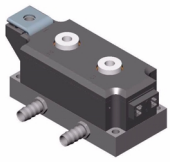
IXYS

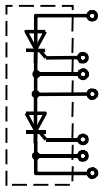
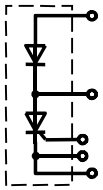
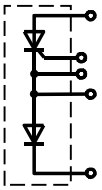
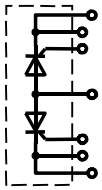
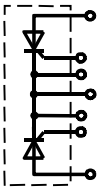
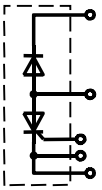
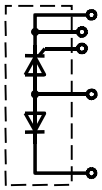


Date: 31.03.2005

Data Sheet Issue: 1

Thyristor/Diode Modules M## 600

Absolute Maximum Ratings

V_{RRM} V_{DRM} [V]	 MCC	 MCD	 MDC	 MCA	 MCK	 MCDA	 MDCA
2000	600-20io1W	600-20io1W	600-20io1W	600-20io1W	600-20io1W	600-20io1W	600-20io1W
2200	600-22io1W	600-22io1W	600-22io1W	600-22io1W	600-22io1W	600-22io1W	600-22io1W

	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_{water} = 17°C, 4l/min [2), 3)]	710	A
$I_{T(AV)M}$	Maximum average on-state current. T_{water} = 40°C, 4l/min [2), 3)]	600	A
$I_{T(AV)M}$	Maximum average on-state current. T_{water} = 85°C, 4l/min [2), 3)]	348	A
$I_{T(RMS)M}$	Nominal RMS on-state current, T_{water} = 17°C, 4l/min [2), 3)]	1116	A
$I_{T(d.c.)}$	D.C. on-state current, T_{water} = 17°C, 4l/min [3)]	921	A
I_{TSM}	Peak non-repetitive surge t_p = 10 ms, V_{RM} = 60%V_{RRM} [4)]	16.5	kA
I_{TSM2}	Peak non-repetitive surge t_p = 10 ms, $V_{RM} \leq$ 10V [4)]	18.2	kA
I^2t	I^2t capacity for fusing t_p = 10 ms, V_{RM} = 60%V_{RRM} [4)]	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) [5)]	150	A/µs
	Critical rate of rise of on-state current (non-repetitive) [5)]	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 [6)]	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 T_{vj} below 25°C.
2) Single phase; 50 Hz, 180° half-sinewave.
3) Current ratings do not include adjustments, which may be necessary due to heat being returned by cable connections.
4) Half-sinewave, 125°C T_{vj} initial.
5) V_D = 67% V_{DRM}, I_{FG} = 2 A, $t_r \leq$ 0.5µs, T_C = 125°C.
6) AC RMS voltage, 50 Hz, 1min test

Thyristor Characteristics

	PARAMETER	MIN.	TYP.	MAX.	TEST CONDITIONS [1]	UNITS
V_{TM}	Maximum peak on-state voltage	-	-	1.69	I_{TM} = 1800 A	V
V_{TM}	Maximum peak on-state voltage	-	-	1.16	I_{TM} = 600 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		
Q_{rr}	Recovered Charge	-	3000	-	I_{TM} = 1000 A, t_p = 1 ms, di/dt = 10A/µs, V_R = 50 V	µC
Q_{ra}	Recovered Charge, 50% chord	-	1800	2400		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	

Diode Characteristics

	PARAMETER	MIN.	TYP.	MAX.	TEST CONDITIONS [1]	UNITS
V_{FM}	Maximum peak forward voltage	-	-	1.11	I_{TM} = 1800 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	-	I_{TM} = 1000 A, t_p = 1ms, di/dt = 10 A/µs, V_R = 50 V	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

Module Characteristics

	PARAMETER	MIN.	TYP.	MAX.	TEST CONDITIONS [1]	UNITS
R_{thJC}	Thermal resistance, junction to case	-	-	0.09	Single Thyristor/Single Diode	K/W
F_1	Mounting force (to heatsink)	4.25	-	5.75	[2]	Nm
F_2	Mounting force (to terminals)	10.2	-	13.8		Nm
W_t	Weight	-	1.8	-		kg

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

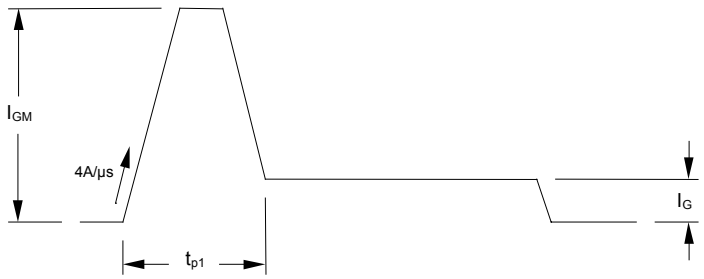
When selecting snubber components, care must be taken not to use excessively large values of snubber capacitor or excessively small values of snubber resistor. Such excessive component values may lead to device damage due to the large resultant values of snubber discharge current. If required, please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

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

and:

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

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

Where V_{T0} = 0.88 V, r_T = 0.46 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	0.0976	0.0955	0.0942	0.0933	0.0920	0.0907	0.09
Sine wave	0.0950	0.0933	0.0924	0.0917	0.0902		

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;
(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.

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

8.3D.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
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	5
r_p	0.07972	3.64310×10^{-3}	4.87795×10^{-3}	1.91134×10^{-3}	2.146406×10^{-3}
τ_p	4.46119	0.71394	0.06312	5.07740×10^{-3}	6.07258×10^{-3}

9.0Reverse recovery ratings

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

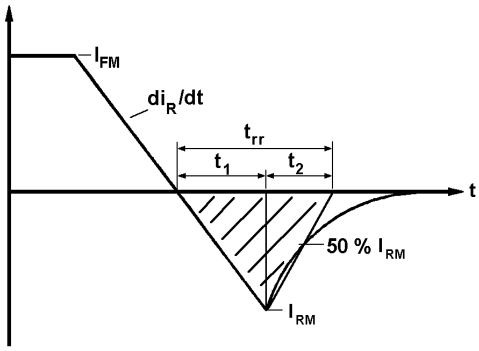


Fig. 1

(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

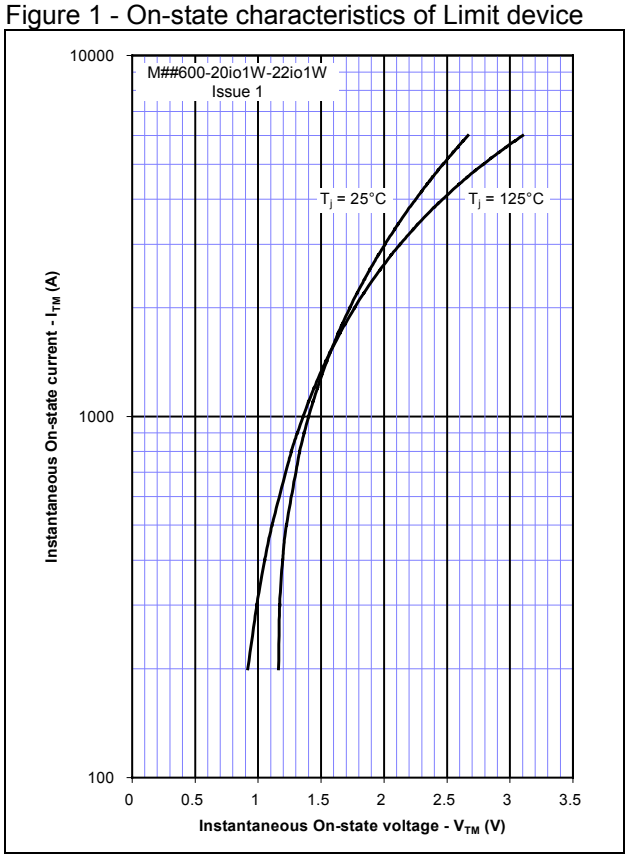


Figure 2 - Transient thermal impedance

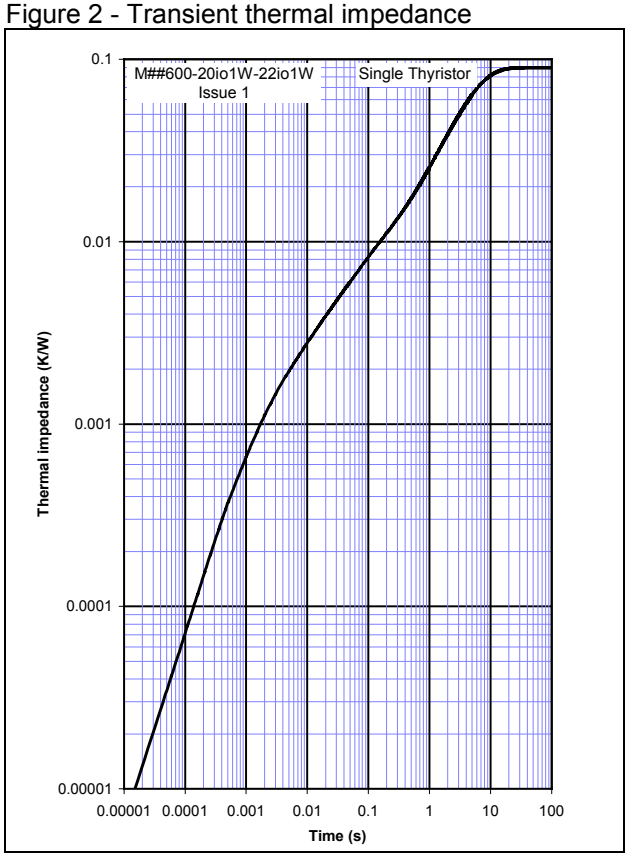


Figure 3 - Gate characteristics - Trigger limits

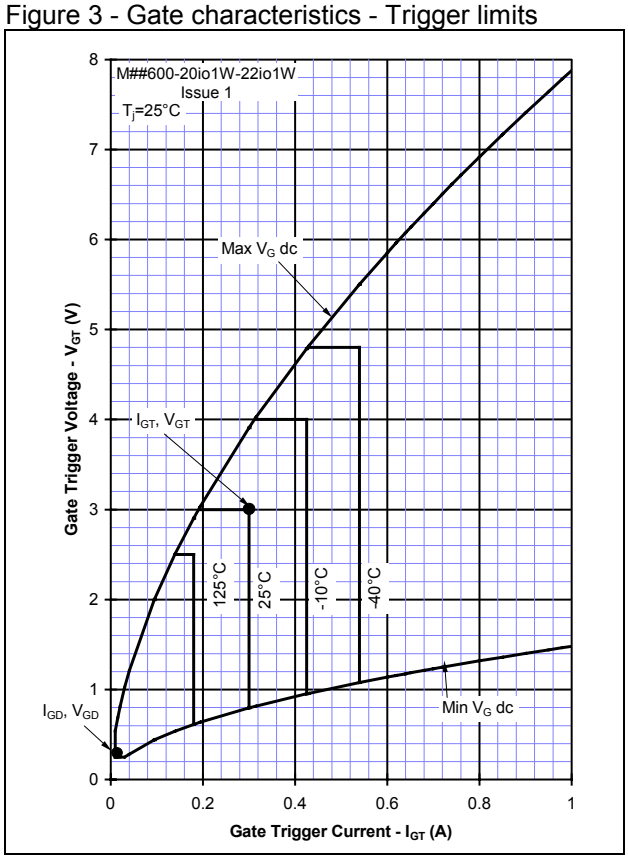


Figure 4 - Gate characteristics - Power curves

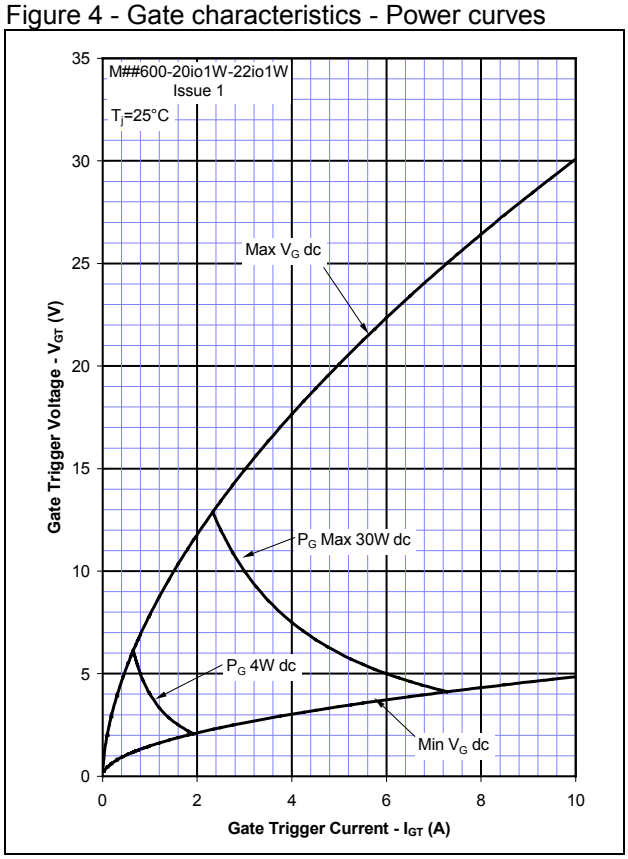


Figure 5 - Total recovered charge, Q_{rr}

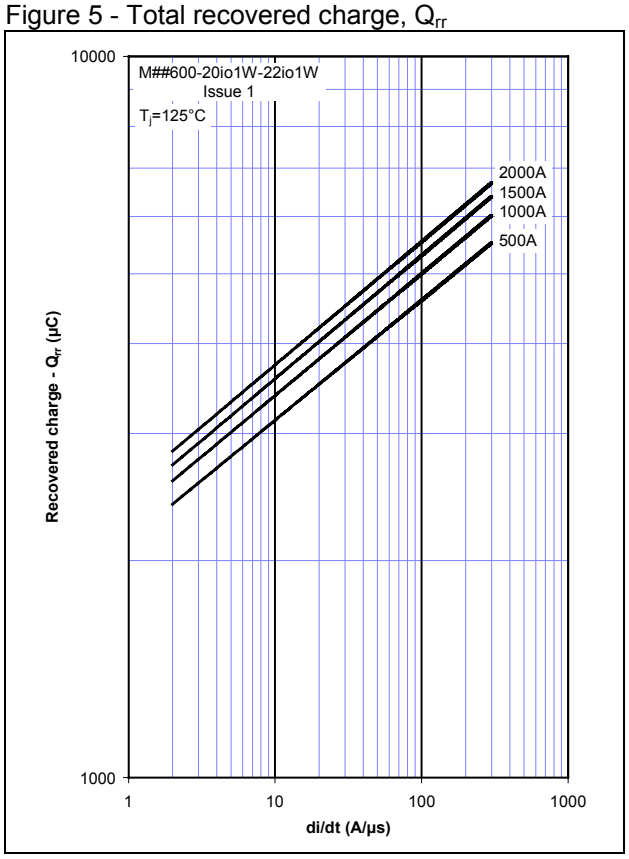


Figure 6 - Recovered charge, Q_{ra} (50% chord)

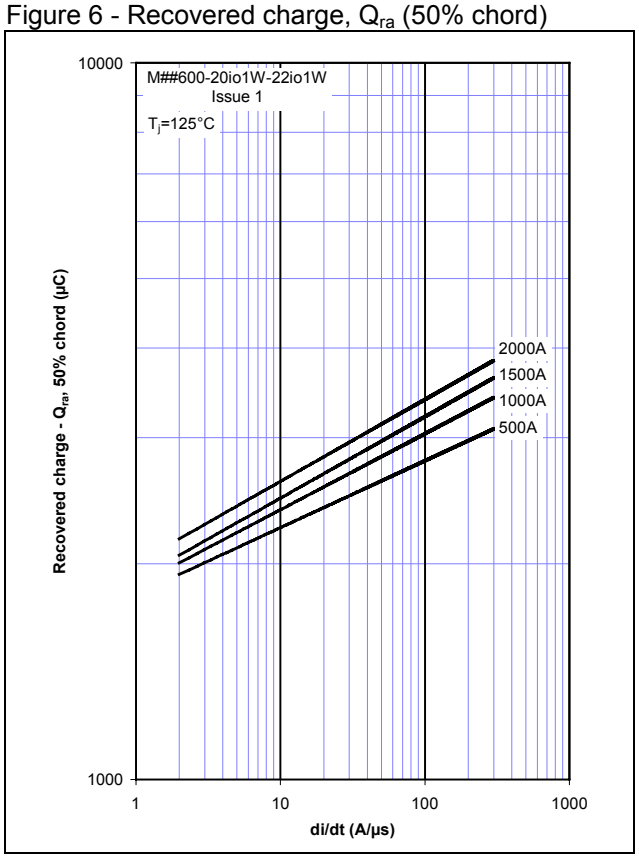


Figure 7 - Peak reverse recovery current, I_{rm}

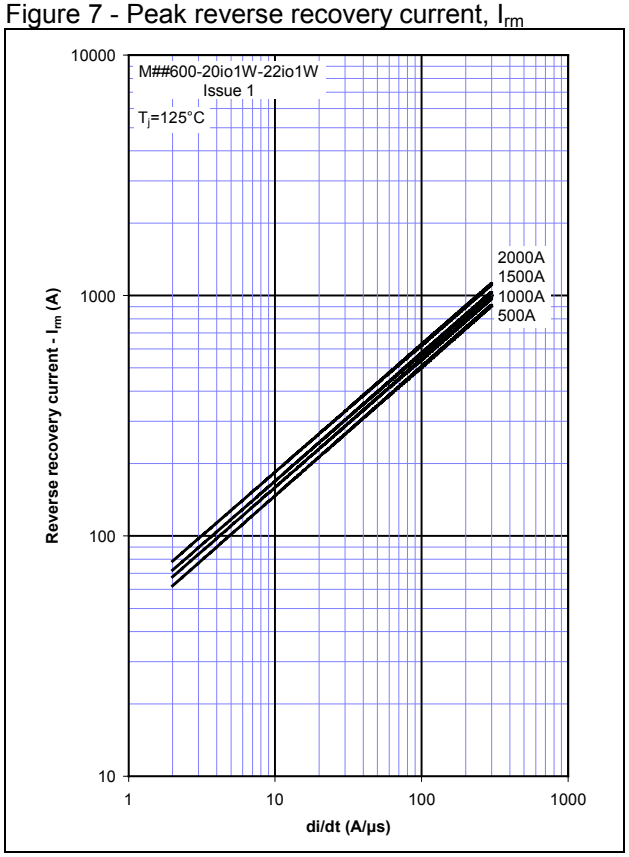


Figure 8 - Maximum recovery time, t_{rr} (50% chord)

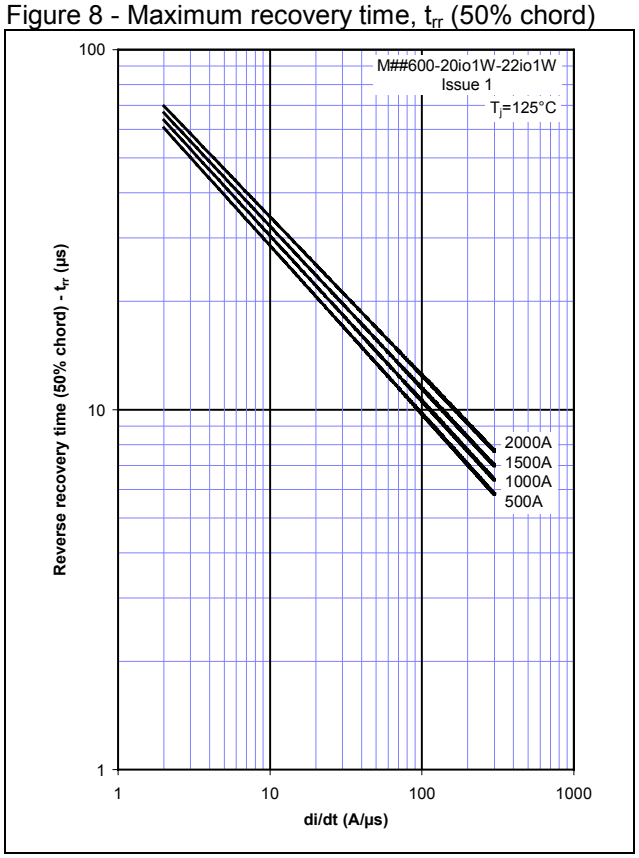


Figure 9 - On-state current vs. Power dissipation - Sine wave

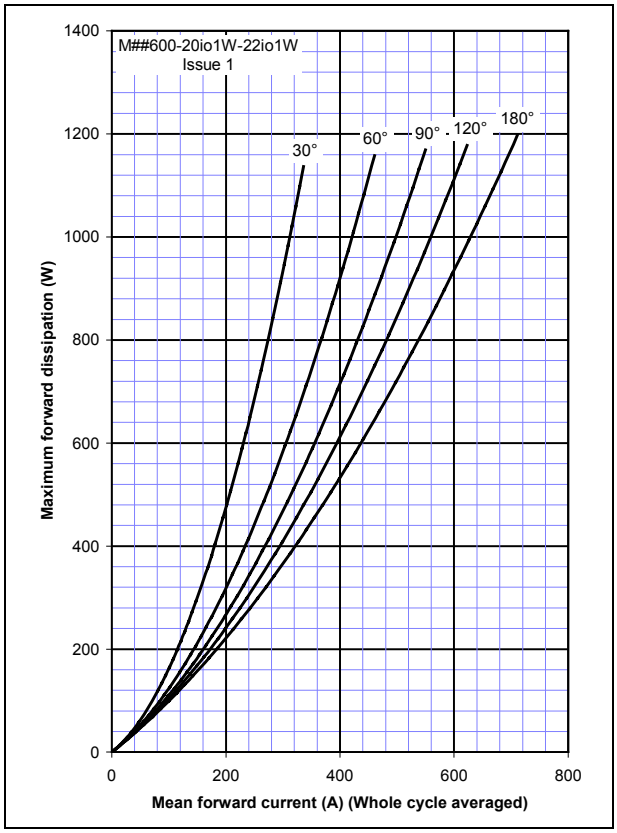


Figure 10 - On-state current vs. water temperature - Sine wave

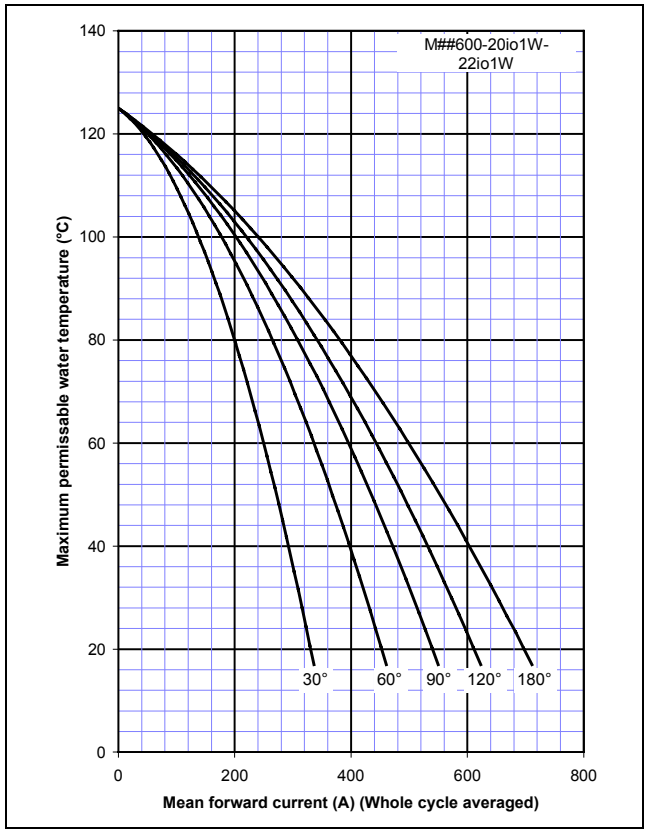


Figure 11 - On-state current vs. Power dissipation - Square wave

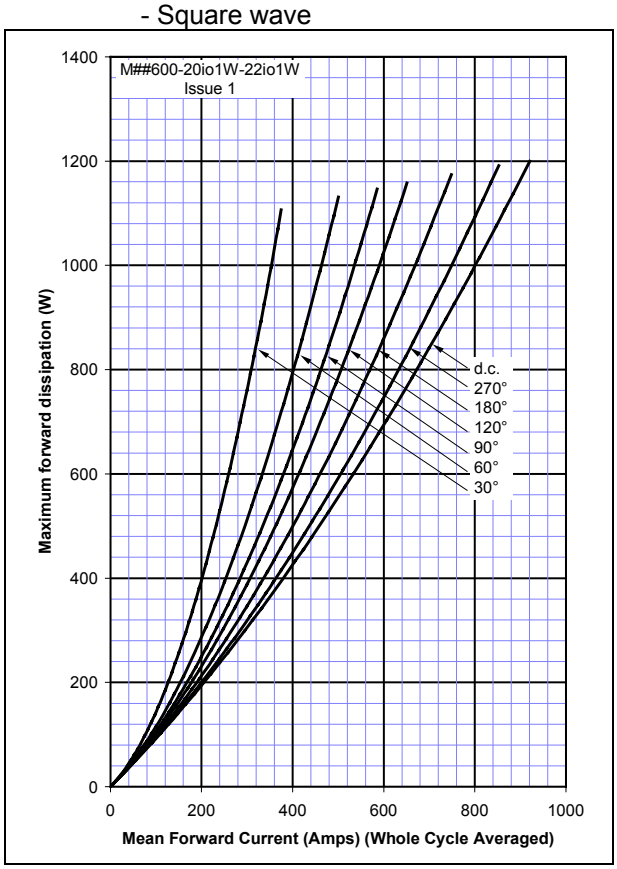


Figure 12 - On-state current vs. water temperature - Square wave

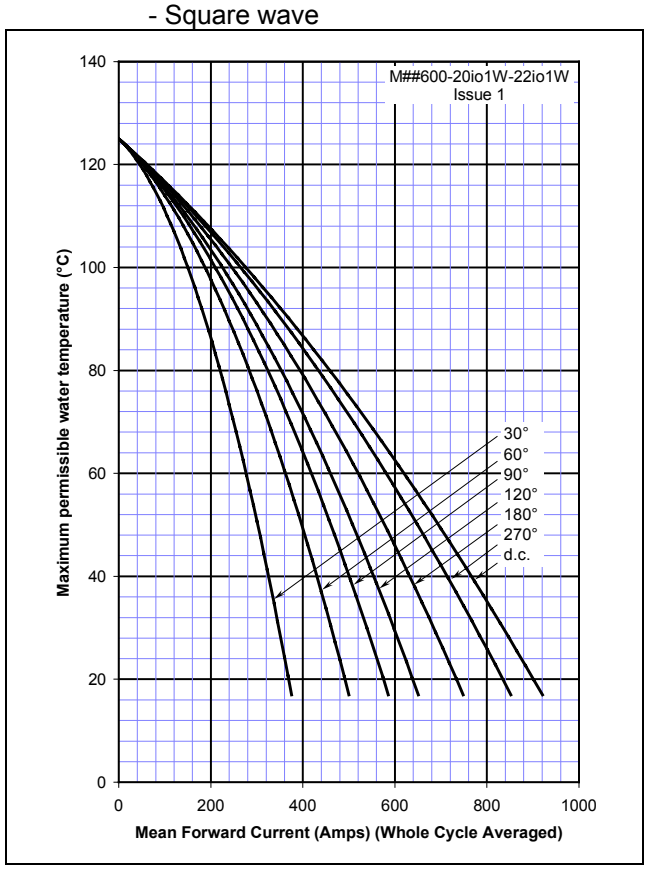


Figure 13 - Maximum surge and I^2t Ratings

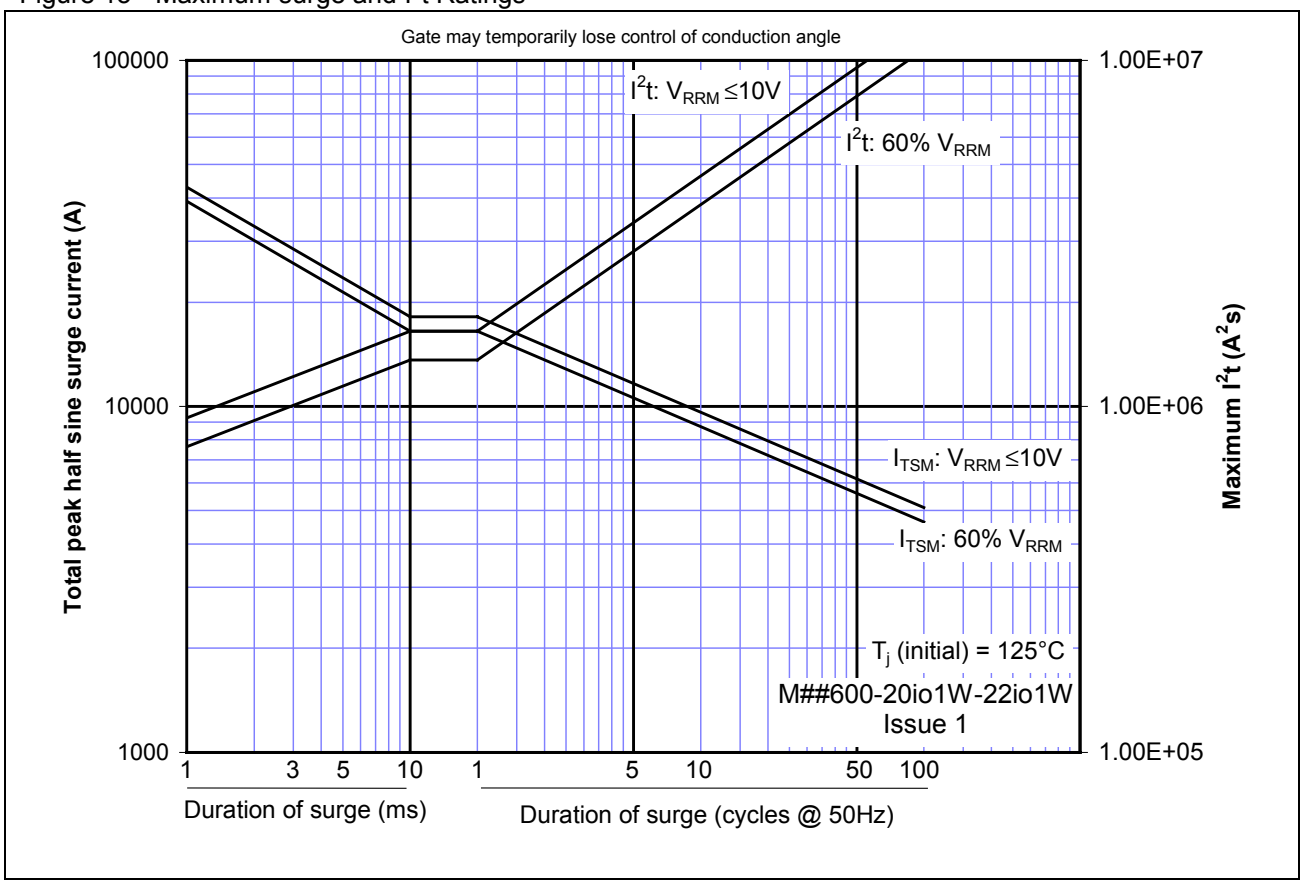
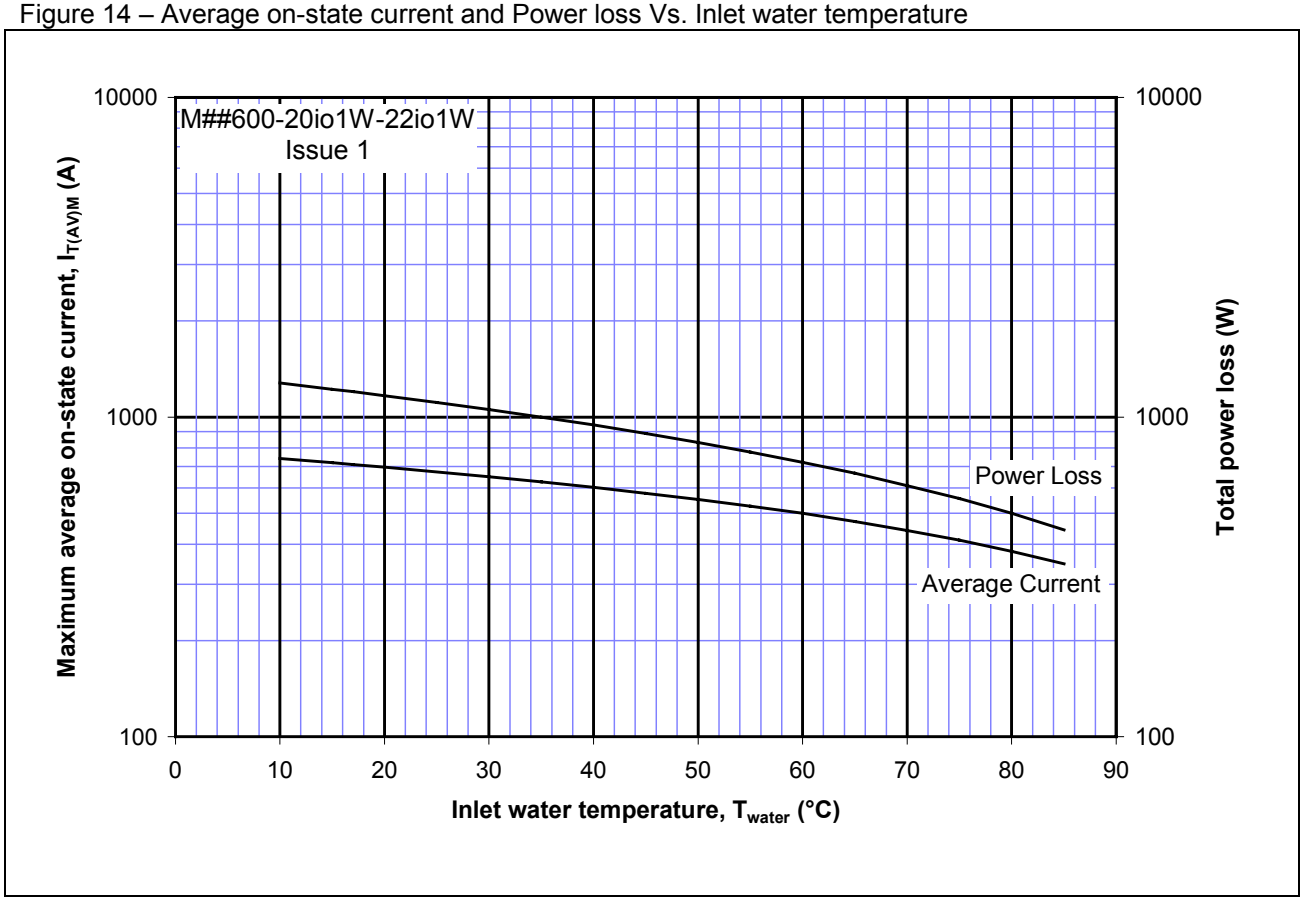


Figure 14 – Average on-state current and Power loss Vs. Inlet water temperature



Diode curves

Figure 15 - Total recovered charge, Q_{rr}

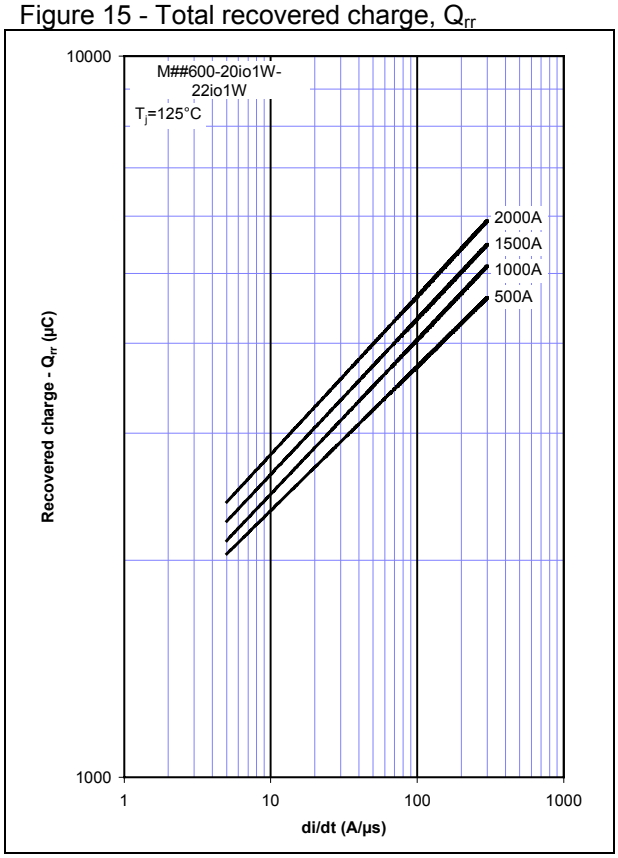


Figure 16 - Recovered charge, Q_{ra} (50% chord)

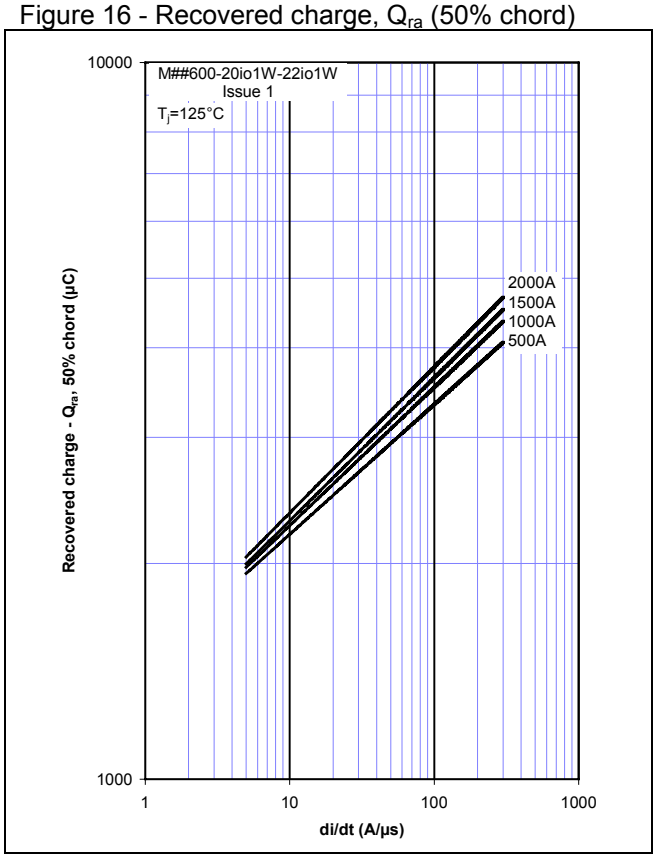


Figure 17 - Peak reverse recovery current, I_{rm}

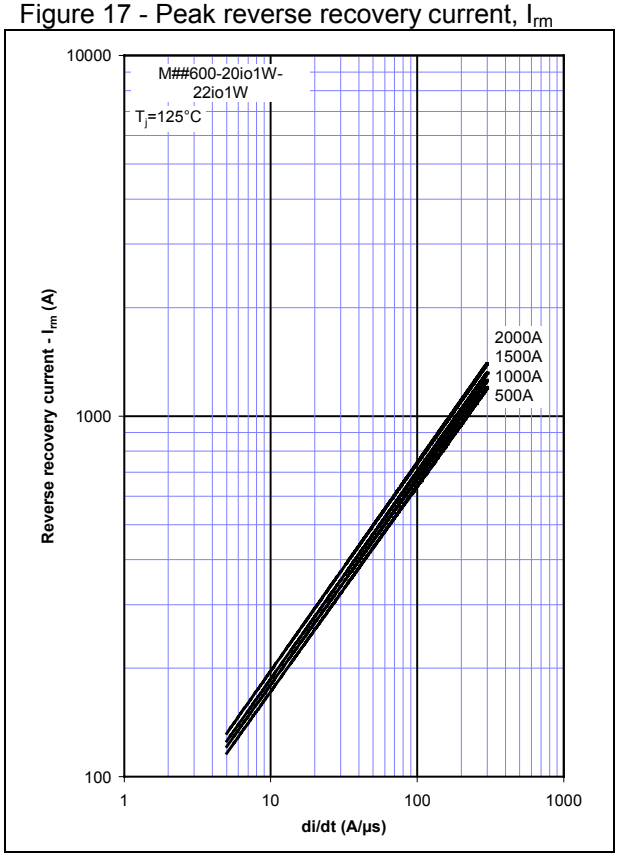


Figure 18 - Maximum recovery time, t_{rr} (50% chord)

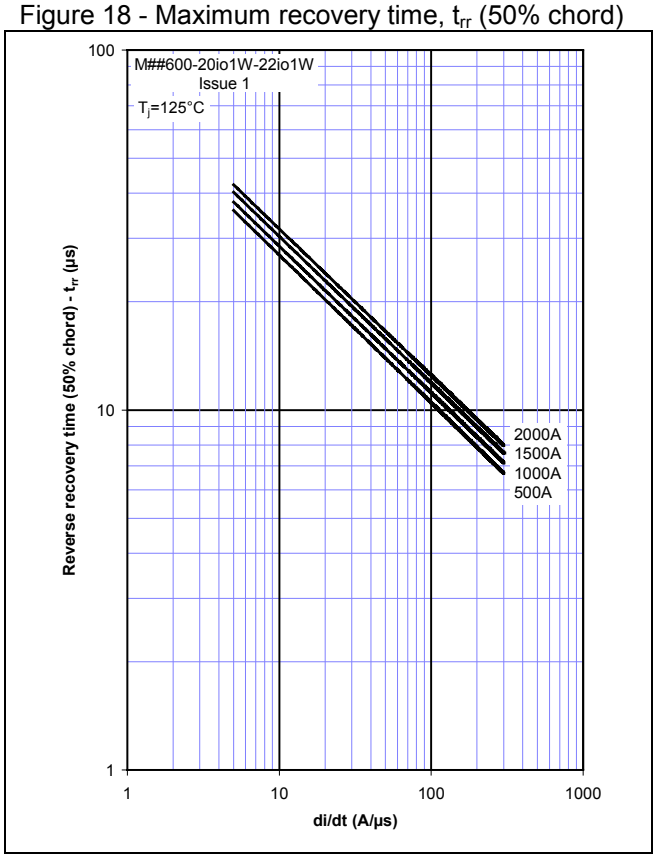
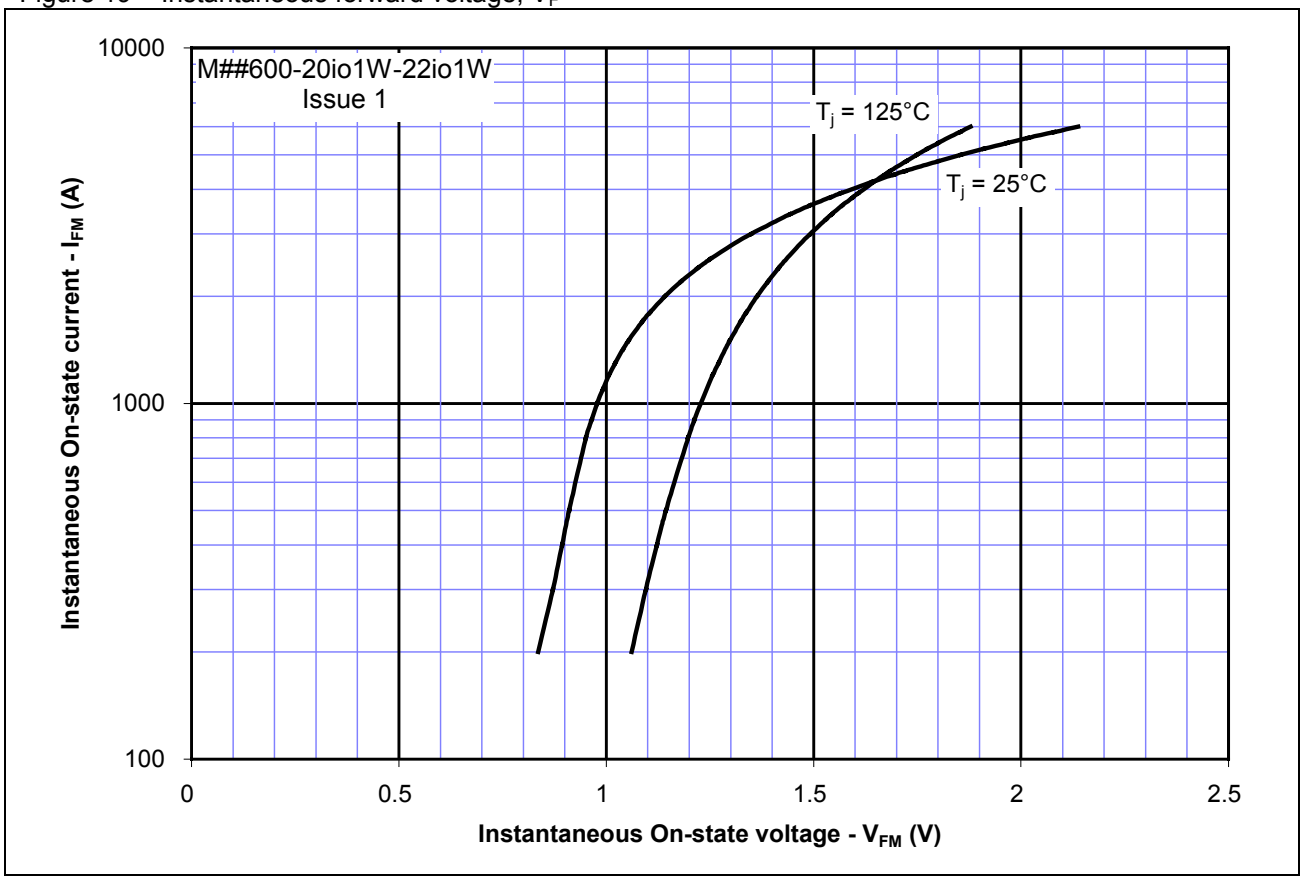
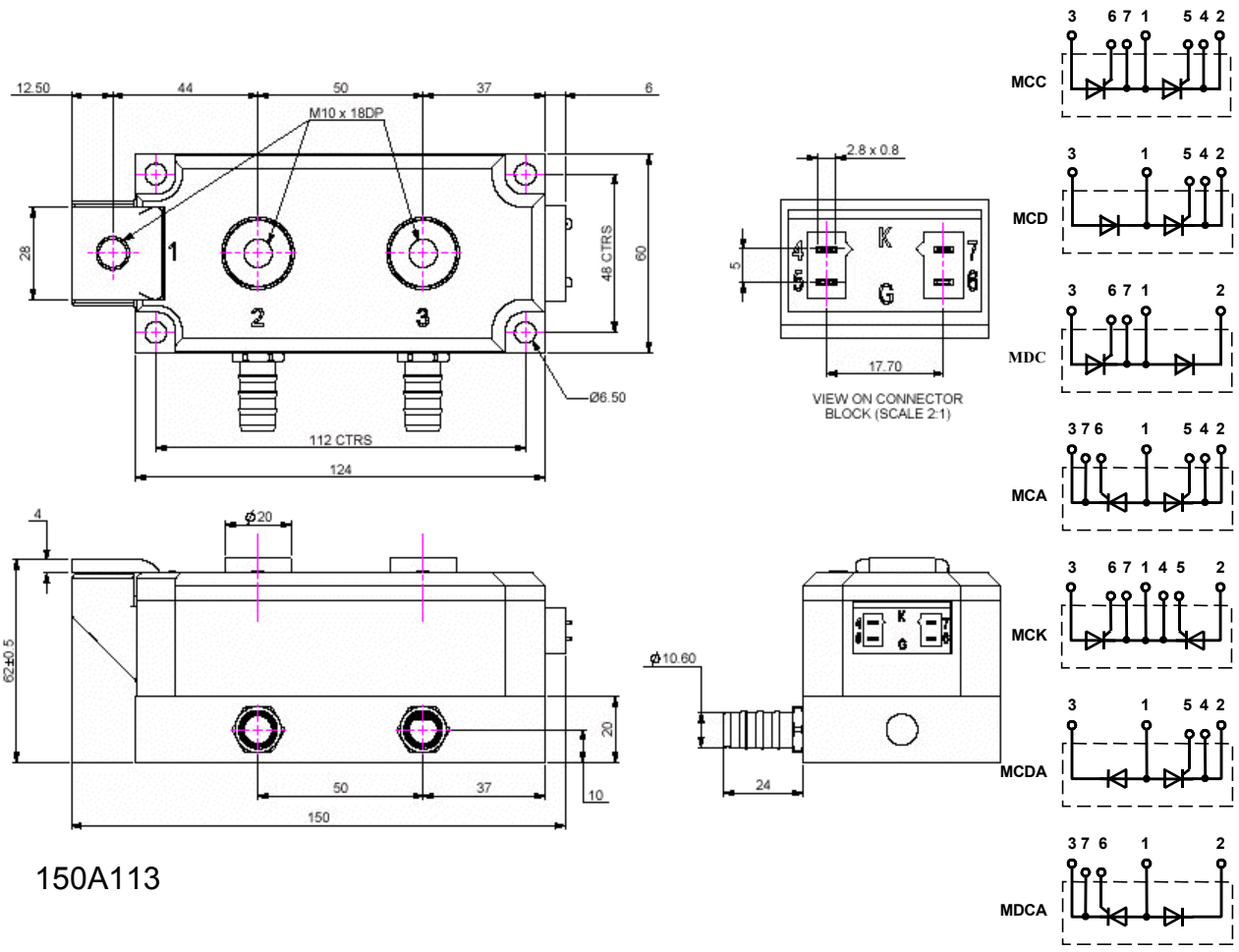


Figure 19 – Instantaneous forward voltage, V_F



Outline Drawing & Ordering Information



ORDERING INFORMATION (Please quote 12 digit code as below)						
M	**##**	**600**	**♦♦**	**io**	**1**	**W**
Fixed Type Code	Configuration code CC, CD, DC, CA, CK, CDA, DCA	Average Current Rating	Voltage code V_{DRM}/100 20-22	i = Critical dv/dt 1000 V/µs o = Typical turn-off time	Fixed Version Code	Water cooled base
Order code: MCD600-20io1W– MCD configuration, 2000V V_{RRM}, water cooled base						

IXYS Semiconductor GmbH
Edisonstraße 15
D-68623 Lampertheim
Tel: +49 6206 503-0
Fax: +49 6206 503-627
E-mail: marcom@ixys.de

IXYS Corporation
3540 Bassett Street
Santa Clara CA 95054 USA
Tel: +1 (408) 982 0700
Fax: +1 (408) 496 0670
E-mail: sales@ixys.net

IXYS
www.ixys.com

WESTCODE
An IXYS Company
www.westcode.com

Westcode Semiconductors Ltd
Langley Park Way, Langley Park,
Chippenham, Wiltshire, SN15 1GE.
Tel: +44 (0)1249 444524
Fax: +44 (0)1249 659448
E-mail: WSL.sales@westcode.com

Westcode Semiconductors Inc
3270 Cherry Avenue
Long Beach CA 90807 USA
Tel: +1 (562) 595 6971
Fax: +1 (562) 595 8182
E-mail: WSI.sales@westcode.com