Soft Recovery Diode
Types M1565V#400 to M1565V#450

The data sheet on the subsequent pages of this document is a scanned copy of existing data for this product.
(Rating Report 97D07 Issue 1)

This data reflects the old part number for this product which is: SM36-45C/FXC394.
This part number must **NOT** be used for ordering purposes – please use the ordering particulars detailed below.

The limitations of this data are as follows:
Only VF outline drawing (W43) in datasheet
Device no longer available for grades 36 & 38 (3600V & 3800V V_{RRM}/V_{DRM})

The following links will direct you to the appropriate outline drawings
Outline W6 – 33mm clamp height capsule
Outline W43 – 26mm clamp height capsule

Where any information on the product matrix page differs from that in the following data, the product matrix must be considered correct

An electronic data sheet for this product is presently in preparation.

For further information on this product, please contact your local ASM or distributor.

Alternatively, please contact Westcode as detailed below.

Ordering Particulars

M1565	V#	♦♦	**0**
Fixed Type Code	VC – 33mm clamp height capsule VF – 26mm clamp height capsule	Voltage code $V_{RRM}/100$ 40-45	Fixed Code

Typical Order Code: M1565VC450, 33mm clamp height capsule, 4500V V_{RRM}/V_{DRM}

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

WESTCODE
An IXYS Company

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

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

www.westcode.com

www.ixys.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

Devices with a suffix code (2-letter, 3-letter or letter/digit/letter combination) added to their generic code are not necessarily subject to the conditions and limits contained in this report.

WESTCODE
SEMICONDUCTORS

Date :- July 97
Rat. Rep:- 97D07
Issue:- 1

Fast Recovery Diode
Type SM36-45FXC394

	VOLTAGE RATINGS	MAXIMUM LIMITS	UNITS
V_{RRM}	Repetitive peak reverse voltage, (note 1).	3600 - 4500	V
V_{RSM}	Non-repetitive peak reverse voltage, (note 1).	3700 – 4600	V

	RATINGS	MAXIMUM LIMITS	UNITS
$I_{F(AV)}$	Mean on-state current, T_{sink}=55°C double side cooled.	1565	A
$I_{F(AV)}$	Mean on-state current, T_{sink}=100°C single side cooled.	460	A
$I_{F(RMS)}$	Nominal RMS on-state current, T_{sink}=25°C.	3080	A
$I_{F(d.c.)}$	D.C. on-state current, T_{sink}=25°C.	2700	A
I_{FSM}	Peak non-repetitive surge tp=10ms, $V_{RM}=0.6V_{RRM}$, (note 2).	19.7	kA
I_{FSM2}	Peak non-repetitive surge tp=10ms, $V_{RM}\leq10V$, (note 2).	21.7	kA
I^2t	I^2t capacity for fusing tp=10ms, $V_{RM}=0.6V_{RRM}$, (note 2).	1.94×10^6	A^2s
I^2t	I^2t capacity for fusing tp=10ms, $V_{RM}\leq10V$, (note 2).	2.35×10^6	A^2s
I^2t	I^2t capacity for fusing tp=3ms, $V_{RM}\leq10V$, (note 2).	1.75×10^6	A^2s
T_{HS}	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 K is applicable for T_j below 25°C.
2) Half-sinewave, 125°C T_j initial.

	CHARACTERISTICS	MIN	TYP	MAX	TEST CONDITIONS	UNITS
V_{FM}	Maximum peak on-state voltage.	-	-	1.8	I_{FM}=2000A.	V
V_0	Threshold voltage.	-	-	1.09		V
r_s	Slope resistance.	-	-	0.36		mΩ
I_{RRM}	Peak reverse current.	-	-	100	Rated V_{RRM}.	mA
		-	-	10	Rated V_{RRM} 25 °C.	mA
R_θ	Thermal resistance.	-	-	0.018	Junction to heatsink, Note 2	K/W
		-	-	0.036	Junction to heatsink, Note 3	K/W
V_{FR}	Max. forward Recovery voltage			90	di_F/dt=1000A/µs	V
Q_{RA}	Reverse recovered charge	-	-	2000	I_{FM}=1000A, di_R/dt=200A/µs note 4	µC
F	Mounting torque.	27	-	34		kN
W_t	Weight.	-	~~1.3~~ 1.6	-		kg

M Baker
19-2-98

Notes:-
1) Unless otherwise indicated T_j=125°C.
2) Double side cooled.
3) Single side cooled
4) tp=500µs,V_R=50V

ORDERING INFORMATION			(Please quote 10 digit code as below)
S M	♦ ♦	FXC	394
Fixed Type Code	Voltage Codes 36 - 45	Fixed Outline Code	Fixed Type Code
Typical order code : SM38FXC394 :- 3800V V_{RRM} 26.5mm clamp height capsule.			

Contents

Page

Notes on the Ratings

Reverse Recovery Loss

Voltage Ratings Table 1

Voltage Class	V_{RRM} V	V_{RSM} V
36	3600	3700
38	3800	3900
40	4000	4100
42	4200	4300
44	4400	4500
45	4500	4600

Extension of voltage grades

1. This Report is applicable to higher or lower voltage grades when supply has been agreed by Sales/Production.

2. A blocking voltage derating factor of 0.13% per deg. Celsius is applicable to this device for T_J below 25°C.

INTRODUCTION

This diode series comprises fast recovery capsule devices with all diffused silicon slices. All these diodes have controlled reverse recovery characteristics with good "K" factors, and are particularly suitable for use in free-wheel applications.

NOTES ON THE RATINGS

(a) Square wave ratings

These ratings are given for leading edge linear rates of rise of forward current of 100 and 500 A/µs.

(b) Energy per pulse characteristics

These curves enable rapid estimation of device dissipation to be obtained for conditions not covered by the frequency ratings.

Let E_p be the Energy per pulse for a given current and pulse width, in joules. Let f be the repetition rate, in Hertz. Let R_{thJ-HS} be the steady state d.c. thermal resistance (junction to heat sink).

Then

$$W_{AV} = E_p * f$$

$$T_{SINK} = T_{J(MAX)} - (E_p * f * R_{thJ-HS})$$

(c) ABCD Constants

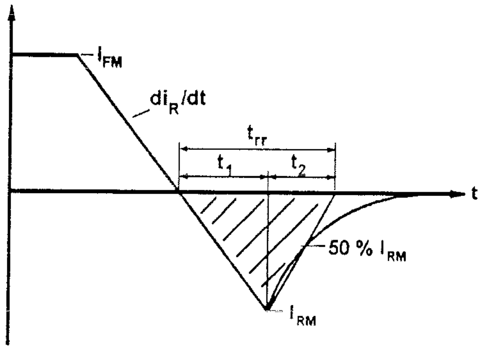
These constants (applicable only over current range of V_f characteristic on page 8) are the coefficients of the expression for the forward characteristic given below:

$$V_f = A + B.\ln(i_f) + C.i_f + D.\sqrt{i_f}$$

where i_F = instantaneous forward current.

(d) Reverse recovery ratings

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



(ii) Q_{RR} is based on a 150 µs integration time

i.e. $$Q_{RR} = \int_{0}^{150\mu s} i_{RR}.dt$$

(iii) $$K - Factor = \frac{t1}{t2}$$

Reverse Recovery Loss

The following procedure is recommended for use where it is necessary to include reverse recovery loss.

(a) Determination by measurement

From waveforms of recovery current obtained from a high frequency shunt (see Note 1) and reverse voltage present during recovery, an instantaneous reverse recovery loss waveform must be constructed. Let the area under this waveform be E joules per pulse. A new sink temperature can then be evaluated from:

$$T_{SINK(new)} = T_{SINK(original)} - E * (k + f * R_{th(J-HS)})$$

where k = 0.2314 (K/W)/s

E = Area under reverse loss waveform per pulse in joules (W.s.)

f = Rated frequency in Hz at the original sink temperature.

$R_{th(J-HS)}$ = d.c. thermal resistance (K/W)

$W_{(tot)} = W_{(original)} + E * f$ The total dissipation is now given by

$$W_{(tot)} = W_{(original)} + E * f$$

(b) Determination without Measurement

In circumstances where it is not possible to measure voltage and current conditions, or for design purposes, the additional losses E in joules may be estimated as follows.

Let be the value of energy per reverse cycle in joules (Fig 9).
Let be the operating frequency in Hz

then $$T_{SINK(new)} = T_{SINK(original)} - (E * f * R_{th})$$

where is the required maximum heat sink temperature and $T_{SINK(original)}$ is the heat sink temperature given with the frequency ratings.

A suitable R-C snubber network is connected across the diode to restrict the transient reverse voltage waveform to a peak value (V_{RM}) of 0.67 of the maximum grade. If a different grade is being used or V_{RM} is other than 0.67 of Grade, the reverse loss may be approximated by a pro rata adjustment of the maximum value obtained from the curves.

Please note Fig. 9 was produced without a snubber connected.

NOTE 1

Reverse Recovery Loss by Measurement

This device has a low reverse recovered charge and peak reverse recovery current. When measuring the charge care must be taken to ensure that:

(a) a.c. coupled devices such as current transformers are not affected by prior passage of high amplitude forward current.

(b) A suitable, polarised, clipping circuit must be connected to the input of the measuring oscilloscope to avoid overloading the internal amplifiers by the relatively high amplitude forward current signal.

(c) Measurement of reverse recovery waveform should be carried out with an appropriate critically damped snubber, connected across diode anode to cathode.

Please note Fig. 9 was produced without a snubber connected.

$$R^2 = 4 * \frac{V_R}{C * di/dt}$$

Where V_R = Commutating source voltage
C = Snubber capacitance
R = Snubber resistance

Computer Modelling Parameters

1 Device Dissipation Calculations

$$I_{AV} = \frac{-Vo + \sqrt{Vo^2 - 4 * ff^2 * r_s * (-W_{AV})}}{2 * ff^2 * r_s}$$

Where $Vo = 1.09\text{V}$, $r_s = 0.36\text{m}\Omega$ $W_{AV} = \frac{\Delta T}{R_{th}}$ $\Delta T = t_{J\max} - t_{HS}$

(a) Calculating V_f using ABCD Coefficients

The on-state characteristic I_f Vs V_f, on Fig. 1 is represented in two ways; (i) the well established V_0 and rt tangent used for rating purposes and (ii) a set of constants A, B, C, D, forming the co-efficients of the representative equation for V_f in terms of i_f given below:

$$V_f = A + B.\ln(I_f) + C.I_f + D.\sqrt{I_f}$$

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

125°C Coefficients		25°C Coefficients	
A	7.511298E-1	A	7.994200E-1
B	2.660584E-3	B	3.014677E-3
C	2.073492E-4	C	8.399341E-5
D	1.393021E-2	D	1.669008E-2

(b) D.C. Thermal Impedance Calculation

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

Where $p = 1$ to n, n is the 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.

t_p = Time Constant of r_{th} term.

D.C. Double Side Cooled				
Term	1	2	3	4
r_p	1.005634e-2	5.404876e-3	1.961208e-3	2.077409e-4
t_p	1.328020e0	1.355146e-1	8.946705e-3	8.397134e-3

D.C. Single Side Cooled				
Term	1	2	3	4
r_p	2.572981e-2	4.323453e-3	4.194505e-3	1.895927e-3
t_p	6.845545e0	5.293073e-1	9.065732e-2	7.557790e-3

Fig. 1 Forward Characteristic of Limit Device

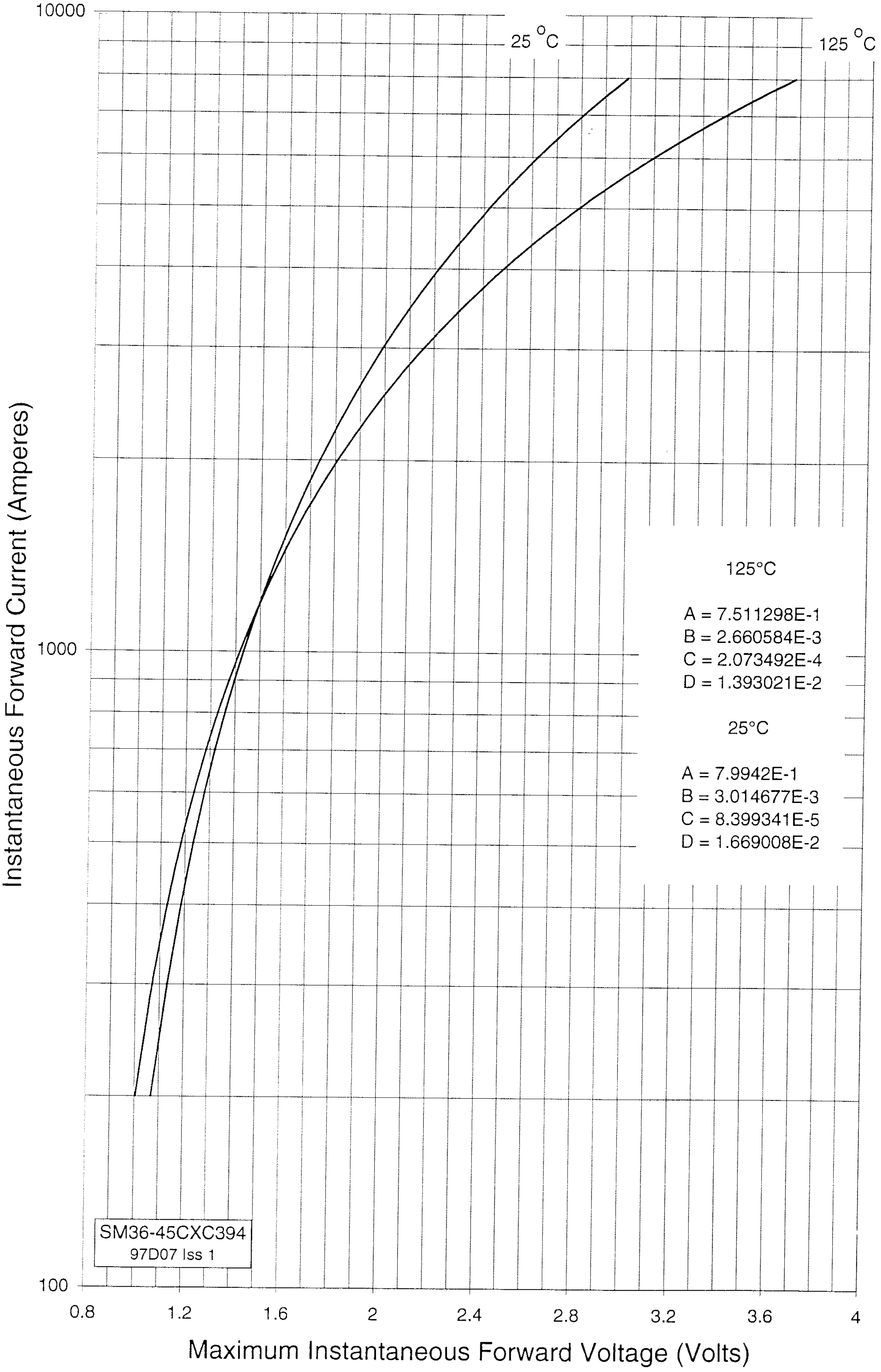


Fig. 2 Transient Thermal Impedance (Junction to Heat Sink)

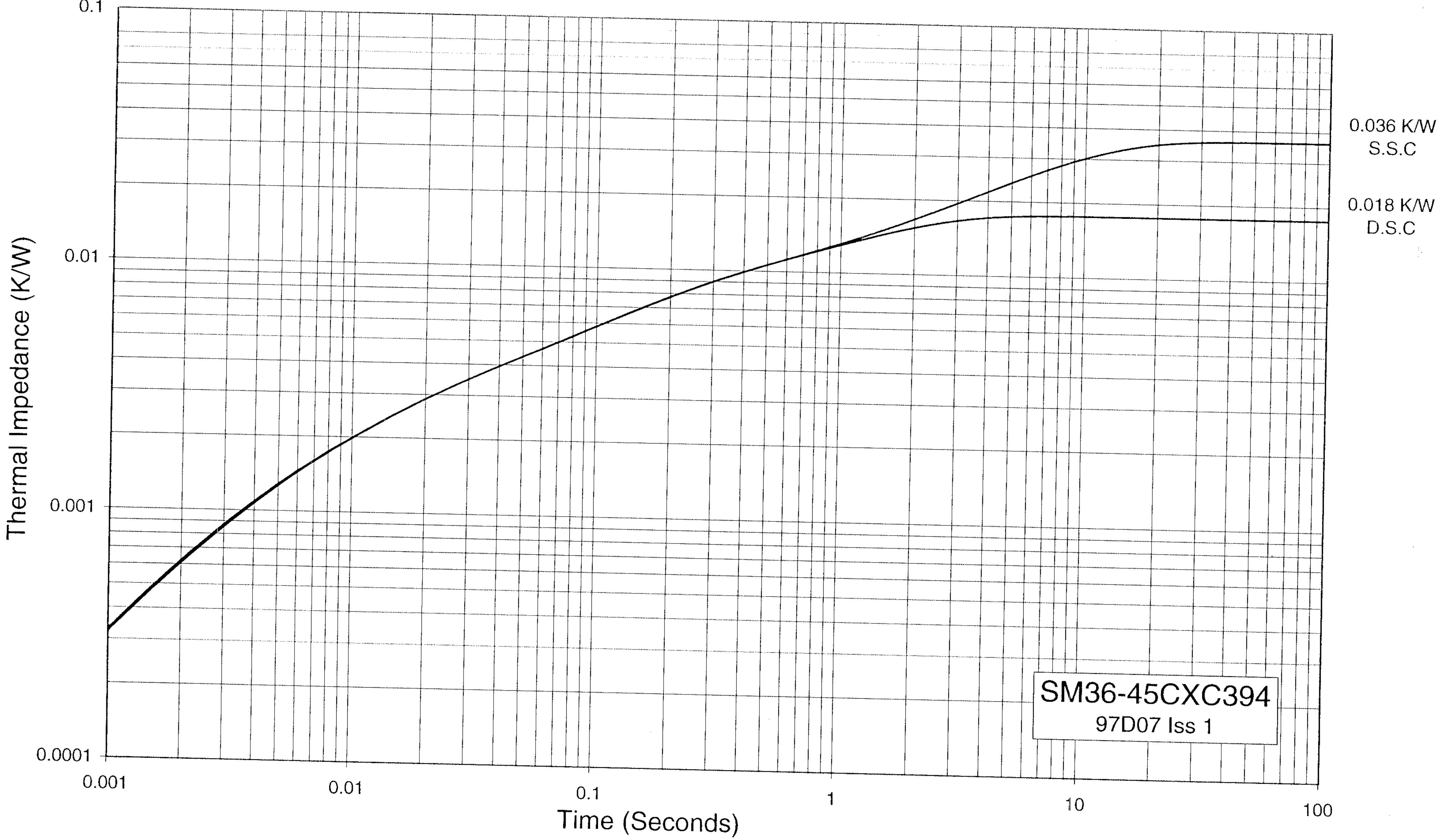


Fig. 3 Maximum Non-Repetitive Surge Current
@ Initial Junction Temperature 125 °C

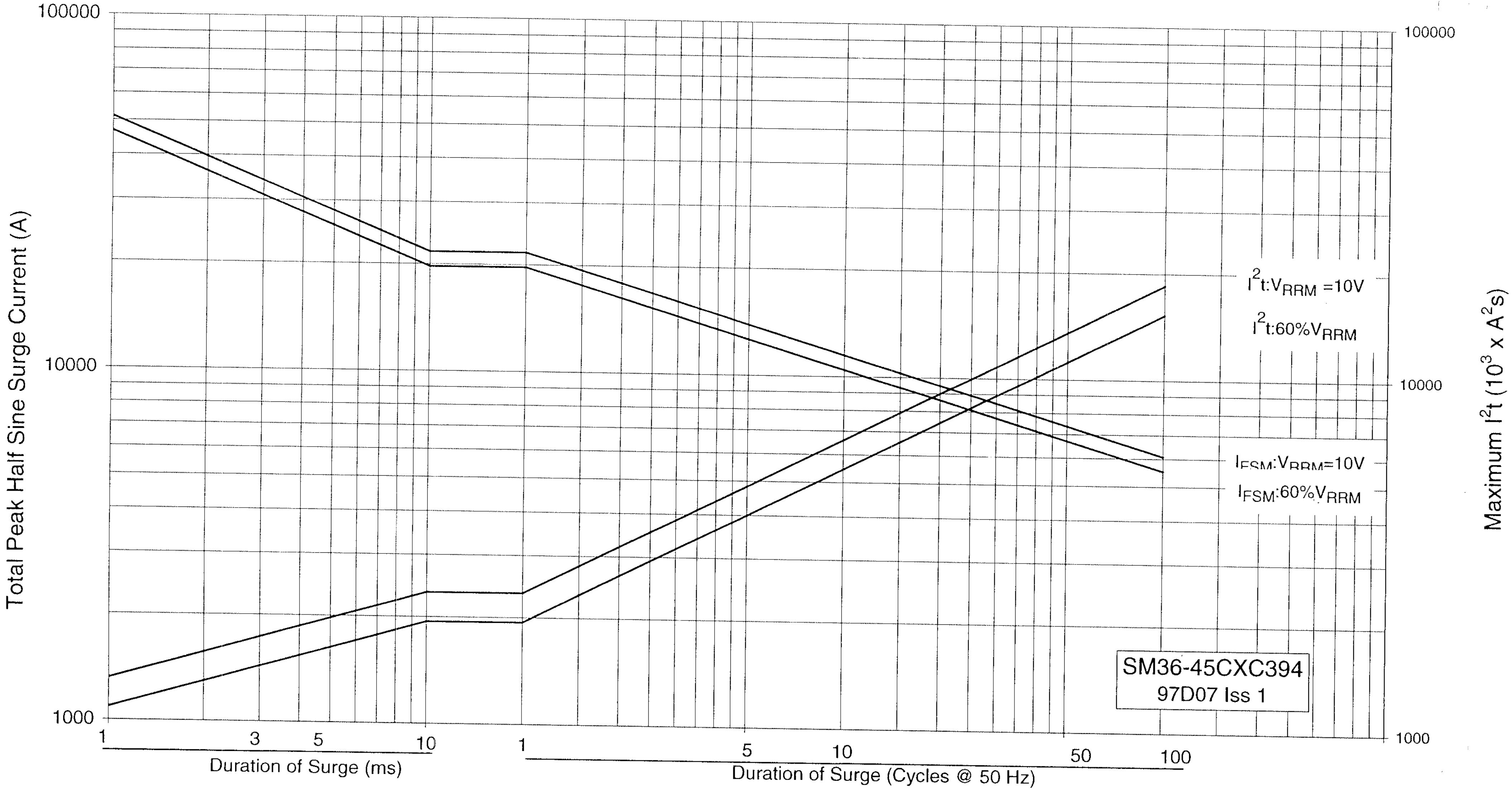


Fig. 4 Forward Recovery Voltage (Maximum Peak)

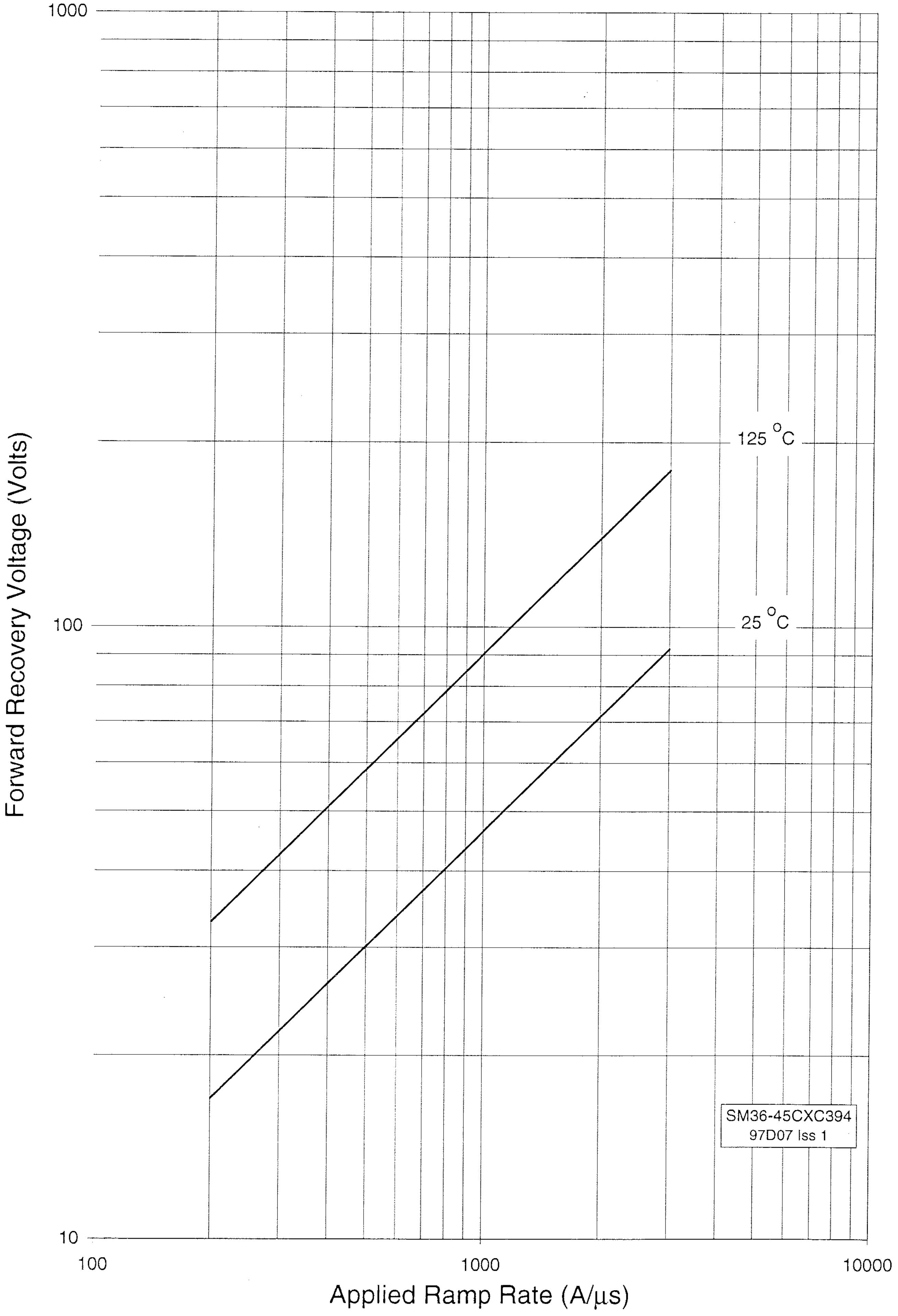


Fig. 5 Maximum Recovered Charge Qra 50 % Chord @ 125 °C Junction Temperature

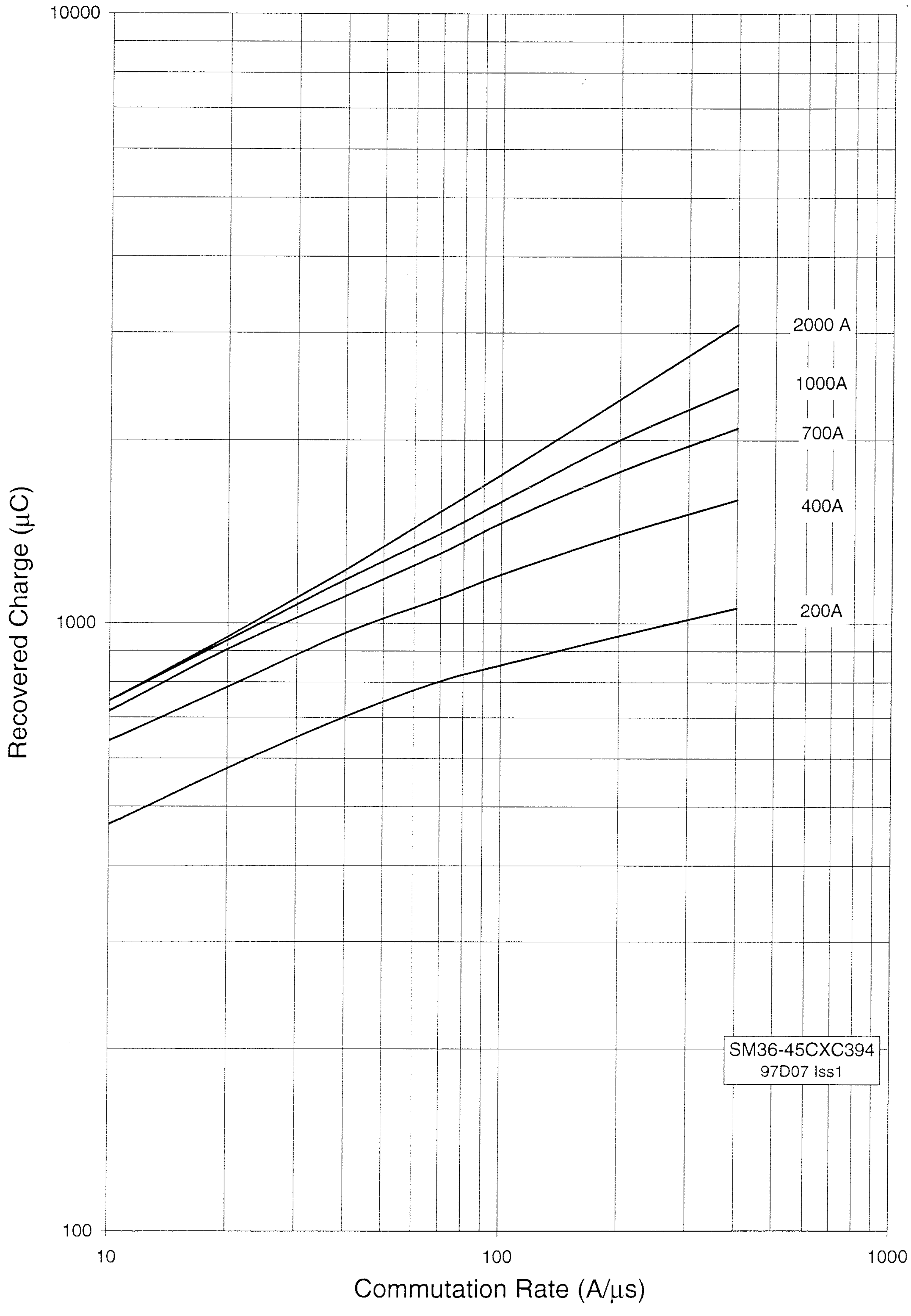


Fig. 6 Maximum Total Recovered Charge Qrr @ 125 °C Junction Temperature

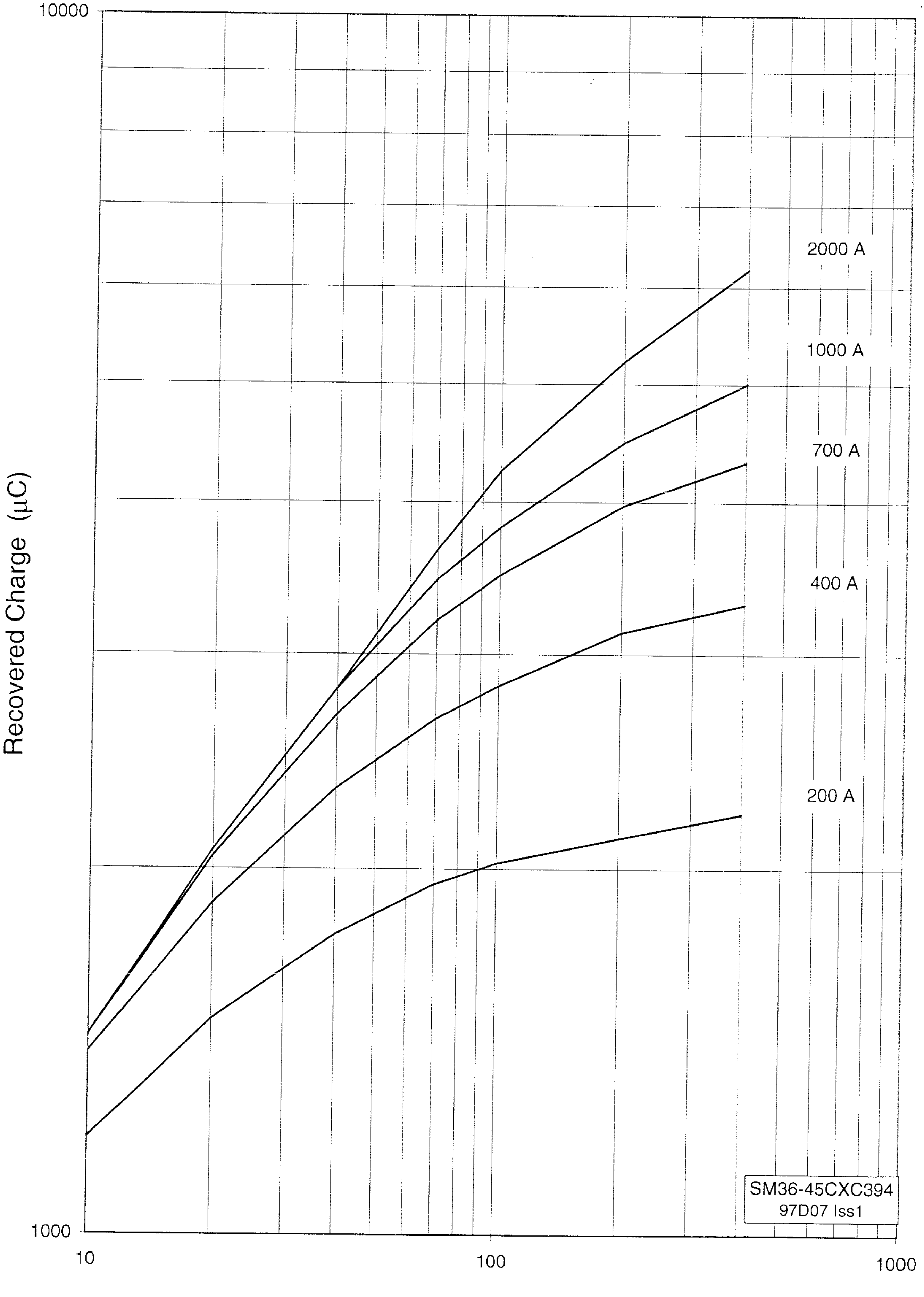


Fig. 7 Maximum Peak Recovered Current I_{RM}

@ 125 °C Junction Temperature

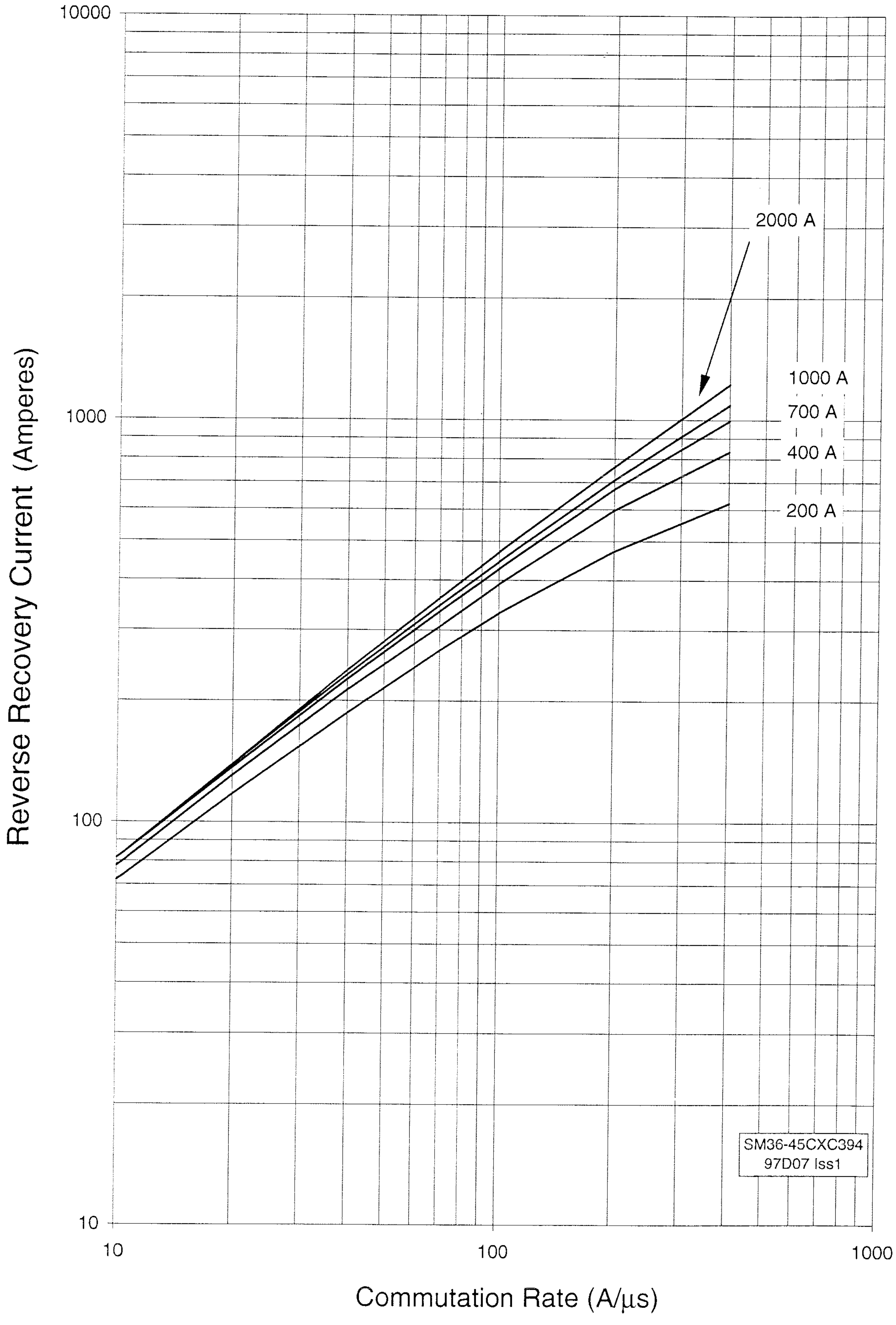


Fig. 8 Maximum Recovery Time t_{rr}

@125 °C Junction Temperature, 50% Chord

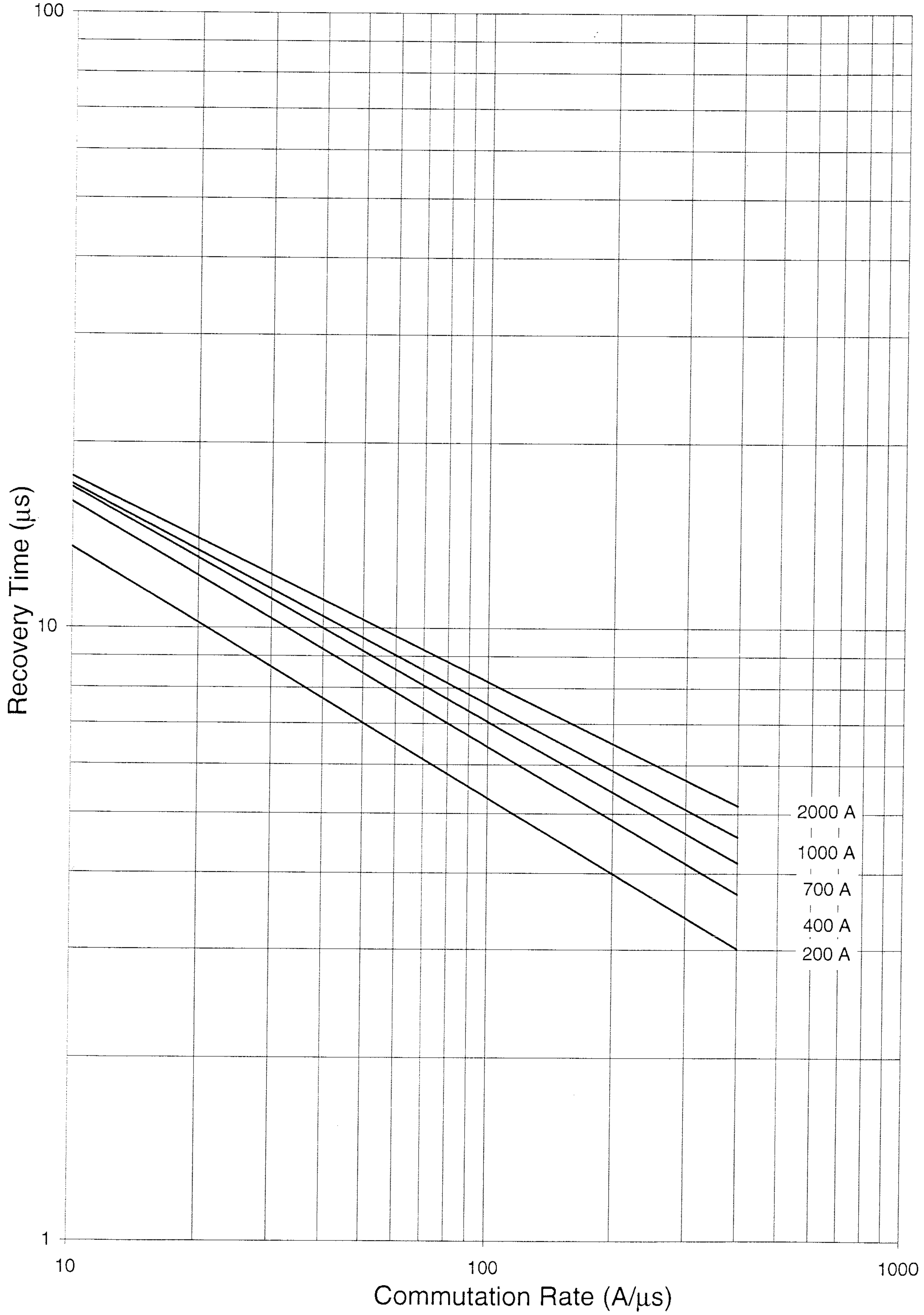


Fig. 9 Maximum Reverse recovered Energy Loss Per Pulse E_R @ 125 °C Junction Temperature Measured without Snubber . V_{RM} =0.67 Voltage Grade

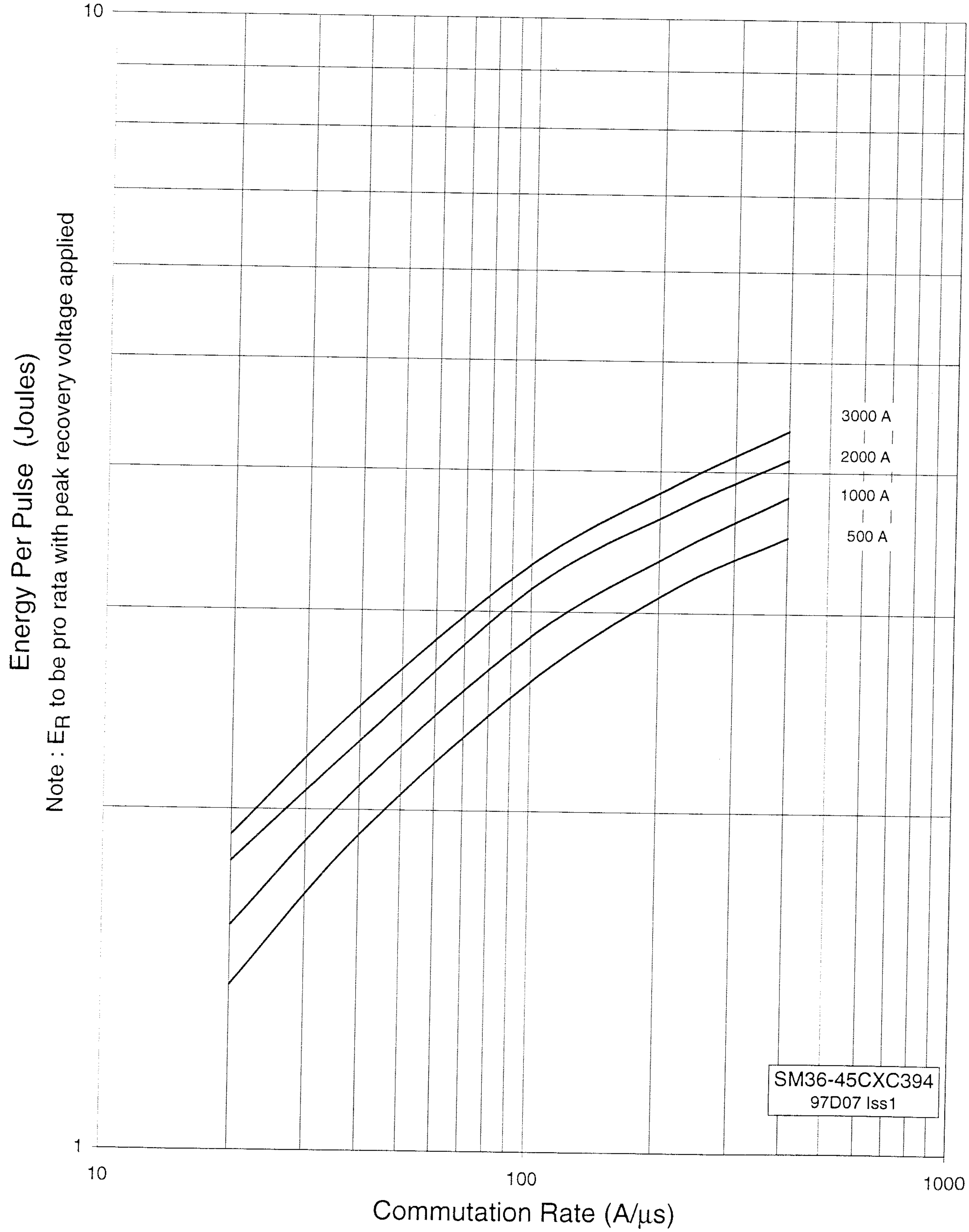


Fig. 10 Frequency vs Pulse Width

Heat Sink Temperature 55^{O}C, di/dt 100 A/μs

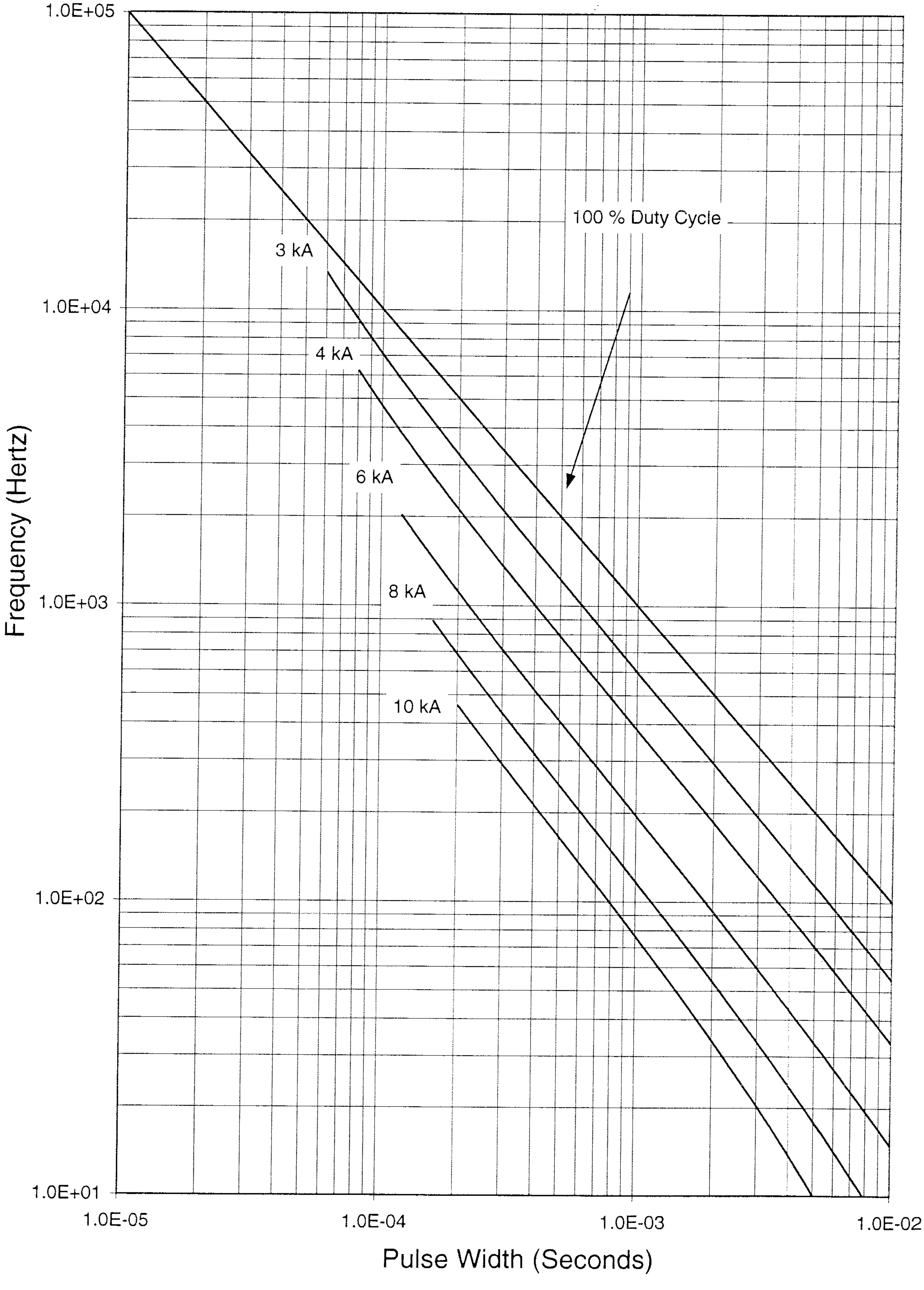


Fig. 11 Frequency vs Pulse Width

Heat Sink Temperature 85^{o}C, di/dt 100 A/µs

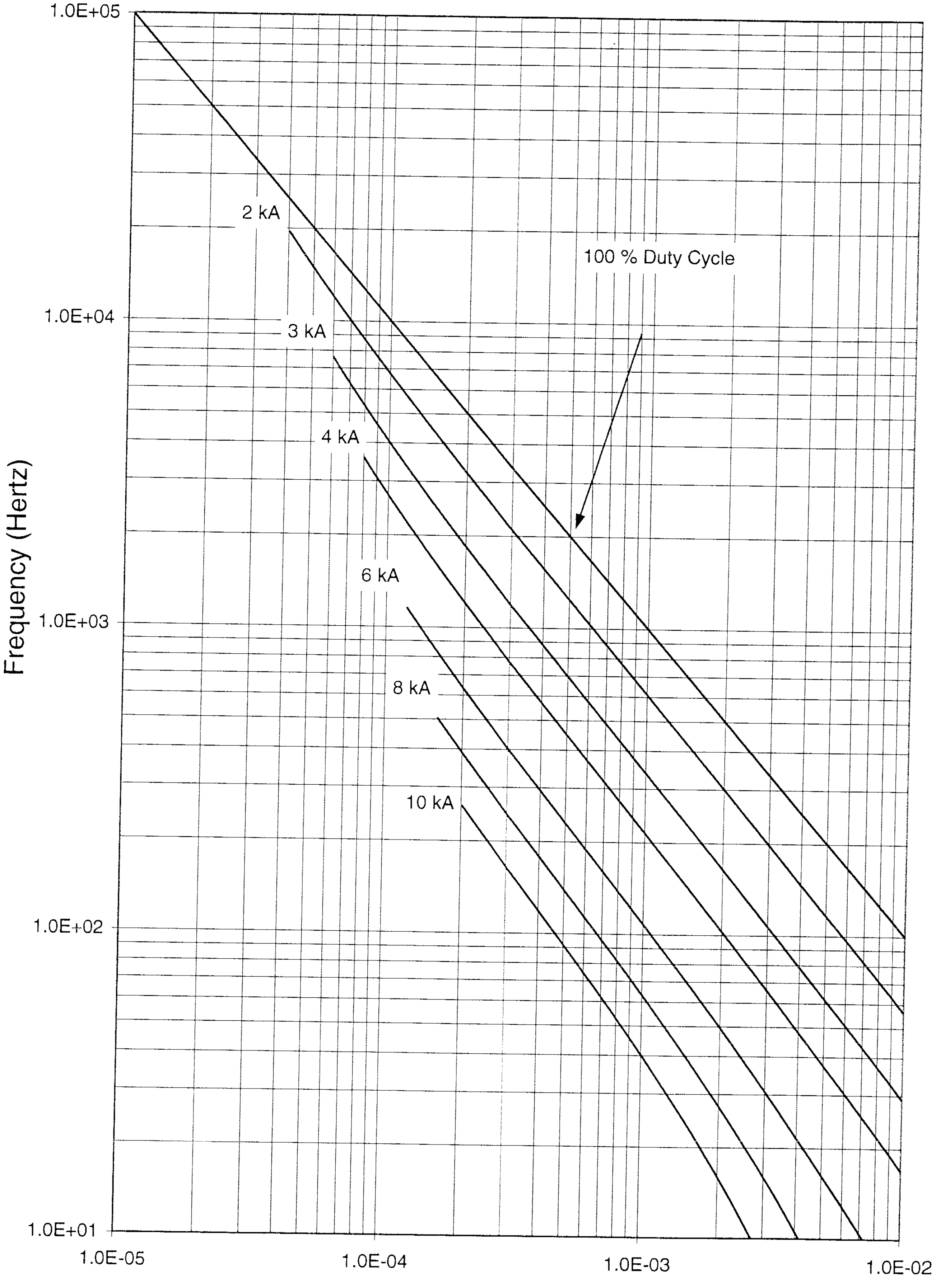


Fig. 12 Frequency vs Pulse Width

Heat Sink Temperature 55°C, di/dt 500 A/µs

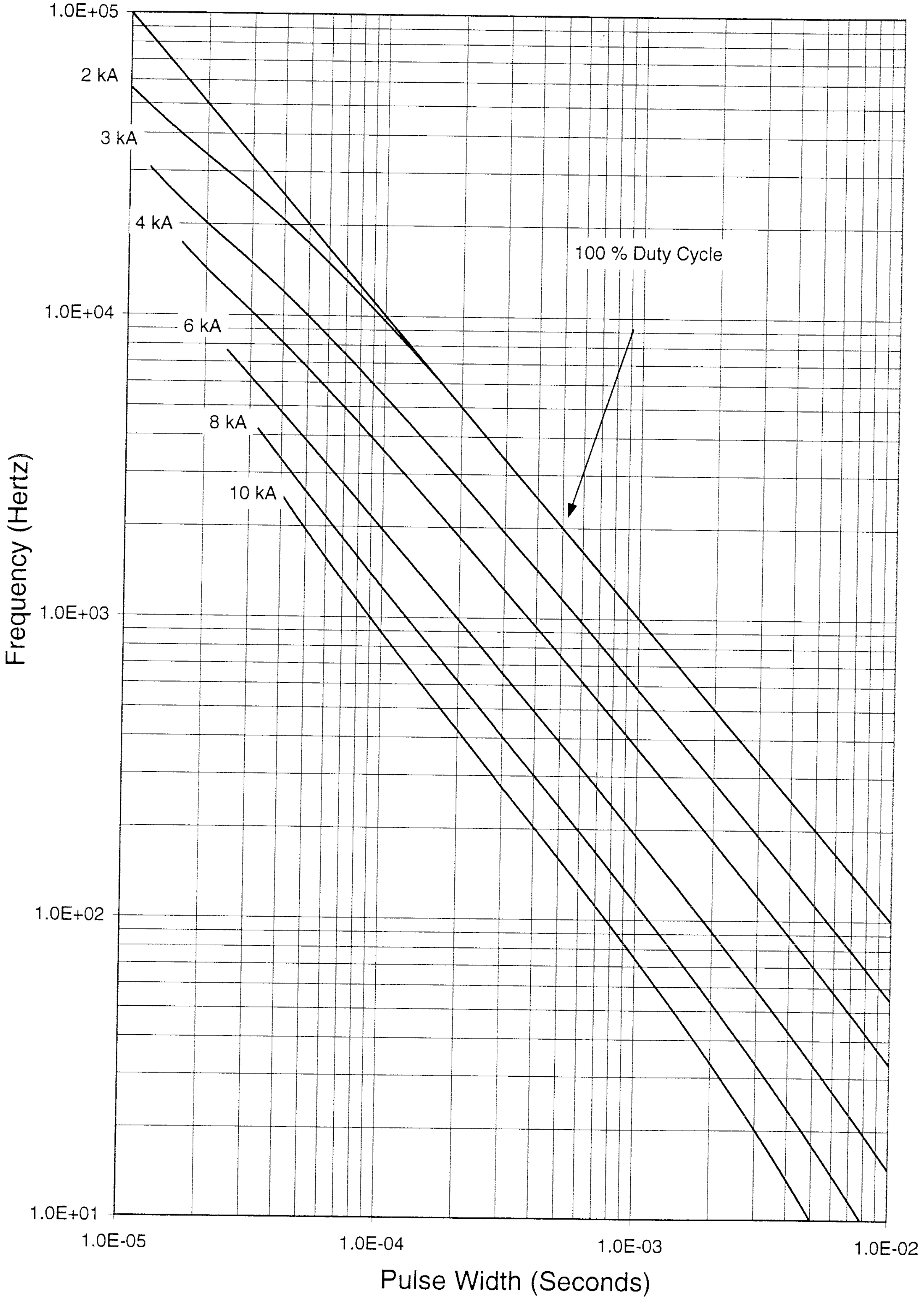


Fig. 13 Frequency vs Pulse Width

Heat Sink Temperature 85°C, di/dt 500 A/μs

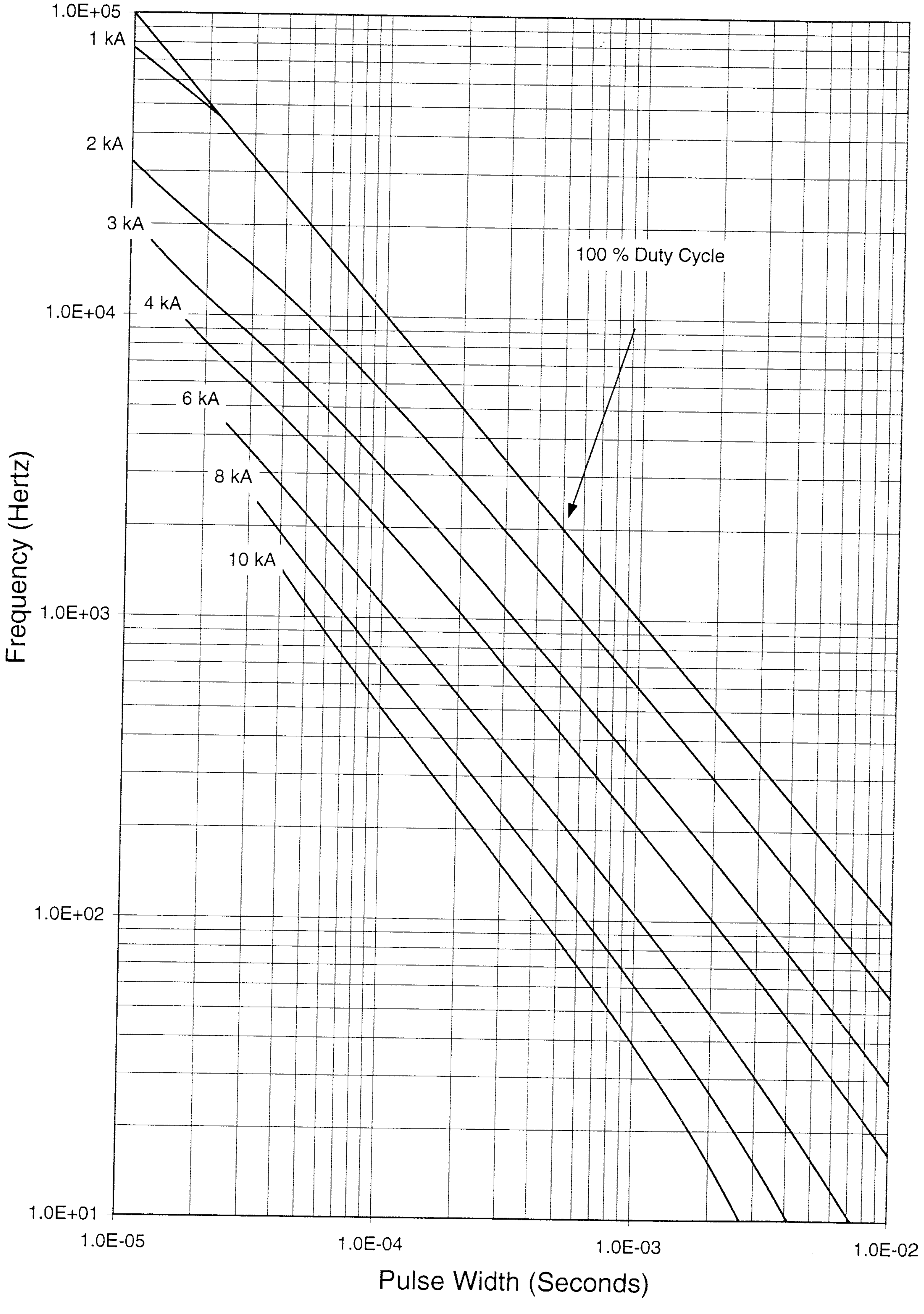


Fig. 14 Energy vs Pulse Width

Junction Temperature 125 °C, di/dt 100 A/µs

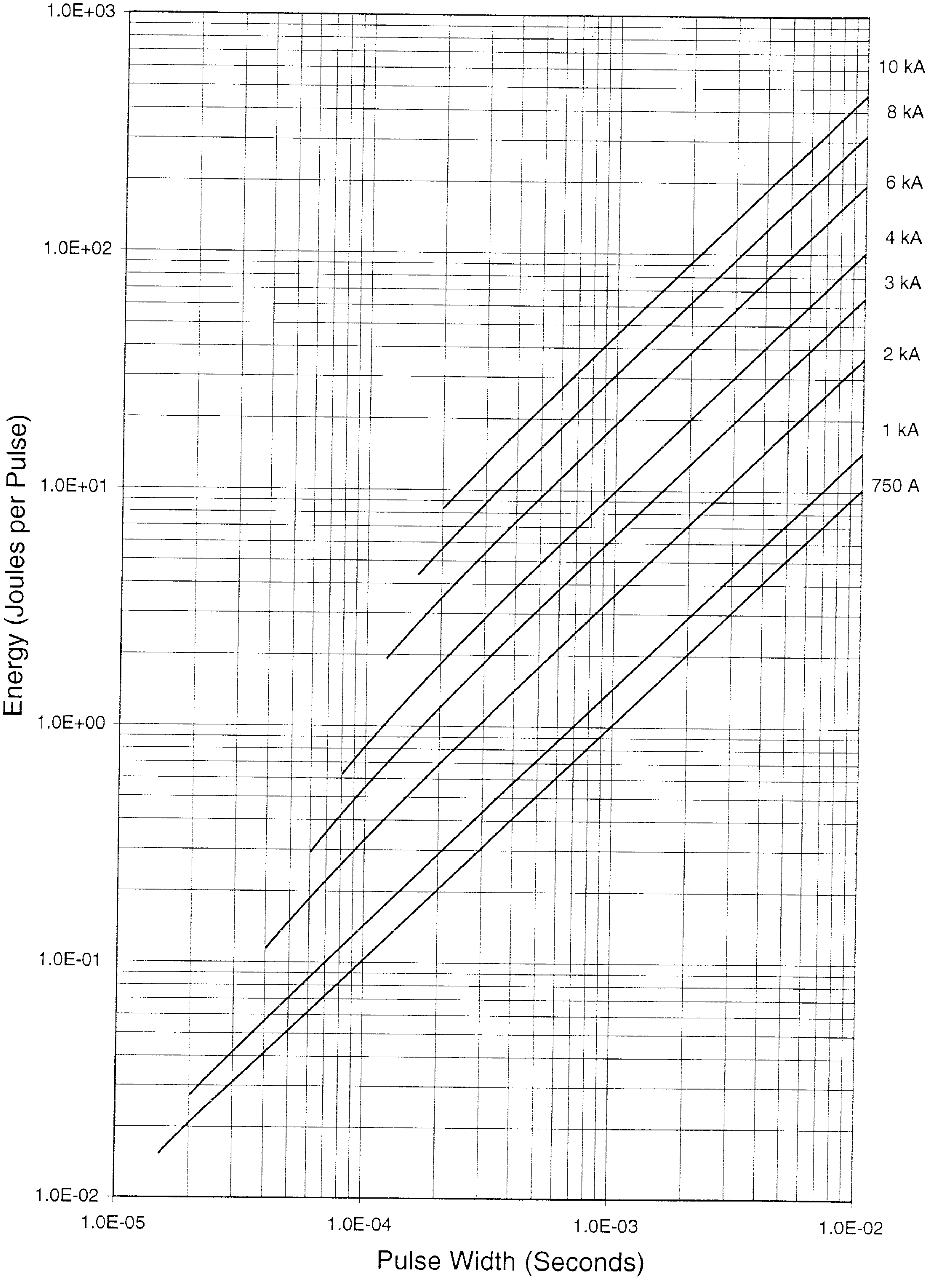


Fig. 15 Energy vs Pulse Width

Junction Temperature 125 °C, di/dt 500 A/µs

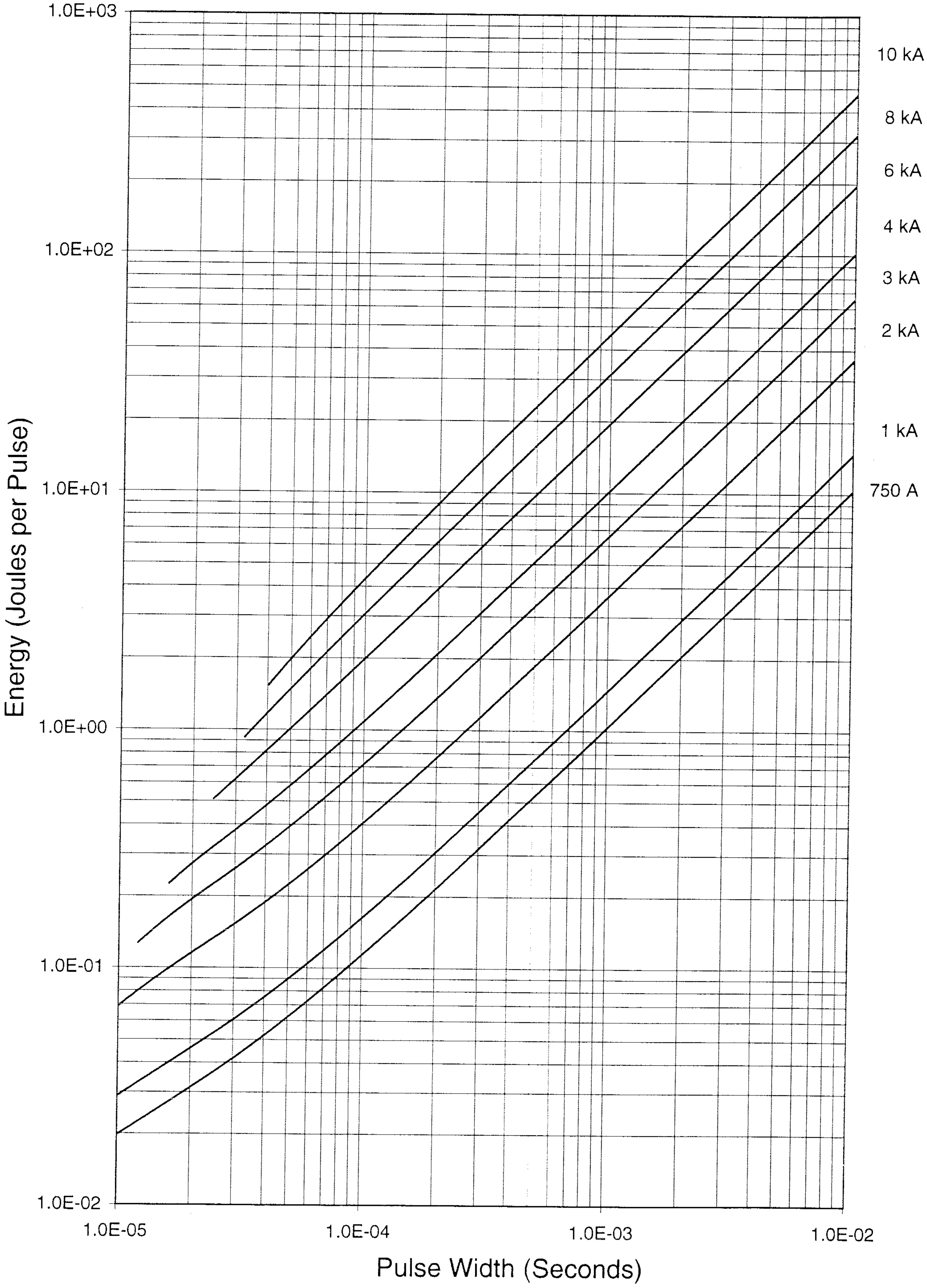


Fig. 16 Frequency vs Pulse Width

Heat Sink Temperature 55^{O}C, Sine Wave

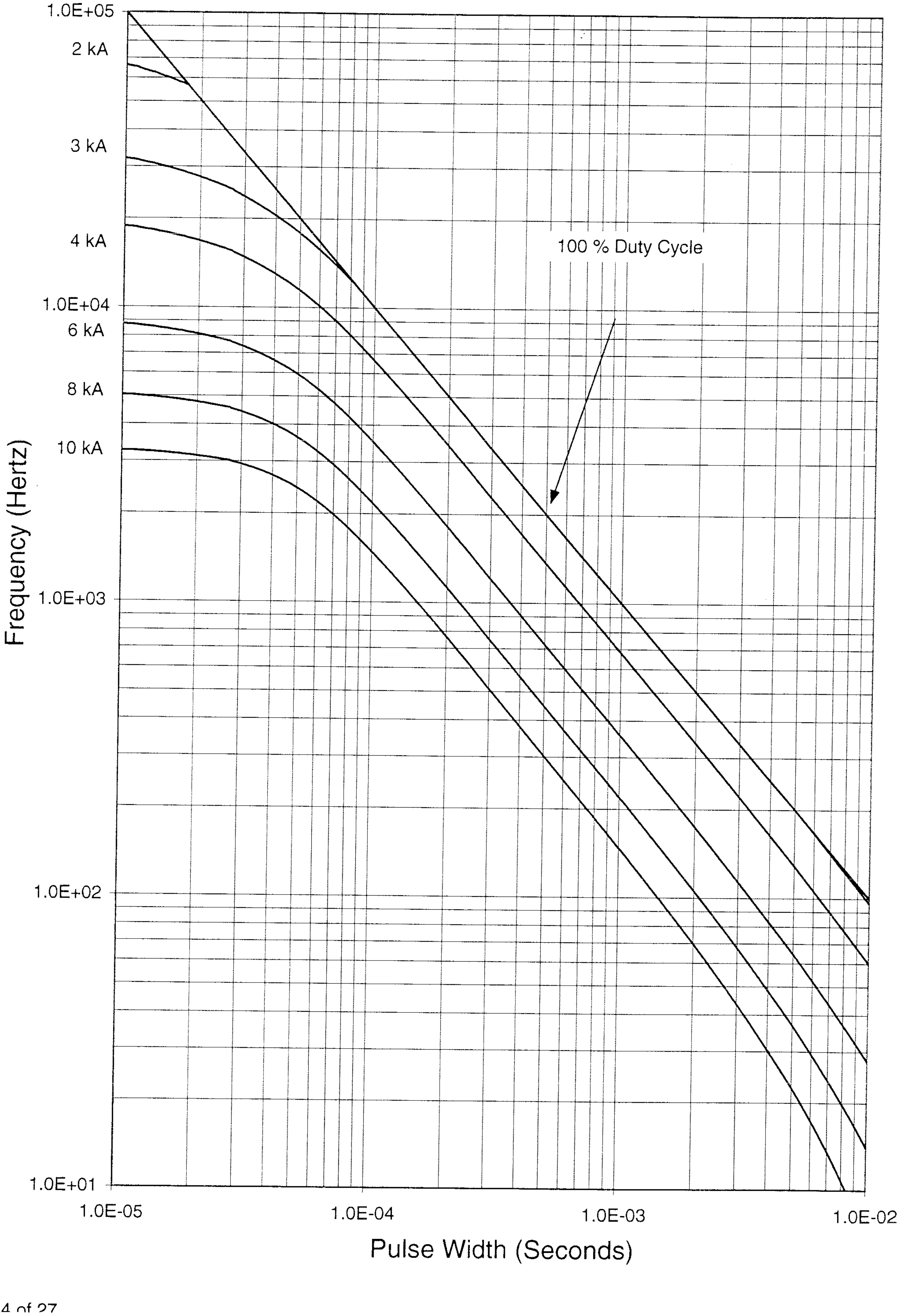


Fig. 17 Frequency vs Pulse Width
Heat Sink Temperature 85°C, Sine Wave

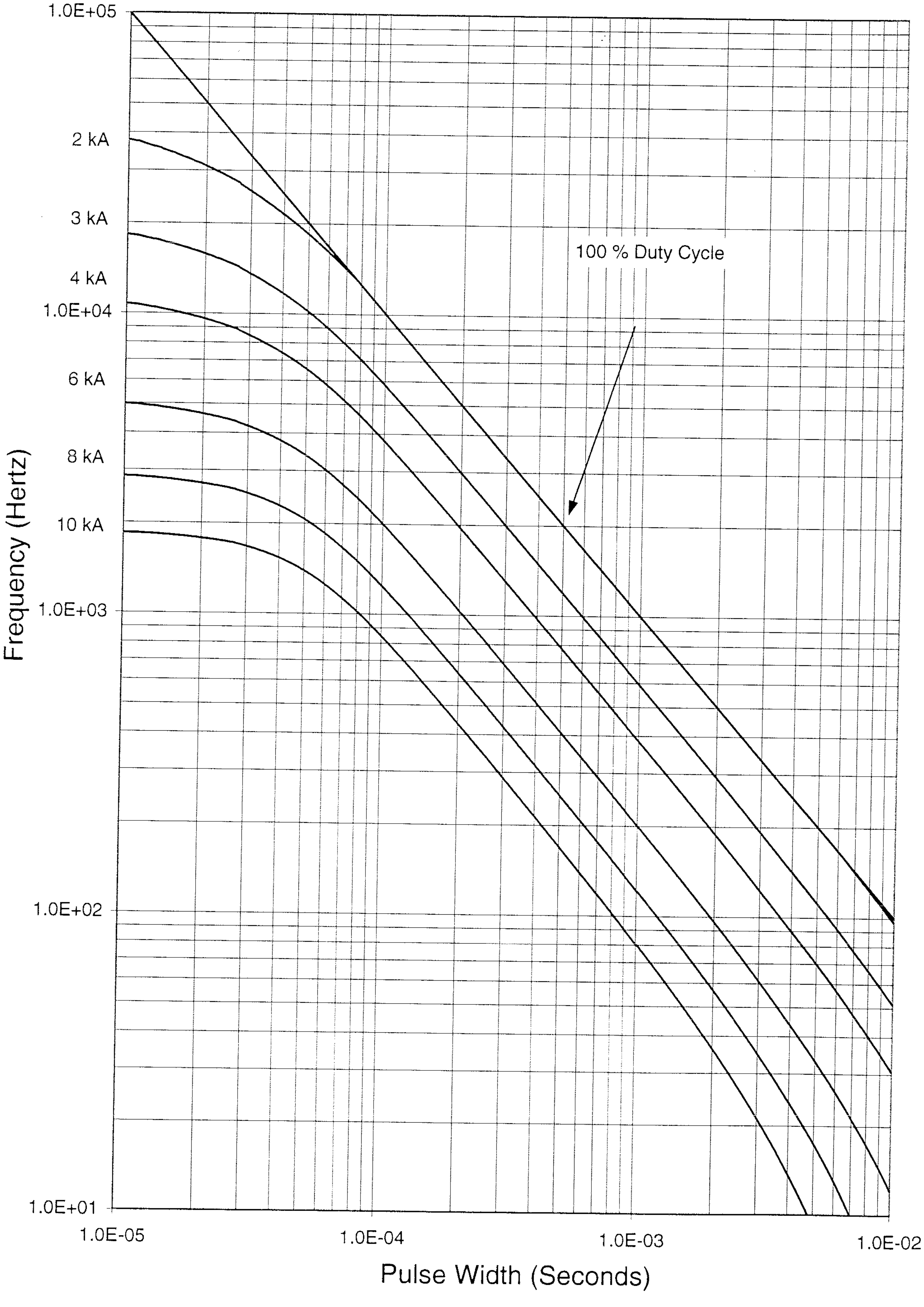


Fig. 18 Energy vs Pulse Width

Junction Temperature 125 °C, Sine Wave

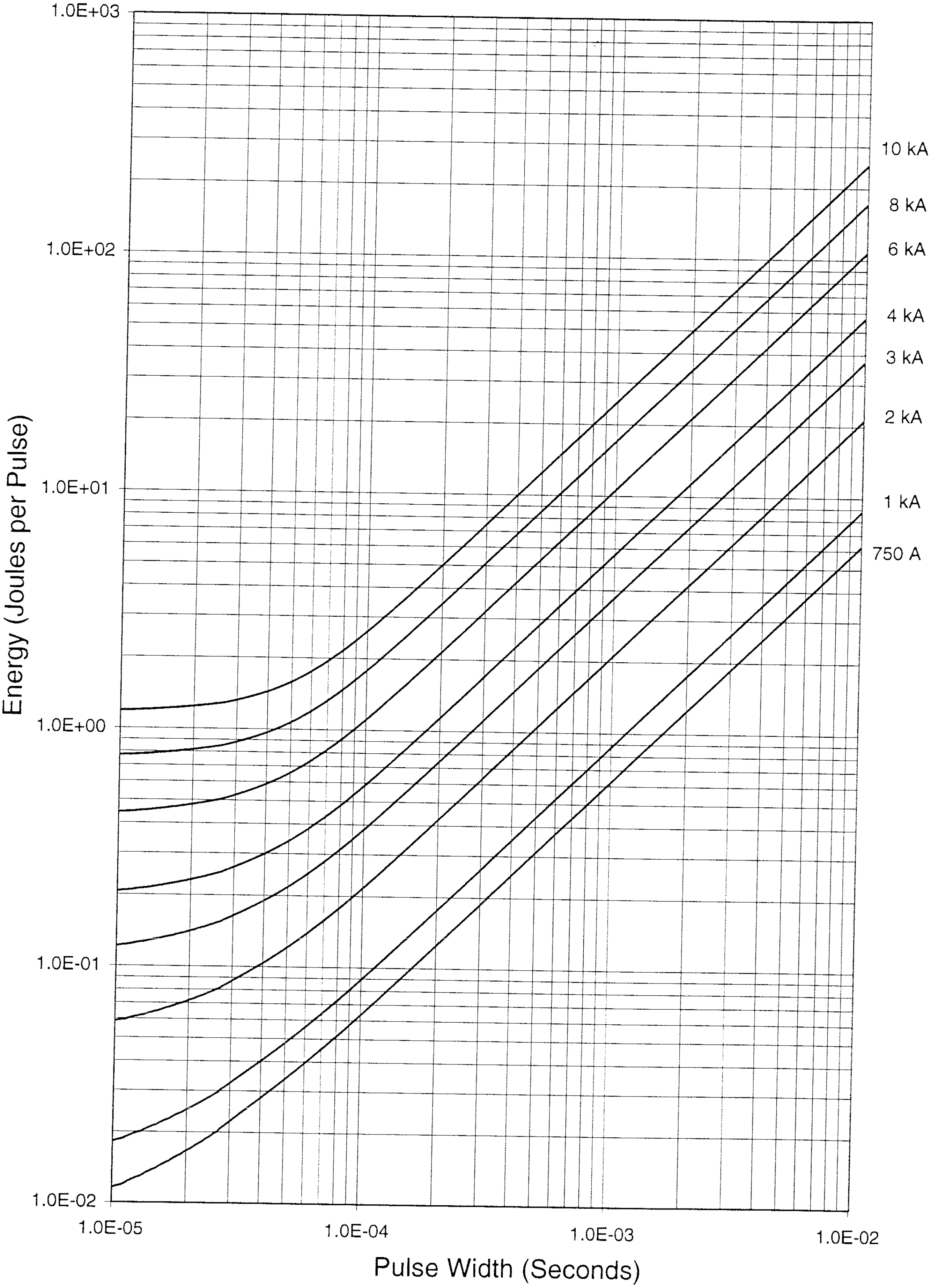
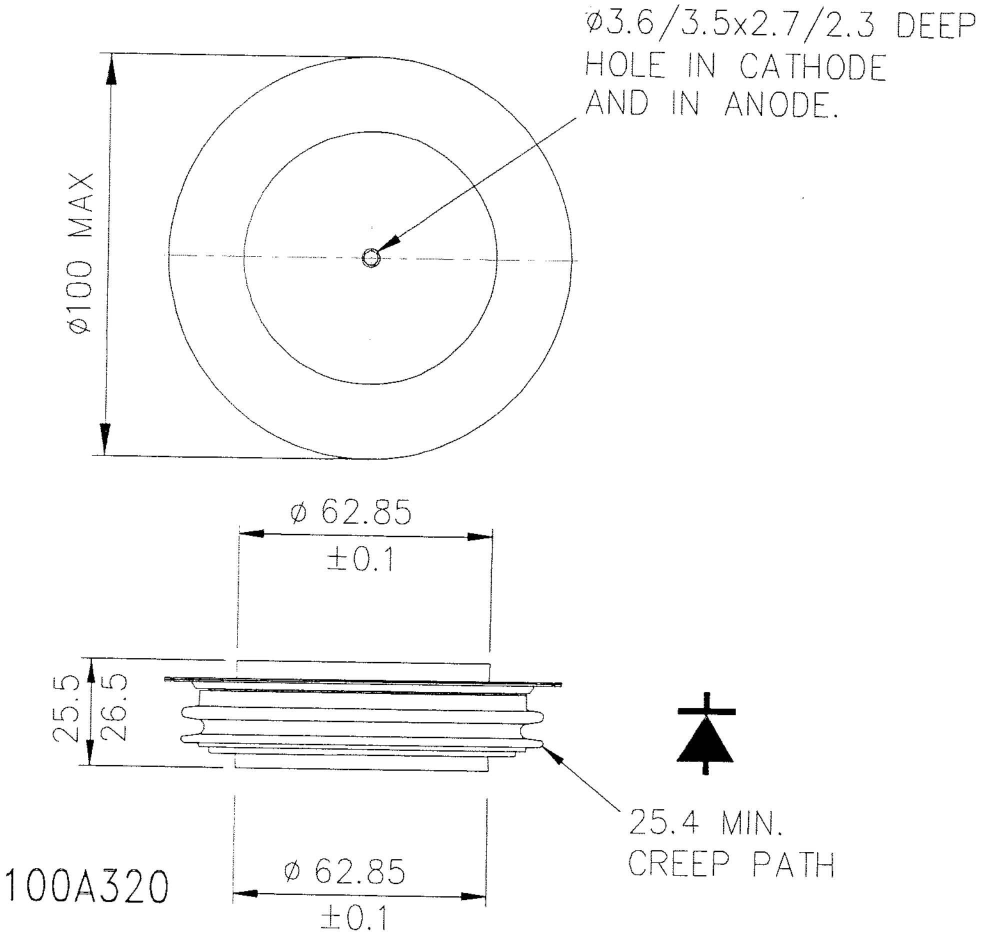


Fig. 19



ORDERING INFORMATION		(Please quote 10 digit code as below)	
SM	**◆ ◆**	**FXC**	**394**
Fixed Type Code	Voltage Code 36 – 45	Clamp height 26.5	Fixed Type Code

Typical order code : SM38FXC394 :- 3800V V_{RRM}, 26.5mm Clamp height capsule.

WESTCODE
SEMICONDUCTORS

WWW: http://www.westcode.com

U.K : Westcode Semiconductors Ltd
P.O. Box 57, Chippenham, Wiltshire, England SN15 1JL
Tel: +44 (0)1249 444524 Fax: +44 (0)1249 659448
E-mail: WSL.sales@btrinc.com

USA : Westcode Semiconductors Inc
3270 Cherry Avenue, Long Beach. California 90807
Tel: 310 595 6971 Fax: 310 595 8182

A member of the BTR group.