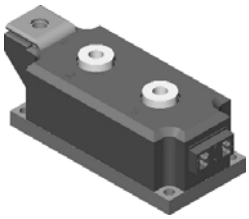
IXYS

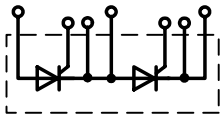
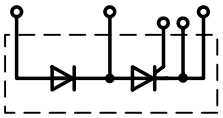
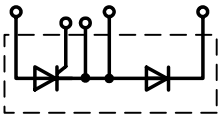
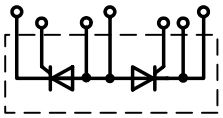
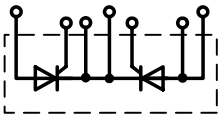


Date: 13.09.2004

Data Sheet Issue: 1

Thyristor/Diode Modules M## 500

Absolute Maximum Ratings

V_{RRM} V_{DRM} [V]	 MCC	 MCD	 MDC	 MCA	 MCK
1200	500-12io1	500-12io1	500-12io1	500-12io1	500-12io1
1400	500-14io1	500-14io1	500-14io1	500-14io1	500-14io1
1600	500-16io1	500-16io1	500-16io1	500-16io1	500-16io1
1800	500-18io1	500-18io1	500-18io1	500-18io1	500-18io1

	VOLTAGE RATINGS	MAXIMUM LIMITS	UNITS
V_{DRM}	Repetitive peak off-state voltage [1]	1200-1800	V
V_{DSM}	Non-repetitive peak off-state voltage [1]	1200-1800	V
V_{RRM}	Repetitive peak reverse voltage [1]	1200-1800	V
V_{RSM}	Non-repetitive peak reverse voltage [1]	1300-1900	V

	OTHER RATINGS	MAXIMUM LIMITS	UNITS
$I_{T(AV)M}$	Maximum average on-state current, T_C = 89°C [2]	500	A
$I_{T(AV)M}$	Maximum average on-state current. T_C = 85°C [2]	545	A
$I_{T(AV)M}$	Maximum average on-state current. T_C = 100°C [2]	376	A
$I_{T(RMS)M}$	Nominal RMS on-state current, T_C = 55°C [2]	1294	A
$I_{T(d.c.)}$	D.C. on-state current, T_C = 55°C	1029	A
I_{TSM}	Peak non-repetitive surge t_p = 10 ms, V_{RM} = 60%V_{RRM} [3]	16.5	kA
I_{TSM2}	Peak non-repetitive surge t_p = 10 ms, $V_{RM} \leq$ 10V [3]	18.2	kA
I^2t	I^2t capacity for fusing t_p = 10 ms, V_{RM} = 60%V_{RRM} [3]	1.36×10^6	A^2s
I^2t	I^2t capacity for fusing t_p = 10 ms, $V_{RM} \leq$ 10 V [3]	1.66×10^6	A^2s
$(di/dt)_{cr}$	Critical rate of rise of on-state current (repetitive) [4]	150	A/µs
	Critical rate of rise of on-state current (non-repetitive) [4]	300	A/µs
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	°C
T_{stg}	Storage temperature range	-40 to +150	°C

Notes:

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

Thyristor Characteristics

	PARAMETER	TEST CONDITIONS [1]	MIN.	TYP.	MAX.	UNITS
V_{TM}	Maximum peak on-state voltage	I_{TM} = 1700 A	-	-	1.5	V
V_{TM}	Maximum peak on-state voltage	I_{TM} = 1500 A	-	-	1.43	V
V_{T0}	Threshold voltage		-	-	0.85	V
r_T	Slope resistance		-	-	0.27	mΩ
$(dv/dt)_{cr}$	Critical rate of rise of off-state voltage	V_D = 80% V_{DRM}, linear ramp, Gate o/c	1000	-	-	V/µs
I_{DRM}	Peak off-state current	Rated V_{DRM}	-	-	70	mA
I_{RRM}	Peak reverse current	Rated V_{RRM}	-	-	70	mA
V_{GT}	Gate trigger voltage	T_{vj} = 25°C, V_D = 10 V, I_T = 3 A	-	-	3.0	V
I_{GT}	Gate trigger current		-	-	300	mA
I_H	Holding current	T_{vj} = 25°C	-	-	1000	mA
t_{gd}	Gate controlled turn-on delay time	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	-	0.6	1.5	µs
t_{gt}	Turn-on time		-	1.2	2.5	
Q_{rr}	Recovered Charge	I_{TM} = 1000 A, t_p = 1 ms, di/dt = 10A/µs, V_R = 50 V	-	2200	-	µC
Q_{ra}	Recovered Charge, 50% chord		-	1600	1900	µC
I_{RM}	Reverse recovery current		-	120	-	A
t_{rr}	Reverse recovery time, 50% chord		-	25	-	µs
t_q	Turn-off time	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	-	200	-	µs
		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	-	300	-	
R_{thJC}	Thermal resistance, junction to case	Single Thyristor	-	-	0.062	K/W
		Whole Module	-	-	0.031	K/W
R_{thCH}	Thermal resistance, case to heatsink	Single Thyristor	-	-	0.02	K/W
		Whole Module	-	-	0.01	K/W
F_1	Mounting force (to heatsink)	[2]	4.25	-	5.75	Nm
F_2	Mounting force (to terminals)		10.2	-	13.8	Nm
W_t	Weight		-	1.5	-	kg

Diode Characteristics

	PARAMETER	TEST CONDITIONS [1]	MIN.	TYP.	MAX.	UNITS
V_{FM}	Maximum peak forward voltage	I_{TM} = 1800 A	-	-	0.98	V
V_{T0}	Threshold voltage		-	-	0.72	V
r_T	Slope resistance		-	-	0.143	mΩ
I_{RRM}	Peak reverse current	Rated V_{RRM}	-	-	50	mA
Q_{rr}	Recovered Charge	I_{TM} = 1000 A, t_p = 1ms, di/dt = 10 A/µs, V_R = 50 V	-	2200	-	µC
Q_{ra}	Recovered Charge, 50% chord		-	1800	2250	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
12	1200	1300	820
14	1400	1500	930
16	1600	1700	1040
18	1800	1900	1150

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

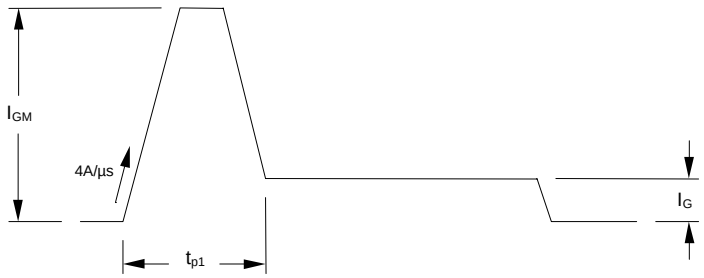
When selecting snubber components, care must be taken not to use excessively large values of snubber capacitor or excessively small values of snubber resistor. Such excessive component values may lead to device damage due to the large resultant values of snubber discharge current. If required, please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

8.1Thyristor Dissipation Calculations

$$I_{AV} = \frac{-V_{T0} + \sqrt{V_{T0}^{\ 2} + 4 \cdot ff^2 \cdot r_T \cdot W_{AV}}}{2 \cdot ff^2 \cdot r_T}$$

and:

$$W_{AV} = \frac{\Delta T}{R_{th}}$$

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

Where V_{T0} = 0.82 V, r_T = 0.27 mΩ,

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		

8.2Calculating thyristor V_T using ABCD Coefficients

The on-state characteristic I_T vs. V_T, on page 6 is represented in two ways;
(i) the well established V_{T0} and r_T tangent used for rating purposes and
(ii) 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.

25°C Coefficients		125°C Coefficients	
A	0.7860338	A	-0.099137717
B	9.929062×10^{-3}	B	0.1987038
C	1.94704×10^{-4}	C	4.23812×10^{-4}
D	7.409213×10^{-3}	D	-0.01453705

8.3D.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 and
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}

9.0Reverse recovery ratings

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

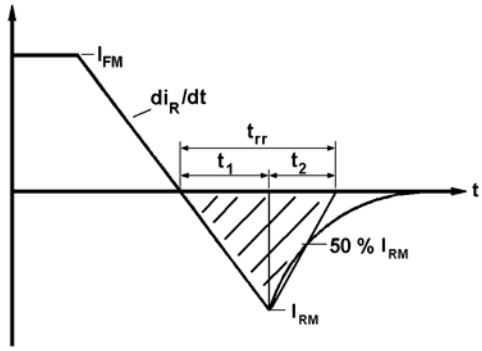


Fig. 1

(ii) Q_{rr} is based on a 150 µs integration time i.e.

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

(iii)

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

Thyristor Curves

Figure 1 - On-state characteristics of Limit device

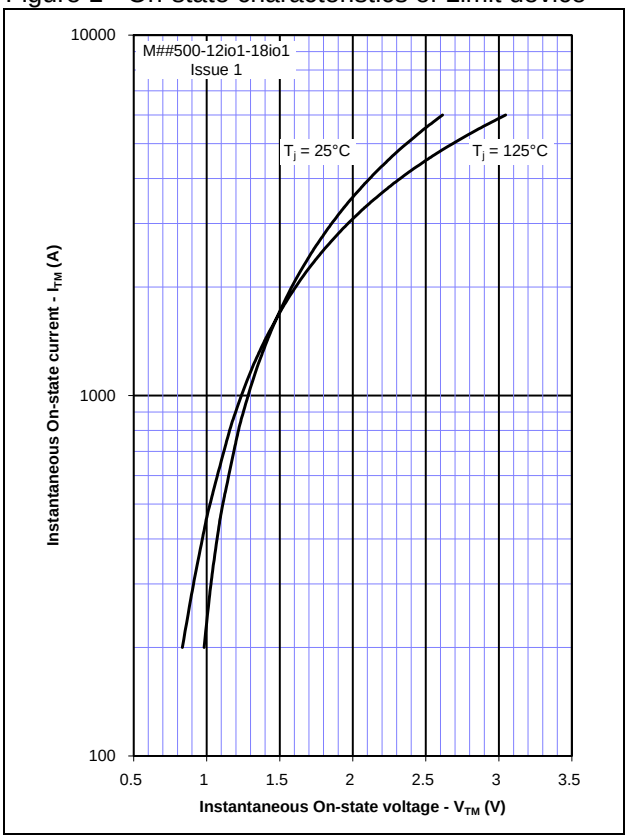


Figure 2 - Transient thermal impedance

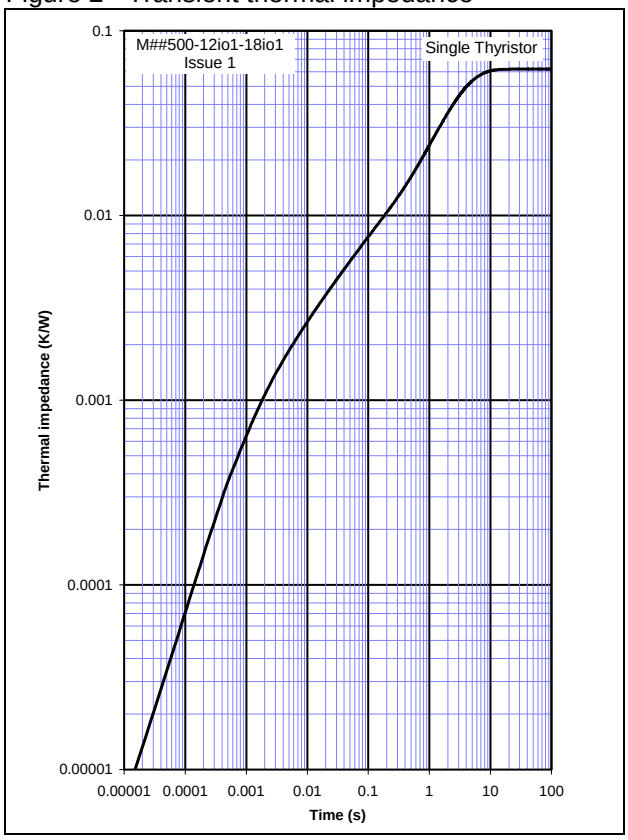


Figure 3 - Gate characteristics - Trigger limits

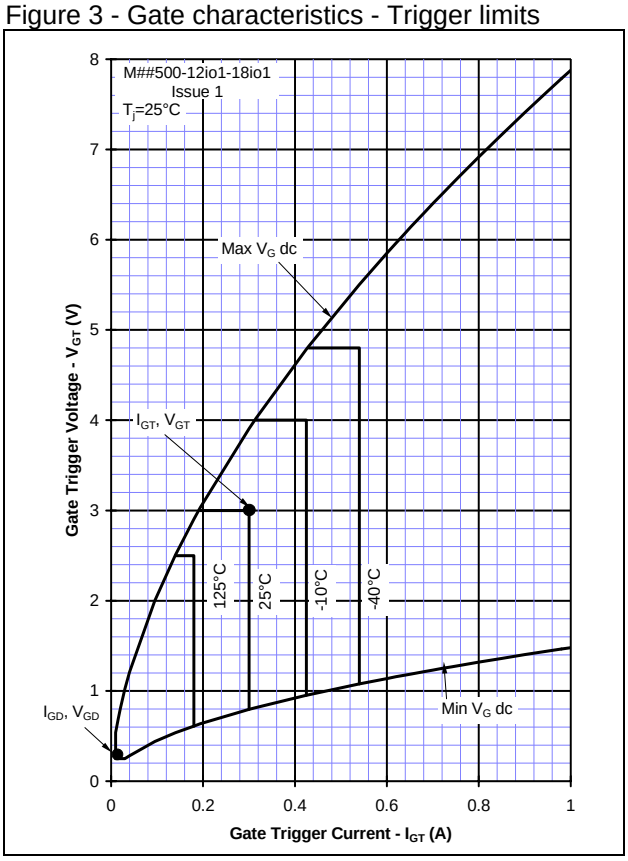


Figure 4 - Gate characteristics - Power curves

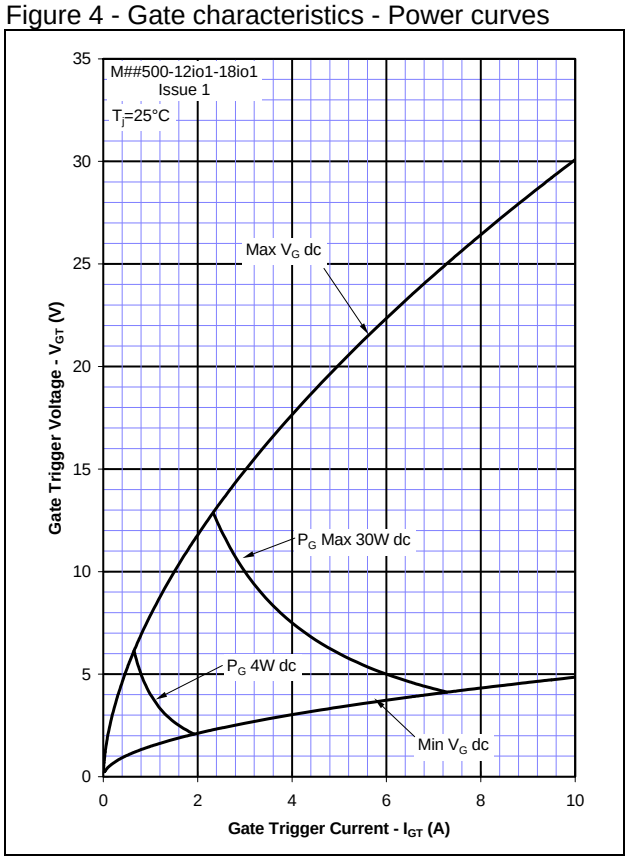


Figure 5 - Total recovered charge, Q_{rr}

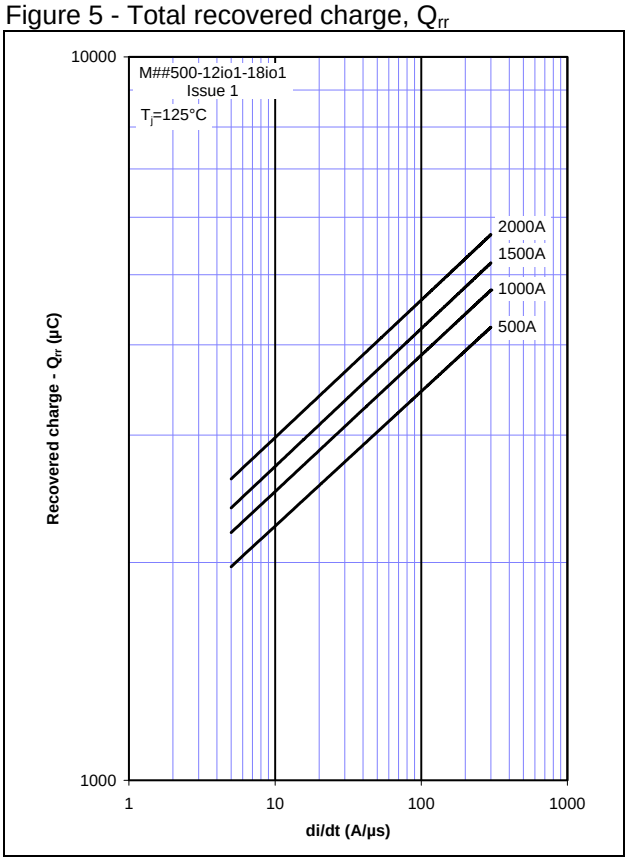


Figure 6 - Recovered charge, Q_{ra} (50% chord)

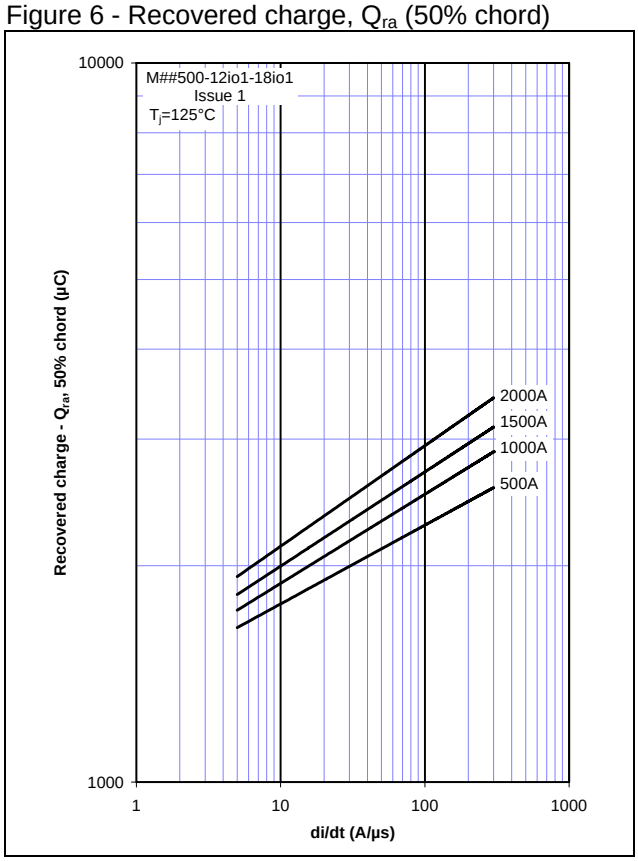


Figure 7 - Peak reverse recovery current, I_{RM}

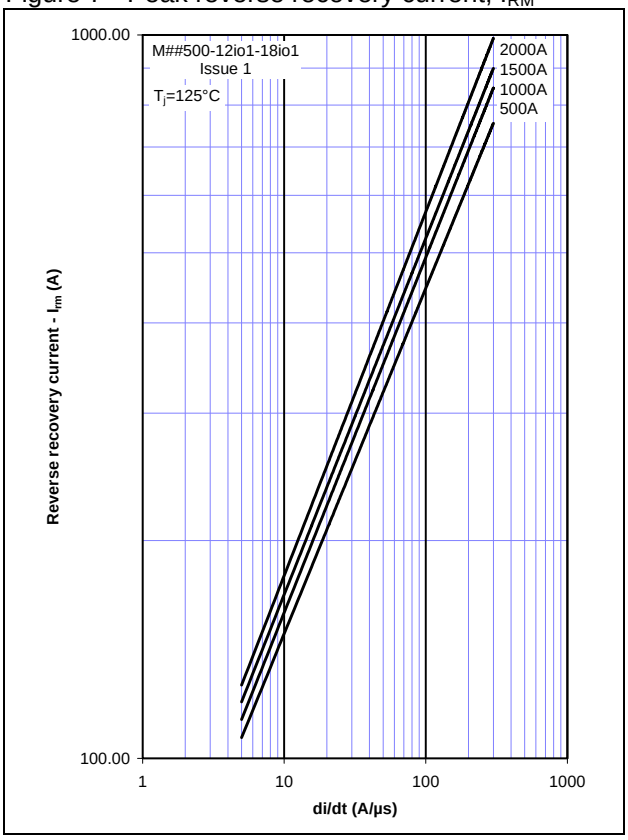


Figure 8 - Maximum recovery time, t_{rr} (50% chord)

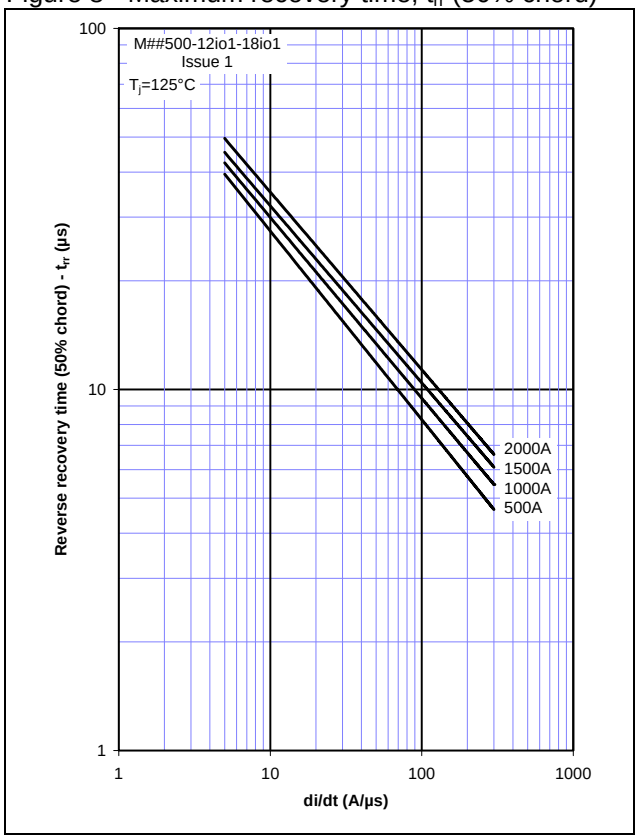


Figure 9 - On-state current vs. Power dissipation - Sine wave

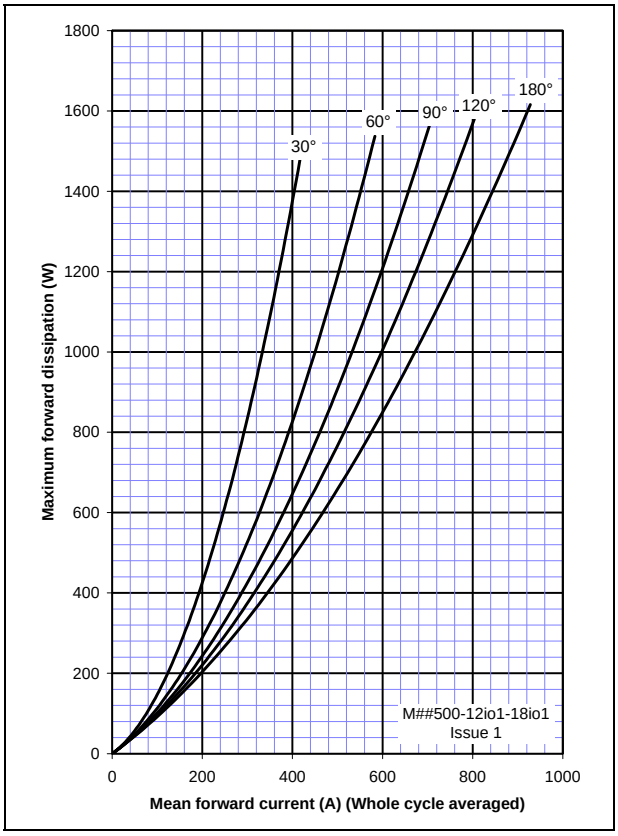


Figure 10 - On-state current vs. Heatsink temperature - Sine wave

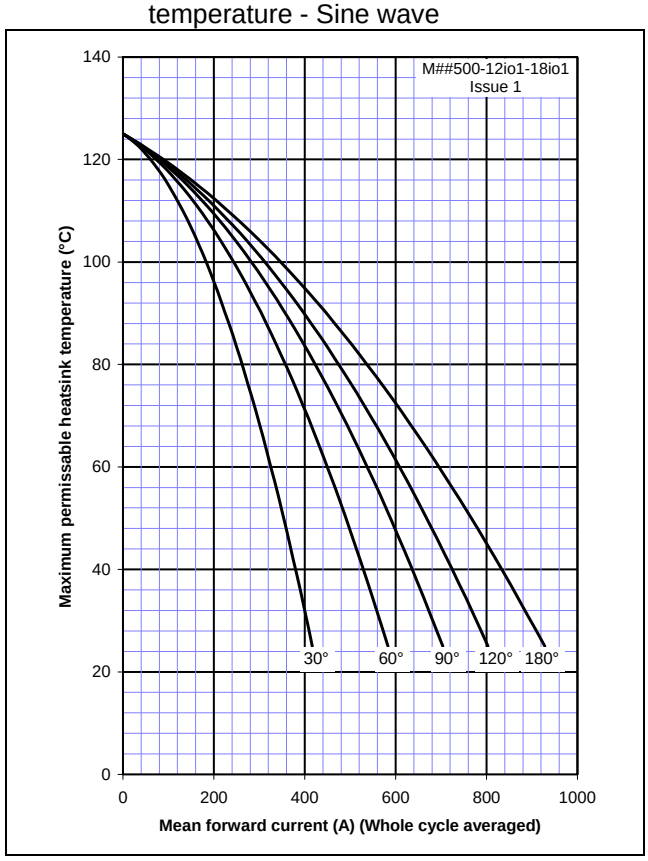


Figure 11 - On-state current vs. Power dissipation - Square wave

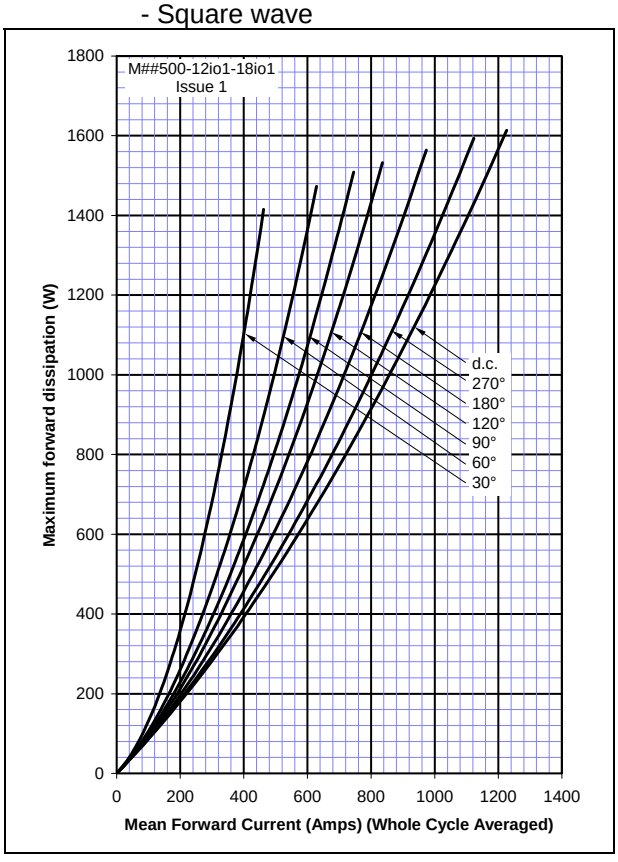


Figure 12 - On-state current vs. Heatsink temperature - Square wave

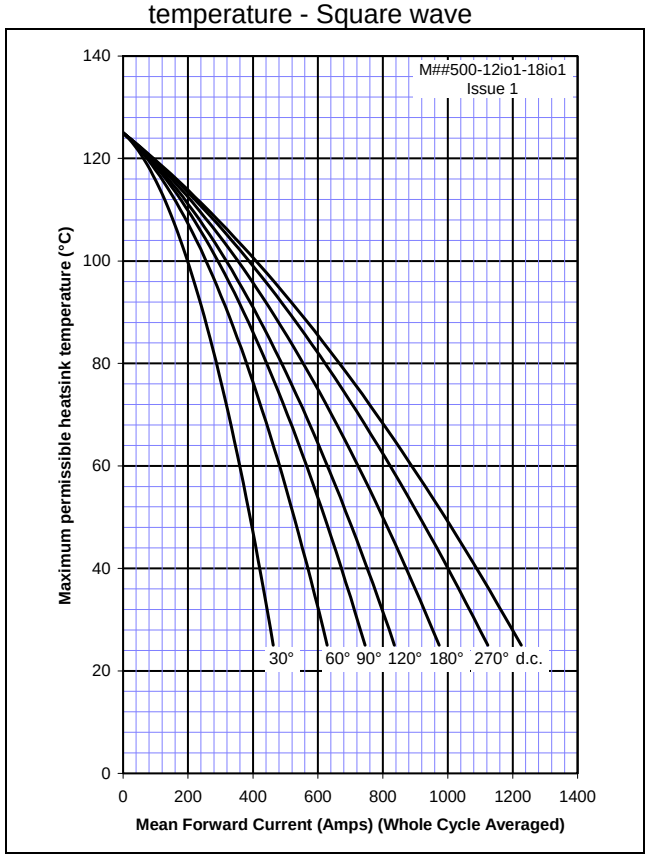
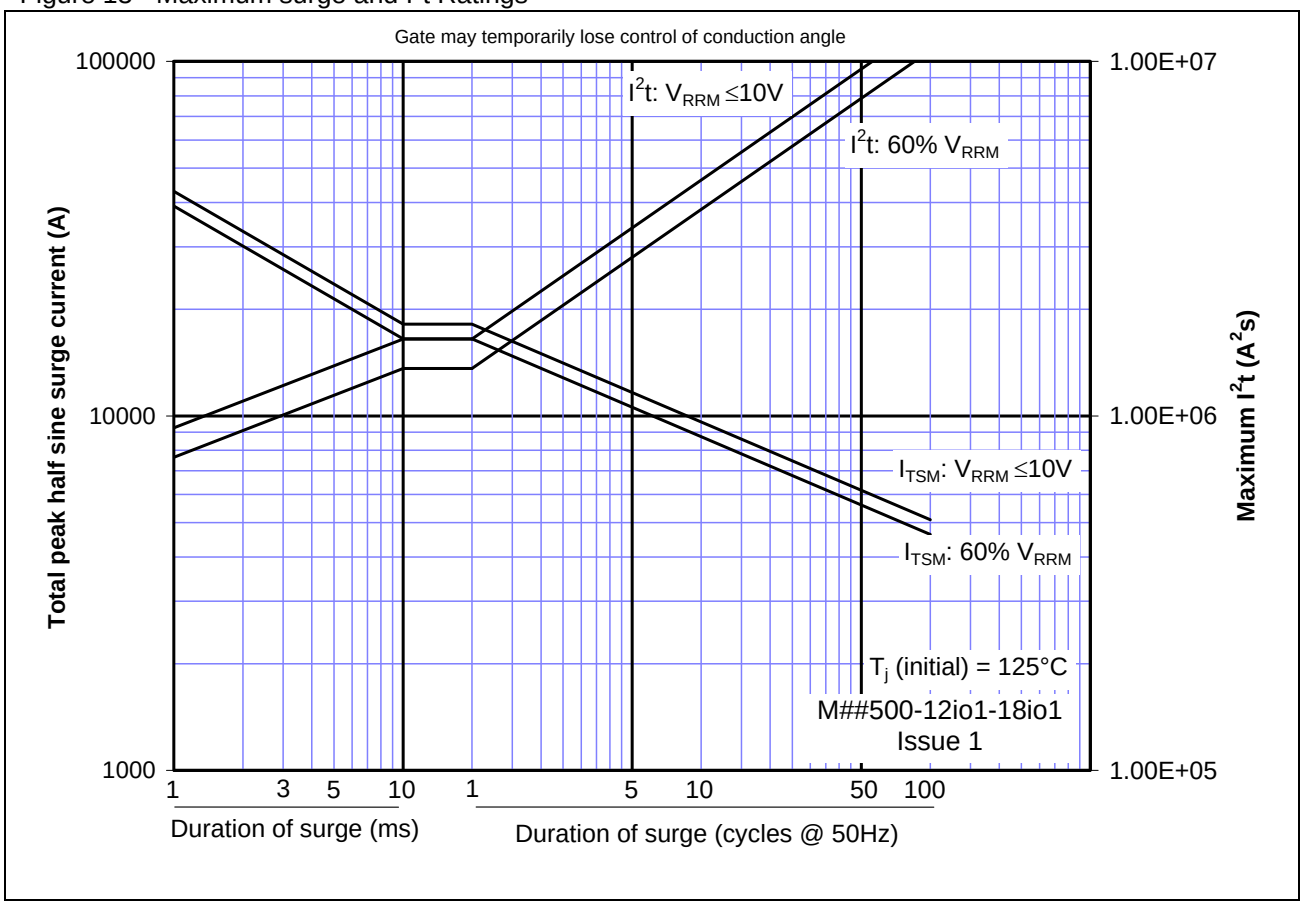


Figure 13 - Maximum surge and I^2t Ratings



Diode curves

Figure 14 - Instantaneous forward voltage V_F

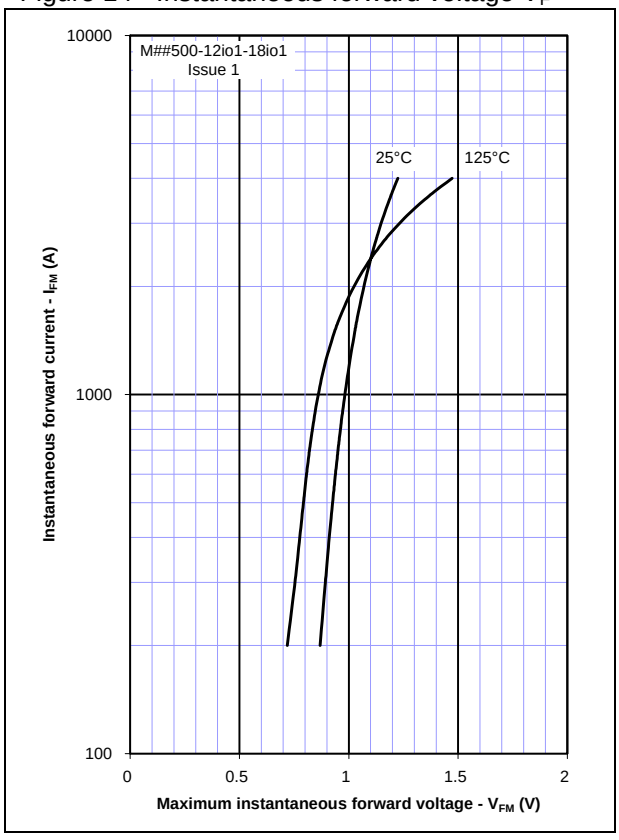


Figure 15 - Transient thermal impedance

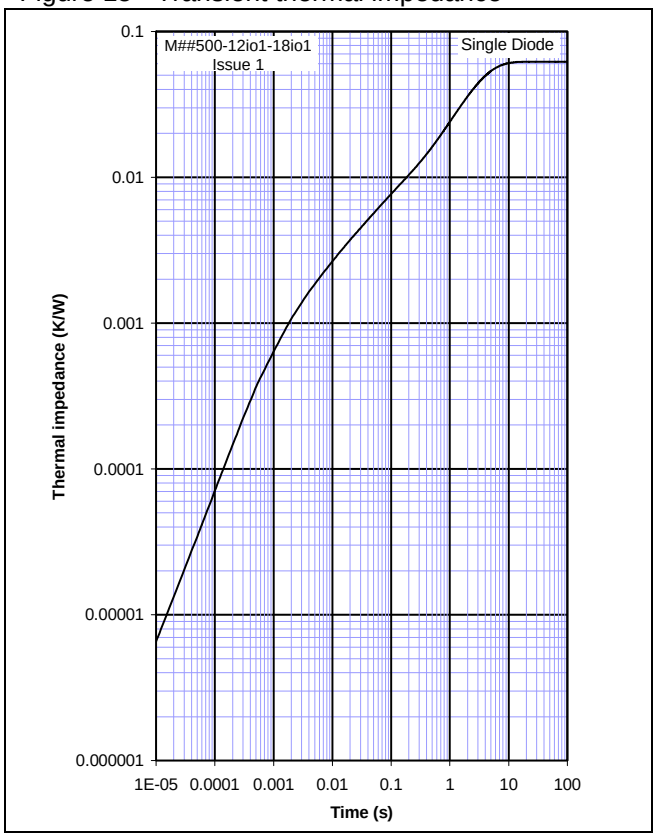


Figure 16 - Total recovered charge, Q_{rr}

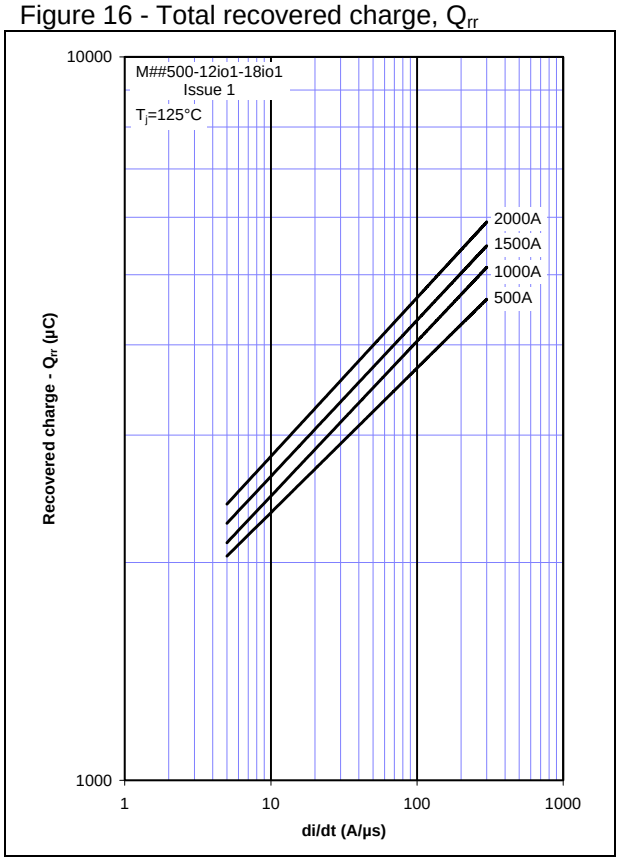


Figure 17 - Recovered charge, Q_{ra} (50% chord)

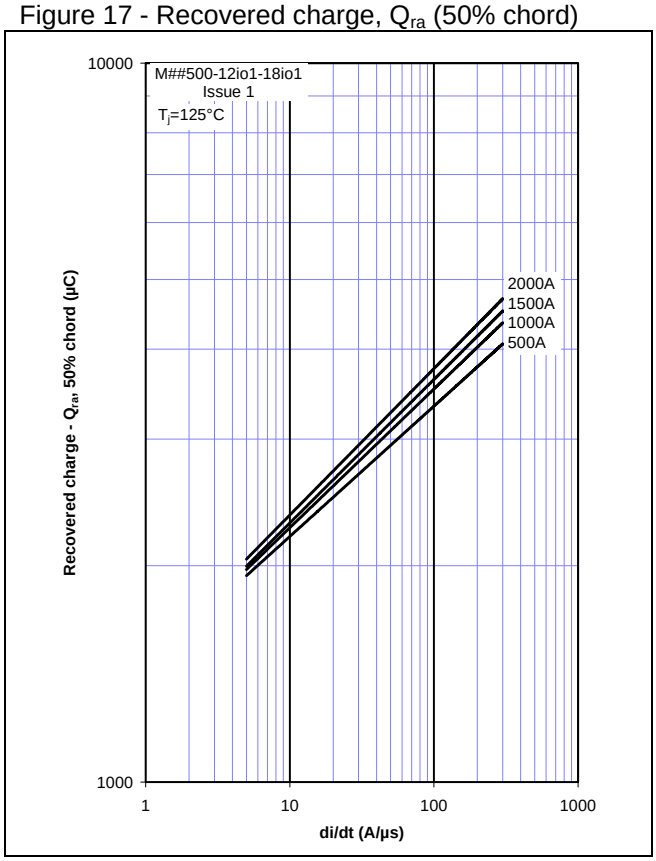


Figure 18 - Peak reverse recovery current, I_{rm}

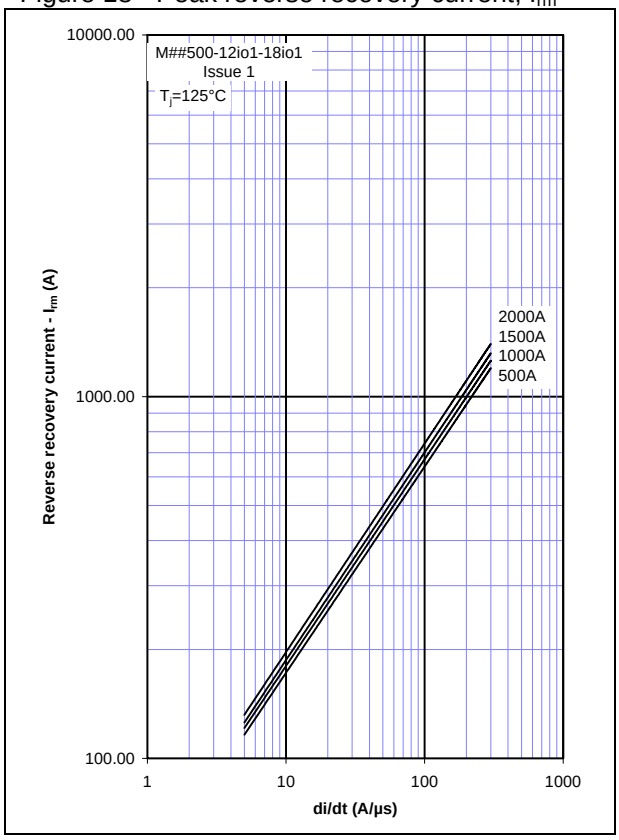
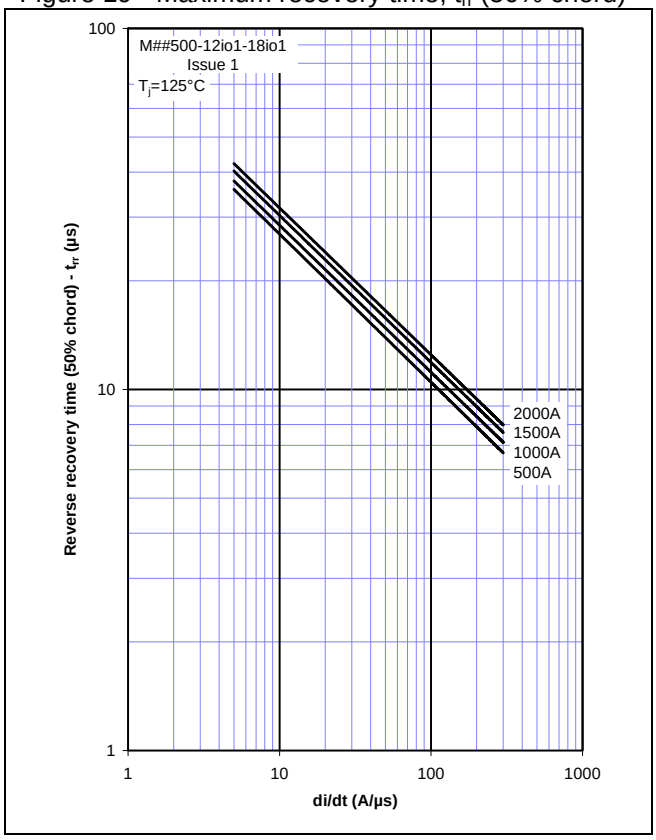
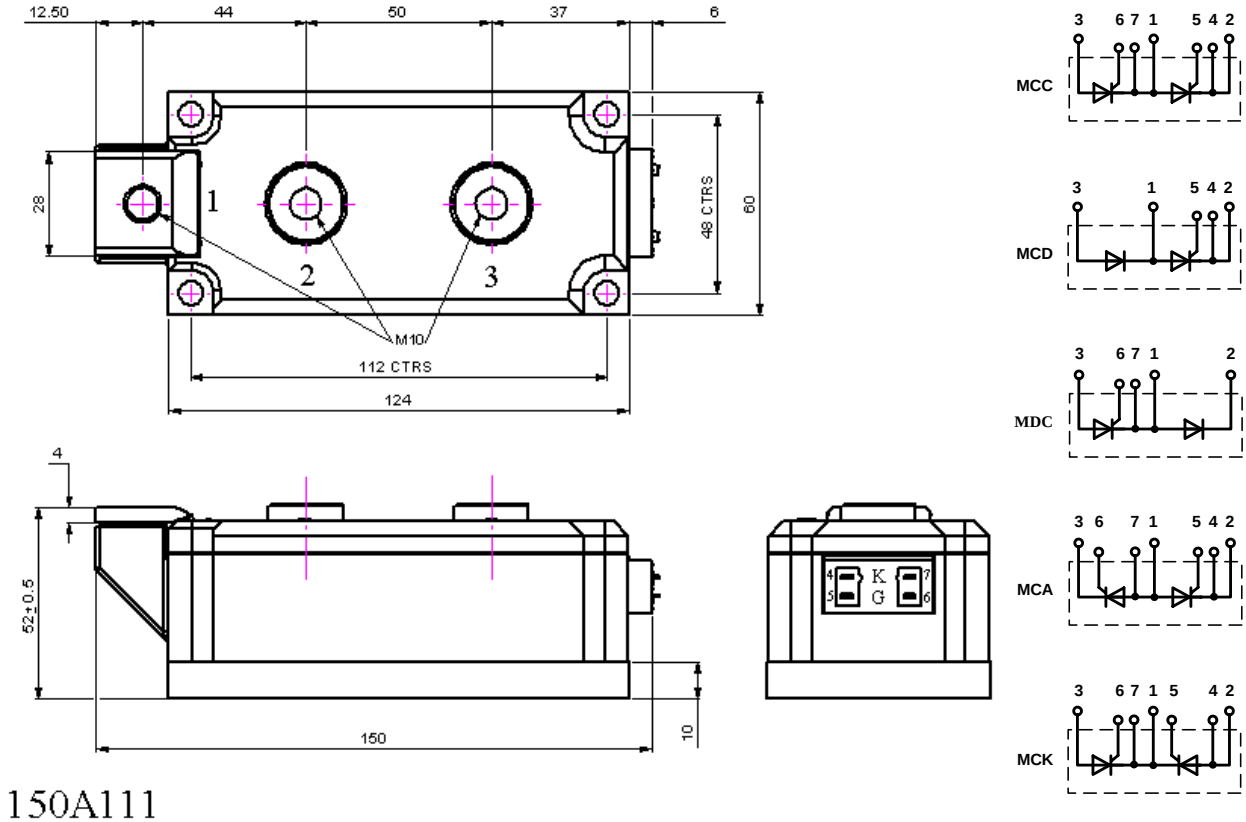


Figure 19 - Maximum recovery time, t_{rr} (50% chord)



Outline Drawing & Ordering Information



ORDERING INFORMATION			(Please quote 11 digit code as below)		
M	**##**	**500**	**♦♦**	**io**	**1**
Fixed Type Code	Configuration code CC, CD, DC, CA, CK	Average Current Rating	Voltage code V_{DRM}/100 12-18	i = Critical dv/dt 1000 V/µs o = Typical turn-off time	Fixed Version Code

Order code: MCD500-14io1– MCD configuration, 1400V V_{DRM}, V_{RRM}

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