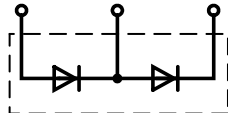
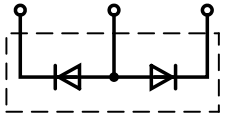
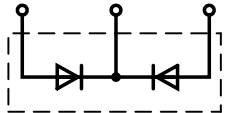


## Dual Diode Modules

### MD#410-24N3 & MD#410-28N3

#### Absolute Maximum Ratings

| $V_{RRM}$<br>[V] |  |  |  |
|------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|                  | MDD                                                                               | MDA                                                                                | MDK                                                                                 |
| 2400             | 410-24N3                                                                          | 410-24N3                                                                           | 410-24N3                                                                            |
| 2800             | 410-28N3                                                                          | 410-28N3                                                                           | 410-28N3                                                                            |

|           | VOLTAGE RATINGS                                   | MAXIMUM LIMITS | UNITS |
|-----------|---------------------------------------------------|----------------|-------|
| $V_{RRM}$ | Repetitive peak reverse voltage <sup>1)</sup>     | 2400-2800      | V     |
| $V_{RSM}$ | Non-repetitive peak reverse voltage <sup>1)</sup> | 2500-2900      | V     |

|                    | OTHER RATINGS                                                                             | MAXIMUM LIMITS | UNITS                 |
|--------------------|-------------------------------------------------------------------------------------------|----------------|-----------------------|
| $I_{F(AV)M}$       | Maximum average on-state current, $T_C = 85^\circ\text{C}$ <sup>2)</sup>                  | 440            | A                     |
| $I_{F(AV)M}$       | Maximum average on-state current, $T_C = 100^\circ\text{C}$ <sup>2)</sup>                 | 360            | A                     |
| $I_{F(RMS)M}$      | Nominal RMS on-state current, $T_C = 55^\circ\text{C}$                                    | 910            | A                     |
| $I_{F(d.c.)}$      | D.C. on-state current, $T_C = 55^\circ\text{C}$                                           | 730            | A                     |
| $I_{FSM}$          | Peak non-repetitive surge $t_p = 10\text{ ms}$ , $V_{RM} = 60\%V_{RRM}$ <sup>3)</sup>     | 7.8            | kA                    |
| $I_{FSM2}$         | Peak non-repetitive surge $t_p = 10\text{ ms}$ , $V_{RM} \leq 10\text{ V}$ <sup>3)</sup>  | 8.5            | kA                    |
| $I^2t$             | $I^2t$ capacity for fusing $t_p = 10\text{ ms}$ , $V_{RM} = 60\%V_{RRM}$ <sup>3)</sup>    | 304            | $\text{kA}^2\text{s}$ |
| $I^2t$             | $I^2t$ capacity for fusing $t_p = 10\text{ ms}$ , $V_{RM} \leq 10\text{ V}$ <sup>3)</sup> | 361            | $\text{kA}^2\text{s}$ |
| $V_{ISOL}$         | Isolation Voltage <sup>4)</sup>                                                           | 3000           | V                     |
| $T_{vj\text{ op}}$ | Operating temperature range                                                               | -40 to +150    | $^\circ\text{C}$      |
| $T_{stg}$          | Storage temperature range                                                                 | -40 to +150    | $^\circ\text{C}$      |

#### Notes:

- 1) De-rating factor of 0.13% per  $^\circ\text{C}$  is applicable for  $T_{vj}$  below  $25^\circ\text{C}$ .
- 2) Single phase; 50 Hz,  $180^\circ$  half-sinewave.
- 3) Half-sinewave,  $150^\circ\text{C}$   $T_{vj}$  initial.
- 4) AC RMS voltage, 50 Hz, 1min test

## Characteristics

|                   | PARAMETER                                   | MIN. | TYP. | MAX.  | TEST CONDITIONS <sup>1)</sup>                                                        | UNITS |
|-------------------|---------------------------------------------|------|------|-------|--------------------------------------------------------------------------------------|-------|
| V <sub>FM</sub>   | Maximum peak forward voltage                | -    | -    | 1.40  | I <sub>FM</sub> = 785 A, T <sub>VJ</sub> =25°C                                       | V     |
| V <sub>T0</sub>   | Threshold voltage                           | -    | -    | 0.85  |                                                                                      | V     |
| r <sub>T</sub>    | Slope resistance                            | -    | -    | 0.45  |                                                                                      | mΩ    |
| I <sub>RRM</sub>  | Peak reverse current                        | -    | -    | 30    | Rated V <sub>RRM</sub>                                                               | mA    |
| Q <sub>rr</sub>   | Recovered Charge                            | -    | 1800 | 2000  | I <sub>TM</sub> = 320A, t <sub>p</sub> =1ms, di/dt =10A/μs,<br>V <sub>R</sub> =100 V | μC    |
| Q <sub>ra</sub>   | Recovered Charge, 50% chord                 | -    | 1600 | -     |                                                                                      | μC    |
| I <sub>rm</sub>   | Reverse recovery current                    | -    | 130  | -     |                                                                                      | A     |
| t <sub>rr</sub>   | Reverse recovery time, 50% chord            | -    | 25   | -     |                                                                                      | μs    |
| R <sub>thJC</sub> | Thermal resistance, junction to case        | -    | -    | 0.11  | Single Diode                                                                         | K/W   |
|                   |                                             | -    | -    | 0.055 | Whole Module                                                                         | K/W   |
| R <sub>thCH</sub> | Thermal resistance, case to heatsink        | -    | -    | 0.04  | Single Diode                                                                         | K/W   |
|                   |                                             | -    | -    | 0.02  | Whole Module                                                                         | K/W   |
| F <sub>1</sub>    | Mounting force (to heatsink) <sup>2)</sup>  | 5.1  | -    | 6.9   |                                                                                      | Nm    |
| F <sub>2</sub>    | Mounting force (to terminals) <sup>2)</sup> | 7.65 | -    | 10.35 |                                                                                      | Nm    |
| W <sub>t</sub>    | Weight                                      | -    | 800  | -     |                                                                                      | g     |

### Notes:

- 1) Unless otherwise indicated T<sub>vj</sub>=150°C.
- 2) Screws must be lubricated.

## Notes on Ratings and Characteristics

### 1.0 Voltage Grade Table

| Voltage Grade | V <sub>RRM</sub><br>V | V <sub>RSM</sub><br>V | V <sub>R</sub><br>DC V |
|---------------|-----------------------|-----------------------|------------------------|
| 2400          | 2400                  | 2500                  | 1800                   |
| 2800          | 2800                  | 2900                  | 2100                   |

### 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<sub>vj</sub> below 25°C.

### 4.0 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.

### 5.0 Computer Modelling Parameters

#### 5.1 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<sub>T0</sub> = 0.85 V, r<sub>T</sub> = 0.45 mΩ.

R<sub>th</sub> = 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                     | 0.1169 | 0.1136 | 0.1125 | 0.1119 | 0.1111 | 0.1105 | 0.1100 |
| Sine wave                       | 0.1110 | 0.1104 | 0.1103 | 0.1102 | 0.1100 |        |        |

| 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  |       |      |

## 5.2 Calculating diode $V_F$ using ABCD Coefficients

The forward characteristic  $I_F$  vs.  $V_F$ , on page 6 is represented by a set of constants A, B, C, D, forming the coefficients of the representative equation for  $V_F$  in terms of  $I_F$  given below:

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

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

| 25°C Coefficients |                            | 150°C Coefficients |                          |
|-------------------|----------------------------|--------------------|--------------------------|
| A                 | 0.9038659                  | A                  | 0.6040343                |
| B                 | 0.03689063                 | B                  | 0.04159079               |
| C                 | $3.62148 \times 10^{-4}$   | C                  | $3.99019 \times 10^{-4}$ |
| D                 | $-1.194003 \times 10^{-4}$ | D                  | $4.39622 \times 10^{-4}$ |

## 5.3 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  $n$  and:

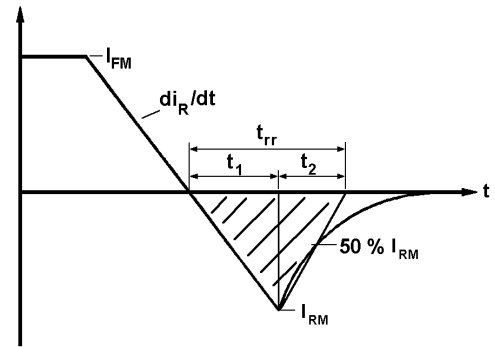
- n = number of terms in the series
- t = Duration of heating pulse in seconds
- $r_t$  = Thermal resistance at time t
- $r_p$  = Amplitude of  $p_{th}$  term
- $\tau_p$  = Time Constant of  $r_{th}$  term

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

| D.C. Single Diode |            |            |                           |                          |
|-------------------|------------|------------|---------------------------|--------------------------|
| Term              | 1          | 2          | 3                         | 4                        |
| $r_p$             | 0.07710048 | 0.02402733 | $8.295585 \times 10^{-3}$ | $6.2613 \times 10^{-4}$  |
| $\tau_p$          | 2.816585   | 0.7063744  | 0.1730958                 | $3.79616 \times 10^{-4}$ |

## 6.0 Reverse recovery ratings

(i)  $Q_{rr}$  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)  $K \text{ Factor} = \frac{t_1}{t_2}$

## Curves

Figure 1 – Forward characteristics of Limit device

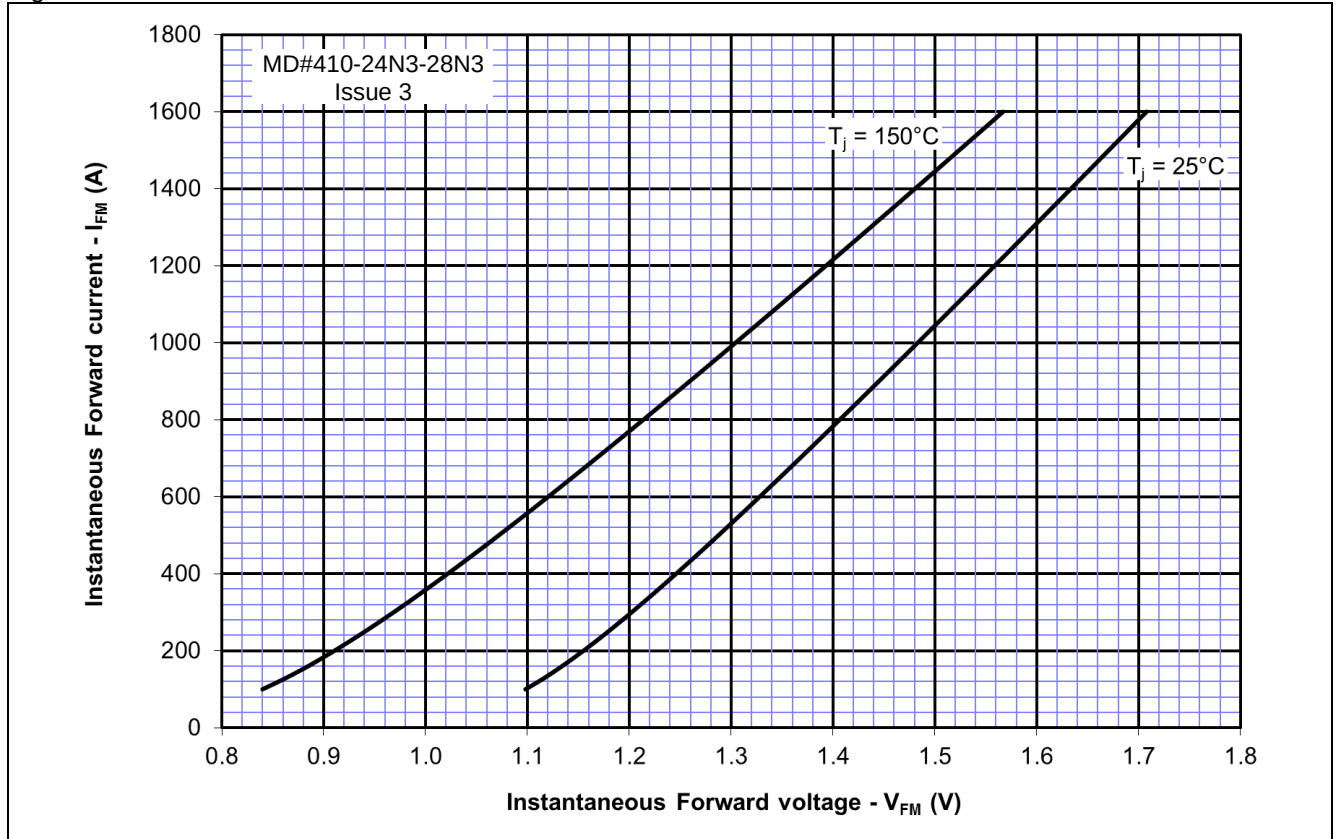


Figure 2 – Maximum surge and  $I^2t$  Ratings

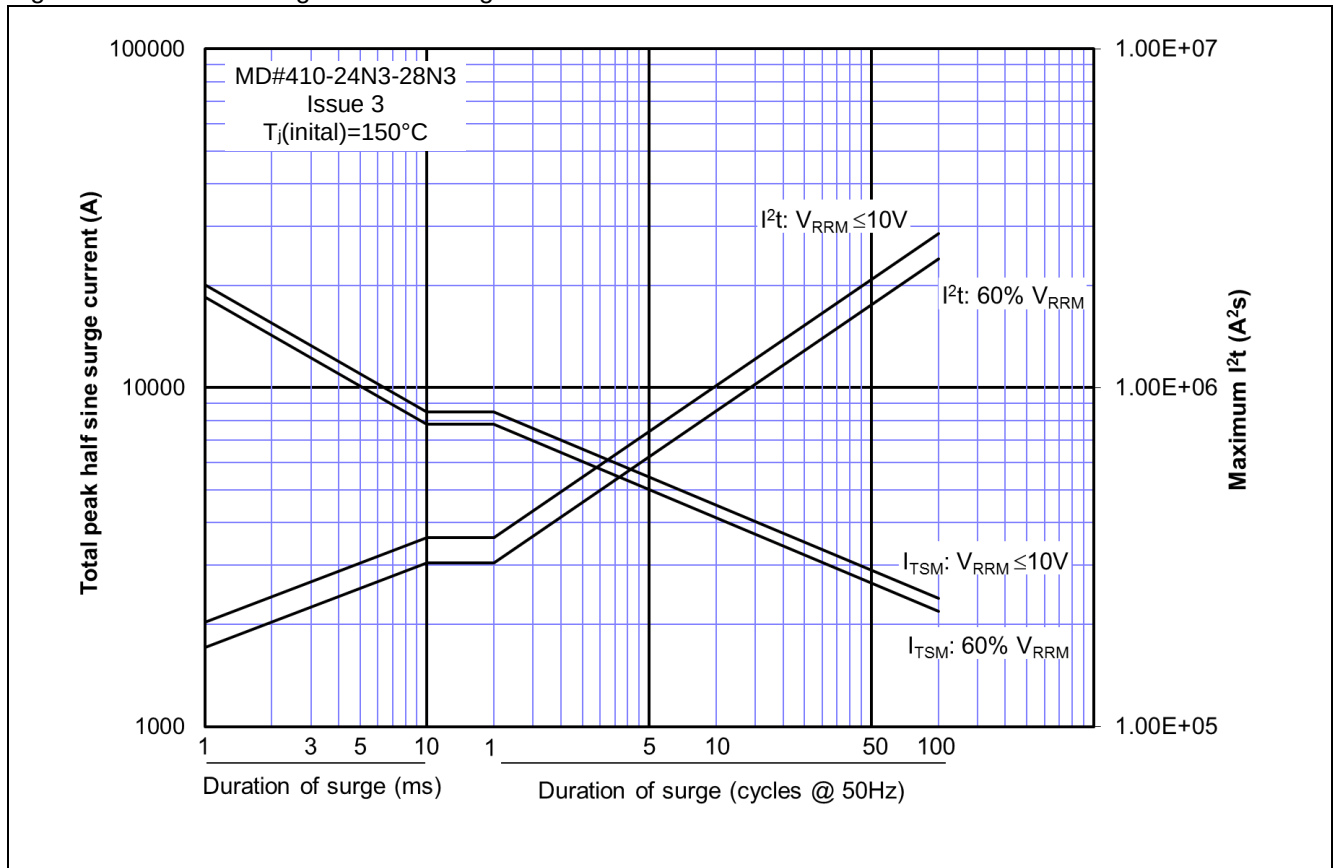


Figure 3 - Total recovered charge,  $Q_{rr}$

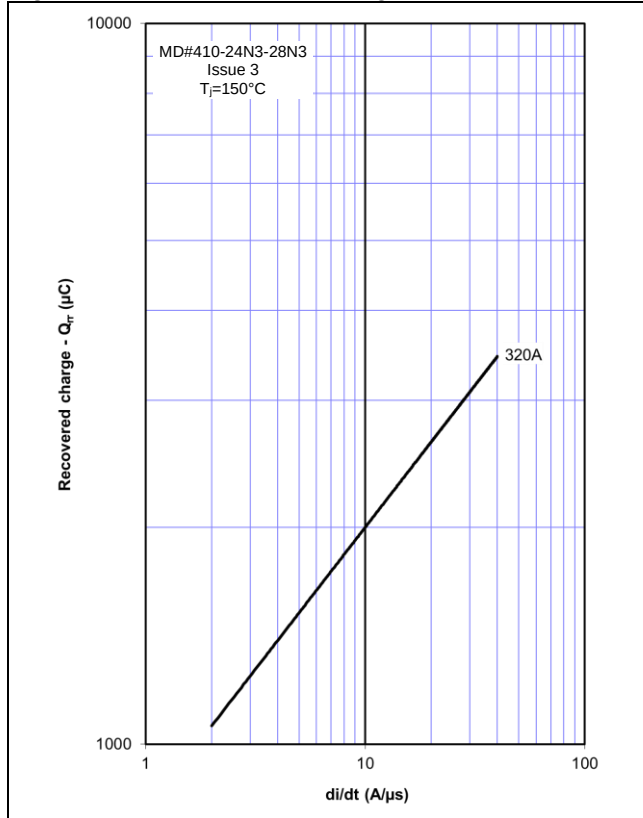


Figure 4 - Recovered charge,  $Q_{ra}$  (50% chord)

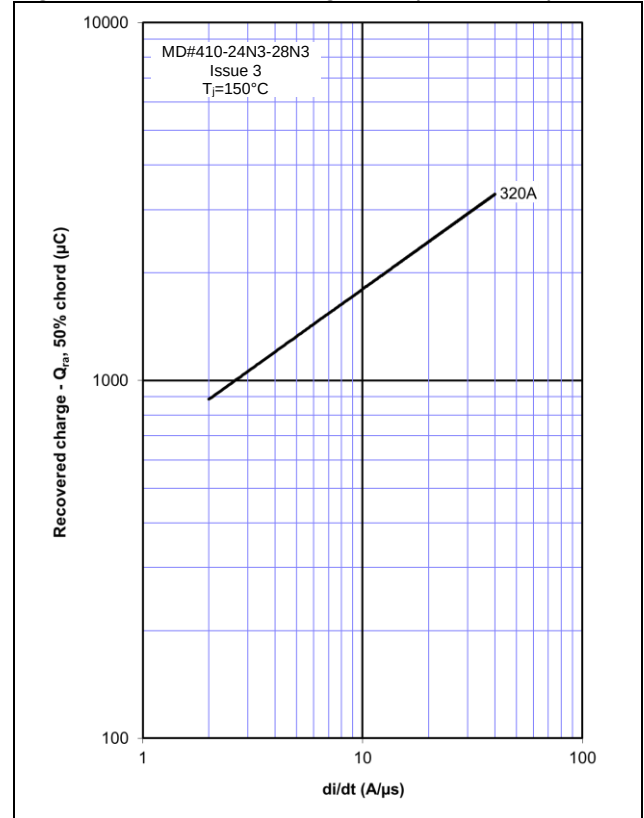


Figure 5 - Peak reverse recovery current,  $I_{rm}$

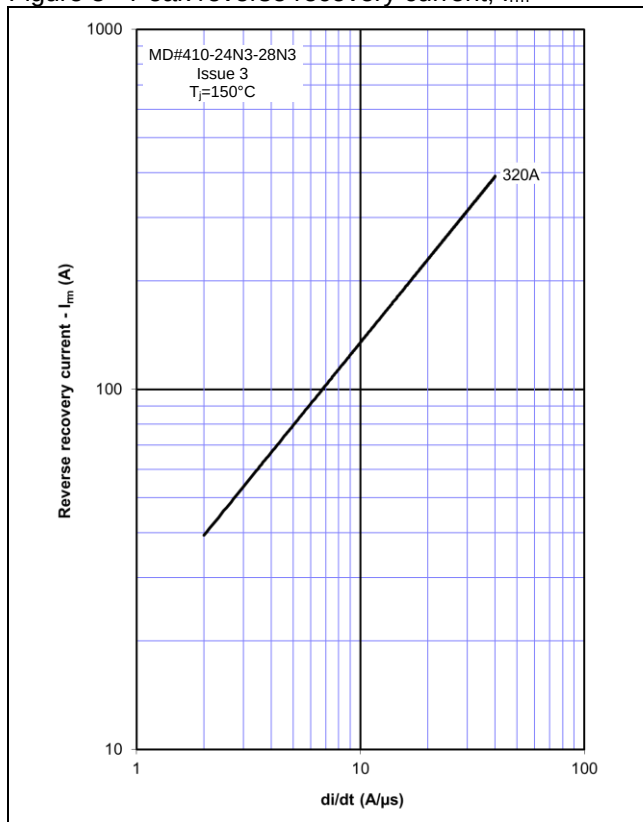


Figure 6 - Maximum recovery time,  $t_{rr}$  (50% chord)

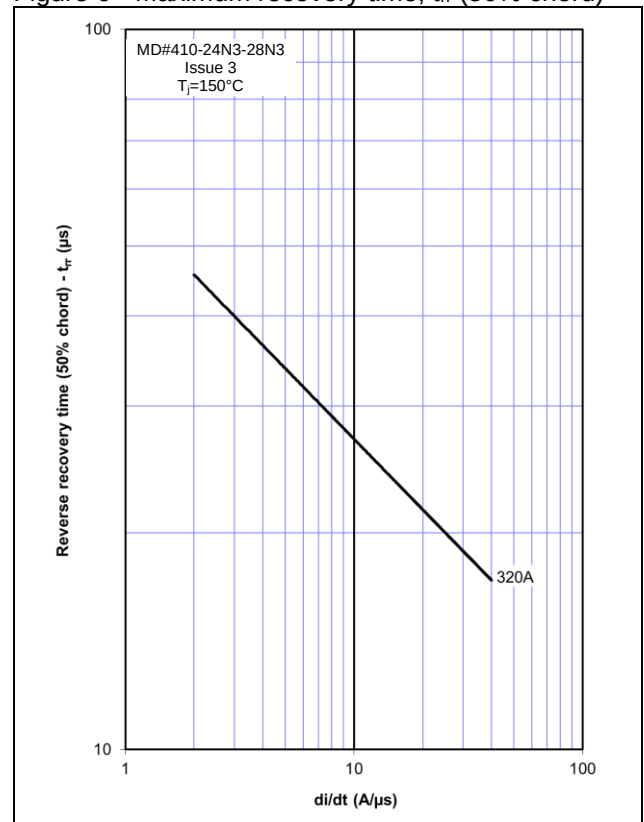


Figure 7 – Forward current vs. Power dissipation

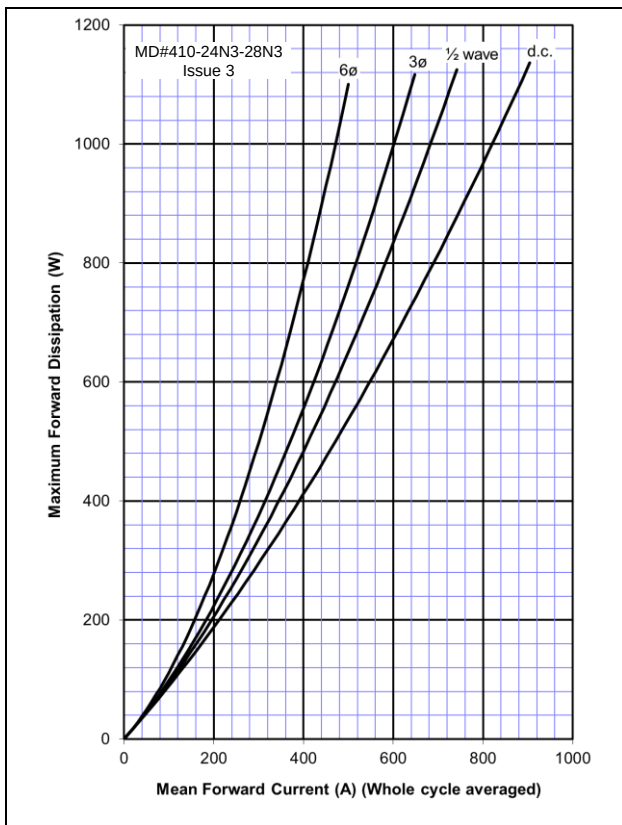


Figure 8 – Forward current vs. Heatsink temperature

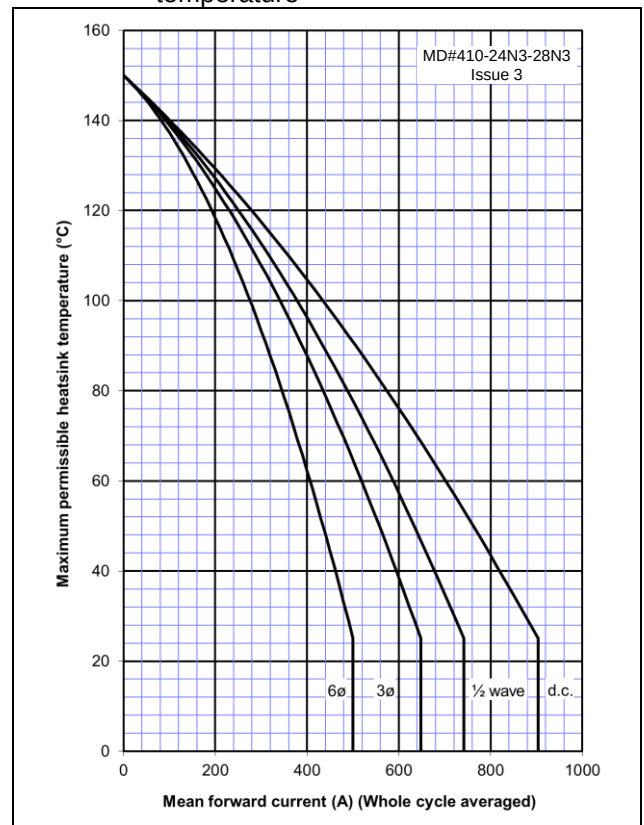
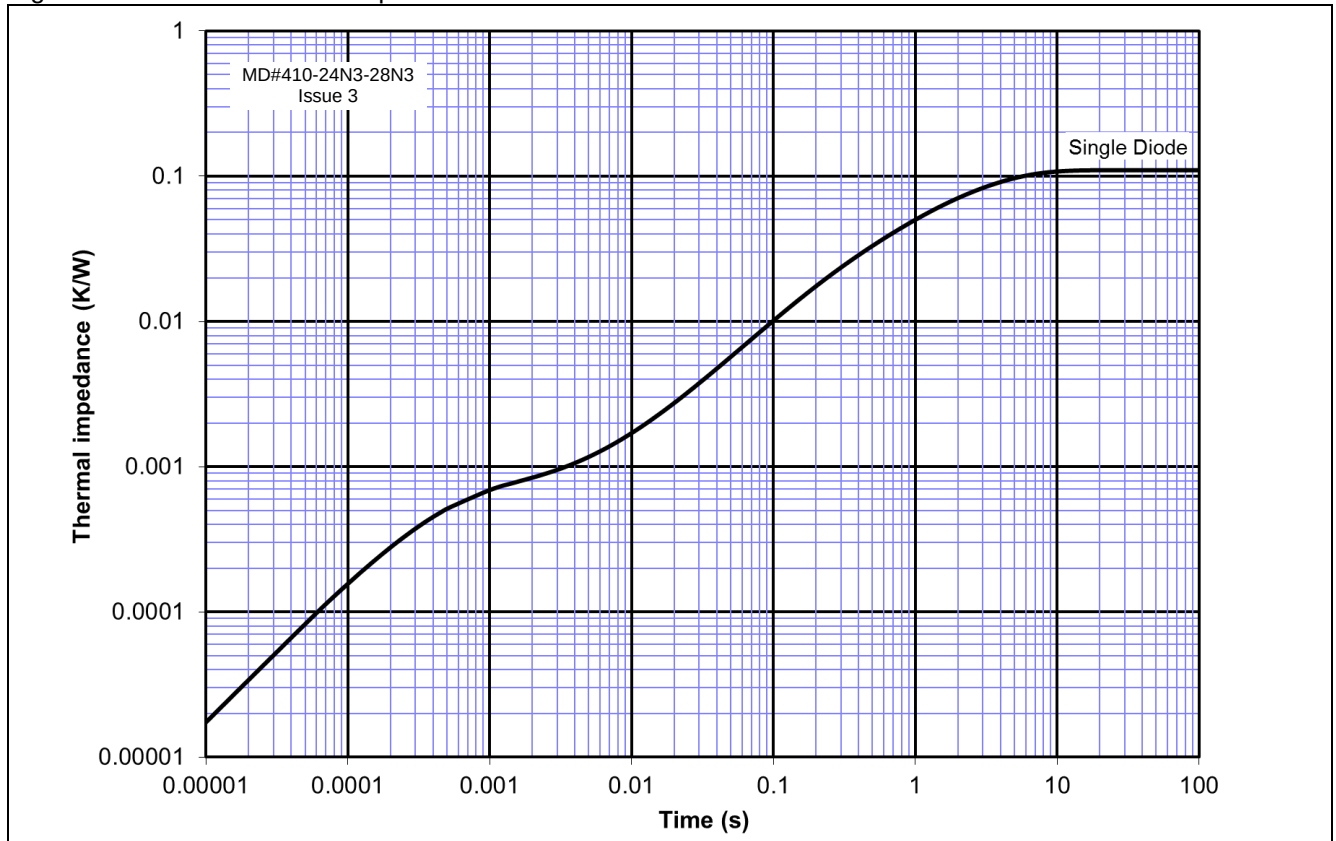
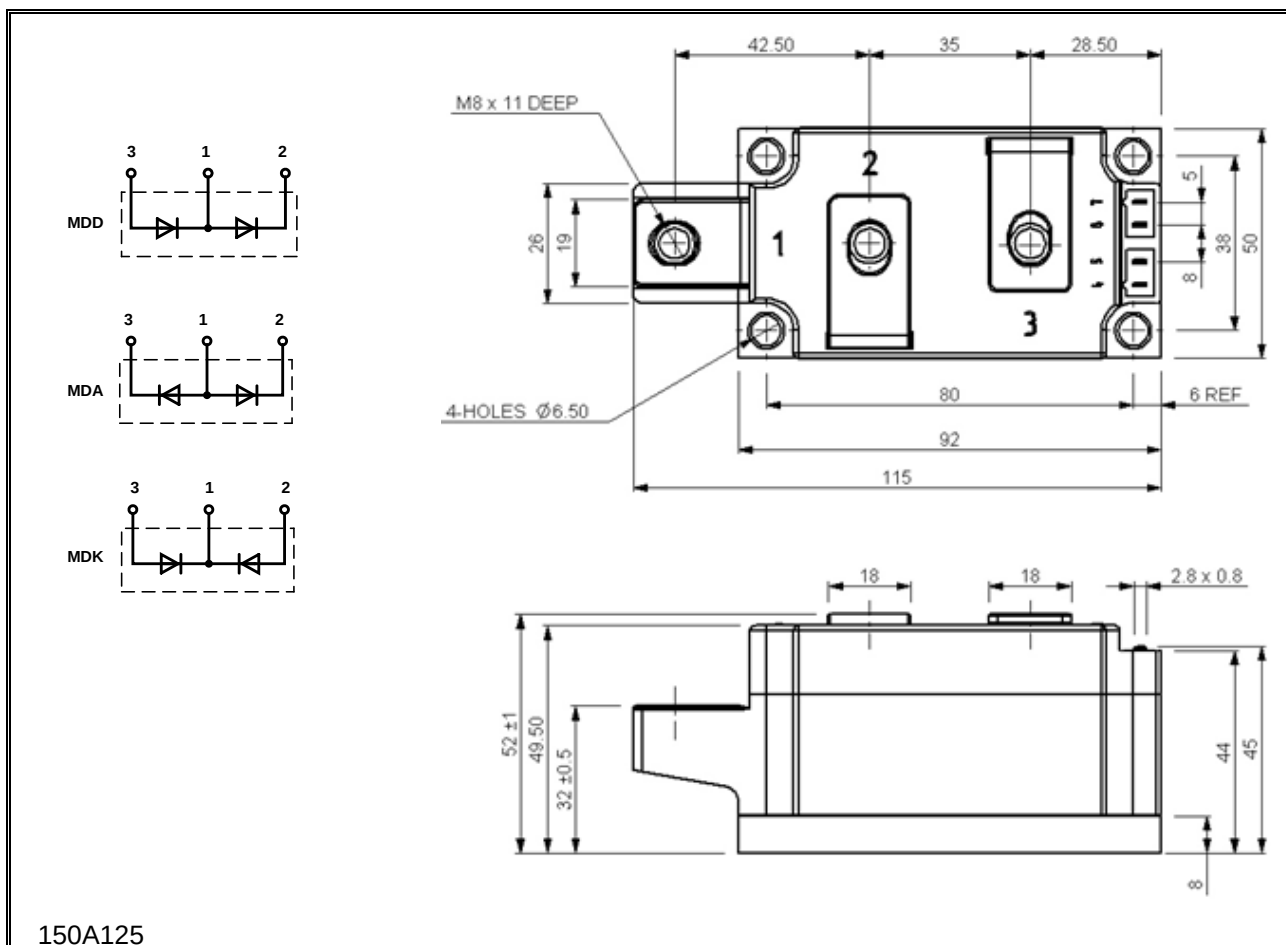


Figure 9 – Transient thermal impedance





## Outline Drawing & Ordering Information



150A125

### ORDERING INFORMATION

(Please quote 11/14 digit code as below)

| M               | D#                            | 410             | ◆◆                               | N              | 3                  |
|-----------------|-------------------------------|-----------------|----------------------------------|----------------|--------------------|
| Fixed Type Code | Configuration Code DD, DA, DK | Fixed Type Code | Voltage code $V_{RRM}/100$ 24-28 | Standard Diode | Fixed Version Code |

 Typical order code: MDA410-28N3—MDA configuration, 2800V  $V_{RRM}$ 

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