



## MAXIMUM ALLOWABLE RATINGS

| Symbols and parameters |  | Units                 | Values                                   | Test conditions   |
|------------------------|--|-----------------------|--|---|
| <b>ON-STATE</b>        |  |                       |  |   |
| $I_{TAV}$              | Mean on-state current  | A                     | 650                                      | $T_c=85\text{ }^\circ\text{C}$ ;<br>180° half-sine wave; 50 Hz  |
| $I_{TRMS}$             | RMS on-state current   | A                     | 1020                                     |   |
| $I_{TSM}$              | Surge on-state current   | kA                    | 14.0<br>16.0                             | $T_j=T_{j\max}$<br>$T_j=25\text{ }^\circ\text{C}$<br>180° half-sine wave;<br>$t_p=10\text{ ms}$ ; single pulse;<br>$V_D=V_R=0\text{ V}$ ;<br>Gate pulse: $I_G=2\text{ A}$ ;<br>$t_{GP}=50\text{ }\mu\text{s}$ ; $di_G/dt\geq 1\text{ A}/\mu\text{s}$  |
|                        |  |                       | 15.0<br>17.0                             | $T_j=T_{j\max}$<br>$T_j=25\text{ }^\circ\text{C}$<br>180° half-sine wave;<br>$t_p=8.3\text{ ms}$ ; single pulse;<br>$V_D=V_R=0\text{ V}$ ;<br>Gate pulse: $I_G=2\text{ A}$ ;<br>$t_{GP}=50\text{ }\mu\text{s}$ ; $di_G/dt\geq 1\text{ A}/\mu\text{s}$ |
| $I^2t$                 | Safety factor  | $A^2s\cdot 10^3$      | 980<br>1280                              | $T_j=T_{j\max}$<br>$T_j=25\text{ }^\circ\text{C}$<br>180° half-sine wave;<br>$t_p=10\text{ ms}$ ; single pulse;<br>$V_D=V_R=0\text{ V}$ ;<br>Gate pulse: $I_G=2\text{ A}$ ;<br>$t_{GP}=50\text{ }\mu\text{s}$ ; $di_G/dt\geq 1\text{ A}/\mu\text{s}$  |
|                        |  |                       | 930<br>1190                              | $T_j=T_{j\max}$<br>$T_j=25\text{ }^\circ\text{C}$<br>180° half-sine wave;<br>$t_p=8.3\text{ ms}$ ; single pulse;<br>$V_D=V_R=0\text{ V}$ ;<br>Gate pulse: $I_G=2\text{ A}$ ;<br>$t_{GP}=50\text{ }\mu\text{s}$ ; $di_G/dt\geq 1\text{ A}/\mu\text{s}$ |
| <b>BLOCKING</b>        |  |                       |  |   |
| $V_{DRM}, V_{RRM}$     | Repetitive peak off-state and Repetitive peak reverse voltages         | V                     | 1000÷1200                                | $T_{j\min} < T_j < T_{j\max}$ ;<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                     | 1100÷1300                                | $T_{j\min} < T_j < T_{j\max}$ ;<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  |
| <b>TRIGGERING</b>      |  |                       |  |   |
| $I_{FGM}$              | Peak forward gate current  | A                     | 8  | $T_j=T_{j\max}$   |
| $V_{RGM}$              | Peak reverse gate voltage  | V                     | 5  |   |
| $P_G$                  | Gate power dissipation   | W                     | 4  | $T_j=T_{j\max}$ 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/ $\mu\text{s}$      | 400                                      | $T_j=T_{j\max}$ ; $V_D=0.67\cdot V_{DRM}$ ; $I_{TM}=2 I_{TAV}$ ;<br>Gate pulse: $I_G=2\text{ A}$ ;<br>$t_{GP}=50\text{ }\mu\text{s}$ ; $di_G/dt\geq 2\text{ A}/\mu\text{s}$   |
| <b>THERMAL</b>         |  |                       |  |   |
| $T_{stg}$              | Storage temperature  | $^\circ\text{C}$      | -40 ÷ 50                                 |   |
| $T_j$                  | Operating junction temperature   | $^\circ\text{C}$      | -40 ÷ 140                                |   |
| $T_{c\text{ op}}$      | Operating temperature  | $^\circ\text{C}$      | -40 ÷ 125                                |   |
| <b>MECHANICAL</b>      |  |                       |  |   |
| a                      | Acceleration under vibration   | $\text{m}/\text{s}^2$ | 50                                       |   |

## CHARACTERISTICS

| Symbols and parameters |  | Units                     | Values               | Conditions   |   |
|------------------------|--|---------------------------|----------------------|--|---|
| <b>ON-STATE</b>        |  |                           |                      |  |   |
| $V_{TM}$               | Peak on-state voltage, max   | V                         | 1.45                 | $T_j=25\text{ }^\circ\text{C}; I_{TM}=1978\text{ A}$   |   |
| $V_{T(TO)}$            | On-state threshold voltage, max  | V                         | 0.85                 | $T_j=T_{j\text{ max}};$  |   |
| $r_T$                  | On-state slope resistance, max   | m $\Omega$                | 0.280                | $0.5\pi I_{TAV} < I_T < 1.5\pi I_{TAV}$  |   |
| $I_L$                  | Latching current, max  | mA                        | 1000                 | $T_j=25\text{ }^\circ\text{C}; V_D=12\text{ V};$<br>Gate pulse: $I_G=2\text{ A};$<br>$t_{GP}=50\text{ }\mu\text{s}; di_G/dt\geq 1\text{ A}/\mu\text{s}$  |   |
| $I_H$                  | Holding current, max   | mA                        | 300                  | $T_j=25\text{ }^\circ\text{C};$<br>$V_D=12\text{ V};$ Gate open  |   |
| <b>BLOCKING</b>        |  |                           |                      |  |   |
| $I_{DRM}, I_{RRM}$     | Repetitive peak off-state and<br>Repetitive peak reverse currents, max | mA                        | 70                   | $T_j=T_{j\text{ max}};$<br>$V_D=V_{DRM}; V_R=V_{RRM}$  |   |
| $(dv_D/dt)_{crit}$     | Critical rate of rise of<br>off-state voltage <sup>1)</sup> , min      | V/ $\mu\text{s}$          | 1000                 | $T_j=T_{j\text{ max}};$<br>$V_D=0.67\cdot V_{DRM};$ Gate open  |   |
| <b>TRIGGERING</b>      |  |                           |                      |  |   |
| $V_{GT}$               | Gate trigger direct voltage, max                                       | V                         | 4.00<br>2.50<br>2.00 | $T_j=T_{j\text{ min}}$<br>$T_j=25\text{ }^\circ\text{C}$<br>$T_j=T_{j\text{ max}}$   | $V_D=12\text{ V}; I_D=3\text{ A};$<br>Direct gate current |
| $I_{GT}$               | Gate trigger direct current, max                                       | mA                        | 400<br>250<br>200    | $T_j=T_{j\text{ min}}$<br>$T_j=25\text{ }^\circ\text{C}$<br>$T_j=T_{j\text{ max}}$   |   |
| $V_{GD}$               | Gate non-trigger direct voltage, min                                   | V                         | 0.25                 | $T_j=T_{j\text{ max}};$<br>$V_D=0.67\cdot V_{DRM};$  |   |
| $I_{GD}$               | Gate non-trigger direct current, min                                   | mA                        | 10.00                | Direct gate current  |   |
| <b>SWITCHING</b>       |  |                           |                      |  |   |
| $t_{gd}$               | Delay time   | $\mu\text{s}$             | 2.00                 | $T_j=25\text{ }^\circ\text{C}; V_D=600\text{ V}; I_{TM}=I_{TAV};$<br>$di/dt=200\text{ A}/\mu\text{s};$<br>Gate pulse: $I_G=2\text{ A}; V_G=20\text{ V};$<br>$t_{GP}=50\text{ }\mu\text{s}; di_G/dt=2\text{ A}/\mu\text{s}$ |   |
| $t_q$                  | Turn-off time <sup>2)</sup> , max                                      | $\mu\text{s}$             | 160                  | $dv_D/dt=50\text{ V}/\mu\text{s}; T_j=T_{j\text{ max}}; I_{TM}=I_{TAV};$<br>$di_R/dt=10\text{ A}/\mu\text{s}; V_R=100\text{ V};$<br>$V_D=0.67 V_{DRM};$  |   |
| $Q_{rr}$               | Total recovered charge, max  | $\mu\text{C}$             | 1140                 | $T_j=125\text{ }^\circ\text{C}; I_{TM}=650\text{ A};$  |   |
| $t_{rr}$               | Reverse recovery time, typ   | $\mu\text{s}$             | 19.0                 | $di_R/dt=-10\text{ A}/\mu\text{s};$  |   |
| $I_{rrM}$              | Peak reverse recovery current, max                                     | A                         | 120                  | $V_R=100\text{ V}$   |   |
| <b>THERMAL</b>         |  |                           |                      |  |   |
| $R_{thjc}$             | Thermal resistance, junction to case                                   |                           |                      |  |   |
|                        | per module   | $^\circ\text{C}/\text{W}$ | 0.0325               | 180° half-sine wave, 50 Hz   |   |
|                        | per arm  | $^\circ\text{C}/\text{W}$ | 0.0650               |  |   |
|                        | per module   | $^\circ\text{C}/\text{W}$ | 0.0310               | DC   |   |
| per arm                | $^\circ\text{C}/\text{W}$  | 0.0620                    |                      |  |   |
| $R_{thch}$             | Thermal resistance, case to heatsink                                   |                           |                      |  |   |
|                        | per module   | $^\circ\text{C}/\text{W}$ | 0.0100               |  |   |
|                        | per arm  | $^\circ\text{C}/\text{W}$ | 0.0200               |  |   |
| <b>INSULATION</b>      |  |                           |                      |  |   |
| $V_{ISOL}$             | Insulation test voltage  | kV                        | 3.00                 | Sine wave, 50 Hz;<br>RMS   | t=60 sec  |
|                        |  |                           | 3.60                 |  | t=1 sec   |
| <b>MECHANICAL</b>      |  |                           |                      |  |   |
| $M_1$                  | Mounting torque (M6) <sup>3)</sup>                                     | Nm                        | 6.00                 | Tolerance $\pm 15\%$   |   |
| $M_2$                  | Terminal connection torque (M10) <sup>3)</sup>                         | Nm                        | 12.00                | Tolerance $\pm 15\%$   |   |
| w                      | Weight, max  | g                         | 1500                 |  |   |

**PART NUMBERING GUIDE**

|    |   |   |     |   |    |   |    |    |   |    |   |   |
|----|---|---|-----|---|----|---|----|----|---|----|---|---|
| MT | 3 | - | 650 | - | 12 | - | A2 | T2 | - | A2 | - | 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 – serial connection  
4 – common Cathode  
5 – common Anode
3. Average On-state Current, A
4. Voltage Code
5. Critical rate of rise of off-state voltage
6. Group of turn-off time ( $dv_D/dt=50 \text{ V}/\mu\text{s}$ )
7. Package Type (M.A2)
8. Ambient Conditions:  
N – Normal

**NOTES**

<sup>1)</sup> Critical rate of rise of off-state voltage

|   |      |
|---|------|
| Symbol of group                           | A2   |
| $(dv_D/dt)_{crit}, \text{ V}/\mu\text{s}$ | 1000 |

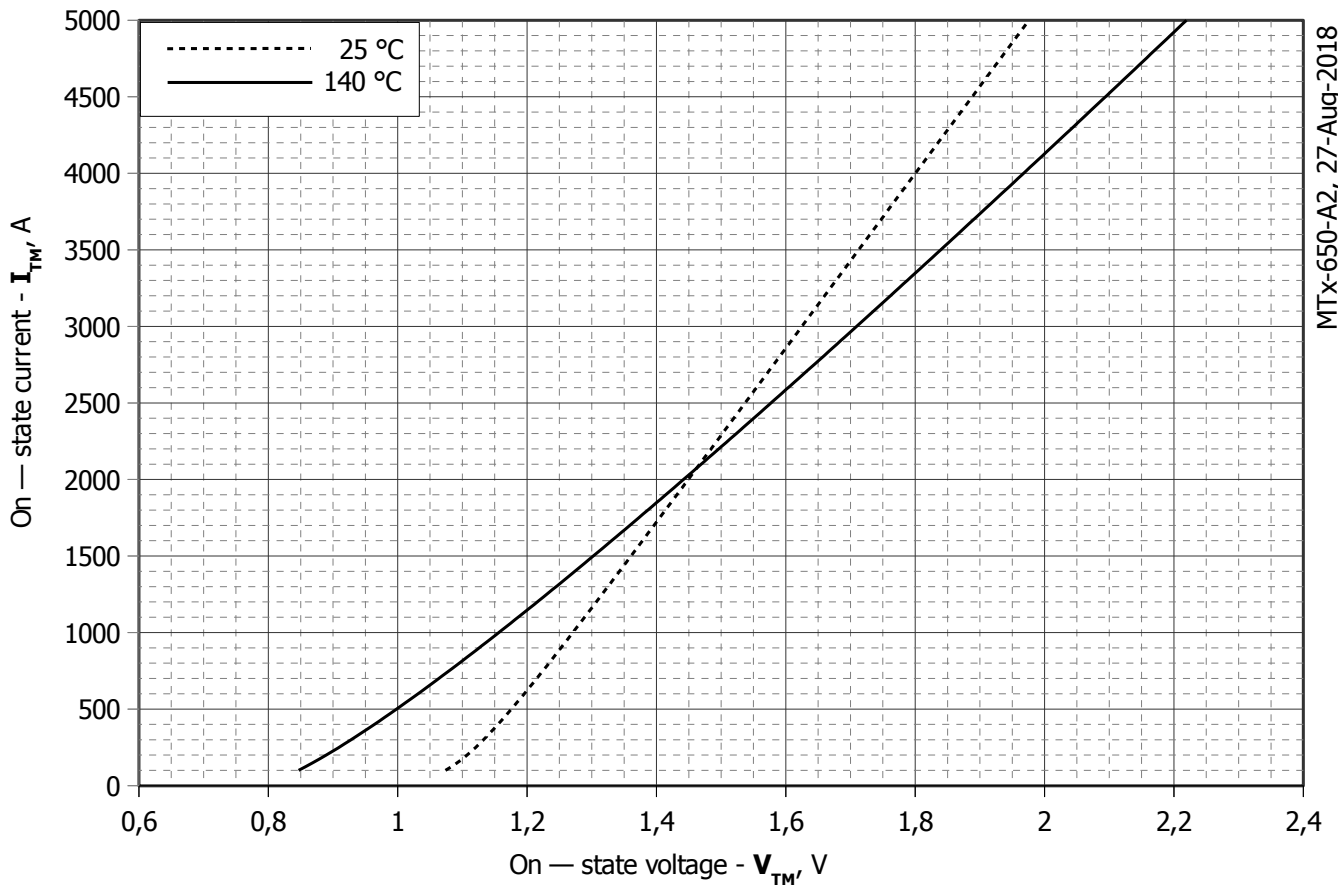
<sup>2)</sup> Turn-off time ( $dv_D/dt=50 \text{ V}/\mu\text{s}$ )

|                    |     |
|--------------------|-----|
| Symbol of group    | T2  |
| $t_q, \mu\text{s}$ | 160 |

<sup>3)</sup> The screws must be lubricated



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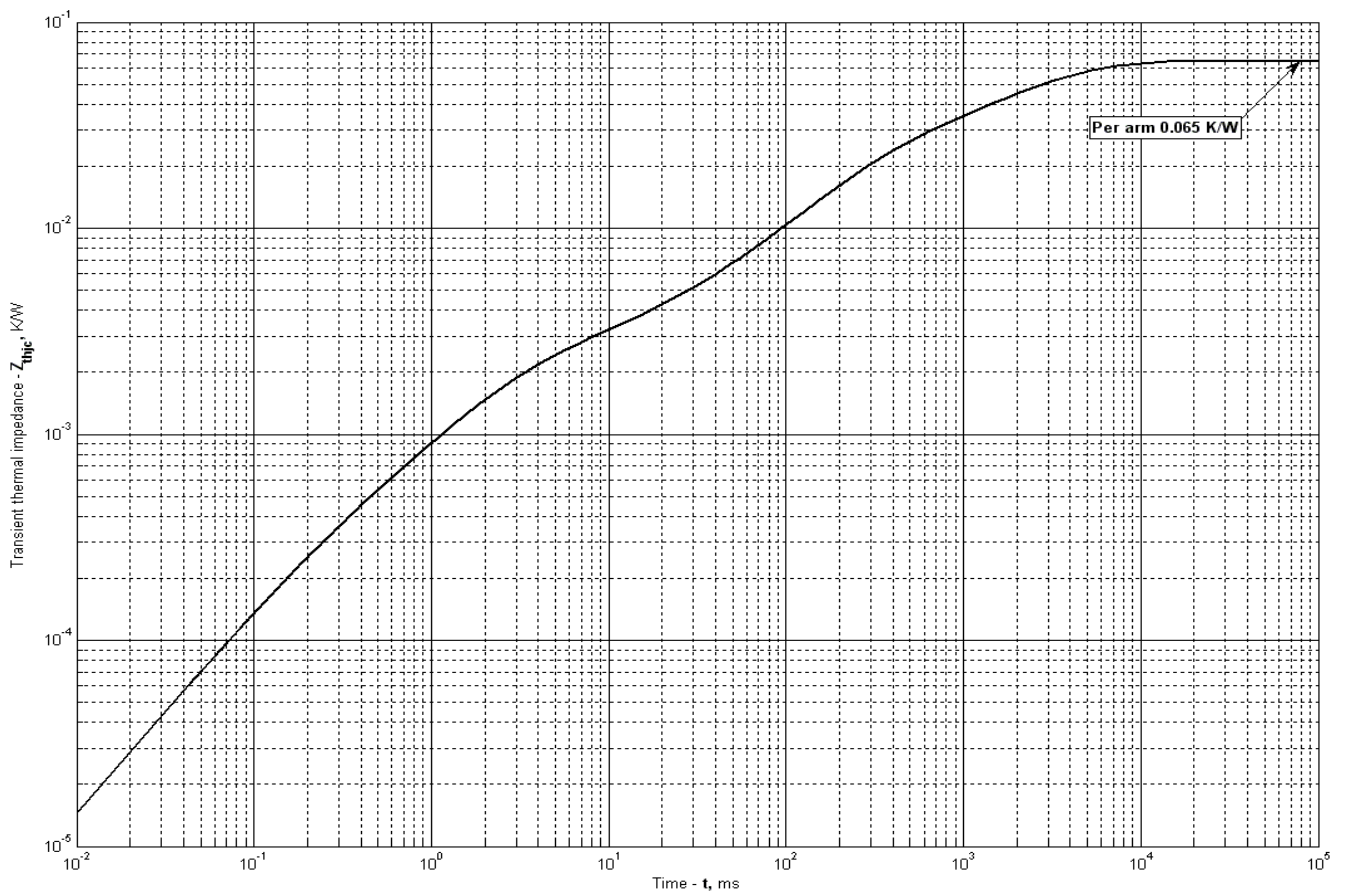
**Fig 1 – On-state characteristics of Limit device**

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> | 0,9106900                   | 0,7938800               |
| <b>B</b> | 0,0001866                   | 0,0002045               |
| <b>C</b> | 0,0368900                   | -0,0072043              |
| <b>D</b> | -0,0025739                  | 0,0065682               |

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



**Fig 2 – Transient thermal impedance**

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.

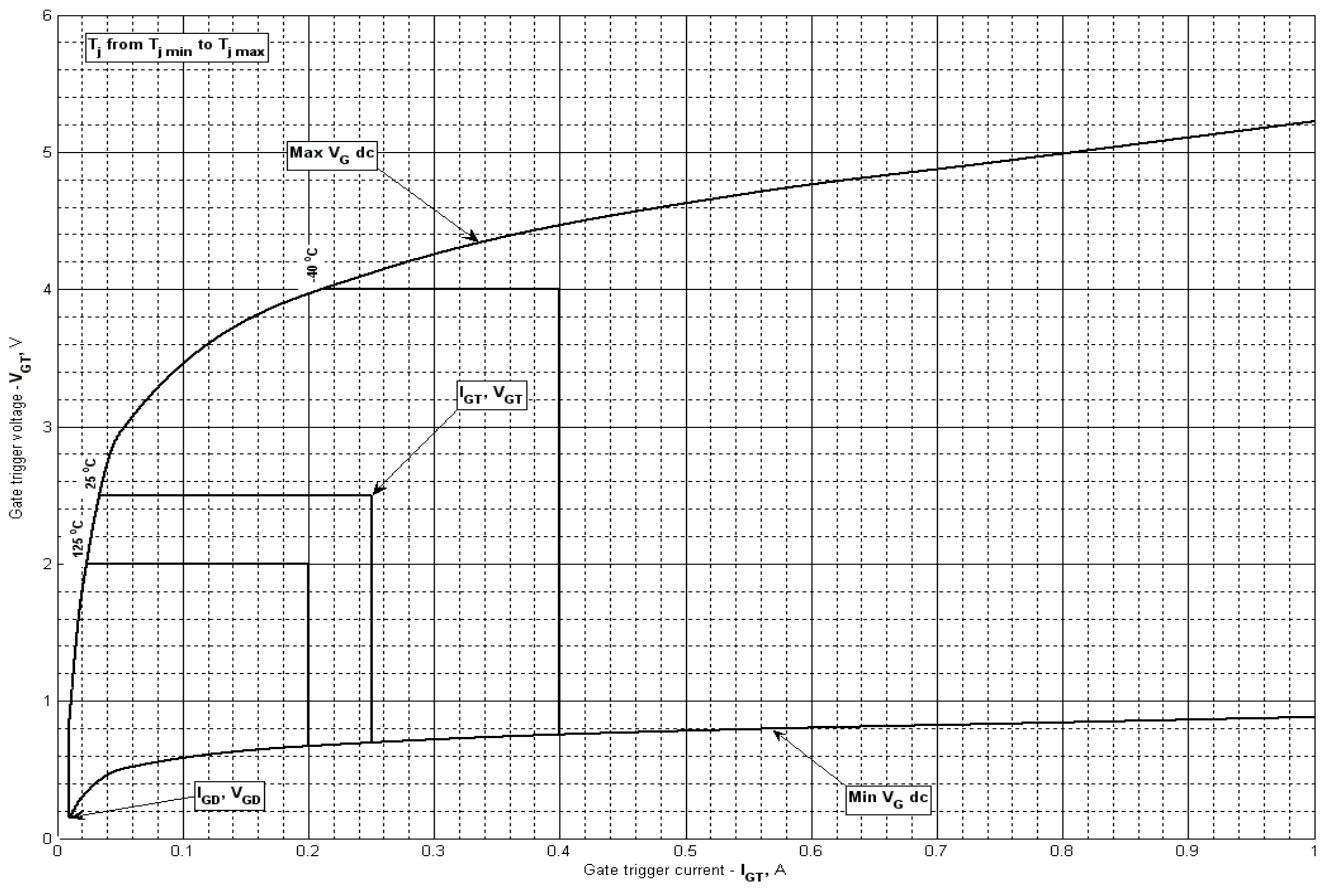
$Z_{thjc}$  = Thermal resistance at time  $t$ .

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

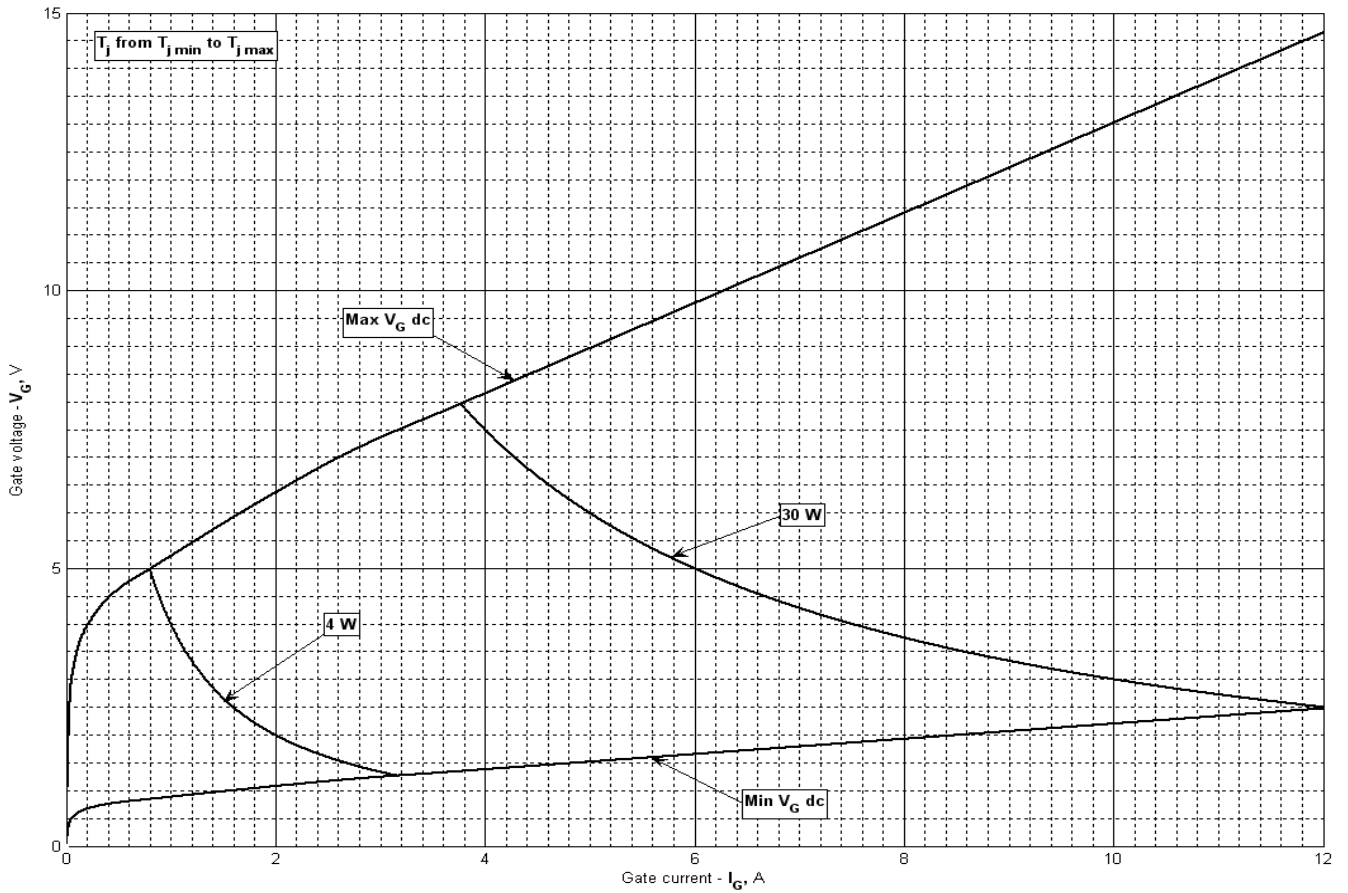
$\tau_i$  = Time constant of  $r_{th}$  term.

| $i$          | 1      | 2      | 3       | 4         | 5        | 6         |
|--------------|--------|--------|---------|-----------|----------|-----------|
| $R_i$ , K/W  | 0.0344 | 0.0112 | 0.01635 | 0.0006528 | 0.001791 | 0.0001363 |
| $\tau_i$ , s | 3.132  | 1.000  | 0.2335  | 0.01038   | 0.002348 | 0.0002448 |

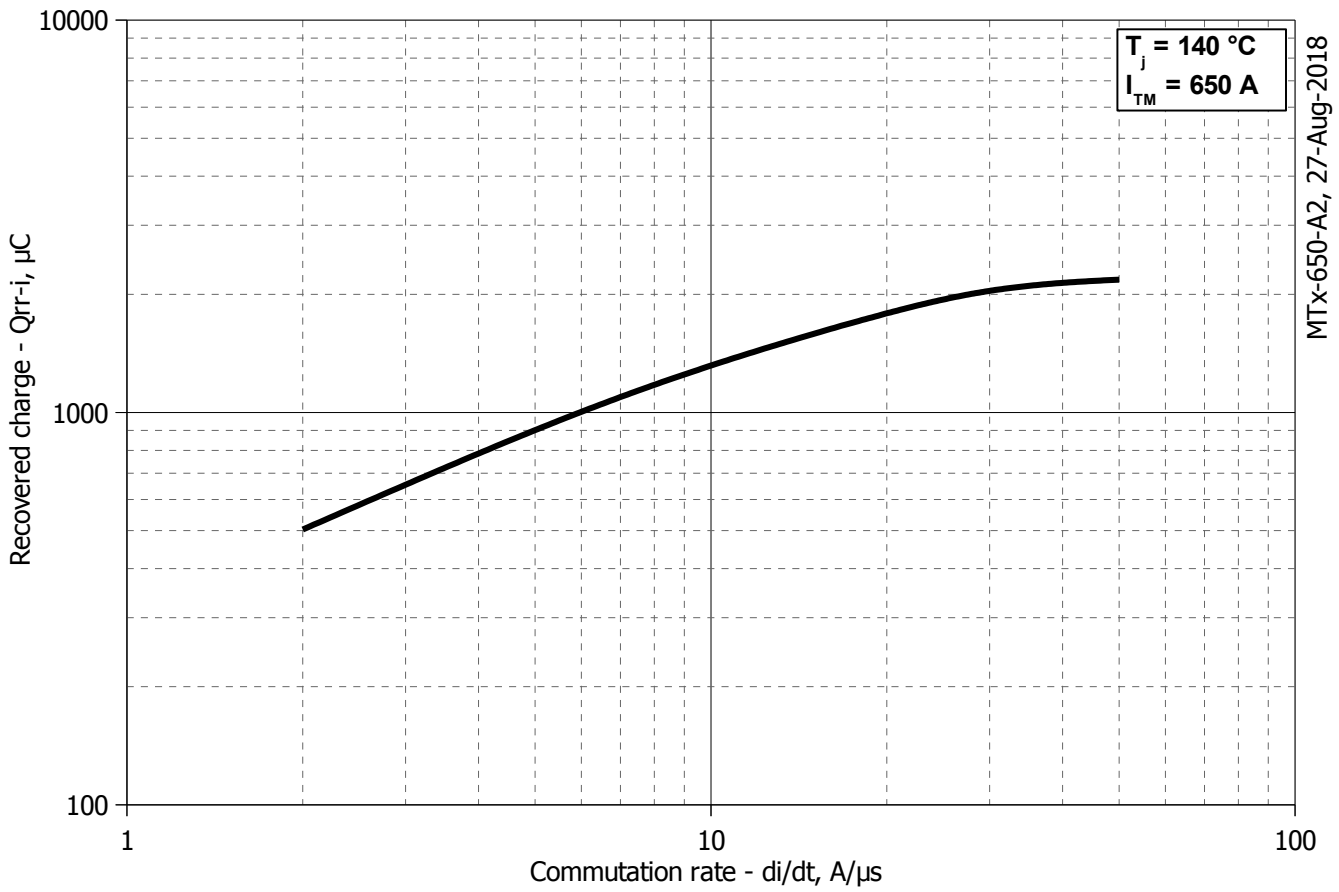
**Transient thermal impedance junction to case  $Z_{thjc}$  model (see Fig. 2)**



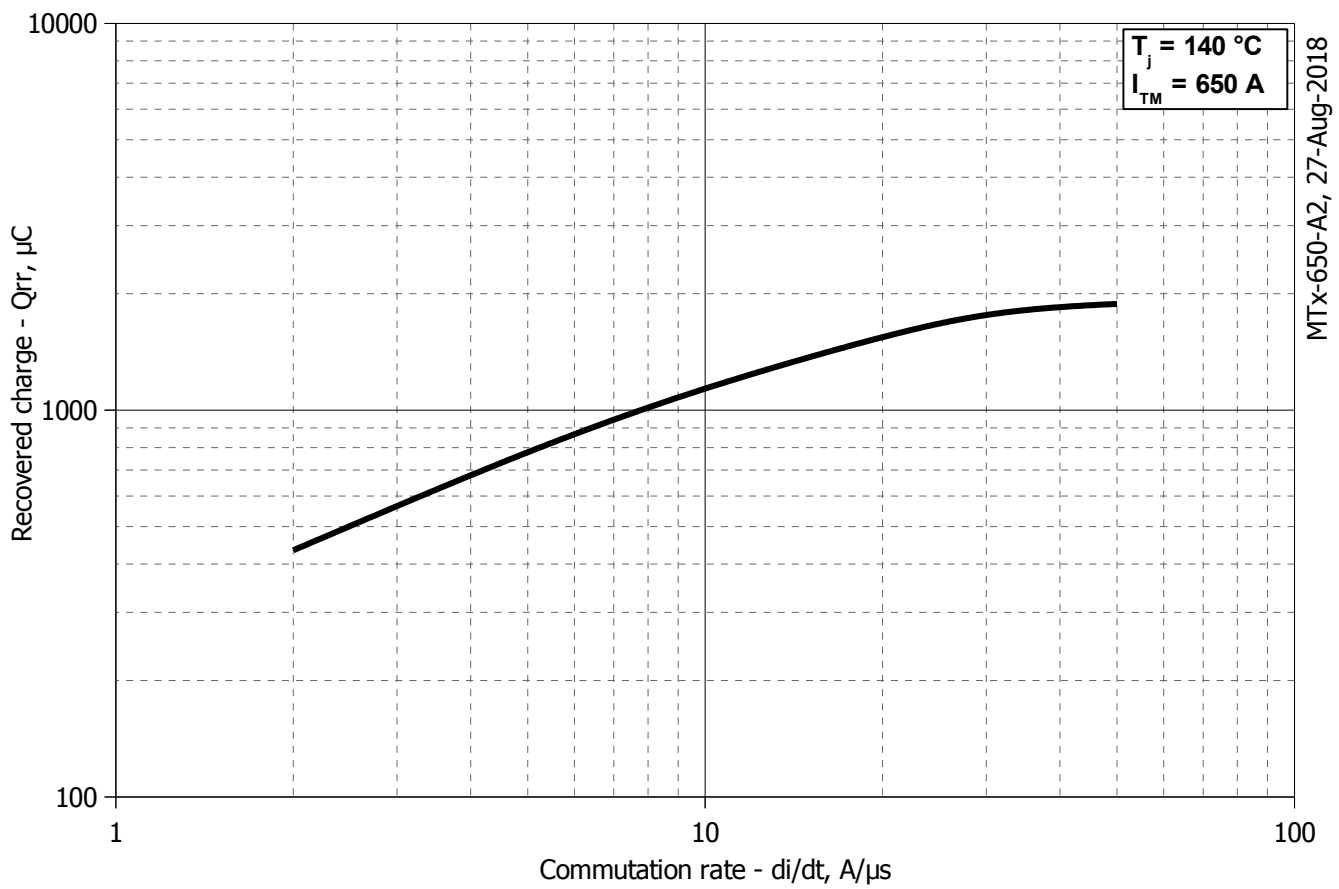
**Fig 3 – Gate characteristics – Trigger limits**



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

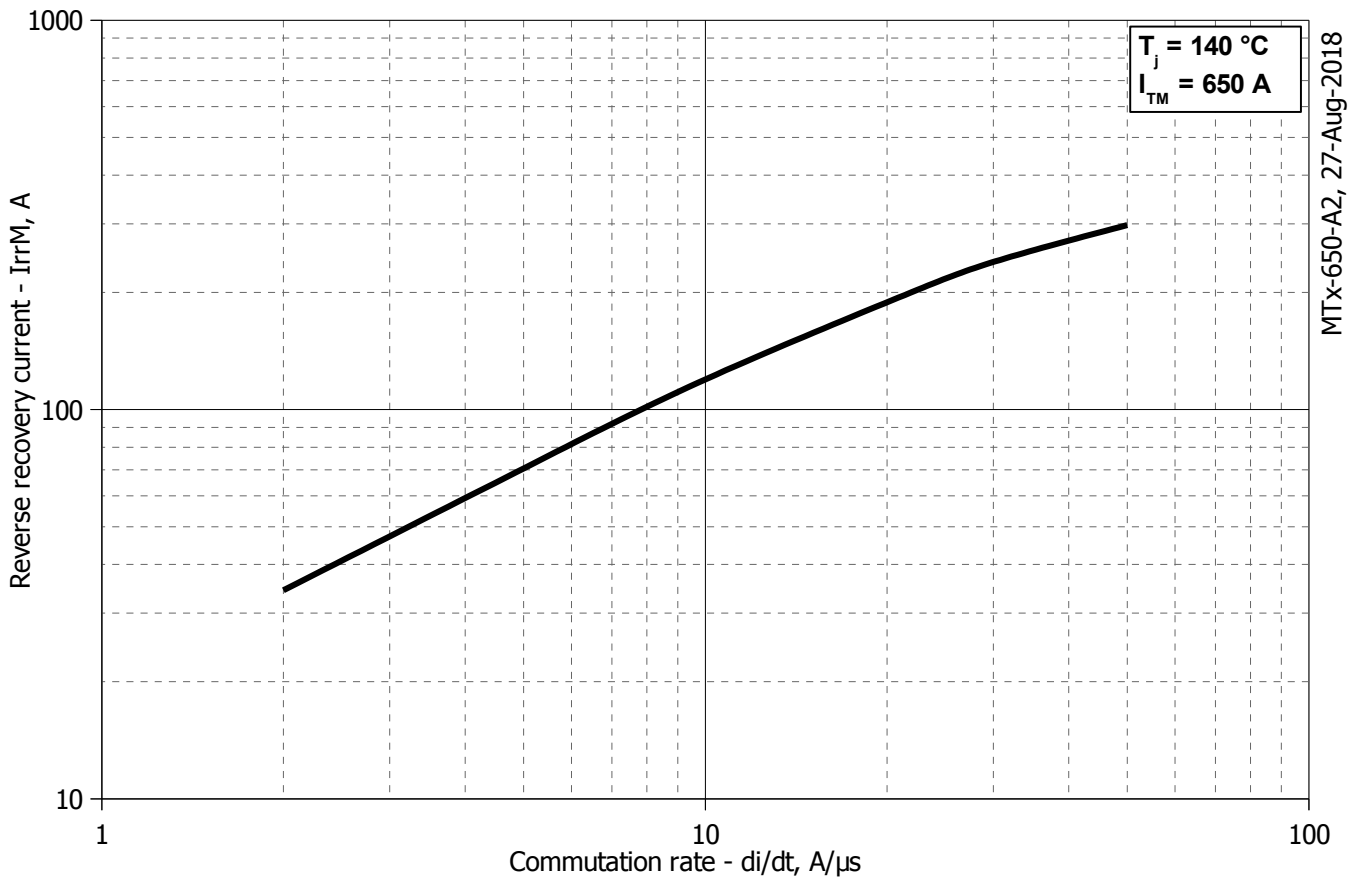


**Fig 5 - Total recovered charge,  $Q_{rr-i}$  (integral)**



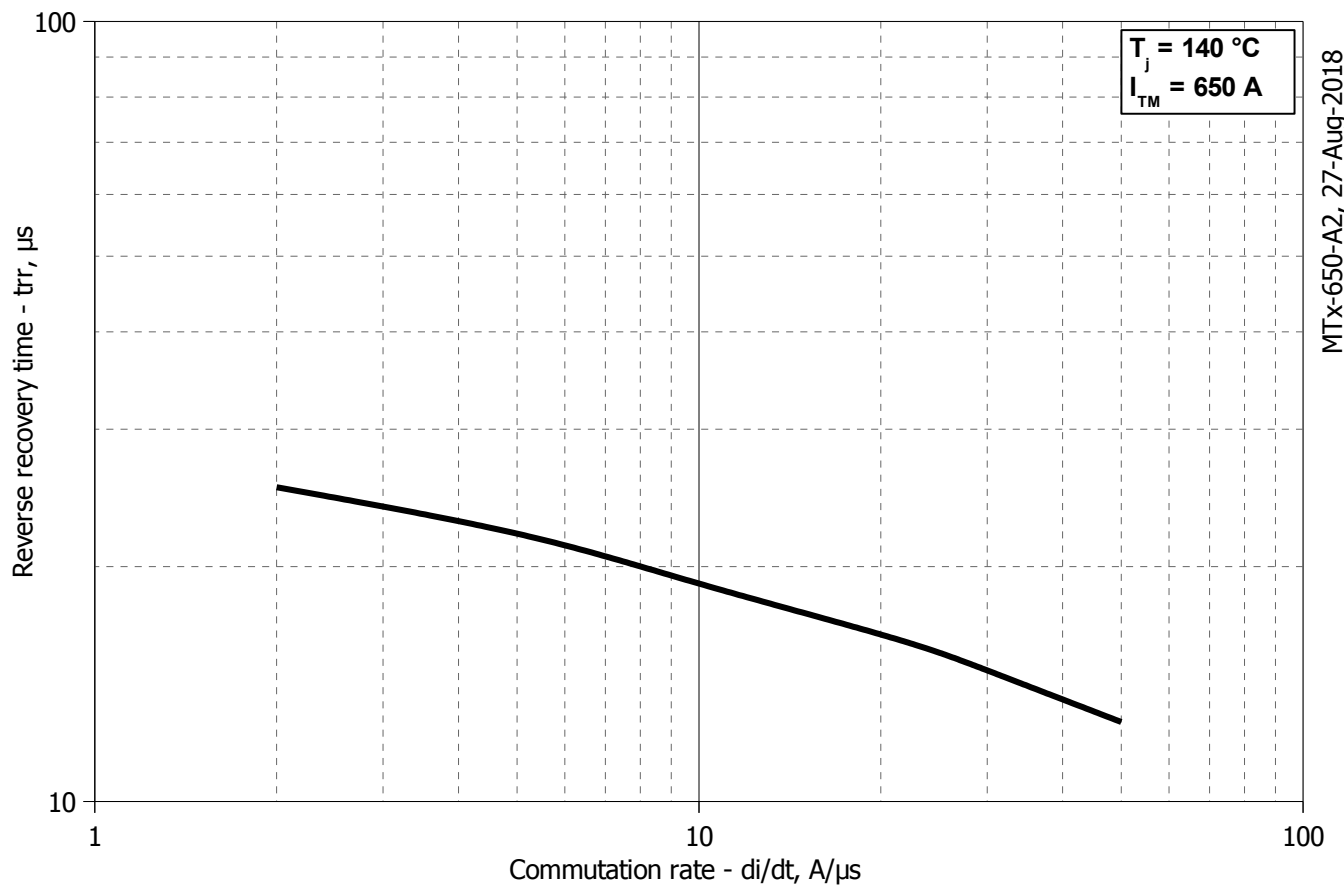
**Fig 6 - Recovered charge,  $Q_{rr}$  (linear)**





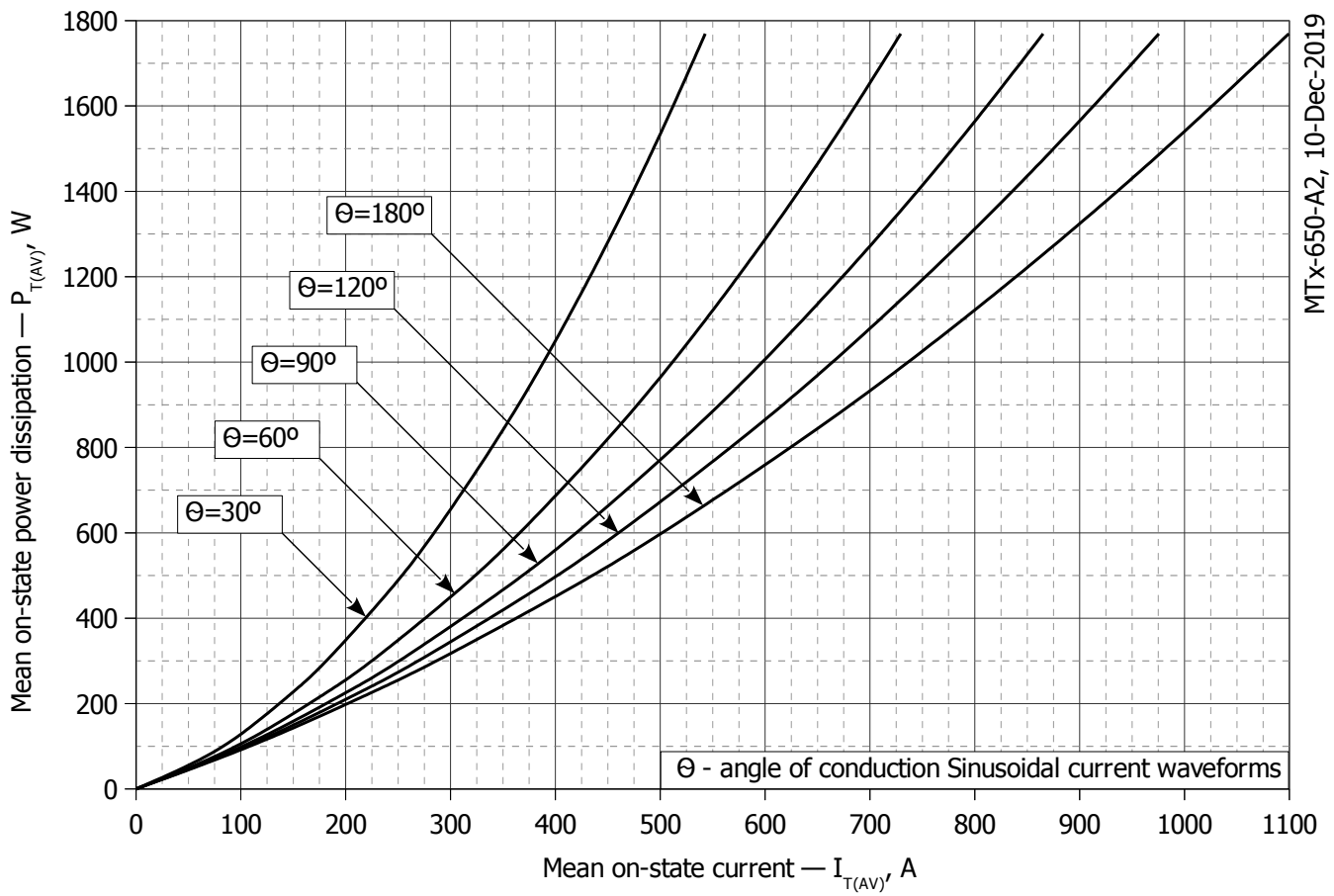
MTx-650-A2, 27-Aug-2018

**Fig 7 - Peak reverse recovery current,  $I_{rrM}$**

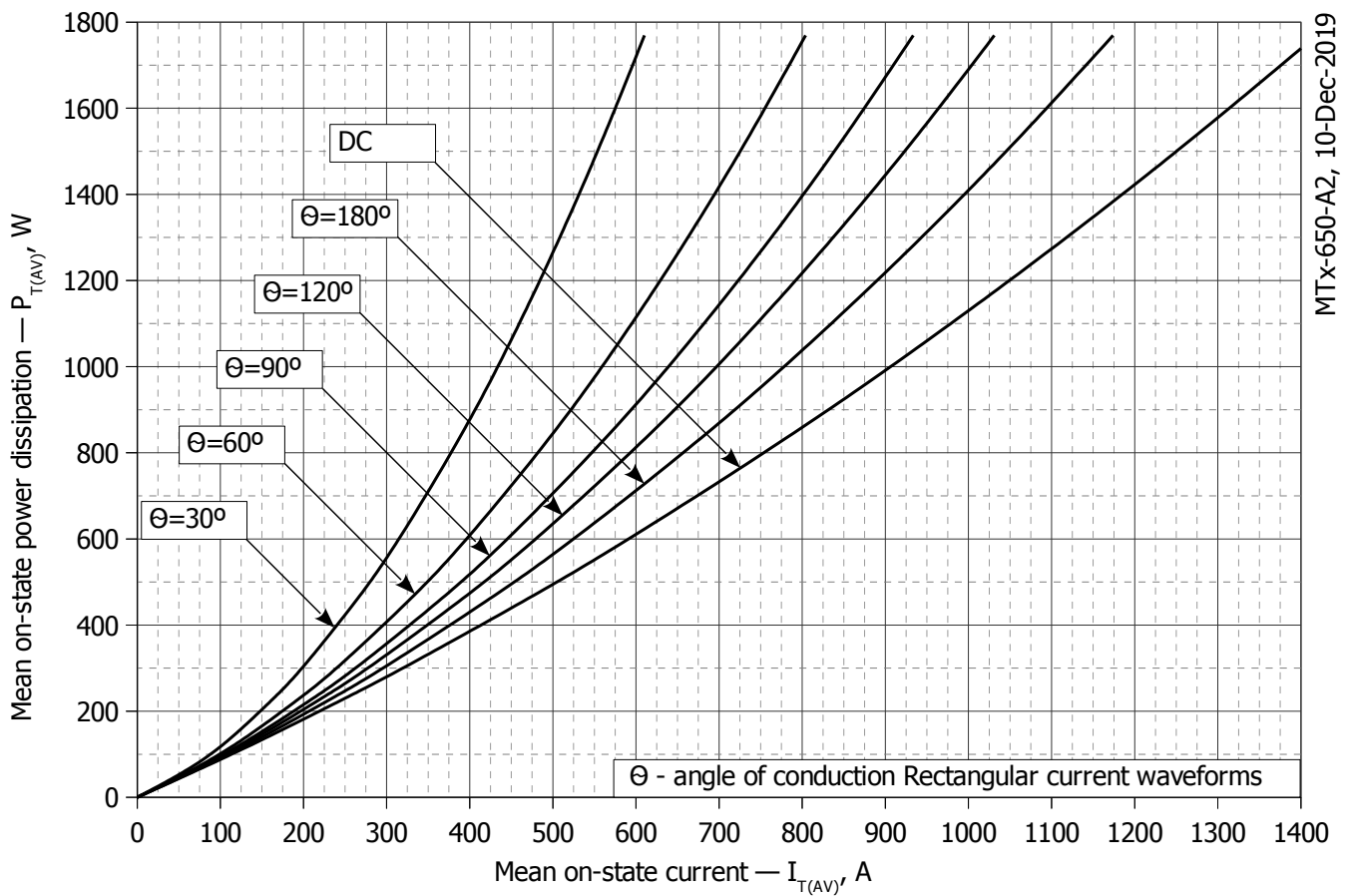


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**Fig 8 - Maximum recovery time,  $t_{rr}$  (25% chord)**



**Fig 9 – On-state power loss (sinusoidal current waveforms)**



**Fig 10 - On-state power loss (rectangular current waveforms)**

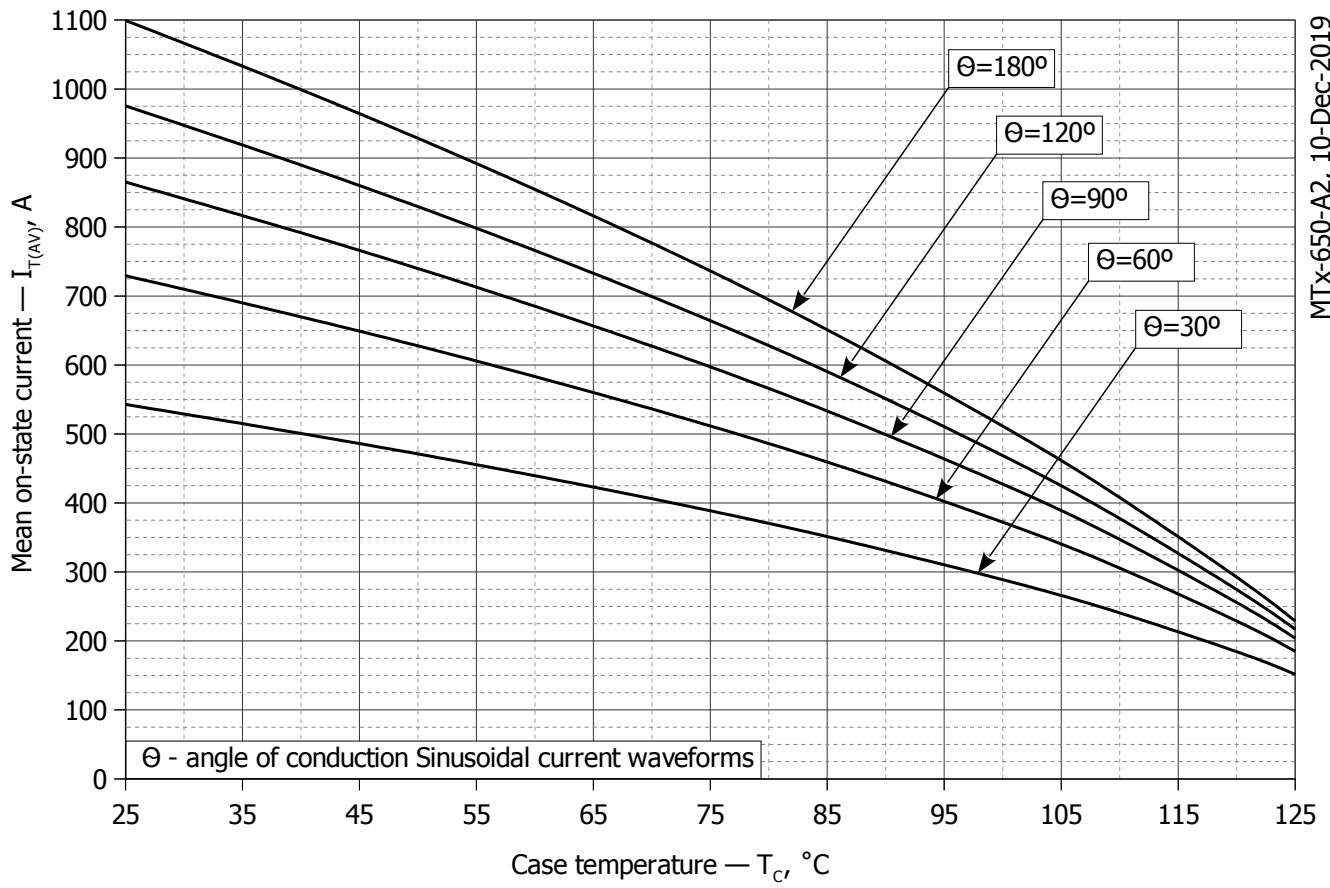


Fig 11 - Maximum case temperature (sinusoidal current waveforms)

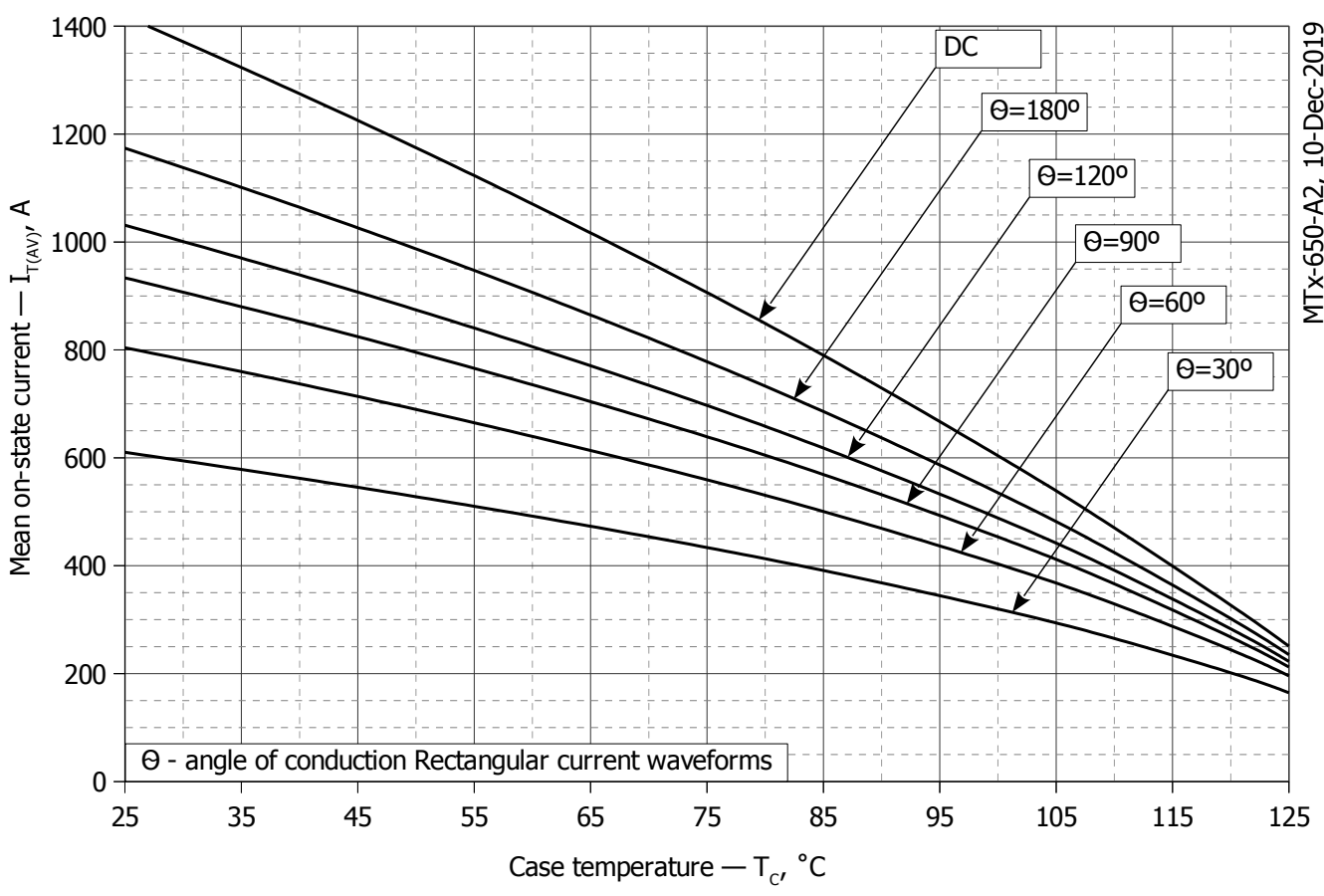
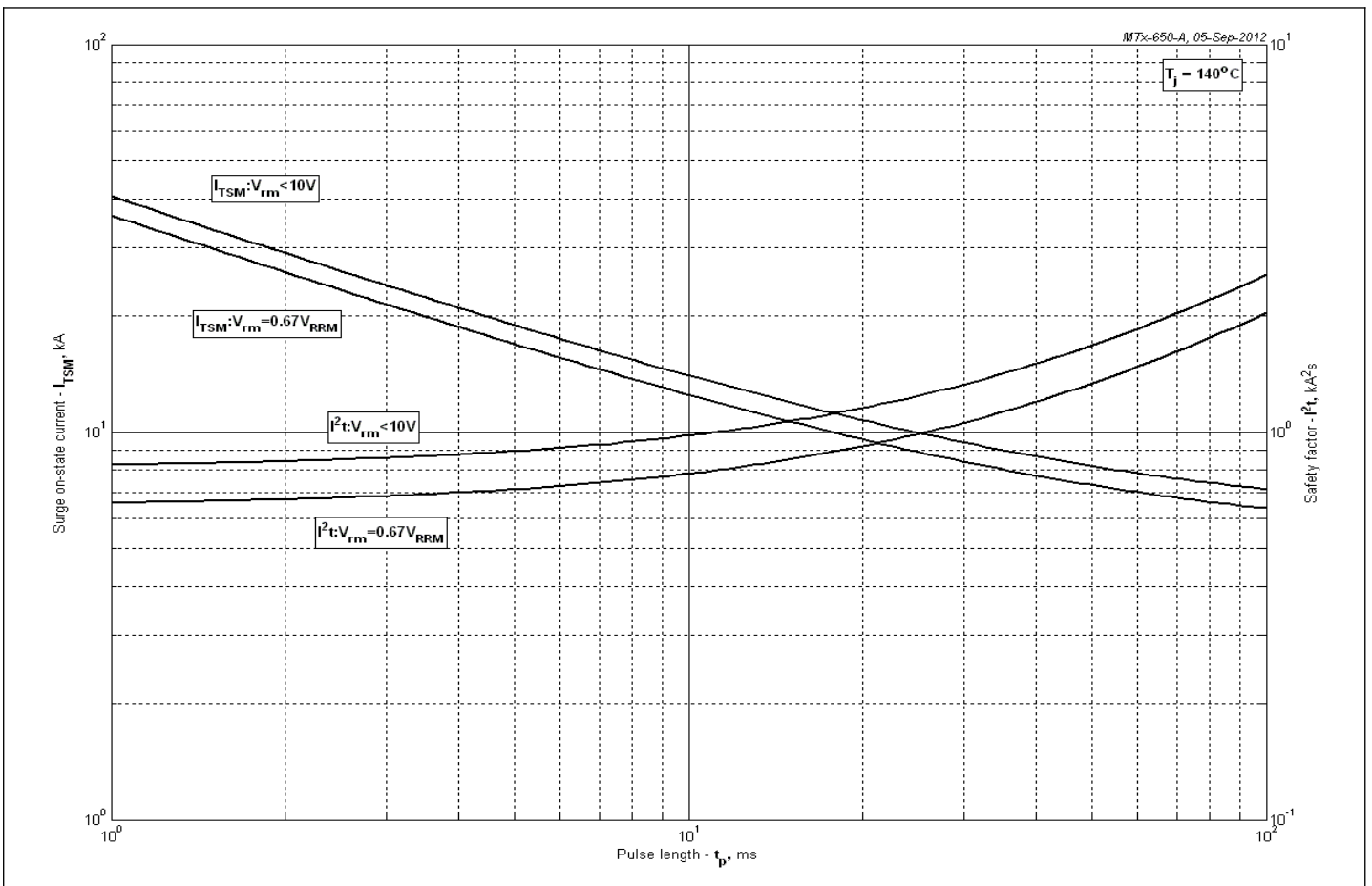
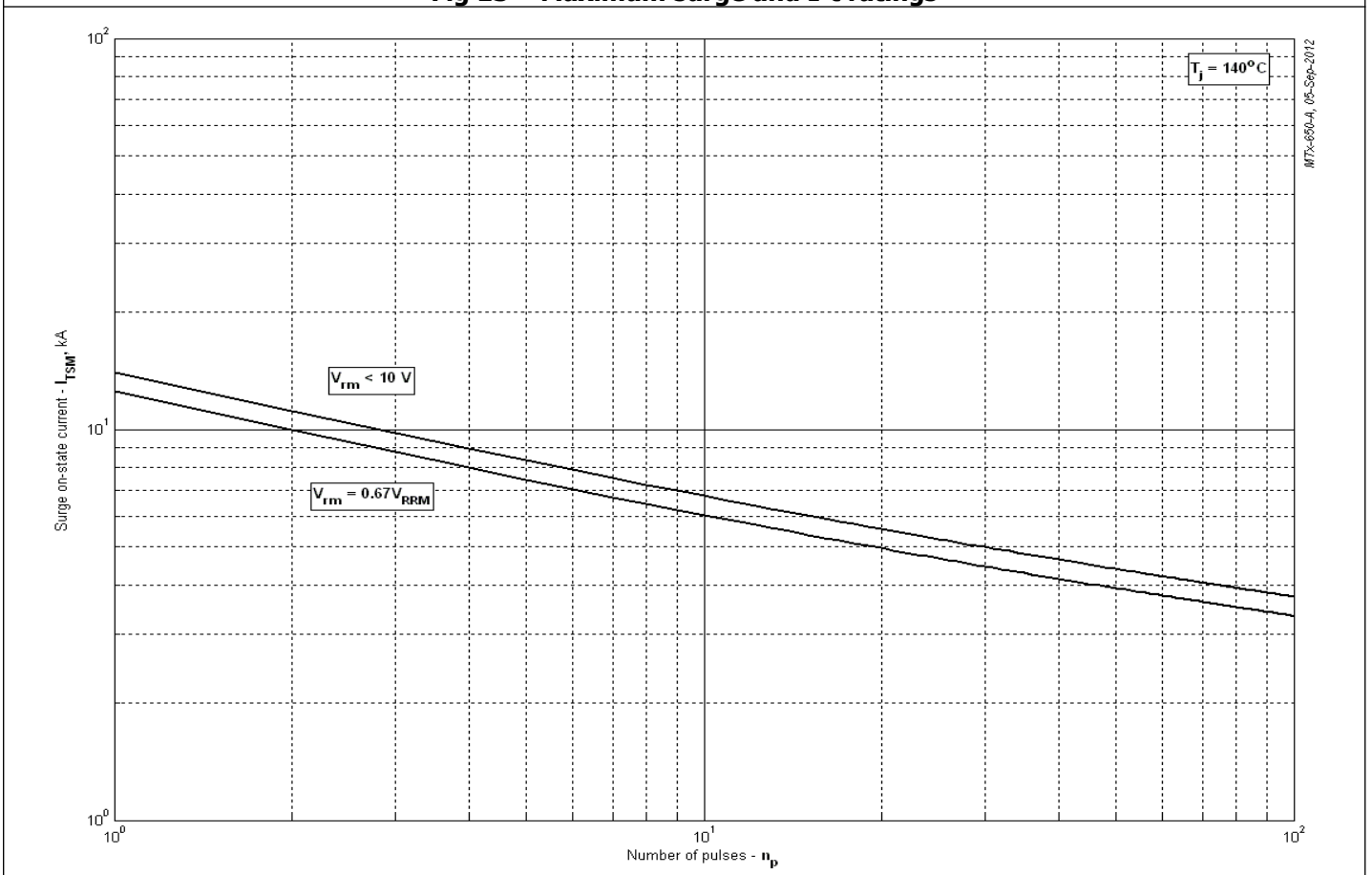


Fig 12 - Maximum case temperature (rectangular current waveforms)



**Fig 13 – Maximum surge and I<sup>2</sup>t ratings**



**Fig 14 - Maximum surge ratings**