

|              |   |                    |
|--------------|---|--------------------|
| $V_{DRM}$    | = | 6500 V             |
| $I_{T(AV)M}$ | = | 340 A              |
| $I_{T(RMS)}$ | = | 540 A              |
| $I_{TSM}$    | = | $4.7 \cdot 10^3$ A |
| $V_{T0}$     | = | 1.20 V             |
| $r_T$        | = | 2.30 m $\Omega$    |

# Phase Control Thyristor

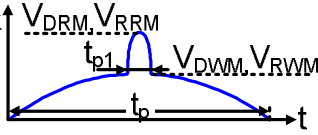
## 5STP 03X6500

Doc. No. 5SYA1003-10 May. 20

- Patented free-floating silicon technology
- Low on-state and switching losses
- Designed for traction, energy and industrial applications
- Optimum power handling capability
- Interdigitated amplifying gate

### Blocking

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

| Parameter  | Symbol                   | Conditions  | 5STP 03X6500 | Unit       |
|--|--------------------------|---|--------------|------------|
| Max. surge peak forward and reverse blocking voltage     | $V_{DSM}$ ,<br>$V_{RSM}$ | $t_p = 10$ ms, $f = 5$ Hz<br>$T_{vj} = 25 \dots 125$ °C, Note 1                                   | 6500         | V          |
| Max repetitive peak forward and reverse blocking voltage | $V_{DRM}$ ,<br>$V_{RRM}$ | $f = 50$ Hz, $t_p = 10$ ms, $t_{p1} = 250$ $\mu$ s,<br>$T_{vj} = 25 \dots 125$ °C, Note 1, Note 2 | 6500         | V          |
| Max crest working forward and reverse voltages           | $V_{DWM}$ ,<br>$V_{RWM}$ |               | 4340         | V          |
| Critical rate of rise of commutating voltage             | $dv/dt_{crit}$           | Exp. to $0.67 \cdot V_{DRM}$ , $T_{vj} = 125$ °C  | 2000         | V/ $\mu$ s |

Characteristic values

| Parameter               | Symbol    | Conditions                    | min | typ | max | Unit |
|-------------------------|-----------|-------------------------------|-----|-----|-----|------|
| Forward leakage current | $I_{DRM}$ | $V_{DRM}$ , $T_{vj} = 125$ °C |     |     | 150 | mA   |
| Reverse leakage current | $I_{RRM}$ | $V_{RRM}$ , $T_{vj} = 125$ °C |     |     | 150 | mA   |

Note 1: Voltage de-rating factor of 0.11% per °C is applicable for  $T_{vj}$  below +25 °C.

Note 2: Recommended minimum ratio of  $V_{DRM} / V_{DWM}$  or  $V_{RRM} / V_{RWM} = 2$ . See App. Note 5SYA 2051.

### Mechanical data

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

| Parameter      | Symbol | Conditions       | min | typ | max | Unit             |
|----------------|--------|------------------|-----|-----|-----|------------------|
| Mounting force | $F_M$  |                  | 8   | 10  | 12  | kN               |
| Acceleration   | $a$    | Device unclamped |     |     | 50  | m/s <sup>2</sup> |
| Acceleration   | $a$    | Device clamped   |     |     | 100 | m/s <sup>2</sup> |

Characteristic values

| Parameter                 | Symbol | Conditions                   | min   | typ | max   | Unit |
|---------------------------|--------|------------------------------|-------|-----|-------|------|
| Weight                    | $m$    |                              |       |     | 0.4   | kg   |
| Housing thickness         | $H$    | $F_M = 10$ kN, $T_a = 25$ °C | 34.79 |     | 35.44 | mm   |
| Surface creepage distance | $D_s$  |                              | 38    |     |       | mm   |
| Air strike distance       | $D_a$  |                              | 21    |     |       | mm   |

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

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## 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, $T_c = 70\text{ °C}$  |     |     | 340                | A                |
| RMS on-state current              | $I_{T(RMS)}$ |   |     |     | 540                | A                |
| Peak non-repetitive surge current | $I_{TSM}$    | $t_p = 10\text{ ms}$ , $T_{vj} = 125\text{ °C}$ ,<br>sine half wave,<br>$V_D = V_R = 0\text{ V}$ , after surge  |     |     | $4.7 \cdot 10^3$   | A                |
| Limiting load integral            | $I^2t$       |   |     |     | $110.5 \cdot 10^3$ | A <sup>2</sup> s |
| Peak non-repetitive surge current | $I_{TSM}$    | $t_p = 10\text{ ms}$ , $T_{vj} = 125\text{ °C}$ ,<br>sine half wave,<br>$V_R = 0.6 \cdot V_{RRM}$ , after surge |     |     | $3.6 \cdot 10^3$   | A                |
| Limiting load integral            | $I^2t$       |   |     |     | $64.8 \cdot 10^3$  | A <sup>2</sup> s |

### Characteristic values

| Parameter         | Symbol     | Conditions   | min | typ  | max  | Unit |
|-------------------|------------|--|-----|------|------|------|
| On-state voltage  | $V_T$      | $I_T = 1000\text{ A}$ , $T_{vj} = 125\text{ °C}$               |     | 3.33 | 3.50 | V    |
| Threshold voltage | $V_{(TO)}$ | $I_T = 300\text{ A} - 900\text{ A}$ , $T_{vj} = 125\text{ °C}$ |     |      | 1.20 | V    |
| Slope resistance  | $r_T$      |  |     |      | 2.30 | mΩ   |
| Holding current   | $I_H$      | $T_{vj} = 25\text{ °C}$  |     |      | 80   | mA   |
|                   |            | $T_{vj} = 125\text{ °C}$                                       |     |      | 60   | mA   |
| Latching current  | $I_L$      | $T_{vj} = 25\text{ °C}$  |     |      | 500  | mA   |
|                   |            | $T_{vj} = 125\text{ °C}$                                       |     |      | 200  | mA   |

## Switching

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

| Parameter                                 | Symbol         | Conditions  | min | typ | max  | Unit             |
|---|----------------|---|-----|-----|------|------------------|
| Critical rate of rise of on-state current | $di/dt_{crit}$ | $T_{vj} = 125\text{ °C}$ ,<br>$I_T = 1000\text{ A}$ ,<br>$V_D \leq 0.67 \cdot V_{DRM}$ ,<br>$I_{GM} = 2\text{ A}$ , $t_r = 0.5\text{ }\mu\text{s}$  |     |     | 100  | A/ $\mu\text{s}$ |
|   |                | Cont.<br>$f = 50\text{ Hz}$   |     |     | 1000 | A/ $\mu\text{s}$ |
| Circuit-commutated turn-off time          | $t_q$          | $T_{vj} = 125\text{ °C}$ , $I_T = 2000\text{ A}$ ,<br>$V_R = 200\text{ V}$ , $di_T/dt = -1.5\text{ A}/\mu\text{s}$ ,<br>$V_D \leq 0.67 \cdot V_{DRM}$ , $dV_D/dt = 20\text{ V}/\mu\text{s}$ |     |     | 1200 | $\mu\text{s}$    |

### Characteristic values

| Parameter                | Symbol   | Conditions   | min  | typ  | max  | Unit           |
|--------------------------|----------|--|------|------|------|----------------|
| Reverse recovery charge  | $Q_{rr}$ | $T_{vj} = 125\text{ °C}$ , $I_T = 2000\text{ A}$ ,<br>$V_R = 200\text{ V}$ , $di_T/dt = -1.5\text{ A}/\mu\text{s}$ | 1000 | 1970 | 2300 | $\mu\text{As}$ |
| Reverse recovery current | $I_{RM}$ |  | 35   | 43   | 50   | A              |
| Gate turn-on delay time  | $t_{gd}$ | $T_{vj} = 25\text{ °C}$ , $V_D = 0.4 \cdot V_{RM}$ ,<br>$I_{GM} = 2\text{ A}$ , $t_r = 0.5\text{ }\mu\text{s}$     |      |      | 3    | $\mu\text{s}$  |

## Triggering

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

| Parameter                 | Symbol             | Conditions | min        | typ | max | Unit |
|---------------------------|--------------------|------------|------------|-----|-----|------|
| Peak forward gate voltage | V <sub>FGM</sub>   |            |            |     | 12  | V    |
| Peak forward gate current | I <sub>FGM</sub>   |            |            |     | 10  | A    |
| Peak reverse gate voltage | V <sub>RGM</sub>   |            |            |     | 10  | V    |
| Average gate power loss   | P <sub>G(AV)</sub> |            | see Fig. 7 |     |     | W    |

Characteristic values

| Parameter                | Symbol          | Conditions  | min | typ | max | Unit |
|--------------------------|-----------------|---|-----|-----|-----|------|
| Gate-trigger voltage     | V <sub>GT</sub> | T <sub>vj</sub> = 25 °C   |     |     | 2.6 | V    |
| Gate-trigger current     | I <sub>GT</sub> | T <sub>vj</sub> = 25 °C   |     |     | 400 | mA   |
| Gate non-trigger voltage | V <sub>GD</sub> | V <sub>D</sub> = 0.4·V <sub>DRM</sub> , T <sub>vjmax</sub> = 125 °C |     |     | 0.3 | V    |
| Gate non-trigger current | I <sub>GD</sub> | V <sub>D</sub> = 0.4·V <sub>DRM</sub> , T <sub>vjmax</sub> = 125 °C |     |     | 10  | mA   |

## Thermal

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

| Parameter                            | Symbol           | Conditions | min | typ | max | Unit |
|--------------------------------------|------------------|------------|-----|-----|-----|------|
| Operating junction temperature range | T <sub>vj</sub>  |            |     |     | 125 | °C   |
| Storage temperature range            | T <sub>stg</sub> |            | -40 |     | 140 | °C   |

Characteristic values

| Parameter                           | Symbol                | Conditions   | min | typ | max | Unit |
|-------------------------------------|-----------------------|--|-----|-----|-----|------|
| Thermal resistance junction to case | R <sub>th(j-c)</sub>  | Double-side cooled<br>F <sub>m</sub> = 8... 12 kN  |     |     | 45  | K/kW |
|                                     | R <sub>th(j-c)A</sub> | Anode-side cooled<br>F <sub>m</sub> = 8... 12 kN   |     |     | 85  | K/kW |
|                                     | R <sub>th(j-c)C</sub> | Cathode-side cooled<br>F <sub>m</sub> = 8... 12 kN |     |     | 95  | K/kW |
| Thermal resistance case to heatsink | R <sub>th(c-h)</sub>  | Double-side cooled<br>F <sub>m</sub> = 8... 12 kN  |     |     | 7.5 | K/kW |
|                                     | R <sub>th(c-h)</sub>  | Single-side cooled<br>F <sub>m</sub> = 8... 12 kN  |     |     | 15  | K/kW |

Analytical function for transient thermal impedance:

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

| i                     | 1      | 2      | 3      | 4      |
|-----------------------|--------|--------|--------|--------|
| R <sub>i</sub> (K/kW) | 26.119 | 13.926 | 4.466  | 0.489  |
| τ <sub>i</sub> (s)    | 0.7510 | 0.0603 | 0.0062 | 0.0022 |

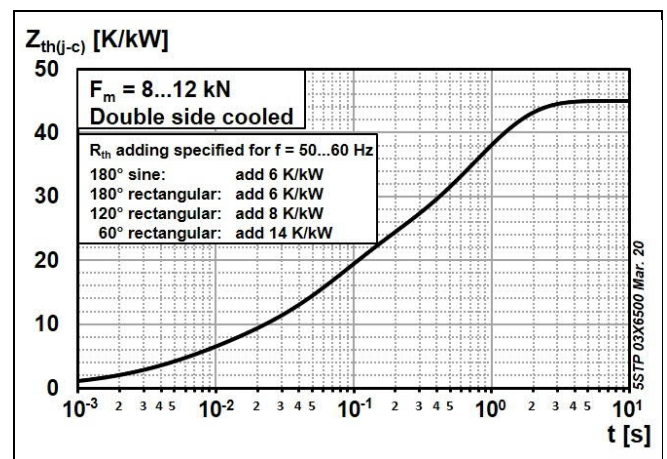


Fig. 1 Transient thermal impedance (junction-to-case) vs. time

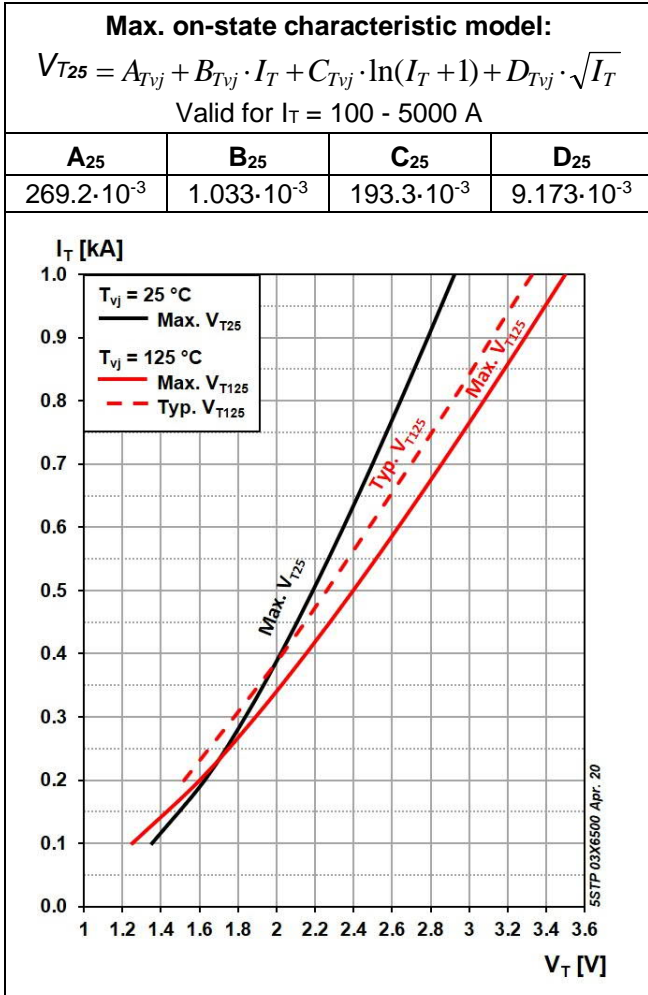


Fig. 2 On-state voltage characteristics

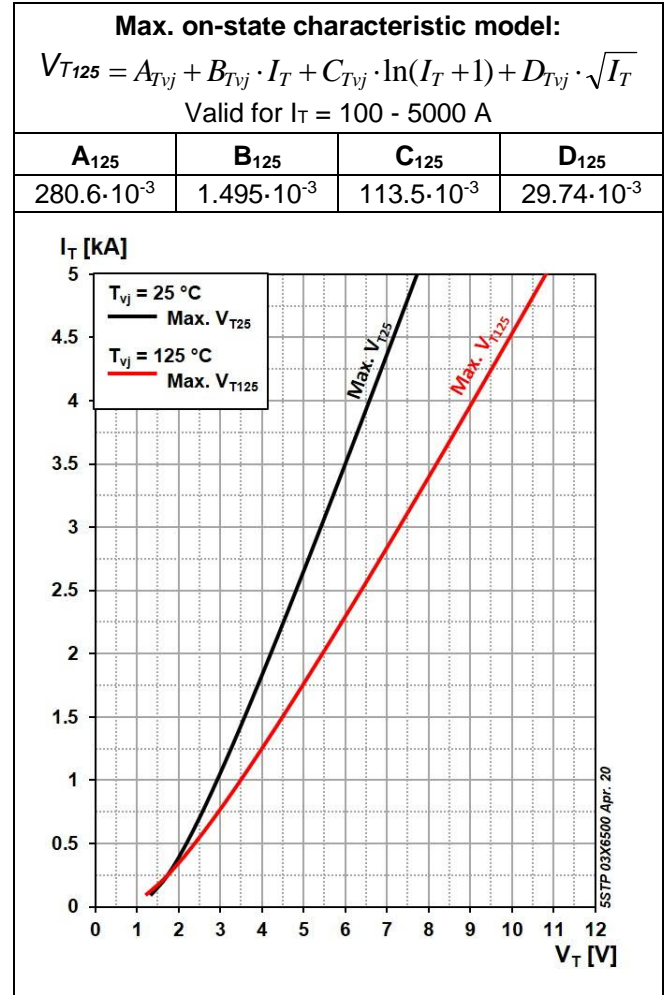


Fig. 3 On-state voltage characteristics

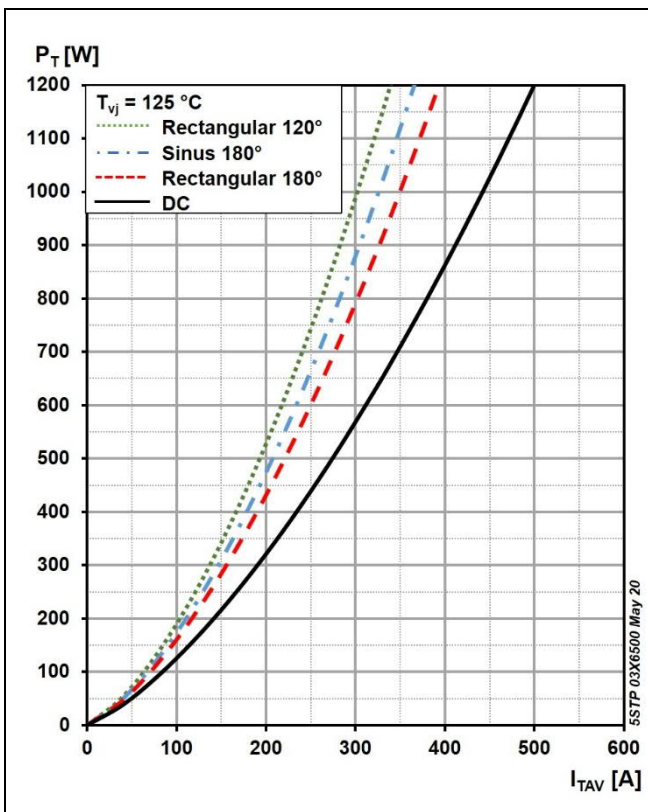


Fig. 4 On-state power dissipation vs. mean on-state current, turn-on losses excluded

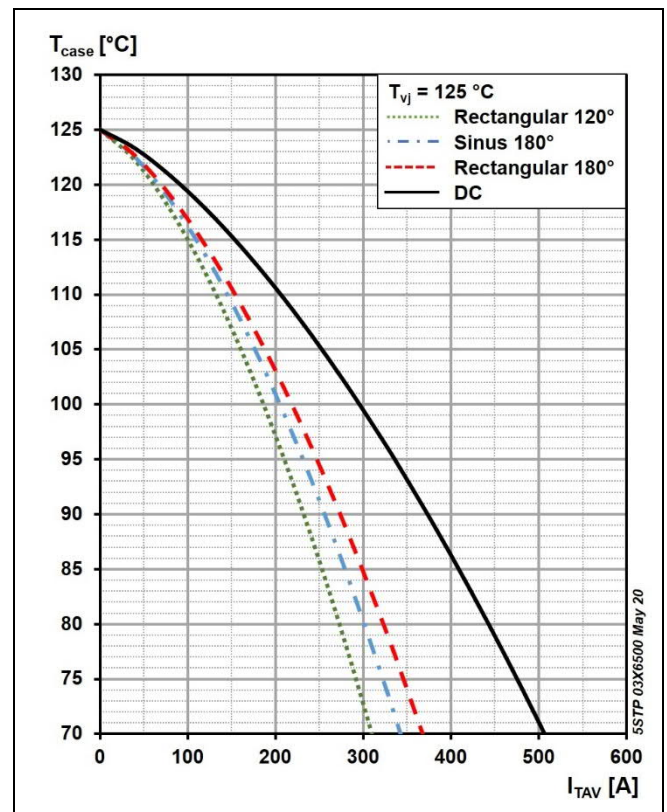


Fig. 5 Max. permissible case temperature vs. mean on-state current, switching losses ignored



Fig. 6 Recommended gate current waveform

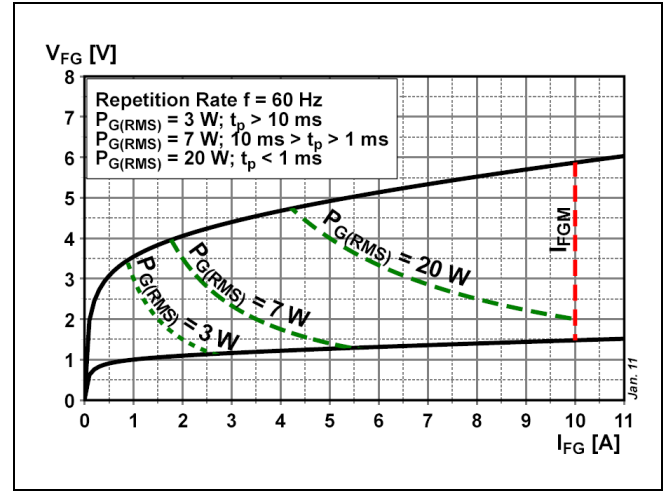


Fig. 7 Max. peak gate power loss

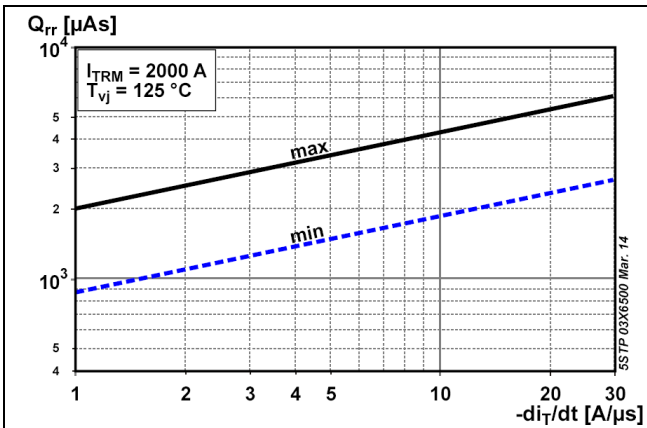


Fig. 8 Reverse recovery charge vs. decay rate of on-state current

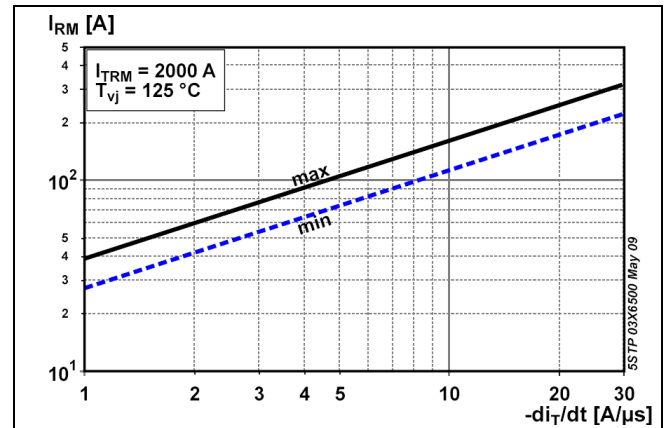


Fig. 9 Peak reverse recovery current vs. decay rate of on-state current

# Turn-on and Turn-off losses

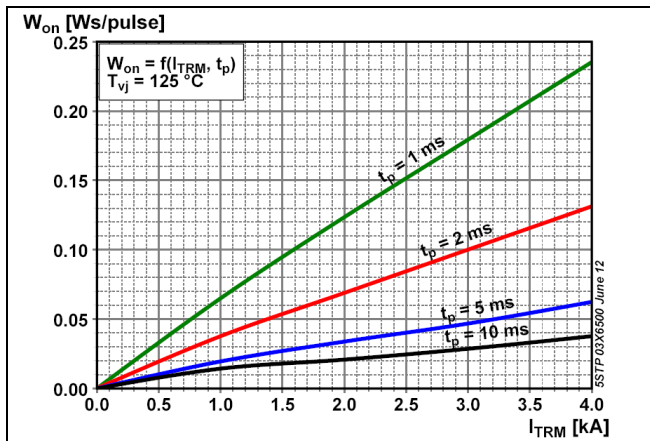


Fig. 10 Turn-on energy, half sinusoidal waves

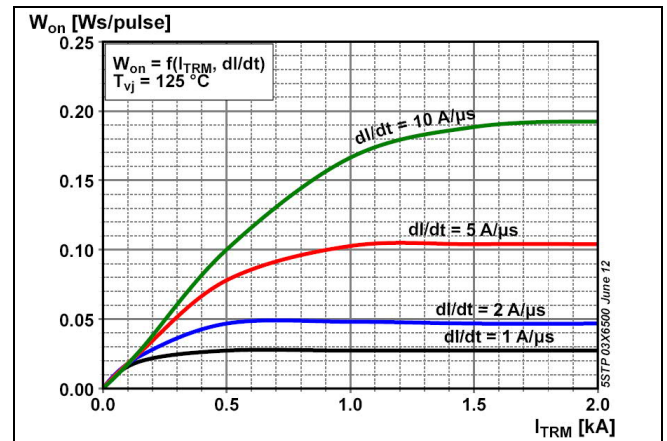


Fig. 11 Turn-on energy, rectangular waves

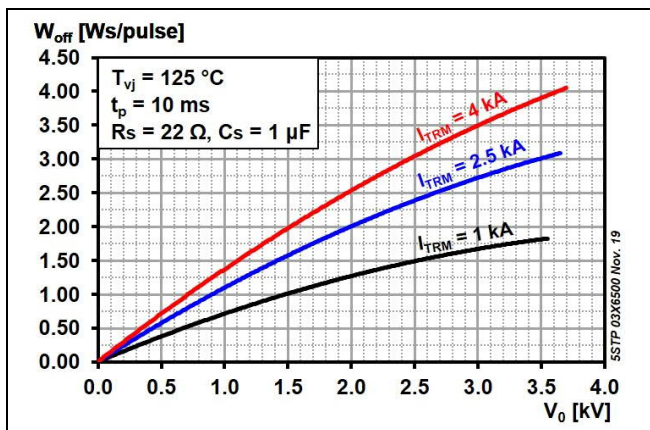


Fig. 12 Typical turn-off energy, half sinusoidal waves

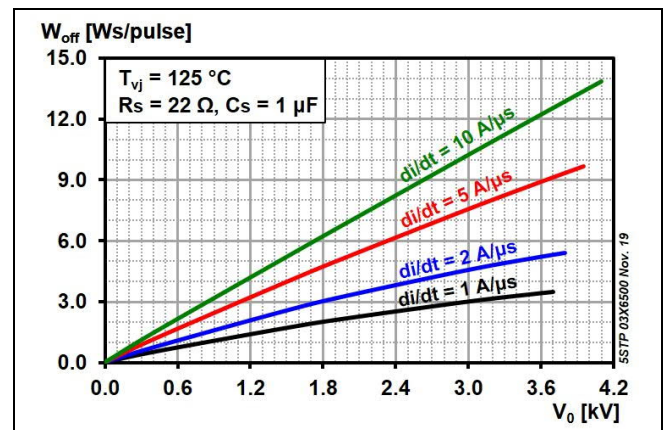


Fig. 13 Typical turn-off energy, rectangular waves

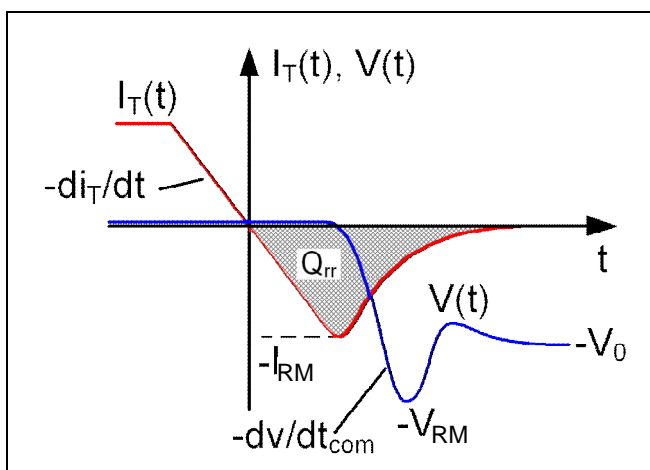


Fig. 14 Current and voltage waveforms at turn-off

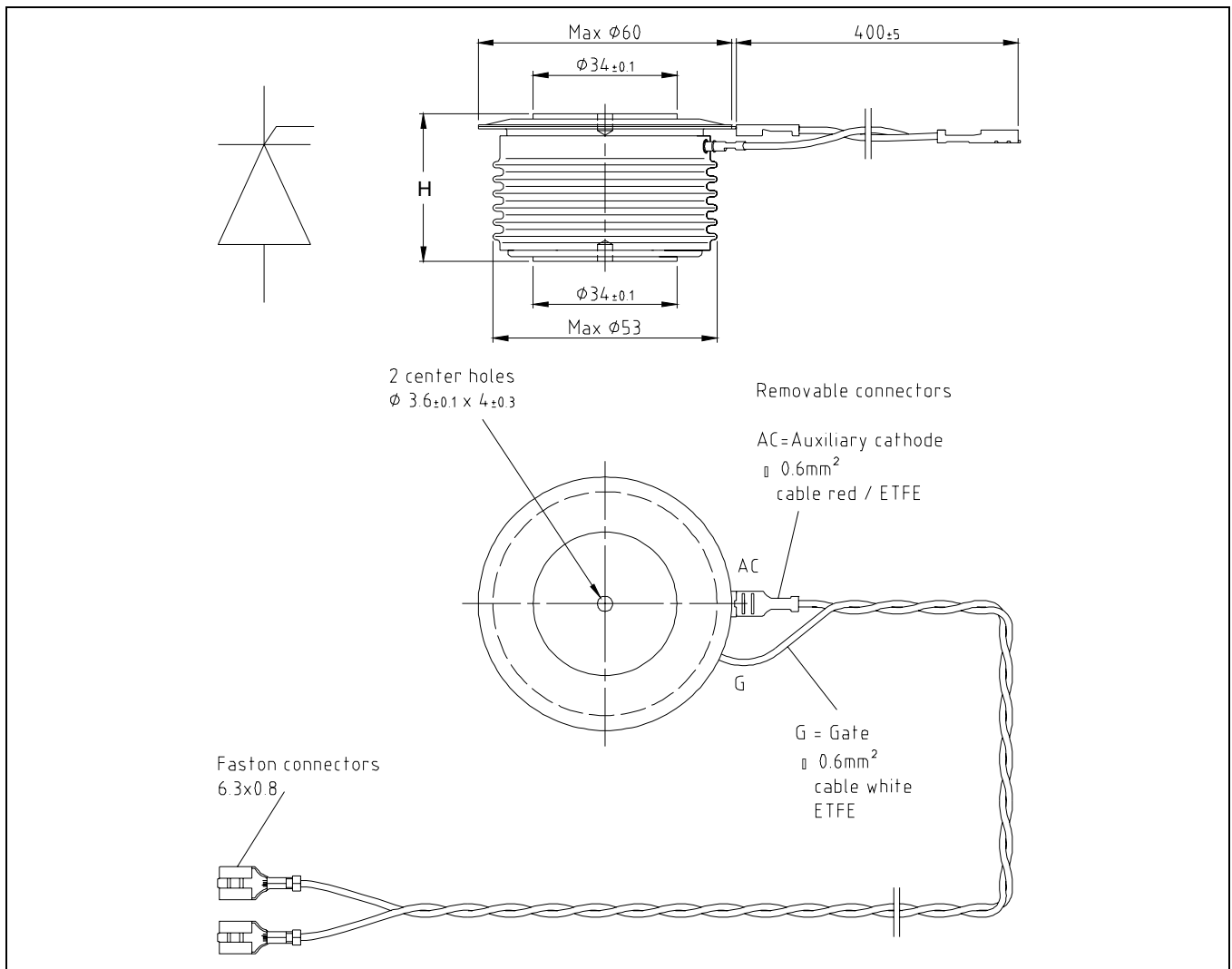
**Total power loss for repetitive waveforms:**

$$P_{TOT} = P_T + W_{on} \cdot f + W_{off} \cdot f$$

where

$$P_T = \frac{1}{T} \int_0^T I_T \cdot V_T(I_T) dt$$

Fig. 15 Relationships for power loss



**Fig. 16** Device Outline Drawing

### Related documents:

|           |   |
|-----------|---|
| 5SYA 2020 | Design of RC-Snubbers for Phase Control Applications                                    |
| 5SYA 2049 | Voltage definitions for phase control and bi-directionally controlled thyristors        |
| 5SYA 2051 | Voltage ratings of high power semiconductors  |
| 5SYA 2034 | Gate-drive recommendations for phase control and bi-directionally controlled thyristors |
| 5SYA 2036 | Recommendations regarding mechanical clamping of Press-Pack High Power Semiconductors   |
| 5SYA 2102 | Surge currents for Phase Control Thyristors   |
| 5SZK 9118 | General Environmental Conditions for High Power Semiconductors                          |

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