



Optimum power handling  
Low on-state and switching losses  
Designed for traction and industrial applications

## Phase Control Stud Thyristor Type T471-250-18

|                                   |            |     |     |     |     |     |           |     |     |      |                                           |      |      |      |      |      |      |  |
|-----------------------------------|------------|-----|-----|-----|-----|-----|-----------|-----|-----|------|-------------------------------------------|------|------|------|------|------|------|--|
| Mean on-state current             |            |     |     |     |     |     | $I_{TAV}$ |     |     |      | 250 A                                     |      |      |      |      |      |      |  |
| Repetitive peak off-state voltage |            |     |     |     |     |     | $V_{DRM}$ |     |     |      | 100...1800 V                              |      |      |      |      |      |      |  |
| Repetitive peak reverse voltage   |            |     |     |     |     |     | $V_{RRM}$ |     |     |      |                                           |      |      |      |      |      |      |  |
| Turn-off time                     |            |     |     |     |     |     | $t_q$     |     |     |      | 125, 160, 200, 250, 320, 400, 500 $\mu s$ |      |      |      |      |      |      |  |
| $V_{DRM}, V_{RRM}, V$             | 100        | 200 | 300 | 400 | 500 | 600 | 700       | 800 | 900 | 1000 | 1100                                      | 1200 | 1300 | 1400 | 1500 | 1600 | 1800 |  |
| Voltage code                      | 1          | 2   | 3   | 4   | 5   | 6   | 7         | 8   | 9   | 10   | 11                                        | 12   | 13   | 14   | 15   | 16   | 18   |  |
| $T_j, ^\circ C$                   | -60...+125 |     |     |     |     |     |           |     |     |      |                                           |      |      |      |      |      |      |  |

### MAXIMUM ALLOWABLE RATINGS

| Symbols and parameters              |                                                                        | Units                            | Values                                       | Test conditions                                                                                            |                                                                                                                                                                                                 |
|-------------------------------------|------------------------------------------------------------------------|----------------------------------|----------------------------------------------|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ON-STATE                            |                                                                        |                                  |                                              |                                                                                                            |                                                                                                                                                                                                 |
| I <sub>TAV</sub>                    | Maximum allowable mean on-state current                                | A                                | 250<br>307                                   | T <sub>c</sub> = 94 °C;<br>T <sub>c</sub> = 85 °C;<br>180° half-sine wave; 50 Hz                           |                                                                                                                                                                                                 |
| I <sub>TRMS</sub>                   | RMS on-state current                                                   | A                                | 393                                          | T <sub>c</sub> = 94 °C;<br>180° half-sine wave; 50 Hz                                                      |                                                                                                                                                                                                 |
| I <sub>TSM</sub>                    | Surge on-state current                                                 | kA                               | 6.5<br>7.5                                   | T <sub>j</sub> =T <sub>j max</sub><br>T <sub>j</sub> =25 °C                                                | 180° half-sine wave;<br>t <sub>p</sub> =10 ms; single pulse;<br>V <sub>D</sub> =V <sub>R</sub> =0 V;<br>Gate pulse: I <sub>G</sub> =2 A;<br>t <sub>GP</sub> =50 μs; di <sub>G</sub> /dt≥1 A/μs  |
|                                     |                                                                        |                                  | 7.0<br>8.0                                   | T <sub>j</sub> =T <sub>j max</sub><br>T <sub>j</sub> =25 °C                                                | 180° half-sine wave;<br>t <sub>p</sub> =8.3 ms; single pulse;<br>V <sub>D</sub> =V <sub>R</sub> =0 V;<br>Gate pulse: I <sub>G</sub> =2 A;<br>t <sub>GP</sub> =50 μs; di <sub>G</sub> /dt≥1 A/μs |
| I <sup>2</sup> t                    | Safety factor                                                          | A <sup>2</sup> s·10 <sup>3</sup> | 210<br>280                                   | T <sub>j</sub> =T <sub>j max</sub><br>T <sub>j</sub> =25 °C                                                | 180° half-sine wave;<br>t <sub>p</sub> =10 ms; single pulse;<br>V <sub>D</sub> =V <sub>R</sub> =0 V;<br>Gate pulse: I <sub>G</sub> =2 A;<br>t <sub>GP</sub> =50 μs; di <sub>G</sub> /dt≥1 A/μs  |
|                                     |                                                                        |                                  | 200<br>260                                   | T <sub>j</sub> =T <sub>j max</sub><br>T <sub>j</sub> =25 °C                                                | 180° half-sine wave;<br>t <sub>p</sub> =8.3 ms; single pulse;<br>V <sub>D</sub> =V <sub>R</sub> =0 V;<br>Gate pulse: I <sub>G</sub> =2 A;<br>t <sub>GP</sub> =50 μs; di <sub>G</sub> /dt≥1 A/μs |
| BLOCKING                            |                                                                        |                                  |                                              |                                                                                                            |                                                                                                                                                                                                 |
| V <sub>DRM</sub> , V <sub>RRM</sub> | Repetitive peak off-state and Repetitive peak reverse voltages         | V                                | 100...1800                                   | T <sub>j min</sub> < T <sub>j</sub> < T <sub>j max</sub> ;<br>180° half-sine wave; 50 Hz;<br>Gate open     |                                                                                                                                                                                                 |
| V <sub>DSM</sub> , V <sub>RSM</sub> | Non-repetitive peak off-state and Non-repetitive peak reverse voltages | V                                | 200...1900                                   | T <sub>j min</sub> < T <sub>j</sub> < T <sub>j max</sub> ;<br>180° half-sine wave; single pulse; Gate open |                                                                                                                                                                                                 |
| V <sub>D</sub> , V <sub>R</sub>     | Direct off-state and Direct reverse voltages                           | V                                | 0.6·V <sub>DRM</sub><br>0.6·V <sub>RRM</sub> | T <sub>j</sub> =T <sub>j max</sub> ;<br>Gate open                                                          |                                                                                                                                                                                                 |

|                    |                                                                   |                  |            |                                                                                                                                                        |
|--------------------|-------------------------------------------------------------------|------------------|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>TRIGGERING</b>  |                                                                   |                  |            |                                                                                                                                                        |
| $I_{FGM}$          | Peak forward gate current                                         | A                | 6          | $T_j = T_{j\ max}$                                                                                                                                     |
| $V_{RGM}$          | Peak reverse gate voltage                                         | V                | 5          |                                                                                                                                                        |
| $P_G$              | Gate power dissipation                                            | W                | 3          | $T_j = T_{j\ max}$ for DC gate current                                                                                                                 |
| <b>SWITCHING</b>   |                                                                   |                  |            |                                                                                                                                                        |
| $(di_T/dt)_{crit}$ | Critical rate of rise of on-state current non-repetitive (f=1 Hz) | A/ $\mu$ s       | 1000       | $T_j = T_{j\ max}$ ; $V_D = 0.67 \cdot V_{DRM}$ ; $I_{TM} = 1700$ A;<br>Gate pulse: $I_G = 2$ A;<br>$t_{GP} = 50$ $\mu$ s; $di_G/dt \geq 2$ A/ $\mu$ s |
| <b>THERMAL</b>     |                                                                   |                  |            |                                                                                                                                                        |
| $T_{stg}$          | Storage temperature                                               | °C               | -60...+50  |                                                                                                                                                        |
| $T_j$              | Operating junction temperature                                    | °C               | -60...+125 |                                                                                                                                                        |
| <b>MECHANICAL</b>  |                                                                   |                  |            |                                                                                                                                                        |
| M                  | Tightening torque                                                 | Nm               | 25...35    |                                                                                                                                                        |
| a                  | Acceleration                                                      | m/s <sup>2</sup> | 100        |                                                                                                                                                        |

## CHARACTERISTICS

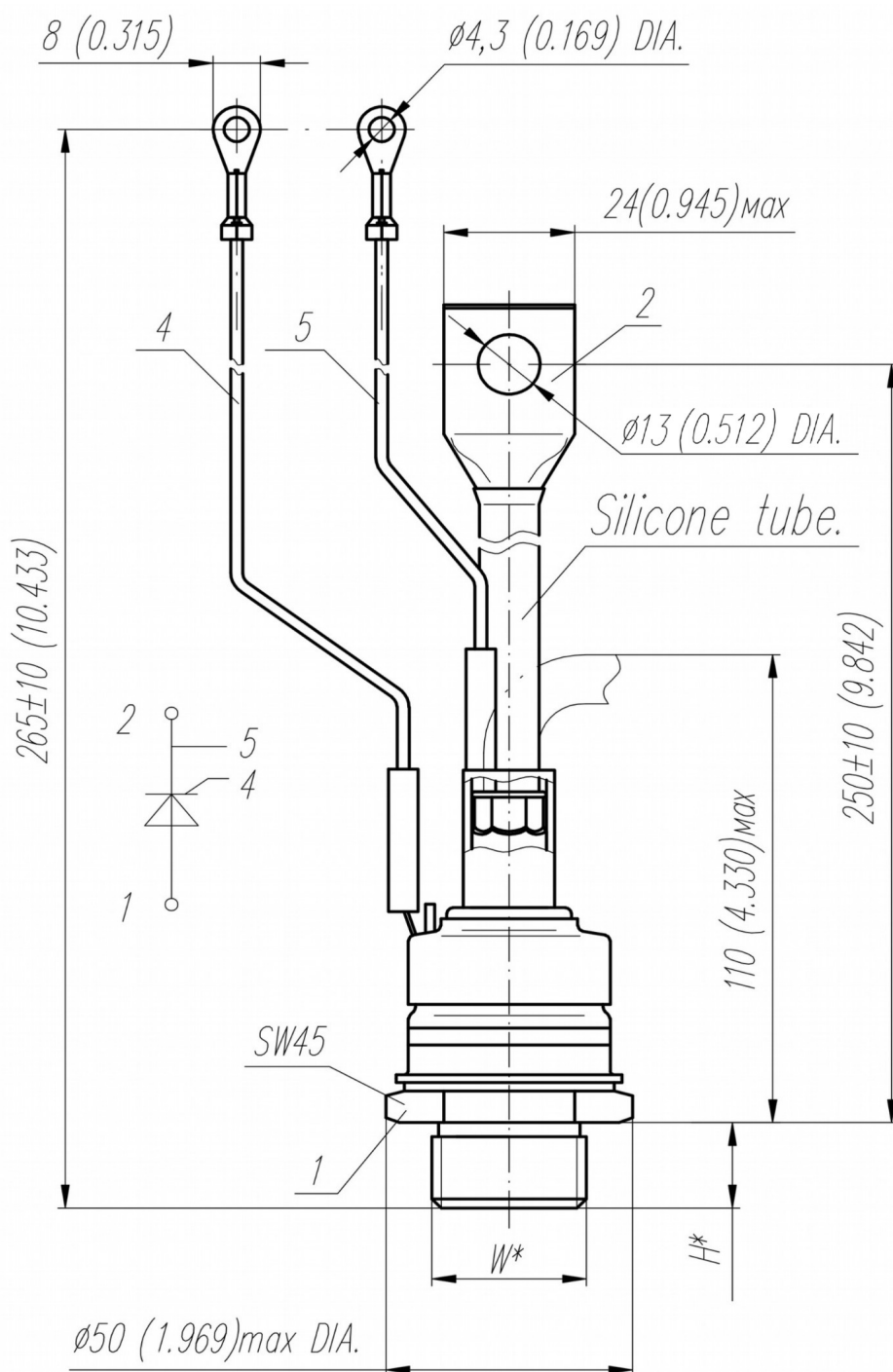
| Symbols and parameters                |                                                                     | Units | Values                            | Conditions                                                                                                                                                                                             |                                                                   |
|---------------------------------------|---------------------------------------------------------------------|-------|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| ON-STATE                              |                                                                     |       |                                   |                                                                                                                                                                                                        |                                                                   |
| V <sub>TM</sub>                       | Peak on-state voltage, max                                          | V     | 1.55                              | T <sub>j</sub> =25 °C; I <sub>TM</sub> =785 A                                                                                                                                                          |                                                                   |
| V <sub>T(TO)</sub>                    | On-state threshold voltage, max                                     | V     | 1.036                             | T <sub>j</sub> =T <sub>j max</sub> ;                                                                                                                                                                   |                                                                   |
| r <sub>T</sub>                        | On-state slope resistance, max                                      | mΩ    | 0.653                             | 0.5 π I <sub>TAV</sub> < I <sub>T</sub> < 1.5 π I <sub>TAV</sub>                                                                                                                                       |                                                                   |
| I <sub>L</sub>                        | Latching current, max                                               | mA    | 700                               | T <sub>j</sub> =25 °C; V <sub>D</sub> =12 V;<br>Gate pulse: I <sub>G</sub> =2 A;<br>t <sub>GP</sub> =50 μs; di <sub>G</sub> /dt≥1 A/μs                                                                 |                                                                   |
| I <sub>H</sub>                        | Holding current, max                                                | mA    | 300                               | T <sub>j</sub> =25 °C;<br>V <sub>D</sub> =12 V; Gate open                                                                                                                                              |                                                                   |
| BLOCKING                              |                                                                     |       |                                   |                                                                                                                                                                                                        |                                                                   |
| I <sub>DRM</sub> , I <sub>RRM</sub>   | Repetitive peak off-state and Repetitive peak reverse currents, max | mA    | 70                                | T <sub>j</sub> =T <sub>j max</sub> ;<br>V <sub>D</sub> =V <sub>DRM</sub> ; V <sub>R</sub> =V <sub>RRM</sub>                                                                                            |                                                                   |
| (dv <sub>D</sub> /dt) <sub>crit</sub> | Critical rate of rise of off-state voltage <sup>1)</sup> , min      | V/μs  | 200, 320, 500, 1000               | T <sub>j</sub> =T <sub>j max</sub> ;<br>V <sub>D</sub> =0.67·V <sub>DRM</sub> ; Gate open                                                                                                              |                                                                   |
| TRIGGERING                            |                                                                     |       |                                   |                                                                                                                                                                                                        |                                                                   |
| V <sub>GT</sub>                       | Gate trigger direct voltage, max                                    | V     | 3.00<br>2.50<br>1.50              | T <sub>j</sub> = T <sub>j min</sub><br>T <sub>j</sub> =25 °C<br>T <sub>j</sub> = T <sub>j max</sub>                                                                                                    | V <sub>D</sub> =12 V; I <sub>D</sub> =3 A;<br>Direct gate current |
| I <sub>GT</sub>                       | Gate trigger direct current, max                                    | mA    | 400<br>250<br>150                 | T <sub>j</sub> = T <sub>j min</sub><br>T <sub>j</sub> = 25 °C<br>T <sub>j</sub> = T <sub>j max</sub>                                                                                                   |                                                                   |
| V <sub>GD</sub>                       | Gate non-trigger direct voltage, min                                | V     | 0.60                              | T <sub>j</sub> =T <sub>j max</sub> ;<br>V <sub>D</sub> =0.67·V <sub>DRM</sub> ;                                                                                                                        |                                                                   |
| I <sub>GD</sub>                       | Gate non-trigger direct current, min                                | mA    | 35.00                             | Direct gate current                                                                                                                                                                                    |                                                                   |
| SWITCHING                             |                                                                     |       |                                   |                                                                                                                                                                                                        |                                                                   |
| t <sub>gd</sub>                       | Delay time, max                                                     | μs    | 1.25                              | T <sub>j</sub> =25 °C; V <sub>D</sub> =1000 V; I <sub>TM</sub> =I <sub>TAV</sub> ;<br>di/dt=200 A/μs;                                                                                                  |                                                                   |
| t <sub>gt</sub>                       | Turn-on time, max                                                   | μs    | 4.00                              | Gate pulse: I <sub>G</sub> =2 A; V <sub>G</sub> =20 V;<br>t <sub>GP</sub> =50 μs; di <sub>G</sub> /dt=2 A/μs                                                                                           |                                                                   |
| t <sub>q</sub>                        | Turn-off time <sup>2)</sup> , max                                   | μs    | 125, 160, 200, 250, 320, 400, 500 | dv <sub>D</sub> /dt=50 V/μs; T <sub>j</sub> =T <sub>j max</sub> ; I <sub>TM</sub> = I <sub>TAV</sub> ;<br>di <sub>R</sub> /dt=-10 A/μs; V <sub>R</sub> =100V;<br>V <sub>D</sub> =0.67·V <sub>DRM</sub> |                                                                   |
| Q <sub>rr</sub>                       | Recovered charge, max                                               | μC    | 1100                              | T <sub>j</sub> =T <sub>j max</sub> ; I <sub>TM</sub> =250 A;                                                                                                                                           |                                                                   |
| t <sub>rr</sub>                       | Reverse recovery time, max                                          | μs    | 20                                | di <sub>R</sub> /dt=-10 A/μs;                                                                                                                                                                          |                                                                   |
| I <sub>rr</sub>                       | Reverse recovery current, max                                       | A     | 110                               | V <sub>R</sub> =100 V                                                                                                                                                                                  |                                                                   |

| THERMAL    |                                           |                             |                  |                |
|------------|-------------------------------------------|-----------------------------|------------------|----------------|
| $R_{thjc}$ | Thermal resistance, junction to case, max | $^{\circ}\text{C}/\text{W}$ | 0.0850           | Direct current |
| MECHANICAL |                                           |                             |                  |                |
| m          | Weight, max                               | g                           | 480              |                |
| $D_s$      | Surface creepage distance                 | mm<br>(inch)                | 12.40<br>(4.882) |                |
| $D_a$      | Air strike distance                       | mm<br>(inch)                | 12.40<br>(4.882) |                |

| PART NUMBERING GUIDE                                                                                                                                                                                                                                                                                                                                    |     |     |     |      |     |     | NOTES                                                                                                                                                                                                                                                                                                                                               |  |  |  |  |  |  |  |                 |    |    |    |    |                                 |     |     |                    |      |     |     |     |     |     |     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|-----|------|-----|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|--|--|-----------------|----|----|----|----|---------------------------------|-----|-----|--------------------|------|-----|-----|-----|-----|-----|-----|
| T                                                                                                                                                                                                                                                                                                                                                       | 471 | 250 | 18  | A2   | E2  | N   | <div>1) Critical rate of rise of off-state voltage</div> <table><tr><td>Symbol of Group</td><td>P2</td><td>K2</td><td>E2</td><td>A2</td></tr><tr><td><math>(dv_D/dt)_{crit}</math>, V/<math>\mu</math>s</td><td>200</td><td>320</td><td>500</td><td>1000</td></tr></table>                                                                          |  |  |  |  |  |  |  | Symbol of Group | P2 | K2 | E2 | A2 | $(dv_D/dt)_{crit}$ , V/ $\mu$ s | 200 | 320 | 500                | 1000 |     |     |     |     |     |     |
| Symbol of Group                                                                                                                                                                                                                                                                                                                                         | P2  | K2  | E2  | A2   |     |     |                                                                                                                                                                                                                                                                                                                                                     |  |  |  |  |  |  |  |                 |    |    |    |    |                                 |     |     |                    |      |     |     |     |     |     |     |
| $(dv_D/dt)_{crit}$ , V/ $\mu$ s                                                                                                                                                                                                                                                                                                                         | 200 | 320 | 500 | 1000 |     |     |                                                                                                                                                                                                                                                                                                                                                     |  |  |  |  |  |  |  |                 |    |    |    |    |                                 |     |     |                    |      |     |     |     |     |     |     |
| 1                                                                                                                                                                                                                                                                                                                                                       | 2   | 3   | 4   | 5    | 6   | 7   |                                                                                                                                                                                                                                                                                                                                                     |  |  |  |  |  |  |  |                 |    |    |    |    |                                 |     |     |                    |      |     |     |     |     |     |     |
| <div>1. Phase Control Thyristor</div> <div>2. Design version</div> <div>3. Mean on-state current, A</div> <div>4. Voltage code</div> <div>5. Critical rate of rise of off-state voltage, V/<math>\mu</math>s</div> <div>6. Turn-off time (<math>dv_D/dt=50</math> V/<math>\mu</math>s)</div> <div>7. Ambient conditions: N – normal; T – tropical</div> |     |     |     |      |     |     | <div>2) Turn-off time (<math>dv_D/dt=50</math> V/<math>\mu</math>s)</div> <table><tr><td>Symbol of Group</td><td>X2</td><td>T2</td><td>P2</td><td>M2</td><td>K2</td><td>H2</td><td>E2</td></tr><tr><td><math>t_{qr}</math>, <math>\mu</math>s</td><td>125</td><td>160</td><td>200</td><td>250</td><td>320</td><td>400</td><td>500</td></tr></table> |  |  |  |  |  |  |  | Symbol of Group | X2 | T2 | P2 | M2 | K2                              | H2  | E2  | $t_{qr}$ , $\mu$ s | 125  | 160 | 200 | 250 | 320 | 400 | 500 |
| Symbol of Group                                                                                                                                                                                                                                                                                                                                         | X2  | T2  | P2  | M2   | K2  | H2  | E2                                                                                                                                                                                                                                                                                                                                                  |  |  |  |  |  |  |  |                 |    |    |    |    |                                 |     |     |                    |      |     |     |     |     |     |     |
| $t_{qr}$ , $\mu$ s                                                                                                                                                                                                                                                                                                                                      | 125 | 160 | 200 | 250  | 320 | 400 | 500                                                                                                                                                                                                                                                                                                                                                 |  |  |  |  |  |  |  |                 |    |    |    |    |                                 |     |     |                    |      |     |     |     |     |     |     |

# OVERALL DIMENSIONS

Package type: T.SB2

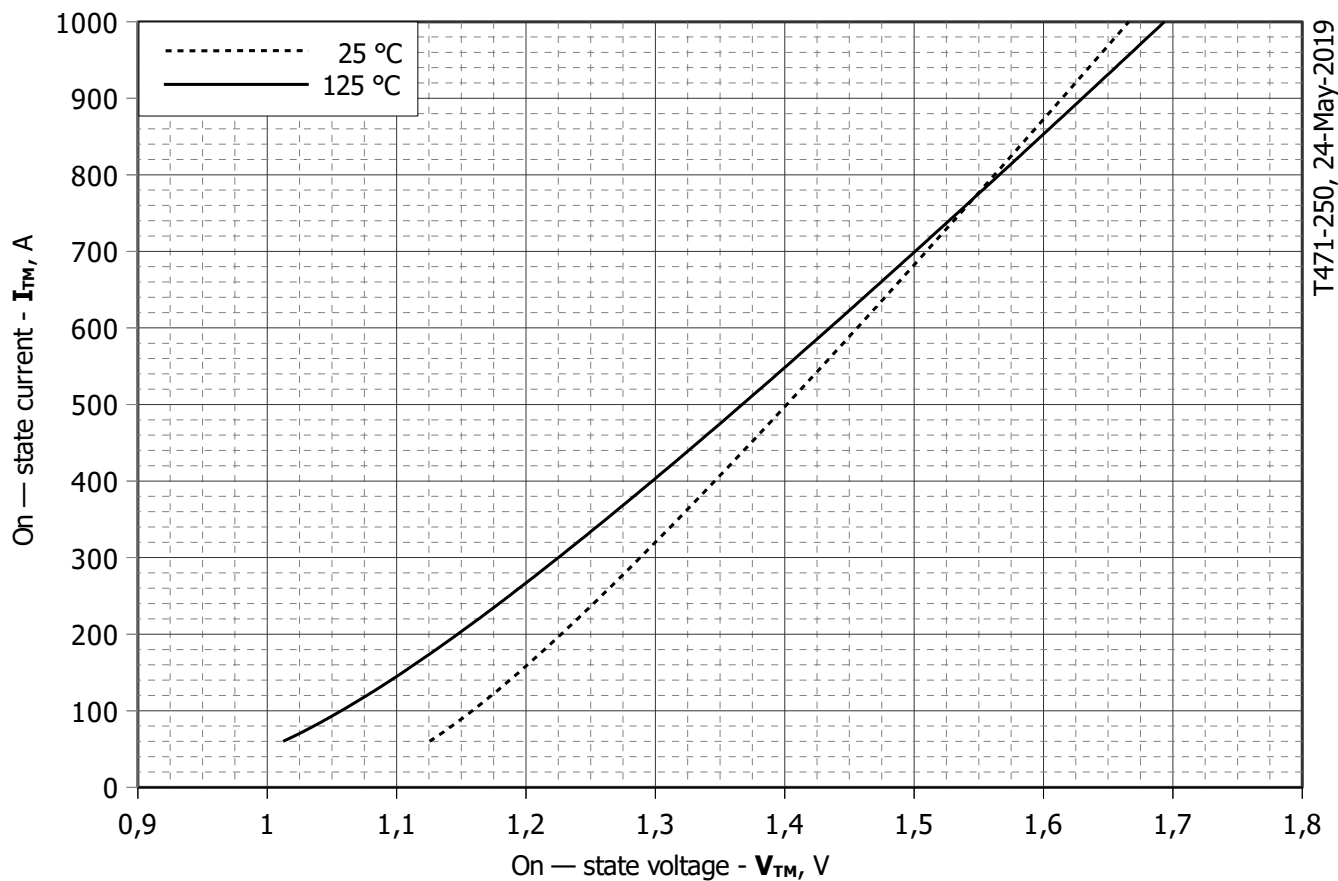


| Type of screw       | W            | H  |
|---------------------|--------------|----|
| Metric Screw Type C | M24x1,5 – 8g | 19 |

| Polarity      | Example of code designation | Reference designation | Colors |          |       |
|---------------|-----------------------------|-----------------------|--------|----------|-------|
|               |                             |                       | Anode  | Cathode  | Gate  |
| Anode to stud | T471-250-18                 |                       | -      | Red tube | White |

All dimensions in millimeters (inches)

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In the interest of product improvement, Proton-Electrotex reserves the right to change data sheet without notice.



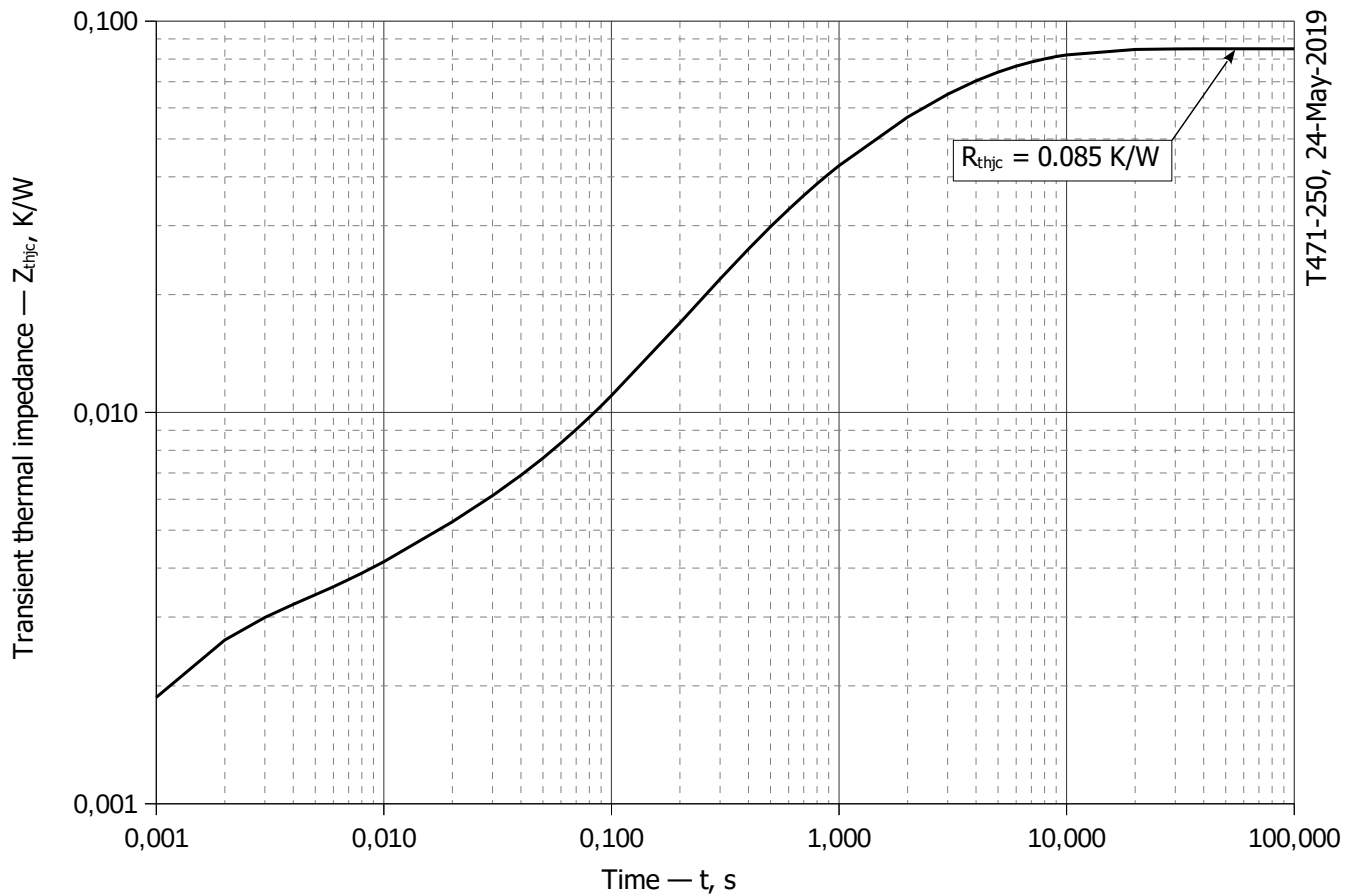
**Fig 1 – On-state characteristics of Limit device**

Analytical function for On-state characteristic:

$$V_T = A + B \cdot i_T + C \cdot \ln(i_T + 1) + D \cdot \sqrt{i_T}$$

|          | Coefficients for max curves |                   |
|----------|-----------------------------|-------------------|
|          | $T_j = 25^\circ\text{C}$    | $T_j = T_{j\max}$ |
| <b>A</b> | 1.00310000                  | 0.82568000        |
| <b>B</b> | 0.00045769                  | 0.00054987        |
| <b>C</b> | 0.01841200                  | 0.03130700        |
| <b>D</b> | 0.00246890                  | 0.00321650        |

**On-state characteristic model (see Fig. 1)**



**Fig 2 – Transient thermal impedance  $Z_{thjc}$  vs. time  $t$**

Analytical function for Transient thermal impedance junction to case  $Z_{thjc}$  for DC:

$$Z_{thjc} = \sum_{i=1}^n R_i \left( 1 - e^{-\frac{t}{\tau_i}} \right)$$

Where  $i = 1$  to  $n$ ,  $n$  is the number of terms in the series.

$t$  = Duration of heating pulse in seconds.

$Z_{thjc}$  = Thermal resistance at time  $t$ .

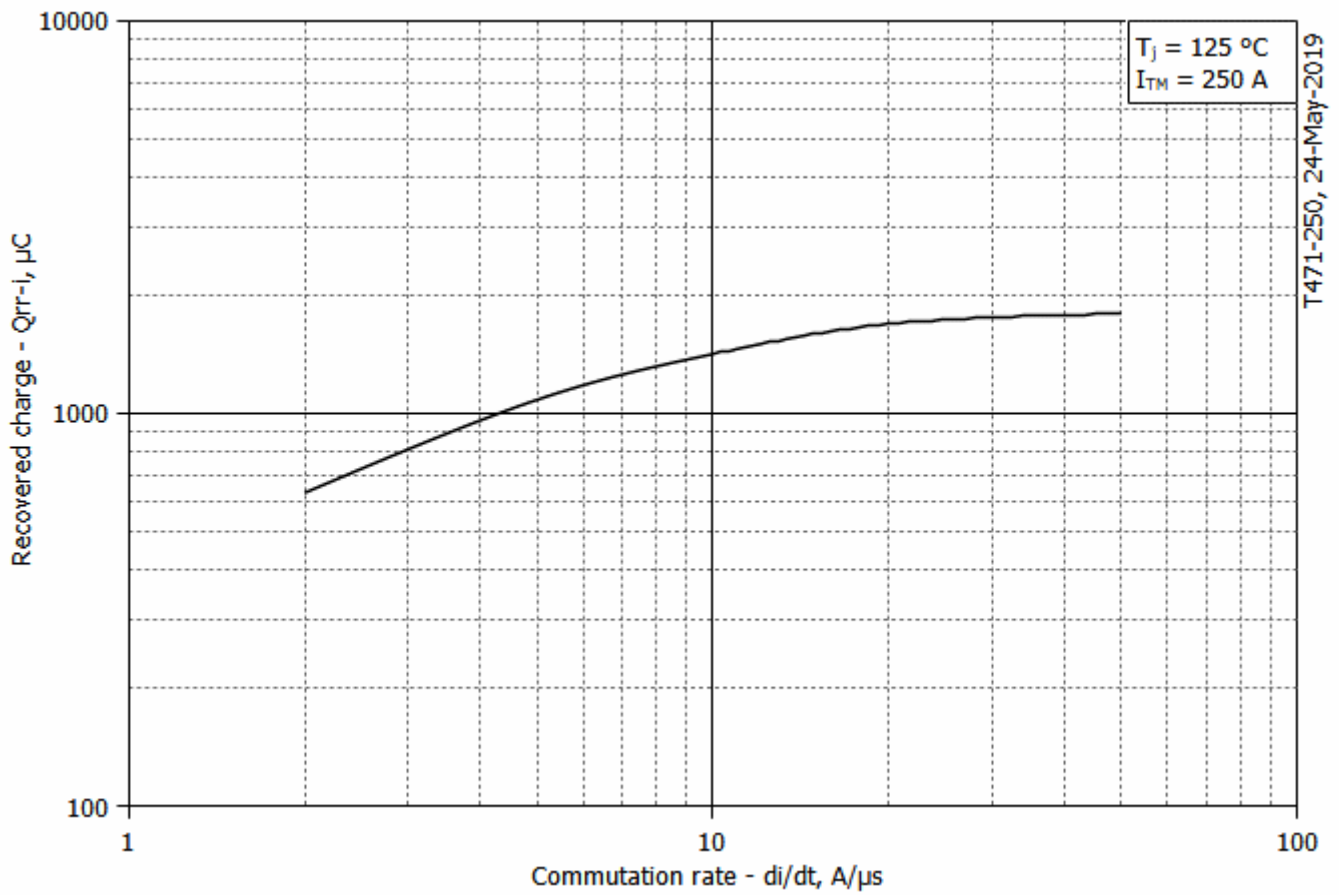
$R_i$  = Amplitude of  $p_{th}$  term.

$\tau_i$  = Time constant of  $r_{th}$  term.

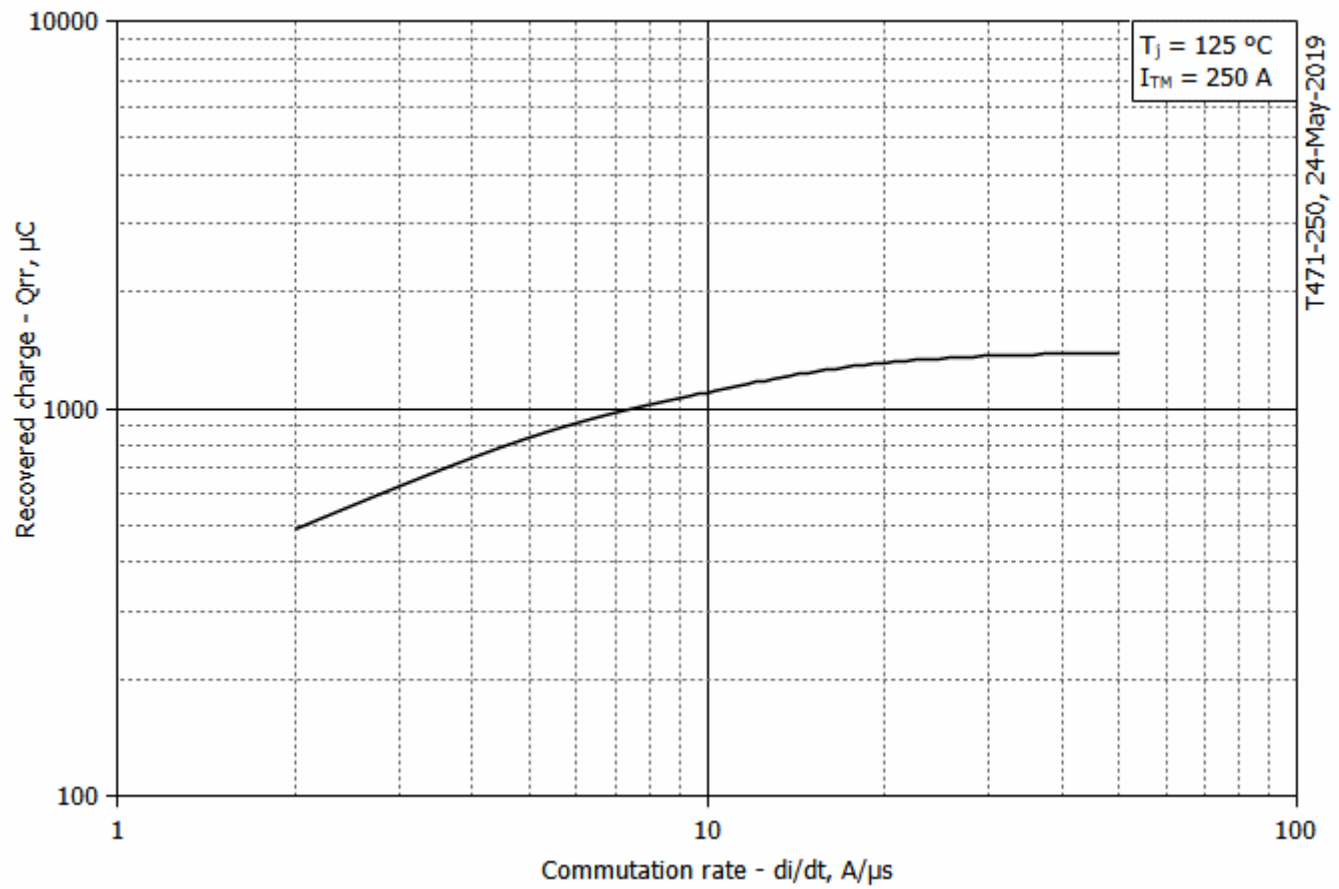
DC

| $i$          | 1        | 2       | 3       | 4        | 5         | 6       |
|--------------|----------|---------|---------|----------|-----------|---------|
| $R_i$ , K/W  | 0.023357 | 0.02733 | 0.01495 | 0.001445 | 0.002488  | 0.01543 |
| $\tau_i$ , s | 4.627    | 2.249   | 0.3406  | 0.01043  | 0.0009112 | 0.9081  |

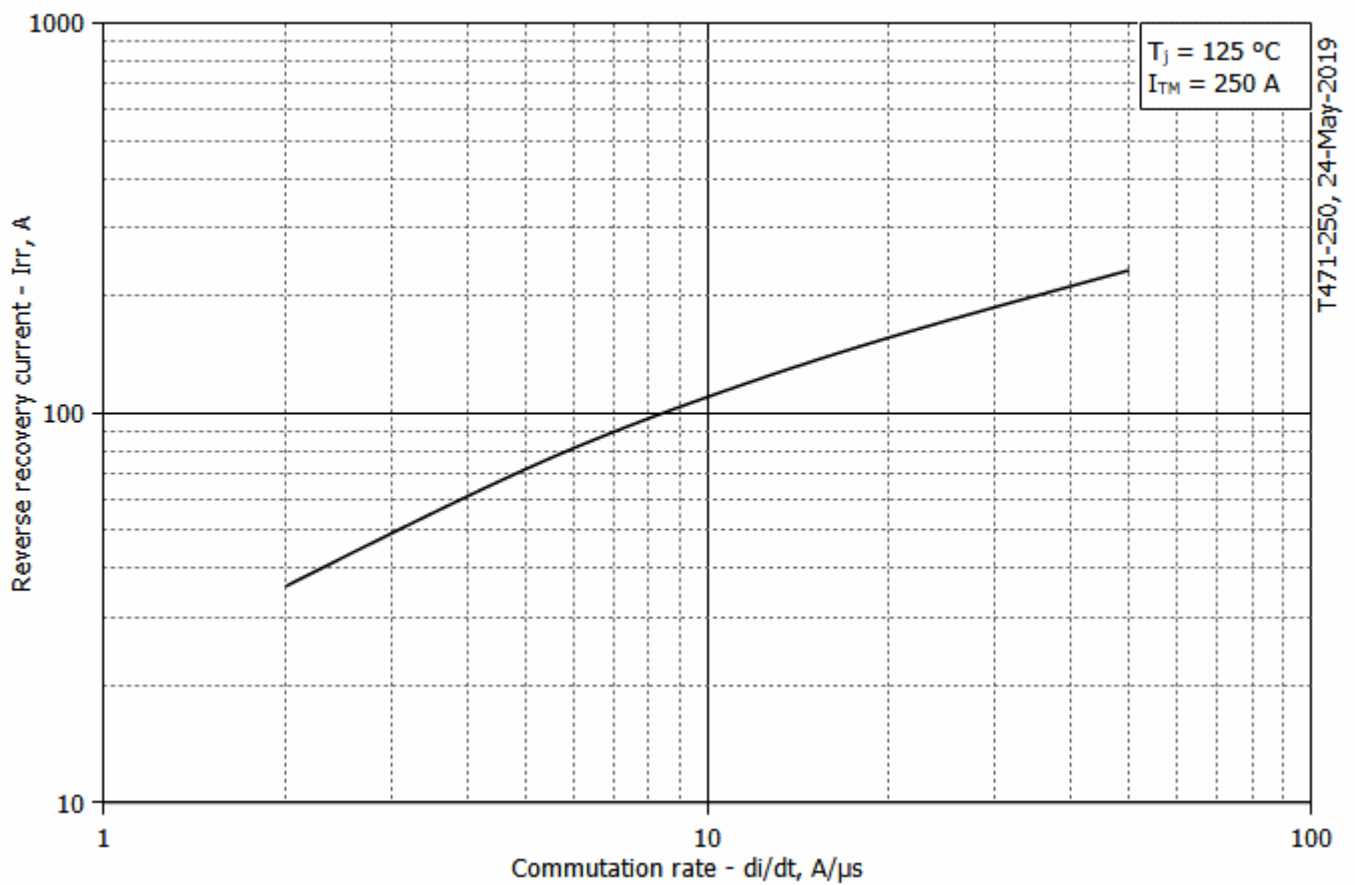
**Transient thermal impedance junction to case  $Z_{thjc}$  model (see Fig. 2)**



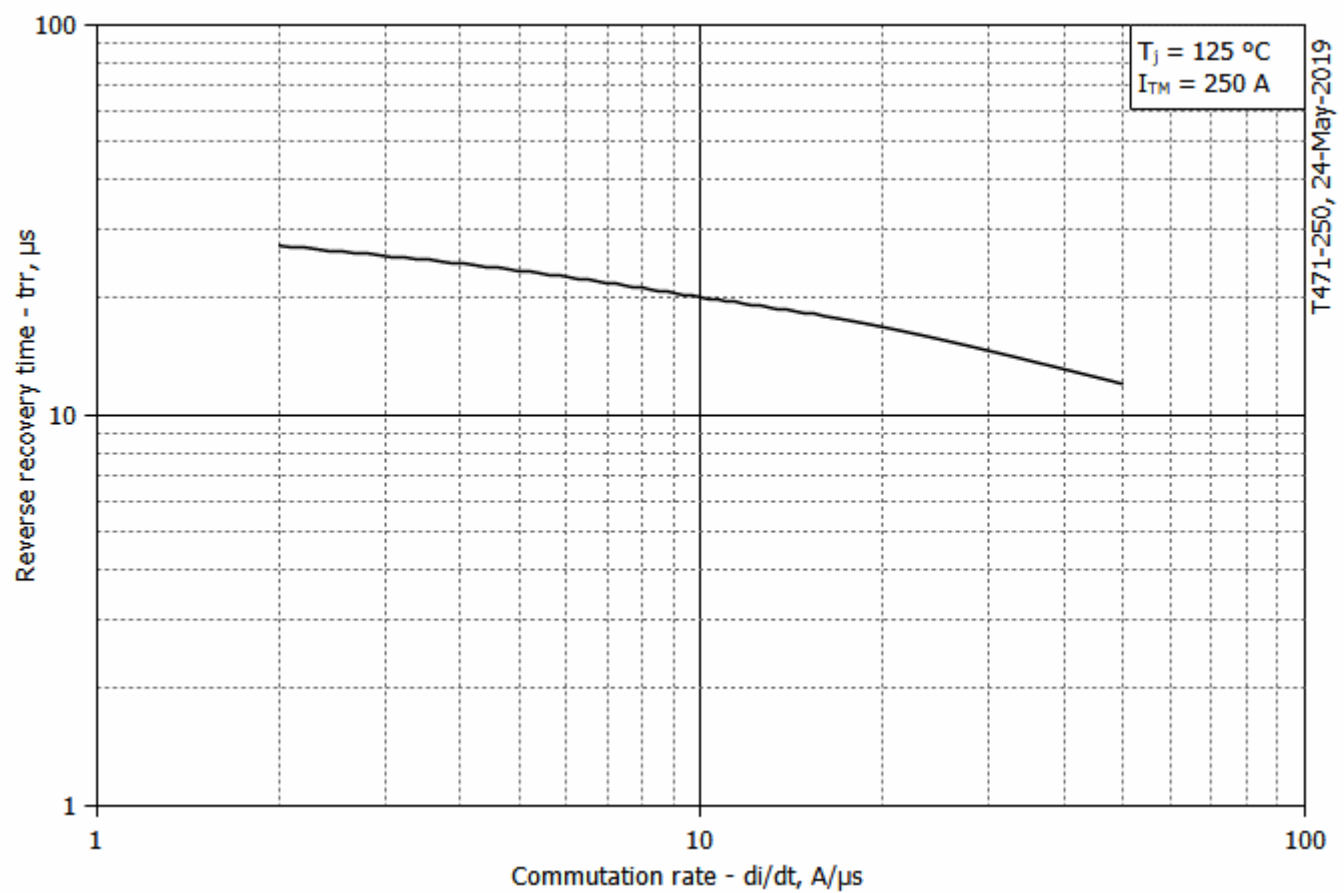
**Fig 3 – Maximum recovered charge  $Q_{rr-i}$  (integral) vs. commutation rate  $di_R/dt$**



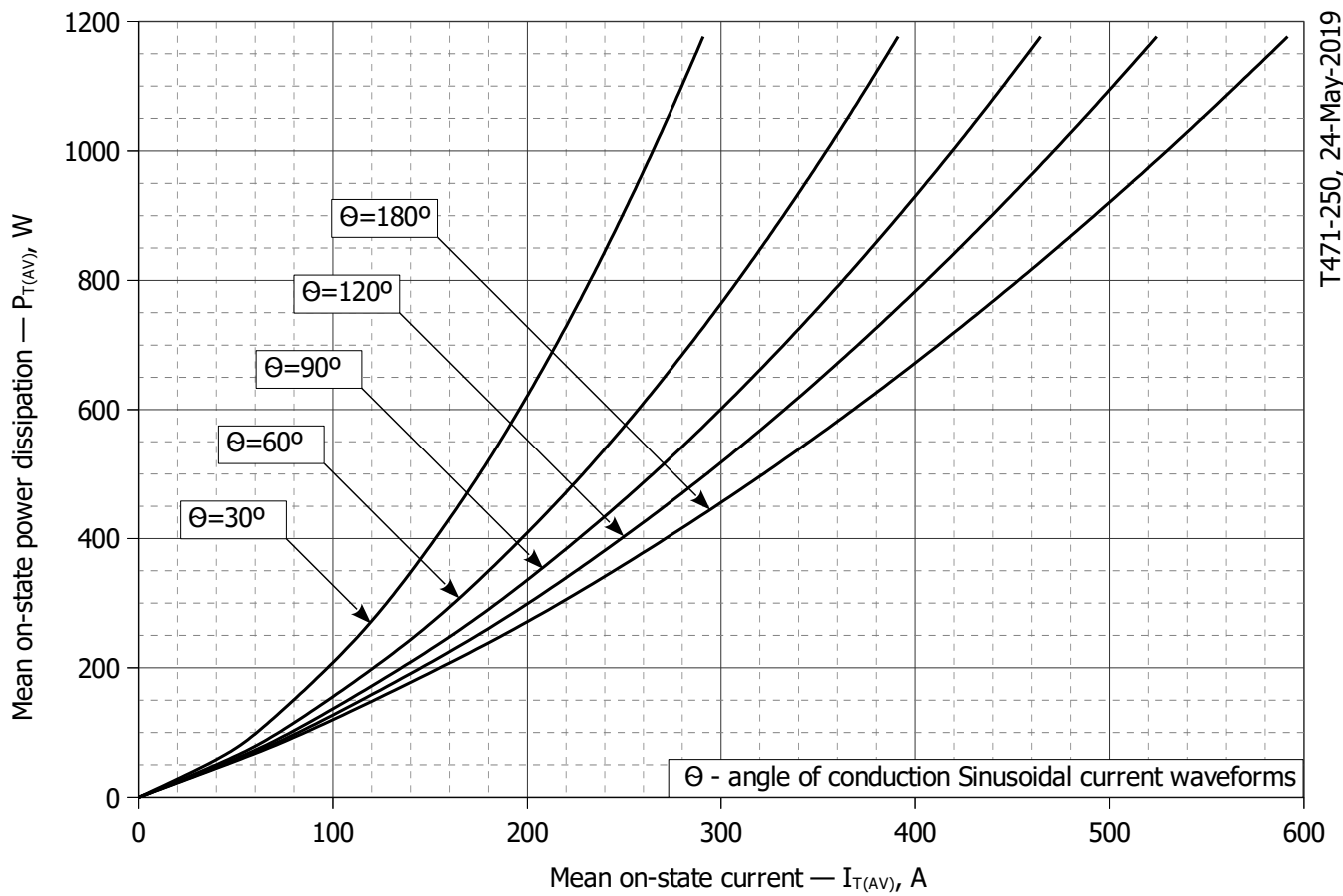
**Fig 4 – Maximum recovered charge  $Q_{rr}$  vs. commutation rate  $di_R/dt$  (25% chord)**



**Fig 5 – Maximum reverse recovery current  $I_{rr}$  vs. commutation rate  $di_R/dt$**

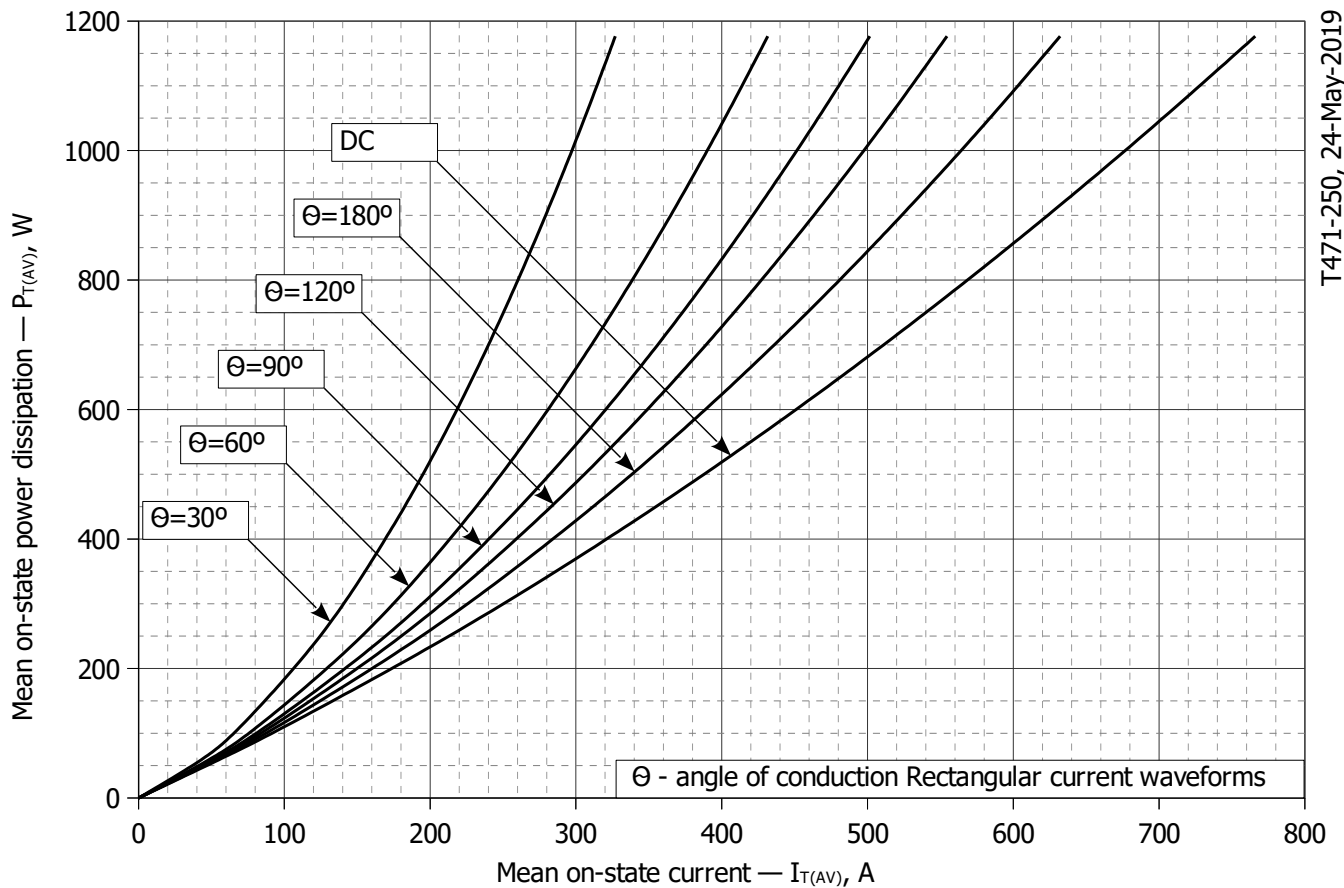


**Fig 6 – Maximum recovery time  $t_{rr}$  vs. commutation rate  $di_R/dt$  (25% chord)**



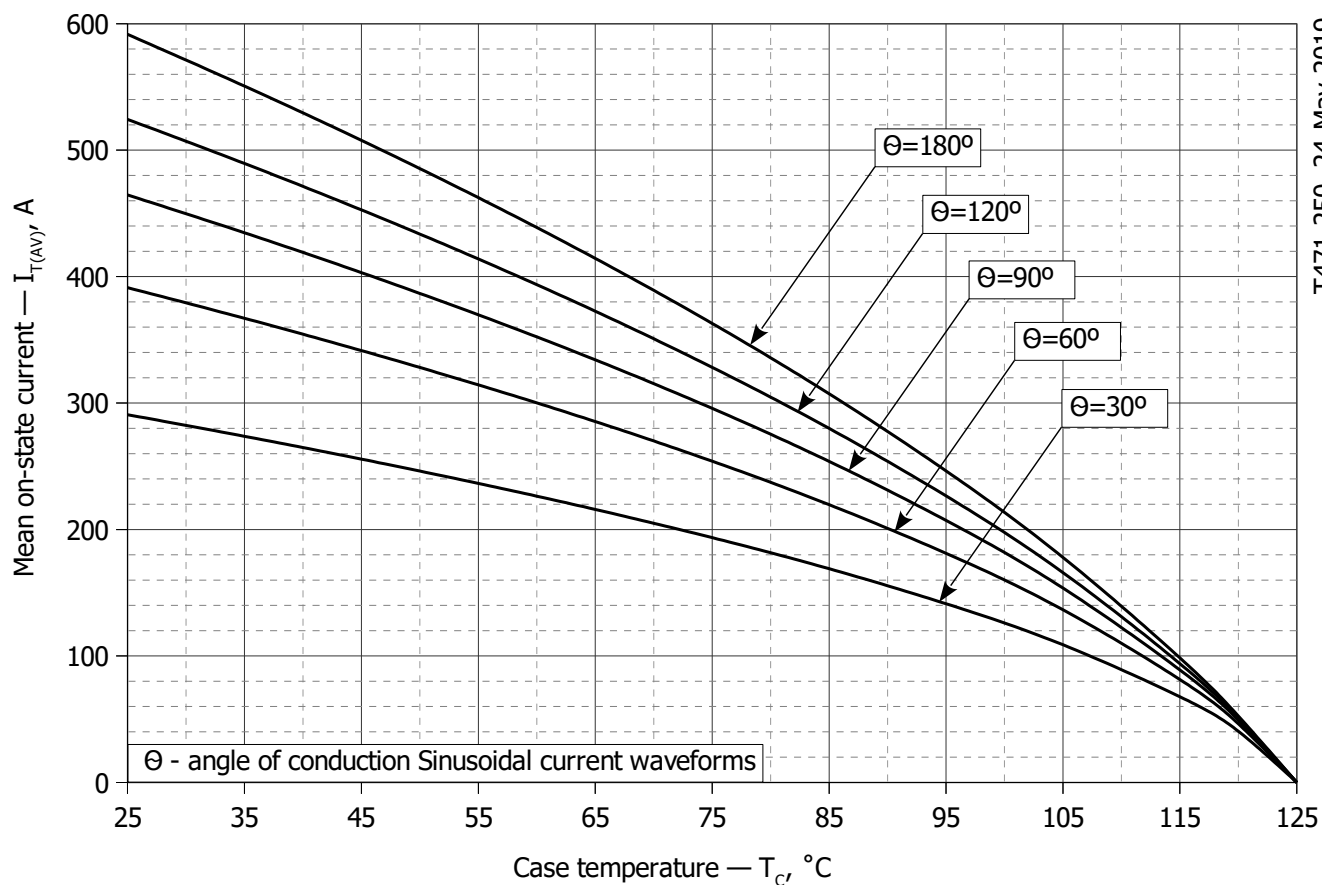
T471-250, 24-May-2019

**Fig. 7 - Mean on-state power dissipation  $P_{TAV}$  vs. mean on-state current  $I_{TAV}$  for sinusoidal current waveforms at different conduction angles ( $f=50\text{Hz}$ )**

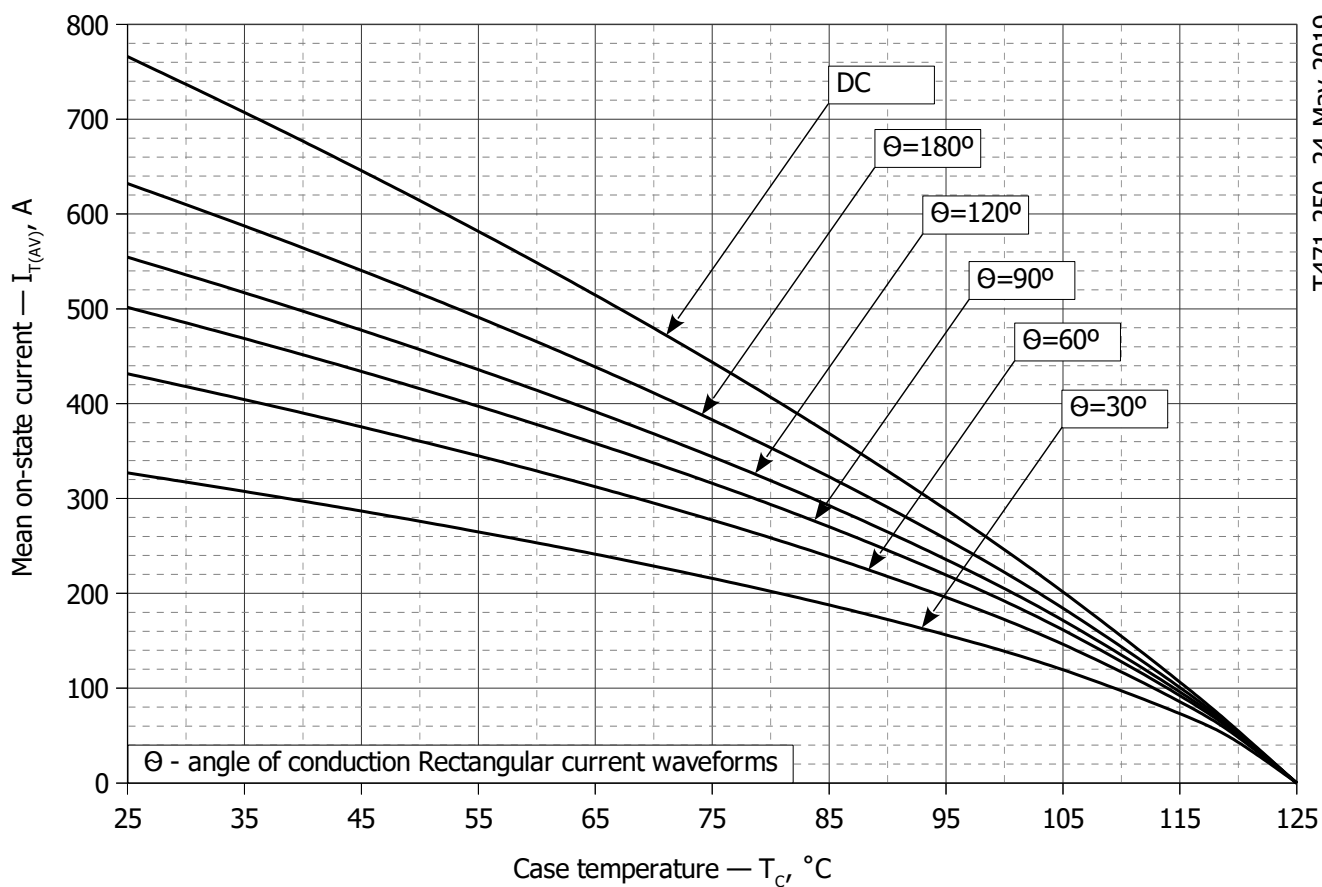


T471-250, 24-May-2019

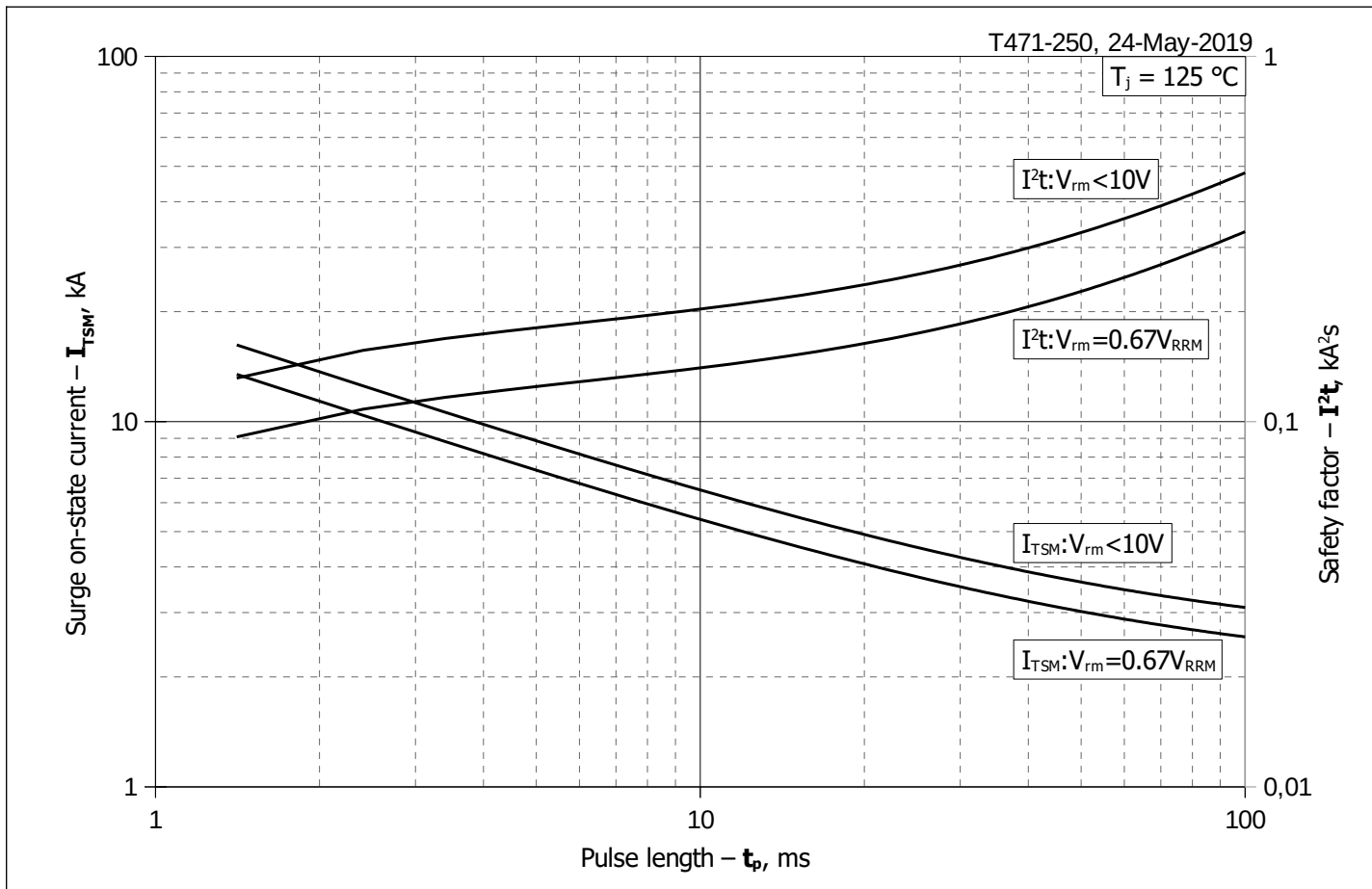
**Fig. 8 – Mean on-state power dissipation  $P_{TAV}$  vs. mean on-state current  $I_{TAV}$  for rectangular current waveforms at different conduction angles and for DC ( $f=50\text{Hz}$ )**



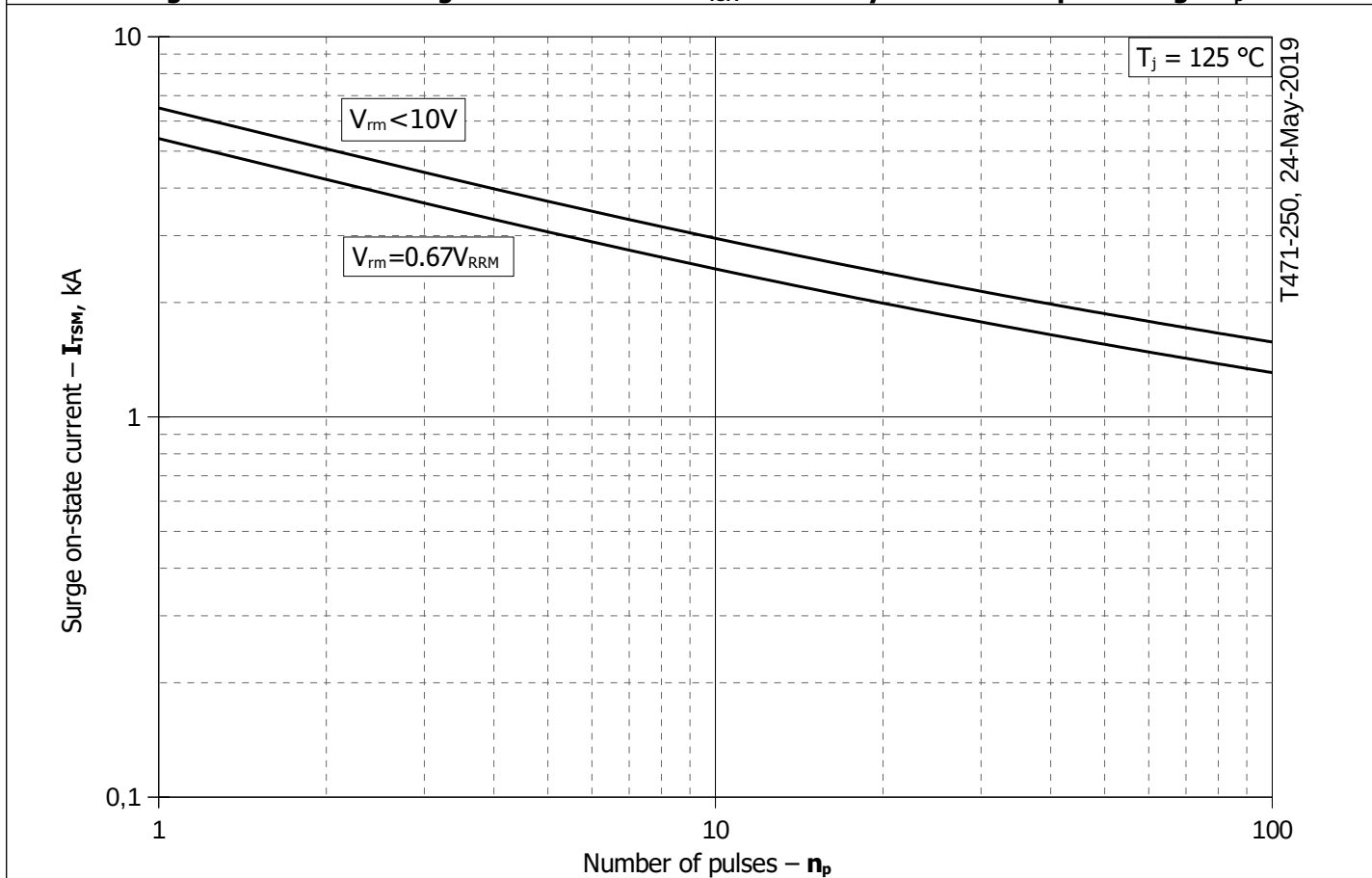
**Fig. 9 – Mean on-state current  $I_{TAV}$  vs. case temperature  $T_c$  for sinusoidal current waveforms at different conduction angles ( $f=50\text{Hz}$ )**



**Fig. 10 - Mean on-state current  $I_{TAV}$  vs. case temperature  $T_c$  for rectangular current waveforms at different conduction angles and for DC ( $f=50\text{Hz}$ )**



**Fig. 11 – Maximum surge on-state current  $I_{TSM}$  and safety factor  $I^2t$  vs. pulse length  $t_p$**



**Fig. 12 - Maximum surge on-state current  $I_{TSM}$  vs. number of pulses  $n_p$**