fig. 4 GCT on-state voltage characteristics

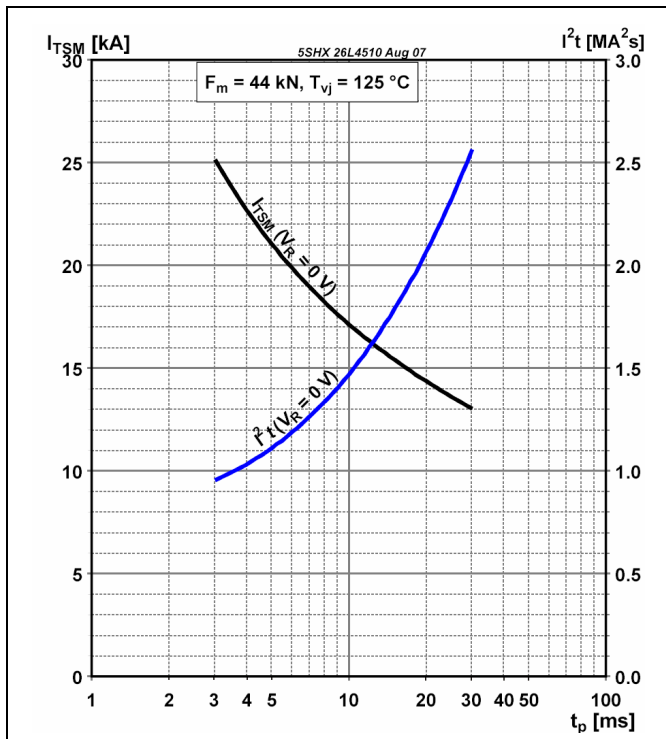


Fig. 5 GCT surge on-state current vs. pulse length, half-sine wave

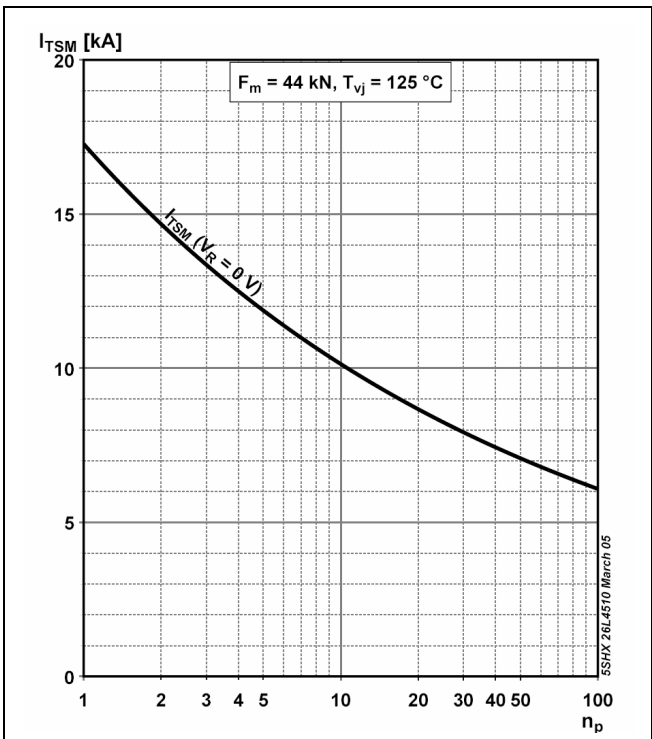


Fig. 6 GCT surge on-state current vs. number of pulses, half-sine wave, 10 ms, 50Hz

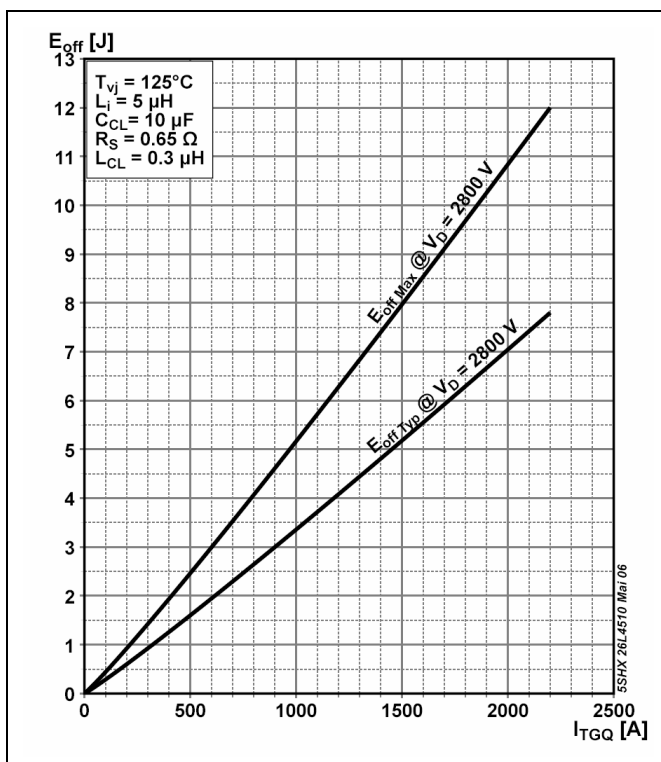


Fig. 7 GCT turn-off energy per pulse vs. turn-off current

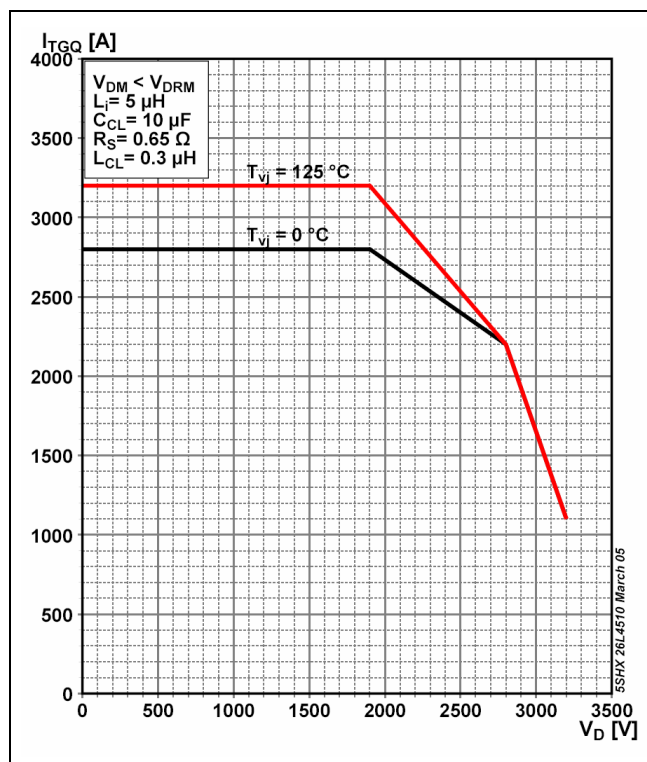


Fig. 8 GCT Safe Operating Area

# Diode Part

Max. on-state characteristic model:

$$V_{F25} = A_{Tvj} + B_{Tvj} \cdot I_T + C_{Tvj} \cdot \ln(I_T + 1) + D_{Tvj} \cdot \sqrt{I_T}$$

Valid for  $I_F = 300 - 15000$  A

| A <sub>25</sub>         | B <sub>25</sub>        | C <sub>25</sub>        | D <sub>25</sub> |
|-------------------------|------------------------|------------------------|-----------------|
| $-463.7 \times 10^{-3}$ | $867.9 \times 10^{-6}$ | $495.5 \times 10^{-3}$ | 0.0             |

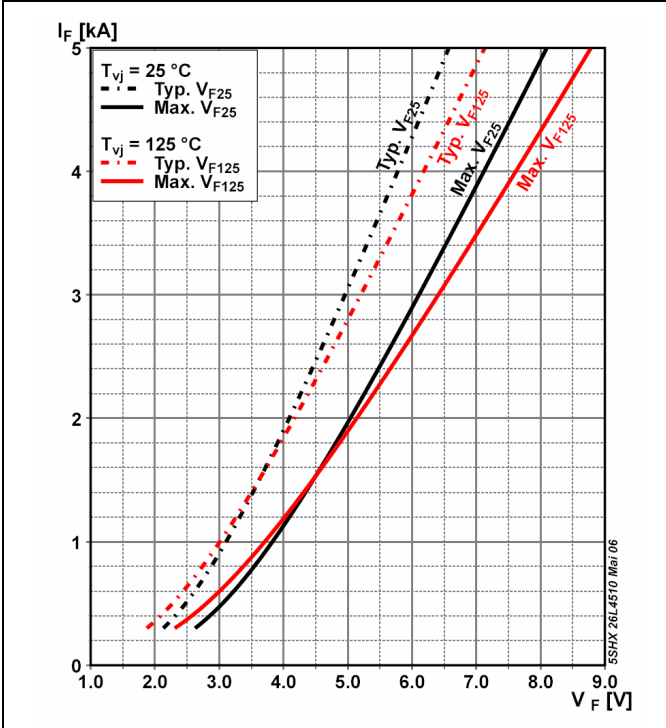


Fig. 9 Diode on-state voltage characteristics

Max. on-state characteristic model:

$$V_{F125} = A_{Tvj} + B_{Tvj} \cdot I_T + C_{Tvj} \cdot \ln(I_T + 1) + D_{Tvj} \cdot \sqrt{I_T}$$

Valid for  $I_T = 300 - 15000$  A

| A <sub>125</sub> | B <sub>125</sub>     | C <sub>125</sub>       | D <sub>125</sub> |
|------------------|----------------------|------------------------|------------------|
| -1.2             | $1.0 \times 10^{-3}$ | $555.4 \times 10^{-3}$ | 0.0              |

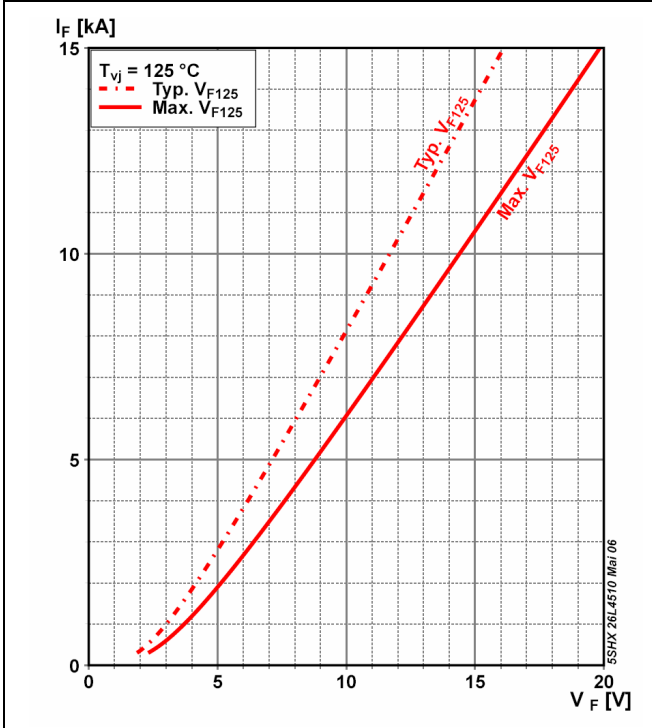


Fig. 10 Diode on-state voltage characteristics

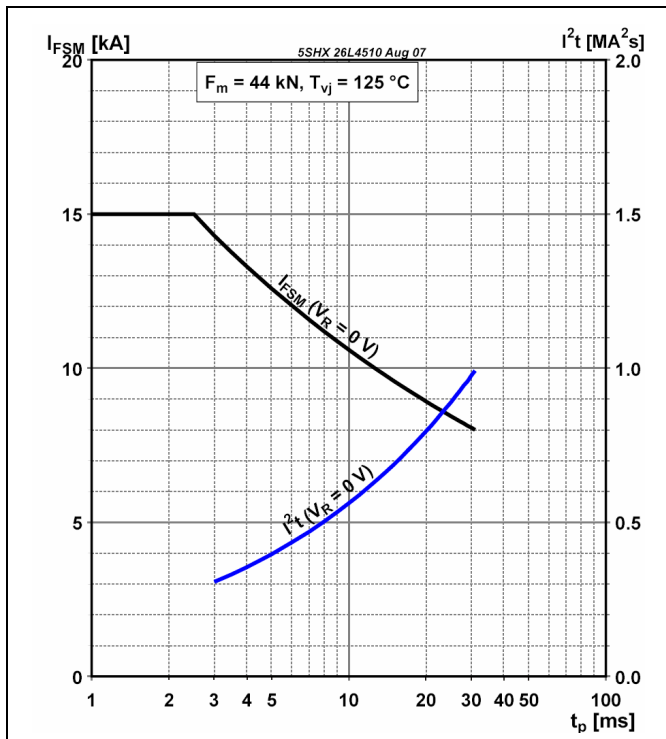


Fig. 11 Diode surge on-state current vs. pulse length, half-sine wave

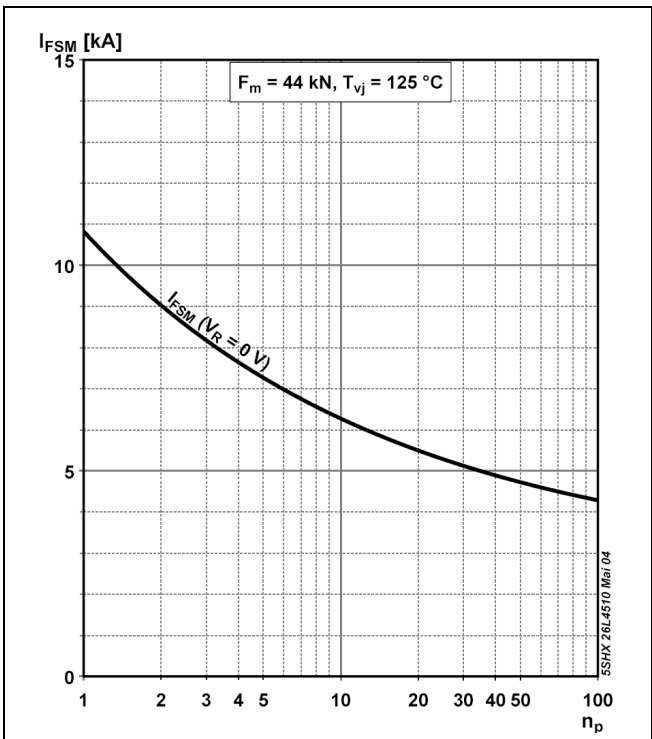


Fig. 12 Diode surge on-state current vs. number of pulses, half-sine wave, 10 ms, 50Hz



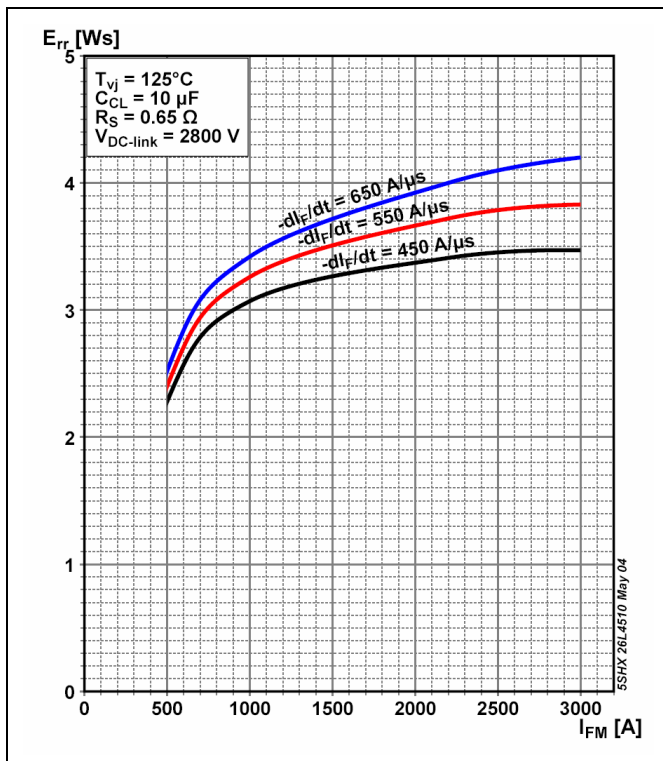


Fig. 13 Upper scatter range of diode turn-off energy per pulse vs. turn-off current

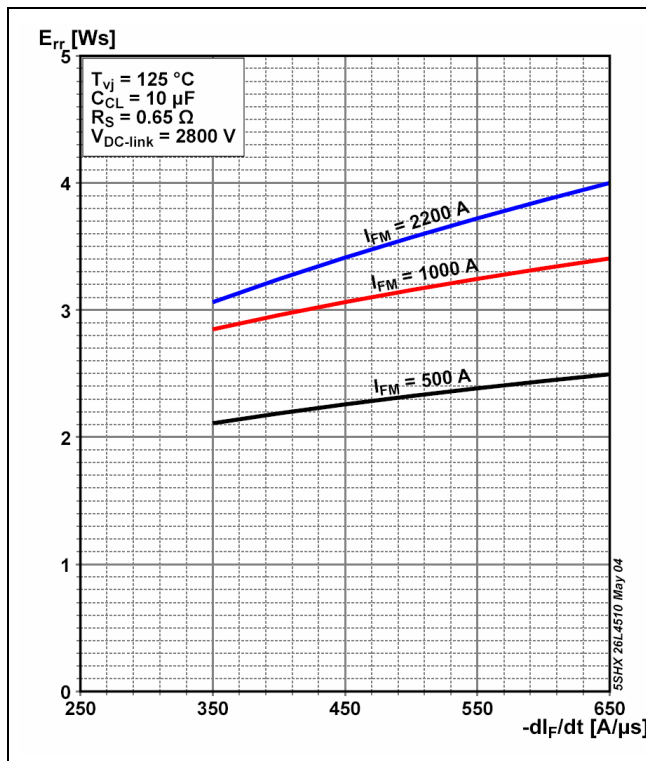


Fig. 14 Upper scatter range of diode turn-off energy per pulse vs decay rate of on-state current

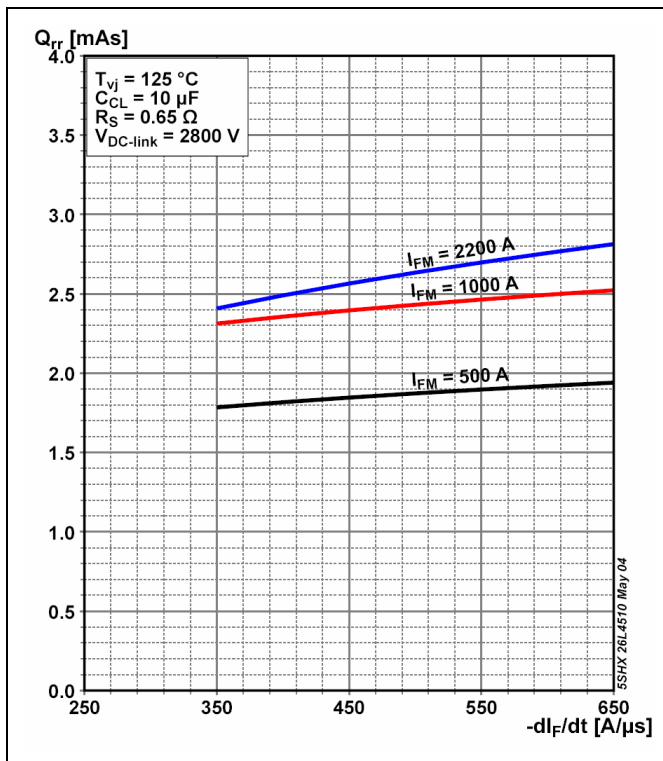


Fig. 15 Upper scatter range of diode reverse recovery charge vs decay rate of on-state current

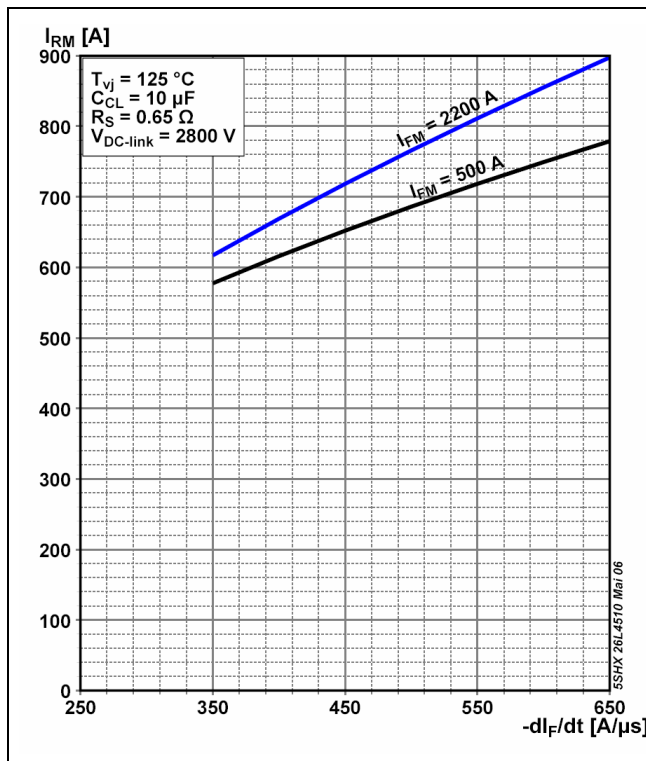


Fig. 16 Upper scatter range of diode reverse recovery current vs decay rate of on-state current

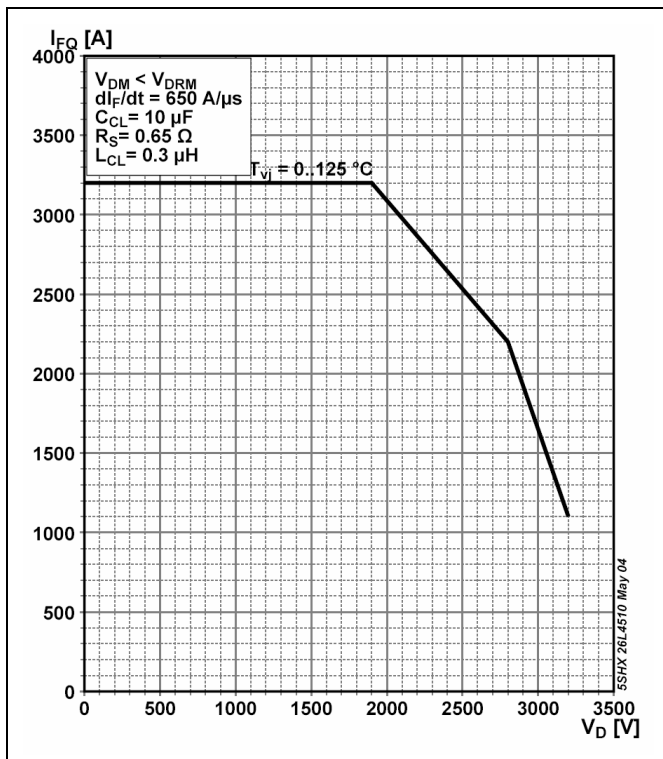


Fig. 17 Diode Safe Operating Area

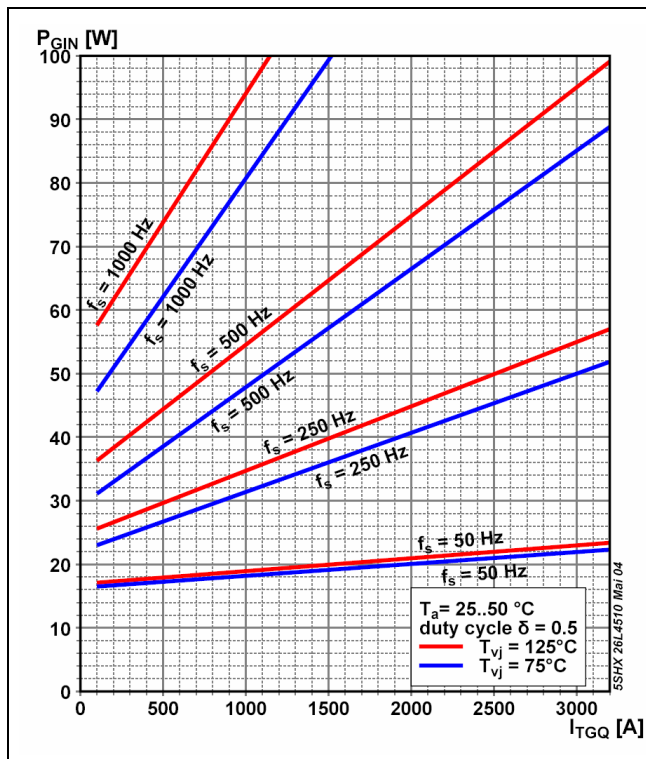


Fig. 18 Max. Gate Unit input power in chopper mode

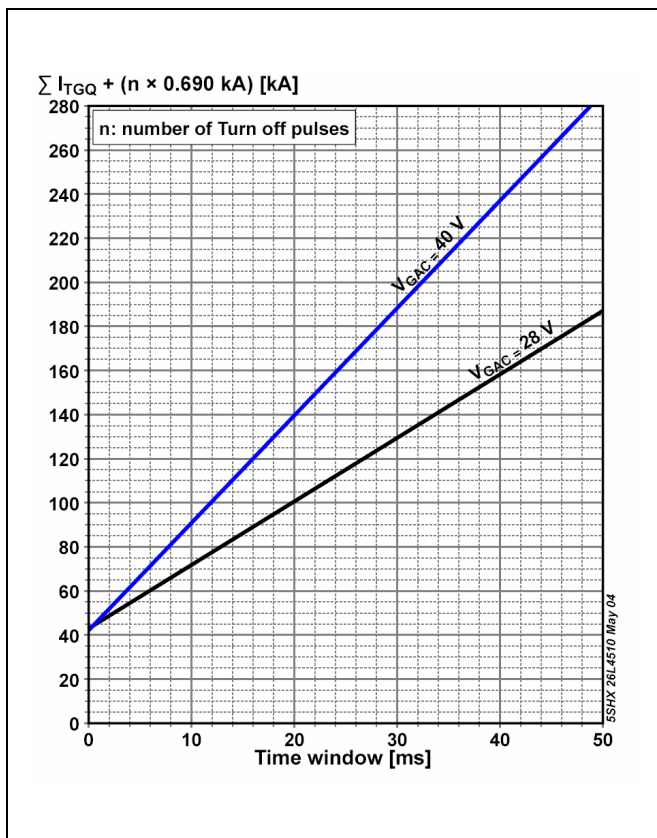


Fig. 19 Burst capability of Gate Unit

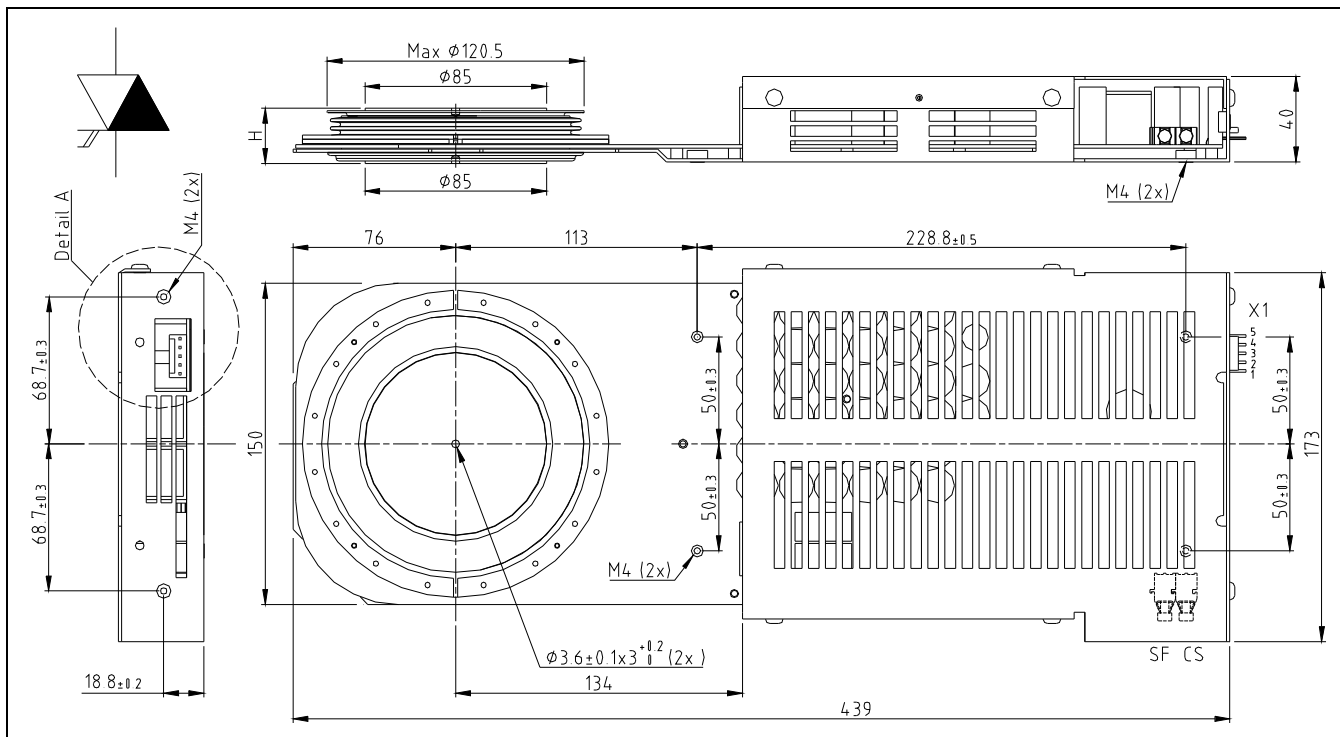


Fig. 20 Outline drawing; all dimensions are in millimeters and represent nominal values unless stated otherwise

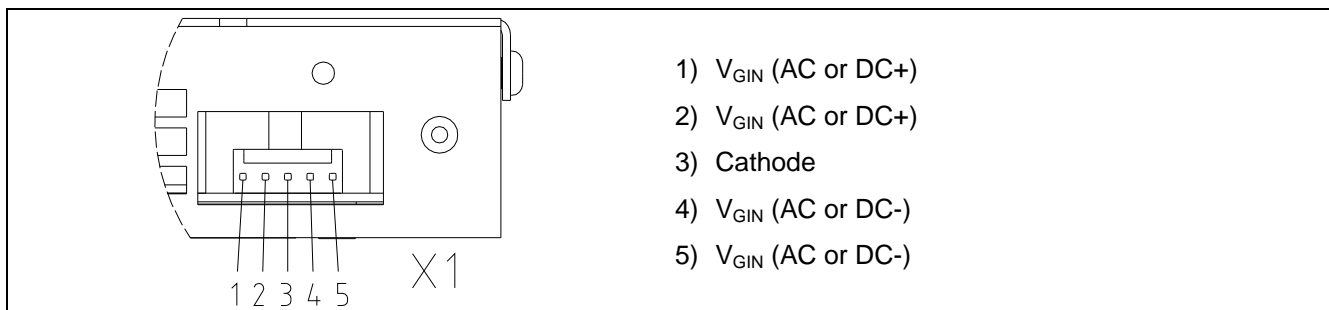


Fig. 21 Detail A: pin out of supply connector X1.

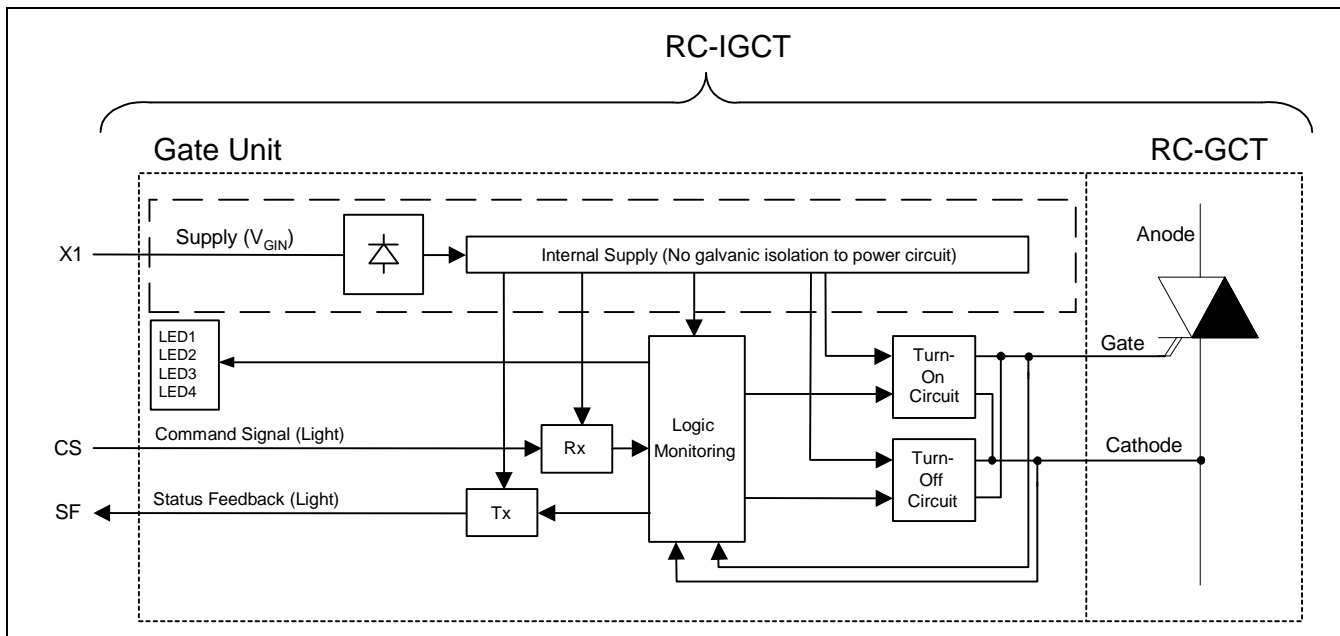


Fig. 22 Block diagram

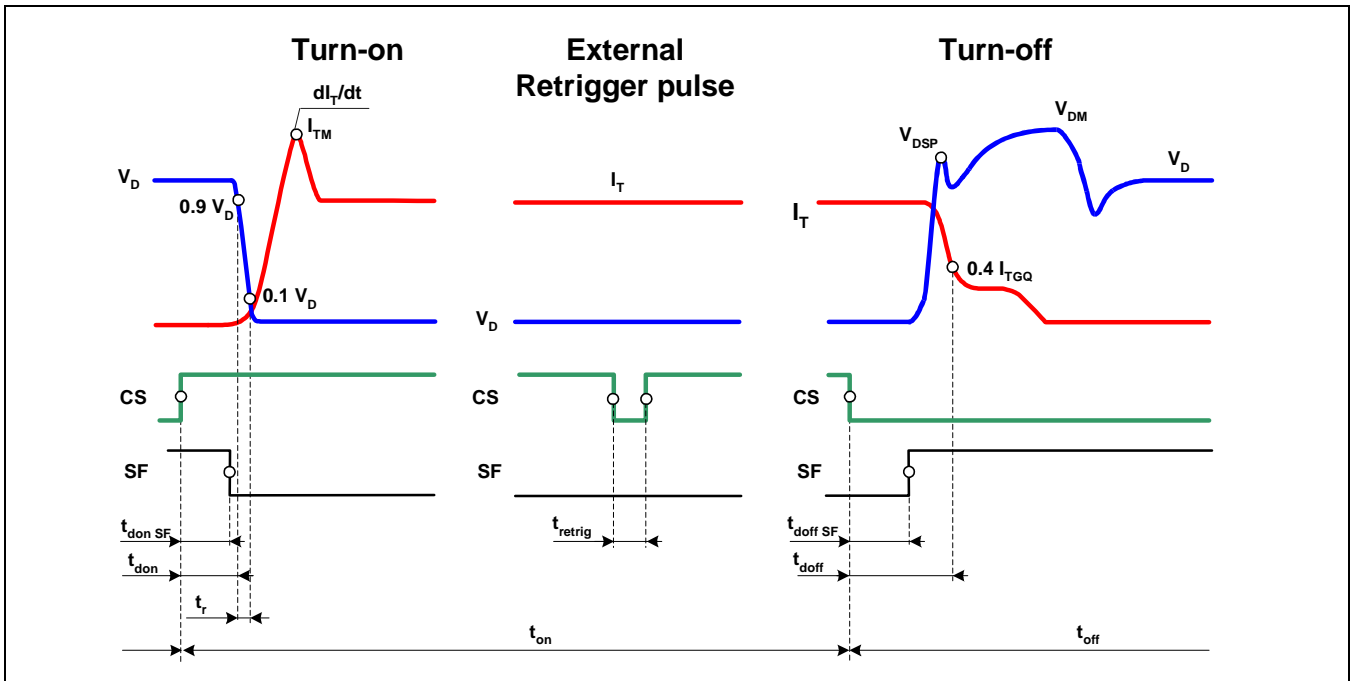


Fig. 23 General current and voltage waveforms with IGCT-specific symbols

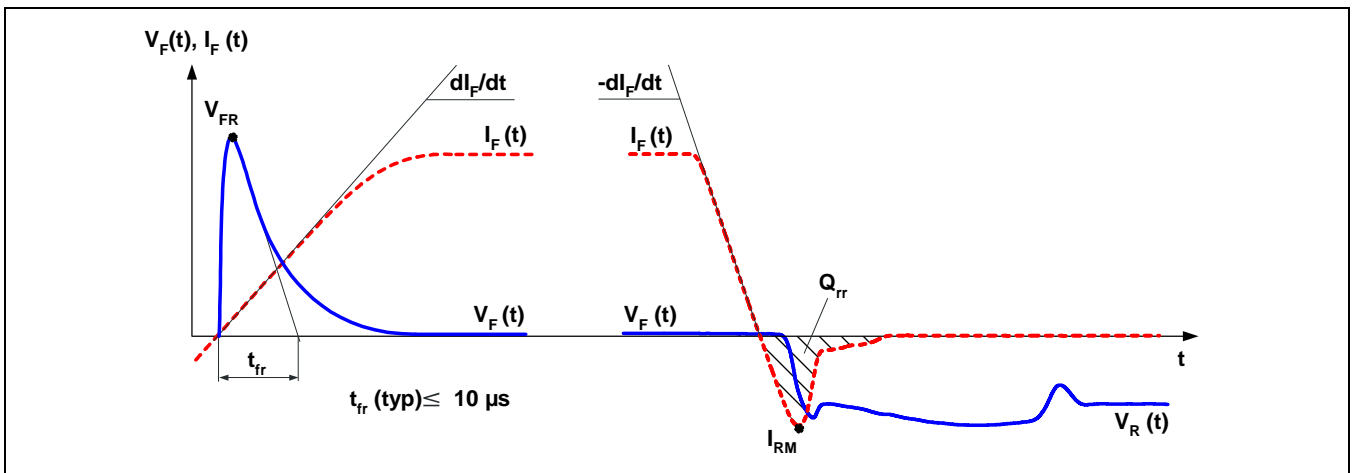
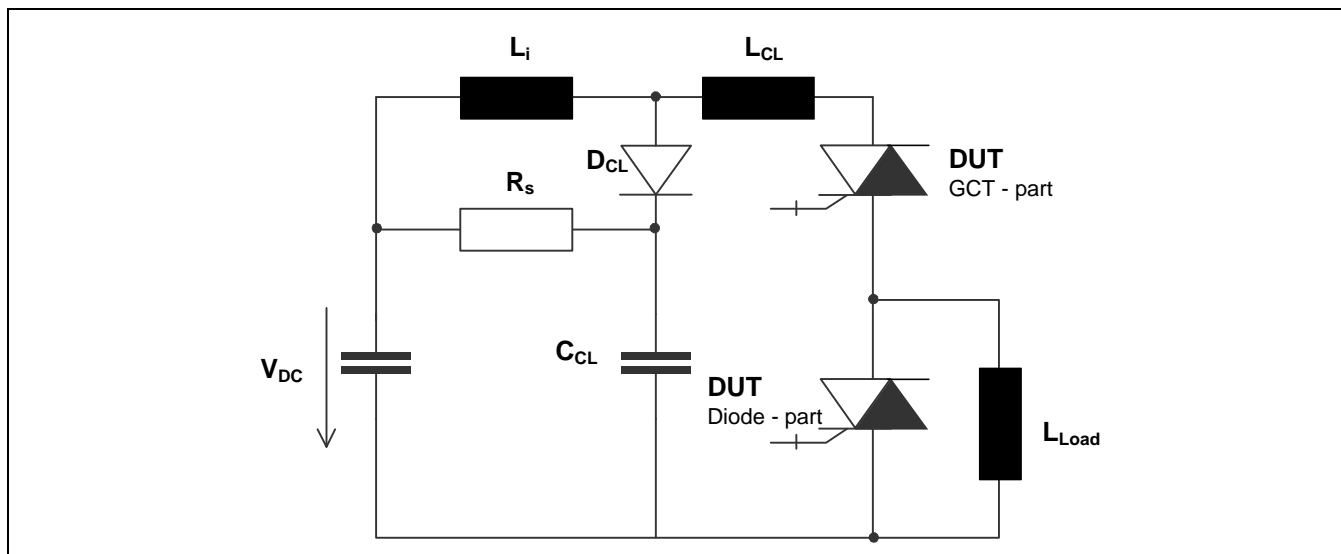


Fig. 24 General current and voltage waveforms with Diode-specific symbols



**Fig. 25** 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 |

Please refer to <http://www.abb.com/semiconductors> for current version of documents.

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