

# Medium Voltage Thyristor

## Types K1010MA600 & K1010MA650

### Absolute Maximum Ratings

	VOLTAGE RATINGS	MAXIMUM LIMITS	UNITS
V <sub>DRM</sub>	Repetitive peak off-state voltage, (note 1)	6000-6500	V
V <sub>DSM</sub>	Non-repetitive peak off-state voltage, (note 1)	6000-6500	V
V <sub>R RM</sub>	Repetitive peak reverse voltage, (note 1)	6000-6500	V
V <sub>R SM</sub>	Non-repetitive peak reverse voltage, (note 1)	6100-6600	V

	OTHER RATINGS	MAXIMUM LIMITS	UNITS
I <sub>T(AV)</sub>	Mean on-state current. T <sub>sink</sub> =55°C, (note 2)	1130	A
I <sub>T(AV)</sub>	Mean on-state current. T <sub>sink</sub> =85°C, (note 2)	790	A
I <sub>T(AV)</sub>	Mean on-state current. T <sub>sink</sub> =85°C, (note 3)	440	A
I <sub>T(RMS)</sub>	Nominal RMS on-state current. T <sub>sink</sub> =25°C, (note 2)	2210	A
I <sub>T(d.c.)</sub>	D.C. on-state current. T <sub>sink</sub> =25°C, (note 4)	1970	A
I <sub>TSM</sub>	Peak non-repetitive surge t <sub>p</sub> =10ms, V <sub>RM</sub> =0.6V <sub>R RM</sub> , (note 5)	12.6	kA
I <sub>TSM2</sub>	Peak non-repetitive surge t <sub>p</sub> =10ms, V <sub>RM</sub> ≤10V, (note 5)	14.0	kA
I <sup>2</sup> t	I <sup>2</sup> t capacity for fusing t <sub>p</sub> =10ms, V <sub>RM</sub> =0.6V <sub>R RM</sub> , (note 5)	794×10 <sup>3</sup>	A <sup>2</sup> s
I <sup>2</sup> t	I <sup>2</sup> t capacity for fusing t <sub>p</sub> =10ms, V <sub>RM</sub> ≤10V, (note 5)	980×10 <sup>3</sup>	A <sup>2</sup> s
di <sub>T</sub> /dt	Maximum rate of rise of on-state current (repetitive), (Note 6)	200	A/μs
	Maximum rate of rise of on-state current (non-repetitive), (Note 6)	1000	A/μs
V <sub>R GM</sub>	Peak reverse gate voltage	5	V
P <sub>G(AV)</sub>	Mean forward gate power	2	W
P <sub>GM</sub>	Peak forward gate power	30	W
V <sub>GD</sub>	Non-trigger gate voltage, (Note 7)	0.25	V
T <sub>HS</sub>	Operating temperature range	-40 to +125	°C
T <sub>stg</sub>	Storage temperature range	-40 to +150	°C

Notes: -

- 1) De-rating factor of 0.13% per °C is applicable for T<sub>j</sub> below 25°C.
- 2) Double side cooled, single phase; 50Hz, 180° half-sinewave.
- 3) Cathode side cooled, single phase; 50Hz, 180° half-sinewave.
- 4) Double side cooled.
- 5) Half-sinewave, 125°C T<sub>j</sub> initial.
- 6) V<sub>D</sub>=67% V<sub>DRM</sub>, I<sub>TM</sub>=2000A, I<sub>FG</sub>=2A, t<sub>r</sub>≤0.5μs, T<sub>case</sub>=125°C.
- 7) Rated V<sub>DRM</sub>.

### Characteristics

	PARAMETER	MIN.	TYP.	MAX.	TEST CONDITIONS (Note 1)	UNITS
$V_{TM}$	Maximum peak on-state voltage	-	-	2.50	$I_{TM}=1000A$	V
$V_0$	Threshold voltage	-	-	1.61		V
$r_T$	Slope resistance	-	-	0.90		m $\Omega$
dv/dt	Critical rate of rise of off-state voltage	1000	-	-	$V_D=80\% V_{DRM}$ , Linear ramp, gate o/c	V/ $\mu$ s
$I_{DRM}$	Peak off-state current	-	-	150	Rated $V_{DRM}$	mA
$I_{RRM}$	Peak reverse current	-	-	150	Rated $V_{RRM}$	mA
$V_{GT}$	Gate trigger voltage	-	-	3.0	$T_j=25^\circ C$ , $V_D=10V$ , $I_T=3A$	V
$I_{GT}$	Gate trigger current	-	-	300		mA
$I_H$	Holding current	-	-	1000	$T_j=25^\circ C$	mA
$t_{gd}$	Gate controlled turn-on delay time	-	0.6	1.0	$I_{FG}=2A$ , $t_r=0.5\mu s$ , $V_D=67\%V_{DRM}$ , $I_{TM}=1000A$ , $di/dt=10A/\mu s$ , $T_j=25^\circ C$	$\mu$ s
$t_{gt}$	Turn-on time	-	1.6	2.5		$\mu$ s
$Q_{rr}$	Recovered Charge	-	6200	7000		$\mu$ C
$Q_{ra}$	Recovered Charge, 50% chord	-	2750	-	$I_{TM}=1000A$ , $t_p=2000\mu s$ , $di/dt=10A/\mu s$ , $V_r=100V$	$\mu$ C
$I_{rm}$	Reverse recovery current	-	150	155		A
$t_{rr}$	Reverse recovery time, 50% chord	-	37	-		$\mu$ s
$t_q$	Turn-off time	600	-	850	$I_{TM}=1000A$ , $t_p=1000\mu s$ , $di/dt=10A/\mu s$ , $V_r=100V$ , $V_{dr}=80\%V_{DRM}$ , $dV_{dr}/dt=20V/\mu s$ (Note 2)	$\mu$ s
		850	-	1150	$I_{TM}=1000A$ , $t_p=1000\mu s$ , $di/dt=10A/\mu s$ , $V_r=100V$ , $V_{dr}=80\%V_{DRM}$ , $dV_{dr}/dt=200V/\mu s$ (Note 2)	
$R_{thJK}$	Thermal resistance, junction to heatsink	-	-	0.015	Double side cooled	K/W
		-	-	0.035	Cathode side cooled	K/W
		-	-	0.027	Anode side cooled	K/W
F	Mounting force	24	-	32	(Note 3)	kN
$W_t$	Weight	-	540	-		kg

Notes: -

- 1) Unless otherwise stated  $T_j=125^\circ C$ .
- 2) Standard test condition for  $t_q$   $dV_{dr}/dt=20V/\mu s$ . For other  $dV_{dr}/dt$  values please consult factory.
- 3) For other clamp forces please consult factory.

## 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
60	6000	6100	3320
65	6500	6600	3600

### 2.0 Extension of Voltage Grades

This report is applicable to other and higher 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  $T_j$  below 25°C.

### 4.0 Repetitive dv/dt

Standard dv/dt is 1000V/μs.

### 5.0 Computer Modelling Parameters

#### 5.1 Device Dissipation Calculations

$$I_{AV} = \frac{-V_0 + \sqrt{V_0^2 + 4 \cdot ff \cdot r_s \cdot W_{AV}}}{2 \cdot ff \cdot r_s} \quad \text{and:} \quad W_{AV} = \frac{\Delta T}{R_{th}}$$

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

Where  $V_0=1.61V$ ,  $r_s=0.90m\Omega$ ,

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

$ff$  = Form factor, see table below.

Supplementary Thermal Impedance							
Conduction Angle	30°	60°	90°	120°	180°	270°	d.c.
Square wave Double Side Cooled	0.0216	0.0195	0.0182	0.0174	0.0164	0.0155	0.0150
Square wave Anode Side Cooled	0.0333	0.0313	0.0301	0.0293	0.0284	0.0275	0.0270
Square wave Cathode Side Cooled	0.0413	0.0390	0.0377	0.0369	0.0359	0.0351	0.0350
Sine wave Double Side Cooled	0.0194	0.0173	0.0164	0.0158	0.0151		
Sine wave Anode Side Cooled	0.0313	0.0293	0.0285	0.0279	0.0271		
Sine wave Cathode Side Cooled	0.0388	0.0367	0.0358	0.0353	0.0351		

Form Factors							
Conduction Angle	30°	60°	90°	120°	180°	270°	d.c.
Square wave	3.46	2.45	2	1.73	1.41	1.15	1
Sine wave	3.98	2.78	2.22	1.88	1.57		

### 5.2 Calculating $V_T$ using ABCD Coefficients

The on-state characteristic  $I_T$  vs.  $V_T$ , on page 5 is represented in two ways;

- (i) the well established  $V_o$  and  $r_s$  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	1.624665861	A	1.143497461
B	-0.02074025	B	0.02036399
C	$5.31549 \times 10^{-4}$	C	$7.17425 \times 10^{-4}$
D	$9.226506 \times 10^{-3}$	D	0.01576106

### 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  $n$ ,  $n$  is the 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.
- $\tau_p$  = Time Constant of  $r$ th term.

D.C. Double Side Cooled				
Term	1	2	3	4
$r_p$	$9.266171 \times 10^{-3}$	$3.903851 \times 10^{-3}$	$1.000914 \times 10^{-3}$	$8.500206 \times 10^{-4}$
$\tau_p$	0.8130294	0.1108562	0.01765125	$1.669867 \times 10^{-3}$

D.C. Cathode Side Cooled				
Term	1	2	3	4
$r_p$	0.0265844	$6.266598 \times 10^{-3}$	$9.776614 \times 10^{-4}$	$7.727025 \times 10^{-4}$
$\tau_p$	4.685406	0.1595806	0.01273907	$1.485356 \times 10^{-3}$

D.C. Anode Side Cooled						
Term	1	2	3	4	5	6
$r_p$	0.01782312	$3.147049 \times 10^{-3}$	$3.914661 \times 10^{-3}$	$8.144810 \times 10^{-4}$	$5.484281 \times 10^{-4}$	$7.475630 \times 10^{-4}$
$\tau_p$	3.911231	0.5627890	0.1208194	0.04179831	$7.812715 \times 10^{-3}$	$1.696434 \times 10^{-3}$

**Curves**

Figure 1 - On-state characteristics of Limit device

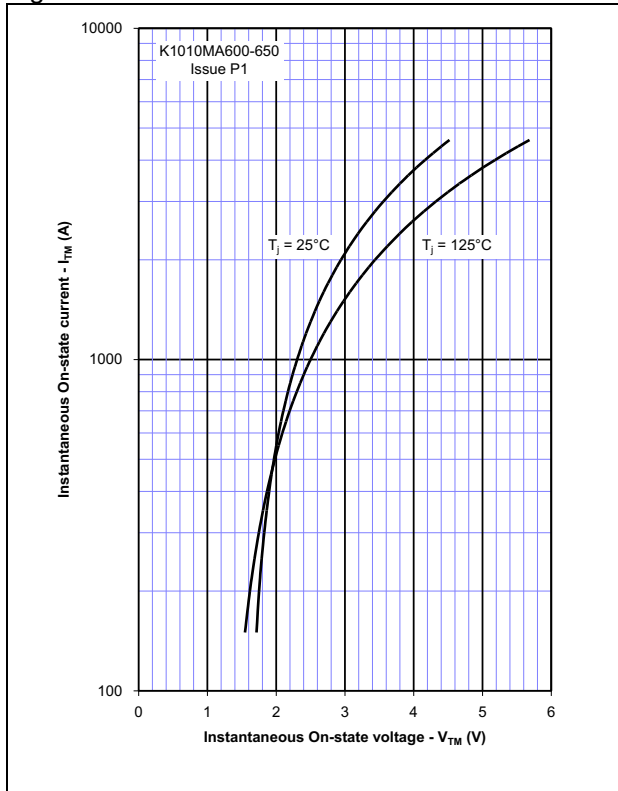


Figure 2 - Transient Thermal Impedance

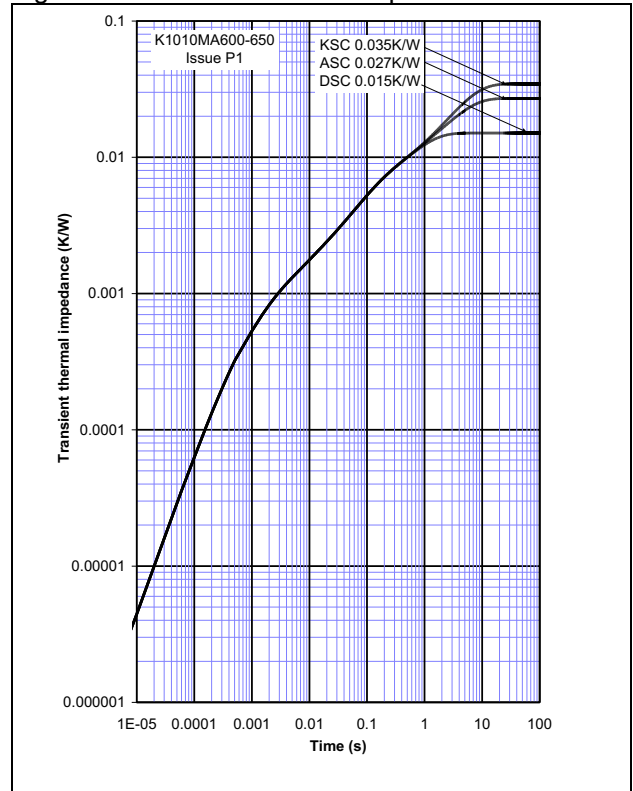


Figure 3 - Gate Characteristics - Trigger Limits

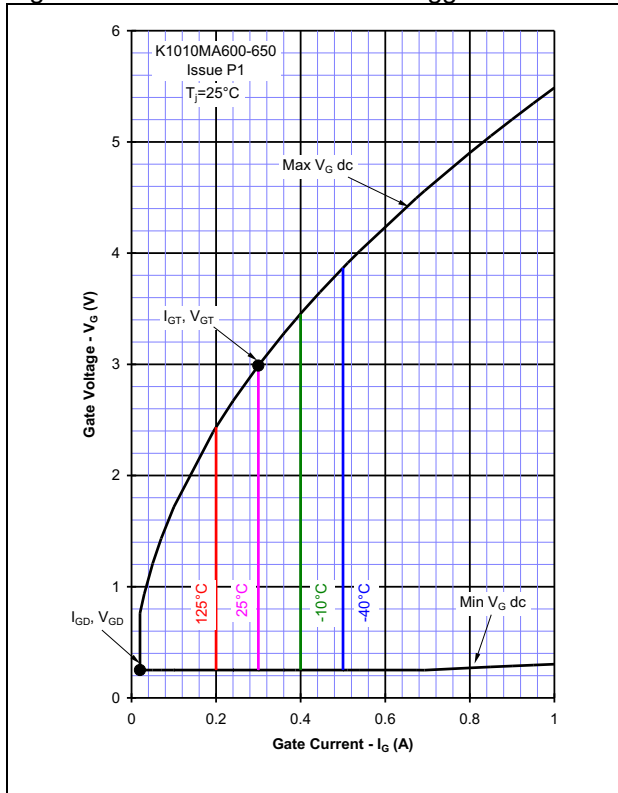


Figure 4 - Gate Characteristics - Power Curves

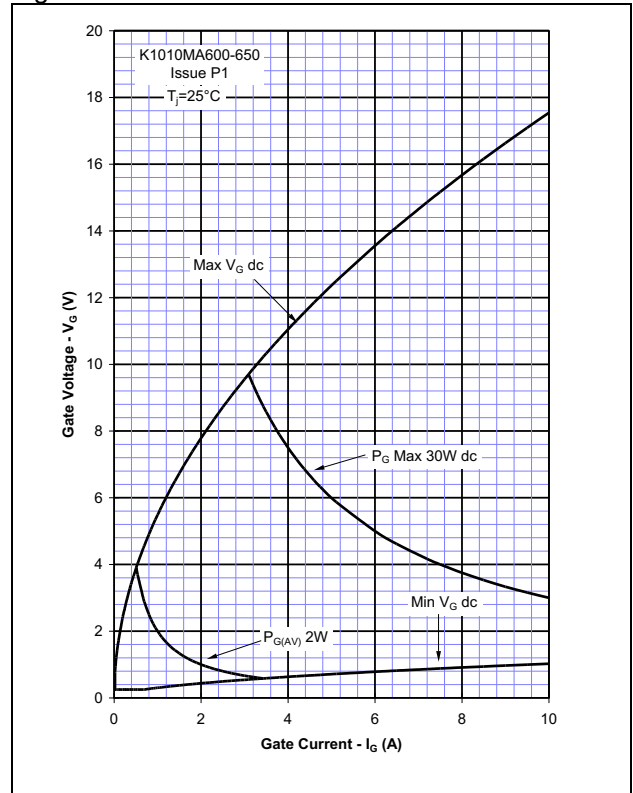


Figure 5 – Recovered Charge,  $Q_{rr}$

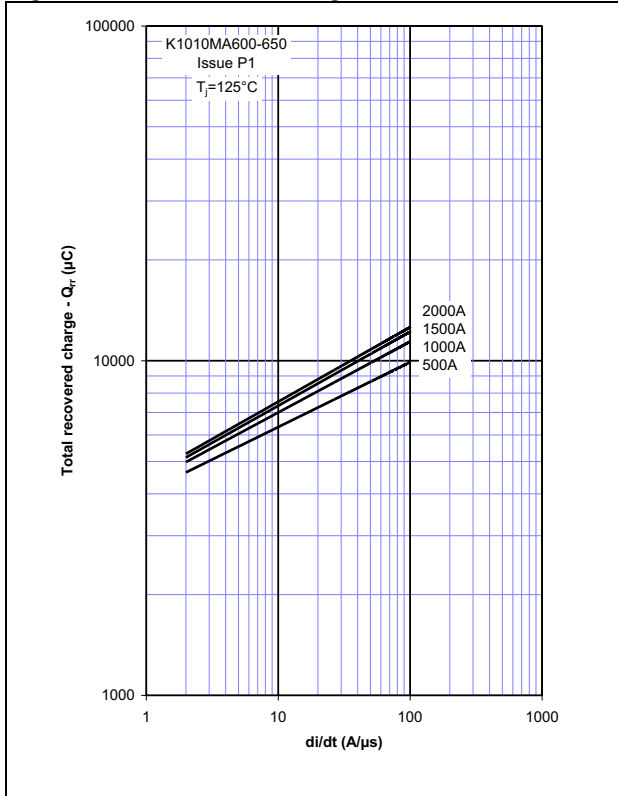


Figure 6 – Recovered charge,  $Q_{ra}$  (50% chord)

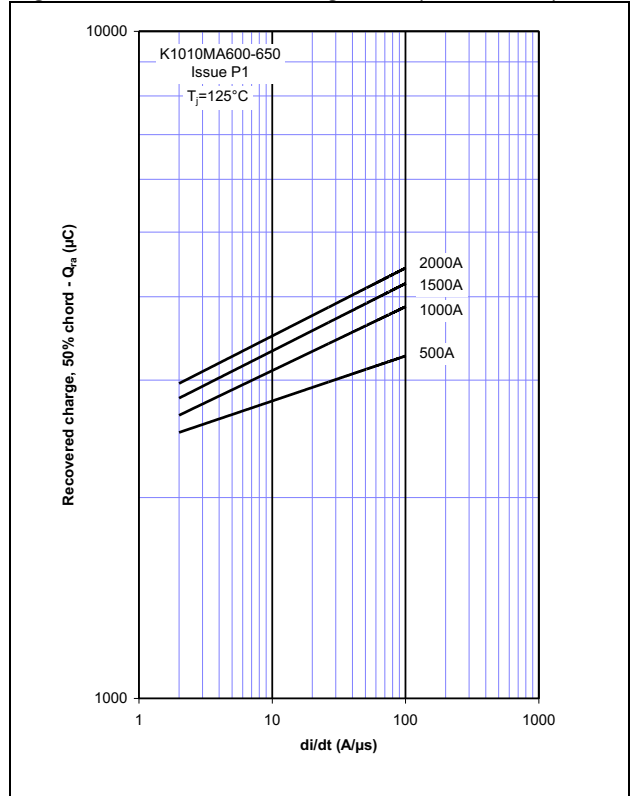


Figure 7 – Reverse recovery current,  $I_{rm}$

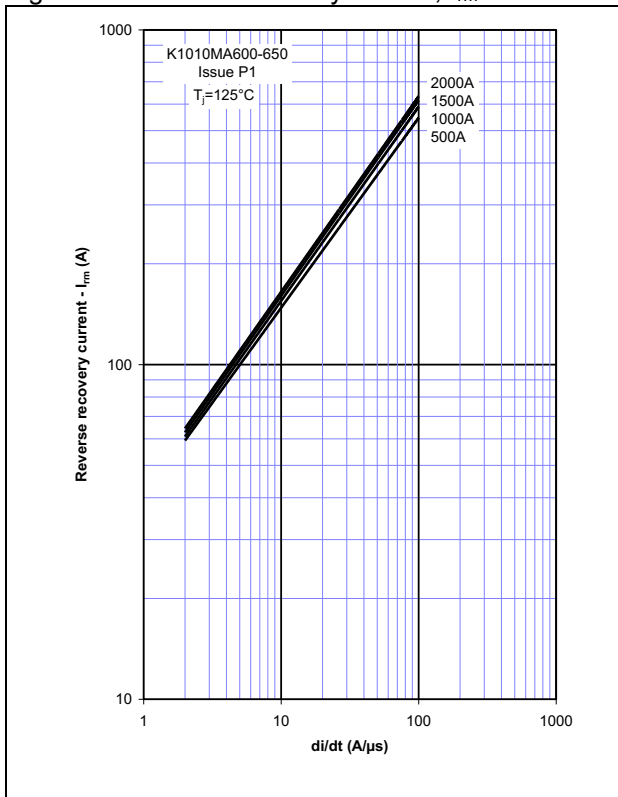


Figure 8 – Reverse recovery time,  $t_{rr}$

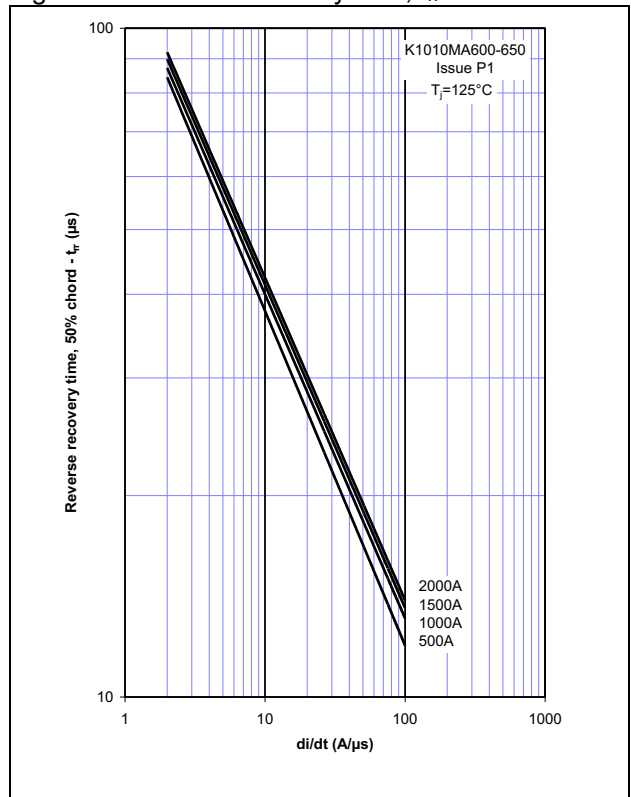


Figure 9 – On-state current vs. Power dissipation – Double Side Cooled (Sine wave)

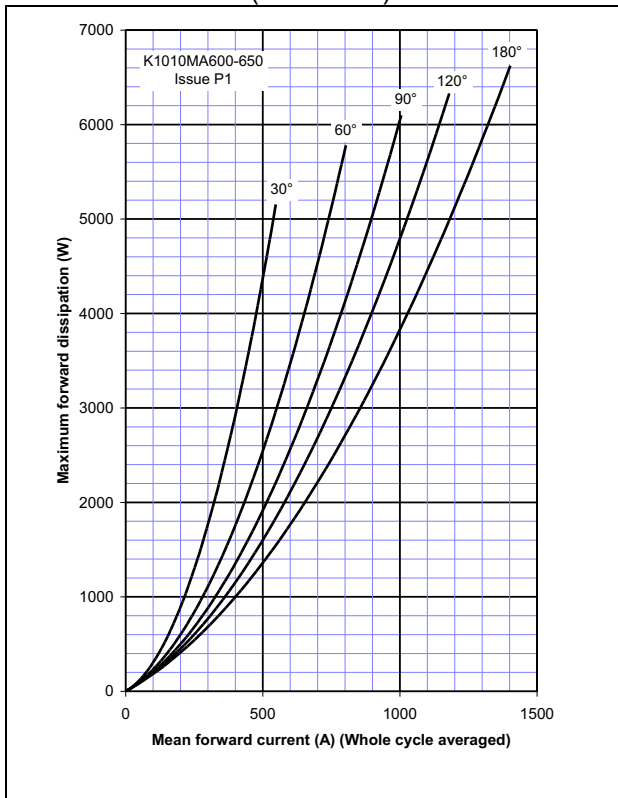


Figure 10 – On-state current vs. Heatsink temperature - Double Side Cooled (Sine wave)

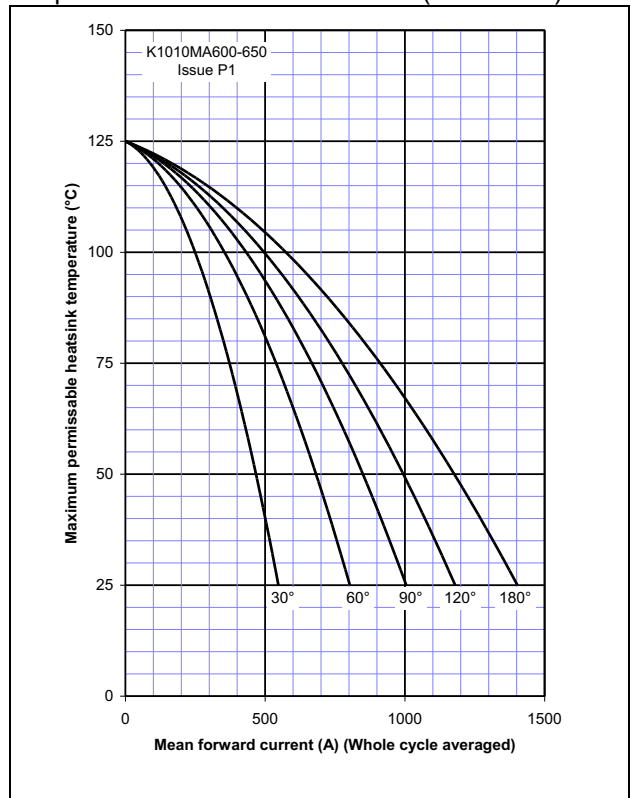


Figure 11 – On-state current vs. Power dissipation – Double Side Cooled (Square wave)

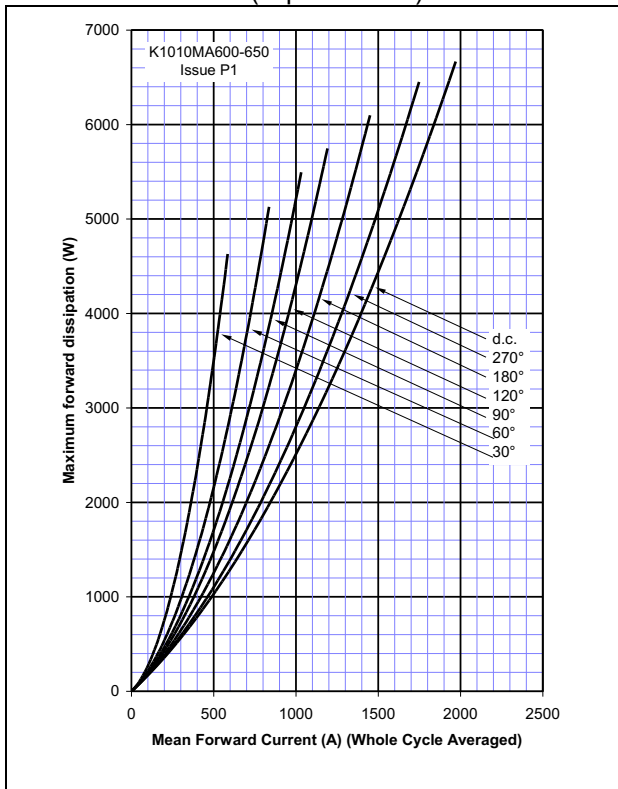


Figure 12 – On-state current vs. Heatsink temperature - Double Side Cooled (Square wave)

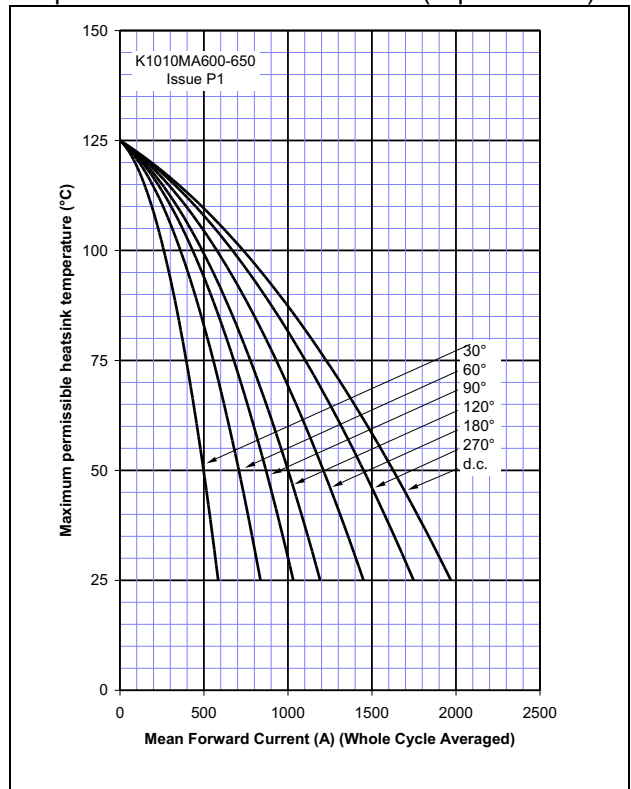


Figure 13 – On-state current vs. Power dissipation – Cathode Side Cooled (Sine wave)

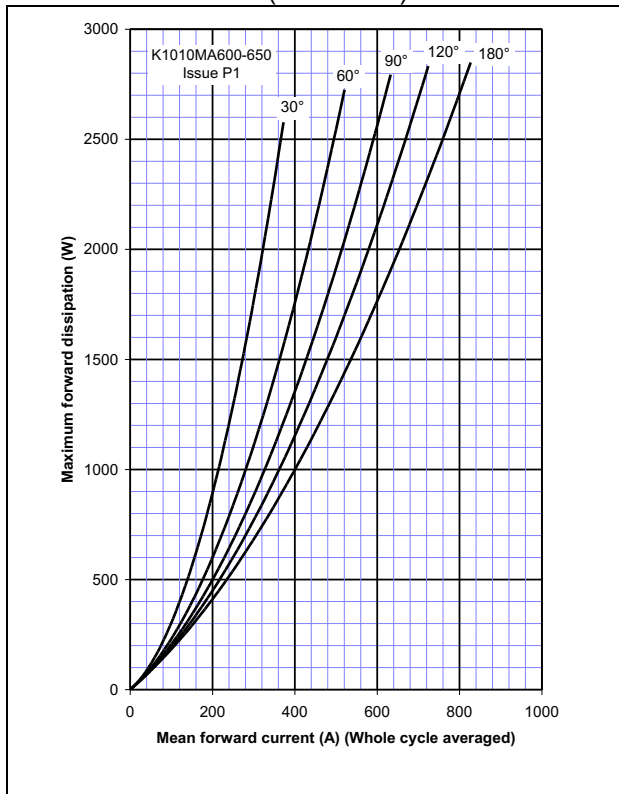


Figure 14 – On-state current vs. Heatsink temperature - Cathode Side Cooled (Sine wave)

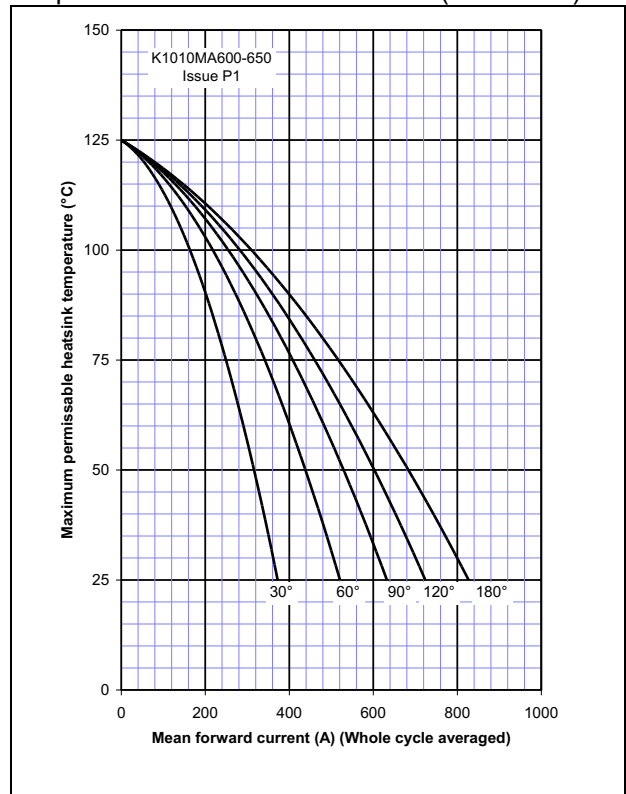


Figure 15 – On-state current vs. Power dissipation – Cathode Side Cooled (Square wave)

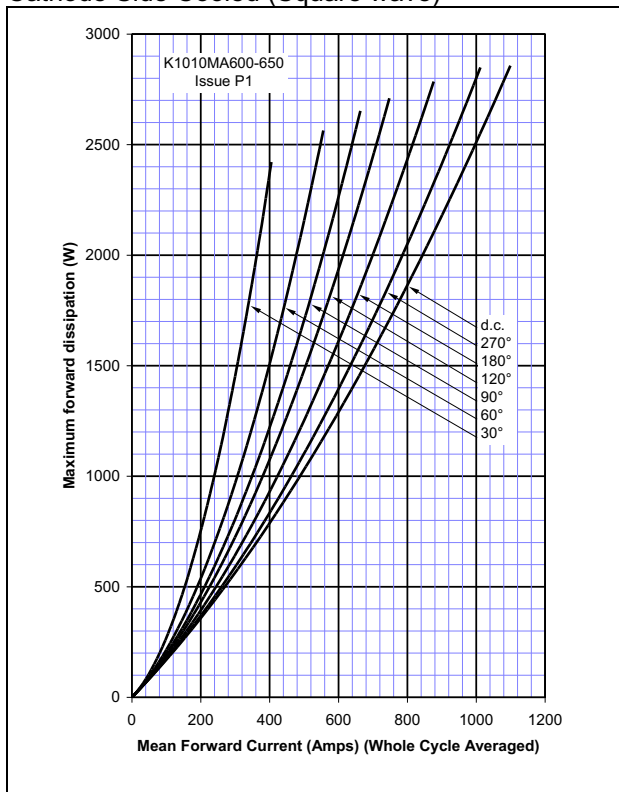


Figure 16 – On-state current vs. Heatsink temperature - Cathode Side Cooled (Square wave)

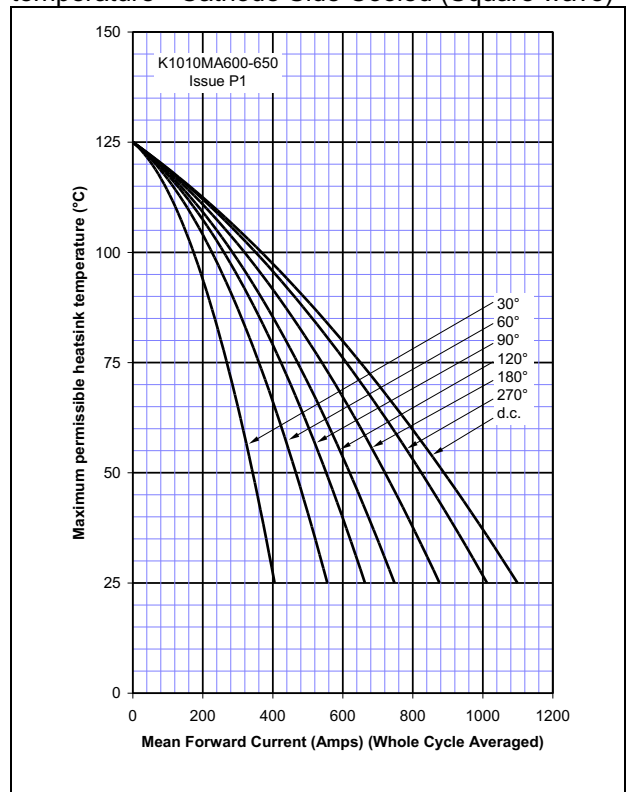
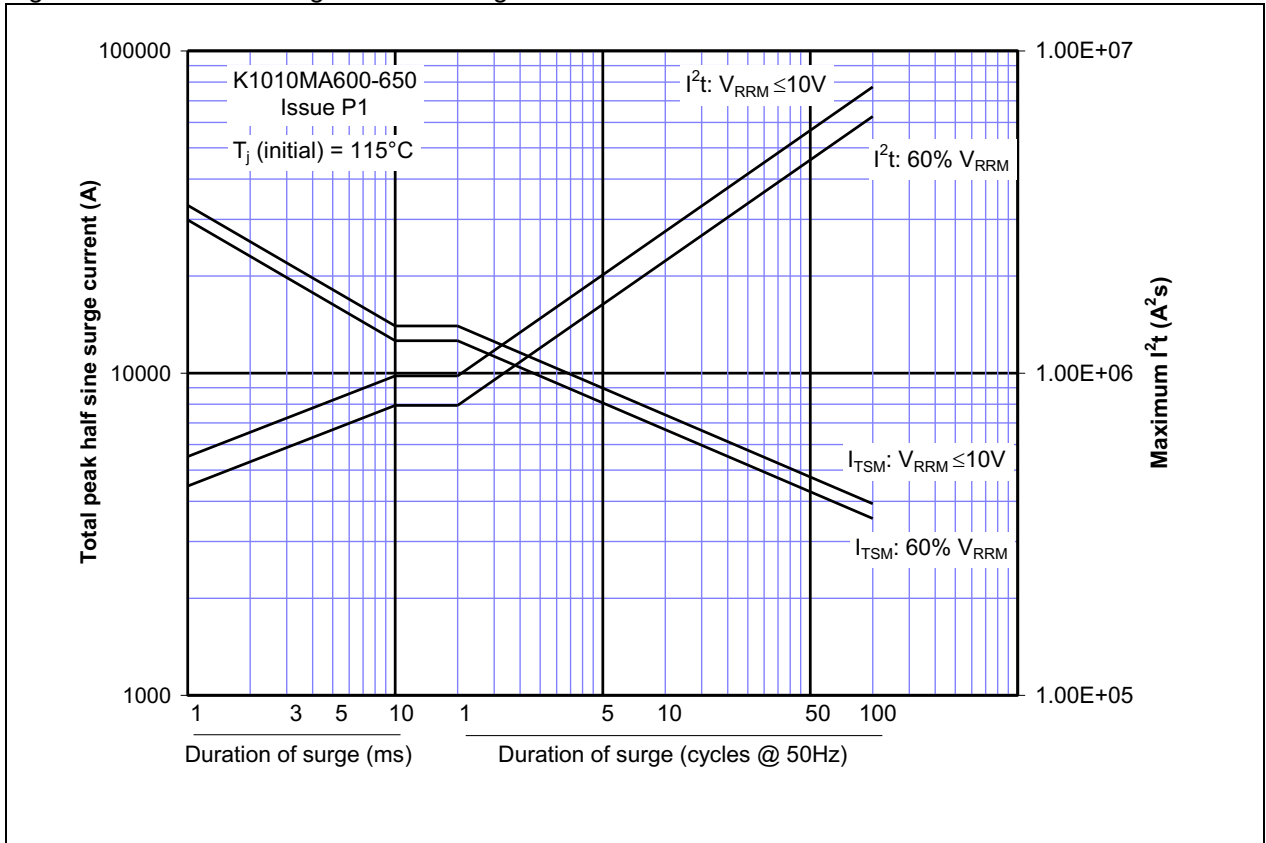
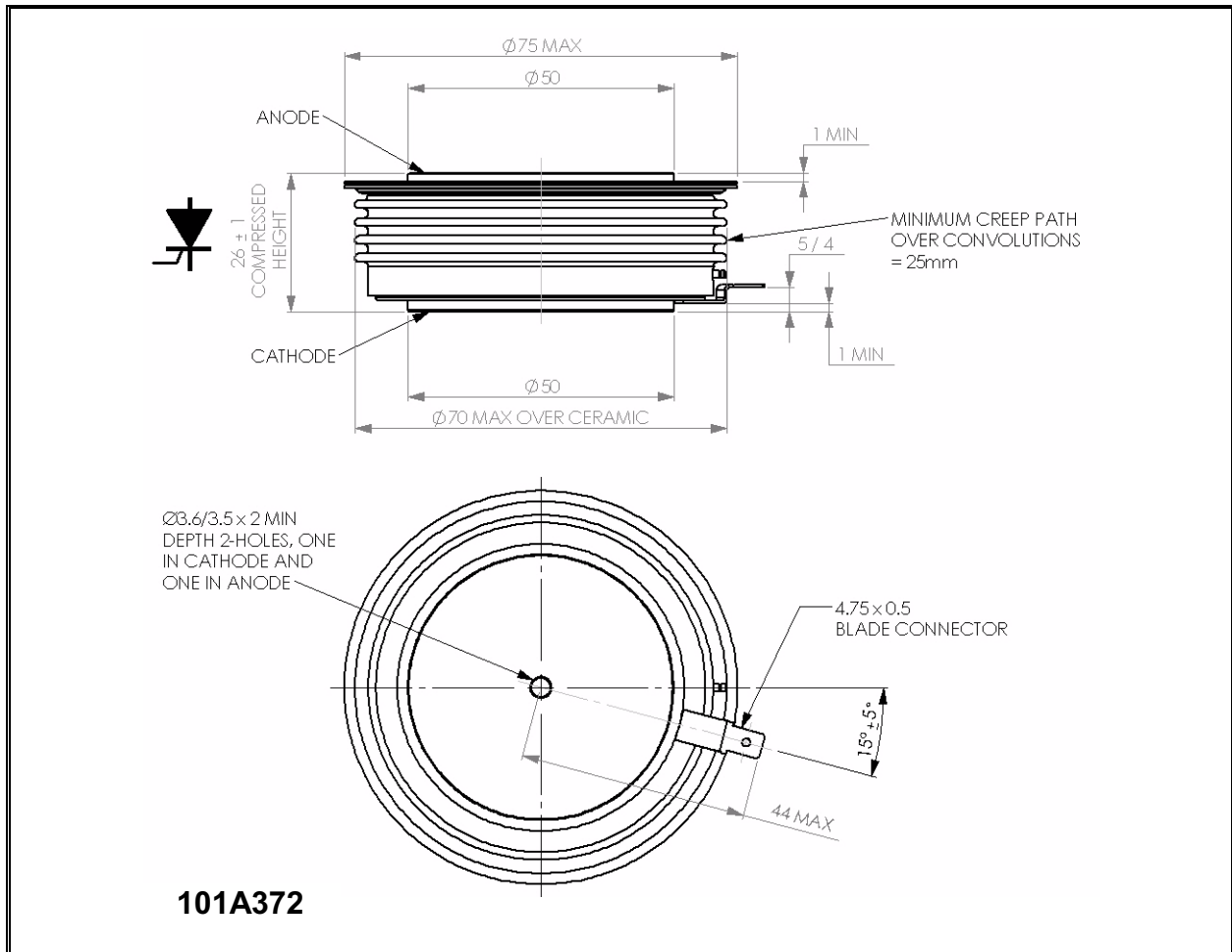




Figure 17 – Maximum surge and  $I^2t$  Ratings



**Outline Drawing & Ordering Information**



**ORDERING INFORMATION**

(Please quote 10 digit code as below)

<b>K1010</b>	<b>MA</b>	<b>◆◆</b>	<b>0</b>
Fixed Type Code	Fixed Outline Code	Voltage Code 60 & 65	Fixed turn-off time code

Typical order code: K1010MA650 – 6500V  $V_{DRM}$ ,  $V_{RRM}$ , 1000V/ $\mu$ s dv/dt, 26mm clamp height capsule.

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