



# Double Diode Module For Phase Control MDx-470-44-A2

| MD3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | MD4 | MD5 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |     |     |
| <p>Technical drawing of the MD3/MD4/MD5 module showing side and front views with dimensions in mm and inches.</p> <p><b>Side View Dimensions:</b></p> <ul style="list-style-type: none"> <li>Top section: 50 (1,969), 44 (1,732), 13 (0,512)</li> <li>Height: 52 (2,047)</li> <li>Bottom section: 10 (0,394)</li> <li>Mounting hole: <math>\phi 6,5</math> (0,256), 4 apertures</li> <li>Overall width: 124 (4,882)</li> <li>Screwing depth: max 17 mm (0,669 in)</li> </ul> <p><b>Front View Dimensions:</b></p> <ul style="list-style-type: none"> <li>Overall width: 149 (5,866)</li> <li>Overall height: 60 (2,362)</li> <li>Mounting hole: M10</li> <li>Section A: 26 (1,024), 26 (1,024), 112 (4,410)</li> <li>Section B: 28 (1,102), 48 (1,890)</li> <li>Section C: 1 (0,039)</li> </ul> <p><b>Top View Dimensions:</b></p> <ul style="list-style-type: none"> <li>Overall width: 149 (5,866)</li> <li>Overall height: 60 (2,362)</li> <li>Mounting hole: M10</li> <li>Section A: 26 (1,024), 26 (1,024), 112 (4,410)</li> <li>Section B: 28 (1,102), 48 (1,890)</li> <li>Section C: 1 (0,039)</li> </ul> <p><b>Detail A (2:1):</b></p> <ul style="list-style-type: none"> <li>Top: 4K1, 5G1</li> <li>Bottom: 7K2, 6G2</li> </ul> |     |     |

All dimensions in millimeters (inches)

## MAXIMUM ALLOWABLE RATINGS

| Symbols and parameters |                                           | Units              | Values             | Test conditions                                                                                        |                                                                                 |
|------------------------|-------------------------------------------|--------------------|--------------------|--------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| ON-STATE               |                                           |                    |                    |                                                                                                        |                                                                                 |
| $I_{FAV}$              | Maximum allowable average forward current | A                  | 561<br>470         | $T_c=100\text{ }^{\circ}\text{C};$<br>$T_c=111\text{ }^{\circ}\text{C};$<br>180° half-sine wave; 50 Hz |                                                                                 |
| $I_{FRMS}$             | RMS forward current                       | A                  | 737                | $T_c=100\text{ }^{\circ}\text{C};$<br>180° half-sine wave; 50 Hz                                       |                                                                                 |
| $I_{FSM}$              | Surge forward current                     | kA                 | 13.0<br>15.0       | $T_j=T_{j\text{ max}}$<br>$T_j=25\text{ }^{\circ}\text{C}$                                             | 180° half-sine wave;<br>$t_p=10\text{ ms};$ single pulse;<br>$V_R=0\text{ V};$  |
|                        |                                           |                    | 14.0<br>16.0       | $T_j=T_{j\text{ max}}$<br>$T_j=25\text{ }^{\circ}\text{C}$                                             | 180° half-sine wave;<br>$t_p=8.3\text{ ms};$ single pulse;<br>$V_R=0\text{ V};$ |
| $I^2t$                 | Safety factor                             | $A^2s\cdot 10^3$   | 840<br>1120        | $T_j=T_{j\text{ max}}$<br>$T_j=25\text{ }^{\circ}\text{C}$                                             | 180° half-sine wave;<br>$t_p=10\text{ ms};$ single pulse;<br>$V_R=0\text{ V};$  |
|                        |                                           |                    | 810<br>1060        | $T_j=T_{j\text{ max}}$<br>$T_j=25\text{ }^{\circ}\text{C}$                                             | 180° half-sine wave;<br>$t_p=8.3\text{ ms};$ single pulse;<br>$V_R=0\text{ V};$ |
| BLOCKING               |                                           |                    |                    |                                                                                                        |                                                                                 |
| $V_{RRM}$              | Repetitive peak reverse voltages          | V                  | 3800...4400        | $T_{j\text{ min}} < T_j < T_{j\text{ max}};$<br>180° half-sine wave; 50 Hz;                            |                                                                                 |
| $V_{RSM}$              | Non-repetitive peak reverse voltages      | V                  | 3900...4500        | $T_{j\text{ min}} < T_j < T_{j\text{ max}};$<br>180° half-sine wave; single pulse;                     |                                                                                 |
| $V_R$                  | Reverse continuous voltages               | V                  | $0.6\cdot V_{RRM}$ | $T_j=T_{j\text{ max}};$                                                                                |                                                                                 |
| THERMAL                |                                           |                    |                    |                                                                                                        |                                                                                 |
| $T_{stg}$              | Storage temperature                       | $^{\circ}\text{C}$ | −40...+50          |                                                                                                        |                                                                                 |
| $T_j$                  | Operating junction temperature            | $^{\circ}\text{C}$ | −40...+150         |                                                                                                        |                                                                                 |
| $T_{c\text{ op}}$      | Operating temperature                     | $^{\circ}\text{C}$ | −40...+125         |                                                                                                        |                                                                                 |
| MECHANICAL             |                                           |                    |                    |                                                                                                        |                                                                                 |
| a                      | Acceleration under vibration              | m/s <sup>2</sup>   | 50                 |                                                                                                        |                                                                                 |

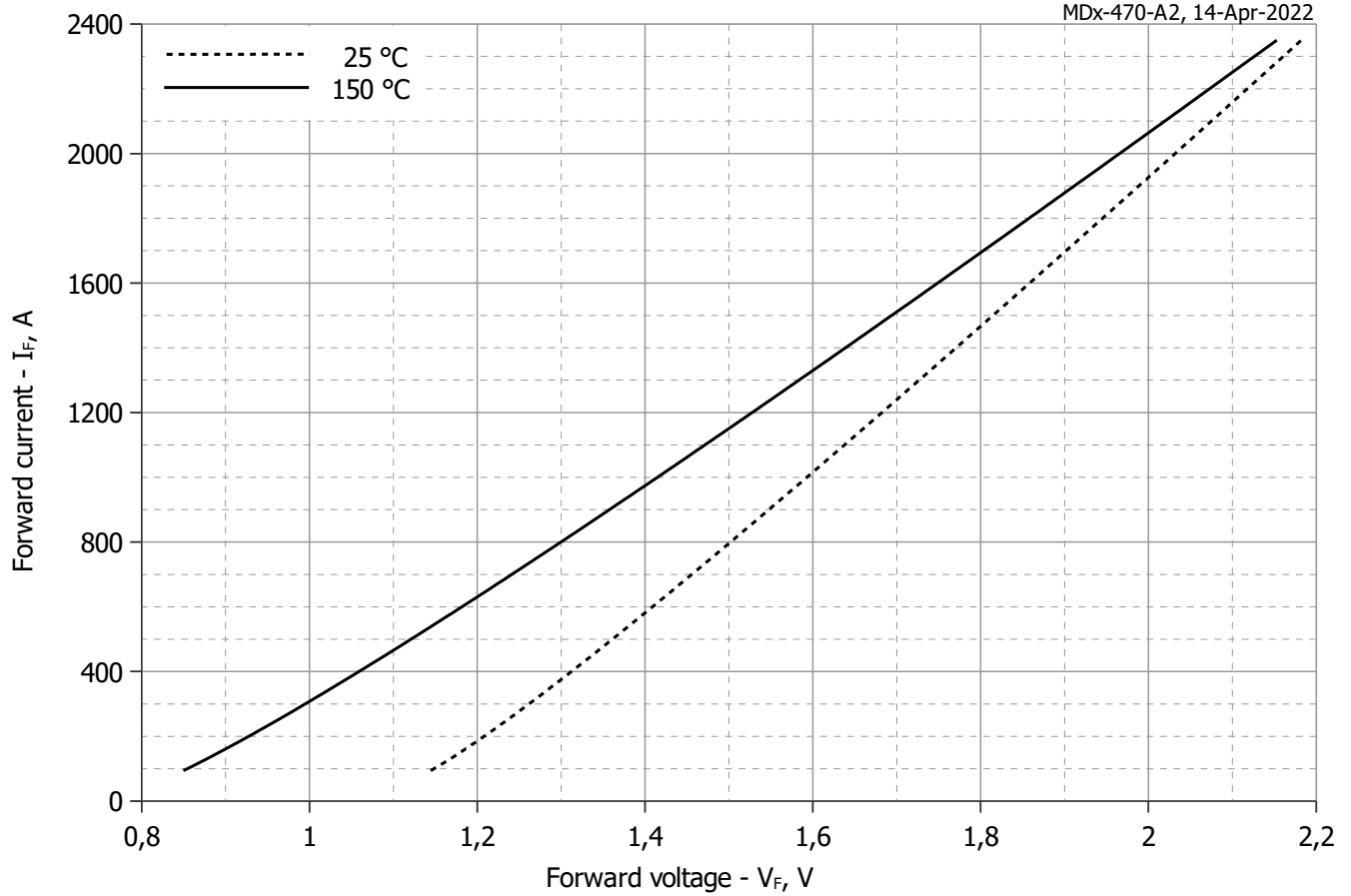
## CHARACTERISTICS

| Symbols and parameters |                                      | Units | Values     | Conditions                                                               |                                  |
|------------------------|--------------------------------------|-------|------------|--------------------------------------------------------------------------|----------------------------------|
| ON-STATE               |                                      |       |            |                                                                          |                                  |
| V <sub>FM</sub>        | Peak forward voltage, max            | V     | 1.70       | T <sub>j</sub> =25 °C; I <sub>FM</sub> =1256 A                           |                                  |
| V <sub>F(TO)</sub>     | Forward threshold voltage, max       | V     | 0.855      | T <sub>j</sub> =T <sub>j max</sub> ;                                     |                                  |
| r <sub>T</sub>         | Forward slope resistance, max        | mΩ    | 0.554      | 0.5 π I <sub>FAV</sub> < I <sub>T</sub> < 1.5 π I <sub>FAV</sub>         |                                  |
| BLOCKING               |                                      |       |            |                                                                          |                                  |
| I <sub>RRM</sub>       | Repetitive peak reverse current, max | mA    | 50<br>3.00 | T <sub>j</sub> =T <sub>j max</sub><br>T <sub>j</sub> =25 °C              | V <sub>R</sub> =V <sub>RRM</sub> |
| SWITCHING              |                                      |       |            |                                                                          |                                  |
| Q <sub>r</sub>         | Recovered charge, max                | μC    | 3300       | T <sub>j</sub> =T <sub>j max</sub> ; I <sub>FM</sub> =I <sub>FAV</sub> ; |                                  |
| t <sub>rr</sub>        | Reverse recovery time, max           | μs    | 61         | di <sub>FM</sub> /dt=-5 A/μs;                                            |                                  |
| I <sub>rr</sub>        | Reverse recovery current, max        | A     | 108        | V <sub>R</sub> =100 V                                                    |                                  |
| THERMAL                |                                      |       |            |                                                                          |                                  |
| R <sub>thjc</sub>      | Thermal resistance, junction to case |       |            |                                                                          |                                  |
|                        | per module                           | °C/W  | 0.0275     | 180° half-sine wave, 50 Hz                                               |                                  |
|                        | per arm                              | °C/W  | 0.0550     |                                                                          |                                  |
|                        | per module                           | °C/W  | 0.0265     | DC                                                                       |                                  |
|                        | per arm                              | °C/W  | 0.0530     |                                                                          |                                  |
| R <sub>thch</sub>      | Thermal resistance, case to heatsink |       |            |                                                                          |                                  |
|                        | per module                           | °C/W  | 0.0100     |                                                                          |                                  |
|                        | per arm                              | °C/W  | 0.0200     |                                                                          |                                  |
| INSULATION             |                                      |       |            |                                                                          |                                  |
| V <sub>ISOL</sub>      | Insulation test voltage              | kV    | 3.00       | Sine wave, 50 Hz;<br>RMS                                                 | t=60 sec                         |
|                        |                                      |       | 3.60       |                                                                          | t=1 sec                          |

| MECHANICAL     |                                                |    |       |                 |
|----------------|------------------------------------------------|----|-------|-----------------|
| M <sub>1</sub> | Mounting torque (M6) <sup>1)</sup>             | Nm | 6.00  | Tolerance ± 15% |
| M <sub>2</sub> | Terminal connection torque (M10) <sup>1)</sup> | Nm | 12.00 | Tolerance ± 15% |
| m              | Weight, max                                    | g  | 1500  |                 |

| PART NUMBERING GUIDE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | NOTES |   |     |     |    |    |    |    |   |   |   |   |  |   |  |   |  |   |  |   |                                         |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|---|-----|-----|----|----|----|----|---|---|---|---|--|---|--|---|--|---|--|---|-----------------------------------------|
| <table><tr><td>MD</td><td>3</td><td>-</td><td>470</td><td>-</td><td>44</td><td>-</td><td>A2</td><td>-</td><td>N</td></tr><tr><td>1</td><td>2</td><td></td><td>3</td><td></td><td>4</td><td></td><td>5</td><td></td><td>6</td></tr></table> <p>1. MD - Rectifier Diode</p> <p>2. Circuit Schematic:</p> <p>3 – serial connection</p> <p>4 – common Cathode</p> <p>5 – common Anode</p> <p>3. Average Forward Current, A</p> <p>4. Voltage Code</p> <p>5. Package Type (M.A2)</p> <p>6. Ambient Conditions:</p> <p>N – Normal</p> | MD    | 3 | -   | 470 | -  | 44 | -  | A2 | - | N | 1 | 2 |  | 3 |  | 4 |  | 5 |  | 6 | <p>1) The screws must be lubricated</p> |
| MD                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 3     | - | 470 | -   | 44 | -  | A2 | -  | N |   |   |   |  |   |  |   |  |   |  |   |                                         |
| 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 2     |   | 3   |     | 4  |    | 5  |    | 6 |   |   |   |  |   |  |   |  |   |  |   |                                         |

The information contained herein is confidential and protected by Copyright  
In the interest of product improvement, Proton-Electrotex reserves the right to change data sheet without notice.

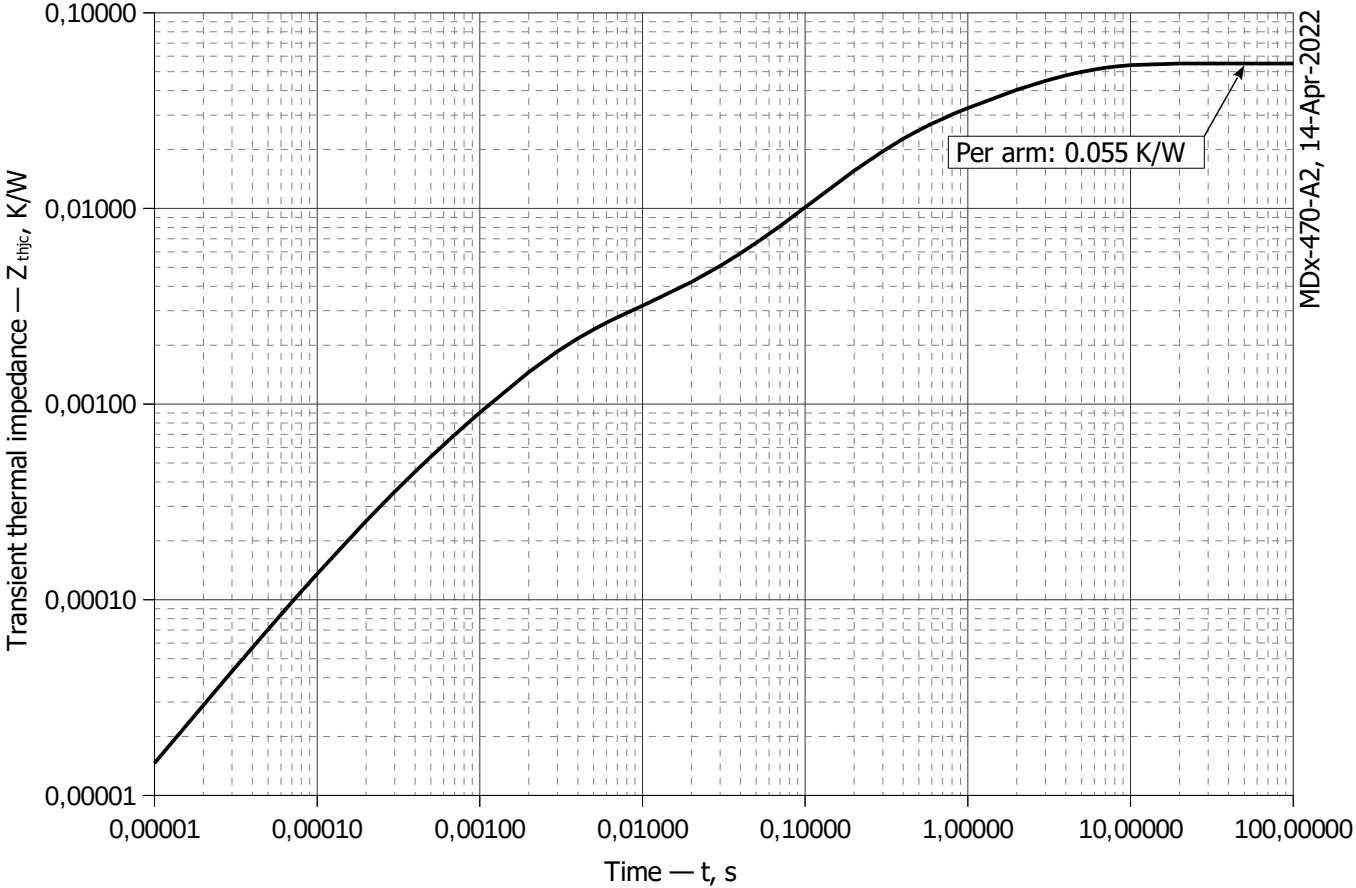
**Fig 1 – Forward characteristics of Limit device**

Analytical function for Forward characteristic:

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

|          | Coefficients for max curves |                    |
|----------|-----------------------------|--------------------|
|          | $T_j = 25^\circ\text{C}$    | $T_j = T_{j \max}$ |
| <b>A</b> | 1.02495941                  | 0.75307563         |
| <b>B</b> | 0.00039182                  | 0.00045984         |
| <b>C</b> | 0.01182806                  | -0.00346265        |
| <b>D</b> | 0.00298085                  | 0.00713798         |

**Forward 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.

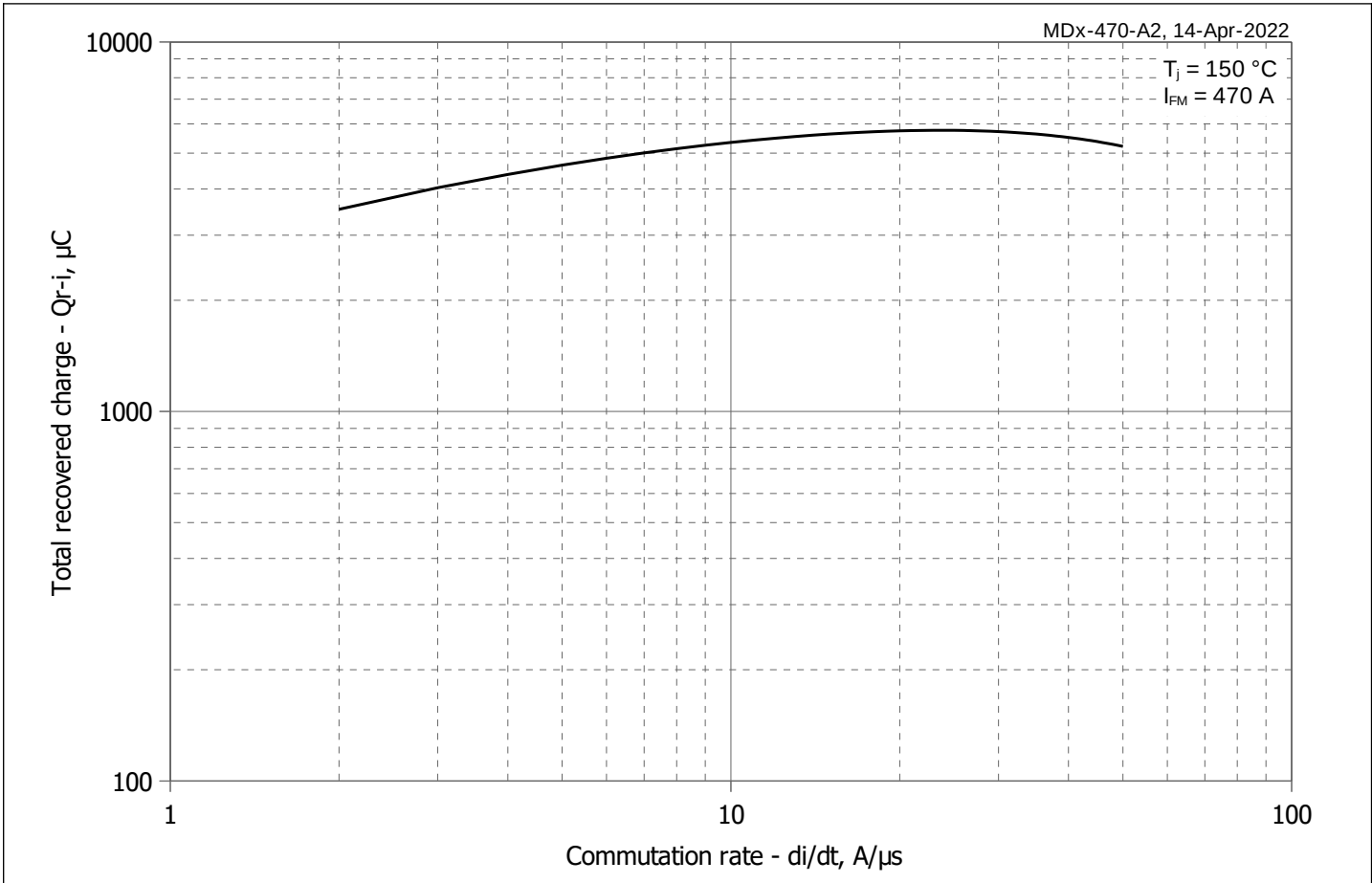
$Z_{thjc}$  = Thermal resistance at time  $t$ .

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

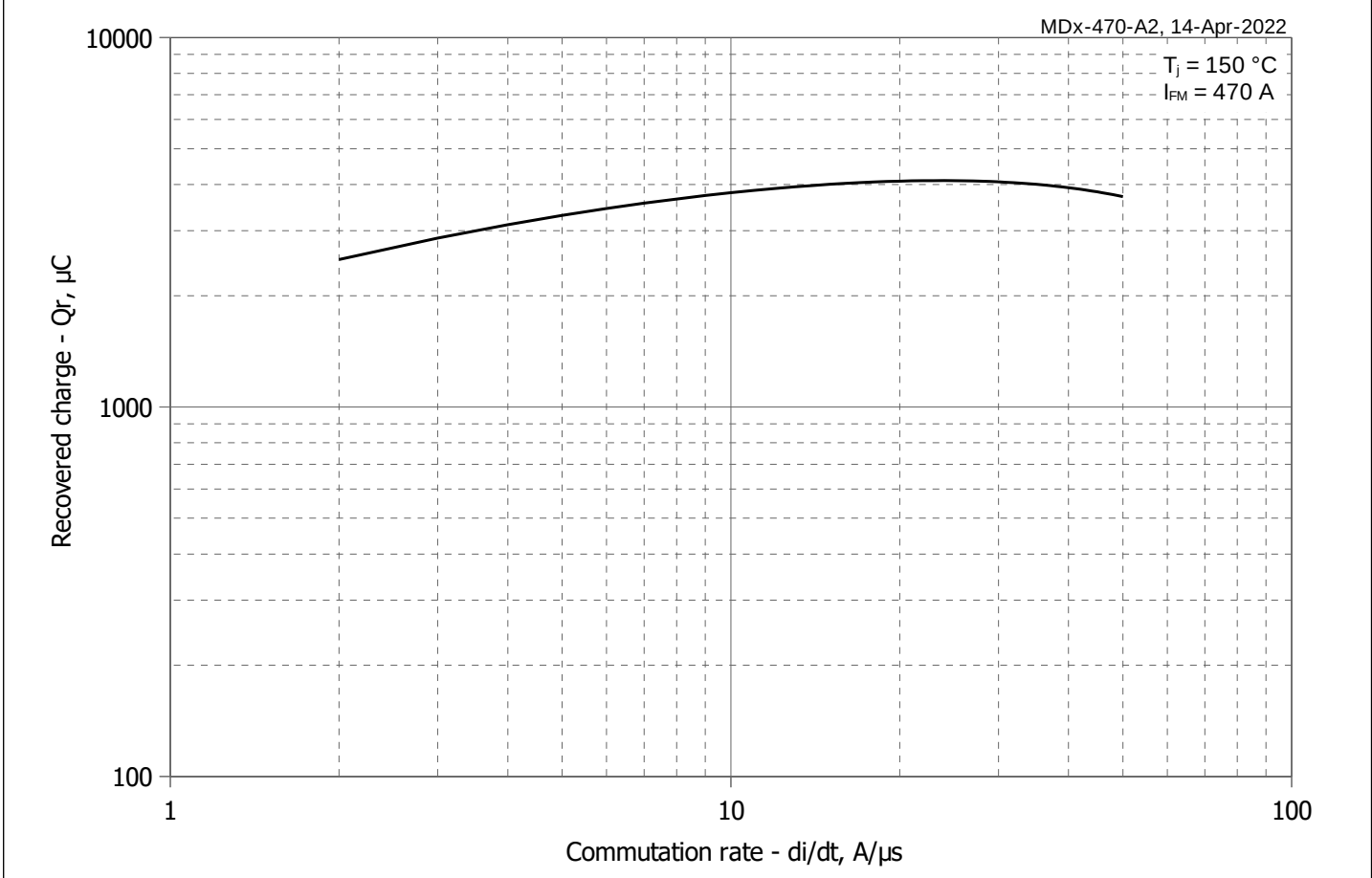
$\tau_i$  = Time constant of  $r_{th}$  term.

| $i$         | 1      | 2      | 3       | 4         | 5        | 6         |
|-------------|--------|--------|---------|-----------|----------|-----------|
| $R_i, K/W$  | 0.0249 | 0.0112 | 0.01635 | 0.0006528 | 0.00179  | 0.000136  |
| $\tau_i, s$ | 3.132  | 1      | 0.2335  | 0.01038   | 0.002348 | 0.0002448 |

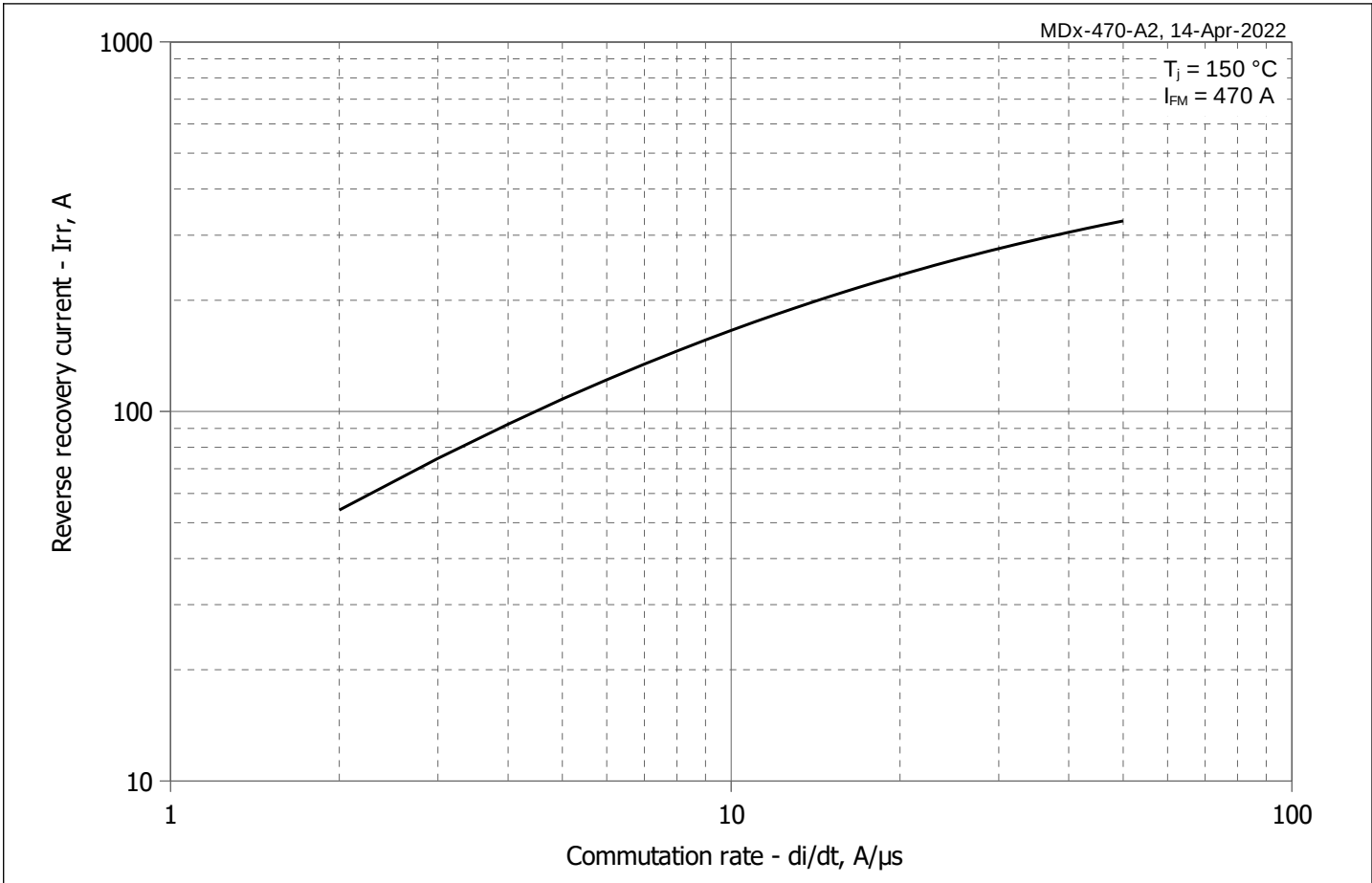
**Transient thermal impedance junction to case  $Z_{thjc}$  model (see Fig. 2)**



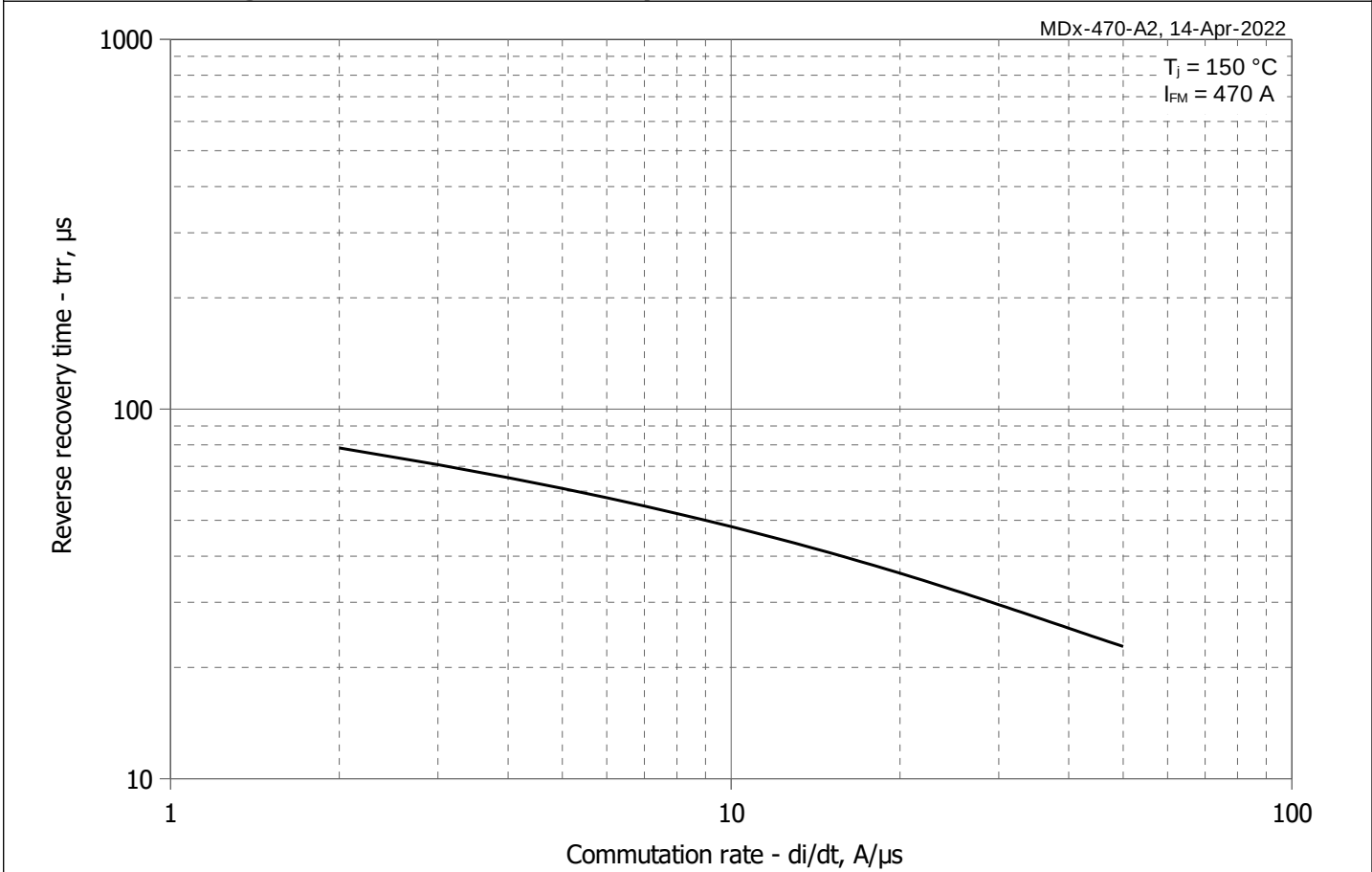
**Fig 3 - Maximum recovered charge  $Q_{r-i}$  (integral) vs. commutation rate  $di_R/dt$**



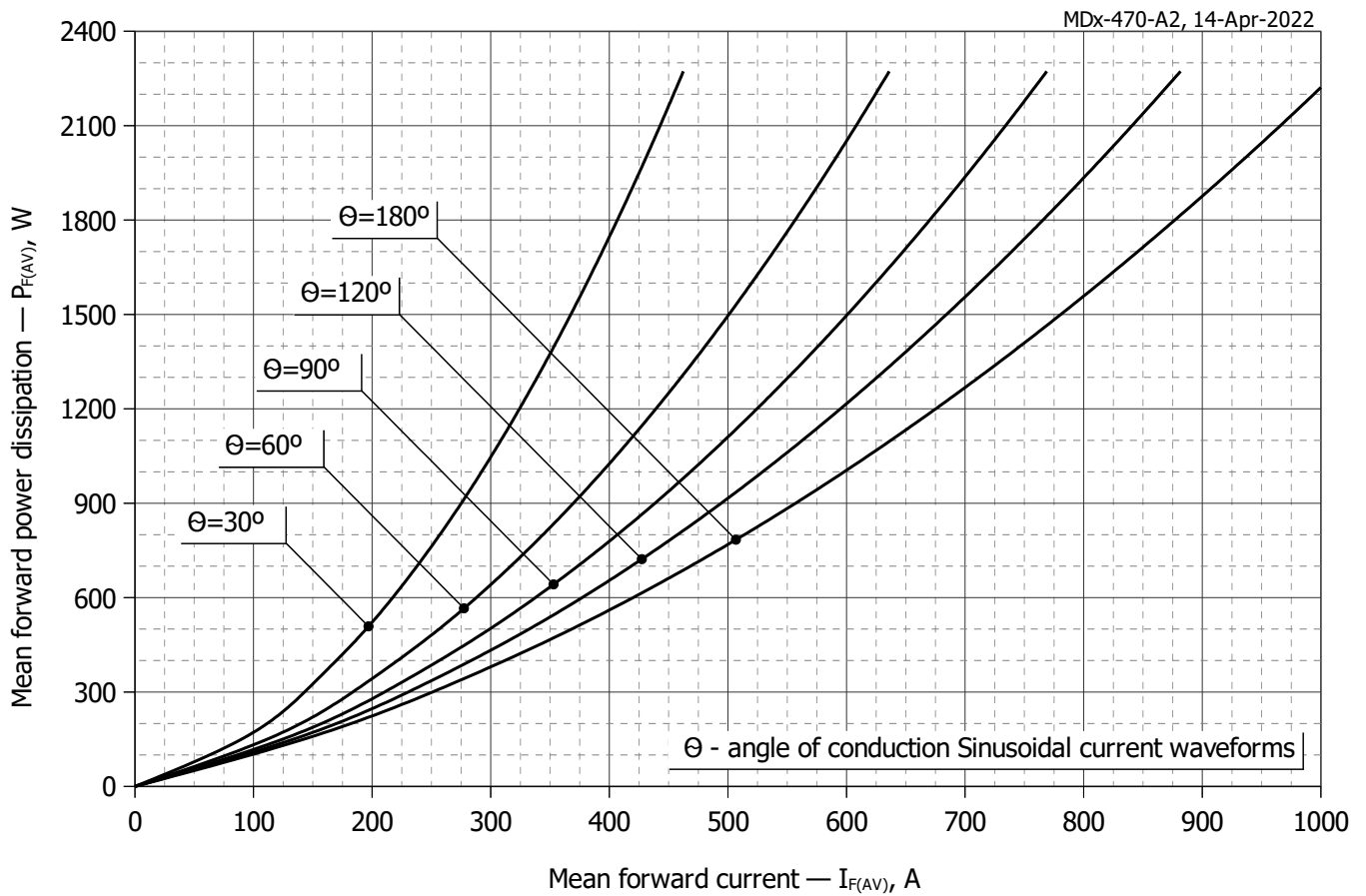
**Fig 4 - Maximum recovered charge  $Q_r$  vs. commutation rate  $di_R/dt$  (25% chord)**



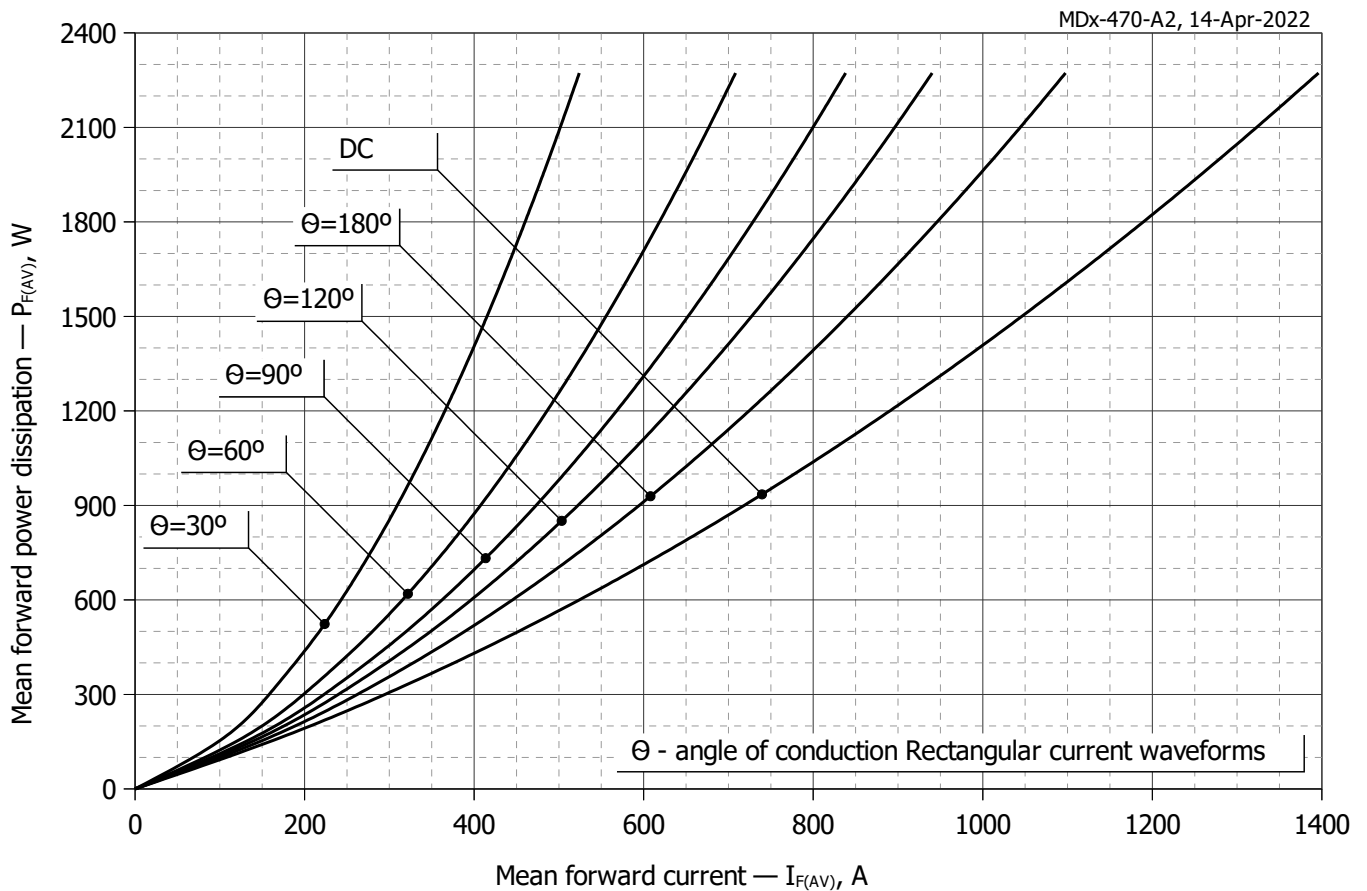
**Fig 5 - Maximum reverse recovery current  $I_{rr}$  vs. commutation rate  $di_R/dt$**



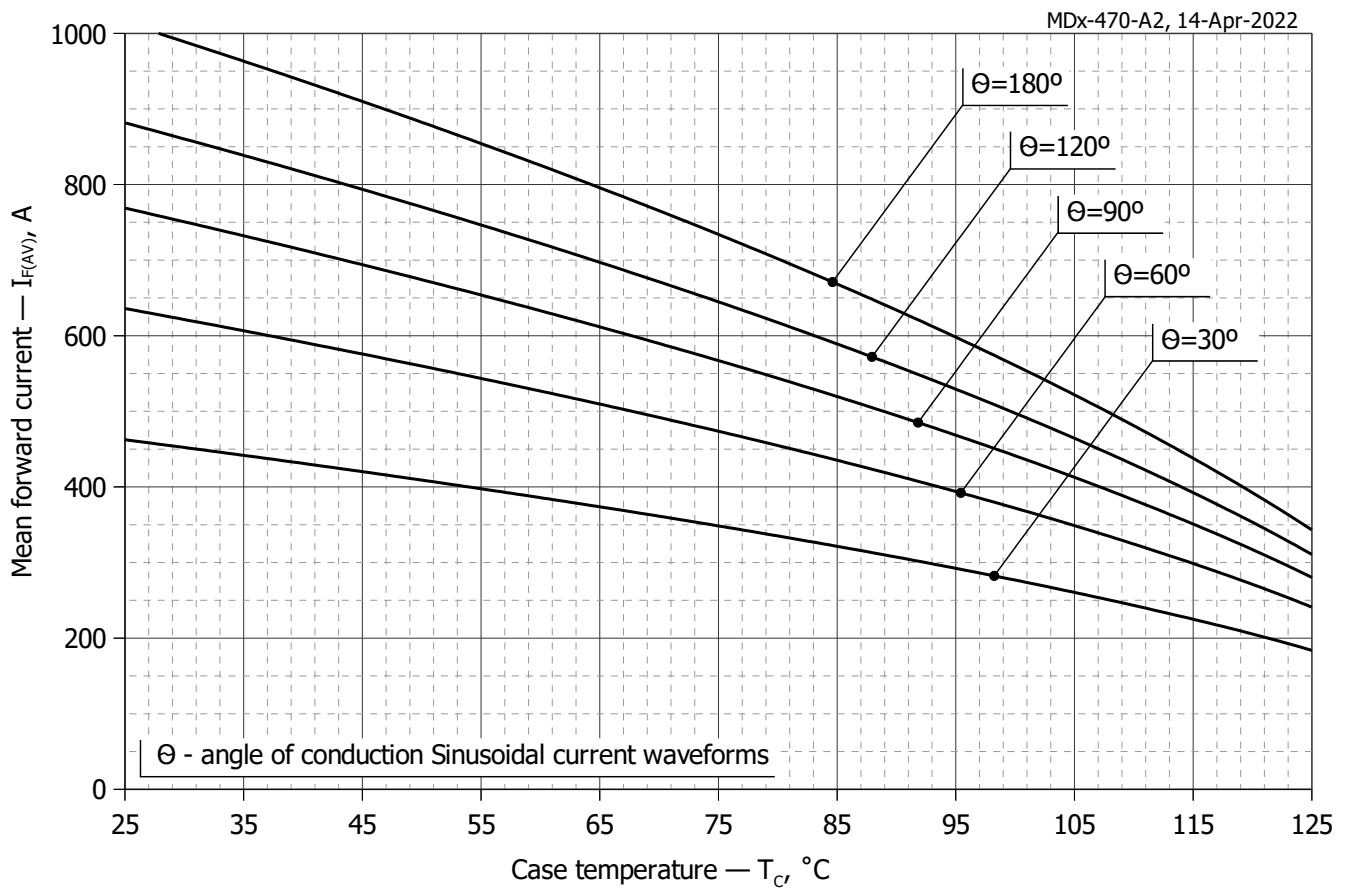
**Fig 6 - Maximum recovery time  $t_{rr}$  vs. commutation rate  $di_R/dt$  (25% chord)**



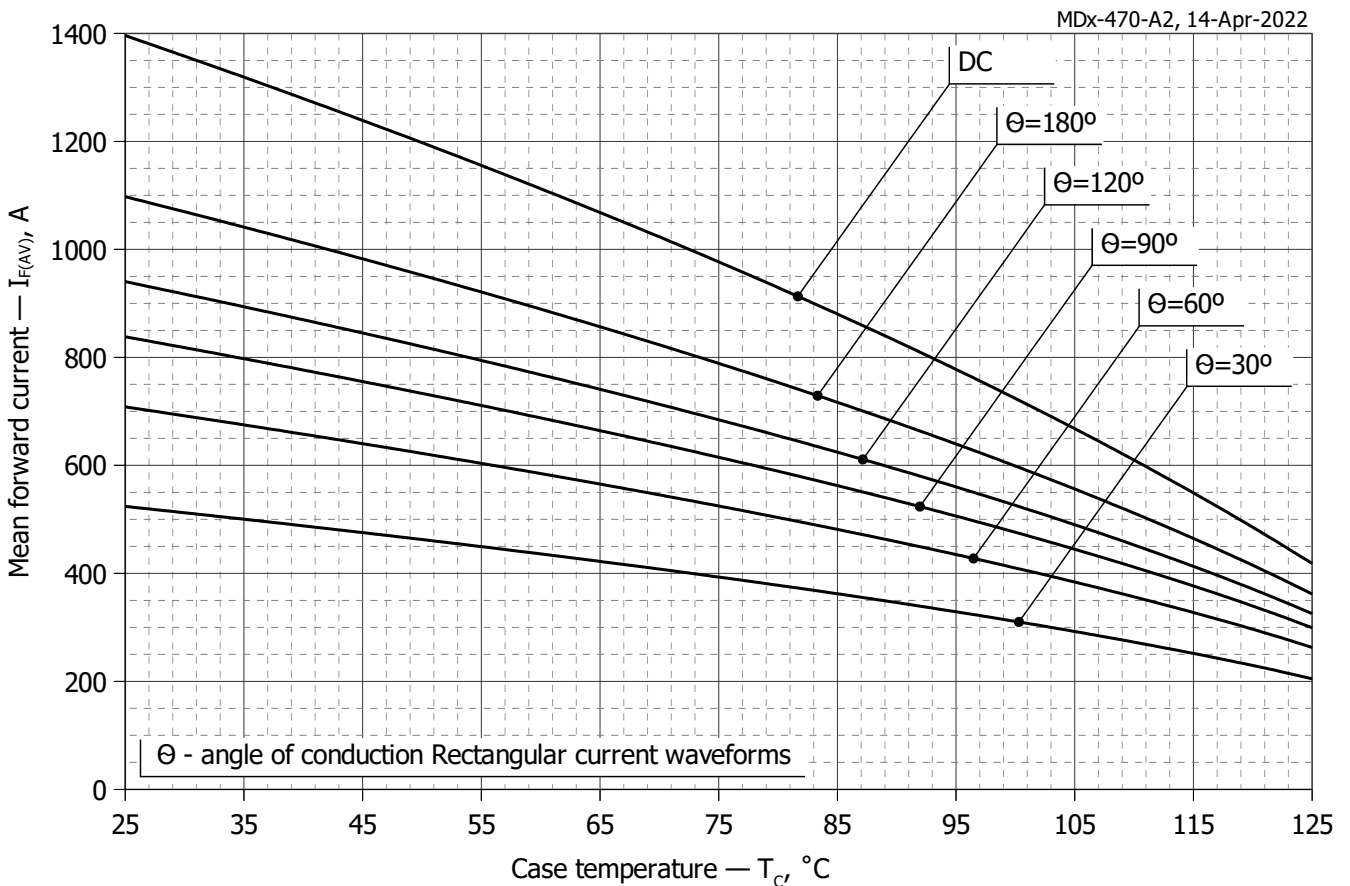
**Fig. 7 - Mean forward power dissipation  $P_{FAV}$  vs. mean forward current  $I_{FAV}$  for sinusoidal current waveforms at different conduction angles ( $f=50\text{Hz}$ )**



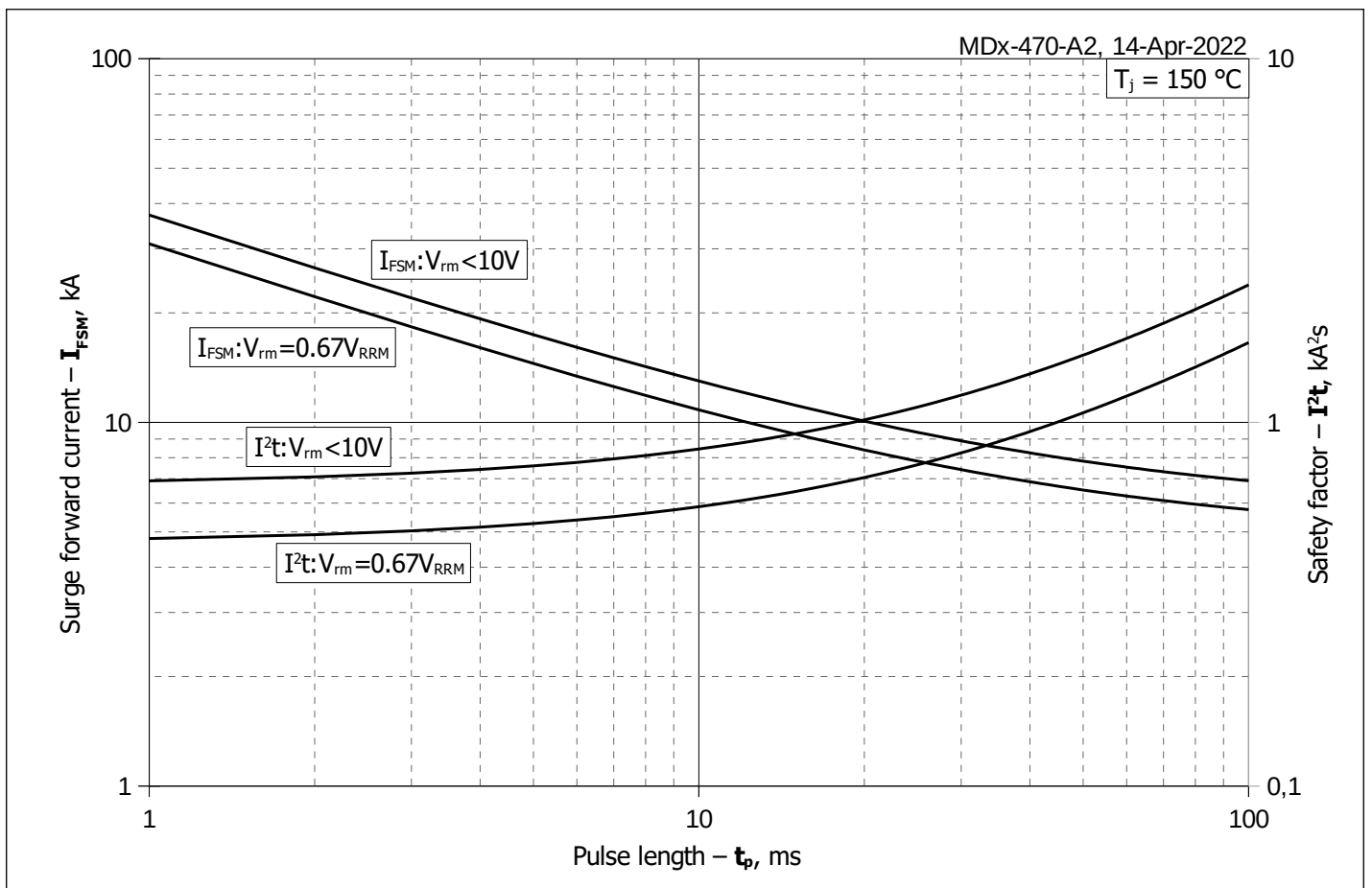
**Fig. 8 - Mean forward power dissipation  $P_{FAV}$  vs. mean forward current  $I_{FAV}$  for rectangular current waveforms at different conduction angles and for DC ( $f=50\text{Hz}$ )**



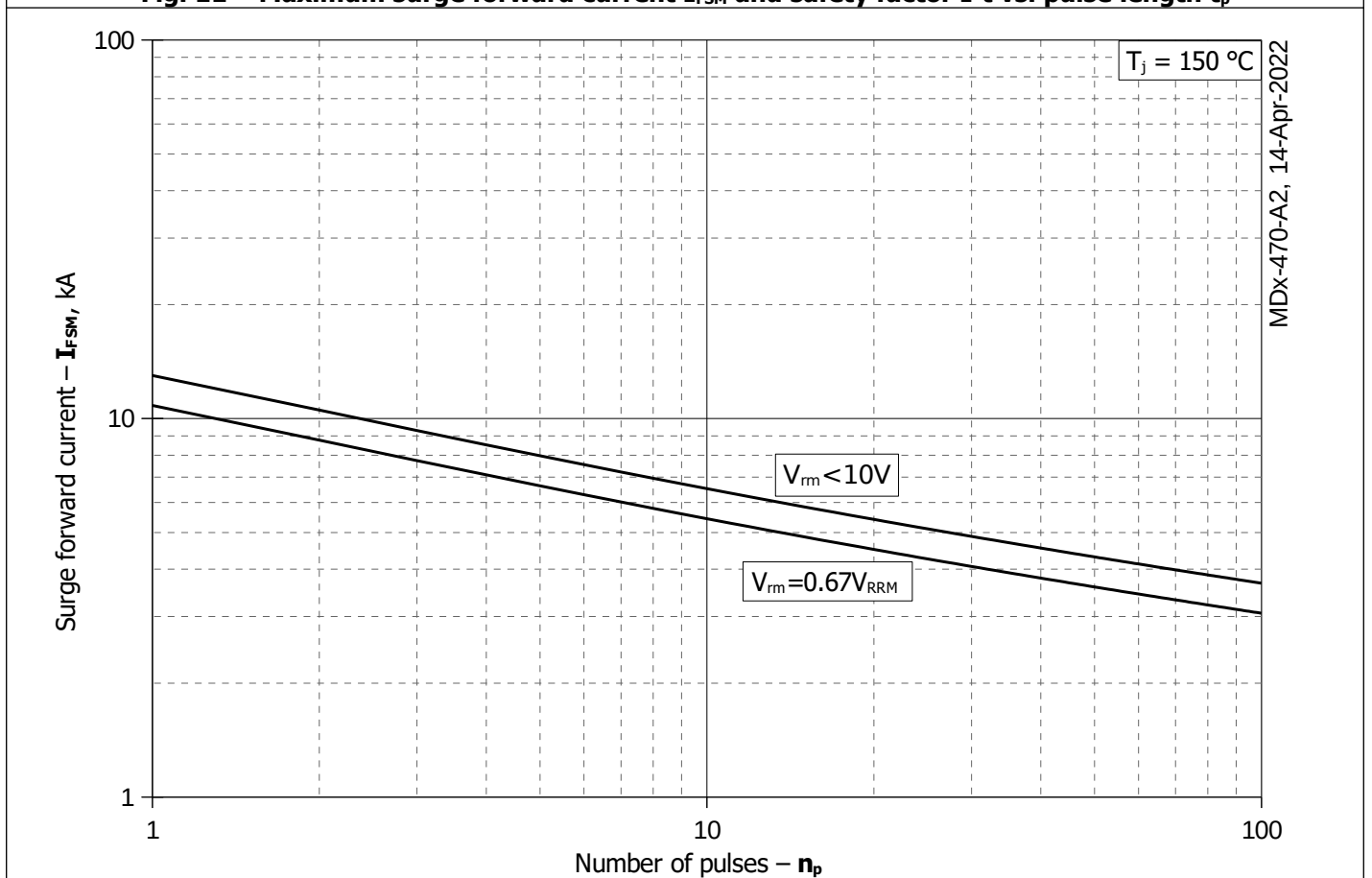
**Fig. 9 – Mean forward current  $I_{FAV}$  vs. case temperature  $T_C$  for sinusoidal current waveforms at different conduction angles ( $f=50\text{Hz}$ )**



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



**Fig. 11 – Maximum surge forward current  $I_{FSM}$  and safety factor  $I^2t$  vs. pulse length  $t_p$**



**Fig. 12 - Maximum surge forward current  $I_{FSM}$  vs. number of pulses  $n_p$**