

# High Power Sonic FRD

## Type E2400EC45E

### Absolute Maximum Ratings

	VOLTAGE RATINGS	MAXIMUM LIMITS	UNITS
$V_{RRM}$	Repetitive peak reverse voltage, (note 1)	4500	V
$V_{RSM}$	Non-repetitive peak reverse voltage, (note 1)	4600	V
$V_{R(d.c.)}$	Maximum reverse d.c. voltage (note 1)	2800	V

	OTHER RATINGS (note 6)	MAXIMUM LIMITS	UNITS
$I_{F(AV)M}$	Mean forward current, $T_{sink}=55^{\circ}C$ , (note 2)	2490	A
$I_{F(AV)M}$	Mean forward current. $T_{sink}=100^{\circ}C$ , (note 2)	1555	A
$I_{F(AV)M}$	Mean forward current. $T_{sink}=100^{\circ}C$ , (note 3)	1045	A
$I_{F(AV)M}$	Mean forward current. $T_{sink}=100^{\circ}C$ , (note 4)	890	A
$I_{F(RMS)}$	Nominal RMS forward current, $T_{sink}=25^{\circ}C$ , (note 2)	4690	A
$I_{F(d.c.)}$	D.C. forward current, $T_{sink}=25^{\circ}C$ , (note 5)	4235	A
$I_{FSM}$	Peak non-repetitive surge $t_p=10ms$ , $V_{RM}=60\%V_{RRM}$ , (note 6)	32.1	kA
$I_{FSM2}$	Peak non-repetitive surge $t_p=10ms$ , $V_{RM}\leq 10V$ , (note 6)	35.3	kA
$I^2t$	$I^2t$ capacity for fusing $t_p=10ms$ , $V_{RM}=60\%V_{RRM}$ , (note 6)	$5.15\times 10^6$	$A^2s$
$I^2t$	$I^2t$ capacity for fusing $t_p=10ms$ , $V_{RM}\leq 10V$ , (note 6)	$6.23\times 10^6$	$A^2s$
$P_{rr}$	Maximum non-repetitive peak reverse recovery power, (note 8)	13.5	MW
$T_{j\ op}$	Operating temperature range	-40 to +140	$^{\circ}C$
$T_{stg}$	Storage temperature range	-40 to +150	$^{\circ}C$

Notes:-

- 1) De-rating factor of 0.13% per  $^{\circ}C$  is applicable for  $T_j$  below  $25^{\circ}C$ .
- 2) Double side cooled, single phase; 50Hz,  $180^{\circ}$  half-sinewave.
- 3) Anode side cooled, single phase; 50Hz,  $180^{\circ}$  half-sinewave.
- 4) Cathode side cooled, single phase; 50Hz,  $180^{\circ}$  half-sinewave.
- 5) Double side cooled.
- 6) Half-sinewave,  $140^{\circ}C$   $T_j$  initial.
- 7) Current ( $I_F$ ) ratings have been calculated using  $V_{TO}$  and  $r_T$  (see page 2)
- 8)  $T_j=T_{j\ op}$ ,  $I_F=2400A$ ,  $di/dt=4000A/\mu s$   $V_r=2800V$  and  $L_s=200nH$ . Test circuit and sample waveform are shown in diagram 1. IGBT type T2400GB45E used as switch.

**Characteristics**

	PARAMETER	MIN.	TYP.	MAX.	TEST CONDITIONS (Note 1)	UNITS
V <sub>FM</sub>	Maximum peak forward voltage	-	3.40	3.65	I <sub>FM</sub> =2400A	V
		-	-	5.34	I <sub>FM</sub> =4800A	
V <sub>T0</sub>	Threshold voltage	-	-	2.114	Current range 2490A - 7470A (Note 2)	V
r <sub>T</sub>	Slope resistance	-	-	0.646		mΩ
V <sub>T01</sub>	Threshold voltage	-	-	2.084	Current range 2400A - 7200A	V
r <sub>T1</sub>	Slope resistance	-	-	0.653		mΩ
V <sub>FRM</sub>	Maximum forward recovery voltage	-	-	230	di/dt = 4000A/μs	V
		-	-	115	di/dt = 4000A/μs, T <sub>j</sub> =25°C	
I <sub>R<sub>RM</sub></sub>	Peak reverse current	-	-	100	Rated V <sub>RRM</sub>	mA
		-	-	2	Rated V <sub>RRM</sub> , T <sub>j</sub> =25°C	
Q <sub>rr</sub>	Recovered charge	-	3900	4350	I <sub>FM</sub> =2400A, t <sub>p</sub> =1ms, di/dt=4000A/μs, V <sub>r</sub> =2800V, 50% Chord (note 3)	μC
Q <sub>ra</sub>	Recovered charge, 50% Chord	-	1300	-		μC
I <sub>rm</sub>	Reverse recovery current	-	2130	2350		A
t <sub>rr</sub>	Reverse recovery time, 50% Chord	-	1.22	-		μs
E <sub>rr</sub>	Reverse recovery energy loss	-	7.2	8		J
R <sub>thJK</sub>	Thermal resistance, junction to heatsink	-	-	0.0056	Double side cooled	K/W
		-	-	0.0101	Anode side cooled	K/W
		-	-	0.0127	Cathode side cooled	
F	Mounting force	60	-	75	(Note 4)	kN
W <sub>t</sub>	Weight	-	1.23	-		kg

**Notes:-**

- 1) Unless otherwise indicated T<sub>j</sub>=140°C.
- 2) V<sub>T0</sub> and r<sub>T</sub> were used to calculate the current ratings illustrated on page one.
- 3) Figures 3-7 were compiled using these conditions. Test circuit and sample waveform are shown in diagram 1.
- 4) For clamp forces outside these limits, please consult factory.

**Additional information on Ratings and Characteristics**

1.0 De-rating Factor

A blocking voltage de-rating factor of 0.13% per °C is applicable to this device for T<sub>j</sub> below 25°C.

2.0 ABCD Constants

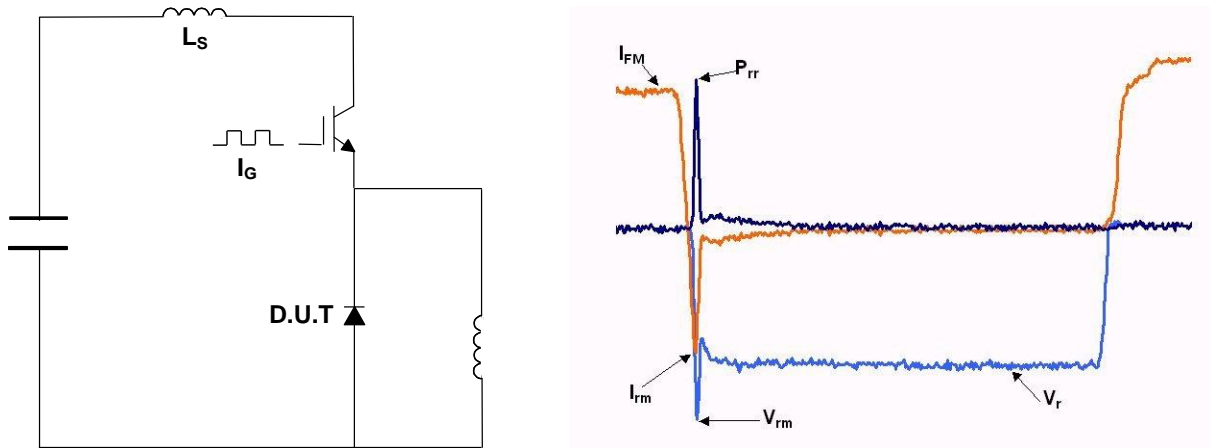
These constants (applicable only over current range of V<sub>F</sub> characteristic in Figure 1) are the coefficients of the expression for the forward characteristic given below:

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

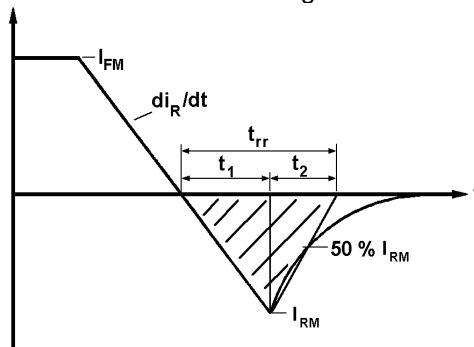
where I<sub>F</sub> = instantaneous forward current.

3.0 Reverse recovery ratings

Diagram 1 – Reverse Recovery test circuit and sample waveform



(i) Q<sub>ra</sub> is based on 50% I<sub>rm</sub> chord as shown in Figure below.



(ii) Q<sub>rr</sub> is based on a 20µs integration time.

i.e. 
$$Q_{rr} = \int_0^{20\mu s} i_{rr} \cdot dt$$

(iii) 
$$K \text{ Factor} = \frac{t_1}{t_2}$$

#### 4.0 Reverse Recovery Loss

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

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:

$$T_{SINK} = T_{J(MAX)} - E \cdot [k + f \cdot R_{th(J-Hs)}]$$

Where k = 0.2314 (°C/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<sub>th(J-Hs)</sub> = d.c. thermal resistance (°C/W)

The total dissipation is now given by:

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

#### 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) AC 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. The formula used for the calculation of this snubber is shown below:

$$R^2 = 4 \cdot \frac{V_r}{C_s \cdot di/dt}$$

Where: V<sub>r</sub> = Commutating source voltage

C<sub>s</sub> = Snubber capacitance

R = Snubber resistance

#### 5.0 Computer Modelling Parameters

##### 5.1 Device Dissipation Calculations

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

Where V<sub>T0</sub> = 2.114V, r<sub>T</sub> = 0.646mΩ

$ff$  = form factor (normally unity for fast diode applications)

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

$$\Delta T = T_{j(MAX)} - T_K$$

## 5.2 Calculation of $V_F$ using ABCD Coefficients

The forward characteristic  $I_F$  Vs  $V_F$ , 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, and 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 in this report 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	140°C Coefficients
A	0.2094065	0.2457206
B	0.1752902	0.04513215
C	$0.2723111 \times 10^{-3}$	$0.2789414 \times 10^{-3}$
D	0.03622895	0.04866113

**Curves**

Figure 1 – Forward characteristics of limit device

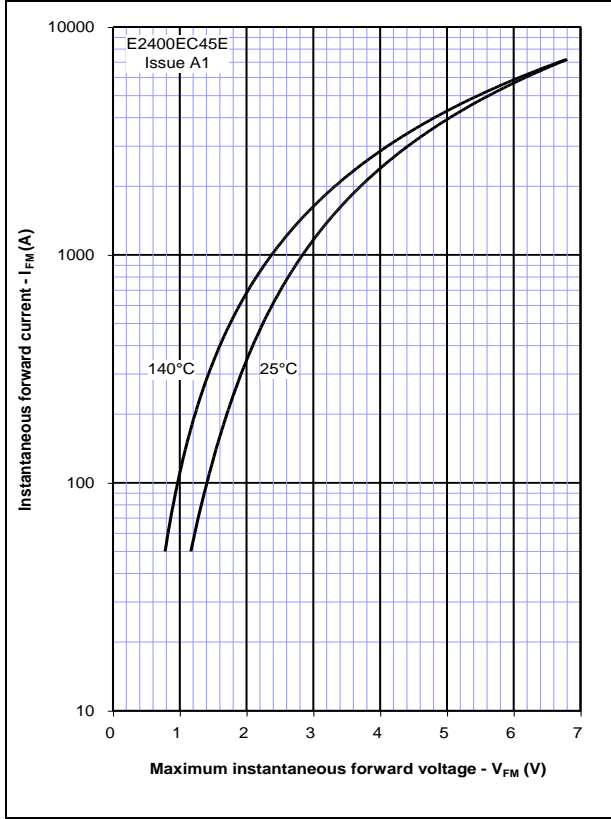


Figure 2 – Maximum forward recovery voltage

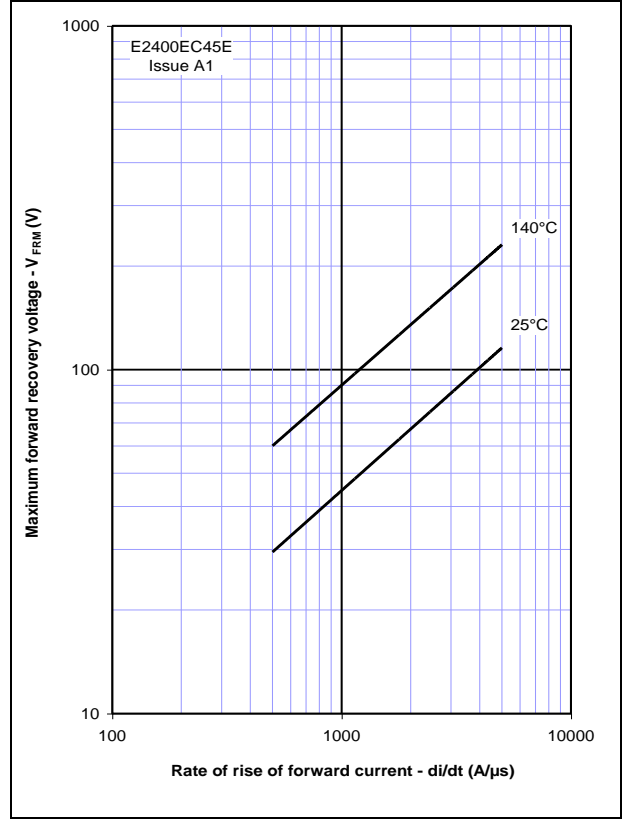


Figure 3 – Maximum recovered charge,  $Q_{rr}$

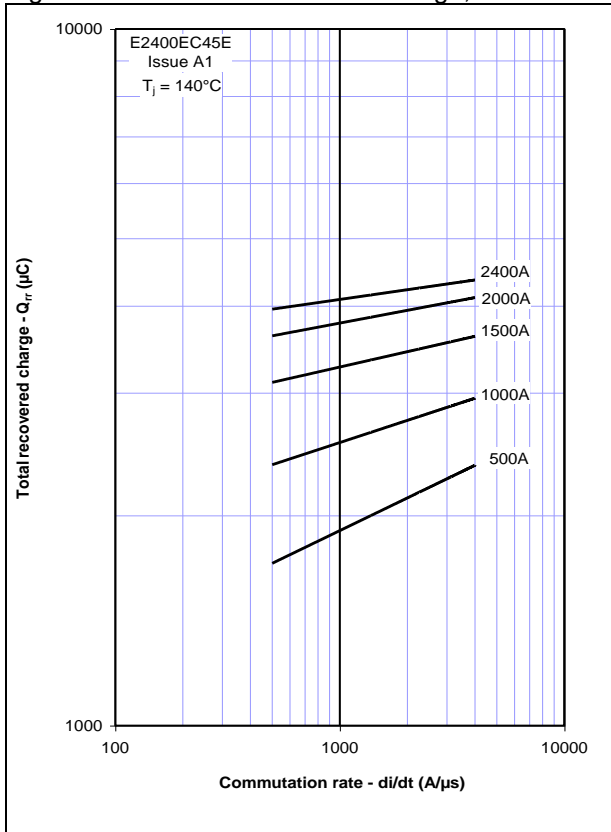


Figure 4 – Maximum recovery charge,  $Q_{ra}$  (50% chord)

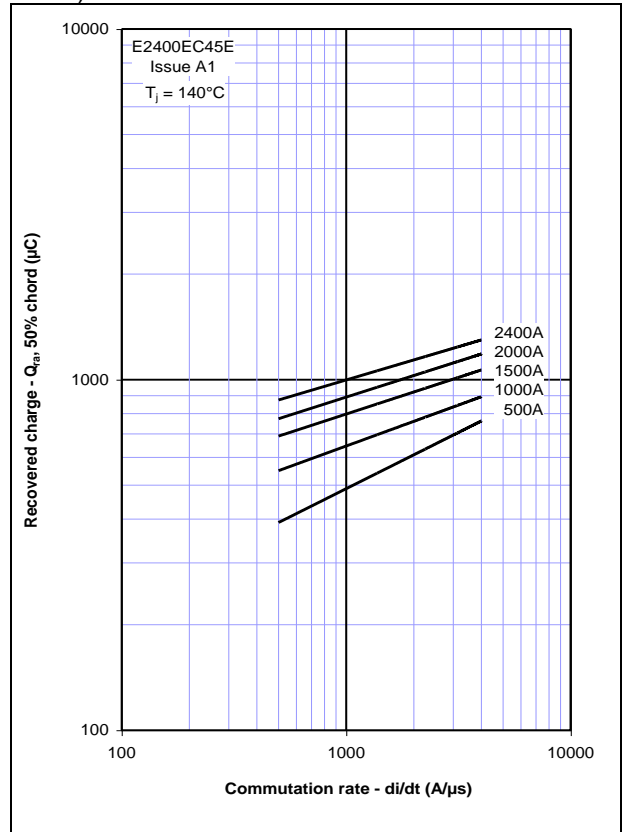


Figure 5 - Maximum reverse current,  $I_{rm}$

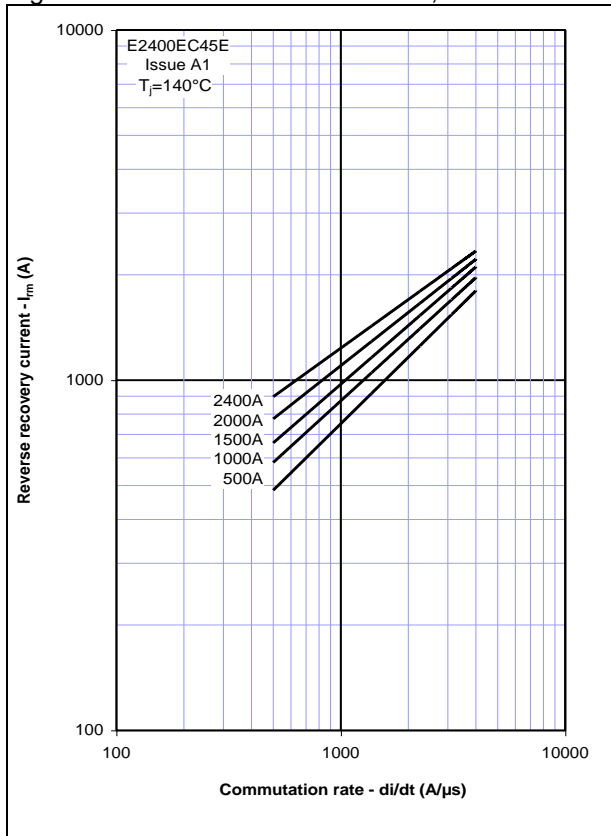


Figure 6 – Maximum recovery time,  $t_{rr}$  (50% chord)

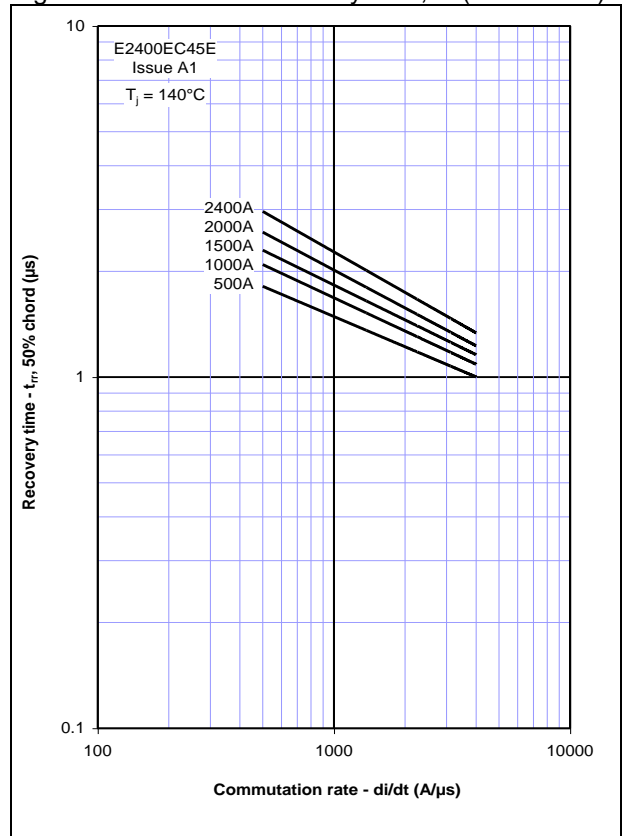


Figure 7 – Typical reverse recovery energy per pulse

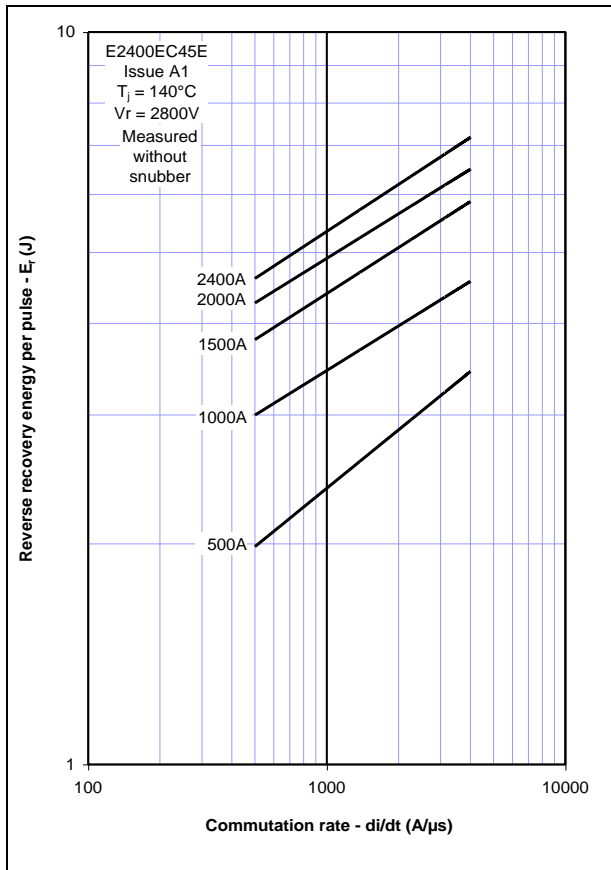


Figure 8 – Safe operating area

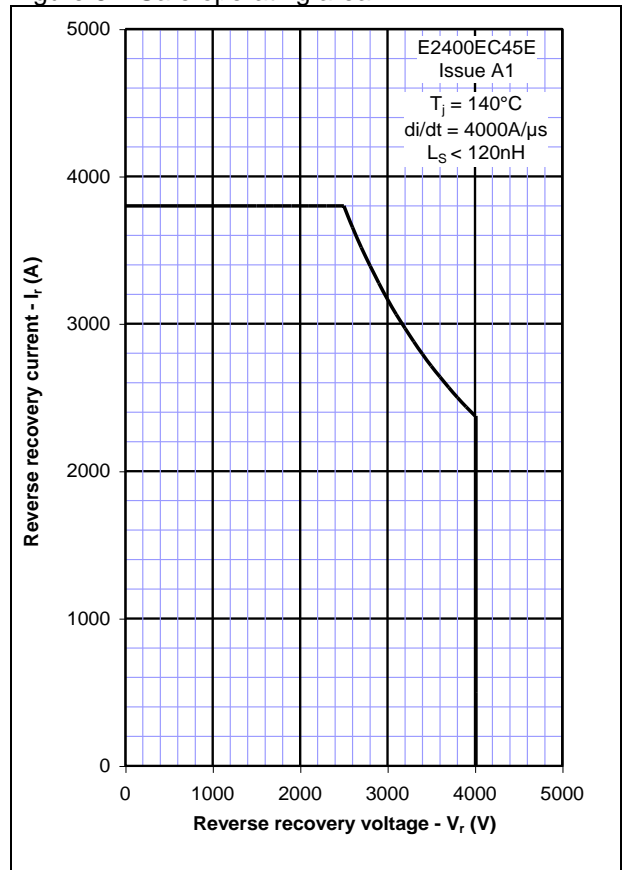


Figure 9 – Transient thermal impedance

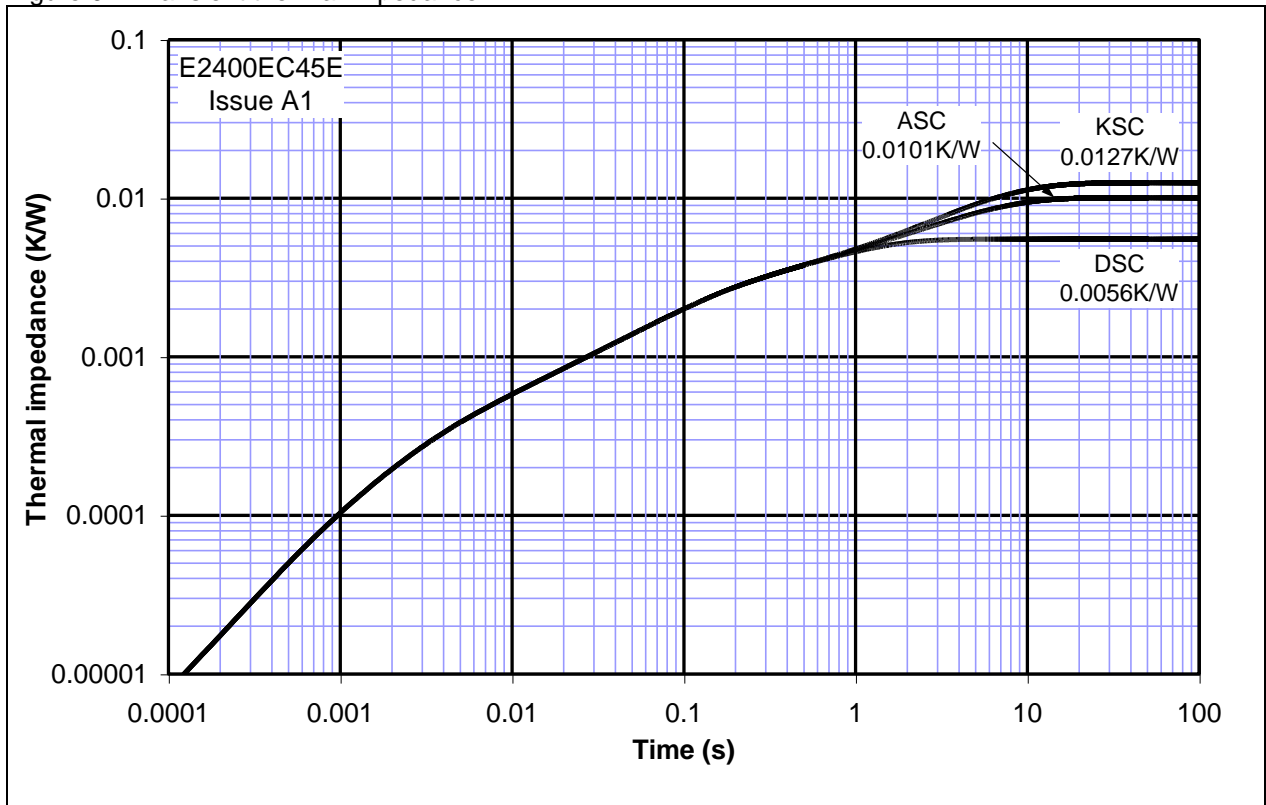
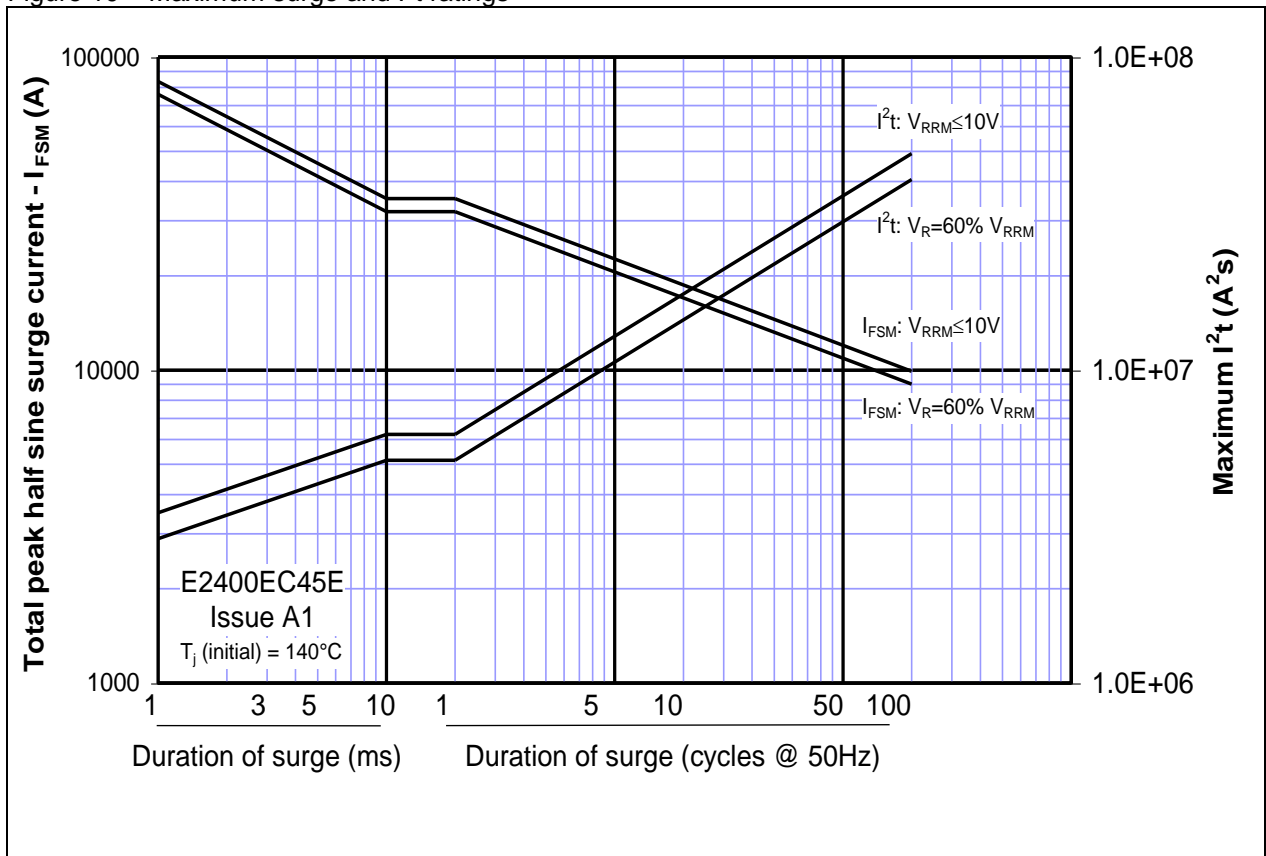
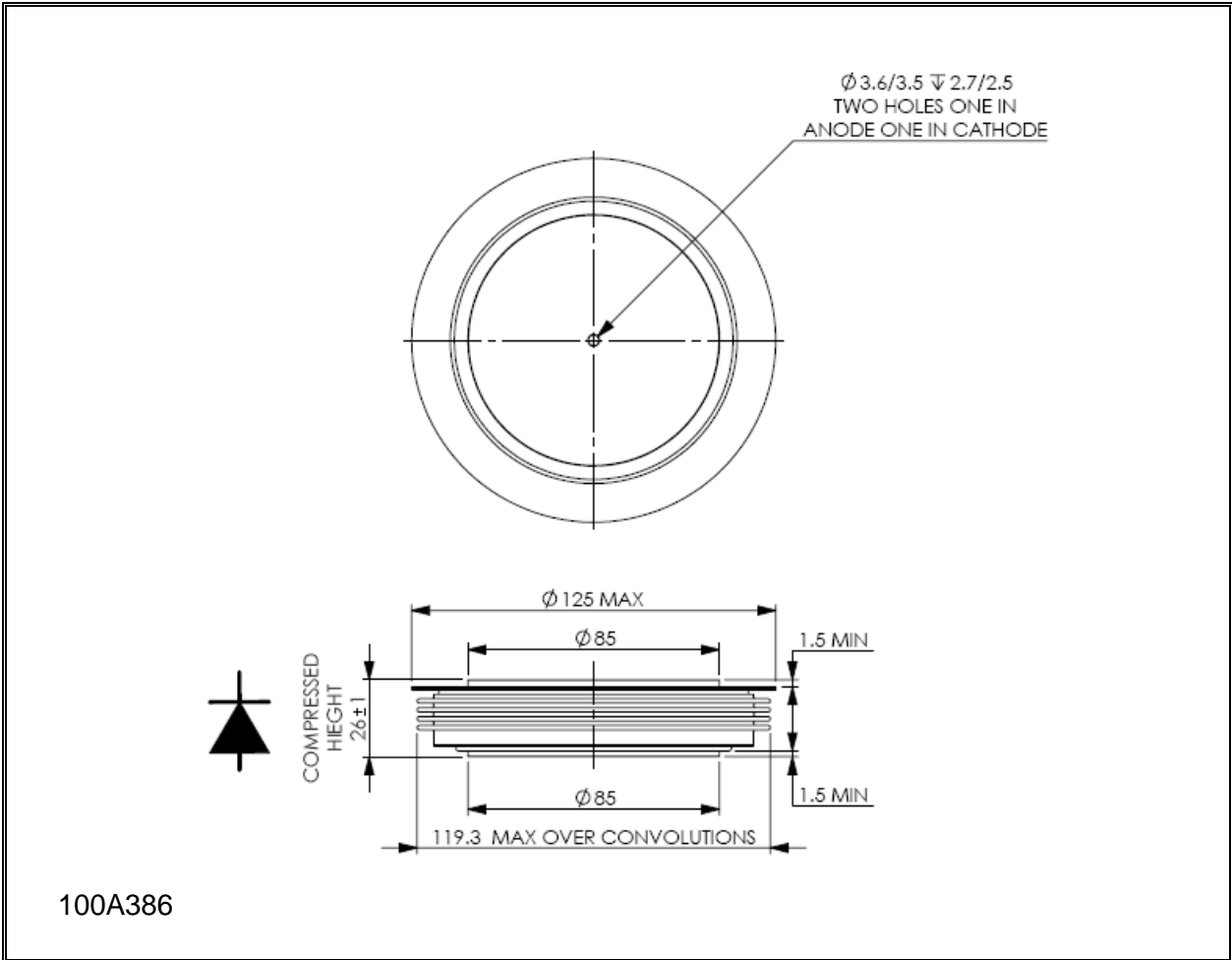


Figure 10 – Maximum surge and I<sup>2</sup>t ratings





**Outline Drawing & Ordering Information**



**ORDERING INFORMATION**

(Please quote 10 digit code as below)

E2400	EC	45	E
Fixed Type Code	Fixed outline code	Fixed voltage code $V_{RRM}/100$ 45	Fixed code, product series

Order code: E2400EC45E – 4500V  $V_{RRM}$ , 26mm clamp height capsule.

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