PROTON-ELECTROTEX
RUSSIA

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

Fast Thyristor
Type TFI333-400-15

Mean on-state current	I_{TAV}	400 A
Repetitive peak off-state voltage	V_{DRM}	1000 ÷ 1500 V
Repetitive peak reverse voltage	V_{RRM}	
Turn-off time	t_q	16.0; 20.0; 25.0; 32.0 μs

V_{DRM}, V_{RRM}, V	1000	1200	1400	1500
Voltage code	10	12	14	15
T_j, °C	– 60 ÷ 125			

MAXIMUM ALLOWABLE RATINGS

Symbols and parameters		Units	Values	Test conditions	
ON-STATE					
I_{TAV}	Mean on-state current	A	400 645	T_c= 90 °C; Double side cooled; T_c= 55 °C; Double side cooled; 180° half-sine wave; 50 Hz	
I_{TRMS}	RMS on-state current	A	628	T_c= 90 °C; Double side cooled; 180° half-sine wave; 50 Hz	
I_{TSM}	Surge on-state current	kA	7.0 8.0	T_j=$T_{j\ max}$ T_j=25 °C	180° half-sine wave; 50 Hz (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=1 A/μs
			8.0 9.2	T_j=$T_{j\ max}$ T_j=25 °C	180° half-sine wave; 60 Hz (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=1 A/μs
I^2t	Safety factor	$A^2s \cdot 10^3$	245 320	T_j=$T_{j\ max}$ T_j=25 °C	180° half-sine wave; 50 Hz (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=1 A/μs
			265 350	T_j=$T_{j\ max}$ T_j=25 °C	180° half-sine wave; 60 Hz (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=1 A/μs
BLOCKING					
V_{DRM}, V_{RRM}	Repetitive peak off-state and Repetitive peak reverse voltages	V	1000÷1500	$T_{j\ min}$< 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	1100÷1600	$T_{j\ min}$< T_j <$T_{j\ max}$; 180° half-sine wave; 50 Hz;single pulse; Gate open	
V_D, V_R	Direct off-state and Direct reverse voltages	V	$0.75 \cdot V_{DRM}$ $0.75 \cdot V_{RRM}$	T_j=$T_{j\ max}$; Gate open	

TRIGGERING				
I_{FGM}	Peak forward gate current	A	6	$T_j=T_{j\ max}$
V_{RGM}	Peak reverse gate voltage	V	5	
P_G	Gate power dissipation	W	3	$T_j=T_{j\ max}$ for DC gate current
SWITCHING				
$(di_T/dt)_{crit}$	Critical rate of rise of on-state current non-repetitive (f=1 Hz)	A/µs	1600	$T_j=T_{j\ max}$; $V_D=0.67 \cdot V_{DRM}$; $I_{TM}=2\ I_{TAV}$; Gate pulse: $I_G=I_{FGM}$; $V_G=20$ V; $t_{GP}=50$ µs; $di_G/dt=1$ A/µs
THERMAL				
T_{stg}	Storage temperature	°C	-60 ÷ 125	
T_j	Operating junction temperature	°C	-60 ÷ 125	
MECHANICAL				
F	Mounting force	kN	9.0 ÷ 11.0	
a	Acceleration	m/s^2	50 100	Device unclamped Device clamped

CHARACTERISTICS

Symbols and parameters		Units	Values	Conditions	
ON-STATE					
V_{TM}	Peak on-state voltage, max	V	2.40	$T_j=25$ °C; $I_{TM}=1256$ A	
$V_{T(TO)}$	On-state threshold voltage, max	V	1.35	$T_j=T_{j\ max}$; $0.5\ \pi\ I_{TAV} < I_T < 1.5\ \pi\ I_{TAV}$	
r_T	On-state slope resistance, max	mΩ	0.85		
I_H	Holding current, max	mA	500	$T_j=25$ °C; $V_D=12$ V; Gate open	
BLOCKING					
I_{DRM}, I_{RRM}	Repetitive peak off-state and Repetitive peak reverse currents, max	mA	50	$T_j=T_{j\ max}$; $V_D=V_{DRM}$; $V_R=V_{RRM}$	
$(dv_D/dt)_{crit}$	Critical rate of rise of off-state voltage[1)], min	V/µs	1000	$T_j=T_{j\ max}$; $V_D=0.67 \cdot V_{DRM}$; Gate open	
TRIGGERING					
V_{GT}	Gate trigger direct voltage, max	V	4.00 2.50 2.00	$T_j=T_{j\ min}$ $T_j=25$ °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	500 300 200	$T_j=T_{j\ min}$ $T_j=25$ °C $T_j=T_{j\ max}$	
V_{GD}	Gate non-trigger direct voltage, min	V	0.25	$T_j=T_{j\ max}$; $V_D=0.67 \cdot V_{DRM}$; Direct gate current	
I_{GD}	Gate non-trigger direct current, min	mA	10.00		
SWITCHING					
t_{gd}	Delay time	µs	2.00	$T_j=25$ °C; $V_D=0.4 \cdot V_{DRM}$; $I_{TM}=I_{TAV}$; Gate pulse: $I_G=I_{FGM}$; $V_G=20$ V; $t_{GP}=50$ µs; $di_G/dt=1$ A/µs	
t_q	Turn-off time[2)], max	µs	16.0; 20.0; 25.0; 32.0	$dv_D/dt=50$ V/µs	$T_j=T_{j\ max}$; $I_{TM}=400$ A; $di_R/dt=-10$ A/µs; $V_R=100$V; $V_D=0.67\ V_{DRM}$
			20.0; 25.0; 32.0; 40.0	$dv_D/dt=200$ V/µs	
Q_{rr}	Total recovered charge, max	µC	150	$T_j=T_{j\ max}$; $I_{TM}=400$ A; $di_R/dt=-50$ A/µs; $V_R=100$ V	
t_{rr}	Reverse recovery time, typ	µs	3.2		
I_{rrM}	Peak reverse recovery current, max	A	94		

THERMAL					
R_{thjc}	Thermal resistance, junction to case, max	°C/W	0.0400	Direct current	Double side cooled
R_{thjc-A}			0.0880		Anode side cooled
R_{thjc-K}			0.0720		Cathode side cooled
R_{thck}	Thermal resistance, case to heatsink, max	°C/W	0.0060	Direct current	
MECHANICAL					
w	Weight, typ	g	110		
D_s	Surface creepage distance	mm (inch)	10.30 (0.405)		
D_a	Air strike distance	mm (inch)	6.30 (0.248)		

NOTES

1) Critical rate of rise of off-state voltage

Symbol of group	A2
$(dv_D/dt)_{crit}$, V/µs	1000

2) Turn-off time (dv_D/dt=50 V/µs)

Symbol of group	T3	P3	M3	K3
t_q, µs	16.0	20.0	25.0	32.0

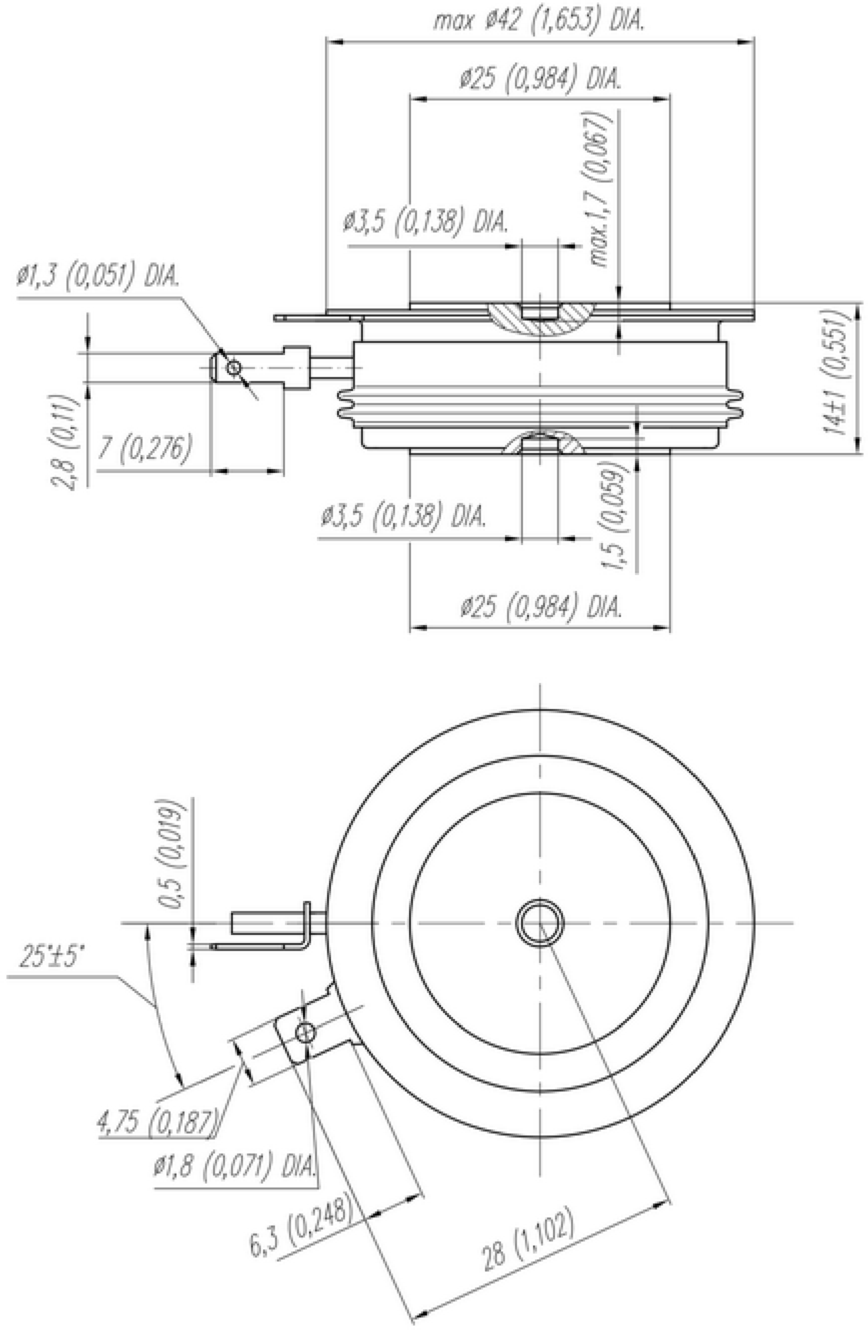
PART NUMBERING GUIDE

TFI	333	400	15	A2	T3	N
1	2	3	4	5	6	7

1. TFI — Fast Thyristor
   TFIS — Fast Thyristor with Distributed Amplified Gate
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. Ambient conditions: N – normal; T – tropical

OVERALL DIMENSIONS

Package type: T.B2



All dimensions in millimeters (inches)

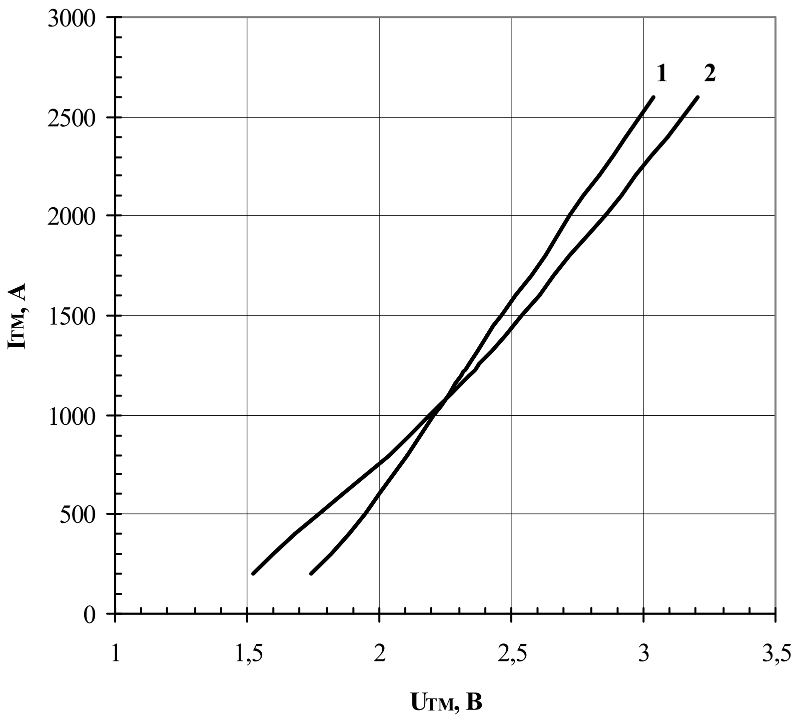
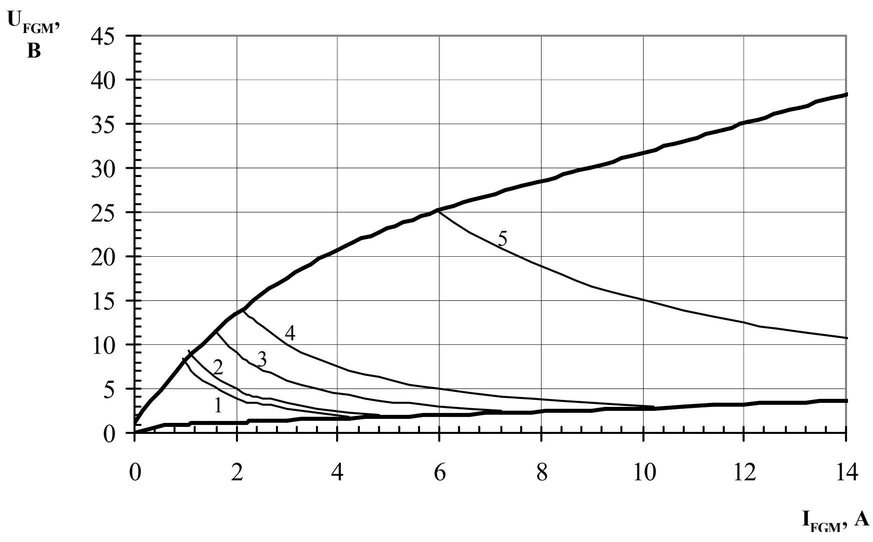


Fig. 1 On-state characteristics of Limit device
1 – T_j=25 °C
2 – T_j=125 °C



Maximum peak gate power loss

Position	On-Off time ratio	Gate pulse length, ms	Gate Pulse Power, W
1	1	DC	8
2	2	10	10
3	20	1	18
4	40	0.5	30
5	200	0.1	150

Fig. 2 Gate characteristics

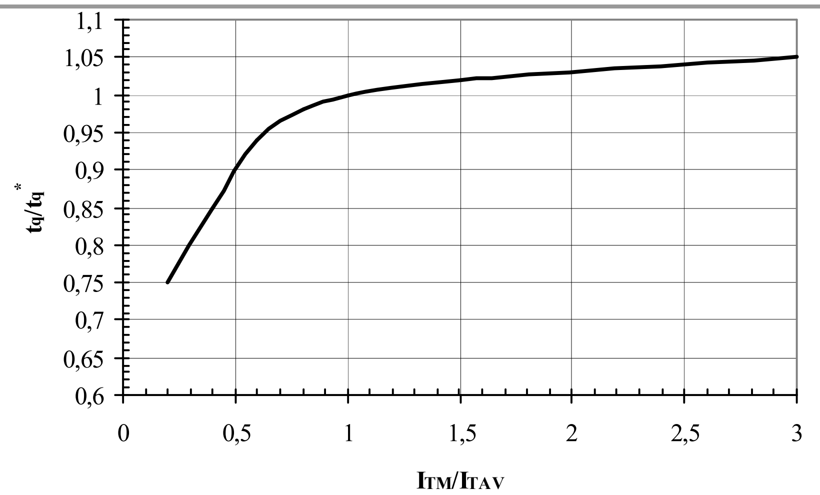


Fig. 3 Turn-off time t_q vs. On-state peak current I_{TM}

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

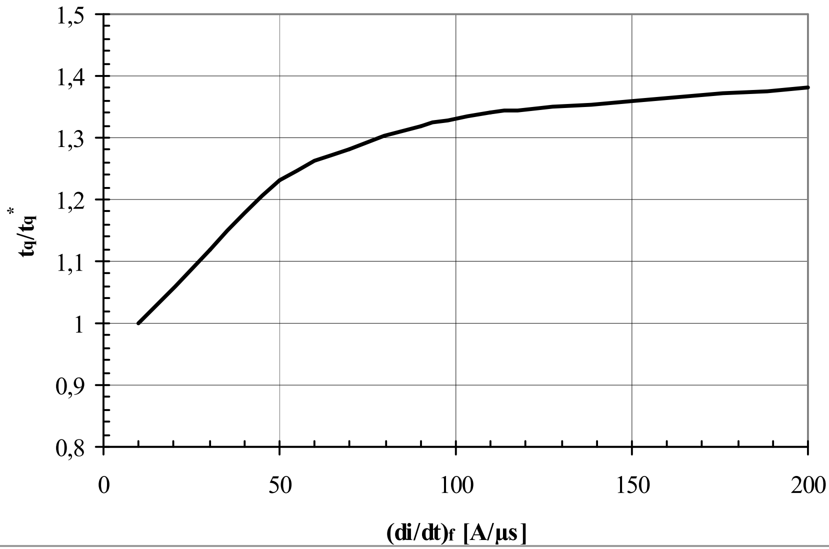


Fig. 4 Turn-off time t_q vs. Rate of fall of on-state current di_R/dt

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

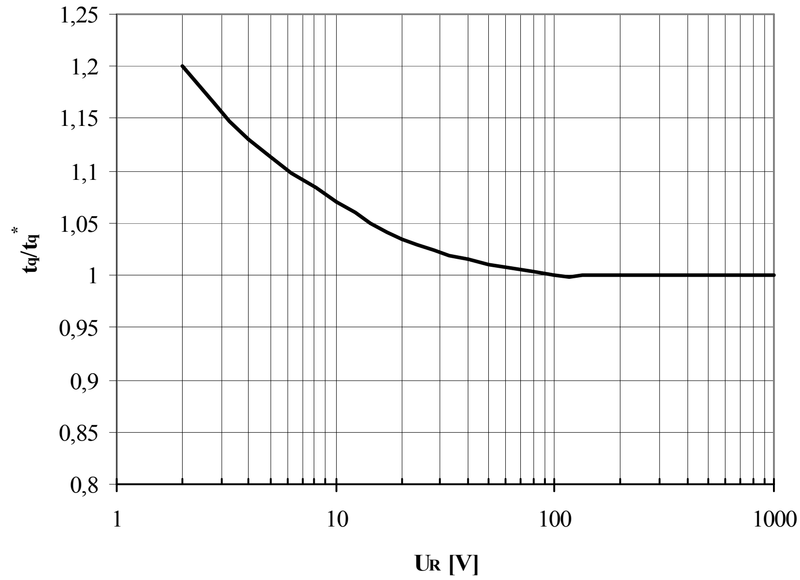


Fig. 5 Turn-off time t_q vs. Reverse voltage V_R

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·V_{DRM}
Typical changes of t_q are normalized to the t_q^* (t_q^* – see data sheet, dv_D/dt=50 V/µs)

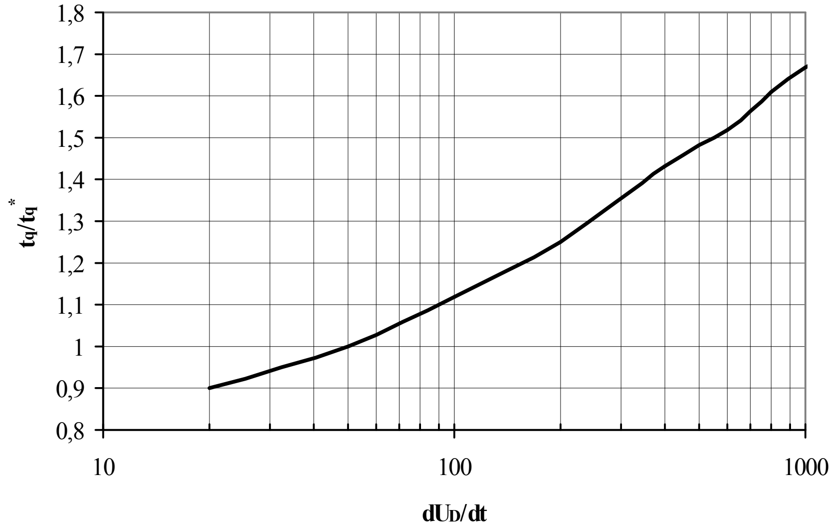


Fig. 6 Turn-off time t_q vs. Rate of rise of commutating voltage dv_D/dt

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)

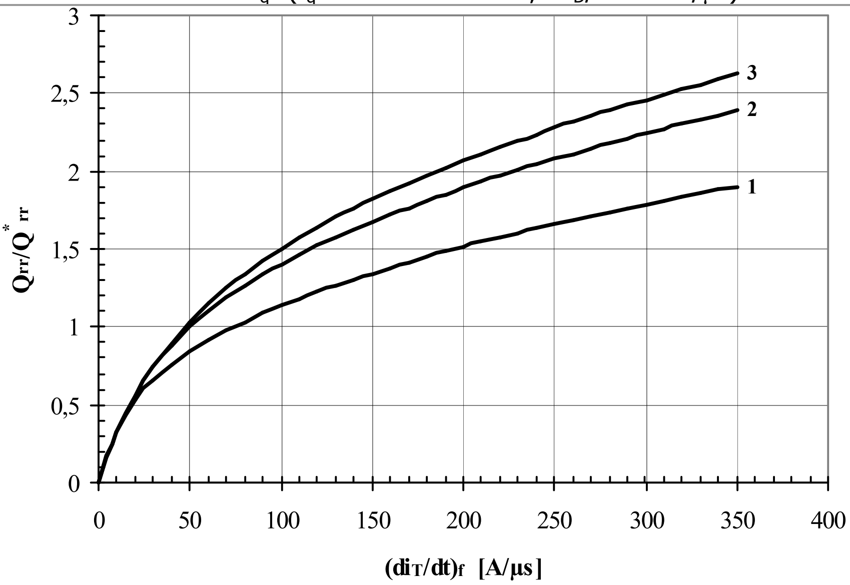


Fig. 7 Reverse recovery charge Q_{rr}, vs. Rate of fall of on-state current di_R/dt
1 – $I_{TM} = 0.5 \cdot I_{TAV}$
2 – $I_{TM} = I_{TAV}$,
3 – $I_{TM} = 1.5 \cdot I_{TAV}$

Conditions: $T_j=T_{j\,max}$; $V_R=100$ V
Typical changes of Q_{rr} are normalized to the Q_{rr}^* (Q_{rr}^* – see data sheet)

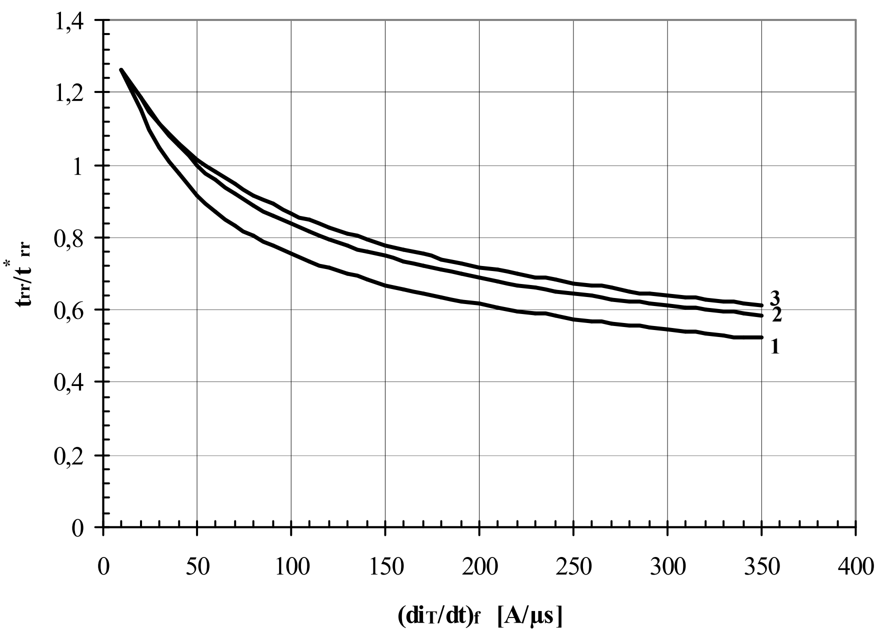


Fig. 8 Reverse recovery time t_{rr} vs. Rate of fall of on-state current di_R/dt
1 – $I_{TM} = 0.5 \cdot I_{TAV}$
2 – $I_{TM} = I_{TAV}$,
3 – $I_{TM} = 1.5 \cdot I_{TAV}$

Conditions: $T_j = T_{j\,max}$; V_R=100 V
Typical changes of t_{rr} are normalized to the t_{rr}^* (t_{rr}^* – see data sheet)

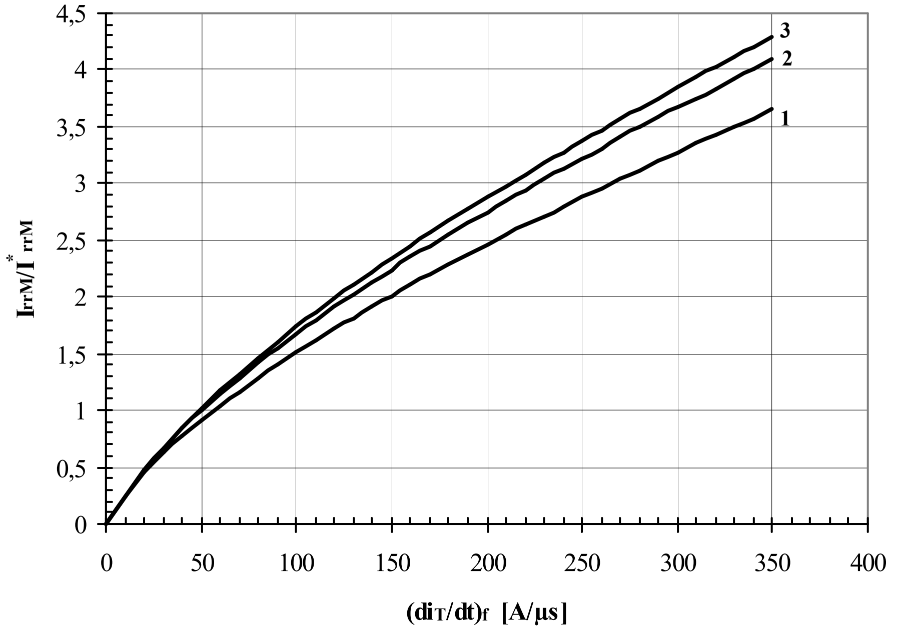


Fig. 9 Peak reverse recovery current I_{rrM} vs. Rate of fall of on-state current di_R/dt
1 – $I_{TM} = 0.5 \cdot I_{TAV}$
2 – $I_{TM} = I_{TAV}$,
3 – $I_{TM} = 1.5 \cdot I_{TAV}$

Conditions: $T_j = T_{j\,max}$; V_R=100 V
Typical changes of I_{rrM} are normalized to the I_{rrM}^* (I_{rrM}^* – see data sheet)

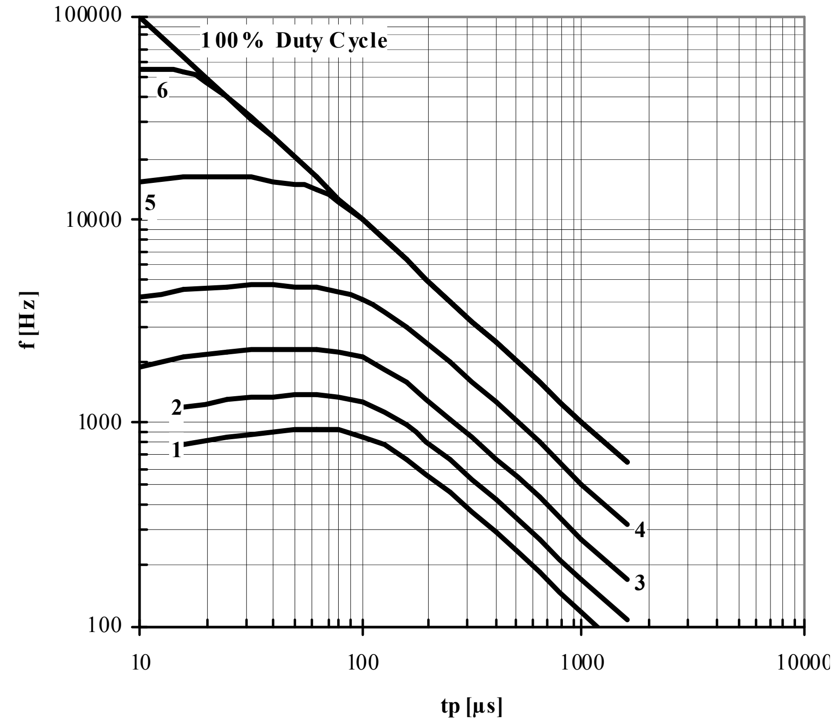


Fig. 10 Sine wave frequency ratings
1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A

Conditions: $V_R \leq 3$ V; $T_C = 55$ °C

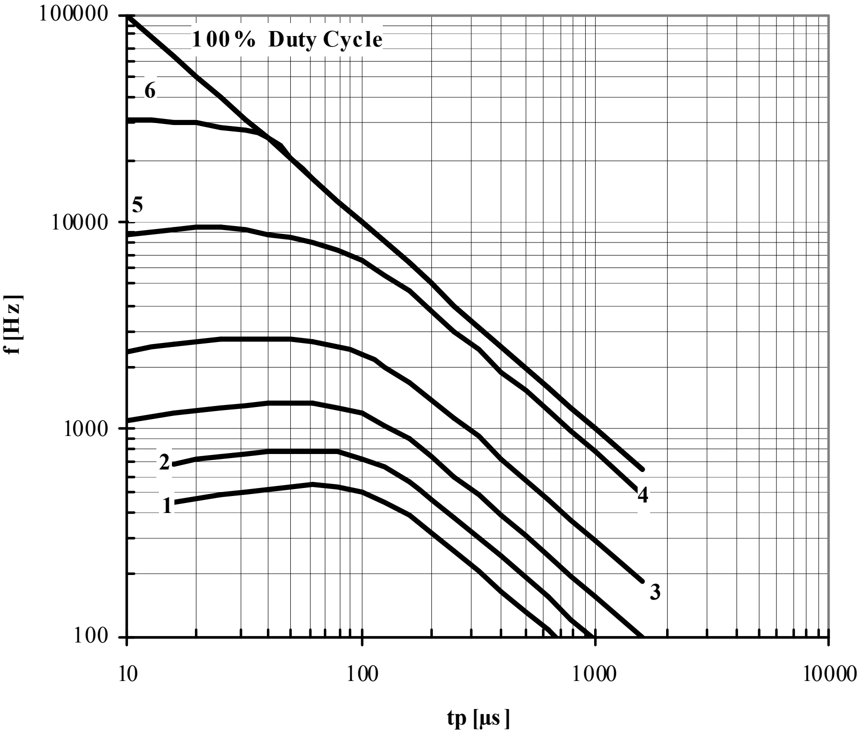


Fig. 11 Sine wave frequency ratings
1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A

Conditions: $V_R \leq 3$ V; $T_C = 90$ °C

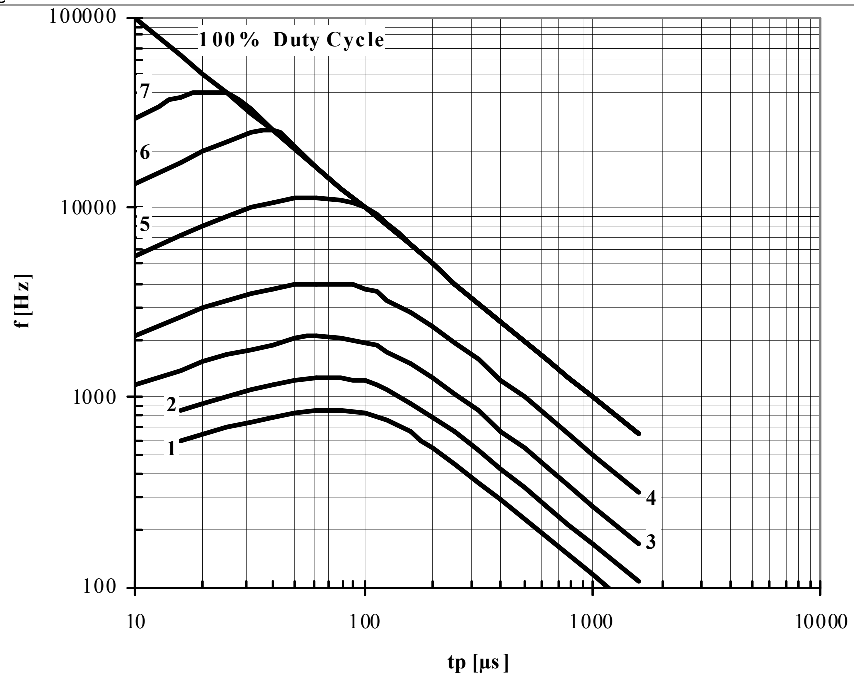


Fig. 12 Sine wave frequency ratings
1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A
7 – I_{TM} = 250 A

Conditions: $V_R = 0.67 \cdot V_{RRM}$; $T_C = 55$ °C

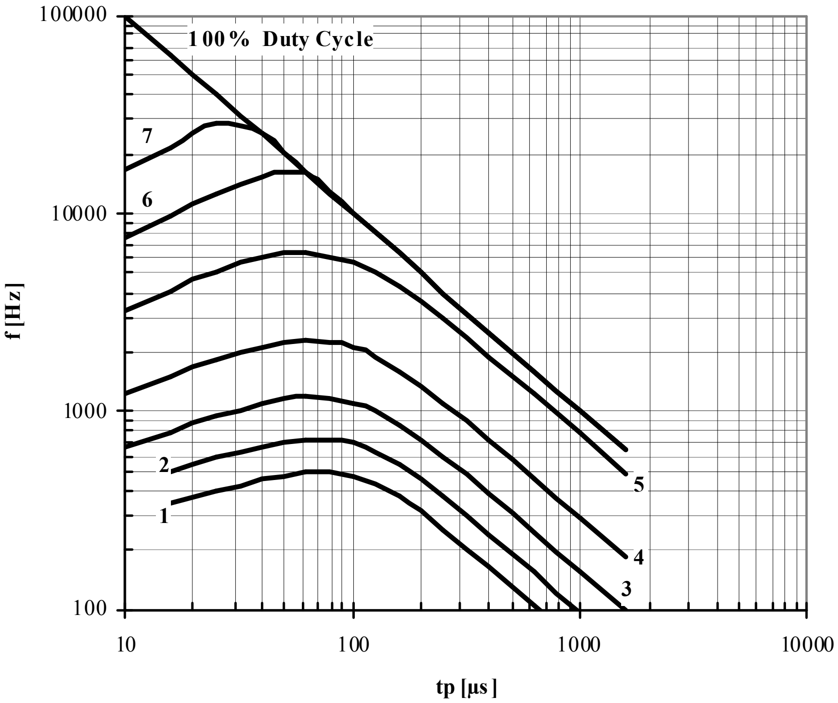


Fig. 13 Sine wave frequency ratings
1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A
7 – I_{TM} = 250 A

Conditions: V_R=0.67·V_{RRM}; T_C=90 °C

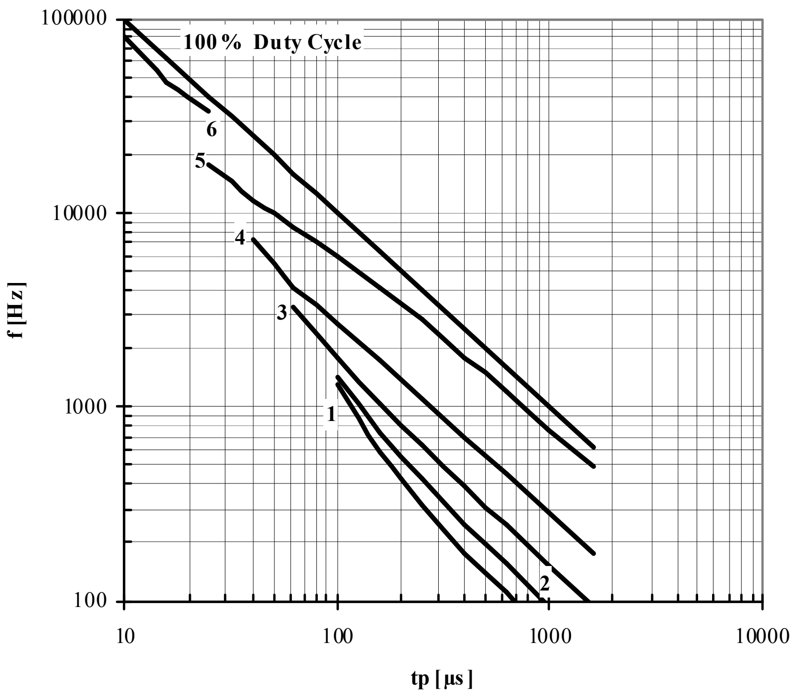


Fig. 14 Square wave frequency ratings
1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A

Conditions: V_R≤3 V; T_C=55 °C; di_F/dt=di_R/dt=100 A/µs

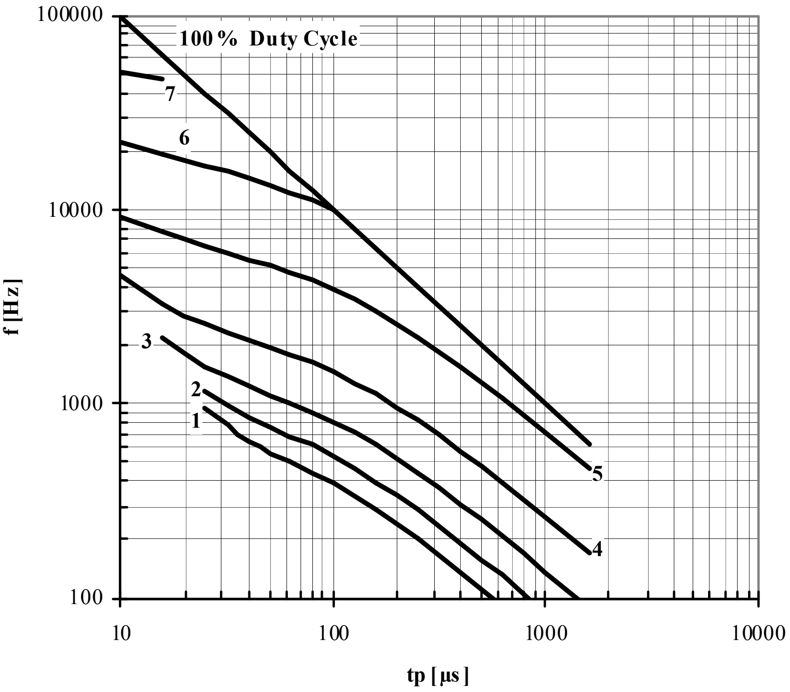


Fig. 15 Square wave frequency ratings
1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A
7 – I_{TM} = 250 A

Conditions: $V_R \leq 3$ V; $T_C = 55\ ^oC$; $di_F/dt = di_R/dt = 500$ A/µs

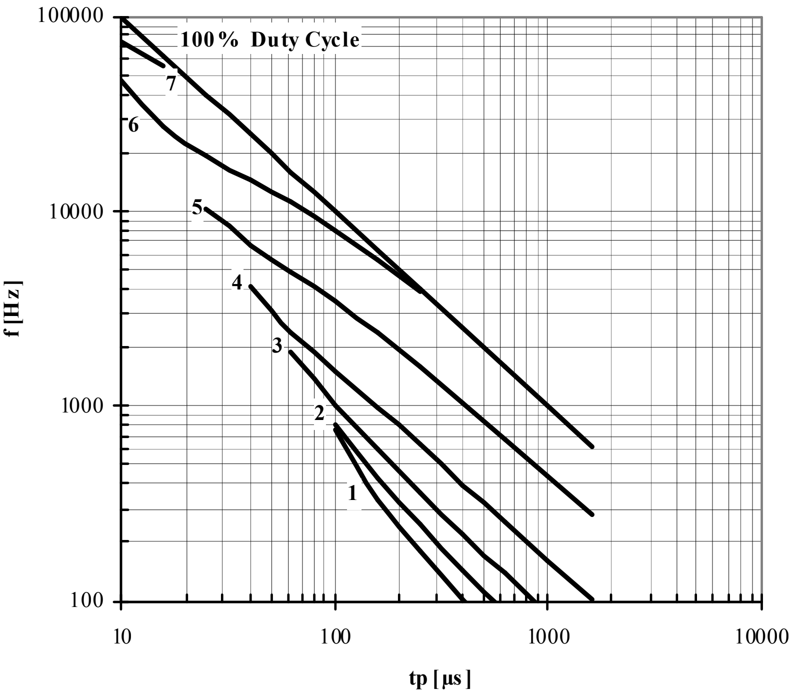


Fig. 16 Square wave frequency ratings
1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A
7 – I_{TM} = 250 A

Conditions: $V_R \leq 3$ V; $T_C = 90\ ^oC$; $di_F/dt = di_R/dt = 100$ A/µs

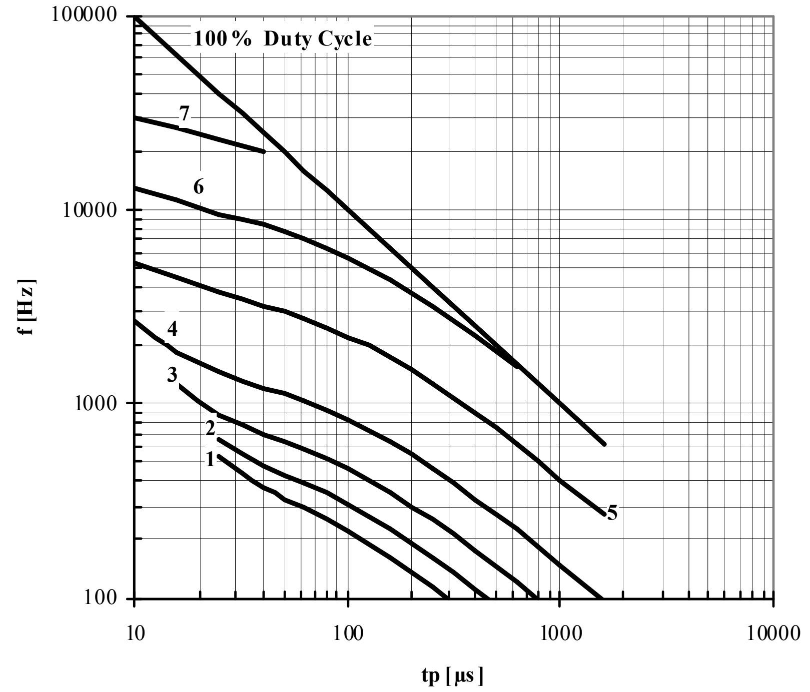


Fig. 17 Square wave frequency ratings

1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A
7 – I_{TM} = 250 A

Conditions: $V_R \leq 3$ V; $T_C = 90$ °C; $di_F/dt = di_R/dt = 500$ A/µs

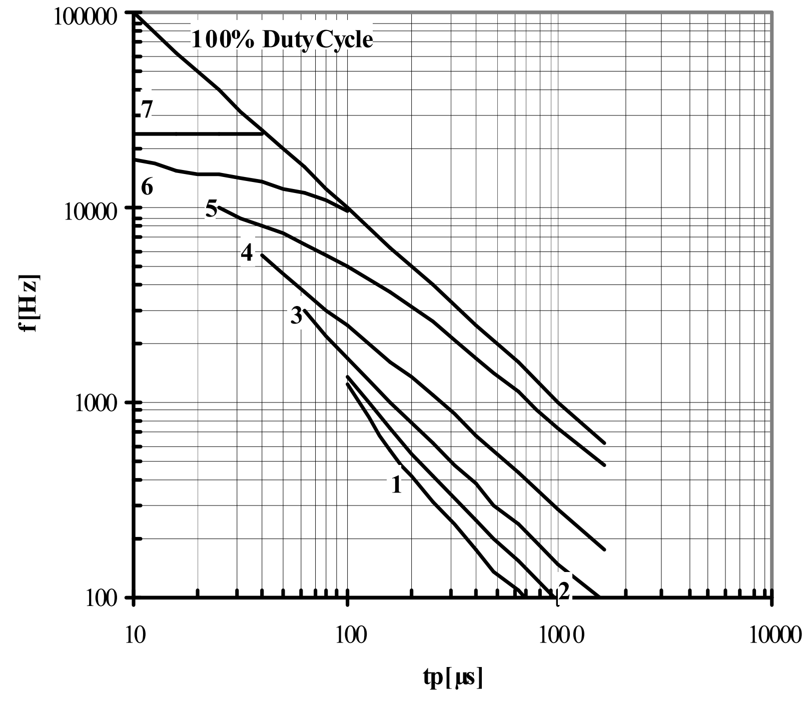


Fig. 18 Square wave frequency ratings

1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A
7 – I_{TM} = 250 A

Conditions: $V_R = 0.67 \cdot V_{RRM}$; $T_C = 55$ °C; $di_F/dt = di_R/dt = 100$ A/µs

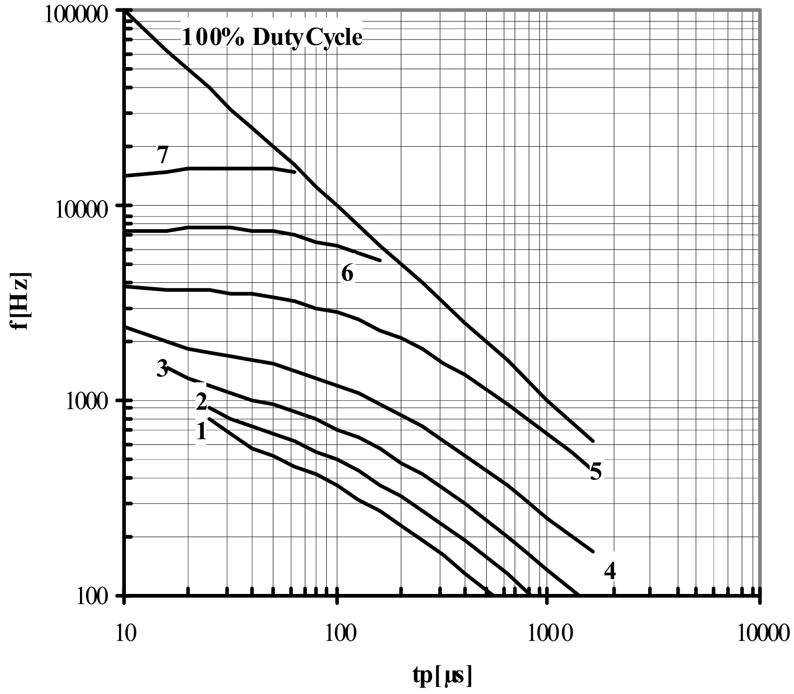


Fig. 19 Square wave frequency ratings

1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A
7 – I_{TM} = 250 A

Conditions: V_R=0.67·V_{RRM}; T_C=55 °C; di_F/dt=di_R/dt=500 A/µs

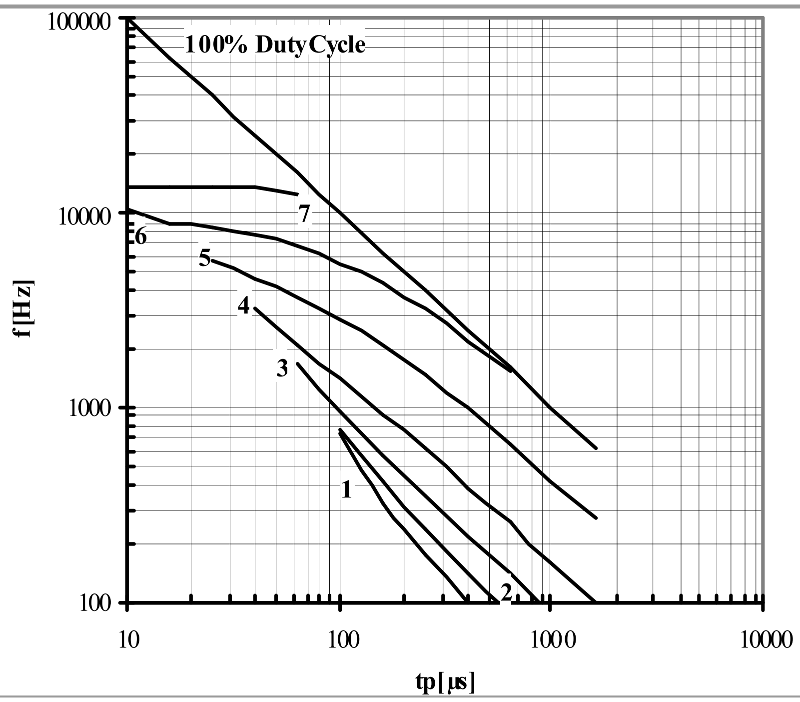


Fig. 20 Square wave frequency ratings

1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A
7 – I_{TM} = 250 A

Conditions: V_R=0.67·V_{RRM}; T_C=90 °C; di_F/dt=di_R/dt=100 A/µs

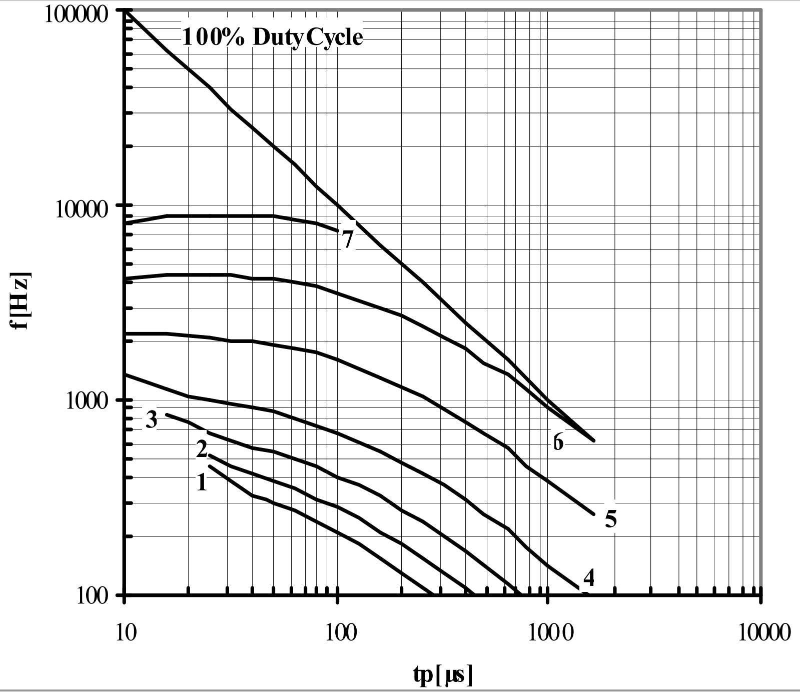


Fig. 21 Square wave frequency ratings

1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A
7 – I_{TM} = 250 A

Conditions: V_R=0.67·V_{RRM}; T_C=90 °C; di_F/dt=di_R/dt=500 A/µs

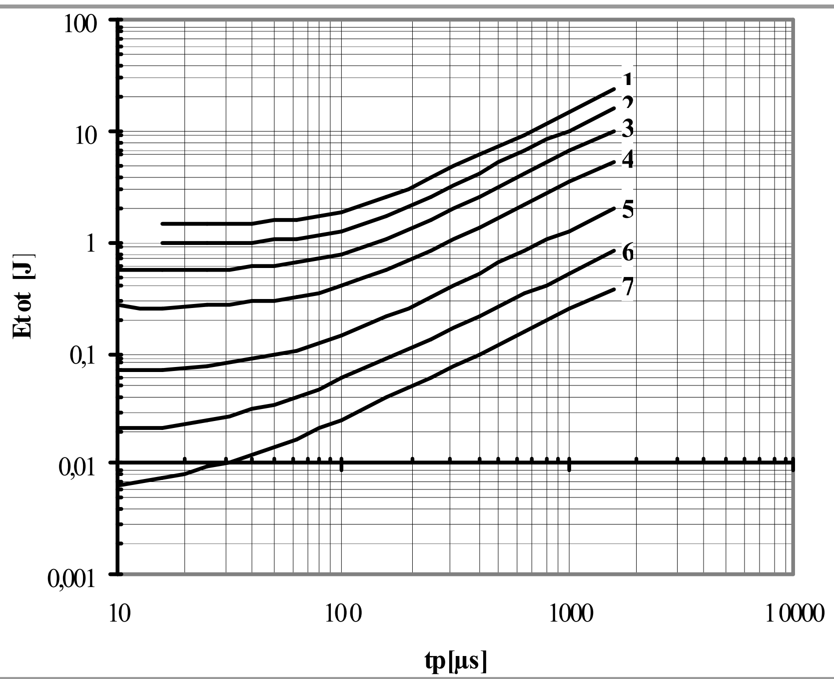


Fig. 22 Sine wave loss energy per pulse

1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A
7 – I_{TM} = 250 A

Conditions: V_R≤3 V

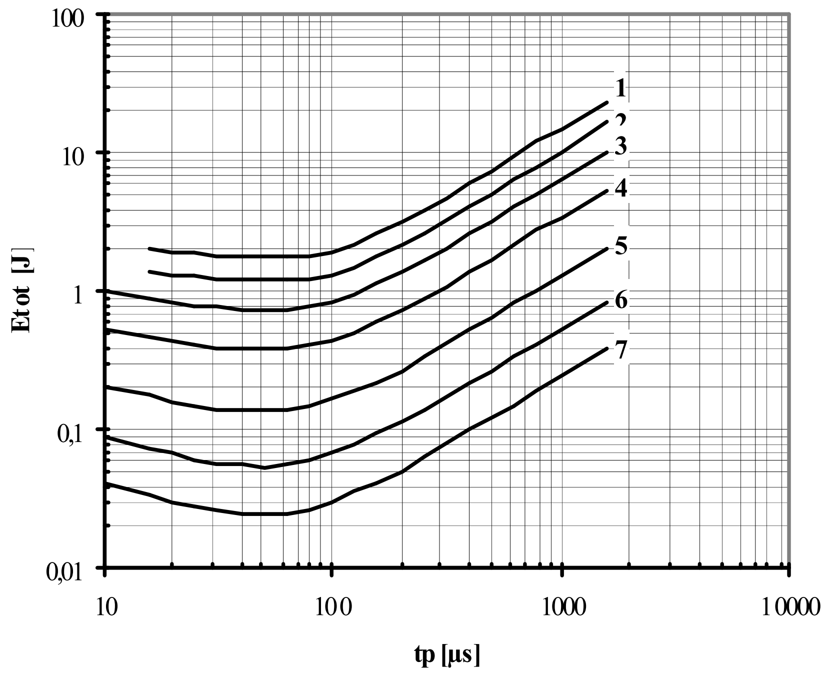


Fig. 23 Sine wave loss energy per pulse
1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A
7 – I_{TM} = 250 A

Conditions: $V_R=0.67 \cdot V_{RRM}$

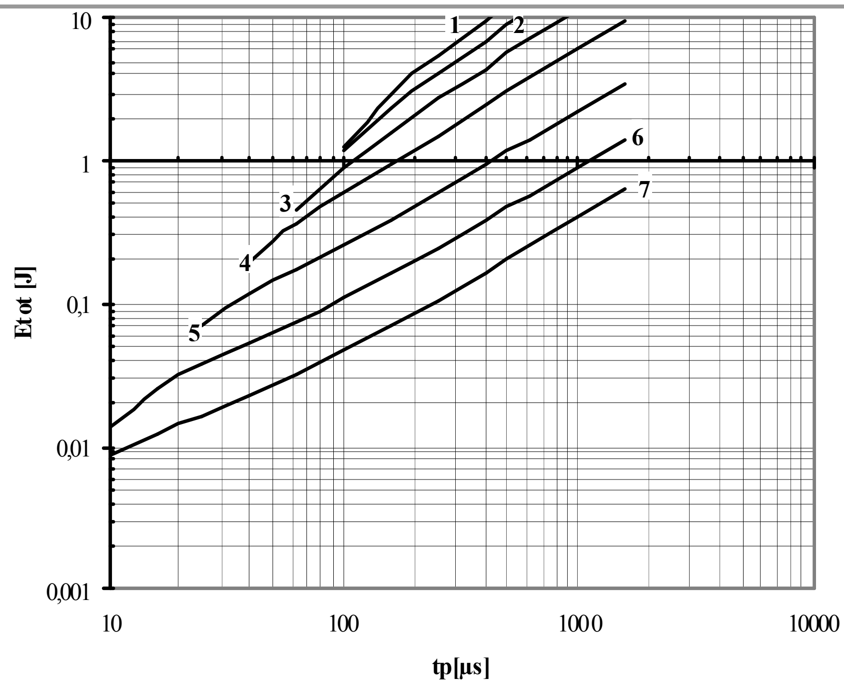


Fig. 24 Square wave loss energy per pulse
1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A
7 – I_{TM} = 250 A

Conditions: $V_R \leq 3$ V; $di_F/dt=di_R/dt=100$ A/µs

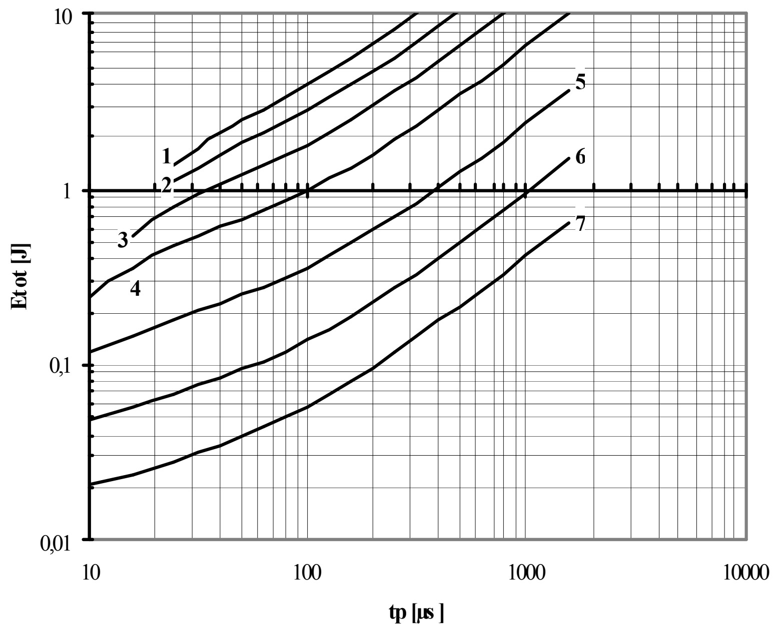


Fig. 25 Square wave loss energy per pulse
1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A
7 – I_{TM} = 250 A

Conditions: V_R≤3 V; $di_F/dt=di_R/dt$=500 A/µs

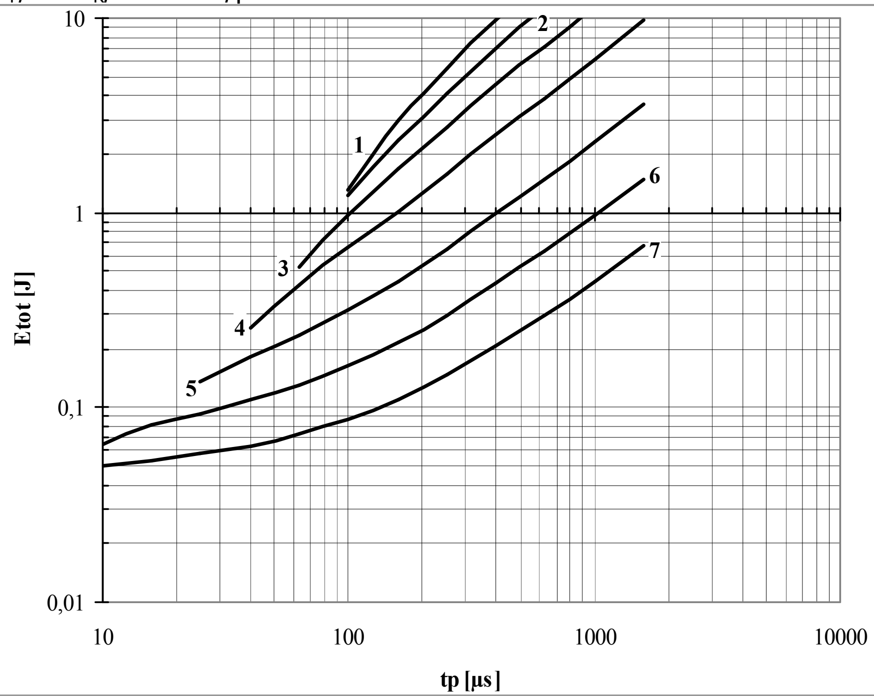


Fig. 26 Square wave loss energy per pulse
1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A
7 – I_{TM} = 250 A

Conditions: $V_R=0.67 \cdot V_{RRM}$; $di_F/dt=di_R/dt$=100 A/µs

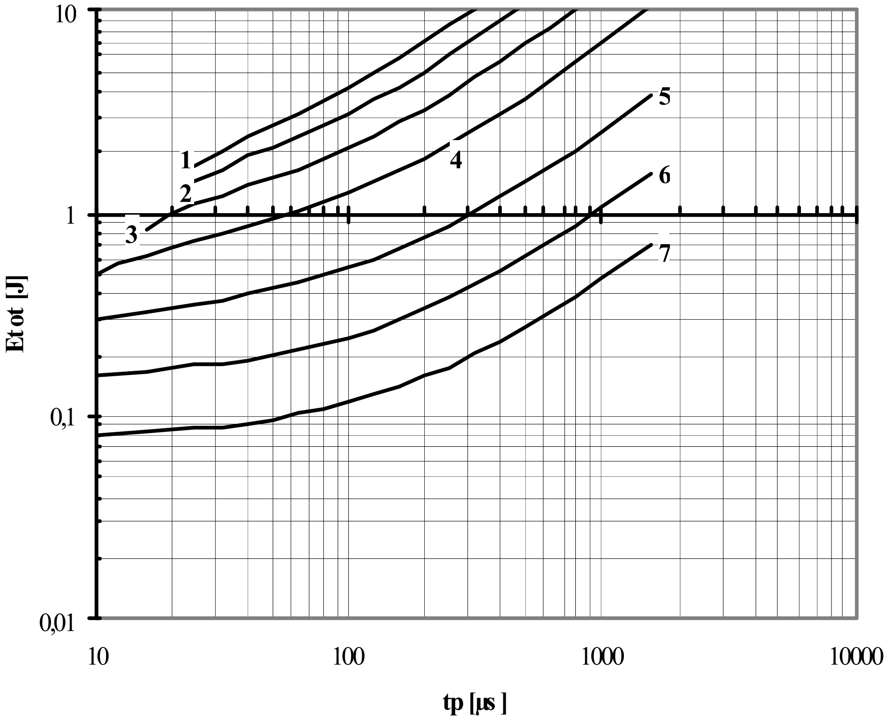


Fig. 27 Square wave loss energy per pulse
1 – I_{TM} = 5000 A
2 – I_{TM} = 4000 A
3 – I_{TM} = 3000 A
4 – I_{TM} = 2000 A
5 – I_{TM} = 1000 A
6 – I_{TM} = 500 A
7 – I_{TM} = 250 A

Conditions: V_R=0.67·V_{RRM}; $di_F/dt=di_R/dt$=500 A/µs

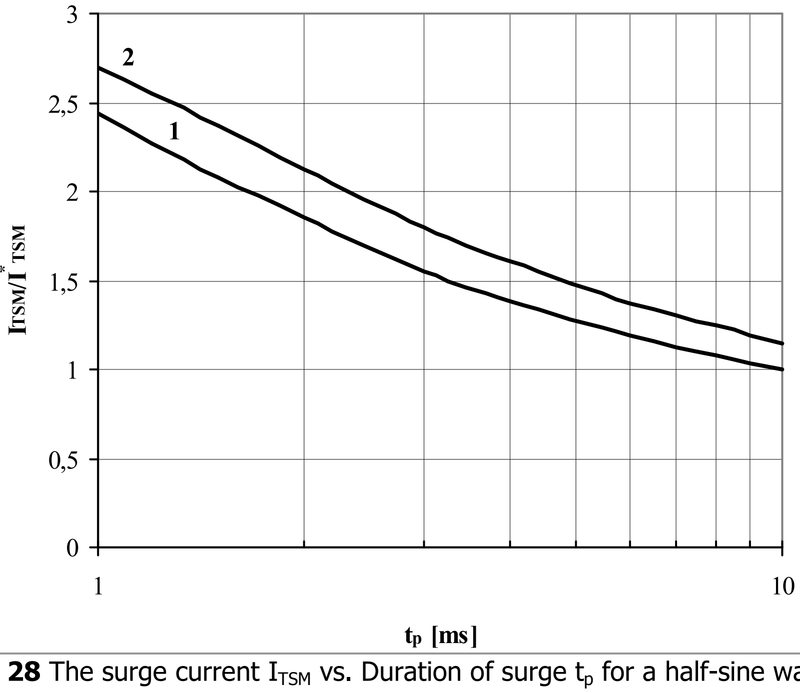


Fig. 28 The surge current I_{TSM} vs. Duration of surge t_p for a half-sine wave
1 – T_j=125 °C
2 – T_j=25 °C

Conditions: V_R=0 V – the peak value of reverse voltage which is applied immediately after the surge current
Typical changes of I_{TSM} are normalized to the I_{TSM}^* (I_{TSM}^* – see data sheet, $T_j=T_{j\,max}$)

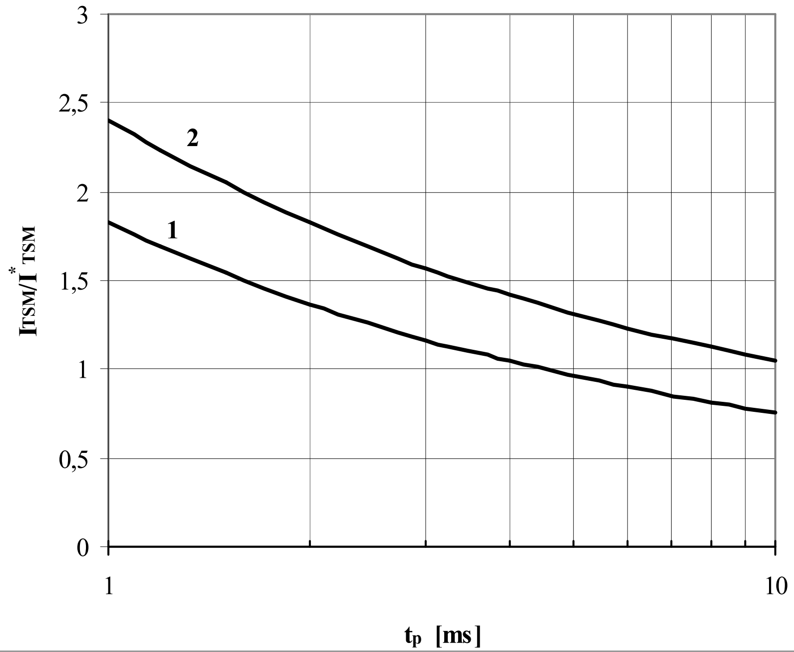


Fig. 29 The surge current I_{TSM} vs. Duration of surge t_p for a half-sine wave
1 – T_j=125 °C
2 – T_j=25 °C

Conditions: $V_R=0.8 \cdot V_{RRM}$ – the peak value of reverse voltage which is applied immediately after the surge current
Typical changes of I_{TSM} are normalized to the I_{TSM}^* (I_{TSM}^* – see data sheet, $T_j=T_{j\ max}$)

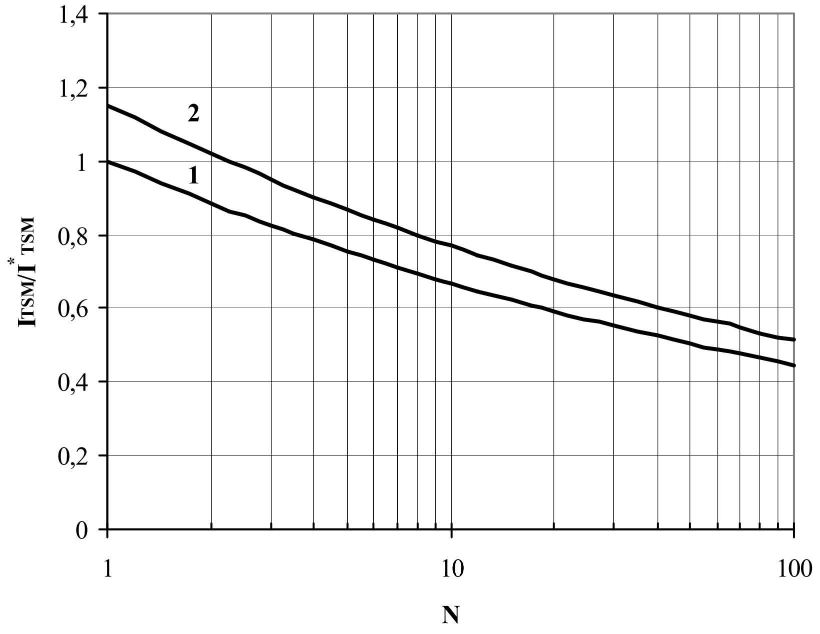


Fig. 30 The surge current I_{TSM} vs. Number of half-sine waves at 50 Hz
1 – T_j=125 °C
2 – T_j=25 °C

Conditions: V_R=0 V – the peak value of reverse voltage which is applied immediately after the surge current
Typical changes of I_{TSM} are normalized to the I_{TSM}^* (I_{TSM}^* – see data sheet, T_j=$T_{j\,max}$)

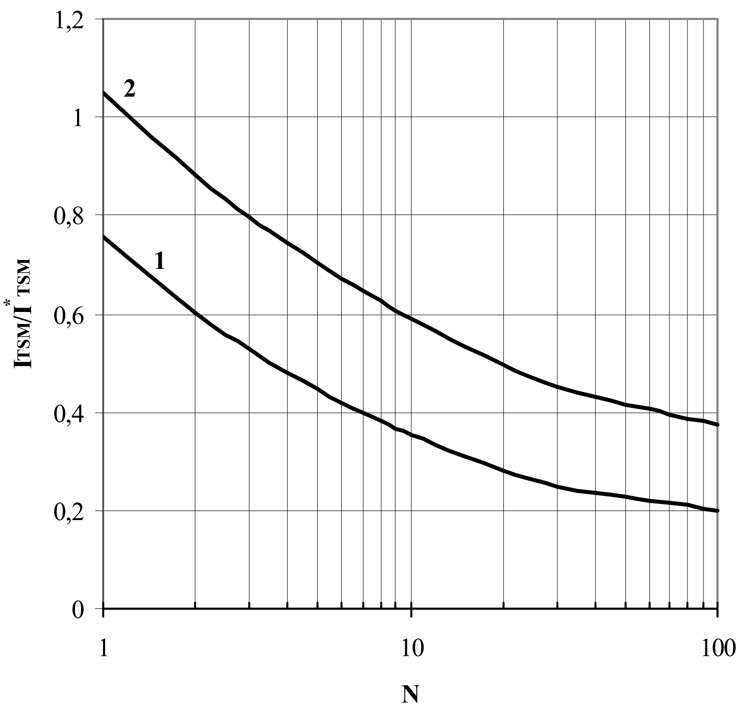


Fig. 31 The surge current I_{TSM} vs. Number of half-sine waves at 50 Hz
1 – T_j=125°C
2 – T_j=25°C

Conditions: V_R=0.8·V_{RRM} – the peak value of reverse voltage which is applied immediately after the surge current
Typical changes of I_{TSM} are normalized to the I_{TSM}^* (I_{TSM}^* – see data sheet, T_j=$T_{j\,max}$)