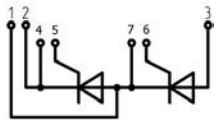
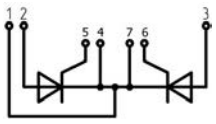
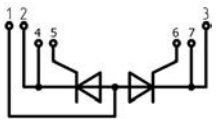
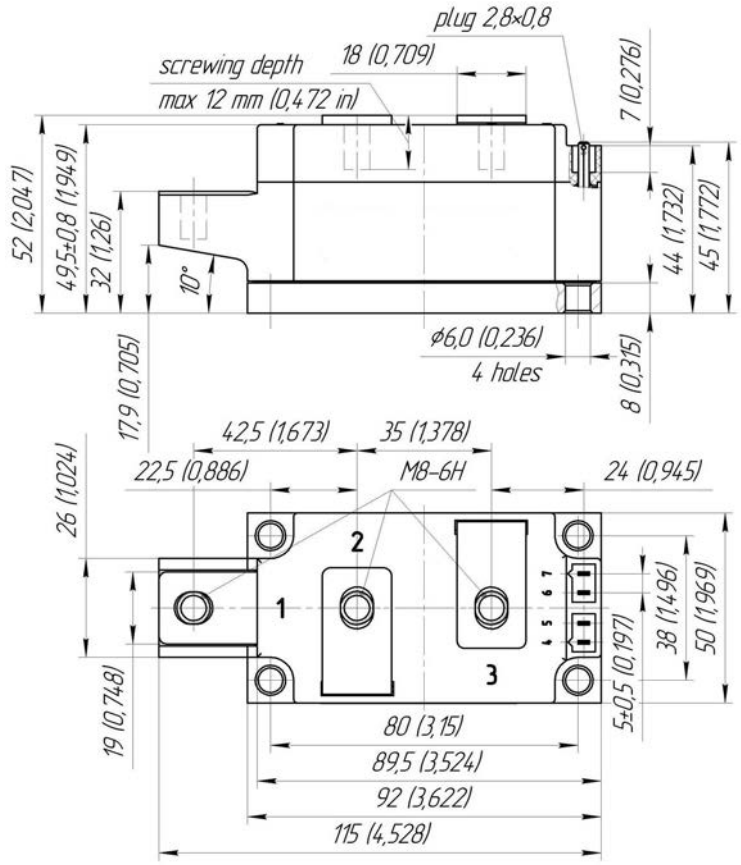
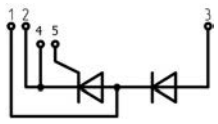
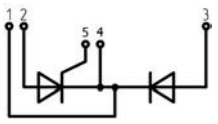
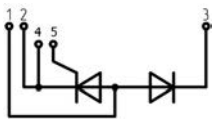
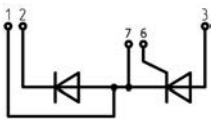
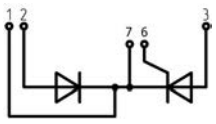
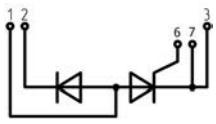
# Thyristor Modules
# MTx-160-36-C1

| | | | | |
|---|---|---|---|---|
| Mean on-state current | | $I_{TAV}$ | 160 A | |
| Repetitive peak off-state voltage | | $V_{DRM}$ | 3000...3600 V | |
| Repetitive peak reverse voltage | | $V_{RRM}$ | | |
| Turn-off time | | $t_q$ | 400 µs | |
| $V_{DRM}$, $V_{RRM}$, V | 3000 | 3200 | 3400 | 3600 |
| Voltage code | 30 | 32 | 34 | 36 |
| $T_j$, °C | –40...+125 | | | |

| MT3 | | MT4 | | MT5 | |
|---|---|---|---|---|---|
|  | |  | |  | |




| MT/D3 | MT/D4 | MT/D5 | MD/T3 | MD/T4 | MD/T5 |
|---|---|---|---|---|---|
|  |  |  |  |  |  |

## MAXIMUM ALLOWABLE RATINGS

| Symbols and parameters | | Units | Values | Test conditions | |
|---|---|---|---|---|---|
| **ON-STATE** | | | | | |
| $I_{TAV}$ | Maximum allowable mean on-state current | A | 160<br>260 | $T_c$=104 °C;<br>$T_c$=85 °C;<br>180° half-sine wave; 50 Hz | |
| $I_{TRMS}$ | RMS on-state current | A | 251 | $T_c$=104 °C;<br>180° half-sine wave; 50 Hz | |
| $I_{TSM}$ | Surge on-state current | kA | 6.0<br>7.0 | $T_j$=$T_{j\,max}$<br>$T_j$=25 °C | 180° half-sine wave;<br>$t_p$=10 ms; single pulse;<br>$V_D$=$V_R$=0 V;<br>Gate pulse:$I_G$=$I_{FGM}$; $V_G$=20 V;<br>$t_{GP}$=500 μs; $di_G/dt$=1 A/μs |
| | | | 6.5<br>7.5 | $T_j$=$T_{j\,max}$<br>$T_j$=25 °C | 180° half-sine wave;<br>$t_p$=8.3 ms; single pulse;<br>$V_D$=$V_R$=0 V;<br>Gate pulse:$I_G$=$I_{FGM}$; $V_G$=20 V;<br>$t_{GP}$=500 μs; $di_G/dt$=1 A/μs |
| $I^2t$ | Safety factor | $A^2s\cdot10^3$ | 180<br>240 | $T_j$=$T_{j\,max}$<br>$T_j$=25 °C | 180° half-sine wave;<br>$t_p$=10 ms; single pulse;<br>$V_D$=$V_R$=0 V;<br>Gate pulse:$I_G$=$I_{FGM}$; $V_G$=20 V;<br>$t_{GP}$=500 μs; $di_G/dt$=1 A/μs |
| | | | 170<br>230 | $T_j$=$T_{j\,max}$<br>$T_j$=25 °C | 180° half-sine wave;<br>$t_p$=8.3 ms; single pulse;<br>$V_D$=$V_R$=0 V;<br>Gate pulse:$I_G$=$I_{FGM}$; $V_G$=20 V;<br>$t_{GP}$=500 μs; $di_G/dt$=1 A/μs |
| **BLOCKING** | | | | | |
| $V_{DRM}$, $V_{RRM}$ | Repetitive peak off-state and Repetitive peak reverse voltages | V | 3000...3600 | $T_{j\,min}$< $T_j$ <$T_{j\,max}$;<br>180° half-sine wave; 50 Hz;<br>Gate open | |
| $V_{DSM}$, $V_{RSM}$ | Non-repetitive peak off-state and Non-repetitive peak reverse voltages | V | 3100...3700 | $T_{j\,min}$< $T_j$ <$T_{j\,max}$;<br>180° half-sine wave; single pulse; Gate open | |
| $V_D$, $V_R$ | Direct off-state and Direct reverse voltages | V | $0.6\cdot V_{DRM}$<br>$0.6\cdot V_{RRM}$ | $T_j$=$T_{j\,max}$;<br>Gate open | |
| **TRIGGERING** | | | | | |
| $I_{FGM}$ | 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 | |
| **SWITCHING** | | | | | |
| $(di_T/dt)_{crit}$ | Critical rate of rise of on-state current non-repetitive (f=1 Hz) | A/μs | 200 | $T_j$=$T_{j\,max}$; $V_D$=$0.67\cdot V_{DRM}$; $I_{TM}$=320 A;<br>Gate pulse: $I_G$=2 A; $V_G$=20 V;<br>$t_{GP}$=50 μs; $di_G/dt$=2 A/μs | |
| **THERMAL** | | | | | |
| $T_{stg}$ | Storage temperature | °C | –40...+50 | | |
| $T_j$ | Operating junction temperature | °C | –40...+125 | | |
| $T_{c\,op}$ | Operating temperature | °C | –40...+125 | | |
| **MECHANICAL** | | | | | |
| a | Acceleration under vibration | $m/s^2$ | 50 | | |

## CHARACTERISTICS

| Symbols and parameters | | Units | Values | Conditions | |
|---|---|---|---|---|---|
| **ON-STATE** | | | | | |
| $V_{TM}$ | Peak on-state voltage, max | V | 2.00 | $T_j$=25 °C; $I_{TM}$= 785 A | |
| $V_{T(TO)}$ | On-state threshold voltage, max | V | 0.999 | $T_j$=$T_{j\,max}$; | |
| $r_T$ | On-state slope resistance, max | mΩ | 1.450 | 0.5 π $I_{TAV}$ < $I_T$ < 1.5 π $I_{TAV}$ | |
| $I_L$ | Latching current, max | mA | 700 | $T_j$=25 °C; $V_D$=12 V;<br>Gate pulse: $I_G$=$I_{FGM}$; $V_G$=20 V;<br>$t_{GP}$=500 μs; $di_G/dt$=1 A/μs | |
| $I_H$ | Holding current, max | mA | 300 | $T_j$=25 °C;<br>$V_D$=12 V; Gate open | |
| **BLOCKING** | | | | | |
| $I_{DRM}$, $I_{RRM}$ | Repetitive peak off-state and Repetitive peak reverse currents, max | mA | 50<br>2.50 | $T_j$=$T_{j\,max}$<br>$T_j$= 25 °C | $V_D$=$V_{DRM}$; $V_R$=$V_{RRM}$ |
| $(dv_D/dt)_{crit}$ | Critical rate of rise of off-state voltage[1)], min | V/μs | 200, 320, 500, 1000, 1600, 2000, 2500 | $T_j$=$T_{j\,max}$;<br>$V_D$=0.67·$V_{DRM}$; Gate open | |
| **TRIGGERING** | | | | | |
| $V_{GT}$ | Gate trigger direct voltage, max | V | 3.00<br>2.00<br>1.50 | $T_j$= $T_{j\,min}$<br>$T_j$=25 °C<br>$T_j$= $T_{j\,max}$ | $V_D$=12 V; $I_D$=3 A;<br>Direct gate current |
| $I_{GT}$ | Gate trigger direct current, max | mA | 250<br>150<br>150 | $T_j$= $T_{j\,min}$<br>$T_j$= 25 °C<br>$T_j$= $T_{j\,max}$ | |
| $V_{GD}$ | Gate non-trigger direct voltage, min | V | 0.55 | $T_j$=$T_{j\,max}$;<br>$V_D$=0.67·$V_{DRM}$;<br>Direct gate current | |
| $I_{GD}$ | Gate non-trigger direct current, min | mA | 45.00 | | |
| **SWITCHING** | | | | | |
| $t_{gd}$ | Delay time, max | μs | 1.65 | $T_j$=25 °C; $V_D$=1500 V; $I_{TM}$=$I_{TAV}$;<br>di/dt=200 A/μs;<br>Gate pulse: $I_G$=2 A; $V_G$=20 V;<br>$t_{GP}$=50 μs; $di_G/dt$=2 A/μs | |
| $t_{gt}$ | Turn-on time, max | μs | 10.00 | | |
| $t_q$ | Turn-off time[2)], max | μs | 400 | $dv_D/dt$=50 V/μs; $T_j$=$T_{j\,max}$; $I_{TM}$=160 A;<br>$di_R/dt$=-10 A/μs; $V_R$=100V;<br>$V_D$=0.67 $V_{DRM}$ | |
| $Q_{rr}$ | Total recovered charge, max | μC | 1410 | $T_j$=$T_{j\,max}$; $I_{TM}$=$I_{TAV}$;<br>$di_R/dt$=-5 A/μs;<br>$V_R$=100 V | |
| $t_{rr}$ | Reverse recovery time, max | μs | 38 | | |
| $I_{rr}$ | Reverse recovery current, max | A | 74 | | |
| **THERMAL** | | | | | |
| $R_{thjc}$ | Thermal resistance, junction to case | | | 180° half-sine wave, 50 Hz | |
| | per module | °C/W | 0.0400 | | |
| | per arm | °C/W | 0.0800 | | |
| $R_{thch}$ | Thermal resistance, case to heatsink | | | | |
| | per module | °C/W | 0.0200 | | |
| | per arm | °C/W | 0.0400 | | |
| **INSULATION** | | | | | |
| $V_{ISOL}$ | Insulation test voltage | kV | 3.00 | Sine wave, 50 Hz; RMS | t=60 sec |
| | | | 3.60 | | t=1 sec |
| **MECHANICAL** | | | | | |
| $M_1$ | Mounting torque (M6)[3)] | Nm | 6.00 | Tolerance ± 15% | |
| $M_2$ | Terminal connection torque (M8)[3)] | Nm | 9.00 | Tolerance ± 15% | |
| m | Weight, max | g | 860 | | |

## PART NUMBERING GUIDE

| MT | 3 | - | 160 | - | 36 | - | A2 | H2 | - | C1 | - | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | 3 | | 4 | | 5 | 6 | | 7 | | 8 |

1. Thyristor module (MT)
   Thyristor – Diode module (MT/D)
   Diode – Thyristor module (MD/T)
2. Circuit Schematic
3. Average On-state Current, A
4. Voltage Code
5. Critical rate of rise of off-state voltage
6. Group of turn-off time ($dv_D/dt$=50 V/μs)
7. Package Type (M.C1)
8. Ambient Conditions:
   N – Normal

## NOTES

[1)] Critical rate of rise of off-state voltage

| Symbol of Group | P2 | K2 | E2 | A2 | T1 | P1 | M1 |
|---|---|---|---|---|---|---|---|
| $(dv_D/dt)_{crit}$, V/μs | 200 | 320 | 500 | 1000 | 1600 | 2000 | 2500 |

[2)] Turn-off time ($dv_D/dt$=50 V/μs)

| Symbol of Group | H2 |
|---|---|
| $t_q$, μs | 400 |

[3)] The screws must be lubricated

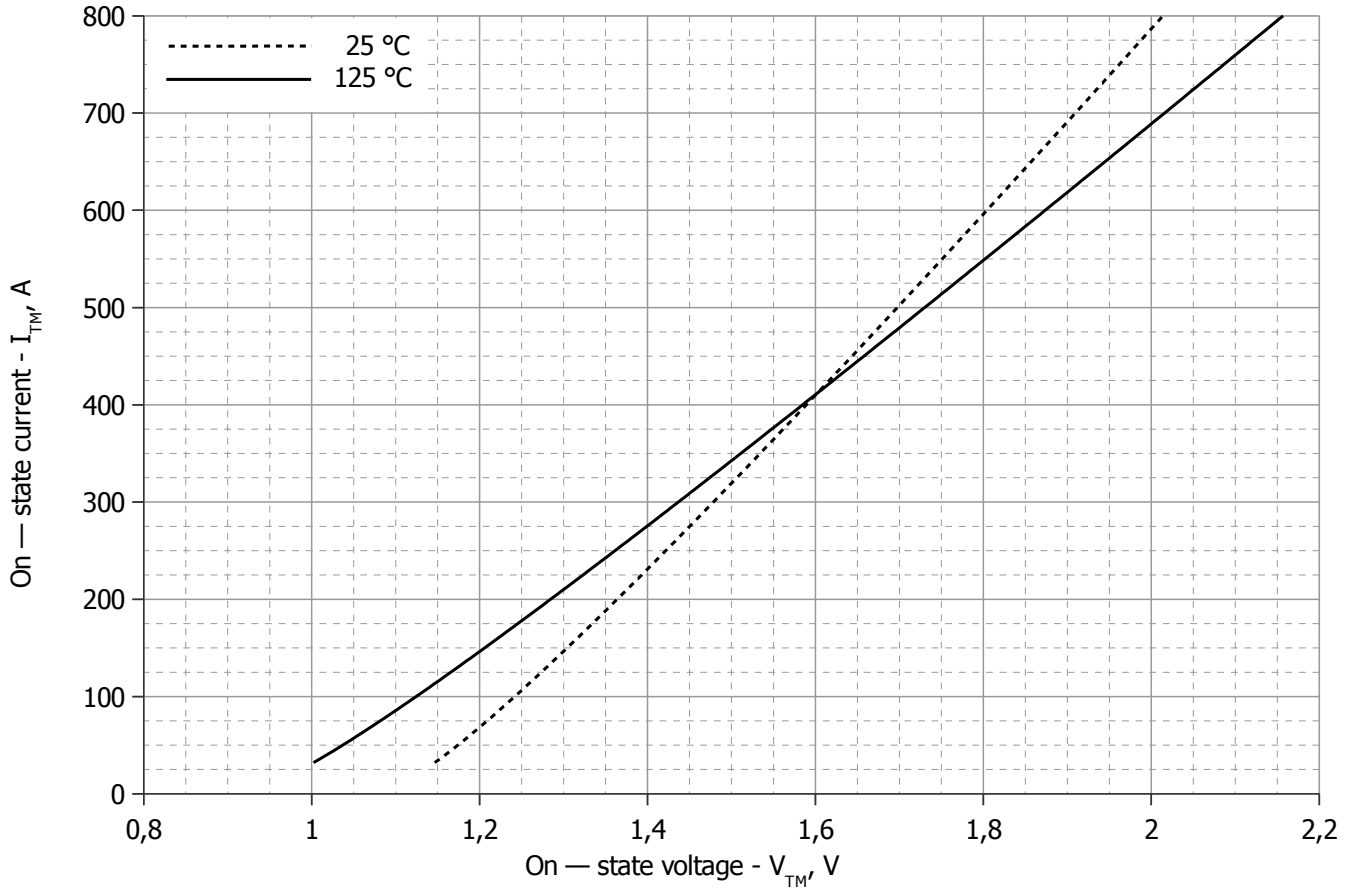



**Fig 1 – On-state characteristics of Limit device**

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°C | $T_j = T_{j\,max}$ |
| **A** | 1.06929617 | 0.90960451 |
| **B** | 0.00091266 | 0.00126766 |
| **C** | 0.00243652 | 0.00249534 |
| **D** | 0.00700676 | 0.00765080 |

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

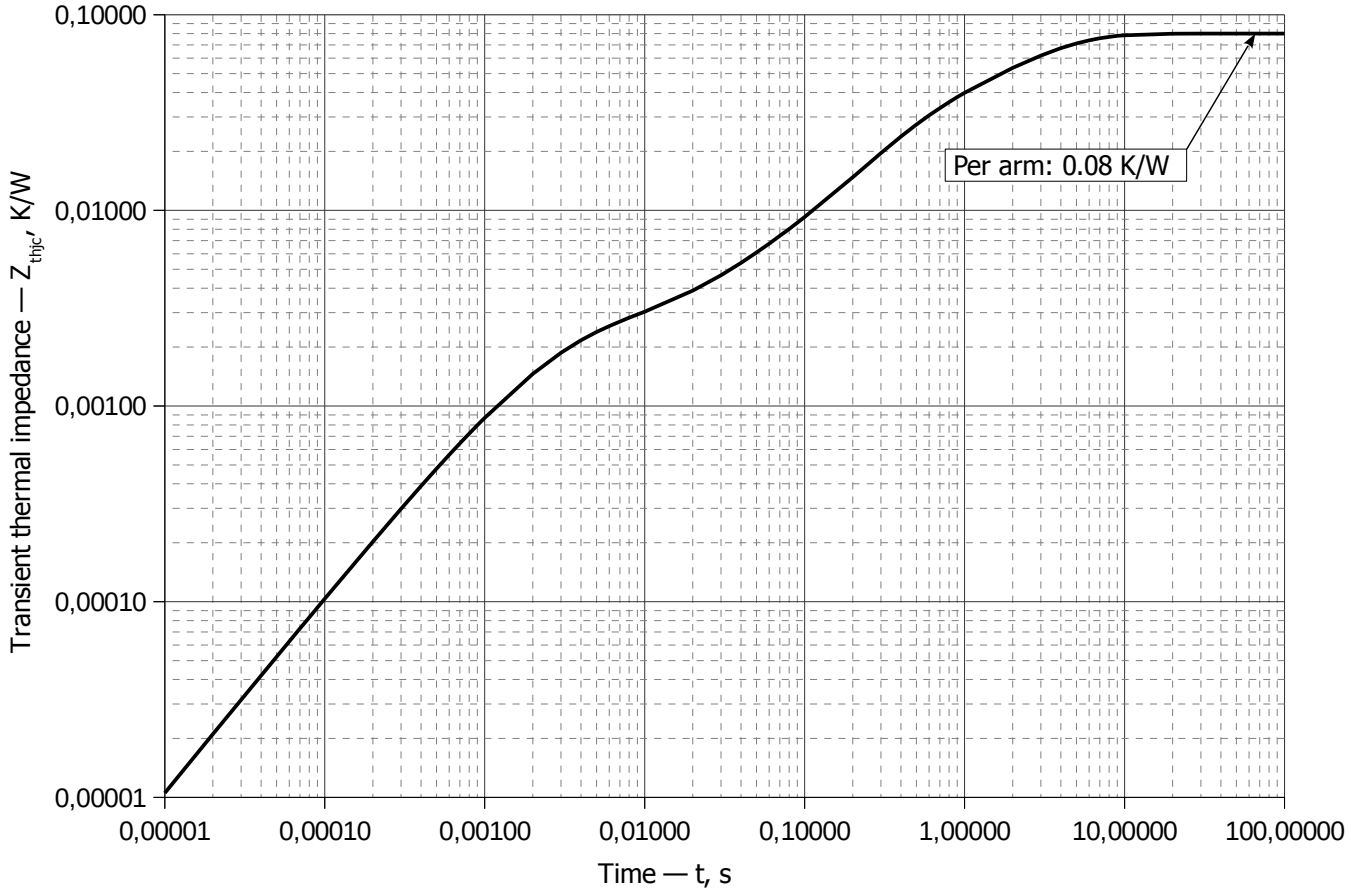



**Fig 2 – Transient thermal impedance $Z_{thjc}$ vs. time t**

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 constatnt of $r_{th}$ term.

| i | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| **$R_i$, K/W** | 0.0507 | 0.007806 | 0.02226 | -0.007688 | 0.00471 | 0.00217 |
| **$\tau_i$, s** | 2.801 | 1.283 | 0.3281 | 0.09408 | 0.0572 | 0.002255 |

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

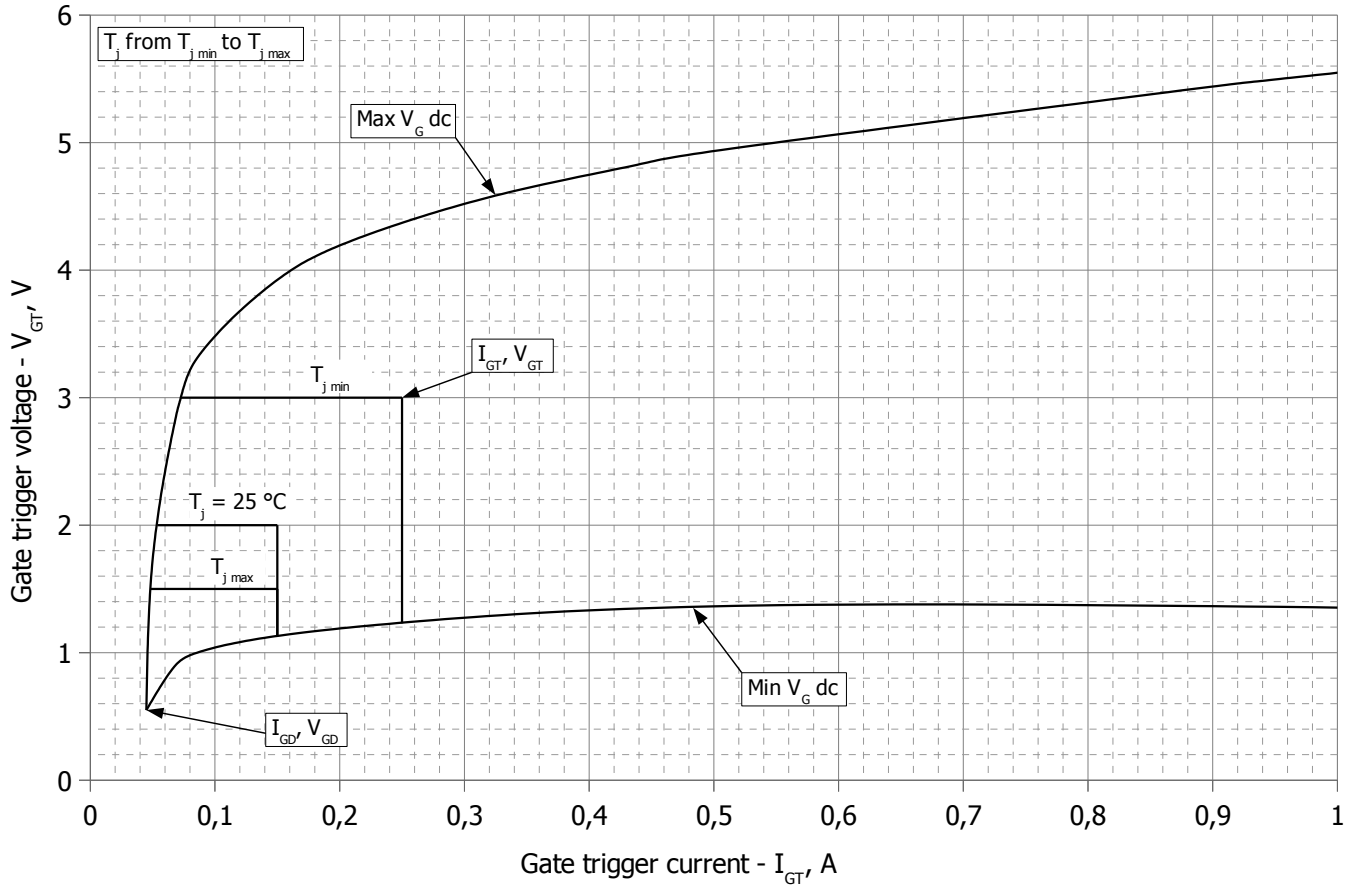



**Fig 3 – Gate characteristics – Trigger limits**

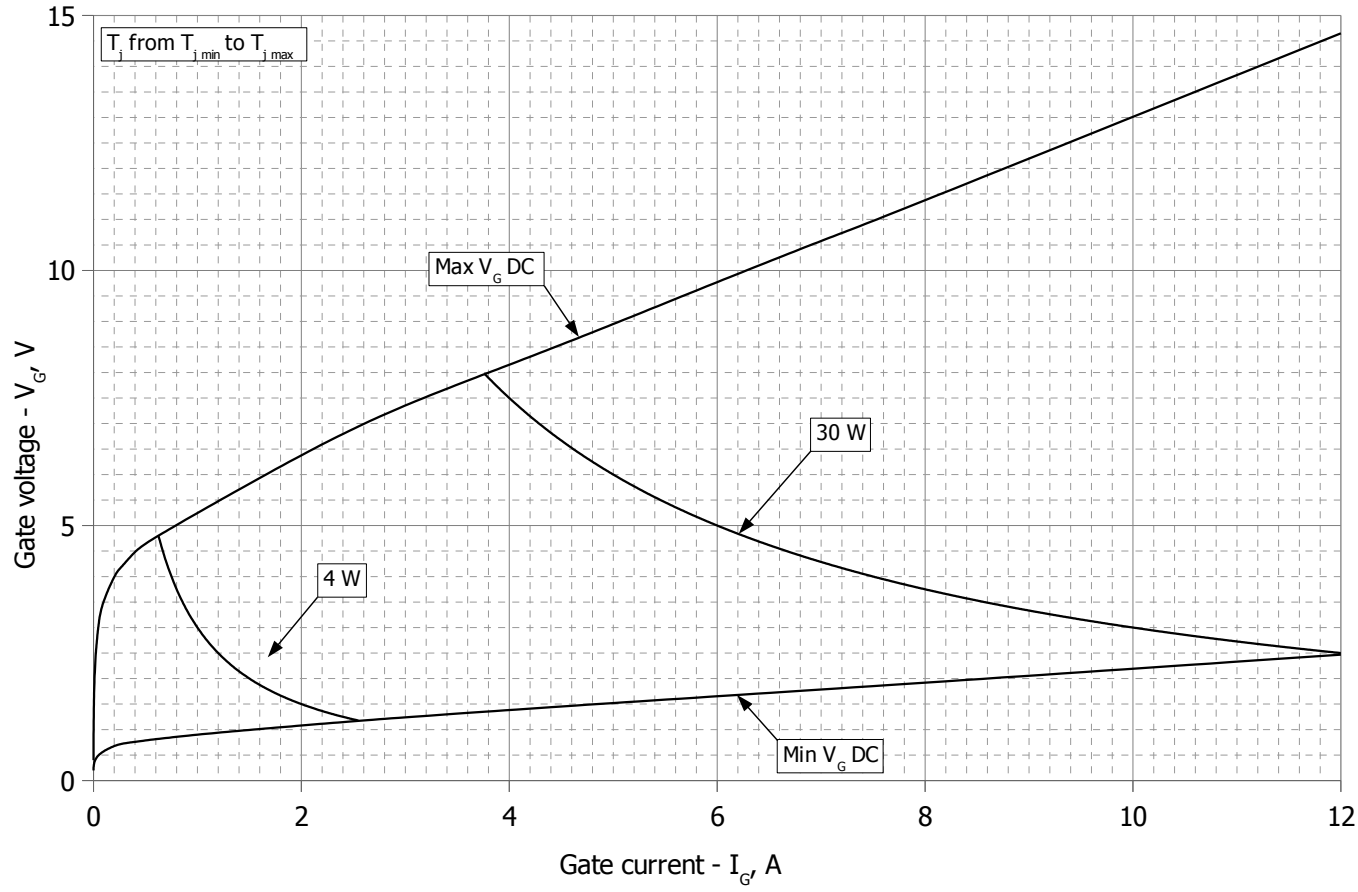



**Fig 4 - Gate characteristics – Power curves**

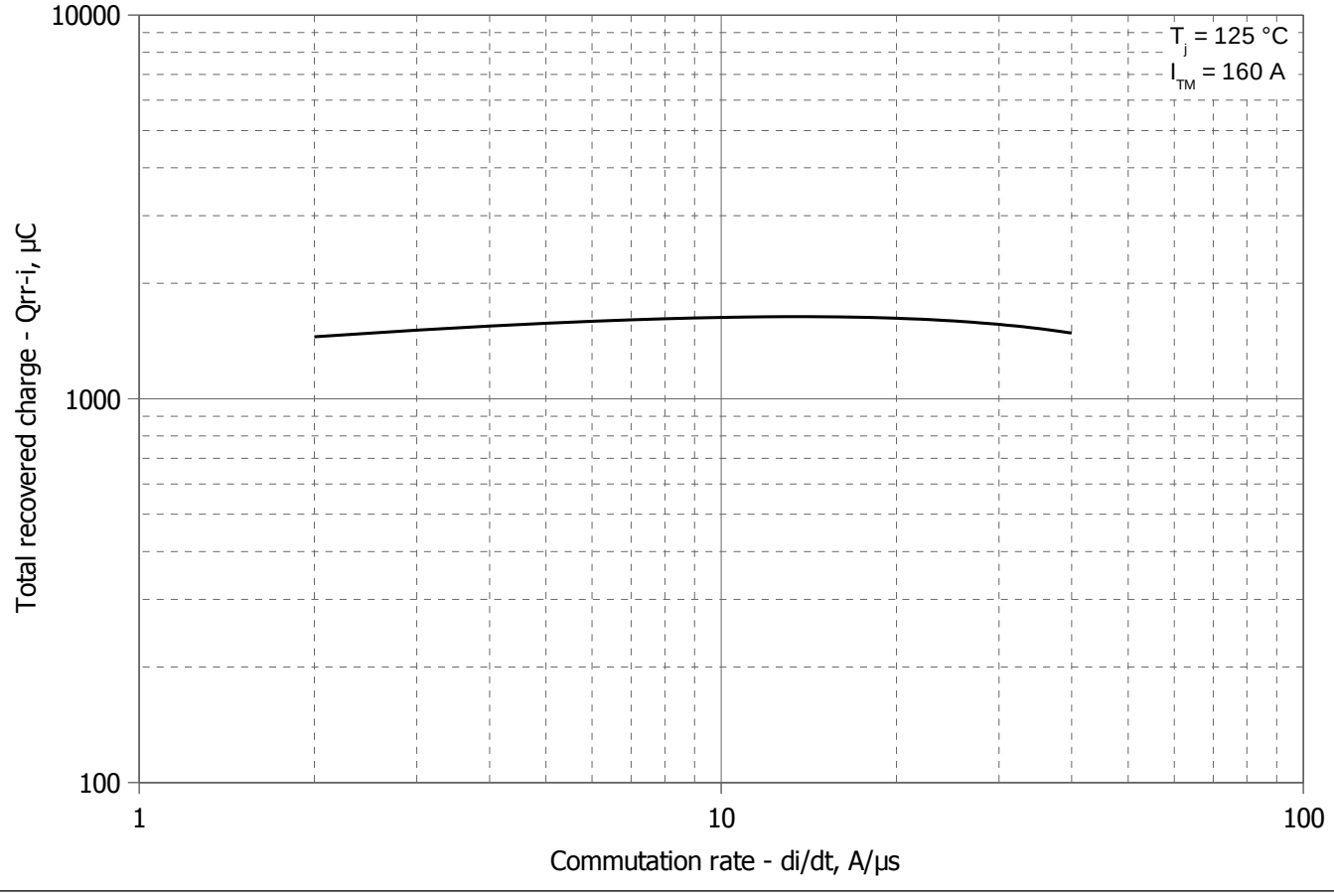



**Fig 5 – Maximum recovered charge $Q_{rr-i}$ (integral) vs. commutation rate $di_R/dt$**

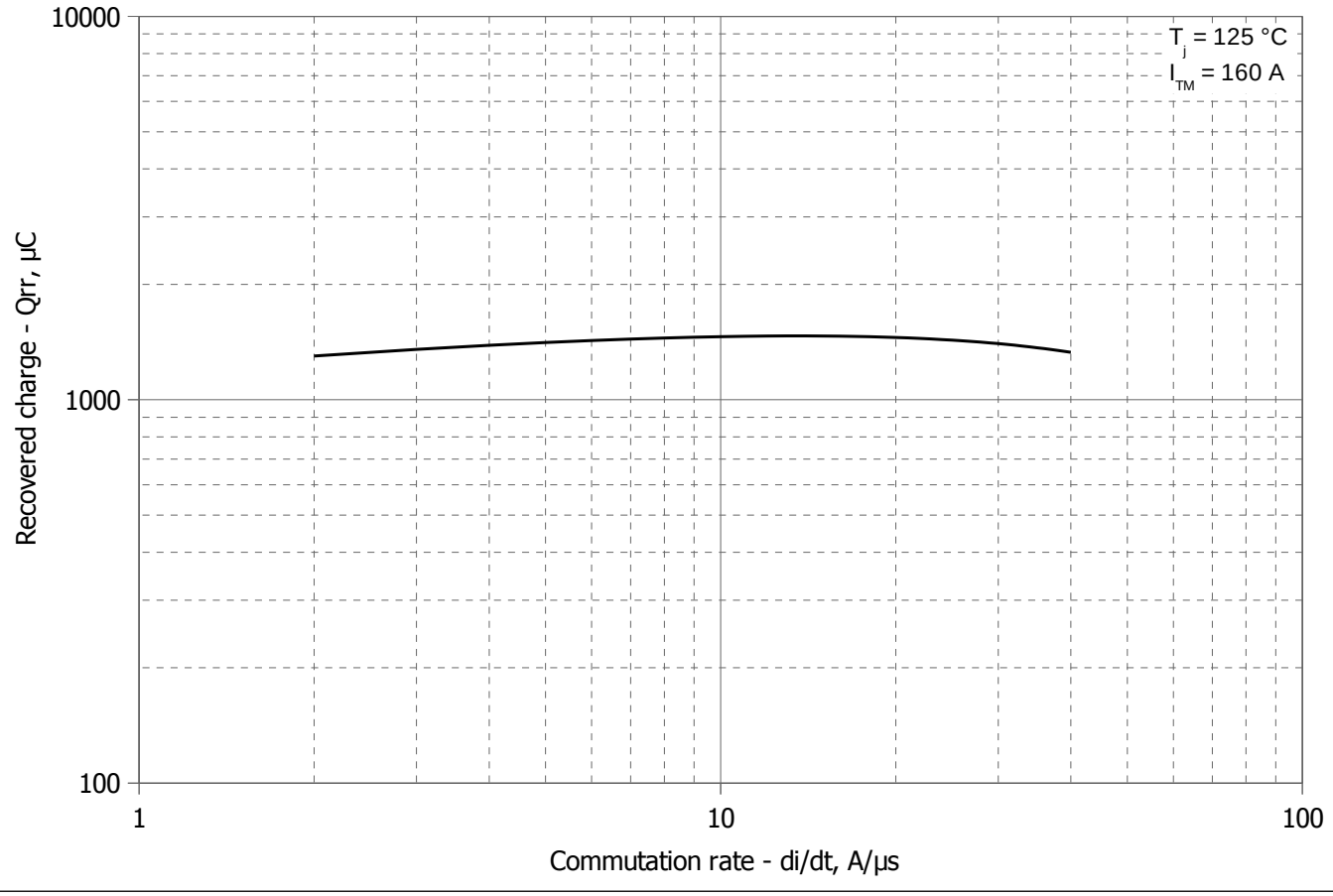



**Fig 6 – Maximum recovered charge $Q_{rr}$ vs. commutation rate $di_R/dt$ (25% chord)**

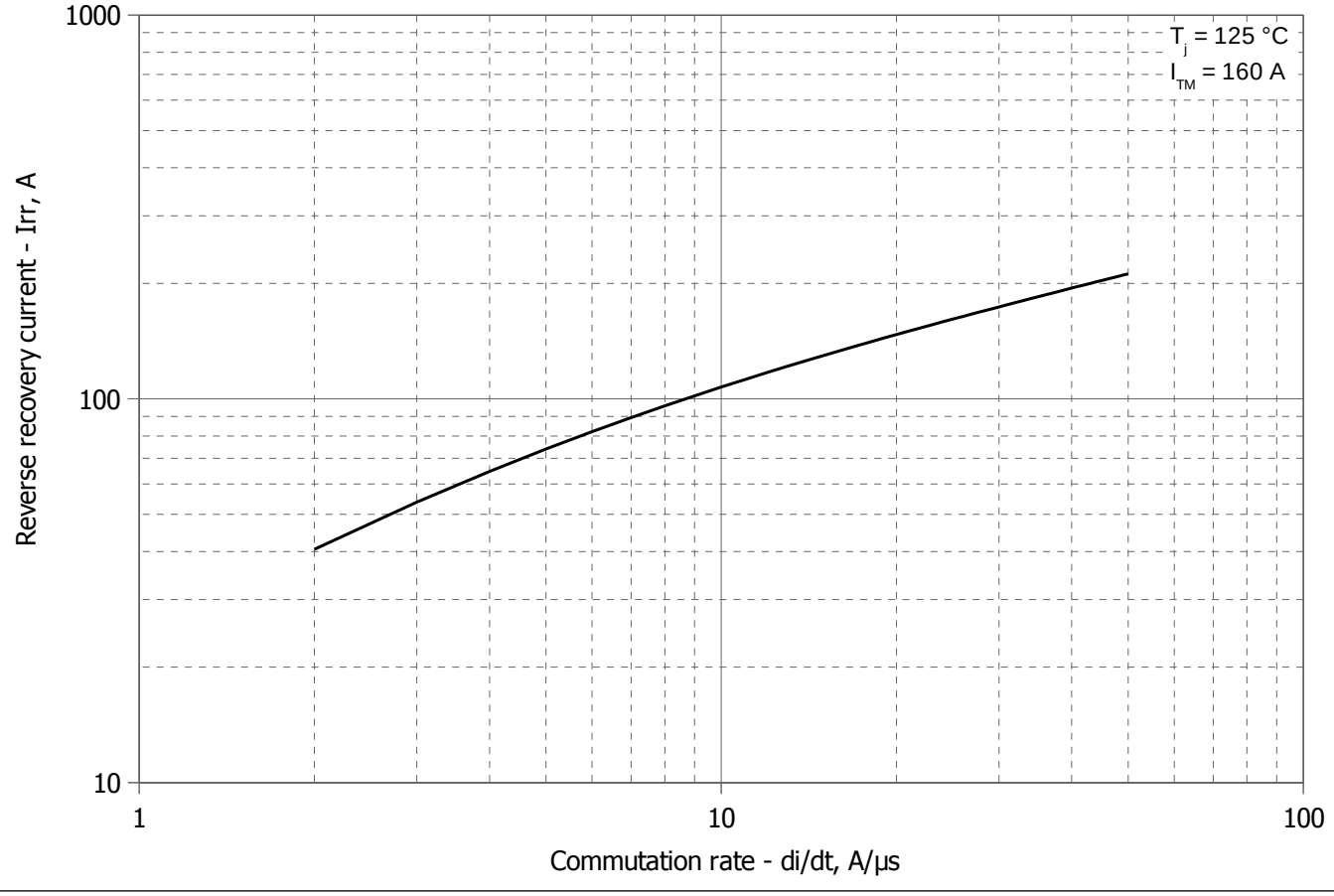



**Fig 7 – Maximum reverse recovery current $I_{rr}$ vs. commutation rate $di_R/dt$**

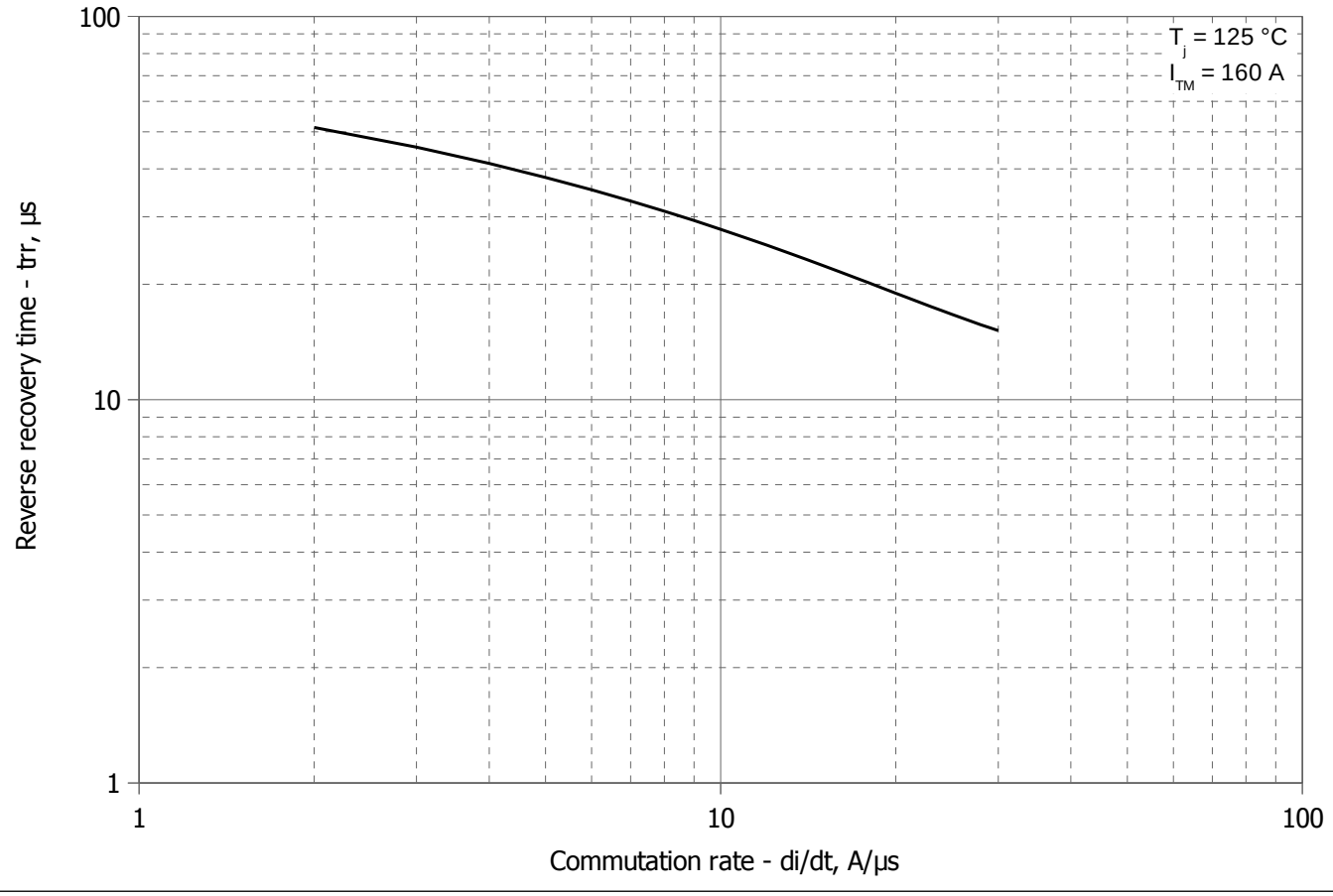



**Fig 8 – Maximum recovery time $t_{rr}$ vs. commutation rate $di_R/dt$ (25% chord)**

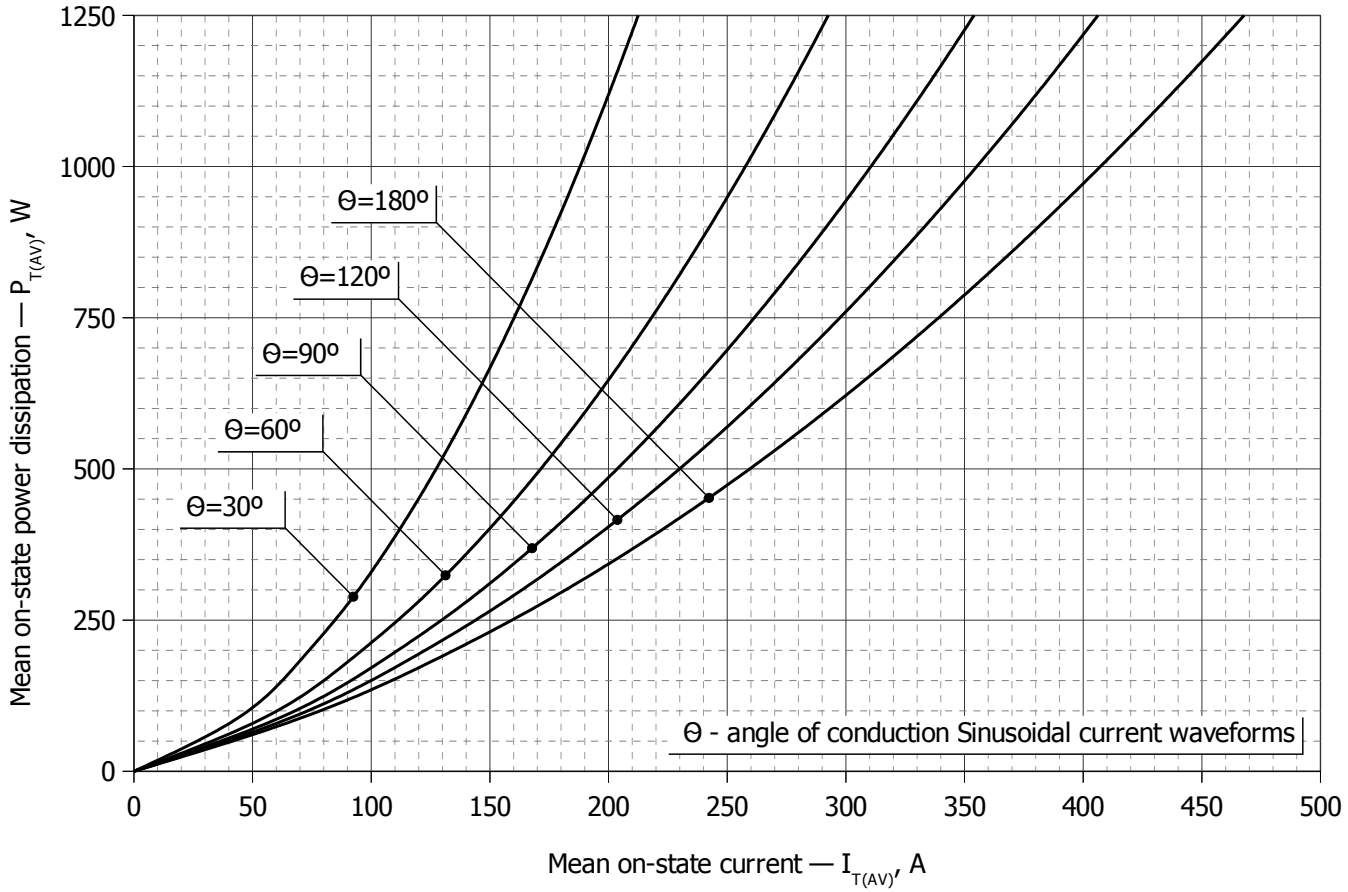



**Fig. 9 - Mean on-state power dissipation $P_{TAV}$ vs. mean on-state current $I_{TAV}$ for sinusoidal current waveforms at different conduction angles (f=50Hz, DSC)**

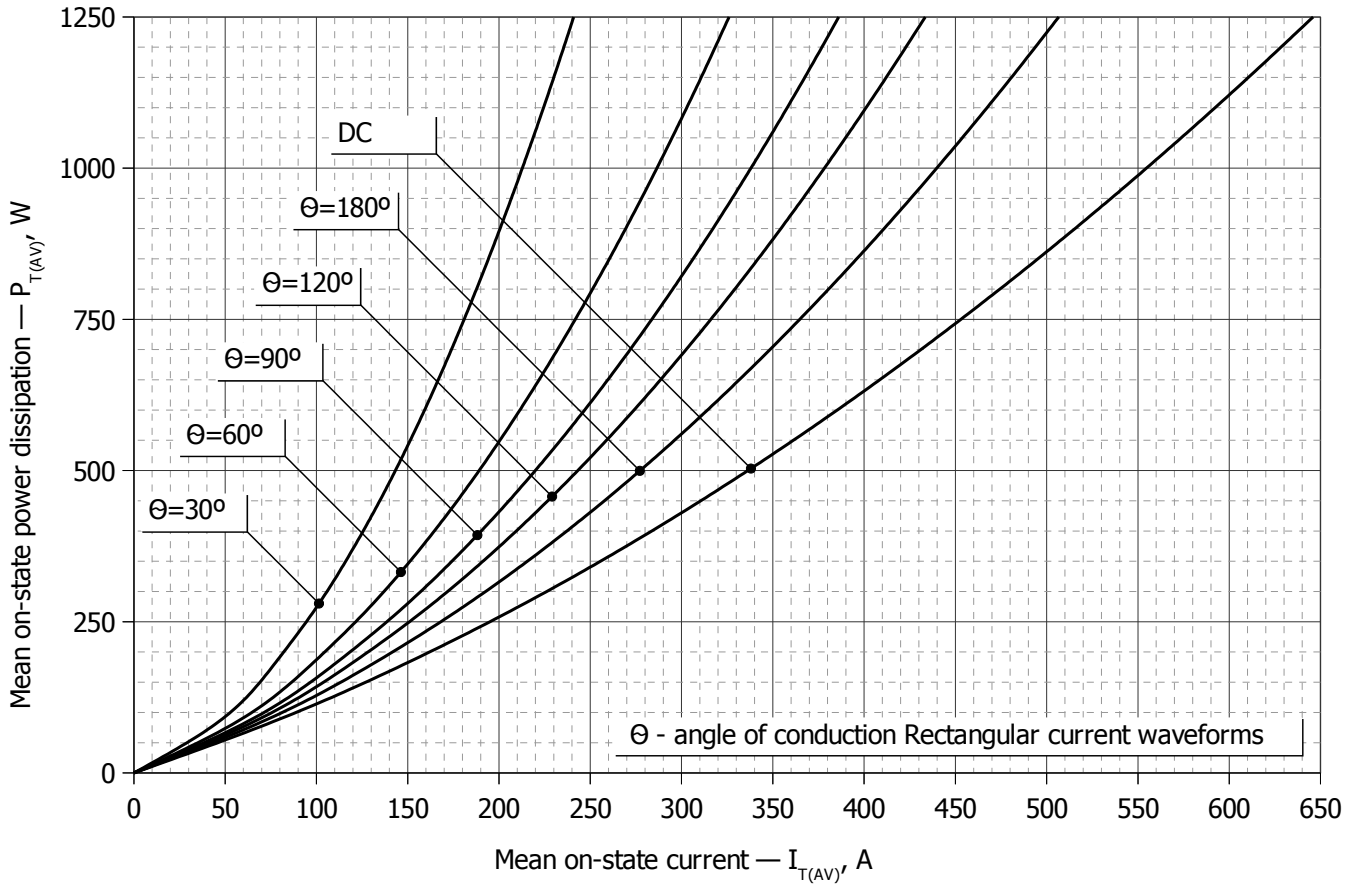



**Fig. 10 – Mean on-state power dissipation $P_{TAV}$ vs. mean on-state current $I_{TAV}$ for rectangular current waveforms at different conduction angles and for DC (f=50Hz, DSC)**

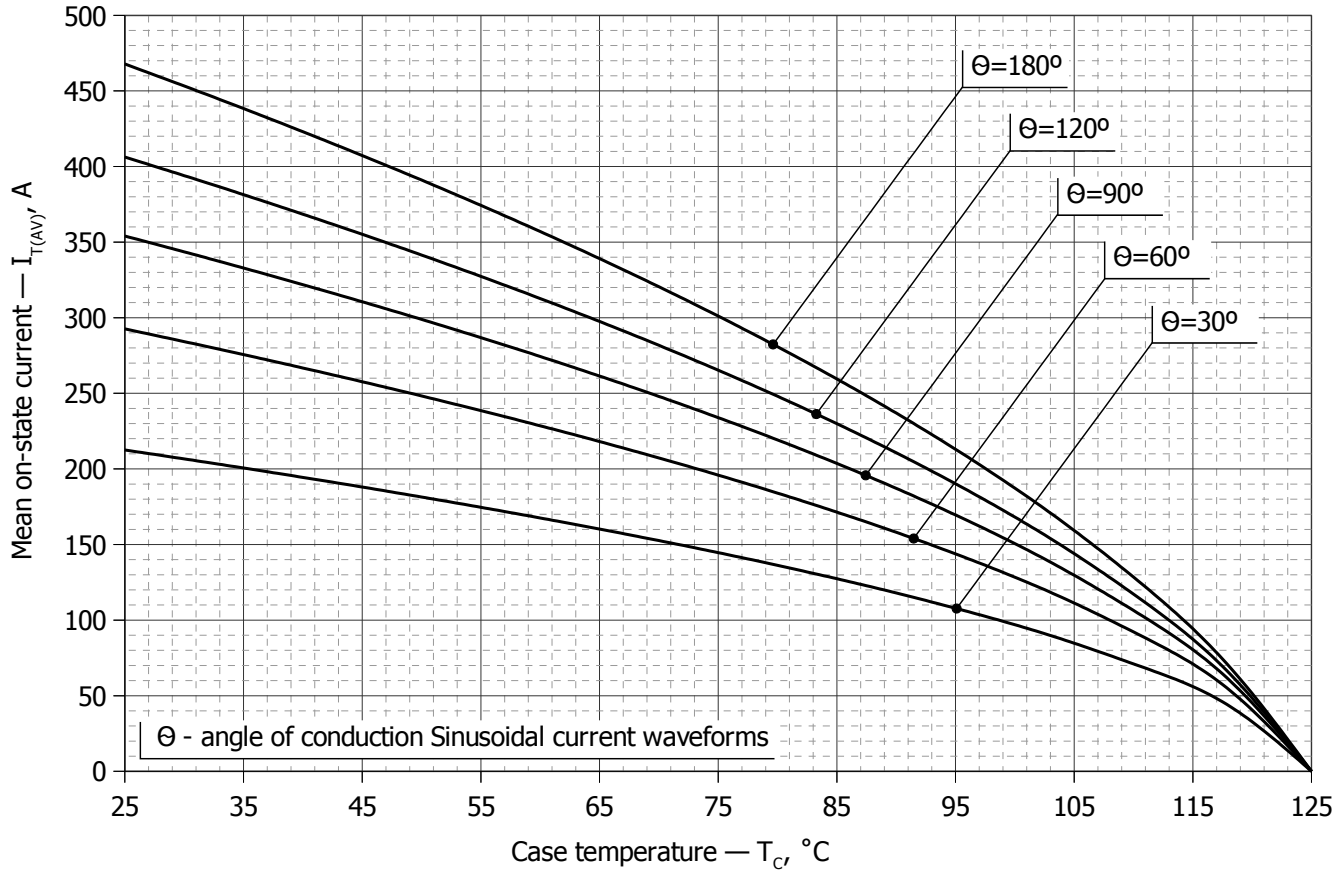



**Fig. 11 – Mean on-state current $I_{TAV}$ vs. case temperature $T_C$ for sinusoidal current waveforms at different conduction angles (f=50Hz, DSC)**

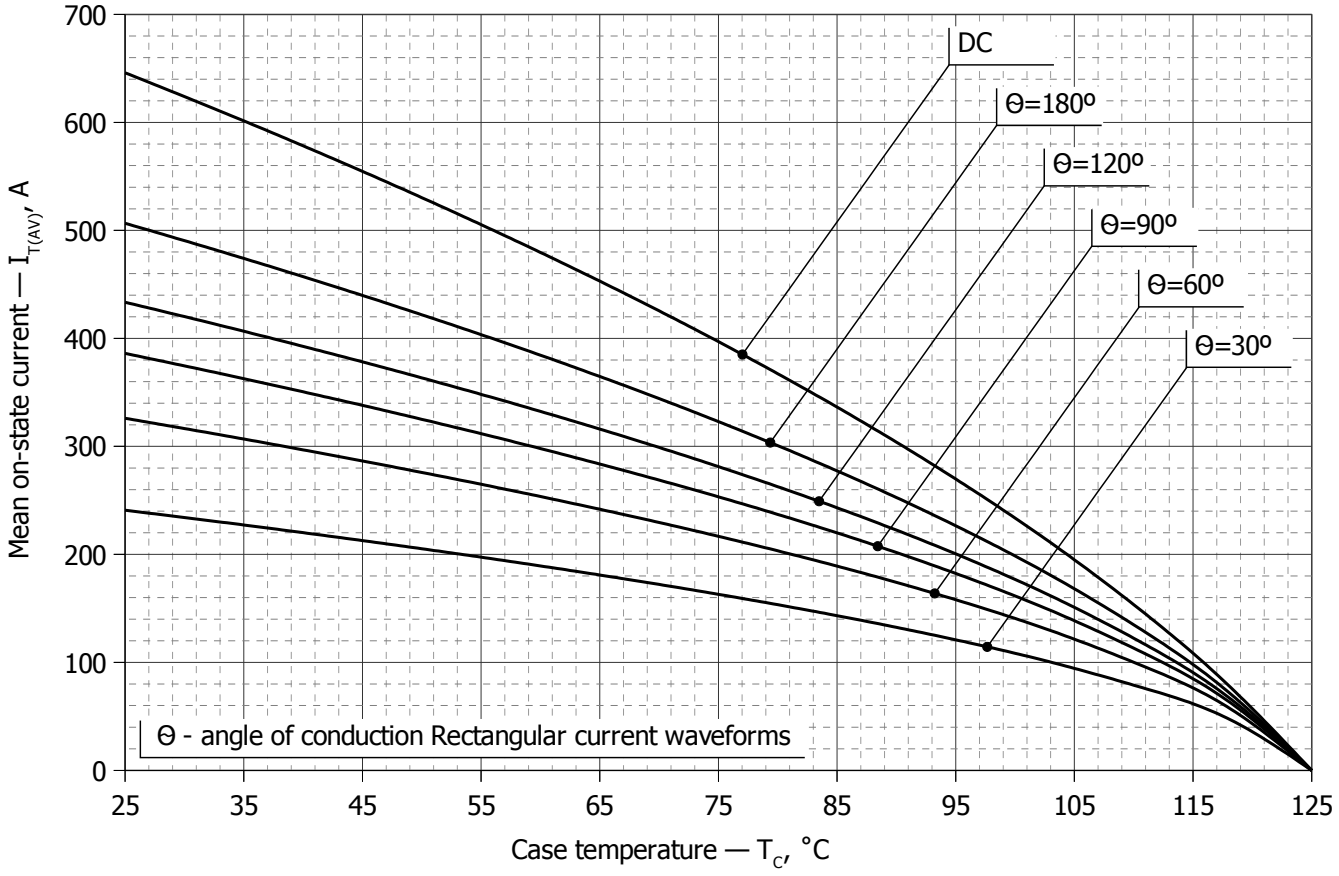



**Fig. 12 - Mean on-state current $I_{TAV}$ vs. case temperature $T_C$ for rectangular current waveforms at different conduction angles and for DC (f=50Hz, DSC)**

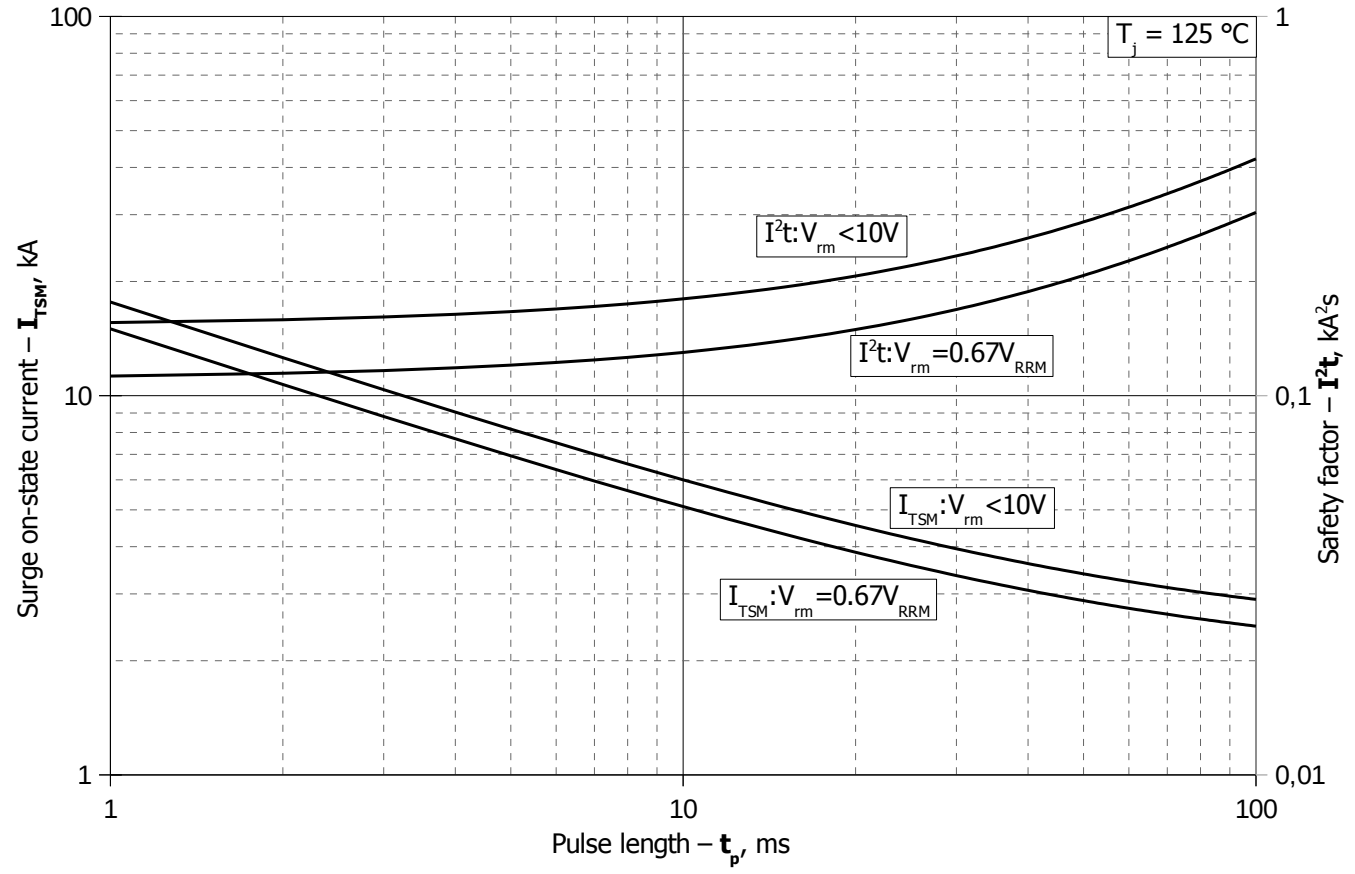



**Fig. 13 – Maximum surge on-state current $I_{TSM}$ and safety factor $I^2t$ vs. pulse length $t_p$**

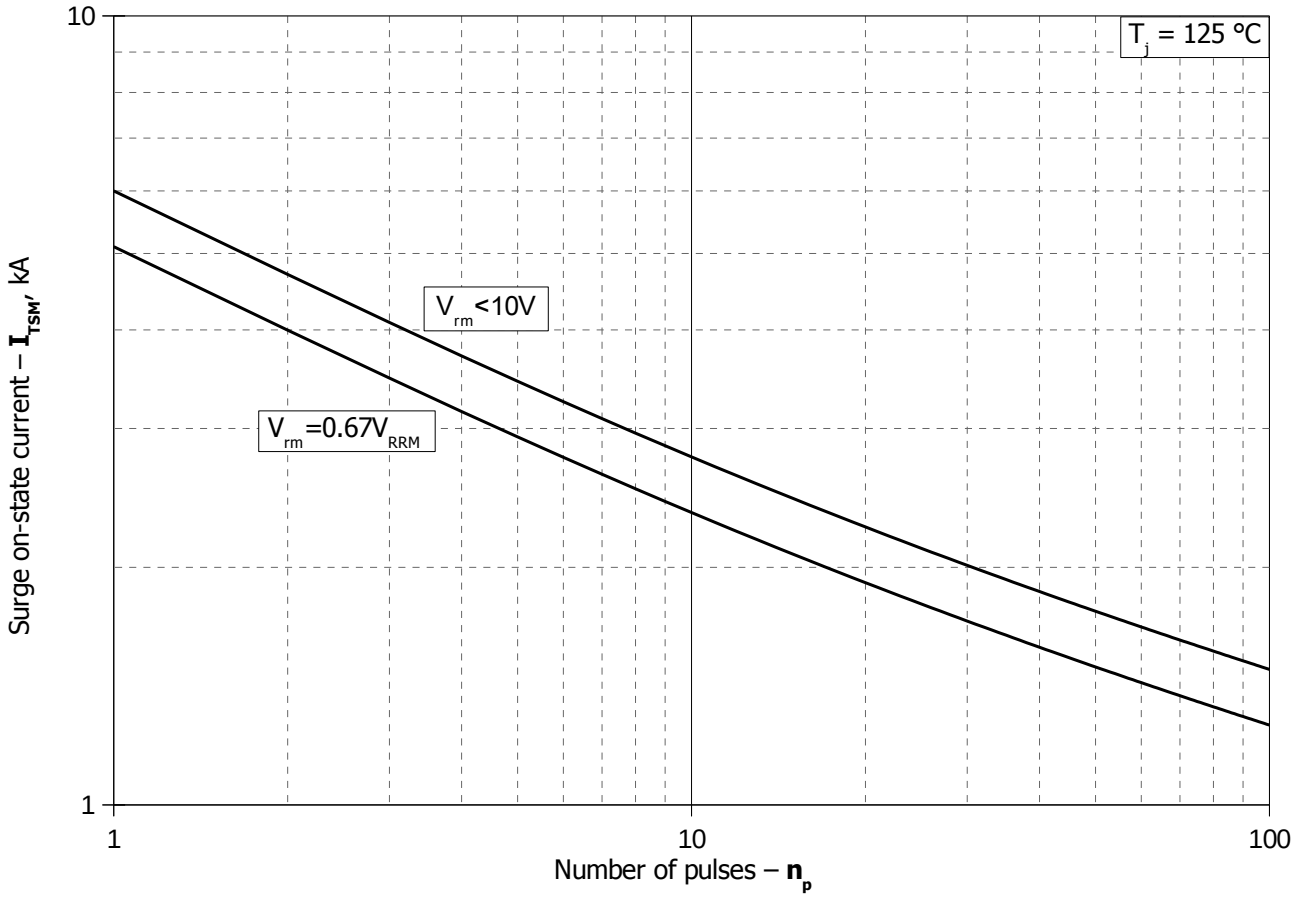



**Fig. 14 - Maximum surge on-state current $I_{TSM}$ vs. number of pulses $n_p$**