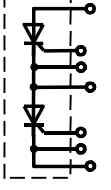
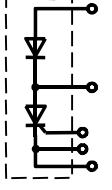
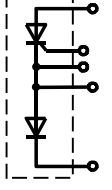
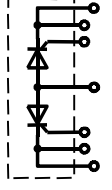
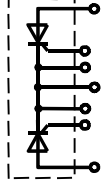
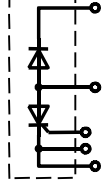
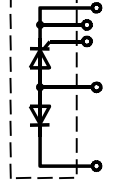


Thyristor/Diode Modules M## 500

Absolute Maximum Ratings

| V_{RRM} V_{DRM} [V] |  |  |  |  |  |  |  |
|-------------------------------|---|---|---|---|--|---|---|
| | MCC | MCD | MDC | MCA | MCK | MCDA | MDCA |
| 2000 | 500-20io1 | 500-20io1 | 500-20io1 | 500-20io1 | 500-20io1 | 500-20io1 | 500-20io1 |
| 2200 | 500-22io1 | 500-22io1 | 500-22io1 | 500-22io1 | 500-22io1 | 500-22io1 | 500-22io1 |

| | VOLTAGE RATINGS | MAXIMUM LIMITS | UNITS |
|-----------|---|----------------|-------|
| V_{DRM} | Repetitive peak off-state voltage ¹⁾ | 2000-2200 | V |
| V_{DSM} | Non-repetitive peak off-state voltage ¹⁾ | 2000-2200 | V |
| V_{RRM} | Repetitive peak reverse voltage ¹⁾ | 2000-2200 | V |
| V_{RSM} | Non-repetitive peak reverse voltage ¹⁾ | 2100-2300 | V |

| | OTHER RATINGS | MAXIMUM LIMITS | UNITS |
|----------------|--|--------------------|------------------------|
| $I_{T(AV)M}$ | Maximum average on-state current, $T_C = 80^\circ\text{C}$ ²⁾ | 500 | A |
| $I_{T(AV)M}$ | Maximum average on-state current. $T_C = 85^\circ\text{C}$ ²⁾ | 460 | A |
| $I_{T(AV)M}$ | Maximum average on-state current. $T_C = 100^\circ\text{C}$ ²⁾ | 323 | A |
| $I_{T(RMS)M}$ | Nominal RMS on-state current, $T_C = 55^\circ\text{C}$ ²⁾ | 1071 | A |
| $I_{T(d.c.)}$ | D.C. on-state current, $T_C = 55^\circ\text{C}$ | 879 | A |
| I_{TSM} | Peak non-repetitive surge $t_p = 10$ ms, $V_{RM} = 60\%V_{RRM}$ ³⁾ | 14.0 | kA |
| I_{TSM2} | Peak non-repetitive surge $t_p = 10$ ms, $V_{RM} \leq 10\text{V}$ ³⁾ | 15.4 | kA |
| I^2t | I^2t capacity for fusing $t_p = 10$ ms, $V_{RM} = 60\%V_{RRM}$ ³⁾ | 0.98×10^6 | A^2s |
| I^2t | I^2t capacity for fusing $t_p = 10$ ms, $V_{RM} \leq 10\text{V}$ ³⁾ | 1.19×10^6 | A^2s |
| $(di/dt)_{cr}$ | Critical rate of rise of on-state current (repetitive) ⁴⁾ | 150 | $\text{A}/\mu\text{s}$ |
| | Critical rate of rise of on-state current (non-repetitive) ⁴⁾ | 300 | $\text{A}/\mu\text{s}$ |
| V_{RGM} | Peak reverse gate voltage | 5 | V |
| $P_{G(AV)}$ | Mean forward gate power | 4 | W |
| P_{GM} | Peak forward gate power | 30 | W |
| V_{ISOL} | Isolation Voltage ⁵⁾ | 3500 | V |
| $T_{vj\ op}$ | Operating temperature range | -40 to +125 | $^\circ\text{C}$ |
| T_{stg} | Storage temperature range | -40 to +150 | $^\circ\text{C}$ |

Notes:

- De-rating factor of 0.13% per $^\circ\text{C}$ is applicable for T_{vj} below 25°C .
- Single phase; 50 Hz, 180° half-sinewave.
- Half-sinewave, 125°C T_{vj} initial.
- $V_D = 67\% V_{DRM}$, $I_{FG} = 2$ A, $t_r \leq 0.5\mu\text{s}$, $T_C = 125^\circ\text{C}$.
- AC RMS voltage, 50 Hz, 1min test

Thyristor Characteristics

| | PARAMETER | MIN. | TYP. | MAX. | TEST CONDITIONS ¹⁾ | UNITS |
|-----------------------|--|------|------|-------|---|-------|
| V _{TM} | Maximum peak on-state voltage | - | - | 1.65 | I _{TM} = 1700 A | V |
| V _{TM} | Maximum peak on-state voltage | - | - | 1.57 | I _{TM} = 1500 A | V |
| V _{T0} | Threshold voltage | - | - | 0.88 | | V |
| r _T | Slope resistance | - | - | 0.46 | | mΩ |
| (dv/dt) _{cr} | Critical rate of rise of off-state voltage | 1000 | - | - | V _D = 80% V _{DRM} , linear ramp, Gate o/c | V/μs |
| I _{DRM} | Peak off-state current | - | - | 70 | Rated V _{DRM} | mA |
| I _{RRM} | Peak reverse current | - | - | 70 | Rated V _{RRM} | mA |
| V _{GT} | Gate trigger voltage | - | - | 3.0 | T _{vj} = 25°C, V _D = 10 V, I _T = 3 A | V |
| I _{GT} | Gate trigger current | - | - | 300 | | mA |
| I _H | Holding current | - | - | 1000 | T _{vj} = 25°C | mA |
| t _{gd} | Gate controlled turn-on delay time | - | 0.6 | 1.5 | I _{FG} = 2 A, t _r = 0.5 μs, V _D = 67%V _{DRM} , I _{TM} = 2000 A, di/dt = 10 A/μs, T _{vj} = 25°C | μs |
| t _{gt} | Turn-on time | - | 1.2 | 2.5 | | μs |
| Q _{rr} | Recovered Charge | - | 3000 | - | | μC |
| Q _{ra} | Recovered Charge, 50% chord | - | 1800 | 2400 | I _{TM} = 1000 A, t _p = 1 ms, di/dt = 10A/μs, V _R = 50 V | μC |
| I _{rm} | Reverse recovery current | - | 140 | - | | A |
| t _{rr} | Reverse recovery time, 50% chord | - | 26 | - | | μs |
| t _q | Turn-off time | - | 200 | - | I _{TM} = 1000 A, t _p = 1 ms, di/dt = 10 A/μs, V _R = 50 V, V _{DR} = 80%V _{DRM} , dv _{DR} /dt = 20 V/μs | μs |
| | | - | 300 | - | I _{TM} = 1000 A, t _p = 1 ms, di/dt = 10 A/μs, V _R = 50 V, V _{DR} = 80%V _{DRM} , dv _{DR} /dt = 200 V/μs | |
| R _{thJC} | Thermal resistance, junction to case | - | - | 0.062 | Single Thyristor | K/W |
| | | - | - | 0.031 | Whole Module | K/W |
| R _{thCH} | Thermal resistance, case to heatsink | - | - | 0.02 | Single Thyristor | K/W |
| | | - | - | 0.01 | Whole Module | K/W |
| F ₁ | Mounting force (to heatsink) | 4.25 | - | 5.75 | | Nm |
| F ₂ | Mounting force (to terminals) | 10.2 | - | 13.8 | ²⁾ | Nm |
| W _t | Weight | - | 1.5 | - | | kg |

Diode Characteristics

| | PARAMETER | MIN. | TYP. | MAX. | TEST CONDITIONS ¹⁾ | UNITS |
|------------------|----------------------------------|------|------|-------|--|-------|
| V _{FM} | Maximum peak forward voltage | - | - | 1.09 | I _{TM} = 1700 A | V |
| V _{T0} | Threshold voltage | - | - | 0.72 | | V |
| r _T | Slope resistance | - | - | 0.143 | | mΩ |
| I _{RRM} | Peak reverse current | - | - | 50 | Rated V _{RRM} | mA |
| Q _{rr} | Recovered Charge | - | 2200 | - | | μC |
| Q _{ra} | Recovered Charge, 50% chord | - | 1800 | 2250 | I _{TM} = 1000 A, t _p = 1 ms, di/dt = 10 A/μs, V _R = 50 V | μC |
| I _{rm} | Reverse recovery current | - | 145 | - | | A |
| t _{rr} | Reverse recovery time, 50% chord | - | 25 | - | | μs |

Notes:

- 1) Unless otherwise indicated T_{vj}=125°C.
- 2) Screws must be lubricated

Notes on Ratings and Characteristics

1.0 Voltage Grade Table

| Voltage Grade | V_{DRM} V_{DSM} V_{RRM} V | V_{RSM} V | V_D V_R DC V |
|---------------|------------------------------------|----------------|---------------------|
| 20 | 2000 | 2100 | 1250 |
| 22 | 2200 | 2300 | 1350 |

2.0 Extension of Voltage Grades

This report is applicable to other voltage grades when supply has been agreed by Sales/Production.

3.0 De-rating Factor

A blocking voltage de-rating factor of 0.13%/°C is applicable to this device for T_{vj} below 25°C.

4.0 Repetitive dv/dt

Standard dv/dt is 1000V/μs.

5.0 Snubber Components

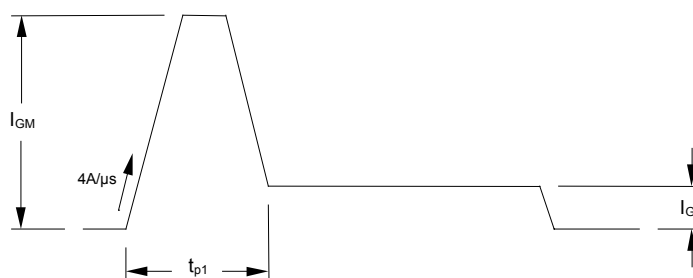
When selecting snubber components, care must be taken not to use excessively large values of snubber capacitor or excessively small values of snubber resistor. Such excessive component values may lead to device damage due to the large resultant values of snubber discharge current. If required, please consult the factory for assistance.

6.0 Rate of rise of on-state current

The maximum un-primed rate of rise of on-state current must not exceed 300A/μs at any time during turn-on on a non-repetitive basis. For repetitive performance, the on-state rate of rise of current must not exceed 150A/μs at any time during turn-on. Note that these values of rate of rise of current apply to the total device current including that from any local snubber network.

7.0 Gate Drive

The nominal requirement for a typical gate drive is illustrated below. An open circuit voltage of at least 30V is assumed. This gate drive must be applied when using the full di/dt capability of the device.



The magnitude of I_{GM} should be between five and ten times I_{GT} , which is shown on page 2. Its duration (t_{p1}) should be 20μs or sufficient to allow the anode current to reach ten times I_L , whichever is greater. Otherwise, an increase in pulse current could be needed to supply the necessary charge to trigger. The 'back-porch' current I_G should remain flowing for the same duration as the anode current and have a magnitude in the order of 1.5 times I_{GT} .

8.0 Computer Modelling Parameters

8.1 Thyristor Dissipation Calculations

$$I_{AV} = \frac{-V_{T0} + \sqrt{V_{T0}^2 + 4 \cdot ff^2 \cdot r_T \cdot W_{AV}}}{2 \cdot ff^2 \cdot r_T} \quad \text{and:} \quad W_{AV} = \frac{\Delta T}{R_{th}}$$

$$\Delta T = T_{j \max} - T_K$$

Where $V_{T0} = 0.88 \text{ V}$, $r_T = 0.46 \text{ m}\Omega$,

R_{th} = Supplementary thermal impedance, see table below and

ff = Form factor, see table below.

| Supplementary Thermal Impedance | | | | | | | |
|---------------------------------|---------|---------|---------|---------|---------|---------|-------|
| Conduction Angle | 30° | 60° | 90° | 120° | 180° | 270° | d.c. |
| Square wave | 0.07067 | 0.06791 | 0.06629 | 0.06525 | 0.06395 | 0.06277 | 0.062 |
| Sine wave | 0.06767 | 0.06536 | 0.06408 | 0.0633 | 0.062 | | |

| Form Factors | | | | | | | |
|------------------|-------|-------|------|-------|-------|-------|------|
| Conduction Angle | 30° | 60° | 90° | 120° | 180° | 270° | d.c. |
| Square wave | 3.464 | 2.449 | 2 | 1.732 | 1.414 | 1.149 | 1 |
| Sine wave | 3.98 | 2.778 | 2.22 | 1.879 | 1.57 | | |

8.2 Calculating V_T/V_F using ABCD Coefficients

The on-state/forward characteristics, I_T vs. V_T , on pages 6 & 9 are represented in two ways;

- the well established V_{T0} and r_T tangent used for rating purposes and
- a set of constants A, B, C, D, forming the coefficients of the representative equation for V_T in terms of I_T given below:

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

The constants, derived by curve fitting software, are given below for both hot and cold characteristics. The resulting values for V_T agree with the true device characteristic over a current range, which is limited to that plotted.

| Thyristor coefficients | | |
|------------------------|----------------------------|--------------------------|
| | 25°C | 125°C |
| A | 2.296566505 | 0.617965877 |
| B | -0.3387419 | 0.01056009 |
| C | -6.25982×10^{-5} | 2.13809×10^{-4} |
| D | 0.04767141 | 0.01430982 |
| Diode coefficients | | |
| | 25°C | 125°C |
| A | 0.578986196 | -0.214099731 |
| B | 0.1048225 | 0.2916851 |
| C | 1.61162×10^{-4} | 5.15459×10^{-4} |
| D | -7.480625×10^{-3} | -0.04232154 |

8.3 D.C. Thermal Impedance Calculation

$$r_t = \sum_{p=1}^{p=n} r_p \cdot \left(1 - e^{-\frac{t}{\tau_p}} \right)$$

Where $p = 1$ to n

- n = number of terms in the series
- t = Duration of heating pulse in seconds.
- r_t = Thermal resistance at time t .
- r_p = Amplitude of p_{th} term.
- τ_p = Time Constant of r_{th} term.

The coefficients for this device are shown in the tables below:

| D.C. | | | | |
|----------|---------|-------------------------|-------------------------|-------------------------|
| Term | 1 | 2 | 3 | 4 |
| r_p | 0.05428 | 4.4894×10^{-3} | 2.3382×10^{-3} | 0.8759×10^{-3} |
| τ_p | 2.69428 | 0.126017 | 0.013878 | 1.435×10^{-3} |

9.0 Reverse recovery ratings

- (i) Q_{ra} is based on 50% I_{rm} chord as shown in Fig. 1

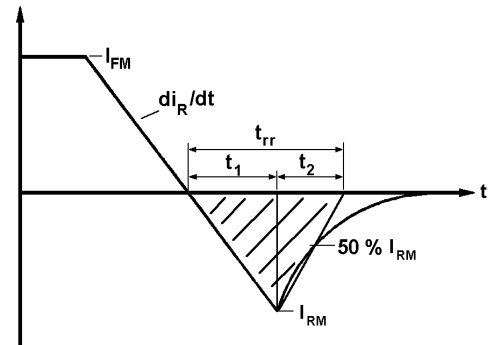


Fig. 1

- (ii) Q_{rr} is based on a $150 \mu s$ integration time i.e.

$$Q_{rr} = \int_0^{150 \mu s} i_{rr} \cdot dt$$

- (iii)

$$K \text{ Factor} = \frac{t_1}{t_2}$$

Thyristor Curves

Figure 1 – On-state characteristics of Limit device

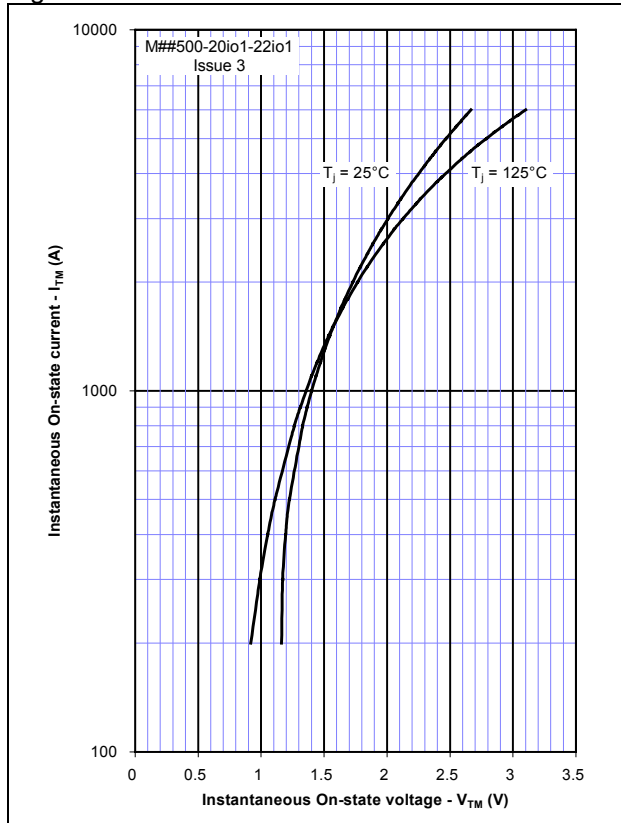


Figure 2 – Transient thermal impedance

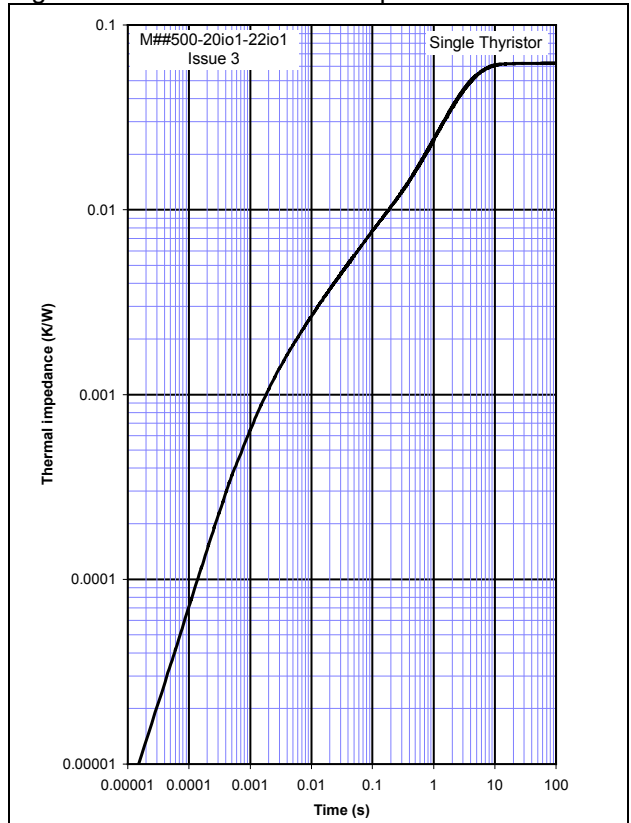


Figure 3 – Gate characteristics - Trigger limits

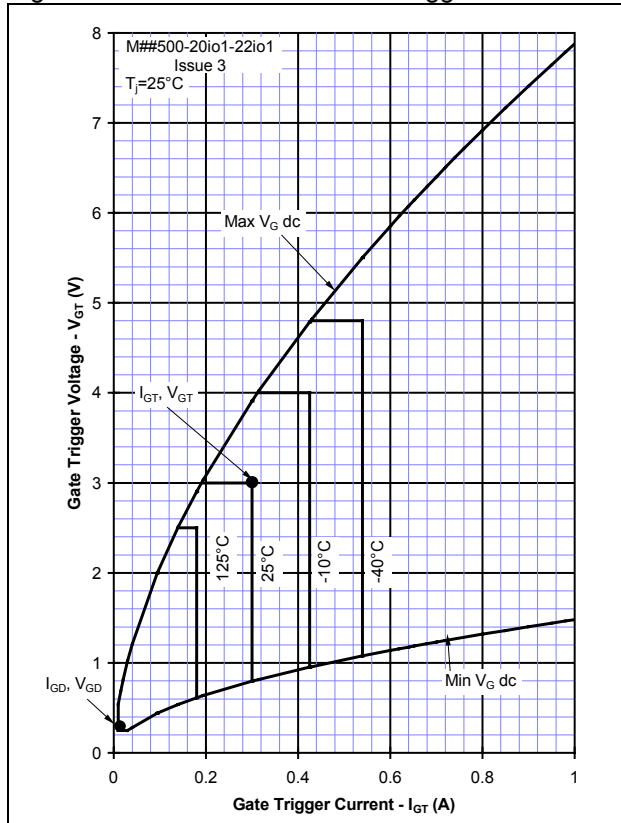


Figure 4 – Gate characteristics – Power curves

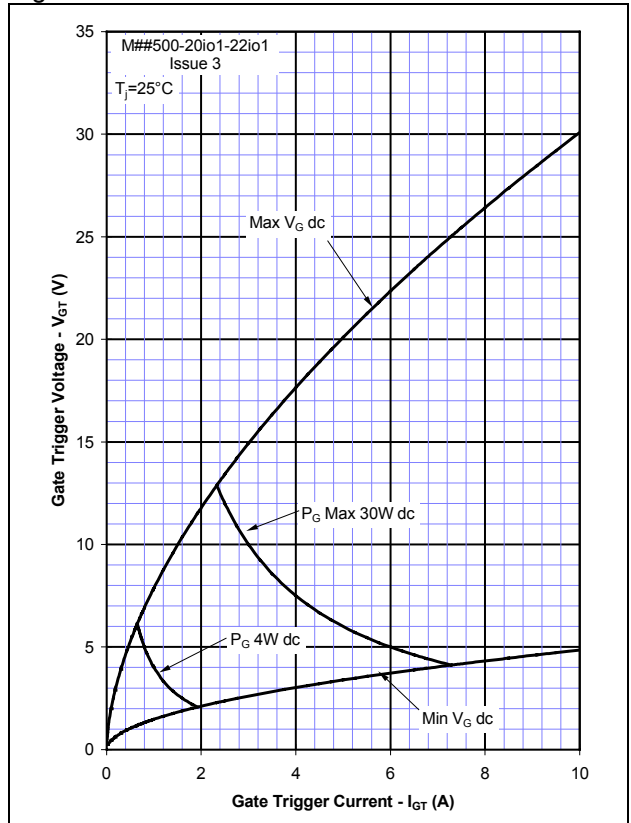


Figure 5 – Total recovered charge, Q_{rr}

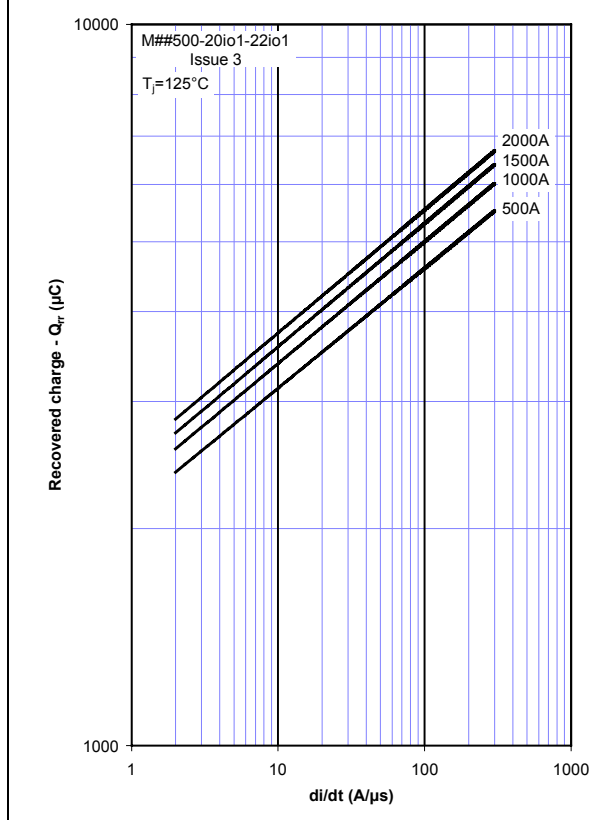


Figure 6 – Recovered charge, Q_{ra} (50% chord)

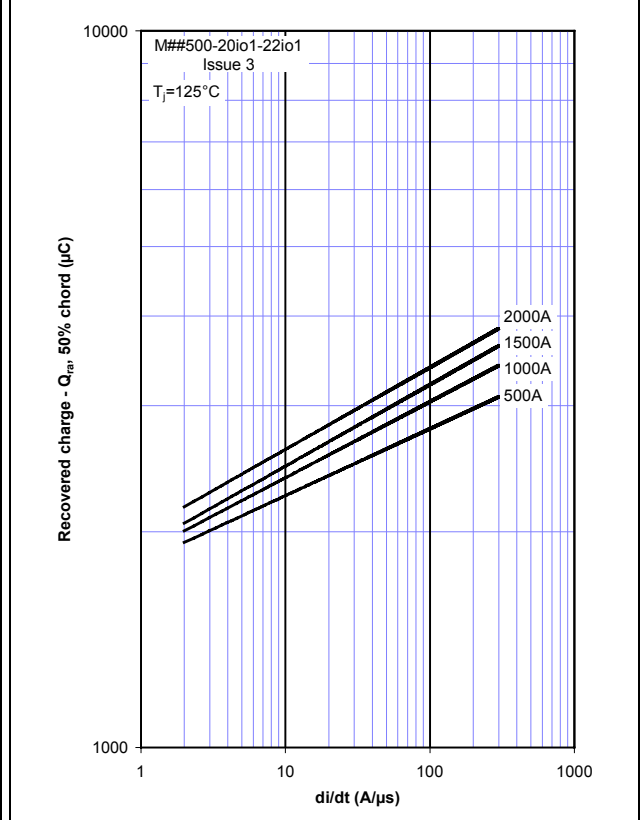


Figure 7 – Peak reverse recovery current, I_{rm}

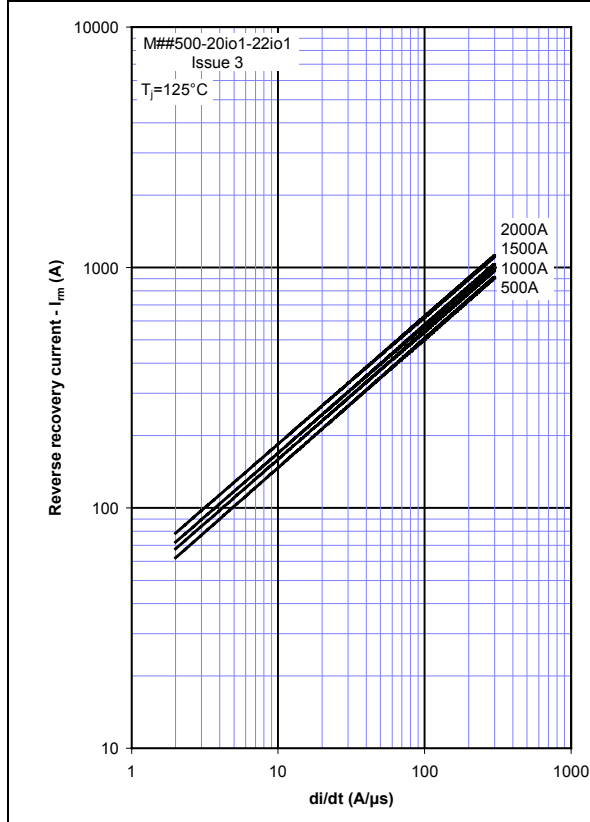


Figure 8 – Maximum recovery time, t_{rr} (50% chord)

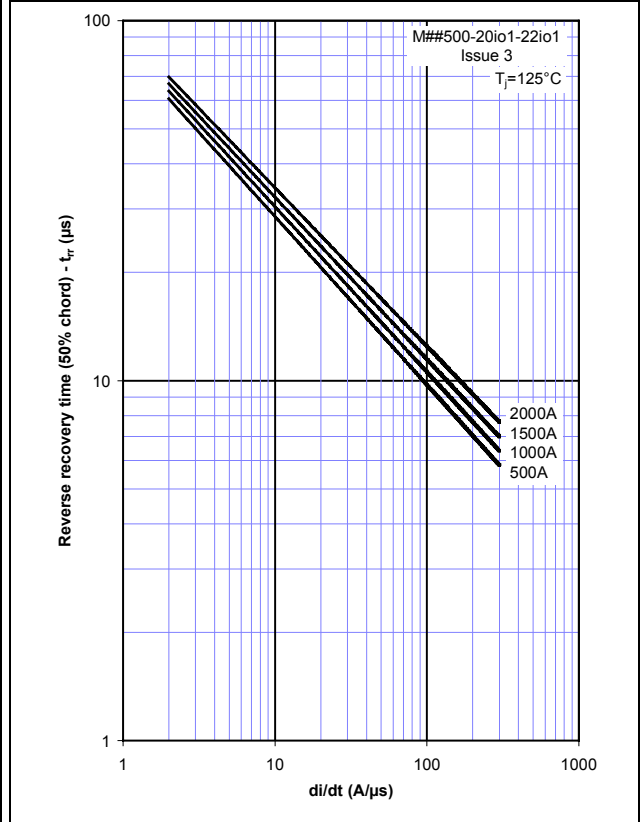


Figure 9 – On-state current vs. Power dissipation – Sine wave

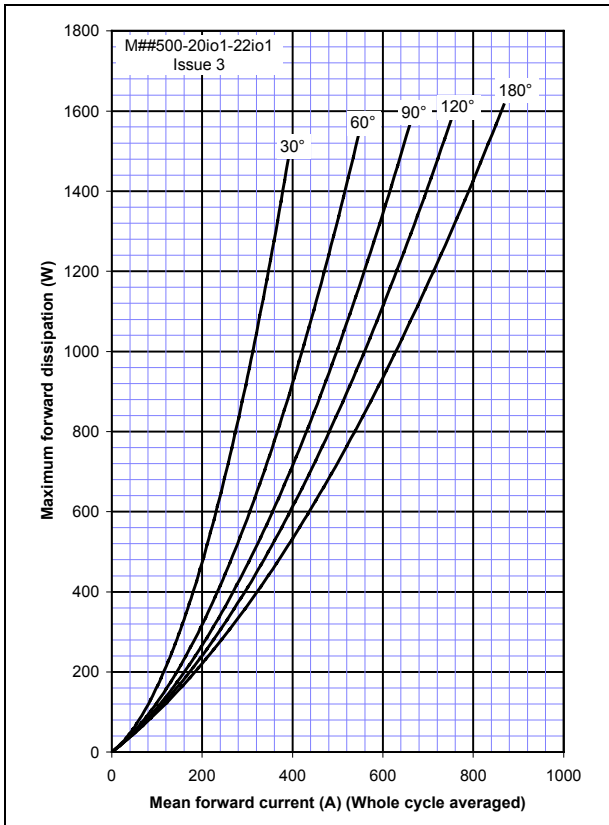


Figure 10 – On-state current vs. case temperature – Sine wave

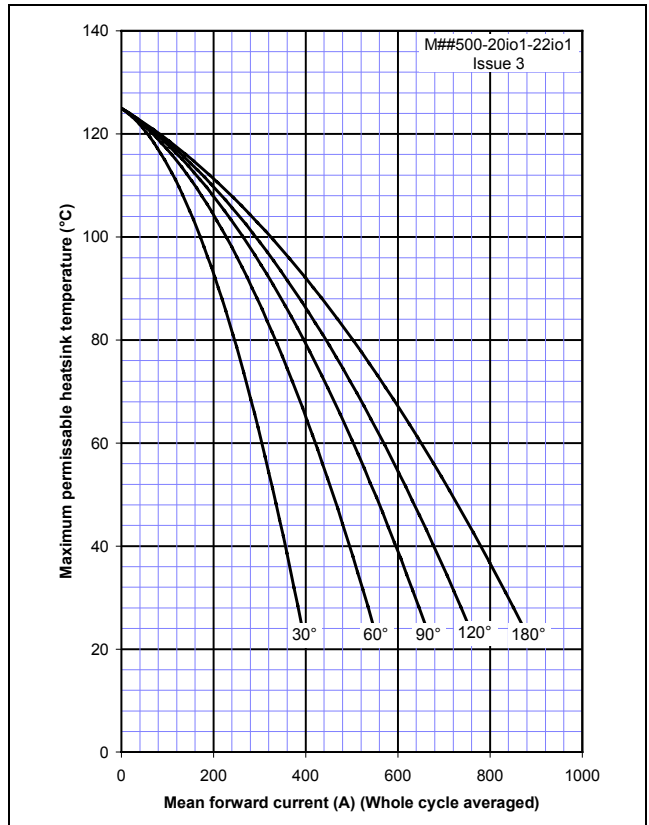


Figure 11 – On-state current vs. Power dissipation – Square wave

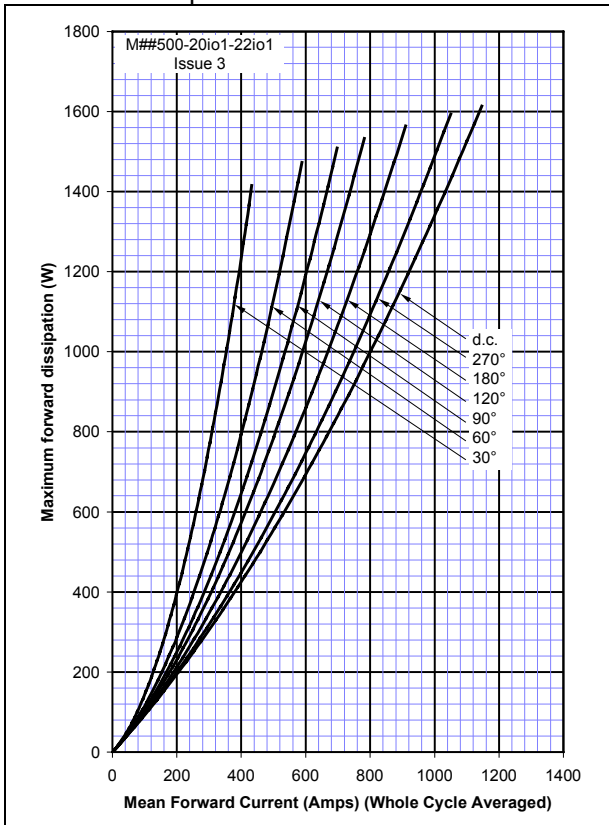


Figure 12 – On-state current vs. case temperature – Square wave

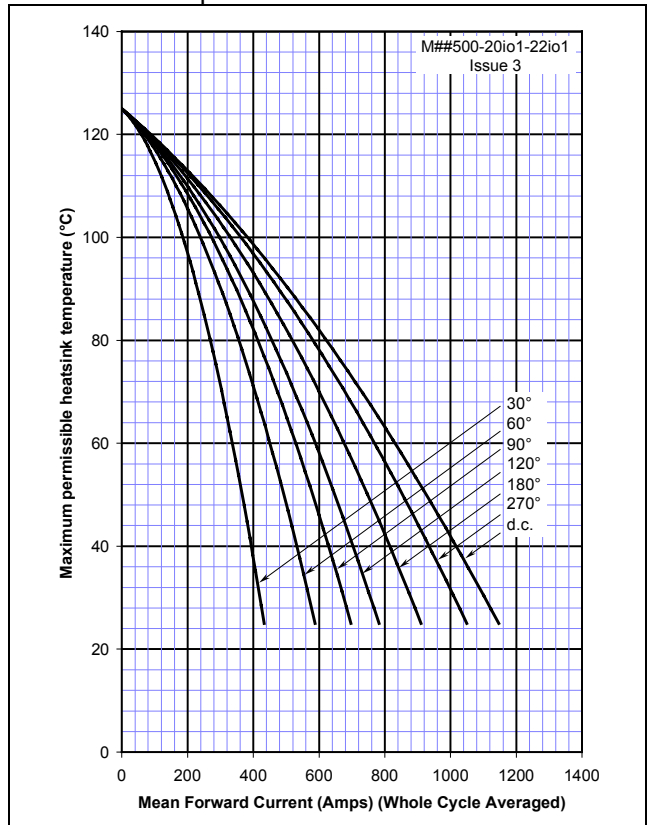
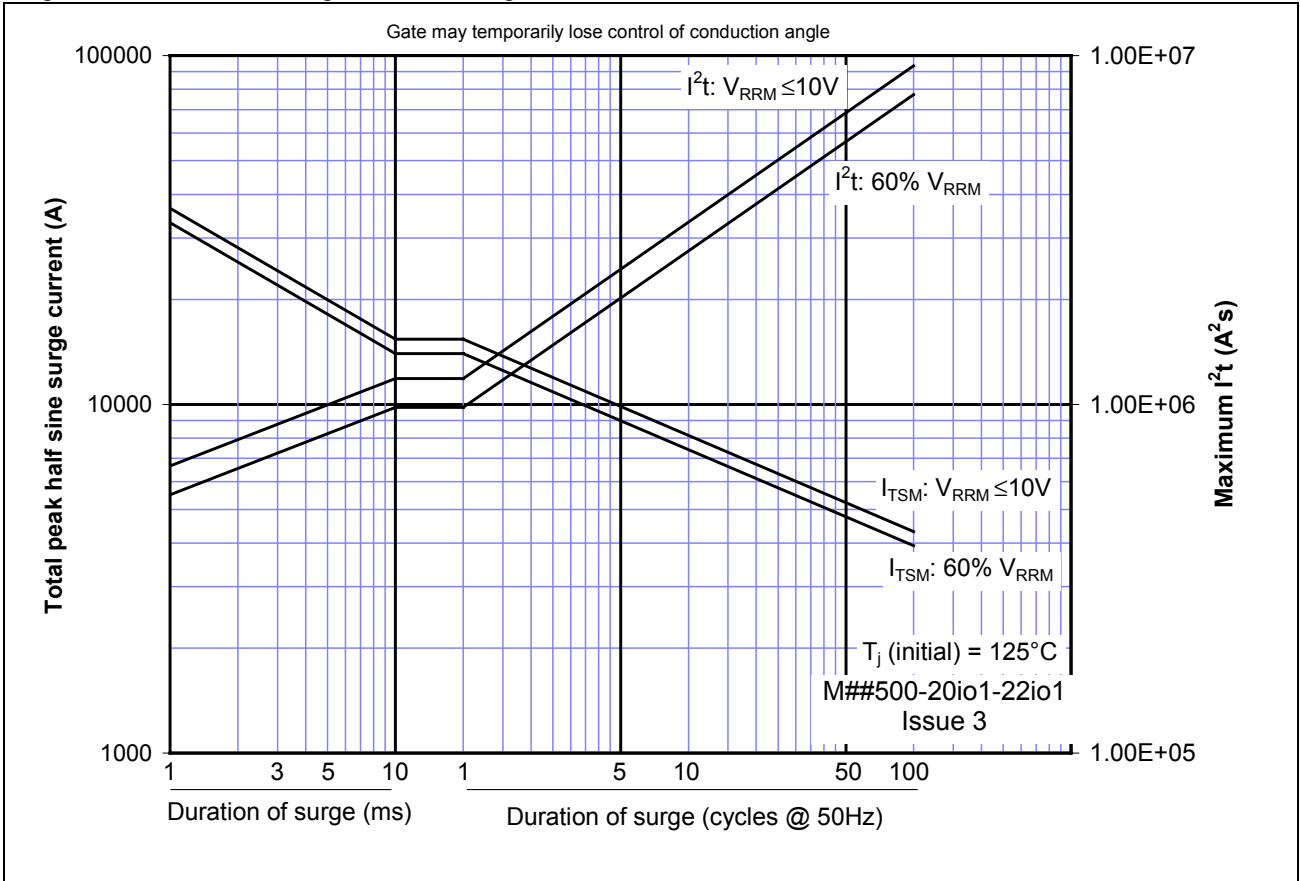


Figure 13 – Maximum surge and I²t Ratings



Diode curves

Figure 14 – Instantaneous forward voltage V_F

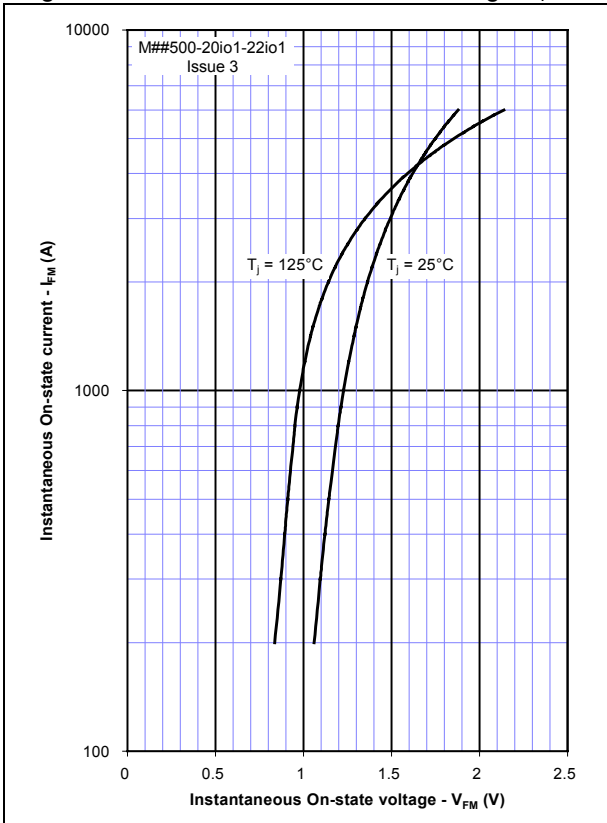


Figure 15 – Transient thermal impedance

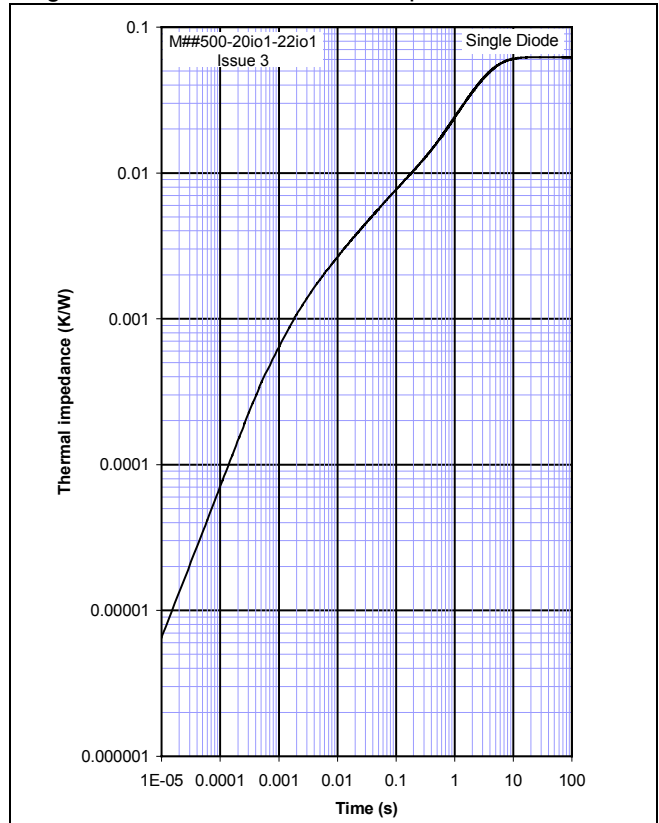


Figure 16 – Total recovered charge, Q_{rr}

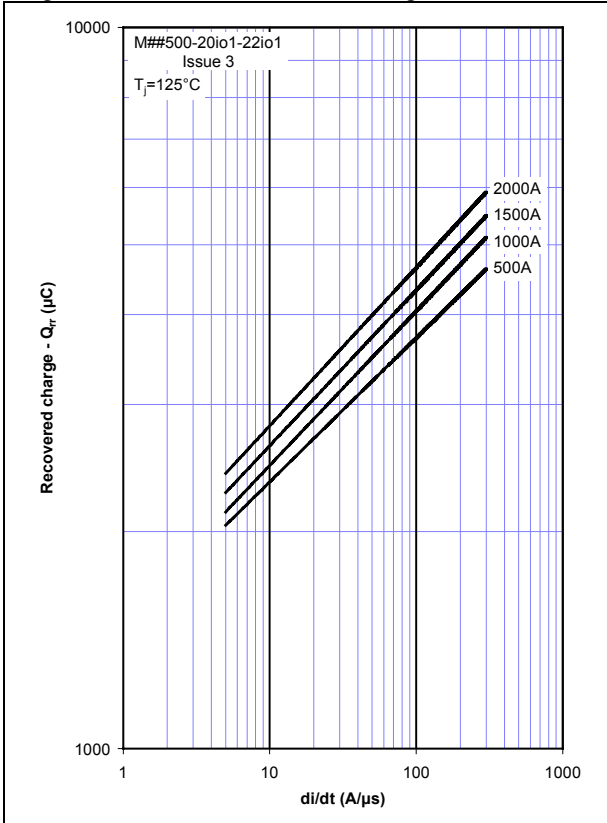


Figure 17 – Recovered charge, Q_{ra} (50% chord)

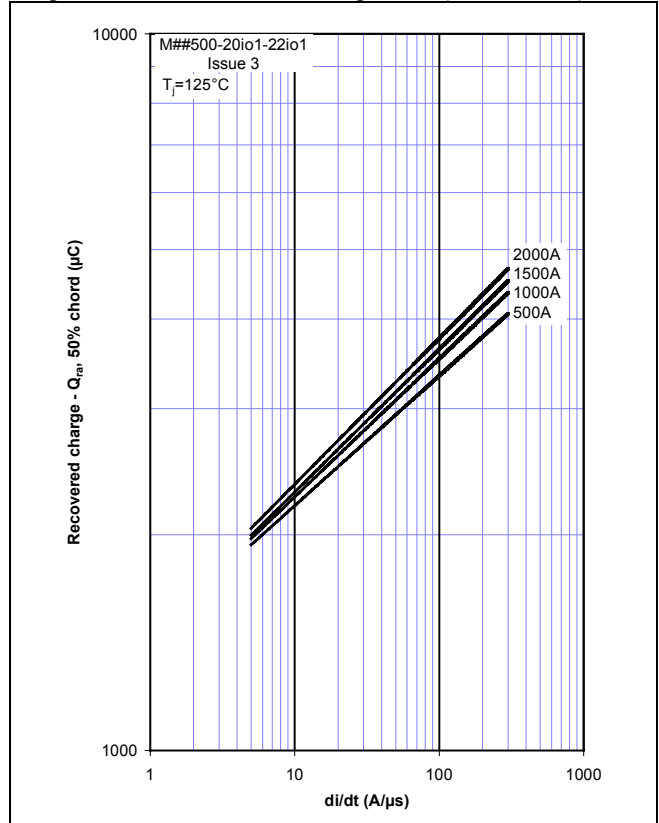


Figure 18 – Peak reverse recovery current, I_{rm}

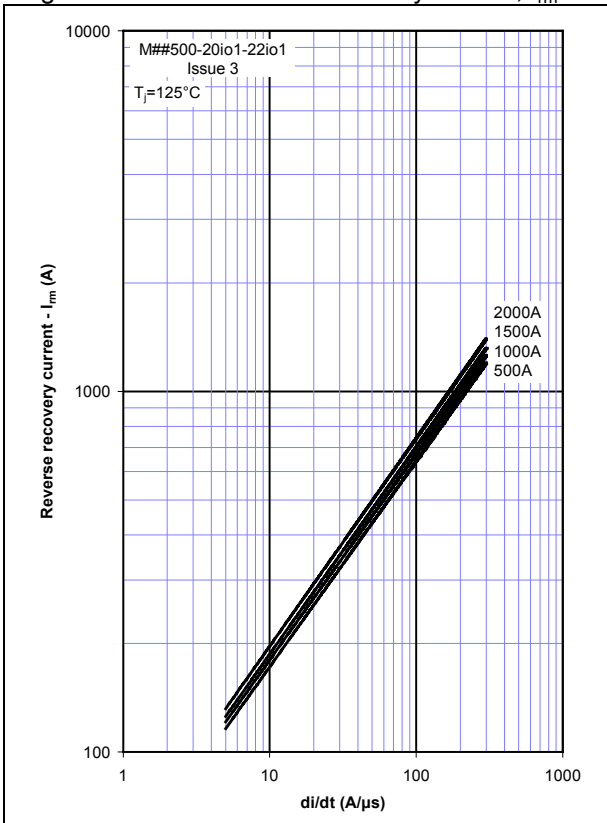
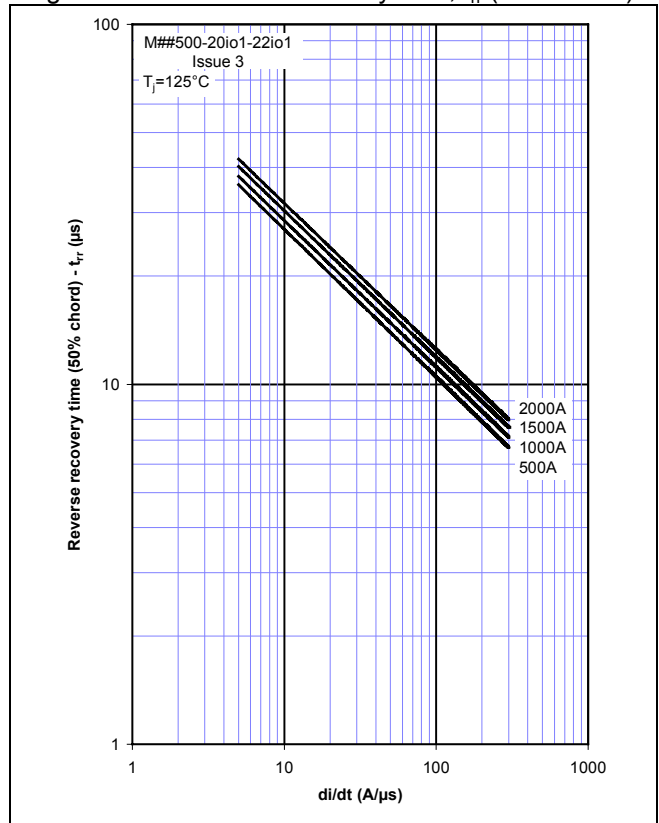
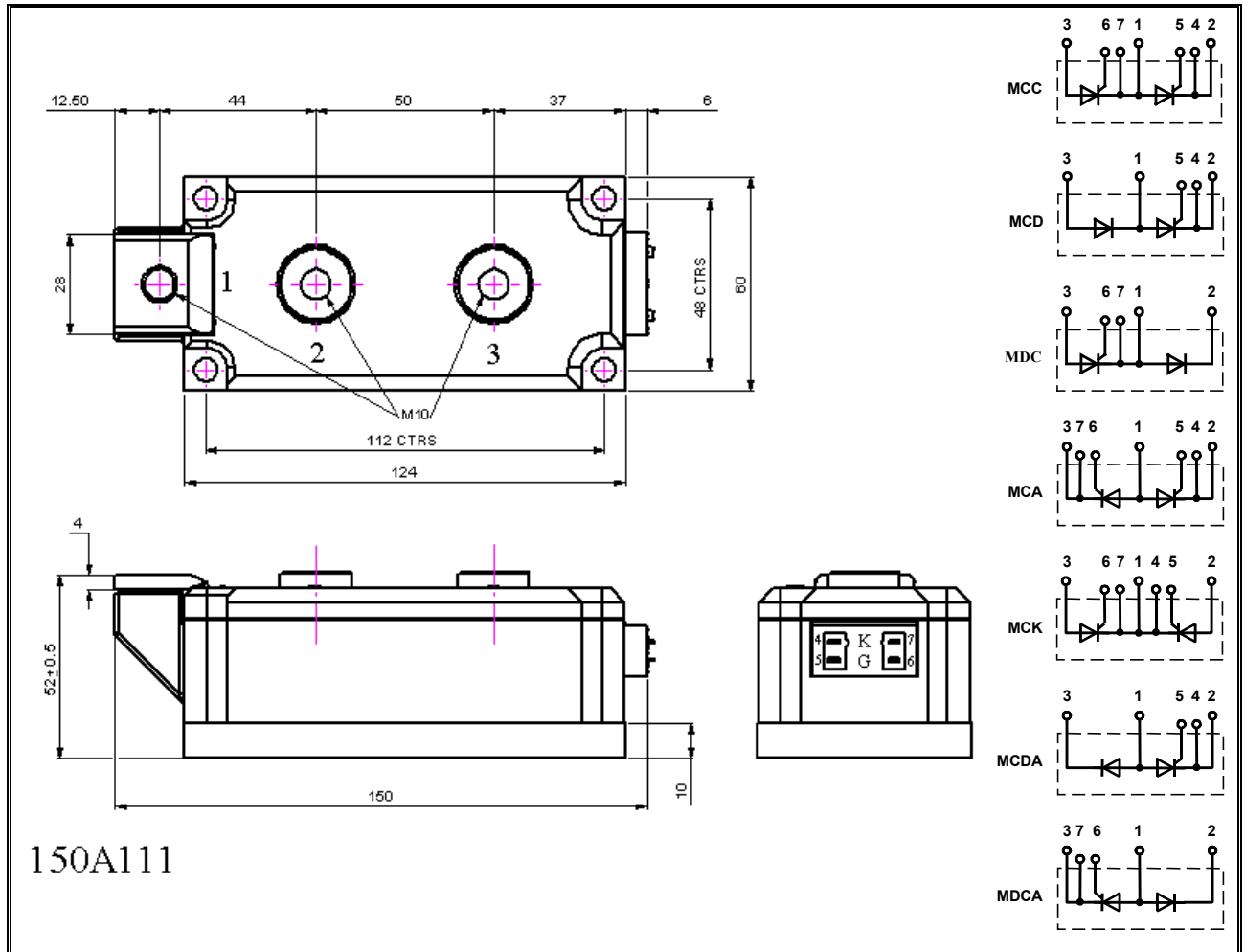


Figure 19 – Maximum recovery time, t_{rr} (50% chord)



Outline Drawing & Ordering Information



150A111

ORDERING INFORMATION

(Please quote 11 digit code as below)

| | | | | | |
|-----------------|---|------------------------|--|---|--------------------|
| M | ## | 500 | ◆◆ | io | 1 |
| Fixed Type Code | Configuration code CC, CD, DC, CA, CK, CDA, DCA | Average Current Rating | Voltage code $V_{RRM}/100$ 20-22 | i = Critical dv/dt 1000 V/μs o = Typical turn-off time | Fixed Version Code |

Order code: MCD500-20io1– MCD configuration, 2000V V_{RRM}

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