PROTON-ELECTROTEX
RUSSIA

High power cycling capability
Low on-state and switching losses
Designed for traction and industrial applications

Phase Control Thyristor
Type T123-250-16

Mean on-state current	I_{TAV}	250 A											
Repetitive peak off-state voltage	V_{DRM}	400...1600 V											
Repetitive peak reverse voltage	V_{RRM}												
Turn-off time	t_q	125, 160, 200, 250, 320, 400, 500 µs											
V_{DRM}, V_{RRM}, V	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600
Voltage code	4	5	6	7	8	9	10	11	12	13	14	15	16
T_j, °C	−60...+125												

MAXIMUM ALLOWABLE RATINGS

|	Symbols and parameters	Units	Values	Test conditions	
ON-STATE					
I_{TAV}	Maximum allowable mean on-state current	A	250 322	T_c=96 °C, Double side cooled T_c=85 °C, Double side cooled 180° half-sine wave; 50 Hz	
I_{TRMS}	RMS on-state current	A	392	T_c=96 °C, Double side cooled 180° half-sine wave; 50 Hz	
I_{TSM}	Surge on-state current	kA	4.5 5.0	$T_j=T_{j max}$ T_j=25 °C	180° half-sine wave; t_p=10 ms; single pulse; $V_D=V_R$=0 V; Gate pulse: I_G=2 A; t_{GP}=50 µs; di_G/dt≥1 A/µs
			4.5 5.0	$T_j=T_{j max}$ 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=2 A; t_{GP}=50 µs; di_G/dt≥1 A/µs
I^2t	Safety factor	$A^2s·10^3$	100 120	$T_j=T_{j max}$ T_j=25 °C	180° half-sine wave; t_p=10 ms; single pulse; $V_D=V_R$=0 V; Gate pulse: I_G=2 A; t_{GP}=50 µs; di_G/dt≥1 A/µs
			80 100	$T_j=T_{j max}$ 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=2 A; 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	400...1600	$T_{j min}< T_j <T_{j max}$; 180° half-sine wave; 50 Hz; Gate open	
V_{DSM}, V_{RSM}	Non-repetitive peak off-state and Non-repetitive peak reverse voltages	V	500...1700	$T_{j min}< T_j <T_{j max}$; 180° half-sine wave; single pulse; Gate open	
V_D, V_R	Direct off-state and Direct reverse voltages	V	$0.6·V_{DRM}$ $0.6·V_{RRM}$	$T_j=T_{j max}$; Gate open	

	TRIGGERING			
I_{FGM}	Peak forward gate current	A	5	$T_j=T_{j\,max}$
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	800	$T_j=T_{j\,max}$; $V_D=0.67\cdot V_{DRM}$; $I_{TM}=640$ A; Gate pulse: $I_G=2$ A; $t_{GP}=50$ μs; $di_G/dt\geq2$ A/μs
	THERMAL			
T_{stg}	Storage temperature	°C	−60...+50	
T_j	Operating junction temperature	°C	−60...+125	
	MECHANICAL			
F	Mounting force	kN	5.0...7.0	
a	Acceleration	m/s^2	50	Device clamped

CHARACTERISTICS

Symbols and parameters		Units	Values	Conditions
ON-STATE				
V_{TM}	Peak on-state voltage, max	V	1.70	$T_j=25$ °C; $I_{TM}=785$ A
$V_{T(TO)}$	On-state threshold voltage, max	V	1.034	$T_j=T_{j\,max}$;
r_T	On-state slope resistance, max	mΩ	0.937	$0.5\,\pi\,I_{TAV} < I_T < 1.5\,\pi\,I_{TAV}$
I_L	Latching current, max	mA	500	$T_j=25$ °C; $V_D=12$ V; Gate pulse: $I_G=2$ A; $t_{GP}=50$ μs; $di_G/dt\geq1$ A/μs
I_H	Holding current, max	mA	250	$T_j=25$ °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	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 2.50 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	400 250 150	$T_j=T_{j\,min}$ $T_j=25$ °C $T_j=T_{j\,max}$
V_{GD}	Gate non-trigger direct voltage, min	V	0.70	$T_j=T_{j\,max}$; $V_D=0.67\cdot V_{DRM}$; Direct gate current
I_{GD}	Gate non-trigger direct current, min	mA	65.00	
SWITCHING				
t_{gd}	Delay time, max	μs	1.10	$T_j=25$ °C; $V_D=600$ V; $I_{TM}=I_{TAV}$;
t_{gt}	Turn-on time, max	μs	3.00	$di/dt=200$ A/μs; Gate pulse: $I_G=2$ A; $V_G=20$ V; $t_{GP}=50$ μs; $di_G/dt=2$ A/μs
t_q	Turn-off time[2], max	μs	125, 160, 200, 250, 320, 400, 500	$dv_D/dt=50$ V/μs; $T_j=T_{j\,max}$; $I_{TM}=I_{TAV}$; $di_R/dt=-10$ A/μs; $V_R=100$V; $V_D=0.67\cdot V_{DRM}$
Q_{rr}	Recovered charge, max	μC	700	$T_j=T_{j\,max}$; $I_{TM}=250$ A; $di_R/dt=-10$ A/μs; $V_R=100$ V
t_{rr}	Reverse recovery time, max	μs	16	
I_{rr}	Reverse recovery current, max	A	88	

THERMAL

R_{thjc}	Thermal resistance, junction to case, max	°C/W	0.070	Direct current	Double side cooled
$R_{thjc\text{-}A}$			0.154		Anode side cooled
$R_{thjc\text{-}K}$			0.126		Cathode side cooled
R_{thck}	Thermal resistance, case to heatsink, max	°C/W	0.010	Direct current	

MECHANICAL

m	Weight, max	g	65	
D_s	Surface creepage distance	mm (inch)	7.94 (0.313)	
D_a	Air strike distance	mm (inch)	5.00 (0.197)	

PART NUMBERING GUIDE

T	123	250	16	A2	E2	N
1	2	3	4	5	6	7

1. Phase Control Thyristor
2. Design version
3. Mean on-state current, A
4. Voltage code
5. Critical rate of rise of off-state voltage, V/μs
6. Turn-off time (dv_D/dt=50 V/μs)
7. 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-off time (dv_D/dt=50 V/μs)

| Symbol of Group	X2	T2	P2	M2	K2	H2	E2
t_q, μs	125	160	200	250	320	400	500
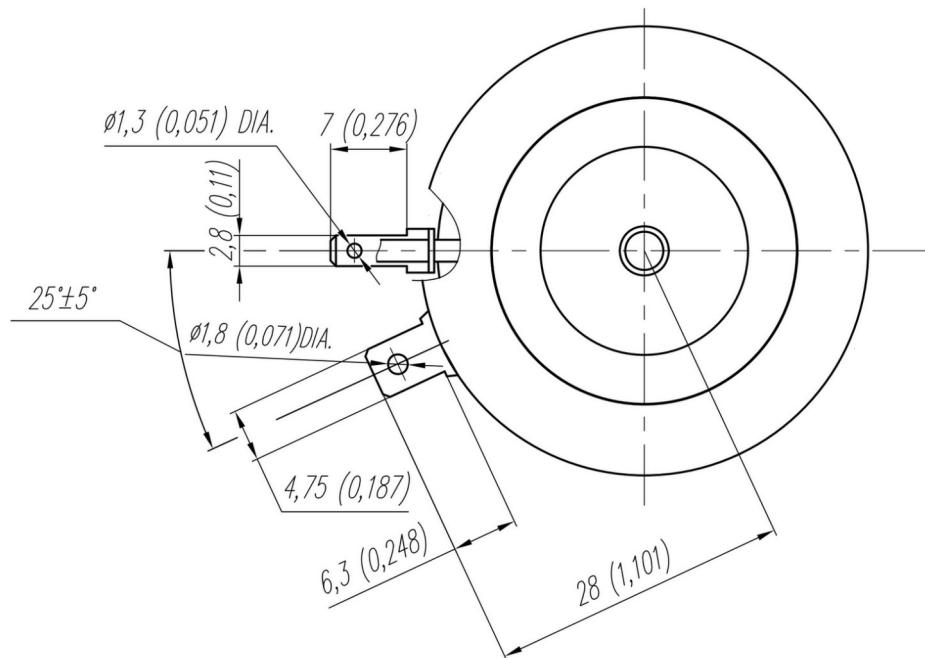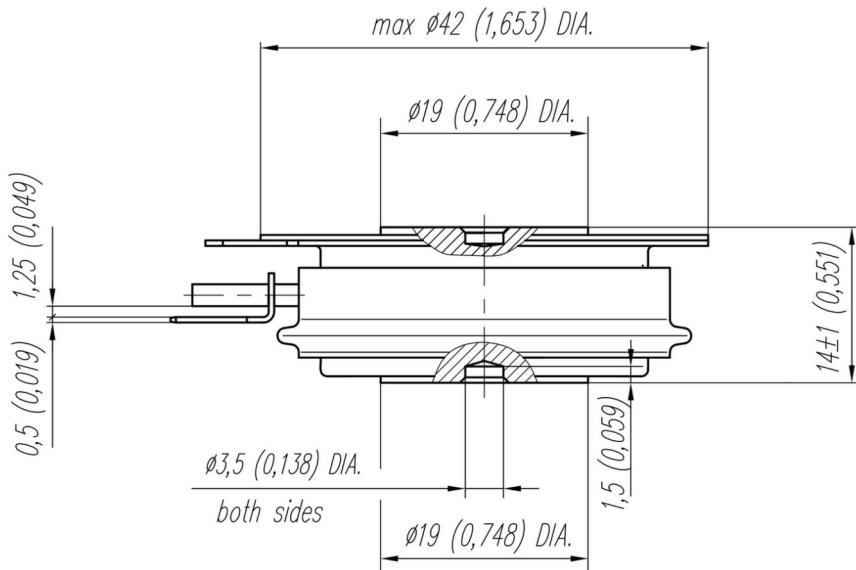
All dimensions in millimeters (inches)
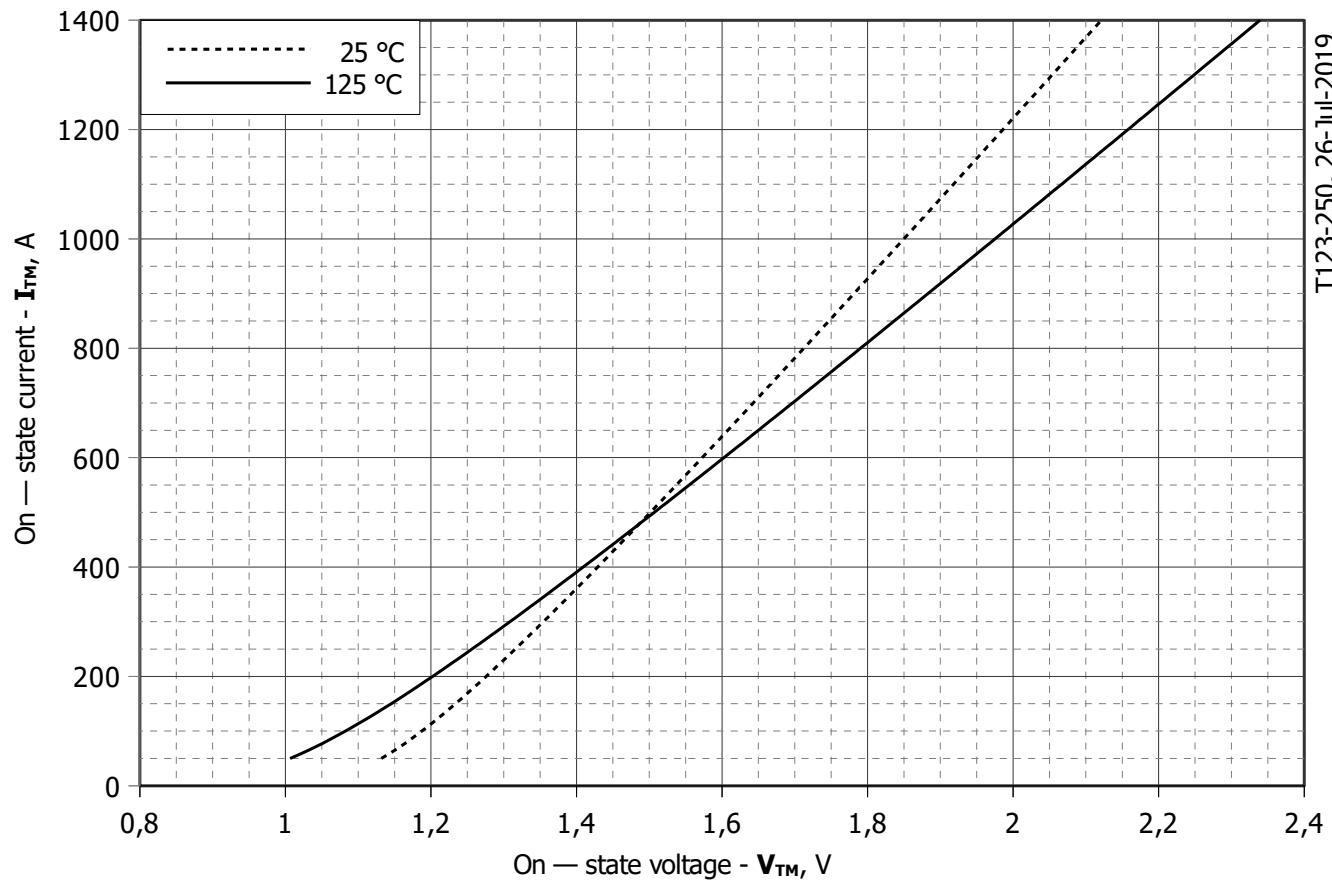
Fig 1 – On-state characteristics of Limit device

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 for max curves	
	$T_j = 25°C$	$T_j = T_{j\,max}$
A	0.96336000	0.77380000
B	0.00065226	0.00087241
C	0.03491800	0.04833400
D	-0.00022113	-0.00016098

On-state characteristic model (see Fig. 1)
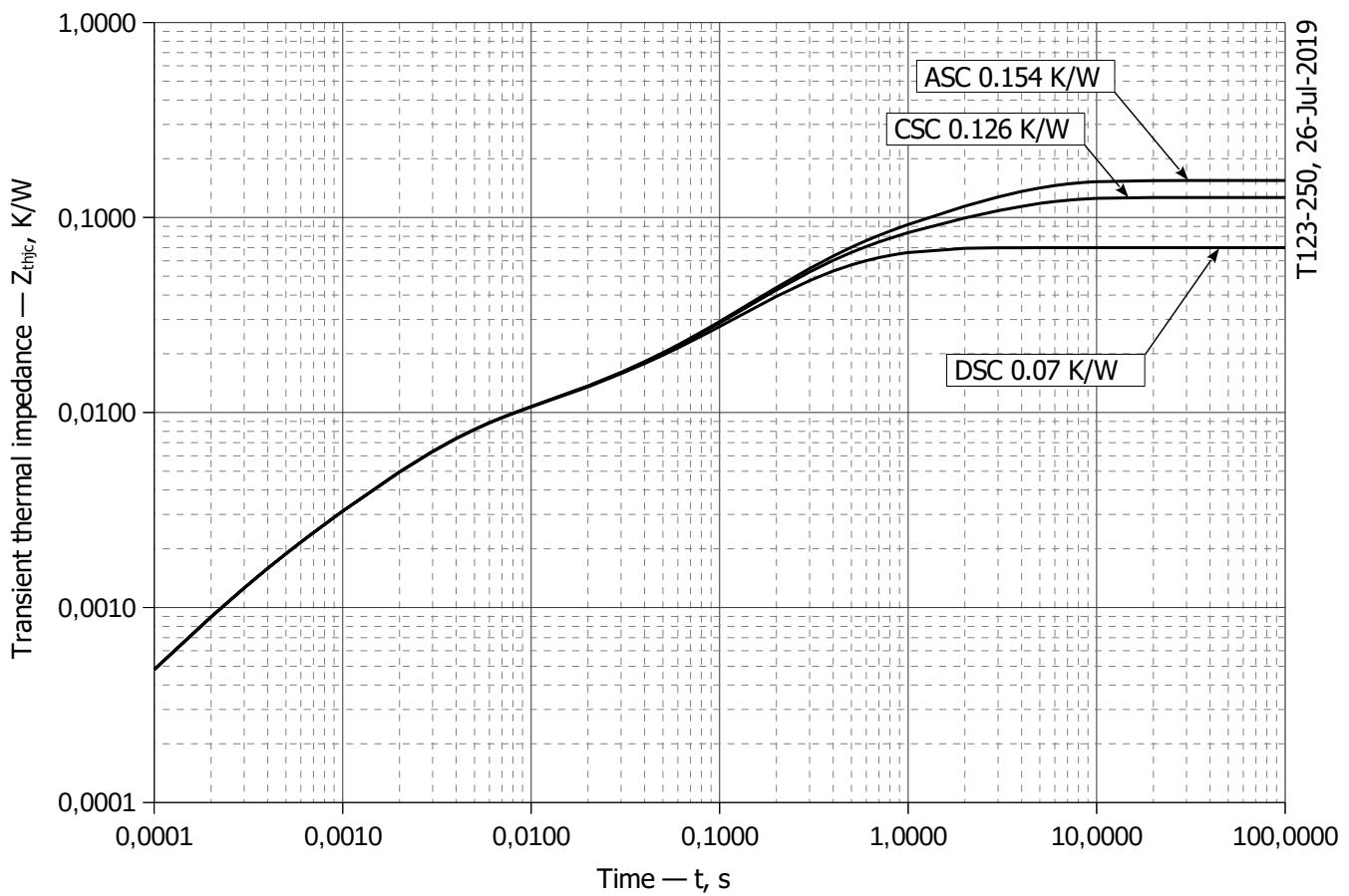
Fig 2 – Transient thermal impedance Z$_{thjc}$ vs. time t

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.

    Z$_{thjc}$ = Thermal resistance at time t.

    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	0.03233	0.02226	0.005231	0.002739	0.006738	0.0006988
τ_i, **s**	0.2392	0.533	0.1478	0.01499	0.002749	0.0002969

DC Anode side cooled

i	1	2	3	4	5	6
R$_i$, K/W	0.08459	0.02327	0.002598	0.006598	0.0006736	0.03694
τ_i, **s**	2.653	0.5669	0.01311	0.00269	0.0002871	0.2416

DC Cathode side cooled

| i	1	2	3	4	5	6
R$_i$, K/W	0.05654	0.03706	0.002638	0.006637	0.0006786	0.02303
τ_i, **s**	2.653	0.2338	0.01361	0.002704	0.000289	0.5476

Transient thermal impedance junction to case Z$_{thjc}$ model (see Fig. 2)
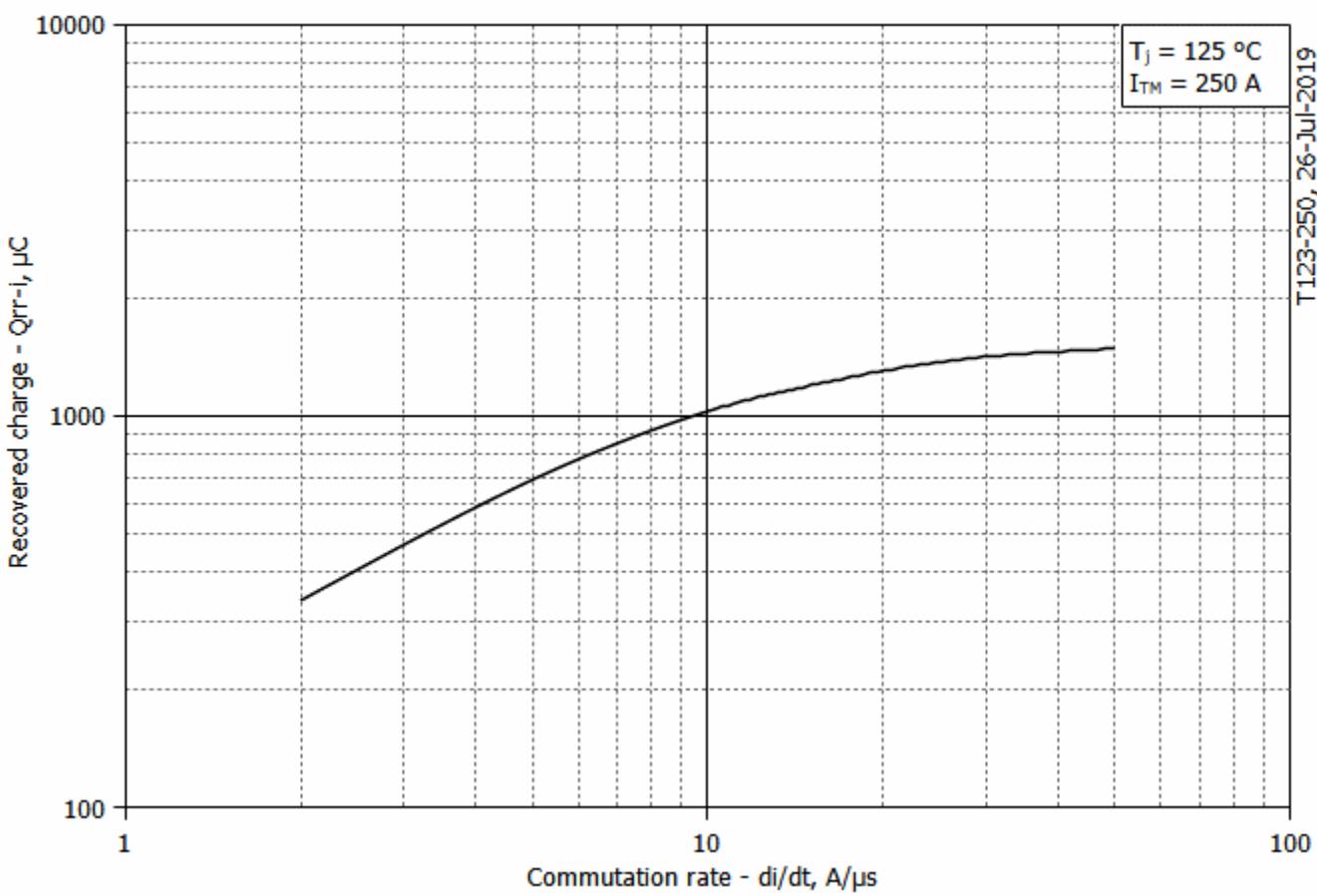
Fig 3 – Maximum recovered charge Q_{rr-i} (integral) vs. commutation rate di_R/dt
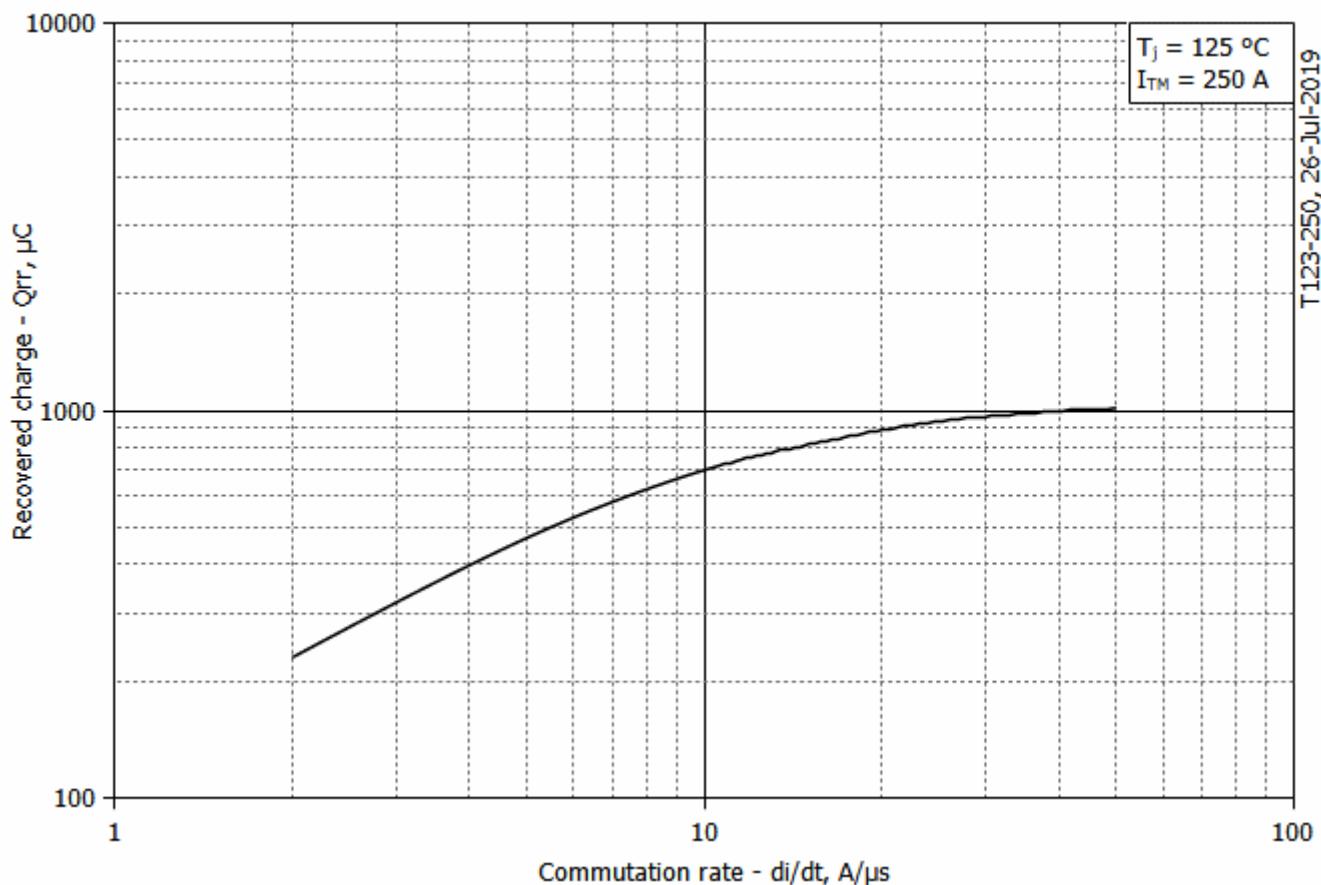
Fig 4 – Maximum recovered charge Q_{rr} vs. commutation rate di_R/dt (25% chord)
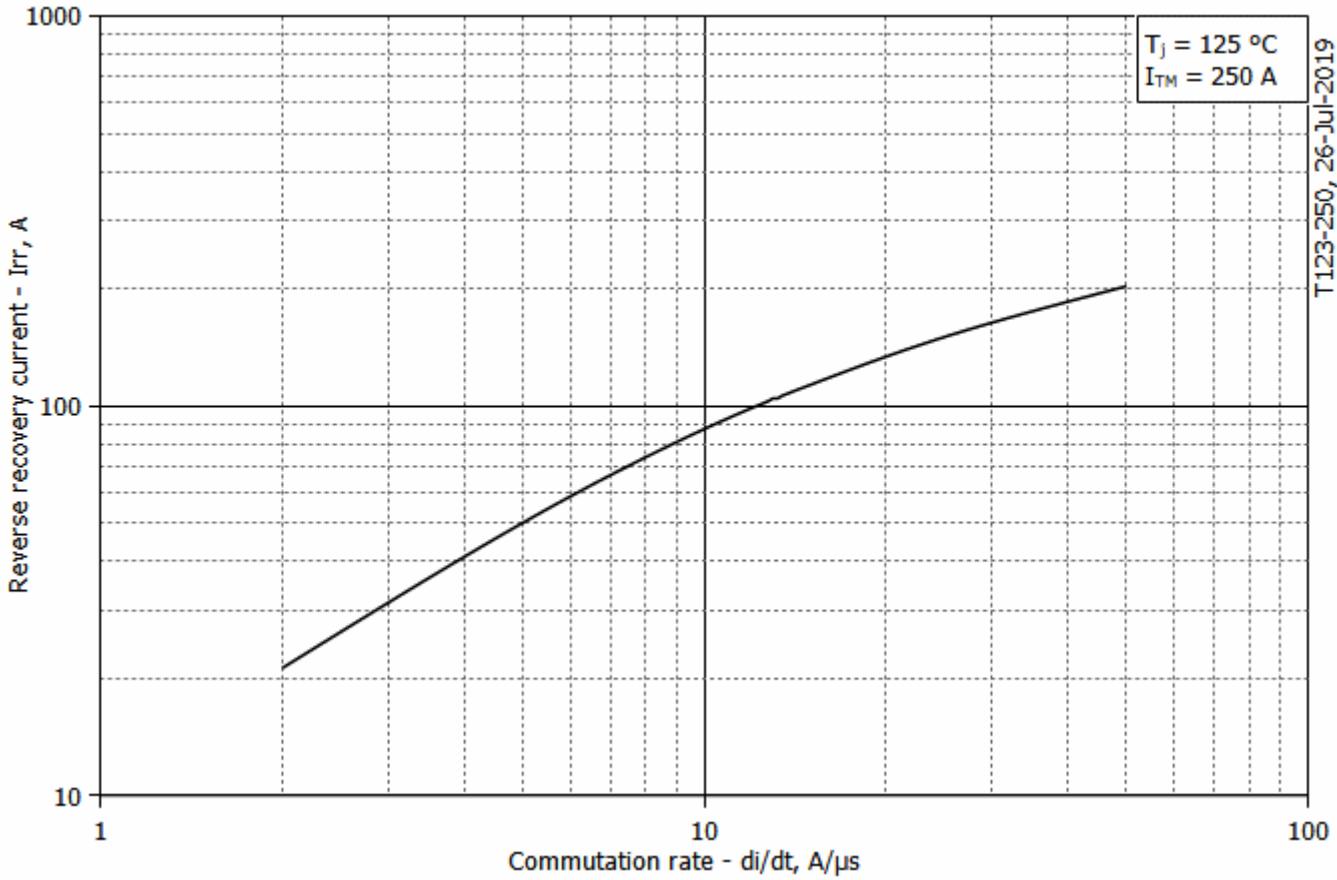
**Fig 5 – Maximum reverse recovery current I$_{rr}$ vs. commutation rate di$_R$/dt**
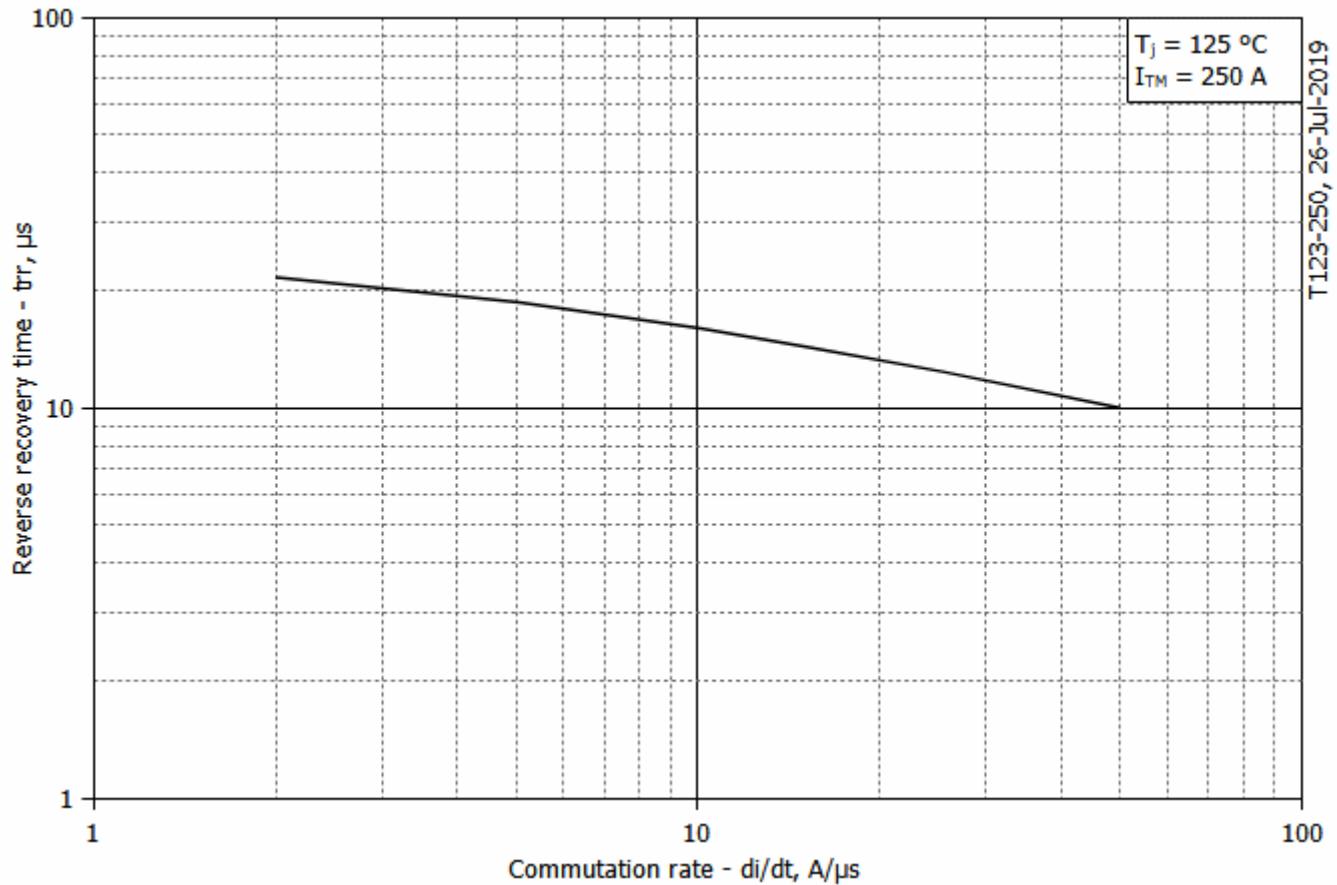
Fig 6 – Maximum recovery time t$_{rr}$ vs. commutation rate di$_R$/dt (25% chord)
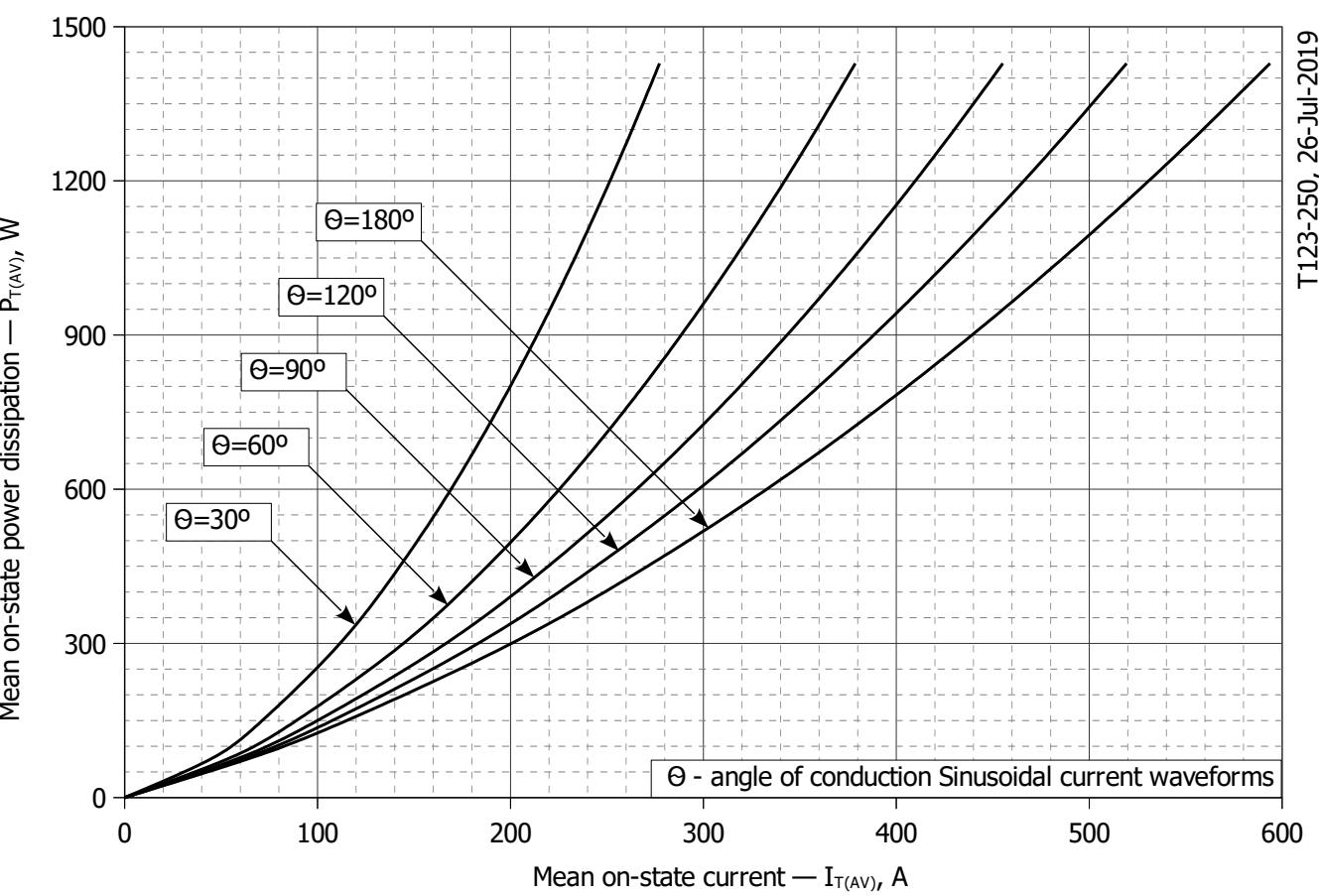
Fig. 7 - Mean on-state power dissipation P$_{TAV}$ vs. mean on-state current I$_{TAV}$ for sinusoidal current waveforms at different conduction angles (f=50Hz, DSC)
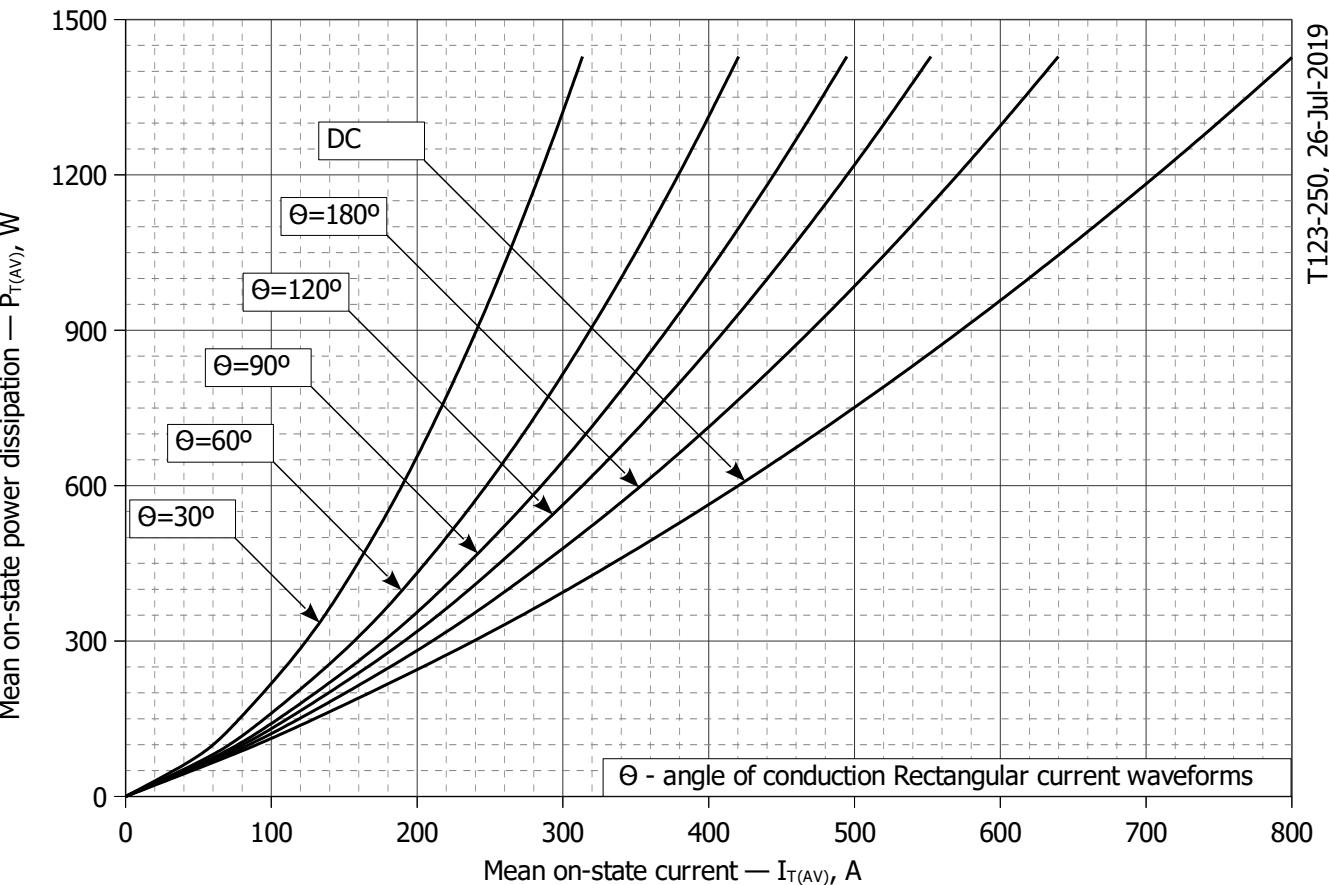

Fig. 8 – Mean on-state power dissipation P$_{TAV}$ vs. mean on-state current I$_{TAV}$ for rectangular current waveforms at different conduction angles and for DC (f=50Hz, DSC)
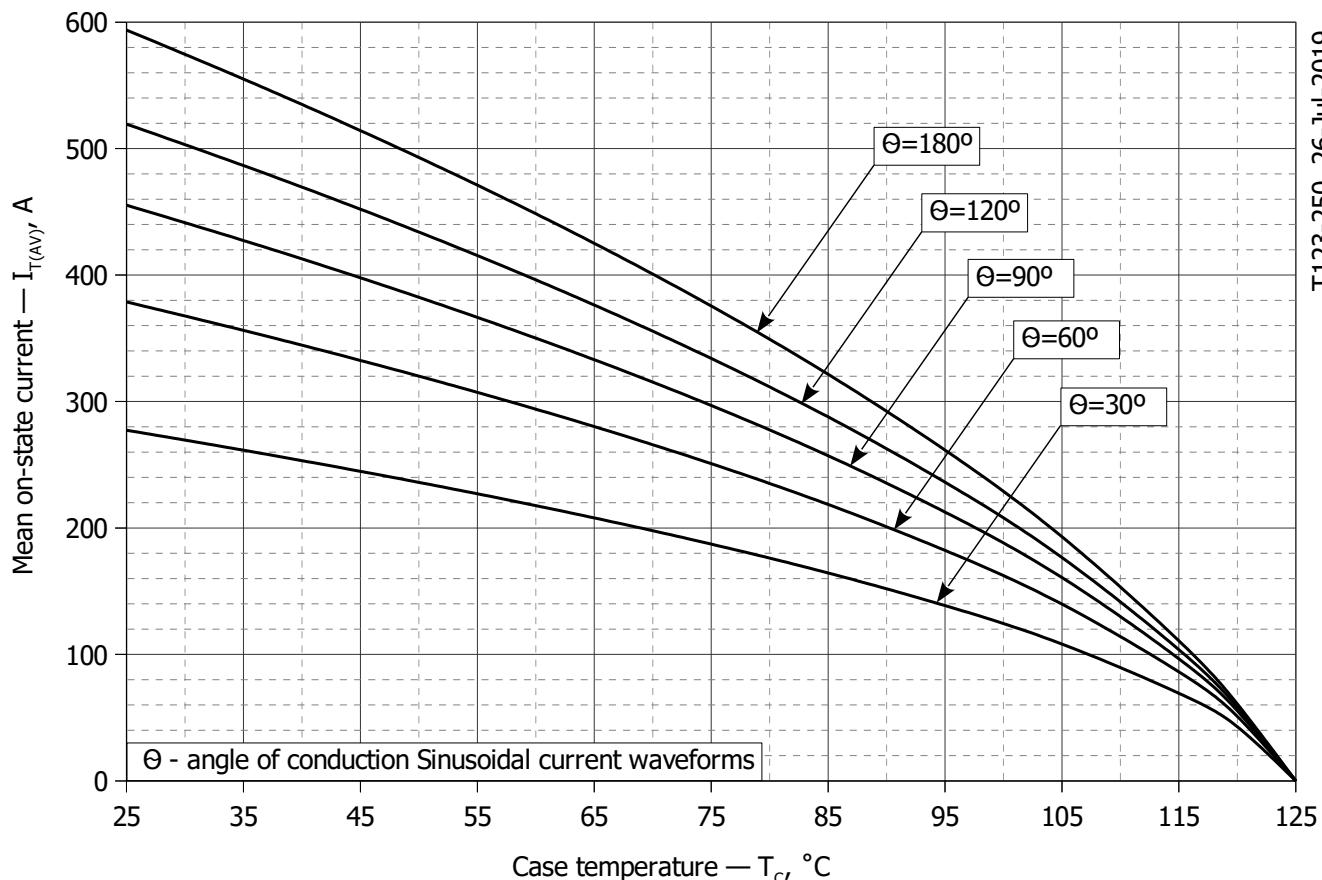
Fig. 9 – Mean on-state current I$_{TAV}$ vs. case temperature T$_C$ for sinusoidal current waveforms at different conduction angles (f=50Hz, DSC)
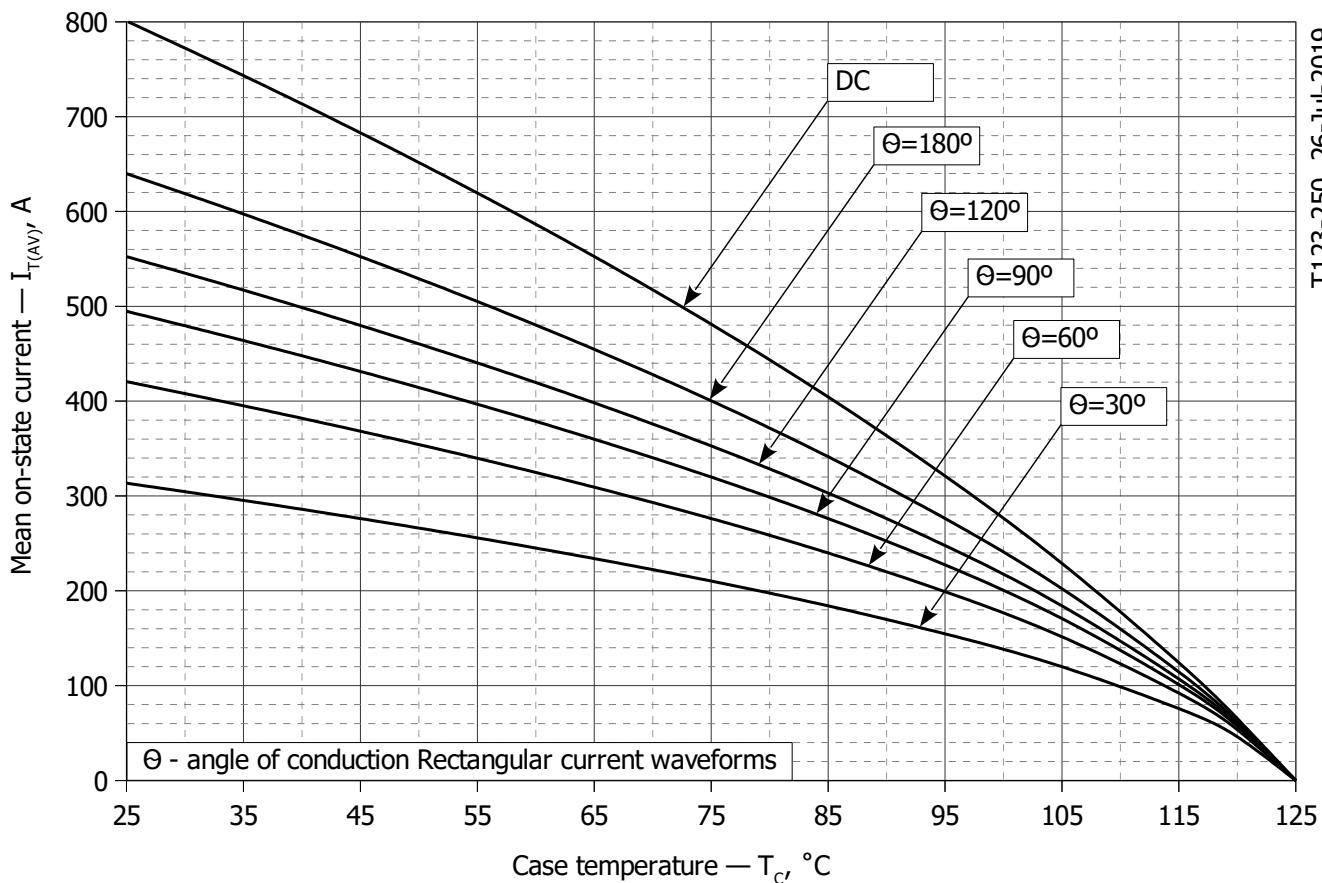
Fig. 10 - Mean on-state current I$_{TAV}$ vs. case temperature T$_C$ for rectangular current waveforms at different conduction angles and for DC (f=50Hz, DSC)

T_j = 125 °C

Surge on-state current – I_{TSM}, kA

Safety factor – I^2t, kA²s

I²t:V_{rm}<10V

I²t:V_{rm}=0.67V_{RRM}

I_{TSM}:V_{rm}<10V

I_{TSM}:V_{rm}=0.67V_{RRM}
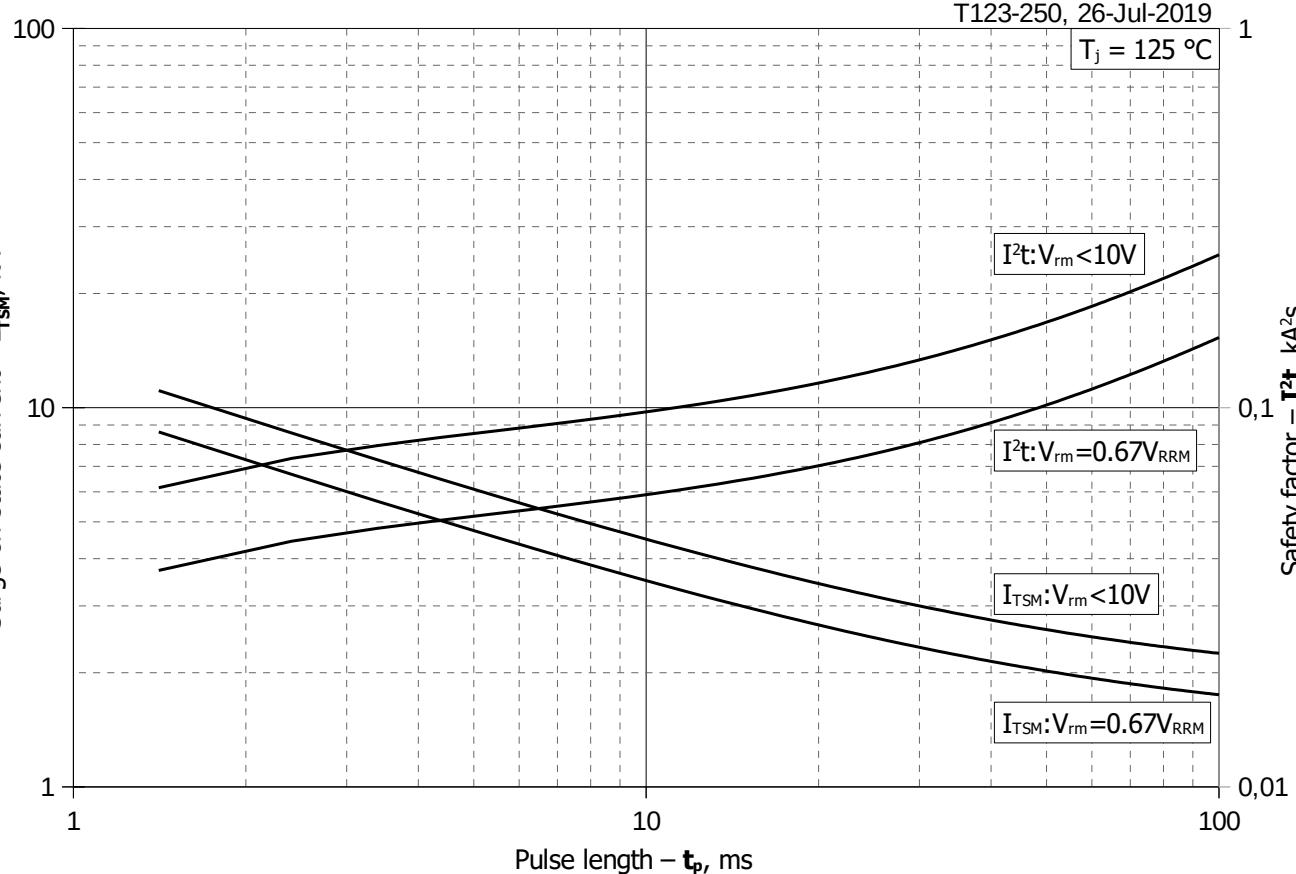
Pulse length – t_p, ms

Fig. 11 – Maximum surge on-state current I_{TSM} and safety factor I^2t vs. pulse length t_p

T_j = 125 °C

Surge on-state current – I_{TSM}, kA

V_{rm}<10V

V_{rm}=0.67V_{RRM}

T123-250, 26-Jul-2019
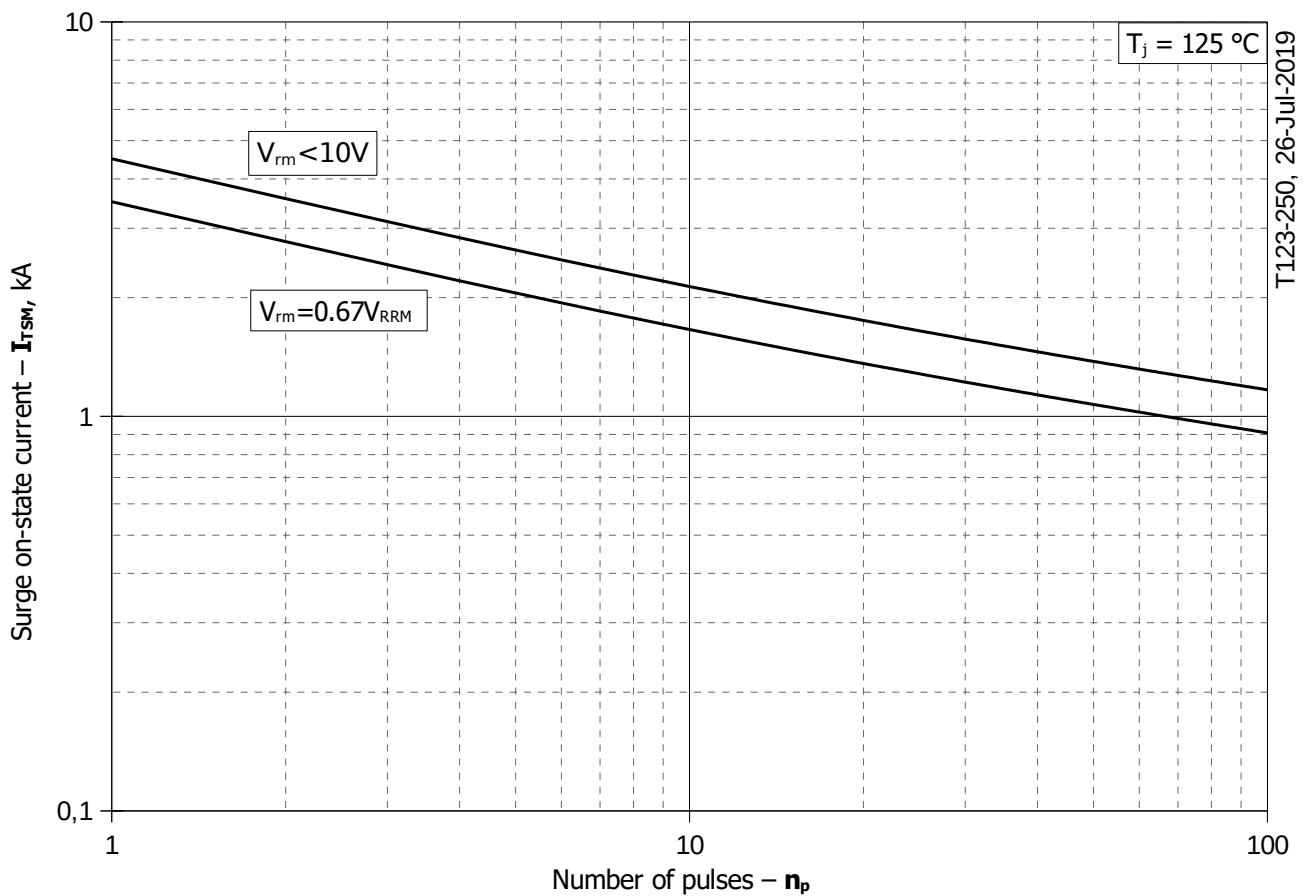
Number of pulses – n_p

Fig. 12 - Maximum surge on-state current I_{TSM} vs. number of pulses n_p