PROTON-ELECTROTEX
RUSSIA

Fast Thyristor
Type TFI273-2000-20

Low switching losses
Low reverse recovery charge
Distributed amplified gate for high di_T/dt

Mean on-state current	I_{TAV}	2000 A
Repetitive peak off-state voltage	V_{DRM}	2000 V
Repetitive peak reverse voltage	V_{RRM}	
Turn-off time	t_q	32.0, 40.0, 50.0, 63.0 µs

V_{DRM}, V_{RRM}, V	2000
Voltage code	20
T_j, °C	–60…+125

MAXIMUM ALLOWABLE RATINGS

Symbols and parameters		Units	Values	Test conditions	
ON-STATE					
I_{TAV}	Mean on-state current	A	2000 2041 3054	T_c=86 °C; Double side cooled; T_c=85 °C; Double side cooled; T_c=55 °C; Double side cooled; 180° half-sine wave; 50 Hz	
I_{TRMS}	RMS on-state current	A	3140	T_c=86 °C; Double side cooled; 180° half-sine wave; 50 Hz	
I_{TSM}	Surge on-state current	kA	40.0 46.0	T_j=$T_{j\,max}$ T_j=25 °C	180° half-sine wave; t_p=10 ms; single pulse; V_D=V_R=0 V; Gate pulse:I_G=I_{FGM}; V_G=20 V; t_{GP}=50 µs; di_G/dt=2 A/µs
			42.0 48.0	T_j=$T_{j\,max}$ T_j=25 °C	180° half-sine wave; t_p=8.3 ms; single pulse; V_D=V_R=0 V; Gate pulse:I_G=I_{FGM}; V_G=20 V; t_{GP}=50 µs; di_G/dt=2 A/µs
I^2t	Safety factor	$A^2s \cdot 10^3$	8000 10500	T_j=$T_{j\,max}$ T_j=25 °C	180° half-sine wave; t_p=10 ms; single pulse; V_D=V_R=0 V; Gate pulse:I_G=I_{FGM}; V_G=20 V; t_{GP}=50 µs; di_G/dt=2 A/µs
			7300 9500	T_j=$T_{j\,max}$ T_j=25 °C	180° half-sine wave; t_p=8.3 ms; single pulse; V_D=V_R=0 V; Gate pulse:I_G=I_{FGM}; V_G=20 V; t_{GP}=50 µs; di_G/dt=2 A/µs
BLOCKING					
V_{DRM}, V_{RRM}	Repetitive peak off-state and Repetitive peak reverse voltages	V	2000	$T_{j\,min}$< T_j <$T_{j\,max}$; 180° half-sine wave; 50 Hz; Gate open	
V_{DSM}, V_{RSM}	Non-repetitive peak off-state and Non-repetitive peak reverse voltages	V	2100	$T_{j\,min}$< T_j <$T_{j\,max}$; 180° half-sine wave; single pulse; Gate open	
V_D, V_R	Direct off-state and Direct reverse voltages	V	$0.6 \cdot V_{DRM}$ $0.6 \cdot V_{RRM}$	T_j=$T_{j\,max}$; Gate open	

TRIGGERING				
I_{FGM}	Peak forward gate current	A	10	$T_j=T_{j\,max}$
V_{RGM}	Peak reverse gate voltage	V	5	
P_G	Gate power dissipation	W	8	$T_j=T_{j\,max}$ for DC gate current
SWITCHING				
$(di_T/dt)_{crit}$	Critical rate of rise of on-state current non-repetitive (f=1 Hz)	A/μs	2500	$T_j=T_{j\,max}$; $V_D=0.67{\cdot}V_{DRM}$; I_{TM}= 6400 A; Gate pulse: I_G=2 A; V_G=20 V; t_{GP}=50 μs; di_G/dt=2 A/μs
THERMAL				
T_{stg}	Storage temperature	°C	–60...+50	
T_j	Operating junction temperature	°C	–60...+125	
MECHANICAL				
F	Mounting force	kN	40.0...50.0	
a	Acceleration	m/s²	50	Device clamped

CHARACTERISTICS

Symbols and parameters		Units	Values	Conditions	
ON-STATE					
V_{TM}	Peak on-state voltage, max	V	2.20	T_j=25 °C; I_{TM}=6280 A	
$V_{T(TO)}$	On-state threshold voltage, max	V	1.289	$T_j=T_{j\,max}$; $0.5\,\pi\,I_{TAV} < I_T < 1.5\,\pi\,I_{TAV}$	
r_T	On-state slope resistance, max	mΩ	0.134		
I_H	Holding current, max	mA	1000	T_j=25 °C; V_D=12 V; Gate open	
BLOCKING					
I_{DRM}, I_{RRM}	Repetitive peak off-state and Repetitive peak reverse currents, max	mA	300	$T_j=T_{j\,max}$; $V_D=V_{DRM}$; $V_R=V_{RRM}$	
$(dv_D/dt)_{crit}$	Critical rate of rise of off-state voltage[1], min	V/μs	200, 320, 500, 1000, 1600, 2000, 2500	$T_j=T_{j\,max}$; $V_D=0.67{\cdot}V_{DRM}$; Gate open	
TRIGGERING					
V_{GT}	Gate trigger direct voltage, max	V	3.00 3.00 1.50	$T_j= T_{j\,min}$ T_j=25 °C $T_j= T_{j\,max}$	V_D=12 V; I_D=3 A; Direct gate current
I_{GT}	Gate trigger direct current, max	mA	500 300 150	$T_j= T_{j\,min}$ T_j= 25 °C $T_j= T_{j\,max}$	
V_{GD}	Gate non-trigger direct voltage, min	V	0.45	$T_j=T_{j\,max}$; $V_D=0.67{\cdot}V_{DRM}$; Direct gate current	
I_{GD}	Gate non-trigger direct current, min	mA	80.00		
SWITCHING					
t_{gd}	Delay time, max	μs	1.10	T_j=25 °C; V_D=1000 V; $I_{TM}=I_{TAV}$; di/dt=200 A/μs; Gate pulse: I_G=2 A; V_G=20 V; t_{GP}=50 μs; di_G/dt=2 A/μs	
t_{gt}	Turn-on time[2], max	μs	2.00, 2.50, 3.20, 4.00		
t_q	Turn-off time[3], max	μs	32.0, 40.0, 50.0, 63.0	dv_D/dt=50 V/μs;	$T_j=T_{j\,max}$; $I_{TM}= I_{TAV}$; di_R/dt=-10 A/μs; V_R=100V; V_D=0.67 V_{DRM}
			40.0, 50.0, 63.0, 80.0	dv_D/dt=200 V/μs;	
Q_{rr}	Total recovered charge, max	μC	800	$T_j=T_{j\,max}$; I_{TM}=2000 A; di_R/dt=-50 A/μs; V_R=100 V	
t_{rr}	Reverse recovery time, max	μs	8.0		
I_{rrM}	Peak reverse recovery current, max	A	200		

THERMAL					
R_{thjc}	Thermal resistance, junction to case, max	°C/W	0.0100	Direct current	Double side cooled
R_{thjc-A}			0.0220		Anode side cooled
R_{thjc-K}			0.0180		Cathode side cooled
R_{thck}	Thermal resistance, case to heatsink, max	°C/W	0.0020	Direct current	
MECHANICAL					
w	Weight, max	g	1600		
D_s	Surface creepage distance	mm (inch)	55.13 (2.170)		
D_a	Air strike distance	mm (inch)	25.10 (0.988)		

PART NUMBERING GUIDE

TFI	273	2000	20	A2	C3	H4	N
1	2	3	4	5	6	7	8

1. TFI — fast inverter thyristor
2. Design version
3. Mean on-state current, A
4. Voltage code
5. Critical rate of rise of off-state voltage
6. Group of turn-off time (dv_D/dt=50 V/µs)
7. Group of turn-on time
8. Ambient conditions: N – normal; T – tropical

NOTES

1) Critical rate of rise of off-state voltage

Symbol of Group	P2	K2	E2	A2	T1	P1	M1
$(dv_D/dt)_{crit}$, V/µs	200	320	500	1000	1600	2000	2500

2) Turn-on time

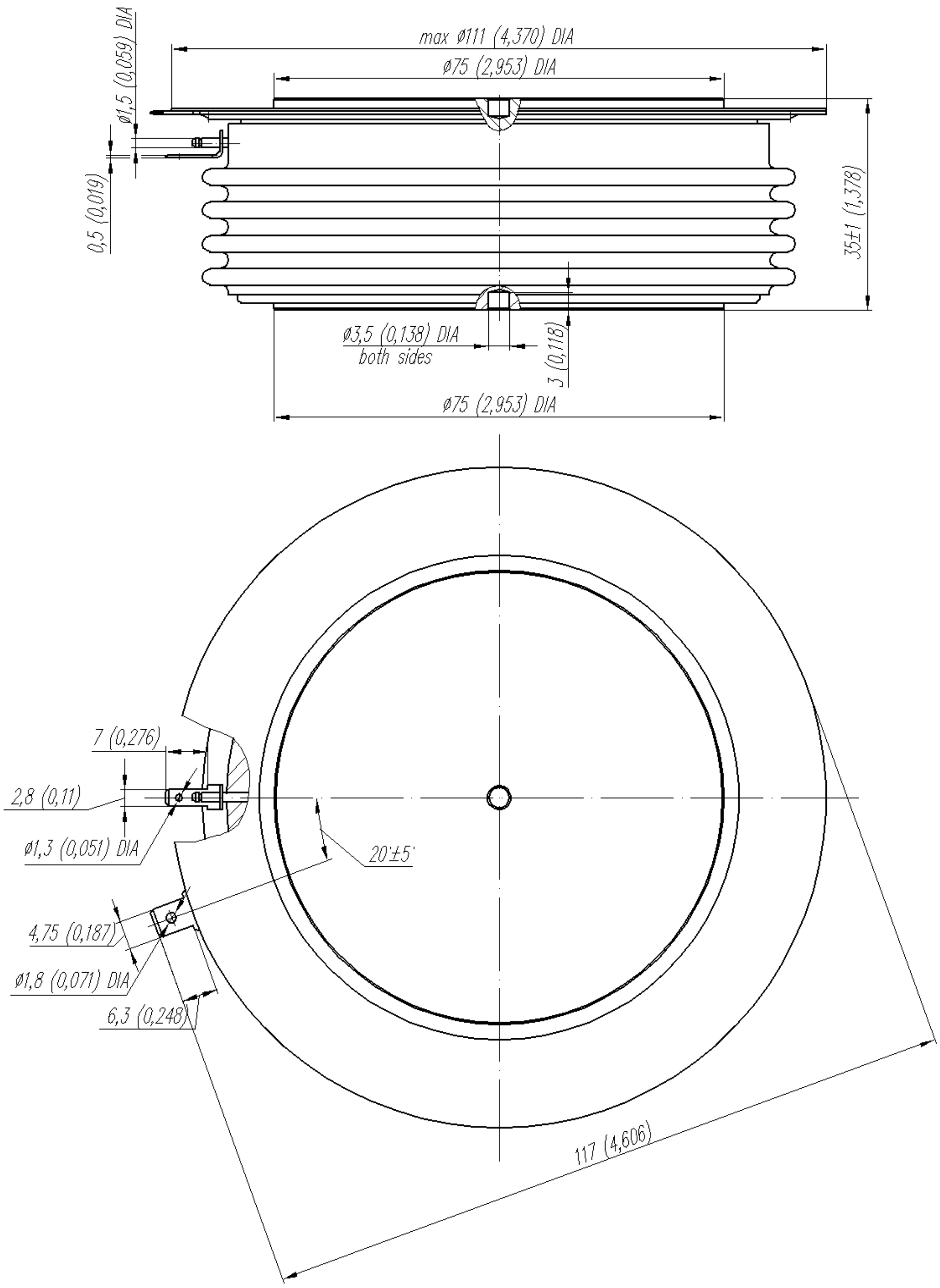
Symbol of group	P4	M4	K4	H4
t_{gt}, µs	2.00	2.50	3.20	4.00

3) Turn-off time (dv_D/dt=50 V/µs)

Symbol of group	K3	H3	E3	C3
t_q, µs	32.0	40.0	50.0	63.0

OVERALL DIMENSIONS

Package type: T.F5



All dimensions in millimeters (inches)

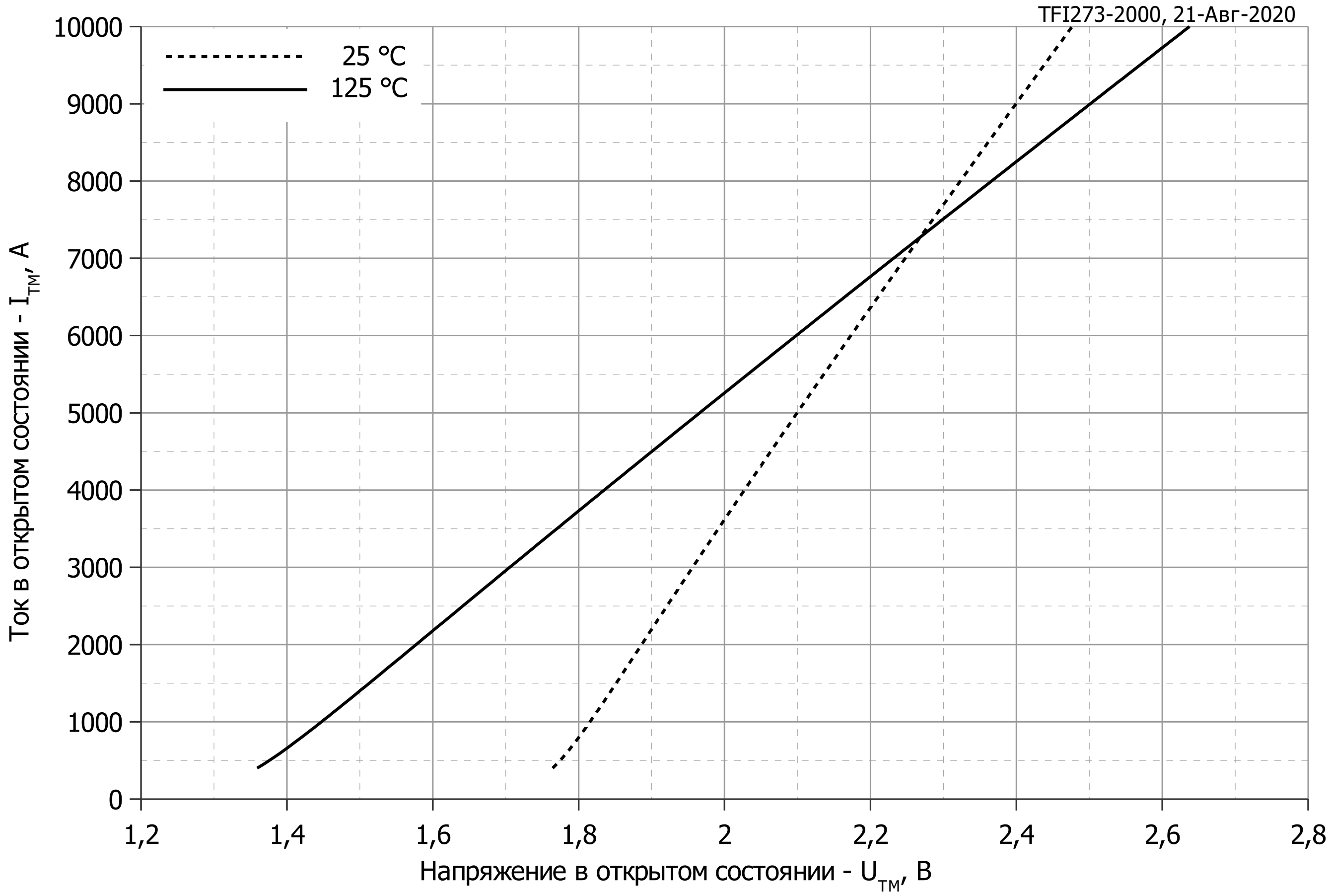


Fig 1 – On-state characteristics of Limit device

Analytical function for On-state characteristic:

$$V_T = A + B \cdot i_T + C \cdot \ln(i_T + 1) + D \cdot \sqrt{i_T}$$

	Coefficients	
	T_j = 25°C	$T_j = T_{j\,max}$
A	1.50298452	1.04020816
B	0.00009551	0.00015670
C	0.05283372	0.06026288
D	-0.00468035	-0.00524666

On-state characteristic model (see Fig. 1).

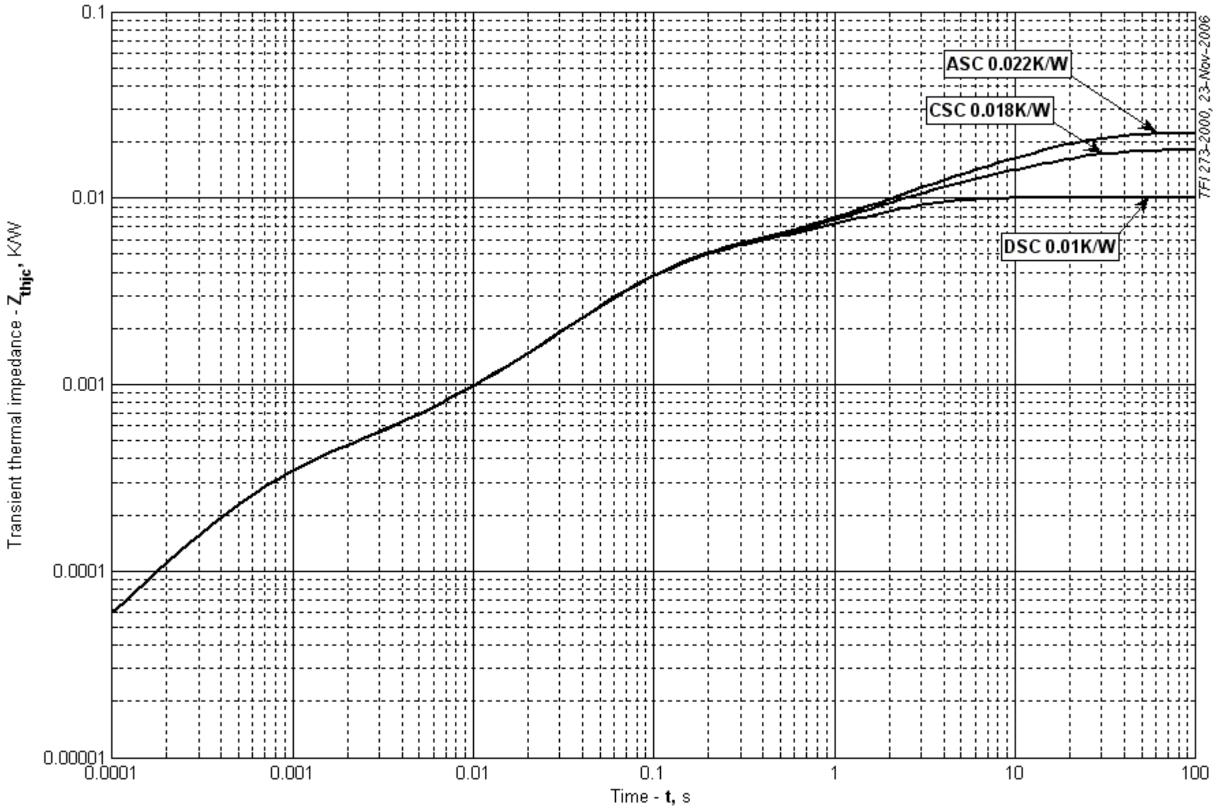


Fig 2 – Transient thermal impedance

Analytical function for Transient thermal impedance junction to case Z_{thjc} for DC:

$$Z_{thjc} = \sum_{i=1}^{n} R_i \left(1 - e^{-\frac{t}{\tau_i}} \right)$$

Where ***i*** = 1 to ***n***, ***n*** is the number of terms in the series.

t = Duration of heating pulse in seconds.

$\mathbf{Z_{thjc}}$ = Thermal resistance at time t.

$\mathbf{R_i}$ = Amplitude of p_{th} term.

τ_i = Time constatnt of r_{th} term.

DC Double side cooled

i	1	2	3	4	5	6
R_i, K/W	0.001774	0.003777	0.0001611	0.0006796	0.0002974	0.00331
τ_i, s	2.276	0.07599	0.003417	0.1692	0.0005483	1.377

DC Anode side cooled

i	1	2	3	4	5	6
R_i, K/W	0.01236	0.004656	0.0005901	0.004178	0.0001632	0.0003062
τ_i, s	13.340	2.011	0.4635	0.08072	0.00394	0.0005608

DC Cathode side cooled

i	1	2	3	4	5	6
R_i, K/W	0.008157	0.004601	0.0006385	0.004186	0.0001632	0.0003067
τ_i, s	13.30	1.922	0.4875	0.08063	0.003967	0.0005616

Transient thermal impedance junction to case Z_{thjc} model (see Fig. 2).

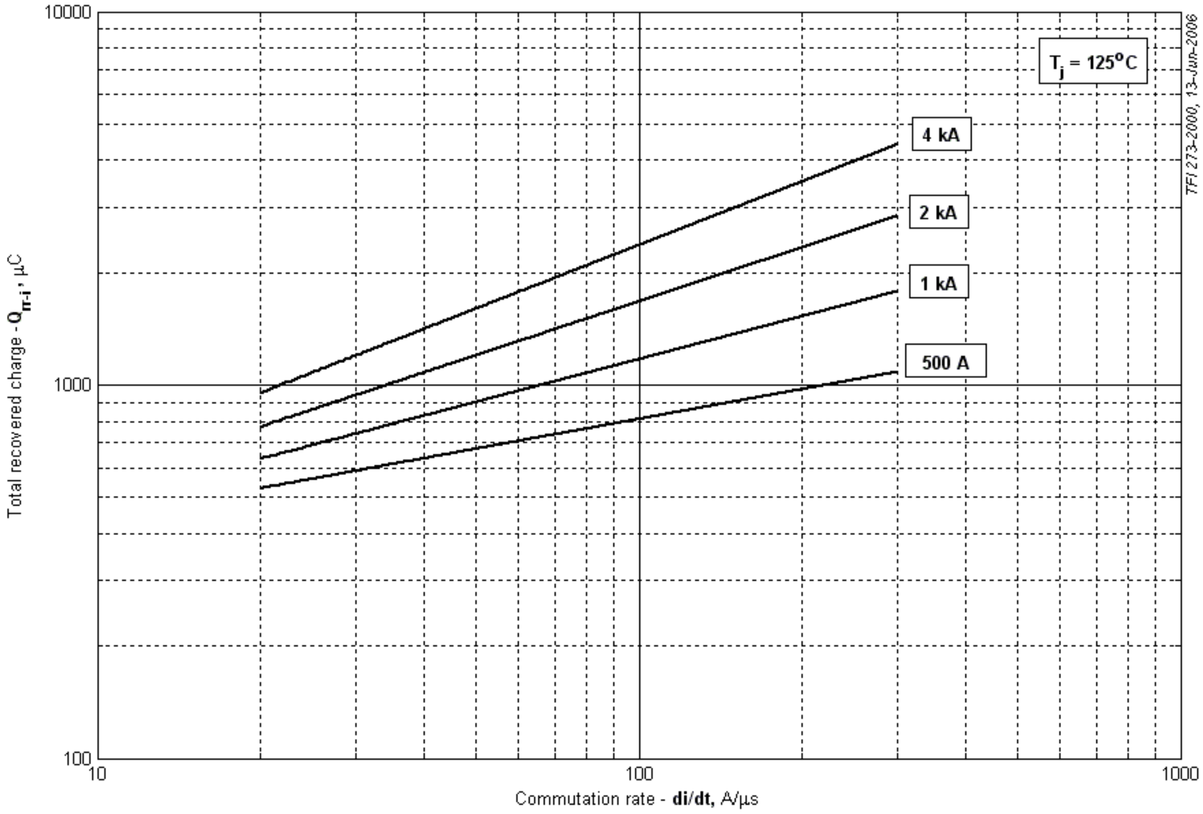


Fig 3 – Total recovered charge, Q_{rr-i} (integral)

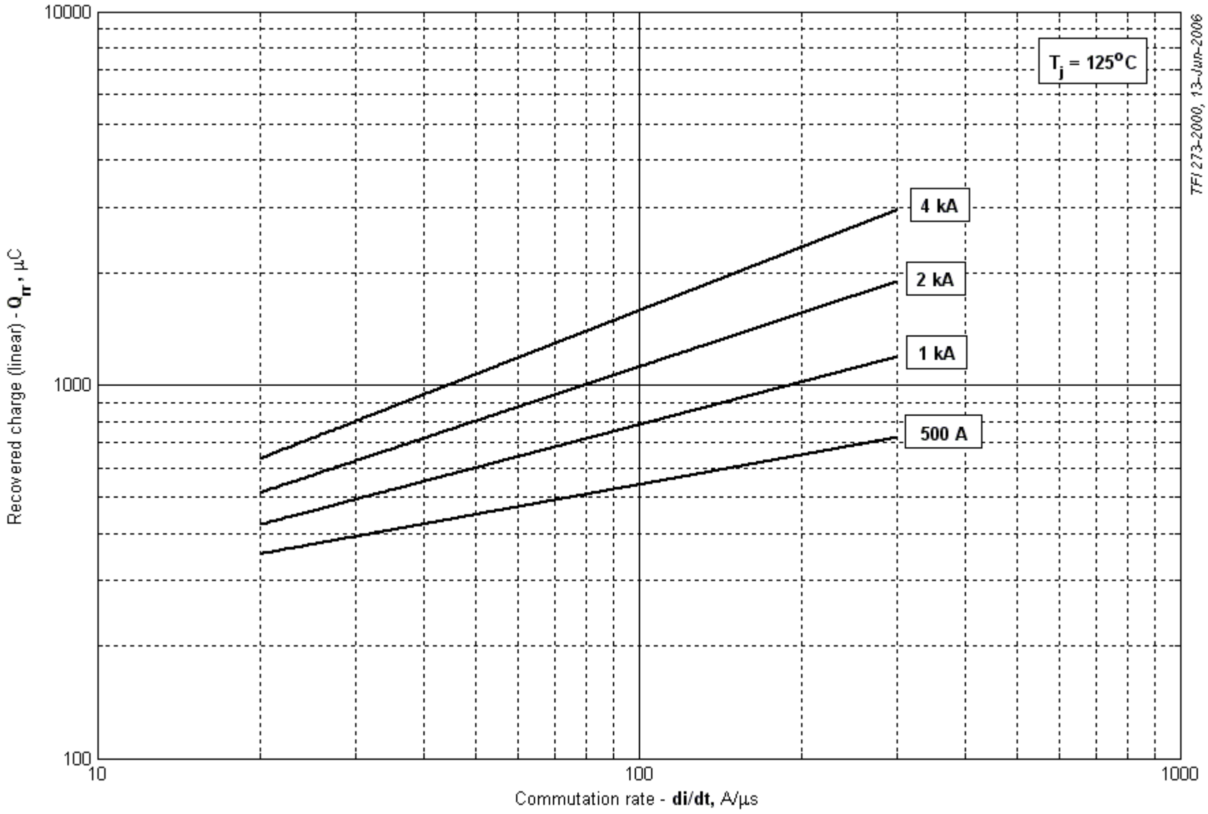


Fig 4 - Recovered charge, Q_{rr} (linear)

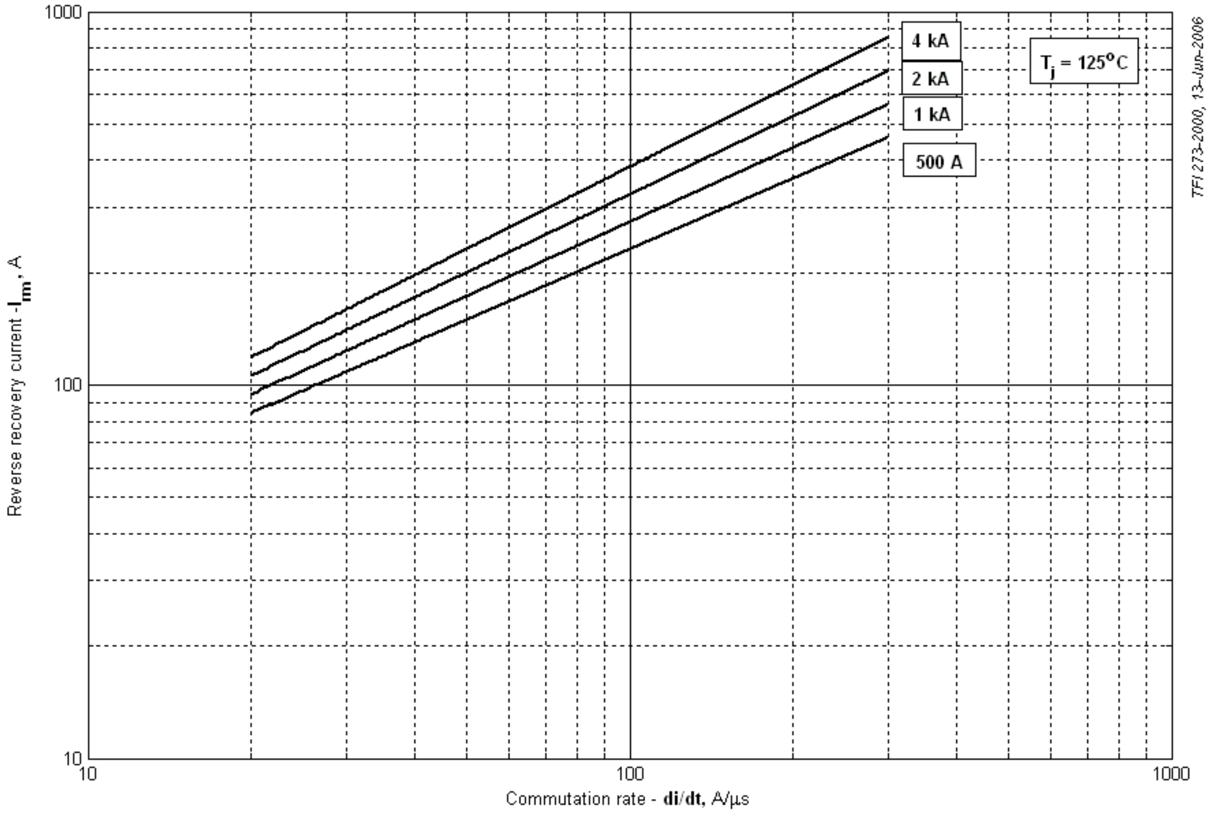


Fig 5 – Peak reverse recovery current, I_{rm}

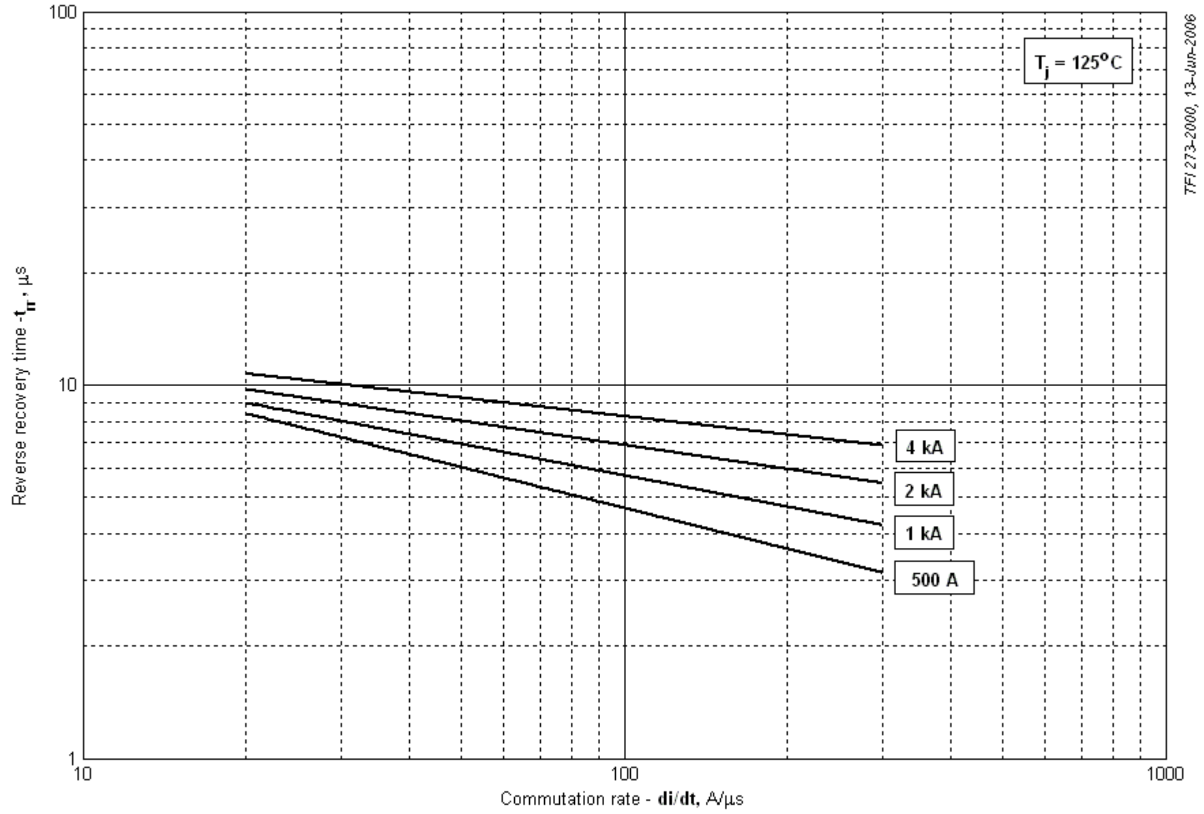


Fig 6 – Typical recovery time, t_{rr} (linear)

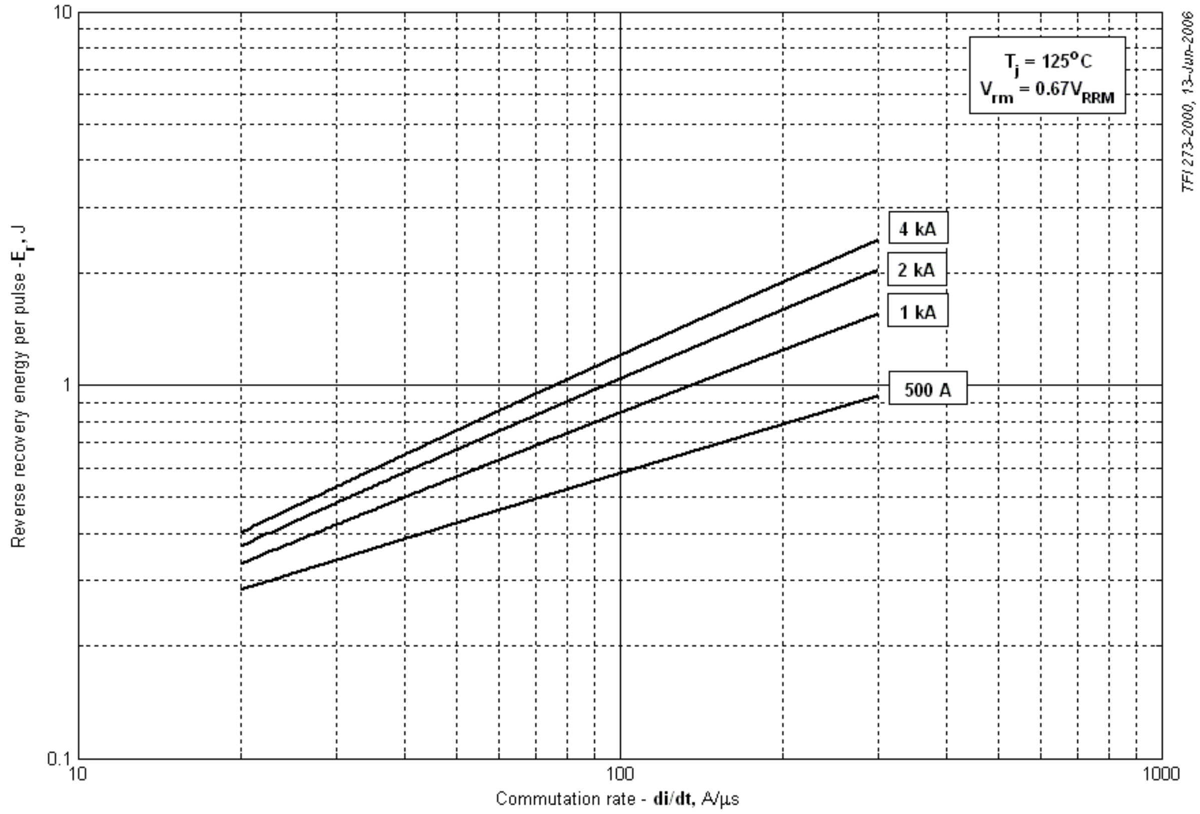


Fig 7 – Reverse recovery energy per pulse

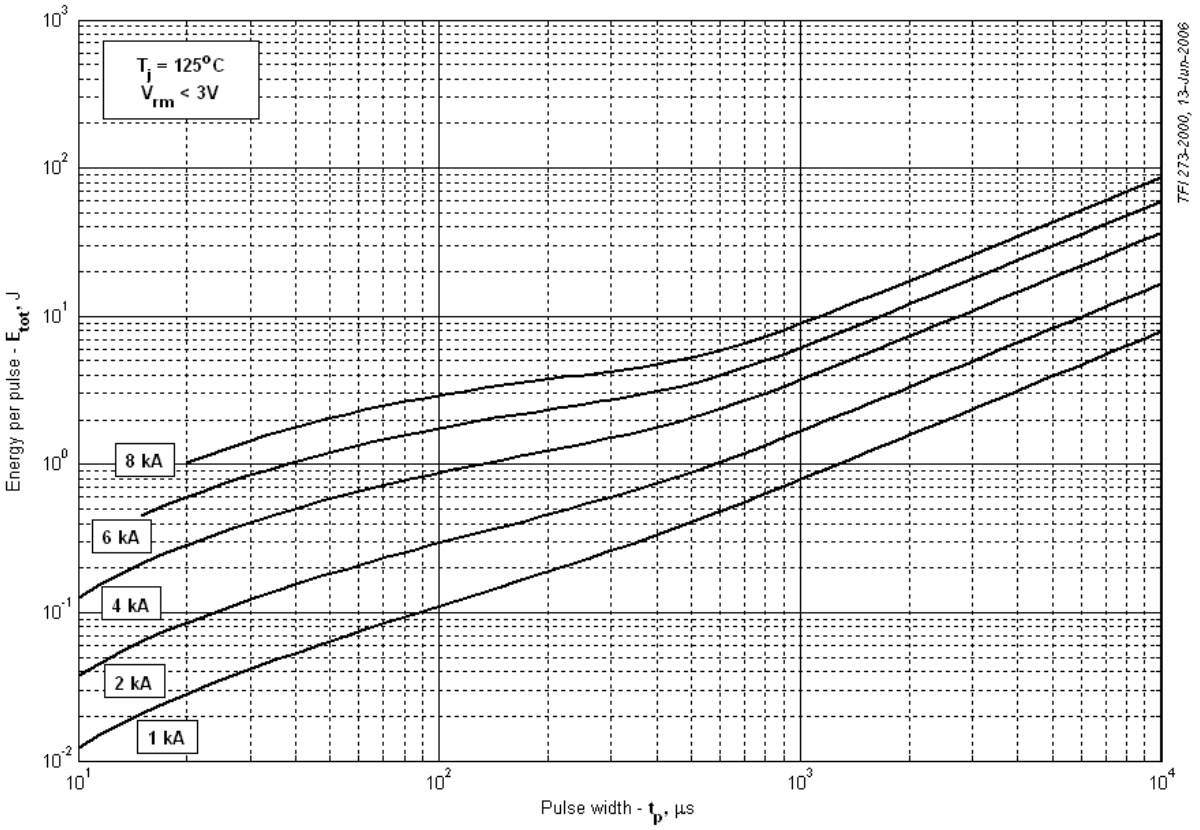


Fig 8 – Sine wave energy per pulse

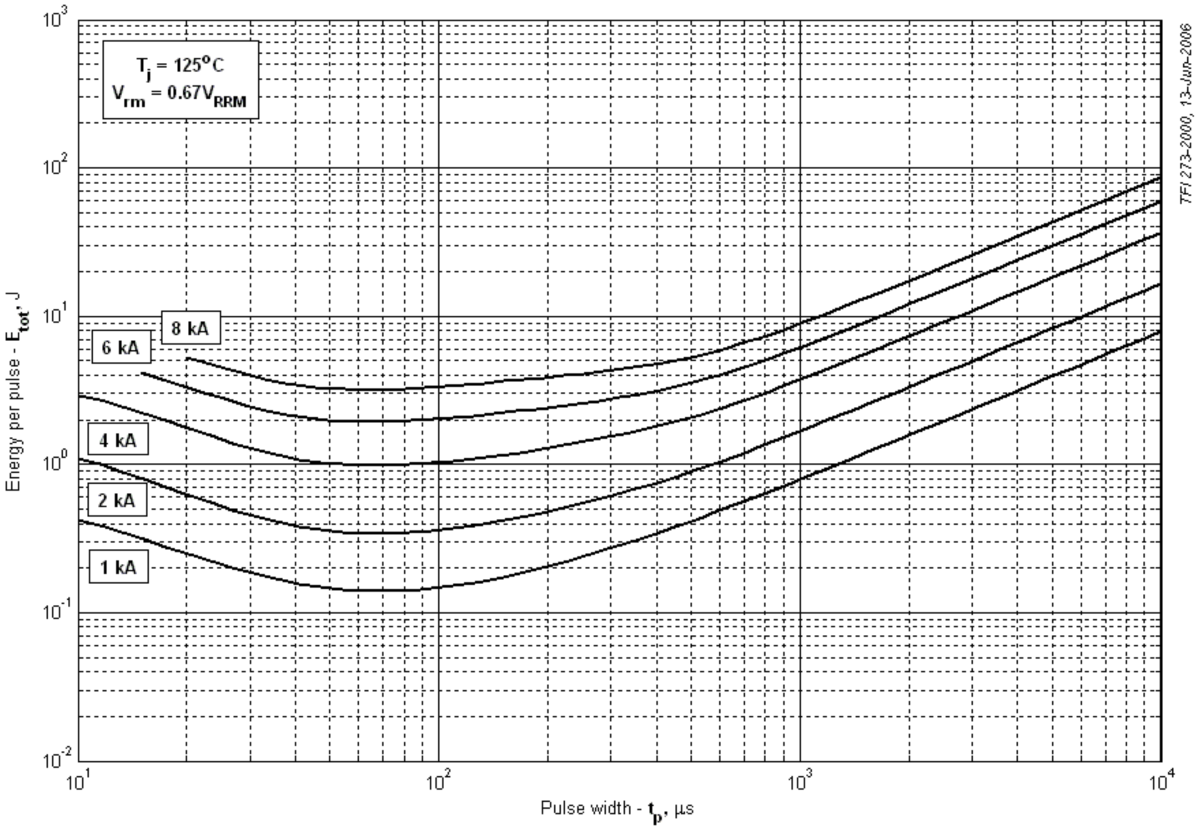


Fig 9 – Sine wave energy per pulse

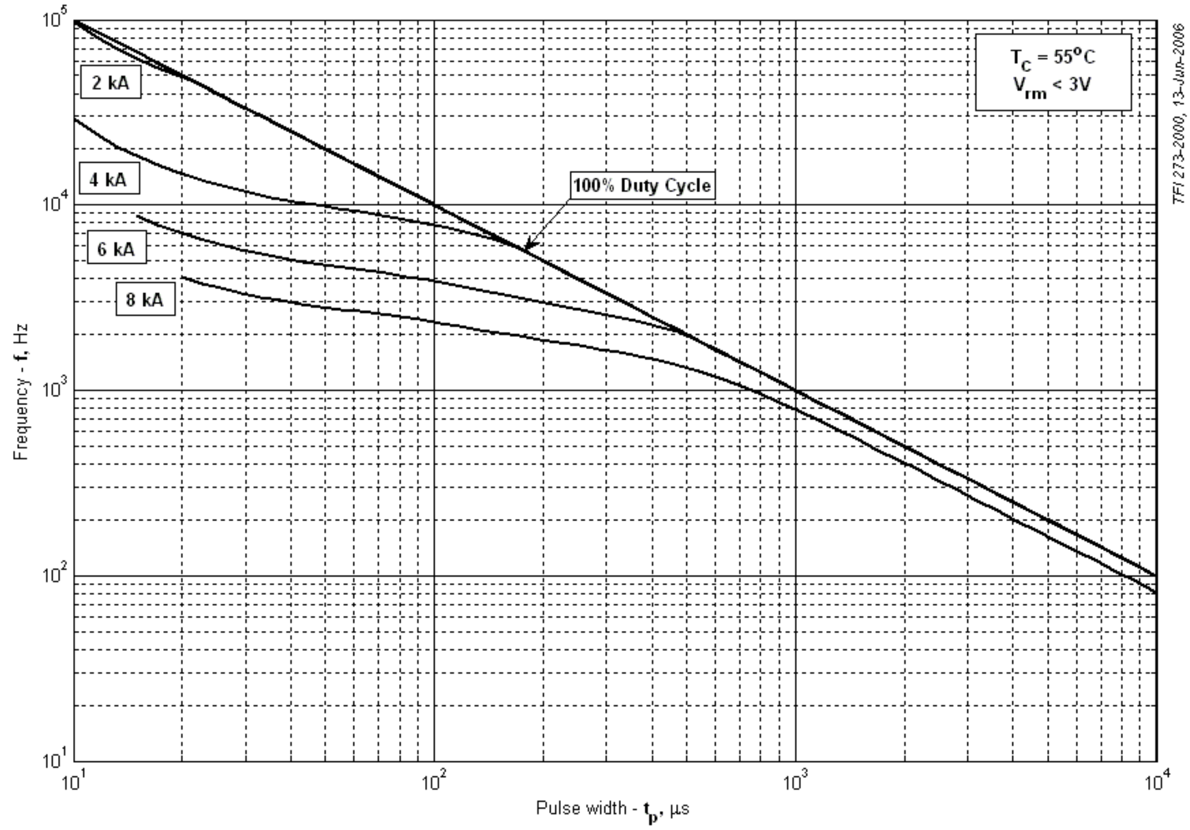


Fig 10 – Sine wave frequency ratings

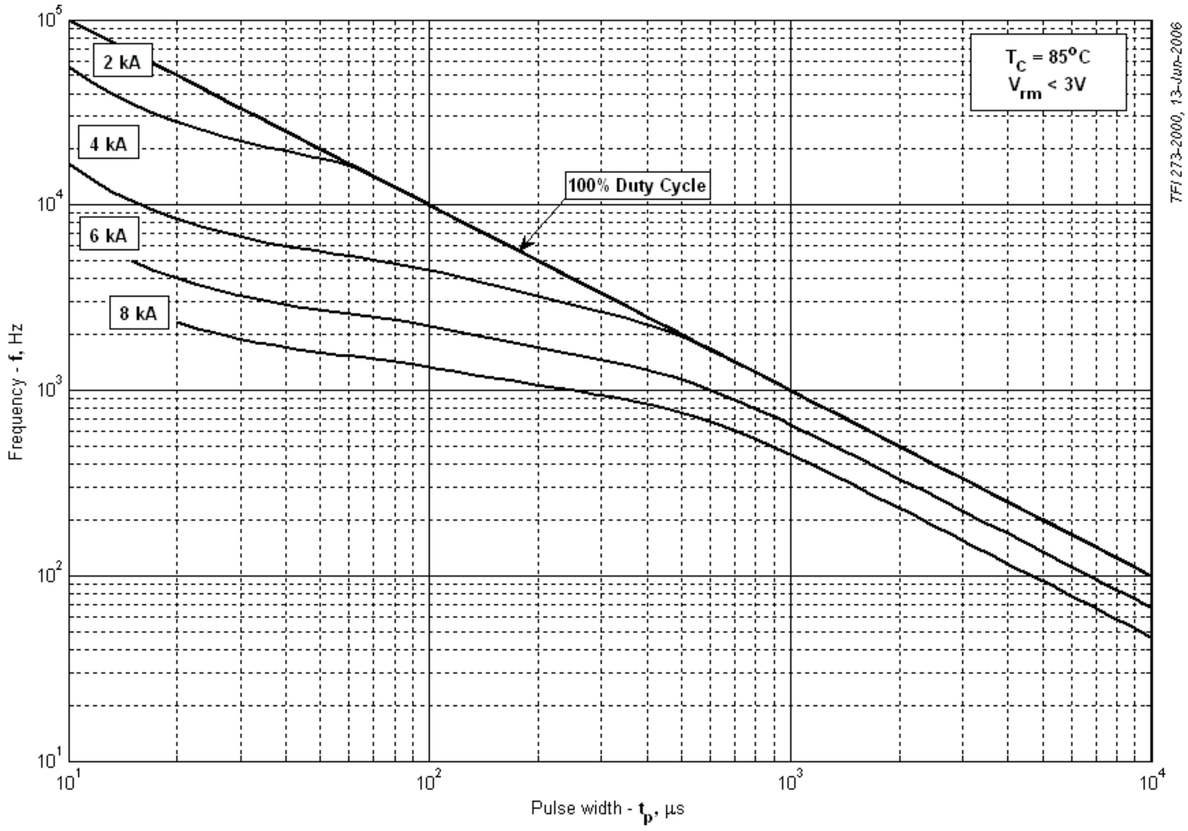


Fig 11 – Sine wave frequency ratings

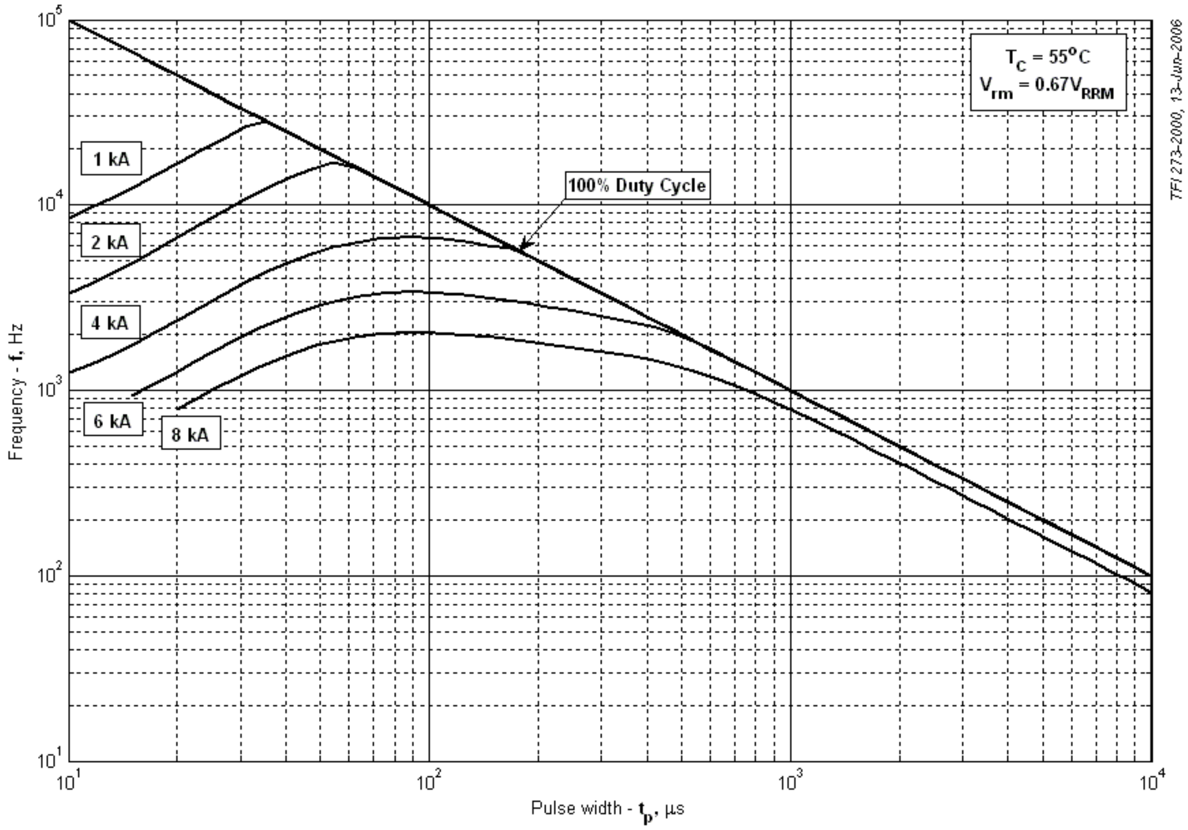


Fig 12 – Sine wave frequency ratings

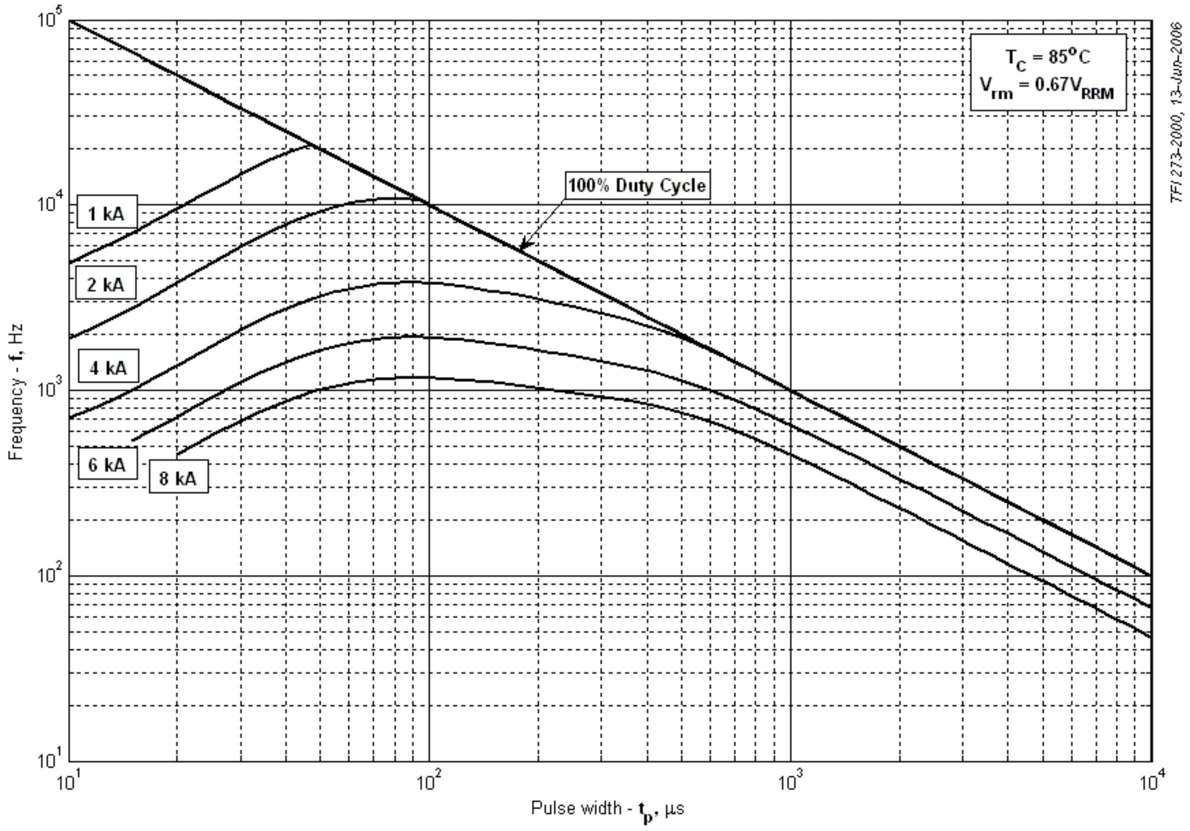


Fig 13 – Sine wave frequency ratings

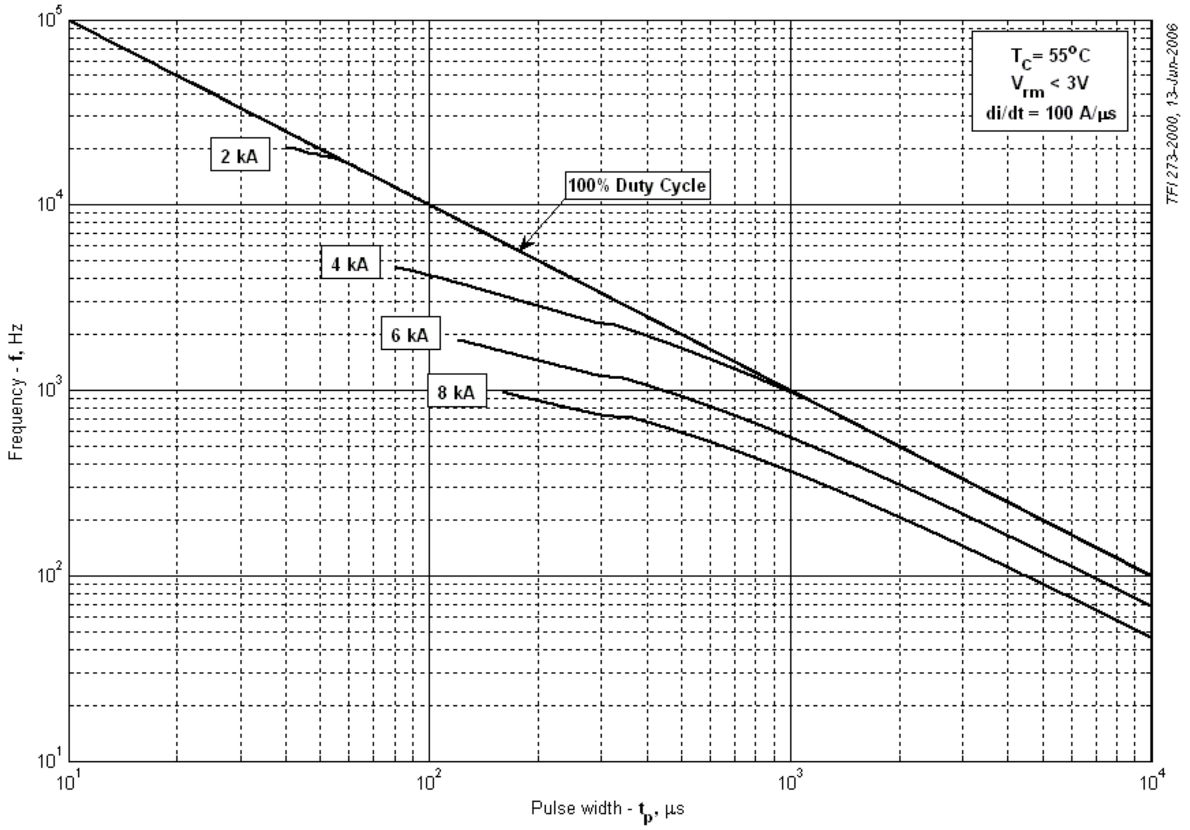


Fig 14 – Square wave frequency ratings

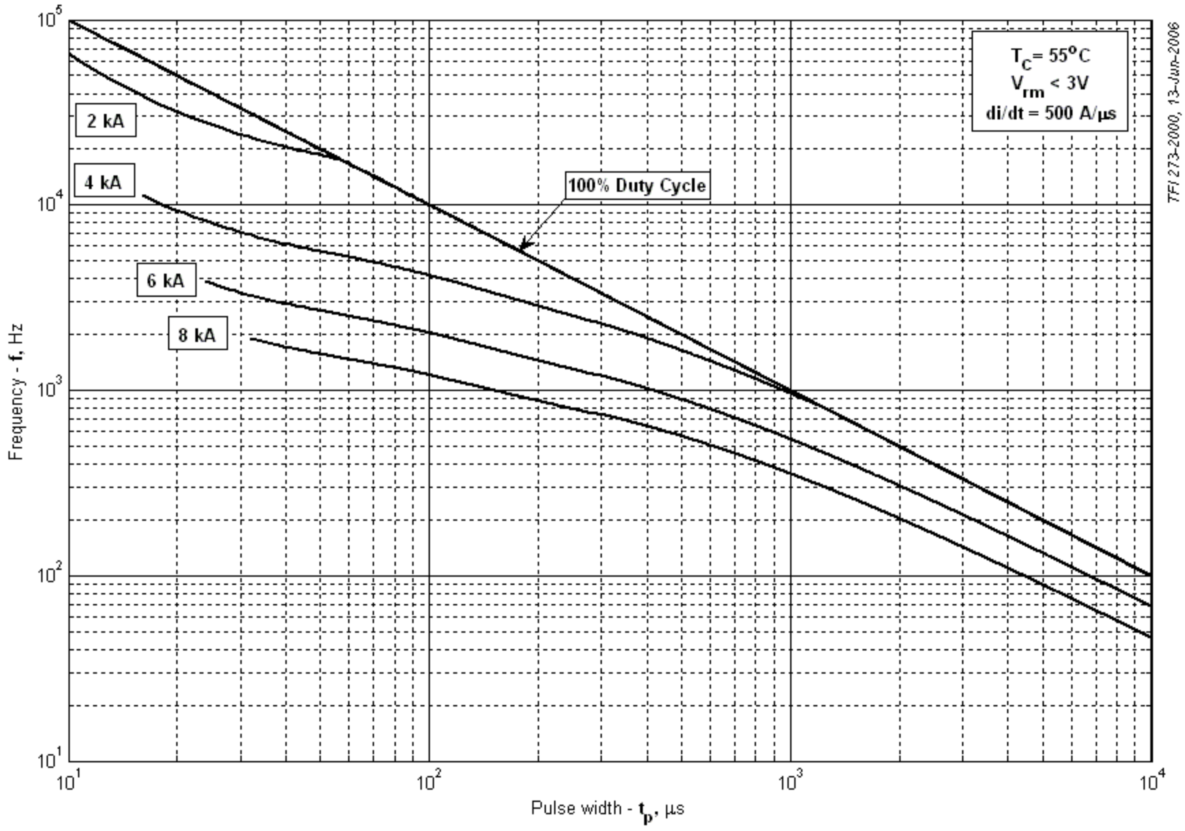


Fig 15 – Square wave frequency ratings

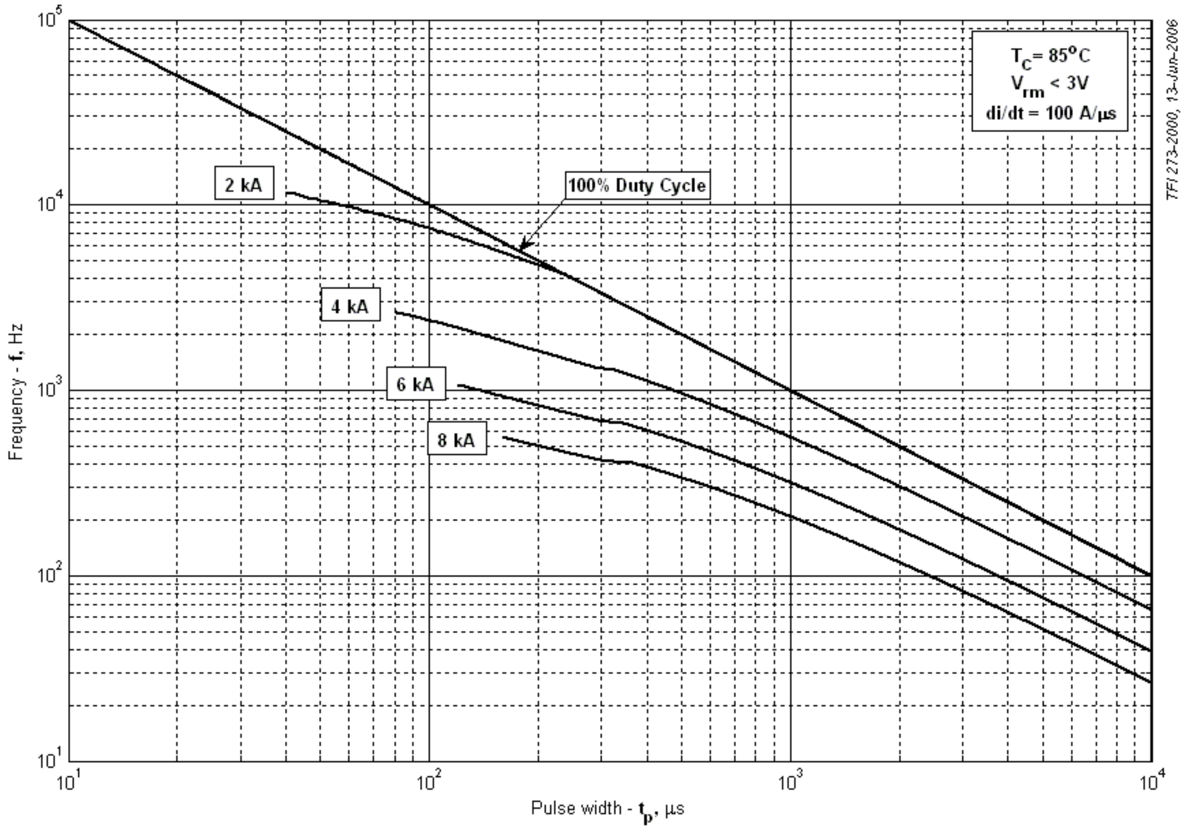


Fig 16 – Square wave frequency ratings

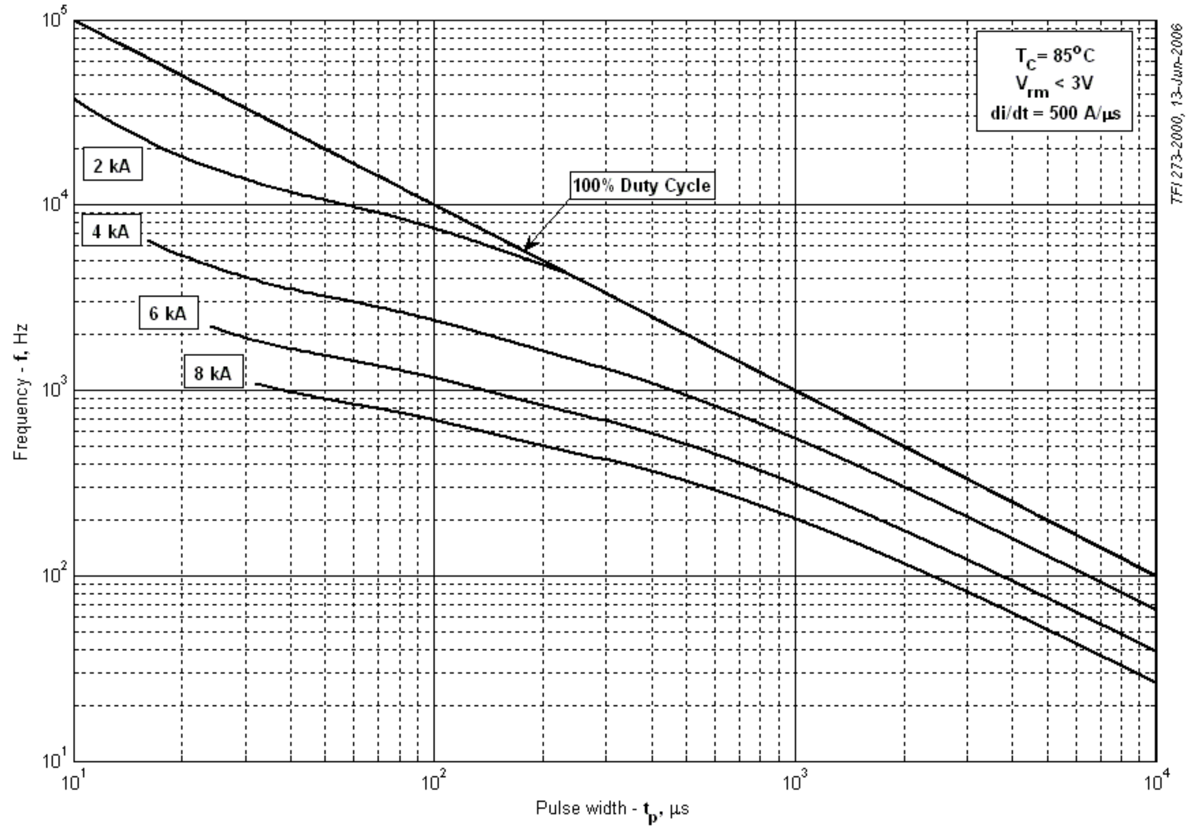


Fig 17 – Square wave frequency ratings

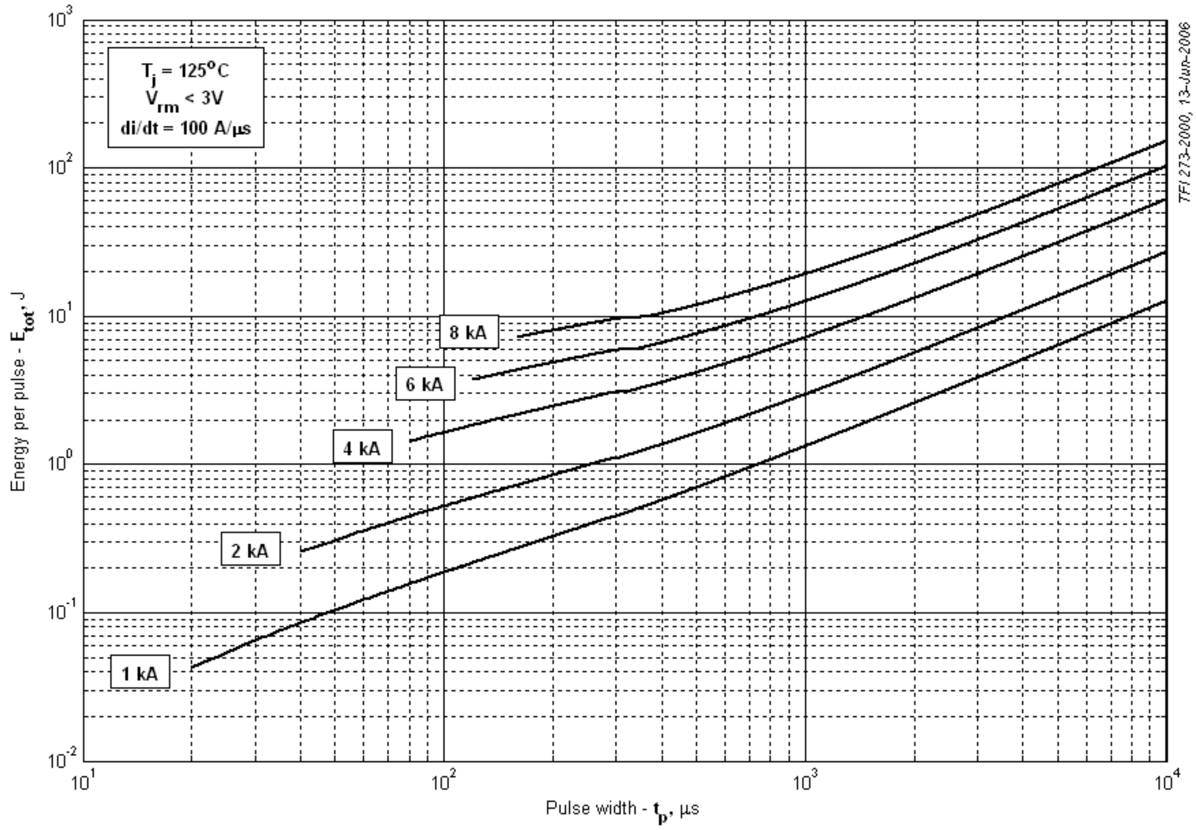


Fig 18 – Square wave energy per pulse

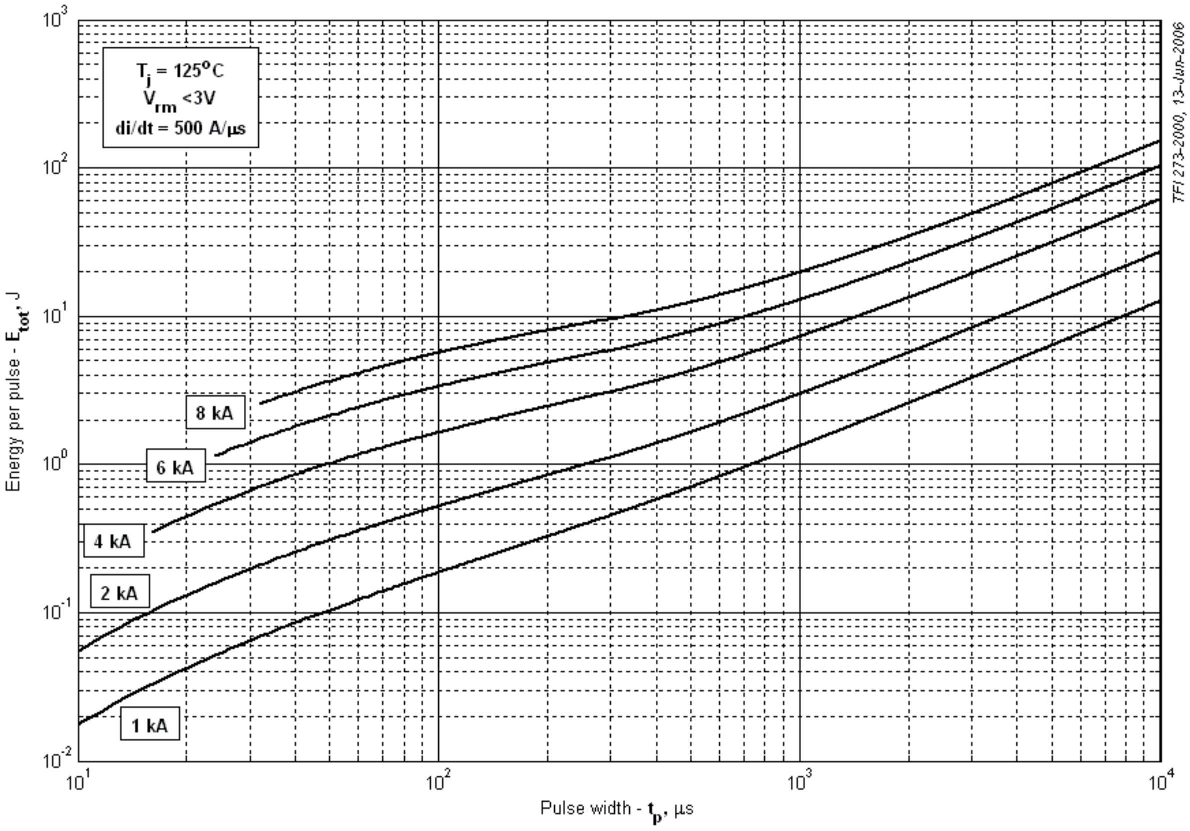


Fig 19 – Square wave energy per pulse

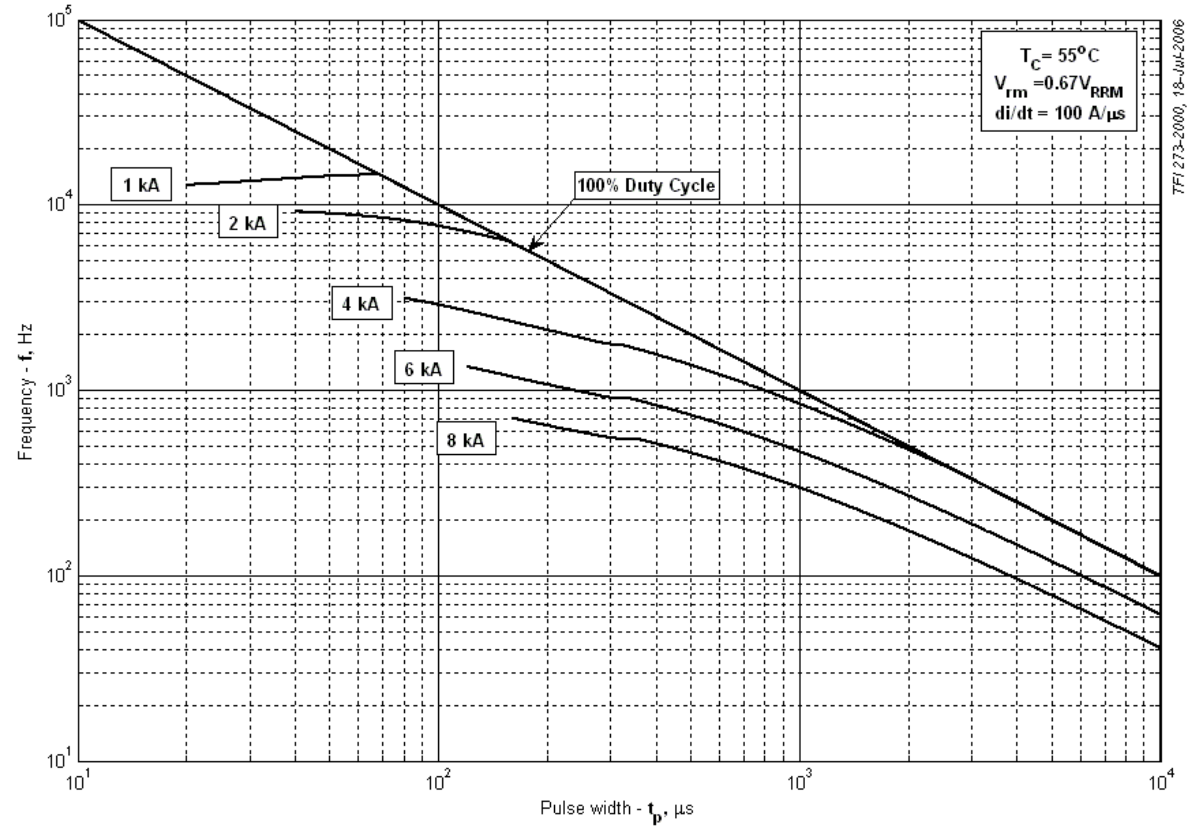


Fig 20 – Square wave frequency ratings

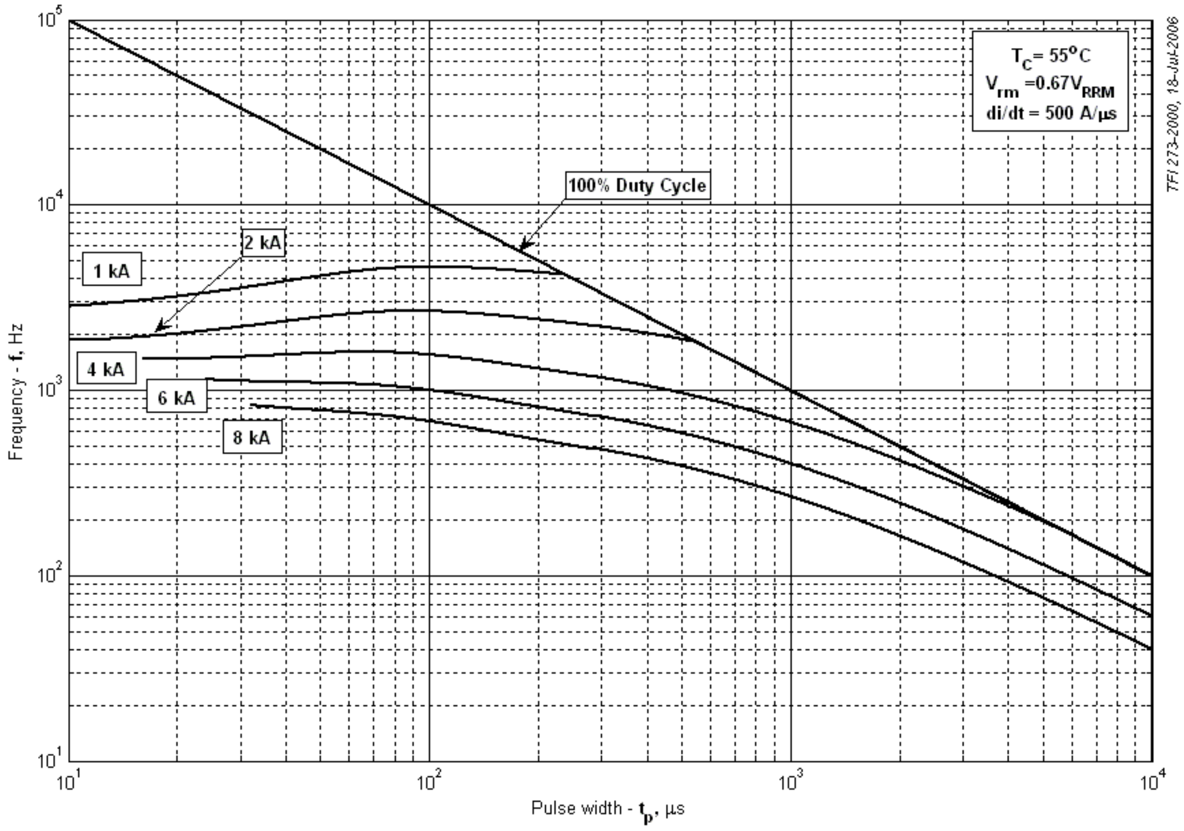


Fig 21 – Square wave frequency ratings

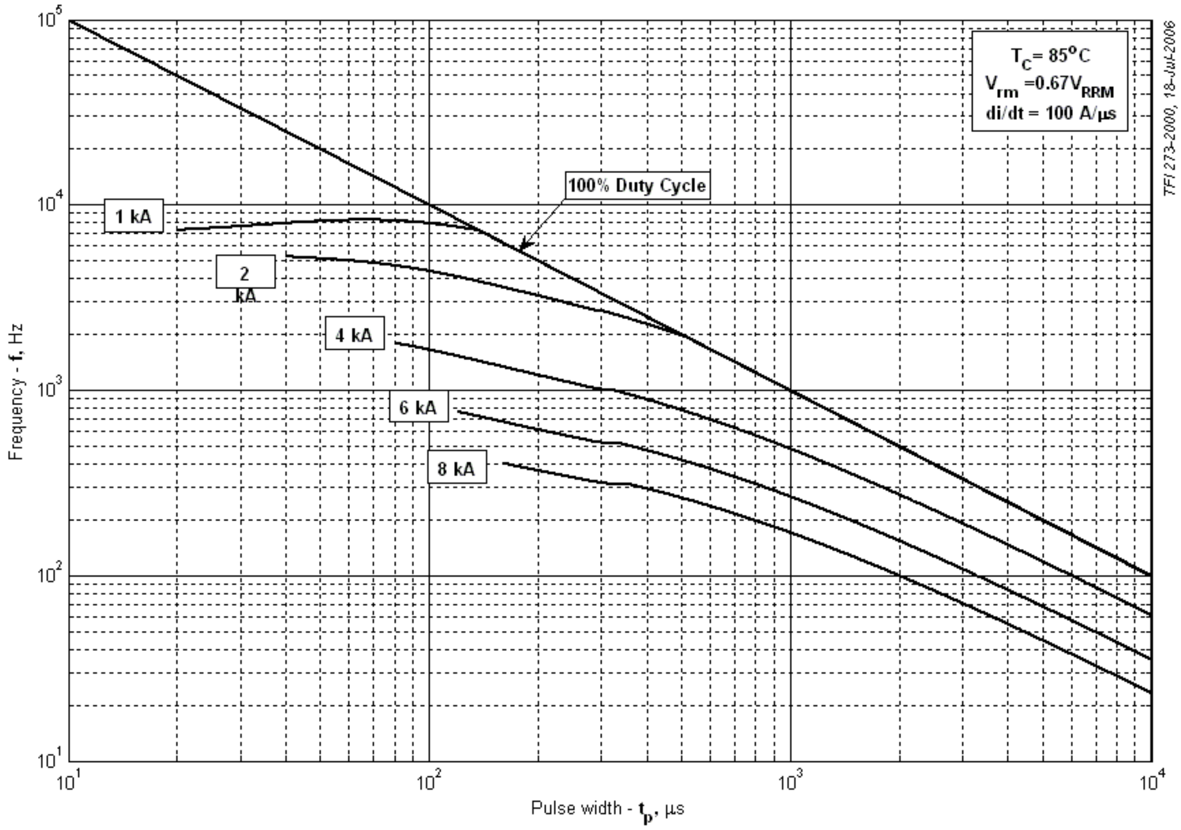


Fig 22 – Square wave frequency ratings

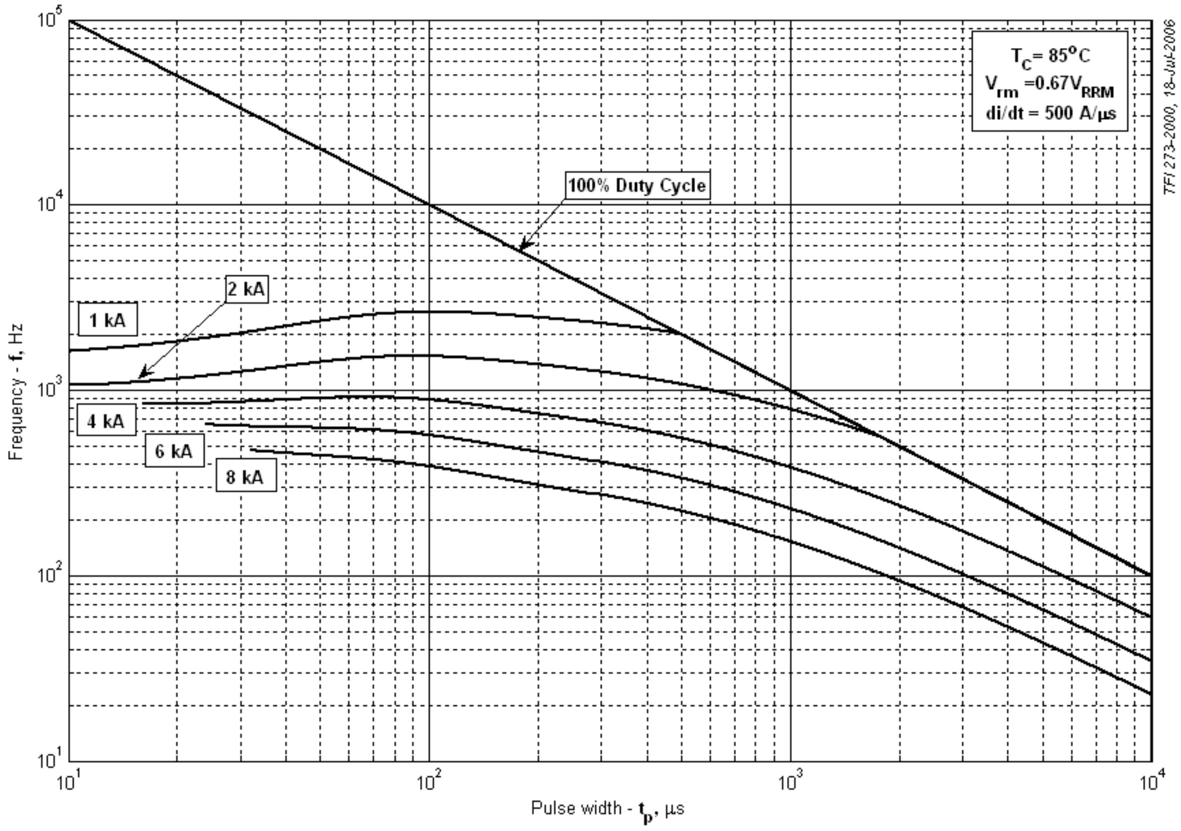


Fig 23 – Square wave frequency ratings

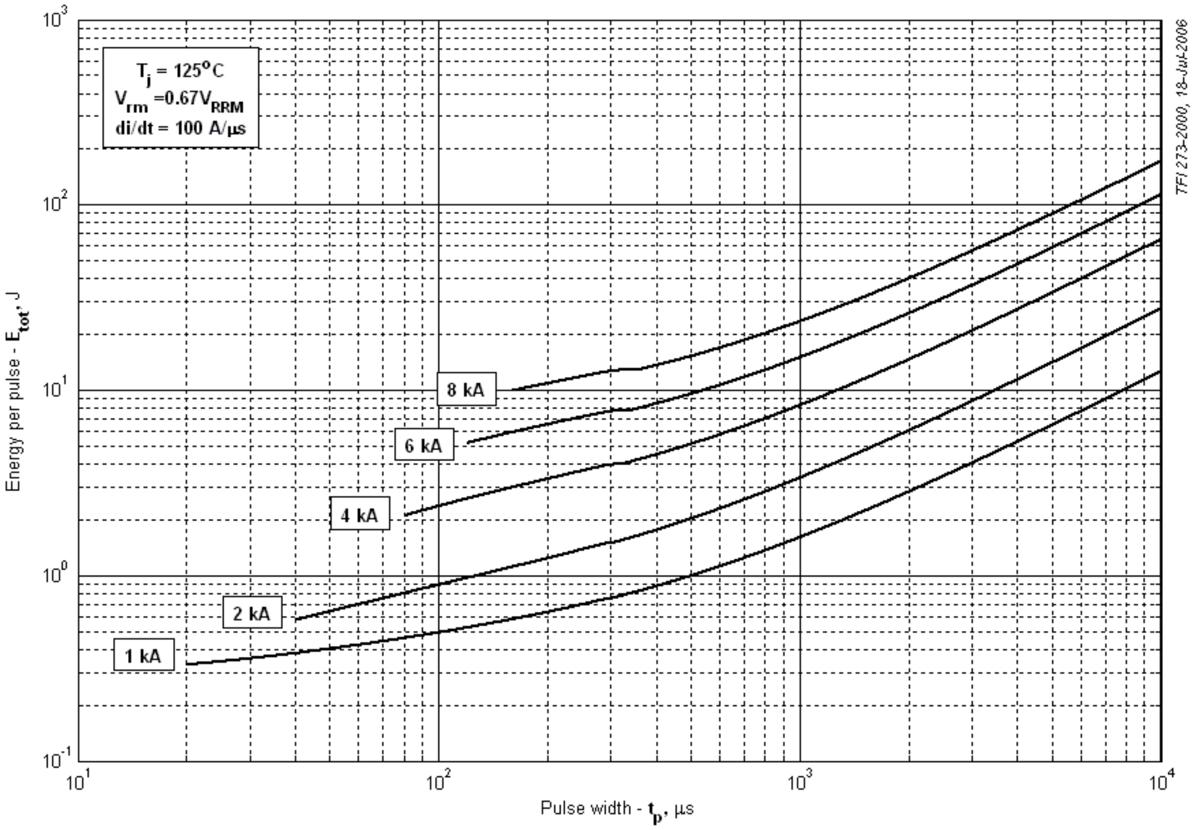


Fig 24 – Square wave energy per pulse

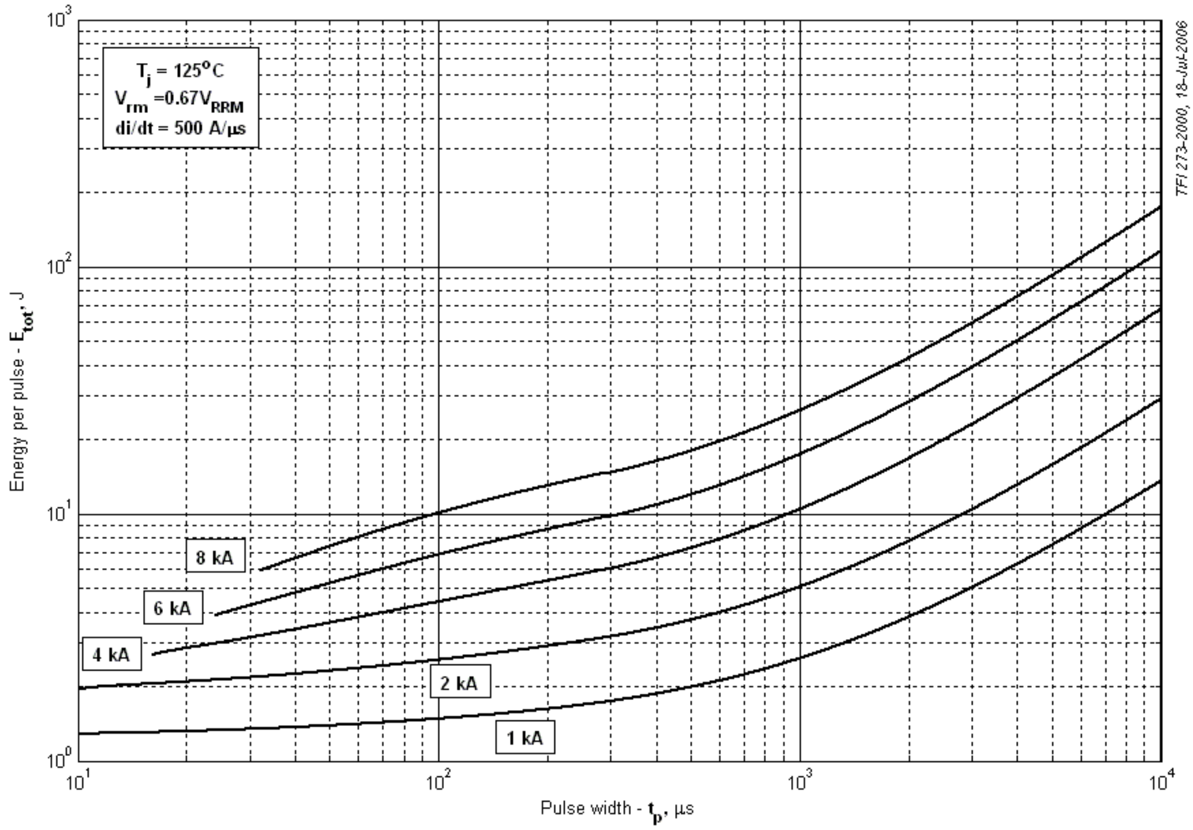


Fig 25 – Square wave energy per pulse

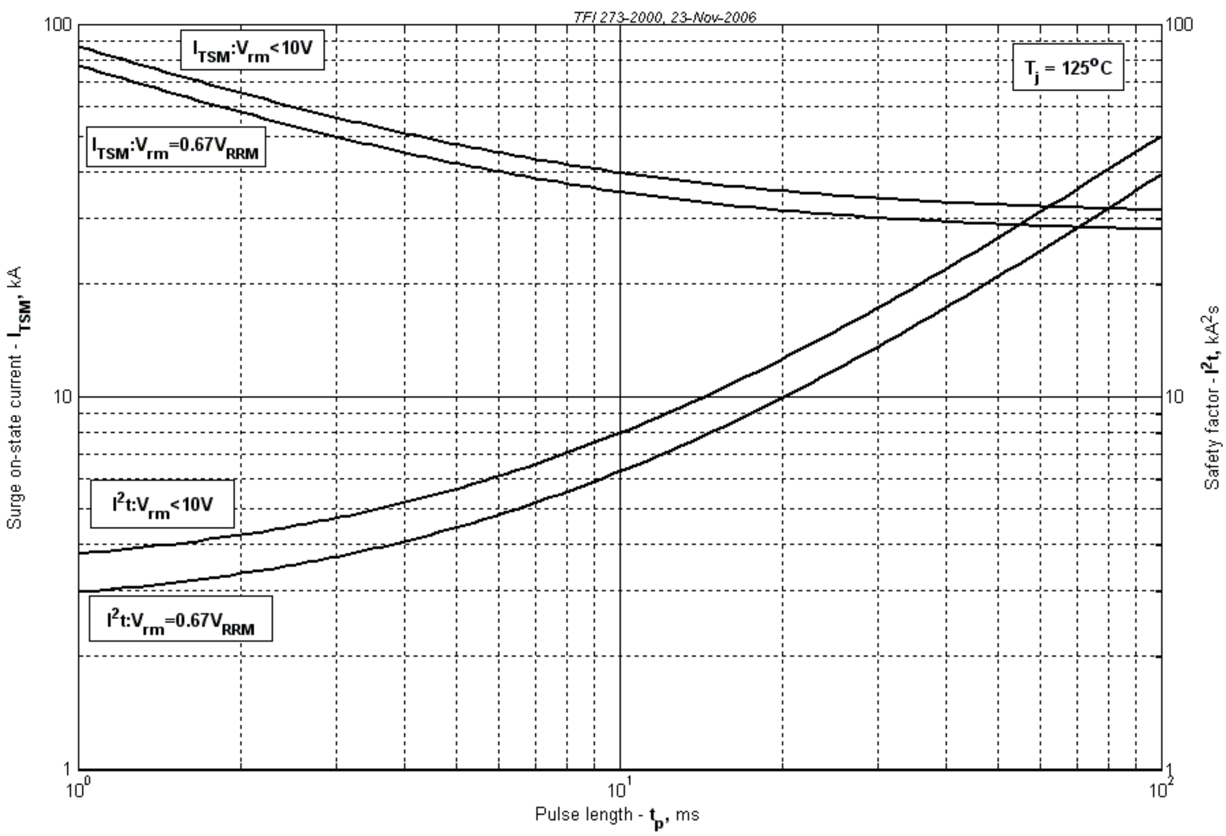


Fig 26 – Maximum surge and I^2t ratings

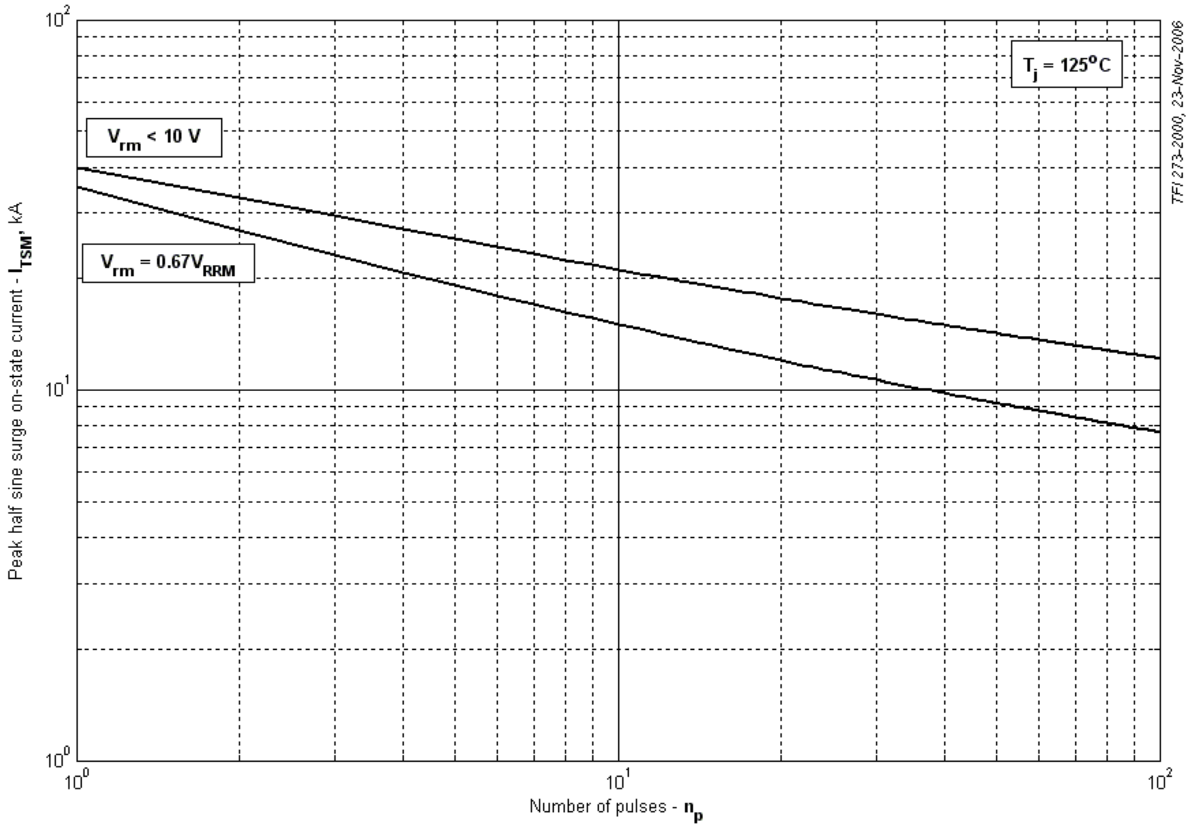


Fig 27 – Maximum surge ratings

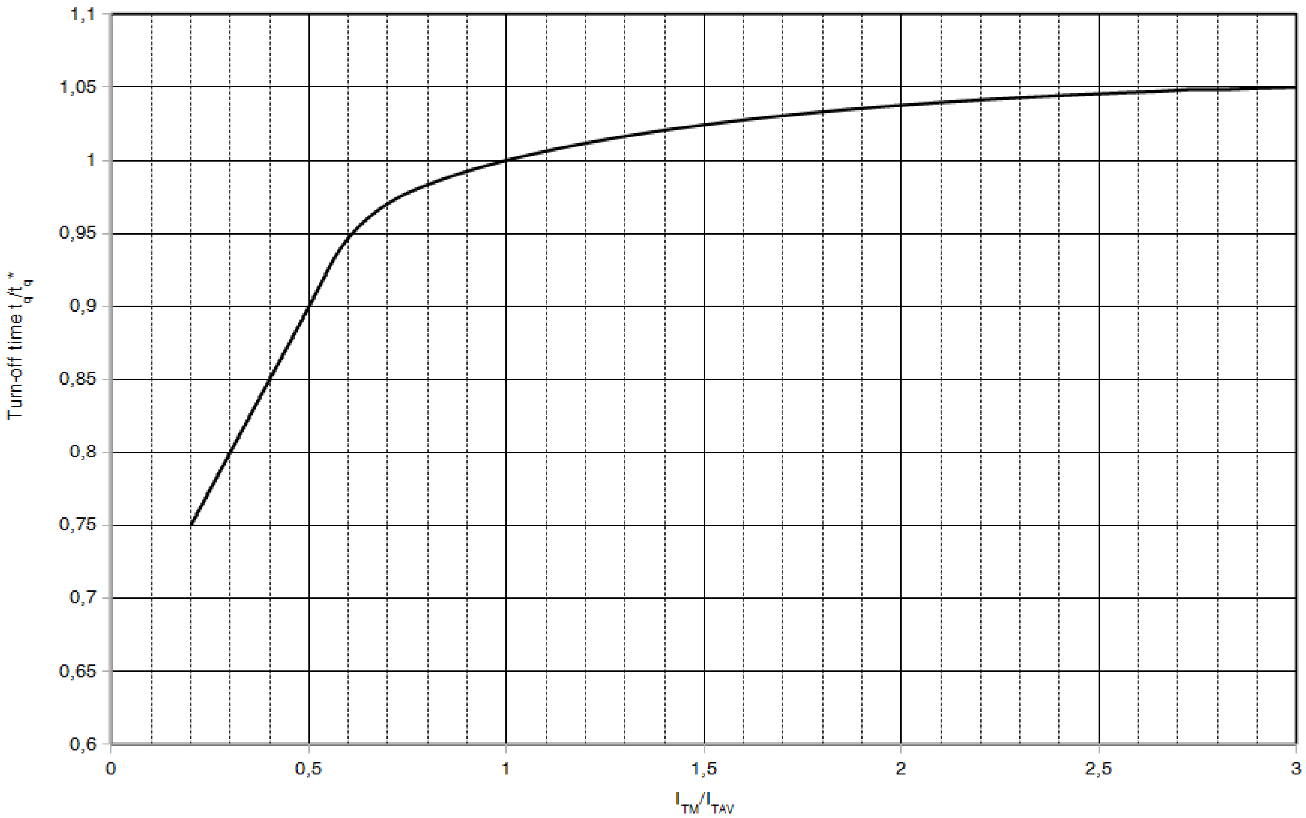


Fig. 28 – Turn-off time t_q vs. On-state peak current I_{TM}

Conditions: $T_j=T_{j\,max}$; $I_{TM}=I_{TAV}$; $V_R=100$ V; $dv_D/dt=50$ V/µs; $V_D=0.67 \cdot V_{DRM}$
Typical changes of t_q are normalized to the t_q^* (t_q^* – see data sheet, $dv_D/dt=50$ V/µs)

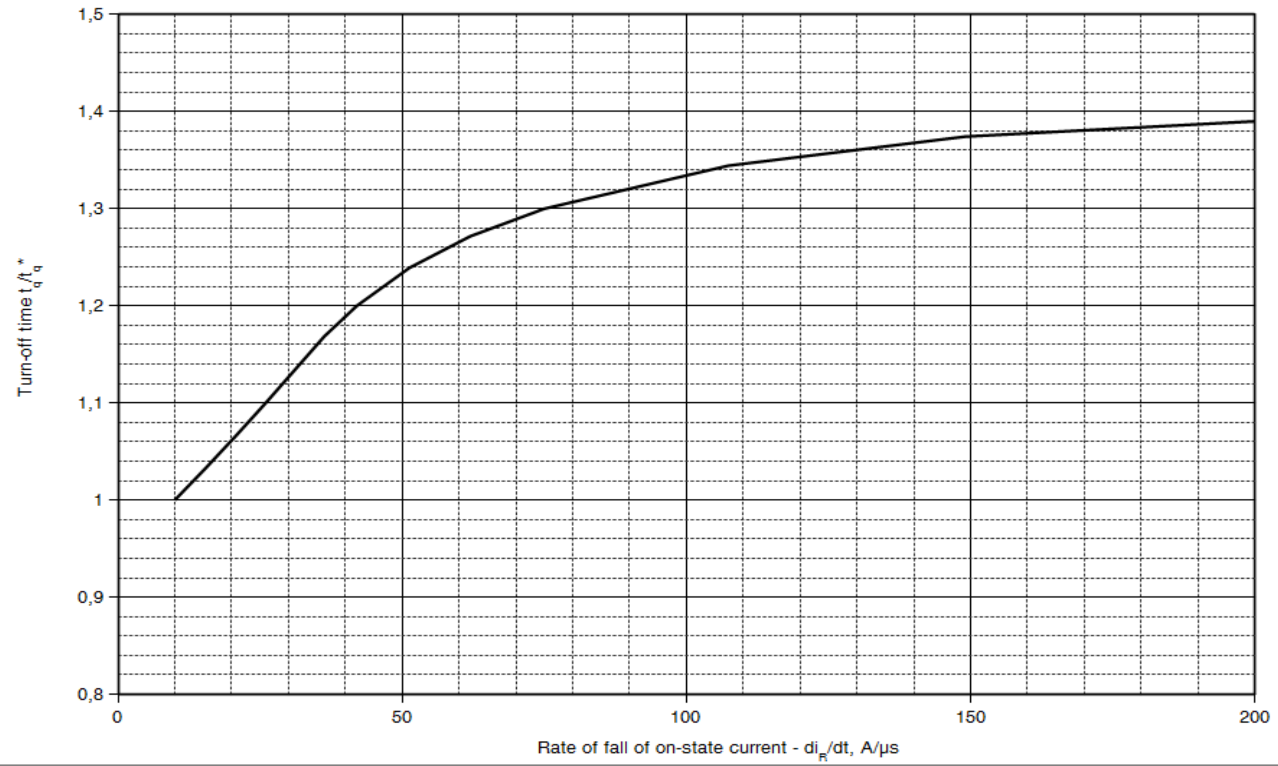


Fig. 29 –Turn-off time t_q vs. Rate of fall of on-state current di_R/dt

Conditions: $T_j=T_{j\,max}$; $I_{TM}=I_{TAV}$; $V_R=100$ V; $dv_D/dt=50$ V/μs; $V_D=0.67 \cdot V_{DRM}$
Typical changes of t_q are normalized to the t_q^* (t_q^* – see data sheet, $dv_D/dt=50$ V/μs)

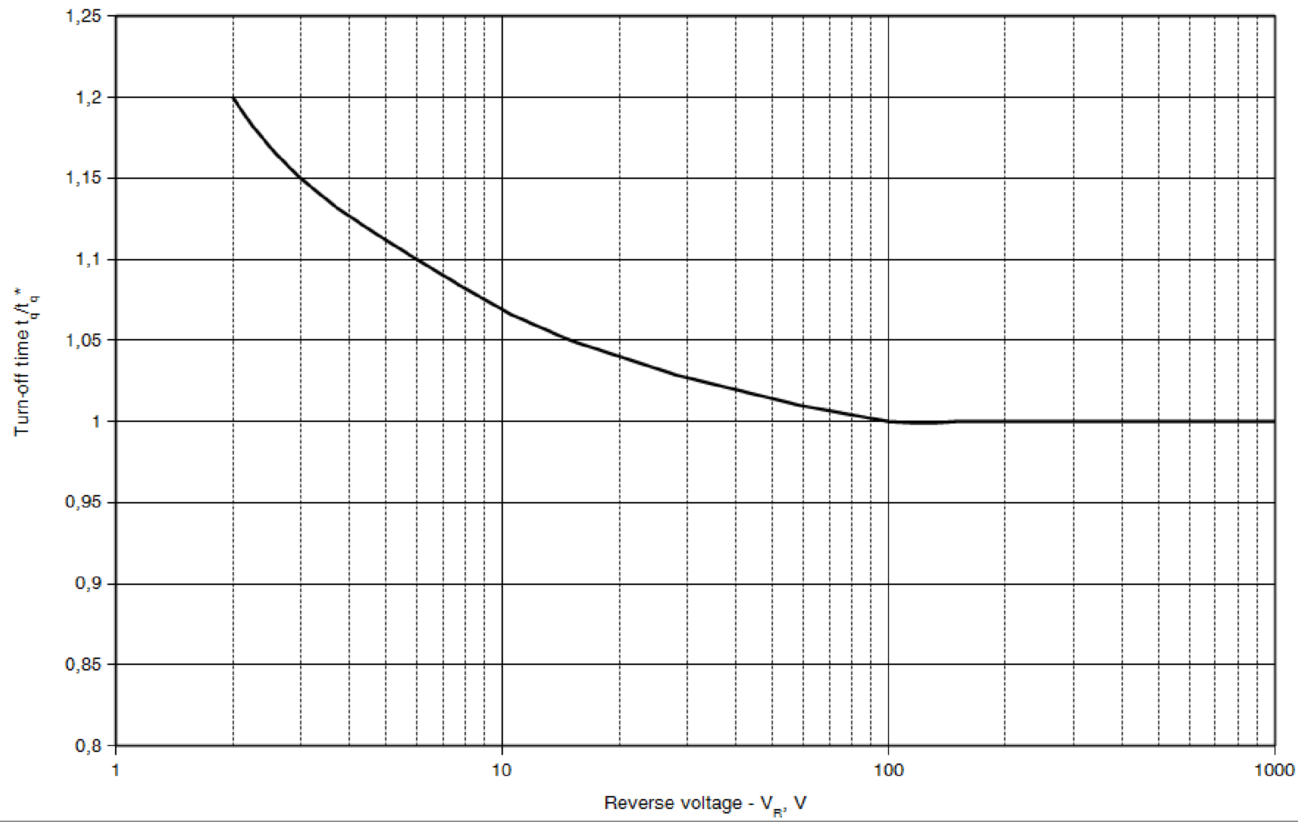


Fig. 30 – Turn-off time t_q vs. Reverse voltage V_R

Conditions: $T_j=T_{j\,max}$; $I_{TM}=I_{TAV}$; $di_R/dt=10$ A/μs; $dv_D/dt=50$ V/μs; $V_D=0.67 \cdot V_{DRM}$
Typical changes of t_q are normalized to the t_q^* (t_q^* – see data sheet, $dv_D/dt=50$ V/μs)

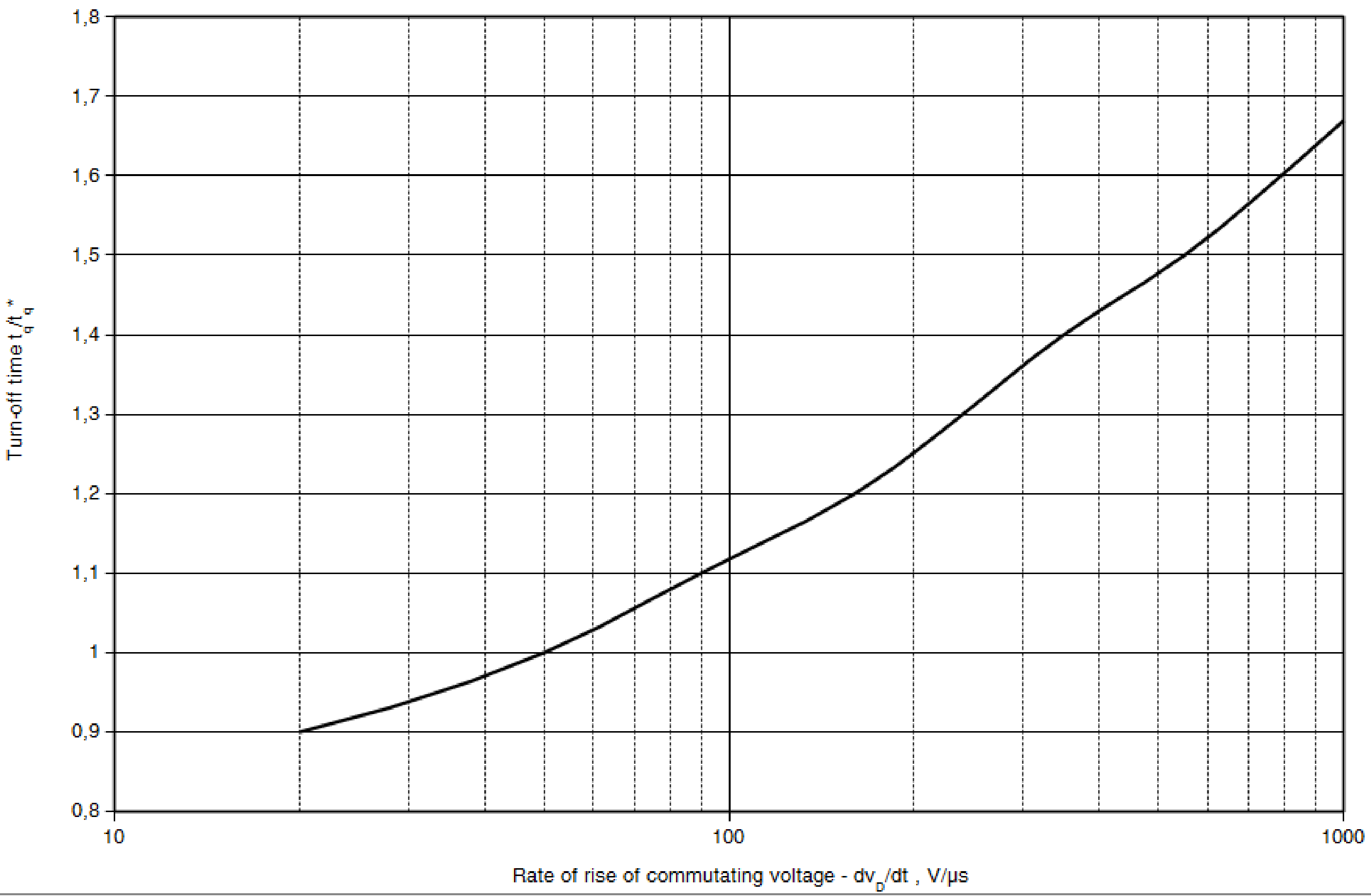


Fig. 31 – Turn-off time t_q vs. Rate of rise of commutating voltage dv_D/dt

Conditions: $T_j=T_{j\,max}$; $I_{TM}=I_{TAV}$; $di_R/dt=10$ A/µs; $V_R=100$ V; $V_D=0.67 \cdot V_{DRM}$
Typical changes of t_q are normalized to the t_q^* (t_q^* – see data sheet, $dv_D/dt=50$ V/µs)