



High power cycling capability  
Low on-state and switching losses  
Designed for traction and industrial applications

## Phase Control Thyristor Type T123-320-18

|                                         |            |     |     |     |     |     |                  |      |      |                                      |      |      |      |      |  |
|-----------------------------------------|------------|-----|-----|-----|-----|-----|------------------|------|------|--------------------------------------|------|------|------|------|--|
| Mean on-state current                   |            |     |     |     |     |     | I <sub>TAV</sub> |      |      | 320 A                                |      |      |      |      |  |
| Repetitive peak off-state voltage       |            |     |     |     |     |     | V <sub>DRM</sub> |      |      | 400...1800 V                         |      |      |      |      |  |
| Repetitive peak reverse voltage         |            |     |     |     |     |     | V <sub>RRM</sub> |      |      |                                      |      |      |      |      |  |
| Turn-off time                           |            |     |     |     |     |     | t <sub>q</sub>   |      |      | 125, 160, 200, 250, 320, 400, 500 μs |      |      |      |      |  |
| V <sub>DRM</sub> , V <sub>RRM</sub> , V | 400        | 500 | 600 | 700 | 800 | 900 | 1000             | 1100 | 1200 | 1300                                 | 1400 | 1500 | 1600 | 1800 |  |
| Voltage code                            | 4          | 5   | 6   | 7   | 8   | 9   | 10               | 11   | 12   | 13                                   | 14   | 15   | 16   | 18   |  |
| T <sub>j</sub> , °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                                | 320<br>338                                   | T <sub>c</sub> =88 °C, Double side cooled<br>T <sub>c</sub> =85 °C, Double side cooled<br>180° half-sine wave; 50 Hz |                                                                                                                                                                                                 |
| I <sub>TRMS</sub>                   | RMS on-state current                                                   | A                                | 502                                          | T <sub>c</sub> =88 °C, Double side cooled<br>180° half-sine wave; 50 Hz                                              |                                                                                                                                                                                                 |
| I <sub>TSM</sub>                    | Surge on-state current                                                 | kA                               | 5.0<br>6.0                                   | 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> =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  |
|                                     |                                                                        |                                  | 5.5<br>6.5                                   | 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> =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> | 120<br>180                                   | 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  |
|                                     |                                                                        |                                  | 120<br>170                                   | 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                                | 400...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                                | 500...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                                                                    |                                                                                                                                                                                                 |

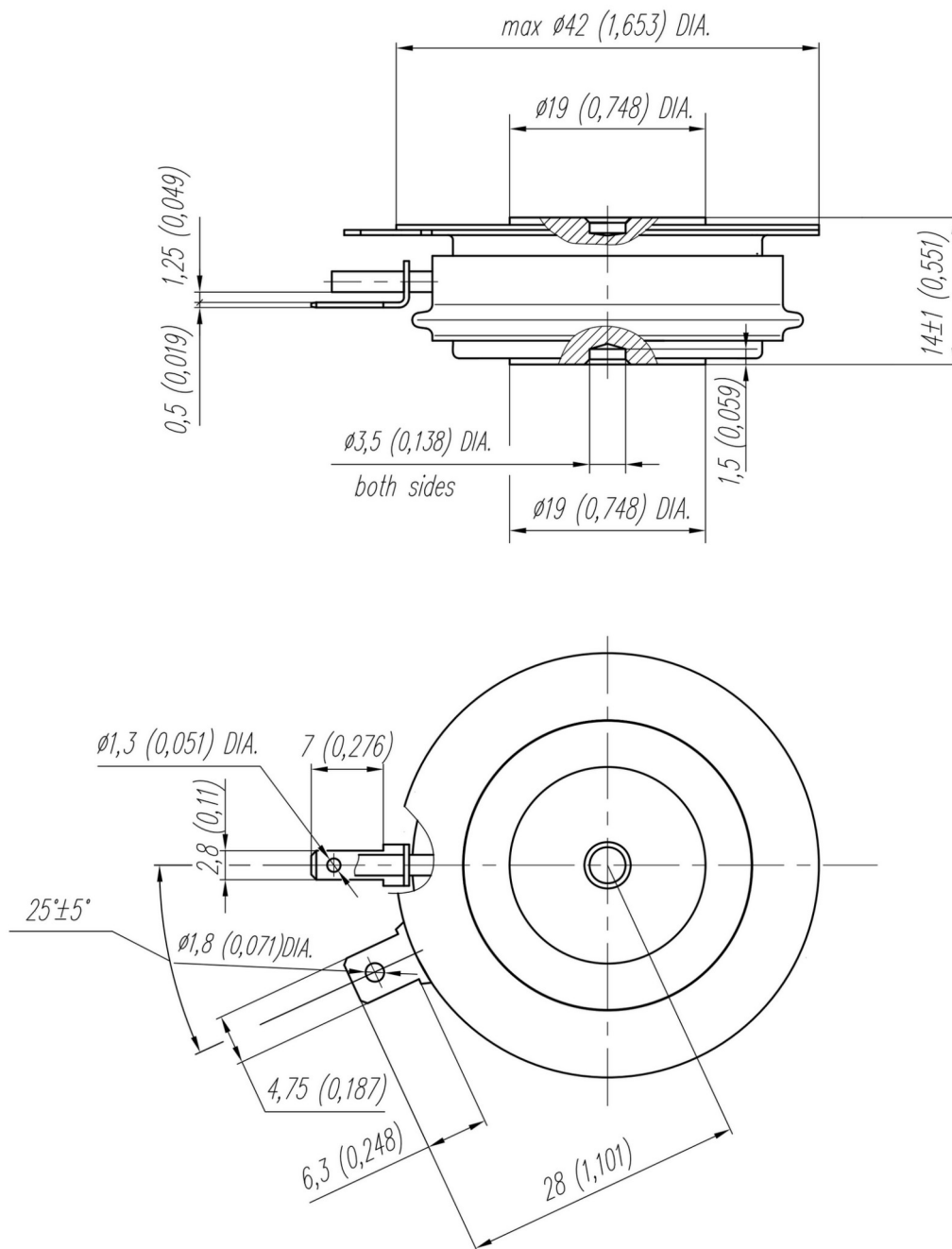
| TRIGGERING         |                                                                              |                    |                  |                                                                                                                                                                                      |
|--------------------|------------------------------------------------------------------------------|--------------------|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $I_{FGM}$          | Peak forward gate current                                                    | A                  | 5                | $T_j = T_{j\max}$                                                                                                                                                                    |
| $V_{RGM}$          | Peak reverse gate voltage                                                    | V                  | 5                |                                                                                                                                                                                      |
| $P_G$              | Gate power dissipation                                                       | W                  | 3                | $T_j = T_{j\max}$ for DC gate current                                                                                                                                                |
| SWITCHING          |                                                                              |                    |                  |                                                                                                                                                                                      |
| $(di_T/dt)_{crit}$ | Critical rate of rise of on-state current non-repetitive ( $f=1\text{ Hz}$ ) | A/ $\mu\text{s}$   | 800              | $T_j = T_{j\max}$ ; $V_D = 0.67 \cdot V_{DRM}$ ; $I_{TM} = 640\text{ A}$ ; Gate pulse: $I_G = 2\text{ A}$ ; $t_{GP} = 50\text{ }\mu\text{s}$ ; $di_G/dt \geq 2\text{ A}/\mu\text{s}$ |
| THERMAL            |                                                                              |                    |                  |                                                                                                                                                                                      |
| $T_{stg}$          | Storage temperature                                                          | $^{\circ}\text{C}$ | $-60 \dots +50$  |                                                                                                                                                                                      |
| $T_j$              | Operating junction temperature                                               | $^{\circ}\text{C}$ | $-60 \dots +125$ |                                                                                                                                                                                      |
| MECHANICAL         |                                                                              |                    |                  |                                                                                                                                                                                      |
| F                  | Mounting force                                                               | kN                 | 5.0...7.0        |                                                                                                                                                                                      |
| a                  | Acceleration                                                                 | $\text{m/s}^2$     | 50               | Device clamped                                                                                                                                                                       |

## CHARACTERISTICS

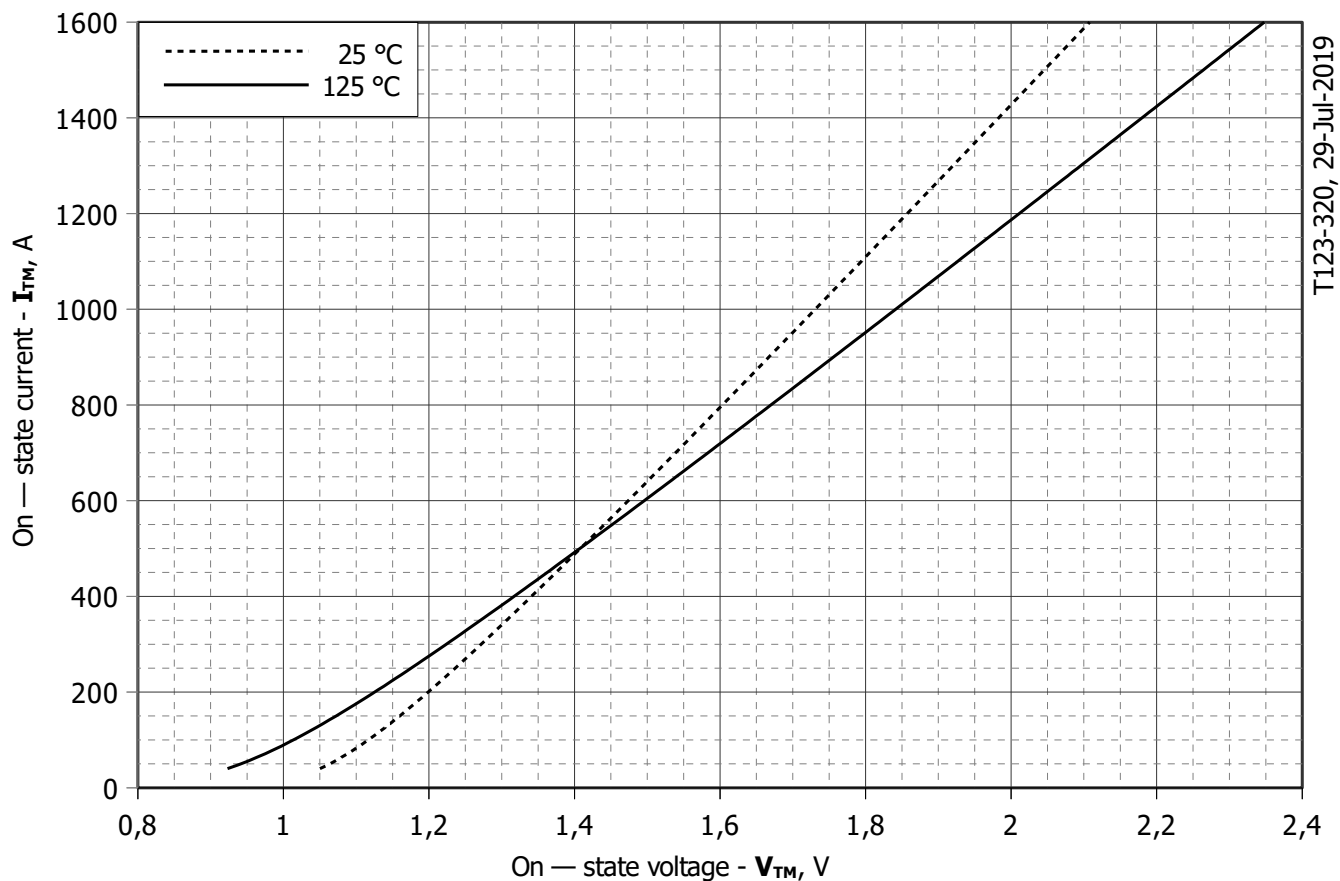
| Symbols and parameters                |                                                                        | Units | Values                                         | Conditions                                                                                                                                                                                             |                                                                   |
|---------------------------------------|------------------------------------------------------------------------|-------|------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| ON-STATE                              |                                                                        |       |                                                |                                                                                                                                                                                                        |                                                                   |
| V <sub>TM</sub>                       | Peak on-state voltage, max                                             | V     | 1.75                                           | T <sub>j</sub> =25 °C; I <sub>TM</sub> =1005 A                                                                                                                                                         |                                                                   |
| V <sub>T(TO)</sub>                    | On-state threshold voltage, max                                        | V     | 0.980                                          | T <sub>j</sub> =T <sub>j max</sub> ;                                                                                                                                                                   |                                                                   |
| r <sub>T</sub>                        | On-state slope resistance, max                                         | mΩ    | 0.856                                          | 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    | 500                                            | 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    | 250                                            | 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<br>Repetitive peak reverse currents, max | mA    | 50                                             | 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<br>off-state voltage <sup>1)</sup> , min      | V/μs  | 200, 320,<br>500, 1000,<br>1600, 2000,<br>2500 | 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     | 0.70                                           | T <sub>j</sub> =T <sub>j max</sub> ;                                                                                                                                                                   |                                                                   |
| I <sub>GD</sub>                       | Gate non-trigger direct current, min                                   | mA    | 65.00                                          | V <sub>D</sub> =0.67·V <sub>DRM</sub> ;<br>Direct gate current                                                                                                                                         |                                                                   |
| SWITCHING                             |                                                                        |       |                                                |                                                                                                                                                                                                        |                                                                   |
| t <sub>gd</sub>                       | Delay time, max                                                        | μs    | 1.10                                           | T <sub>j</sub> =25 °C; V <sub>D</sub> =1000 V; I <sub>TM</sub> =I <sub>TAV</sub> ;                                                                                                                     |                                                                   |
| t <sub>gt</sub>                       | Turn-on time, max                                                      | μs    | 3.00                                           | di/dt=200 A/μs;<br>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,<br>200, 250,<br>320, 400,<br>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    | 700                                            | T <sub>j</sub> =T <sub>j max</sub> ; I <sub>TM</sub> =320 A;                                                                                                                                           |                                                                   |
| t <sub>rr</sub>                       | Reverse recovery time, max                                             | μs    | 16                                             | di <sub>R</sub> /dt=-10 A/μs;                                                                                                                                                                          |                                                                   |
| I <sub>rr</sub>                       | Reverse recovery current, max                                          | A     | 88                                             | V <sub>R</sub> =100 V                                                                                                                                                                                  |                                                                   |

| THERMAL             |                                           |              |                 |                |                     |
|---------------------|-------------------------------------------|--------------|-----------------|----------------|---------------------|
| R <sub>thjc</sub>   | Thermal resistance, junction to case, max | °C/W         | 0.070           | Direct current | Double side cooled  |
| R <sub>thjc-A</sub> |                                           |              | 0.154           |                | Anode side cooled   |
| R <sub>thjc-K</sub> |                                           |              | 0.126           |                | Cathode side cooled |
| R <sub>thck</sub>   | Thermal resistance, case to heatsink, max | °C/W         | 0.010           | Direct current |                     |
| MECHANICAL          |                                           |              |                 |                |                     |
| m                   | Weight, max                               | g            | 65              |                |                     |
| D <sub>s</sub>      | Surface creepage distance                 | mm<br>(inch) | 7.94<br>(0.313) |                |                     |
| D <sub>a</sub>      | Air strike distance                       | mm<br>(inch) | 5.00<br>(0.197) |                |                     |

| PART NUMBERING GUIDE                                |     |     |     |      |      |      | NOTES                                                                                                                                                                                                                                                                           |  |  |  |  |  |  |                 |    |    |    |    |    |    |    |                                              |     |     |     |      |      |      |      |
|-----------------------------------------------------|-----|-----|-----|------|------|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|--|-----------------|----|----|----|----|----|----|----|----------------------------------------------|-----|-----|-----|------|------|------|------|
| T                                                   | 123 | 320 | 18  | A2   | E2   | N    | 1) Critical rate of rise of off-state voltage                                                                                                                                                                                                                                   |  |  |  |  |  |  |                 |    |    |    |    |    |    |    |                                              |     |     |     |      |      |      |      |
| 1                                                   | 2   | 3   | 4   | 5    | 6    | 7    | <table><tr><td>Symbol of Group</td><td>P2</td><td>K2</td><td>E2</td><td>A2</td><td>T1</td><td>P1</td><td>M1</td></tr><tr><td>(dv<sub>D</sub>/dt)<sub>crit</sub>, V/μs</td><td>200</td><td>320</td><td>500</td><td>1000</td><td>1600</td><td>2000</td><td>2500</td></tr></table> |  |  |  |  |  |  | Symbol of Group | P2 | K2 | E2 | A2 | T1 | P1 | M1 | (dv <sub>D</sub> /dt) <sub>crit</sub> , V/μs | 200 | 320 | 500 | 1000 | 1600 | 2000 | 2500 |
| Symbol of Group                                     | P2  | K2  | E2  | A2   | T1   | P1   | M1                                                                                                                                                                                                                                                                              |  |  |  |  |  |  |                 |    |    |    |    |    |    |    |                                              |     |     |     |      |      |      |      |
| (dv <sub>D</sub> /dt) <sub>crit</sub> , V/μs        | 200 | 320 | 500 | 1000 | 1600 | 2000 | 2500                                                                                                                                                                                                                                                                            |  |  |  |  |  |  |                 |    |    |    |    |    |    |    |                                              |     |     |     |      |      |      |      |
| 1. Phase Control Thyristor                          |     |     |     |      |      |      | 2) Turn-off time (dv <sub>D</sub> /dt=50 V/μs)                                                                                                                                                                                                                                  |  |  |  |  |  |  |                 |    |    |    |    |    |    |    |                                              |     |     |     |      |      |      |      |
| 2. Design version                                   |     |     |     |      |      |      | <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>t<sub>q</sub>, μs</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 <sub>q</sub> , μs                          | 125 | 160 | 200 | 250  | 320  | 400  | 500  |
| Symbol of Group                                     | X2  | T2  | P2  | M2   | K2   | H2   | E2                                                                                                                                                                                                                                                                              |  |  |  |  |  |  |                 |    |    |    |    |    |    |    |                                              |     |     |     |      |      |      |      |
| t <sub>q</sub> , μs                                 | 125 | 160 | 200 | 250  | 320  | 400  | 500                                                                                                                                                                                                                                                                             |  |  |  |  |  |  |                 |    |    |    |    |    |    |    |                                              |     |     |     |      |      |      |      |
| 3. Mean on-state current, A                         |     |     |     |      |      |      |                                                                                                                                                                                                                                                                                 |  |  |  |  |  |  |                 |    |    |    |    |    |    |    |                                              |     |     |     |      |      |      |      |
| 4. Voltage code                                     |     |     |     |      |      |      |                                                                                                                                                                                                                                                                                 |  |  |  |  |  |  |                 |    |    |    |    |    |    |    |                                              |     |     |     |      |      |      |      |
| 5. Critical rate of rise of off-state voltage, V/μs |     |     |     |      |      |      |                                                                                                                                                                                                                                                                                 |  |  |  |  |  |  |                 |    |    |    |    |    |    |    |                                              |     |     |     |      |      |      |      |
| 6. Turn-off time (dv <sub>D</sub> /dt=50 V/μs)      |     |     |     |      |      |      |                                                                                                                                                                                                                                                                                 |  |  |  |  |  |  |                 |    |    |    |    |    |    |    |                                              |     |     |     |      |      |      |      |
| 7. Ambient conditions: N – normal; T – tropical     |     |     |     |      |      |      |                                                                                                                                                                                                                                                                                 |  |  |  |  |  |  |                 |    |    |    |    |    |    |    |                                              |     |     |     |      |      |      |      |



All dimensions in millimeters (inches)



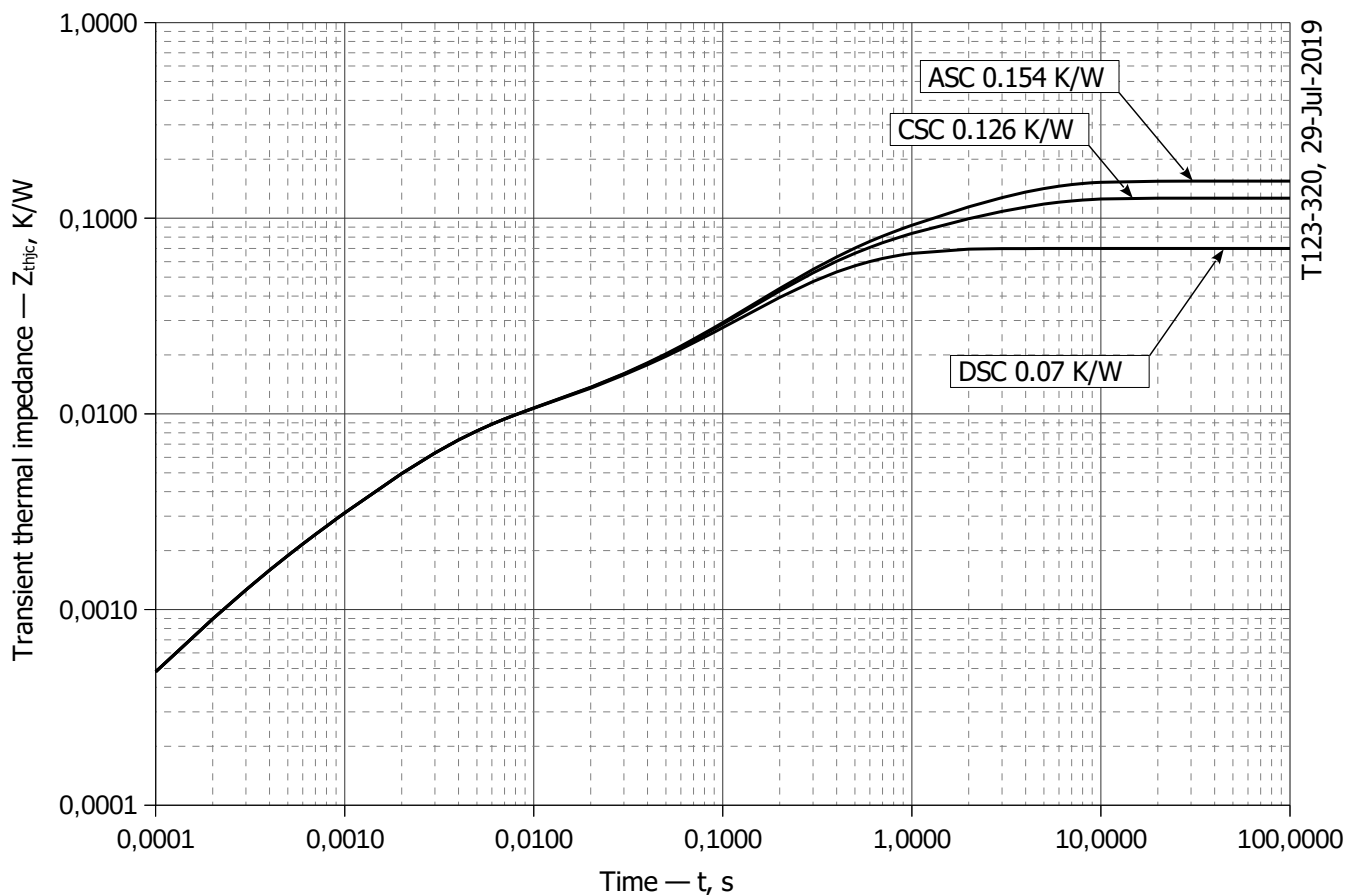
**Fig 1 – On-state characteristics of Limit device**

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 |                         |
|----------|-----------------------------|-------------------------|
|          | $T_j = 25^\circ\text{C}$    | $T_j = T_{j\text{max}}$ |
| <b>A</b> | 0,89359000                  | 0,70710000              |
| <b>B</b> | 0,00061709                  | 0,00082668              |
| <b>C</b> | 0,03773700                  | 0,05213900              |
| <b>D</b> | -0,00128490                 | -0,00166490             |

**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 Double side cooled

| $i$          | 1       | 2       | 3        | 4        | 5        | 6         |
|--------------|---------|---------|----------|----------|----------|-----------|
| $R_i$ , K/W  | 0.03233 | 0.02226 | 0.005231 | 0.002739 | 0.006738 | 0.0006988 |
| $\tau_i$ , s | 0.2392  | 0.533   | 0.1478   | 0.01499  | 0.002749 | 0.0002969 |

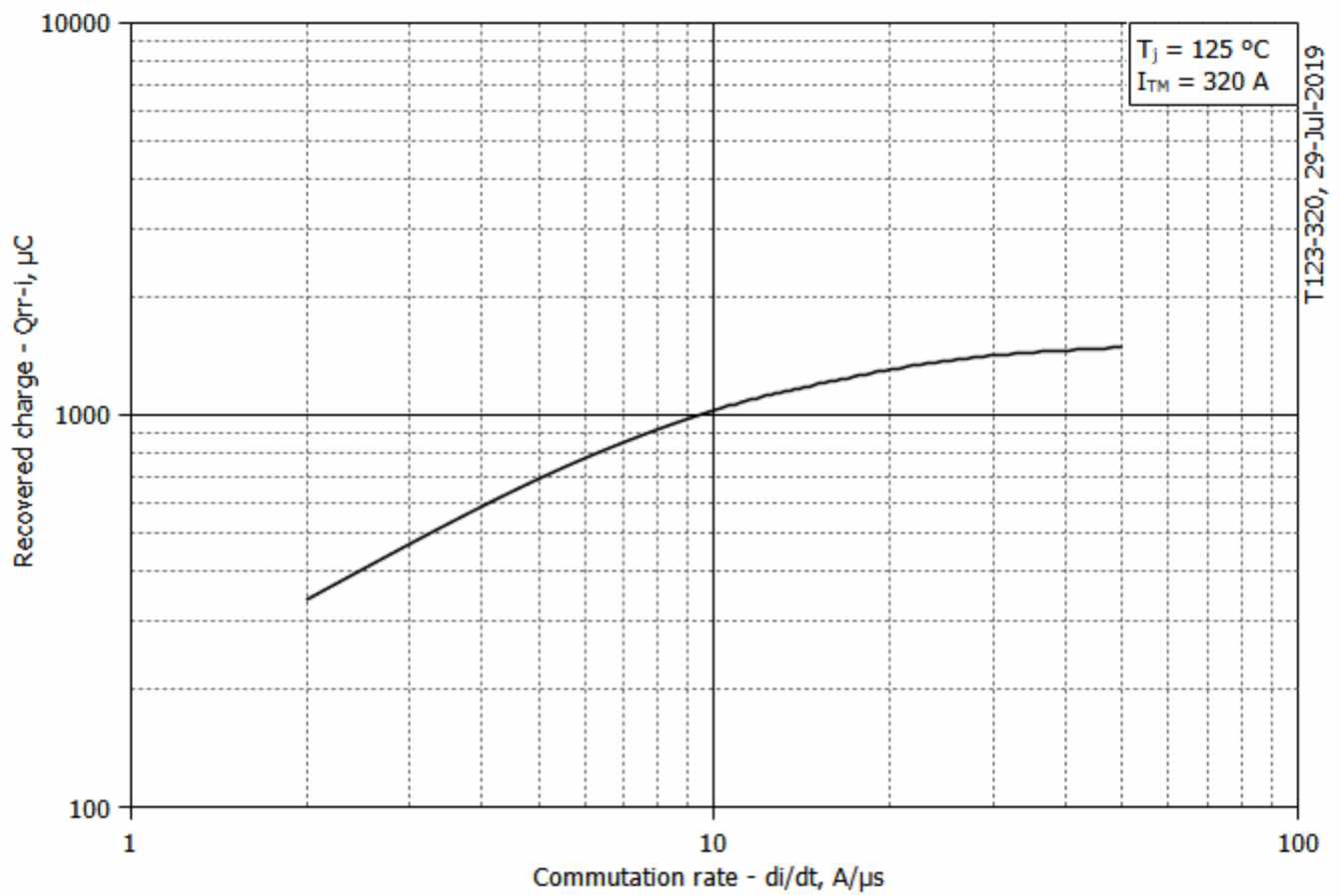
DC Anode side cooled

| $i$          | 1       | 2       | 3        | 4        | 5         | 6       |
|--------------|---------|---------|----------|----------|-----------|---------|
| $R_i$ , K/W  | 0.08459 | 0.02327 | 0.002598 | 0.006598 | 0.0006736 | 0.03694 |
| $\tau_i$ , s | 2.653   | 0.5669  | 0.01311  | 0.00269  | 0.0002871 | 0.2416  |

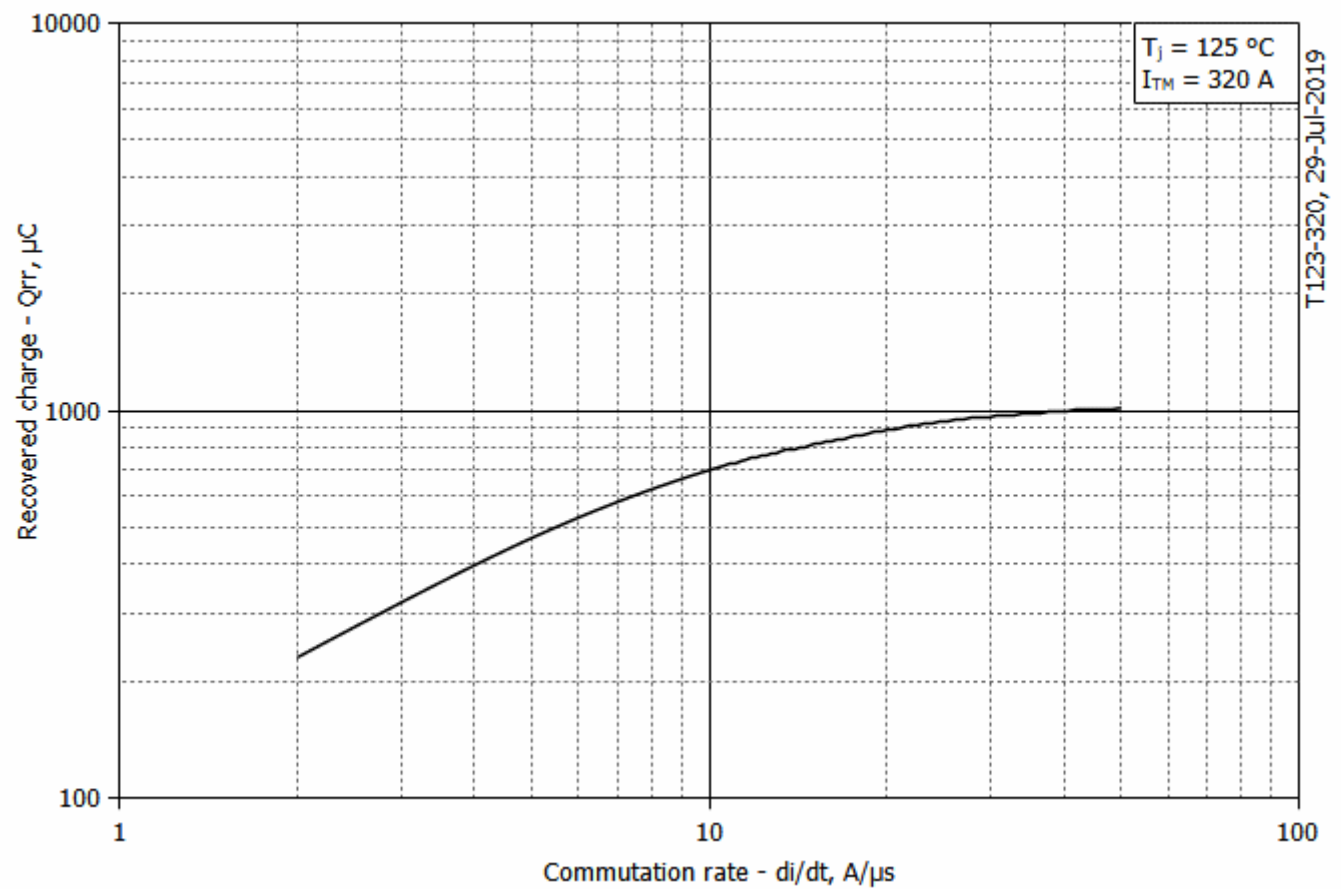
DC Cathode side cooled

| $i$          | 1       | 2       | 3        | 4        | 5         | 6       |
|--------------|---------|---------|----------|----------|-----------|---------|
| $R_i$ , K/W  | 0.05654 | 0.03706 | 0.002638 | 0.006637 | 0.0006786 | 0.02303 |
| $\tau_i$ , s | 2.653   | 0.2338  | 0.01361  | 0.002704 | 0.000289  | 0.5476  |

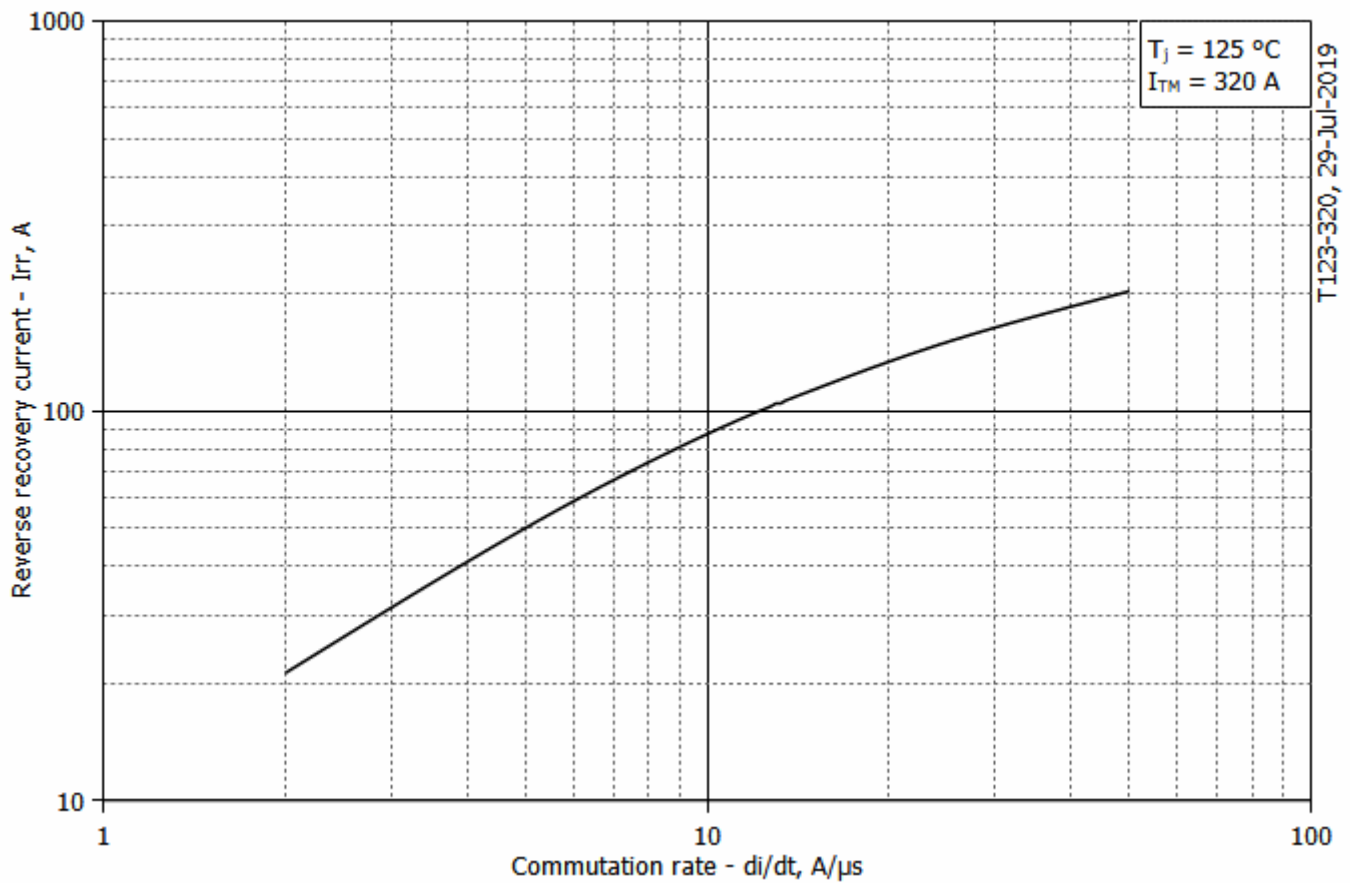
**Transient thermal impedance junction to case  $Z_{thjc}$  model (see Fig. 2)**



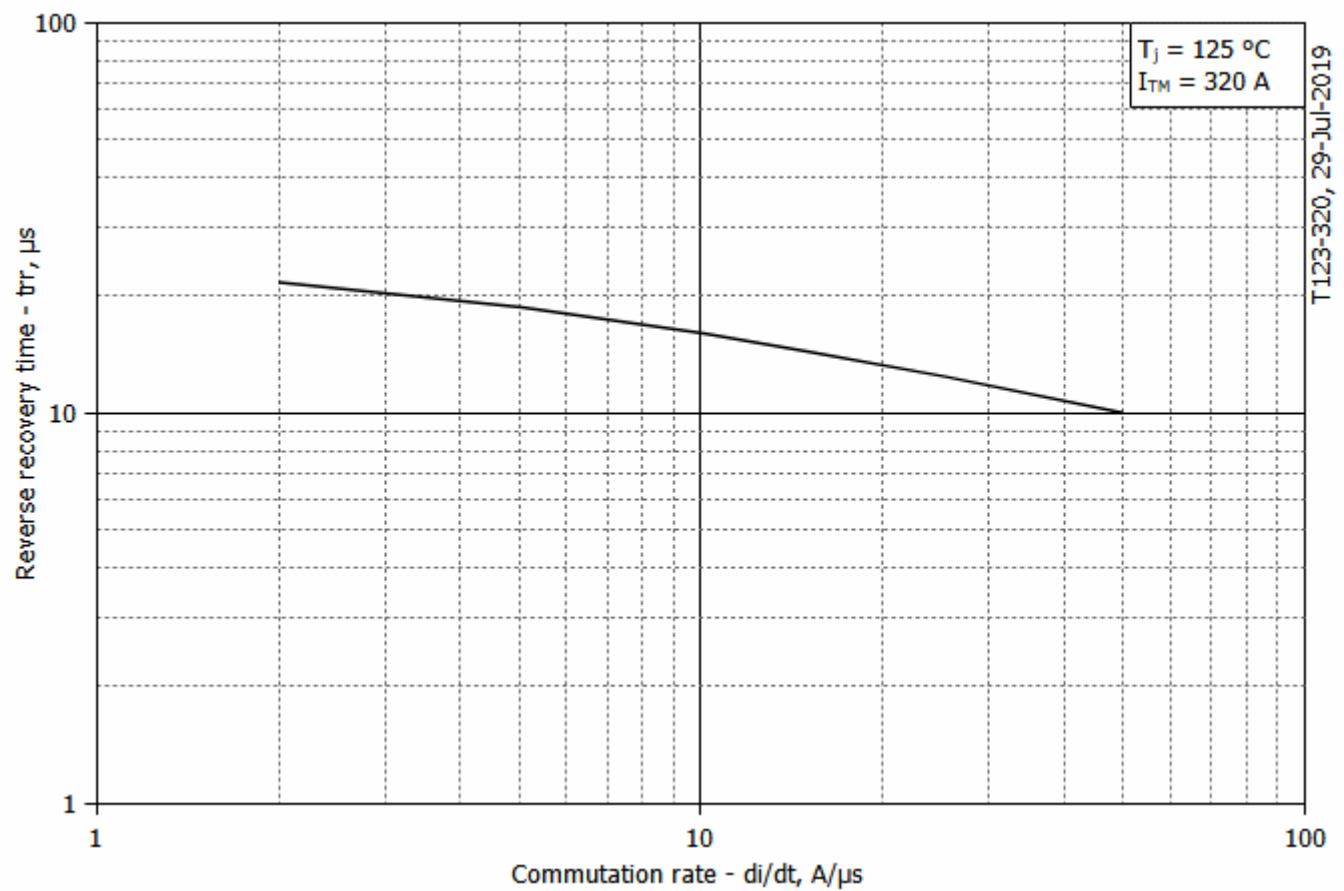
**Fig 3 – Maximum recovered charge  $Q_{rr-i}$  (integral) vs. commutation rate  $di_R/dt$**



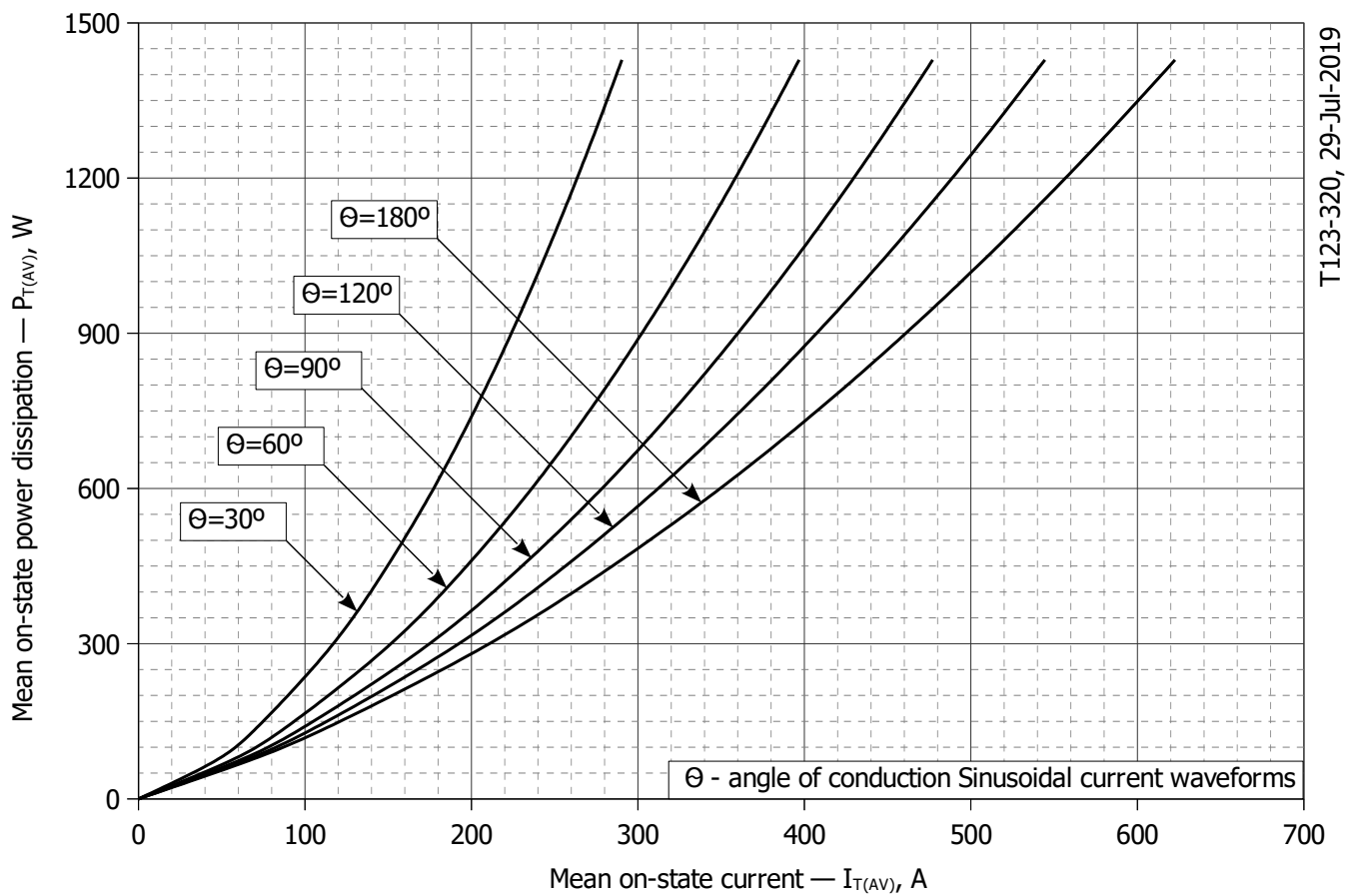
**Fig 4 – Maximum recovered charge  $Q_{rr}$  vs. commutation rate  $di_R/dt$  (25% chord)**



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

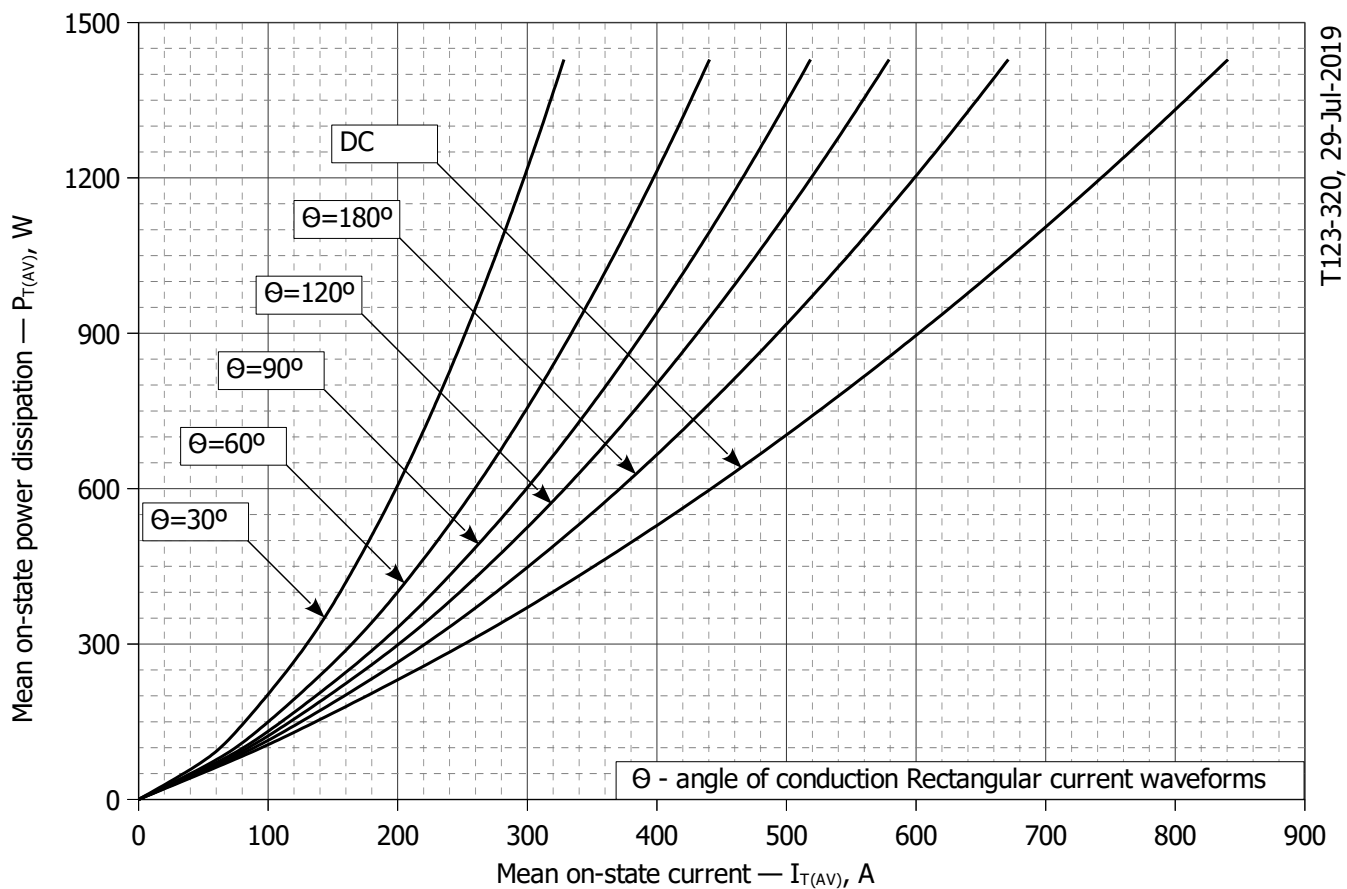


**Fig 6 – Maximum recovery time  $t_{rr}$  vs. commutation rate  $di_R/dt$  (25% chord)**



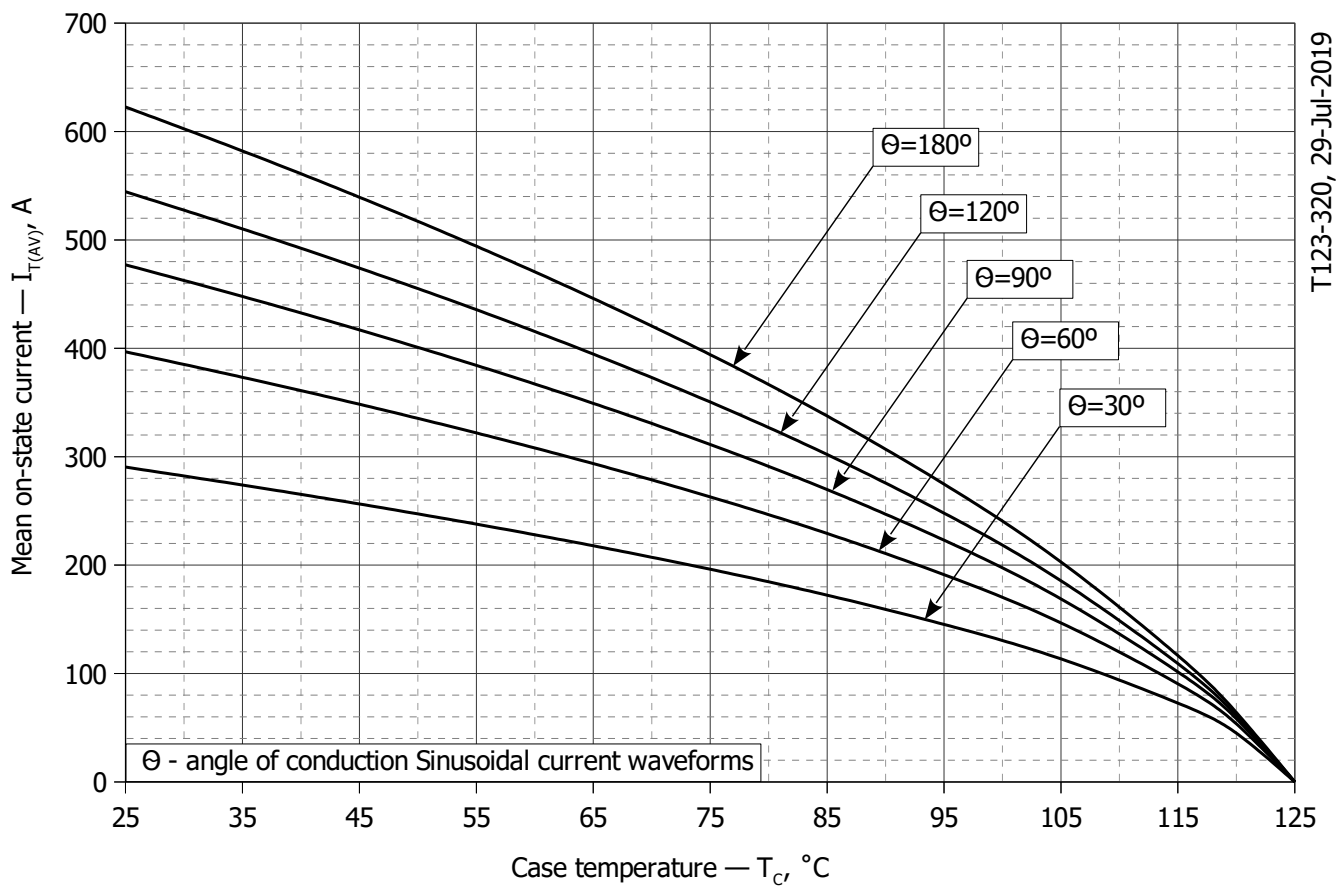
T123-320, 29-Jul-2019

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



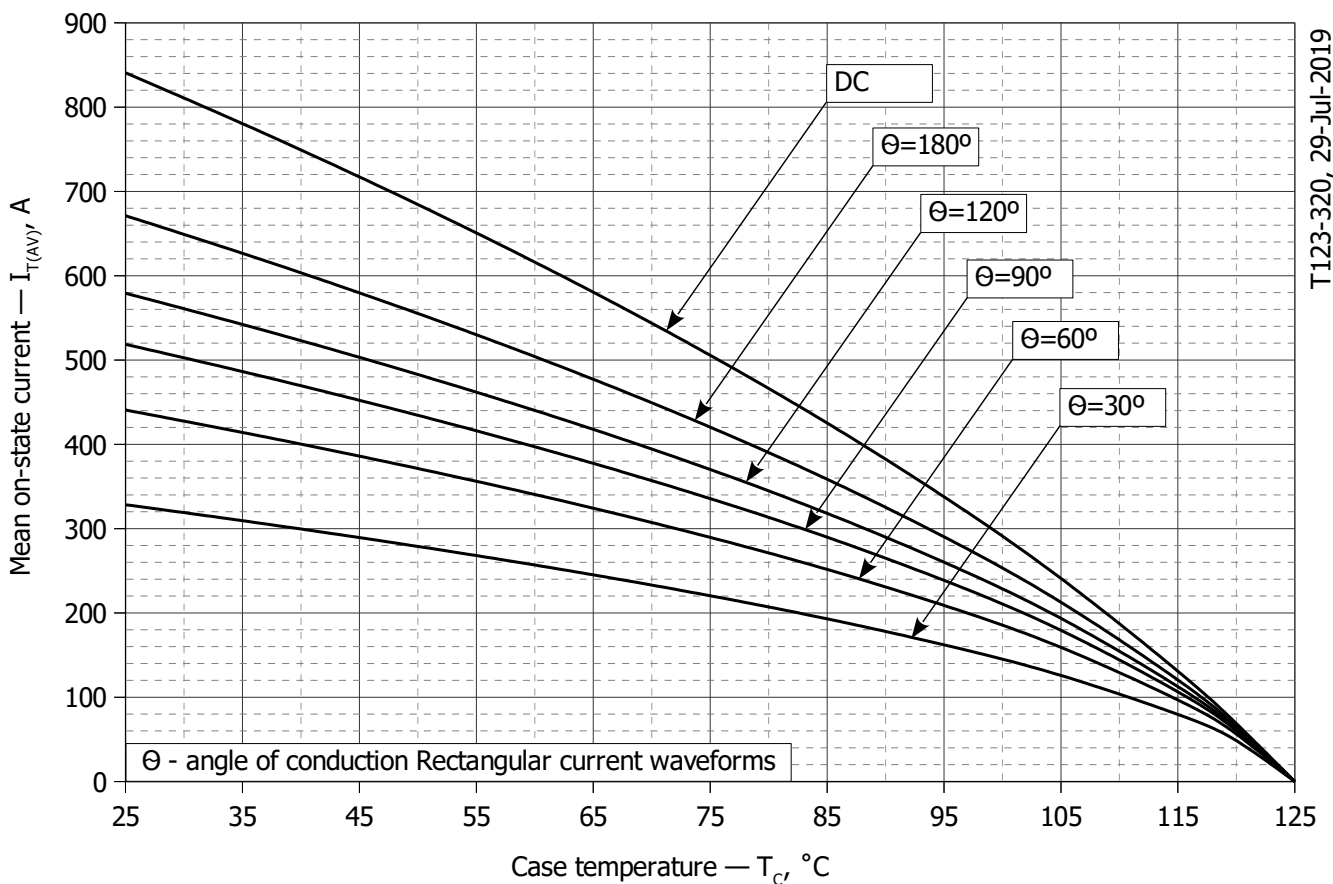
T123-320, 29-Jul-2019

**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 ( $f=50\text{Hz}$ , DSC)**



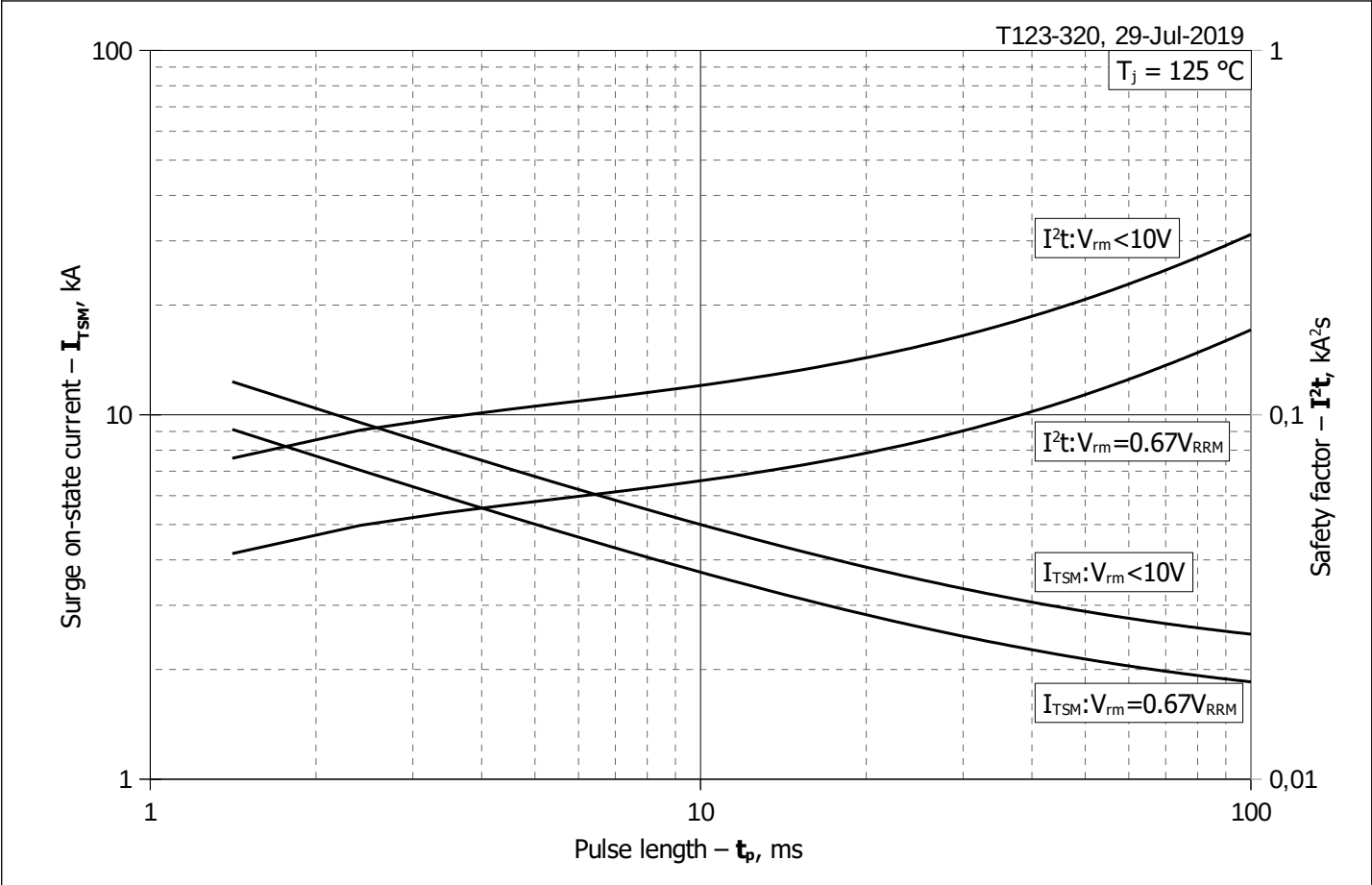
T123-320, 29-Jul-2019

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

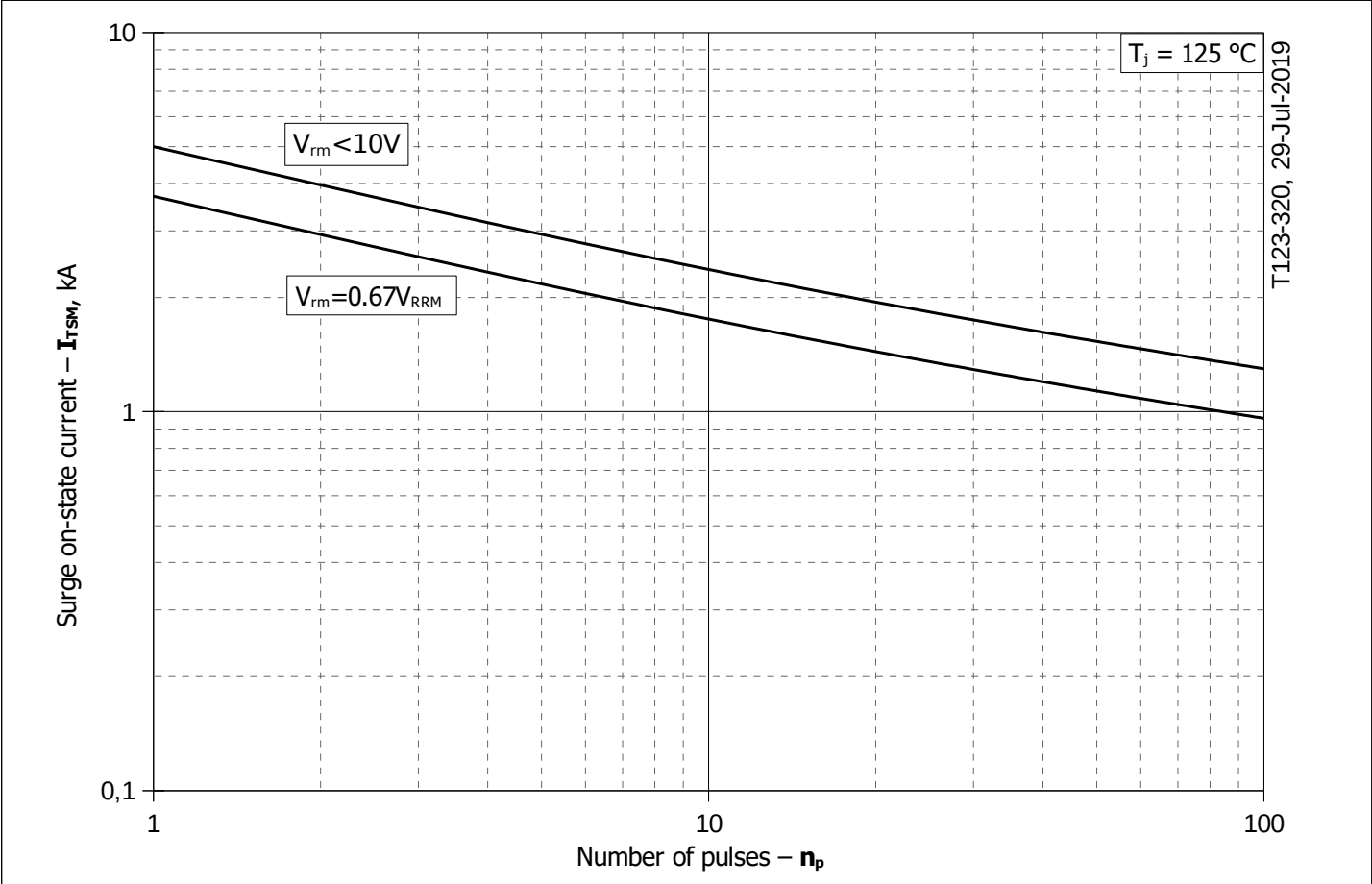


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**Fig. 10 - Mean on-state current  $I_{TAV}$  vs. case temperature  $T_c$  for rectangular current waveforms at different conduction angles and for DC ( $f=50\text{Hz}$ , DSC)**



**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  $n_p$**