



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

Phase Control Thyristor Type T233-500-18

Mean on-state current				I_{TAV}	500 A			
Repetitive peak off-state voltage				V_{DRM}	1000...1800 V			
Repetitive peak reverse voltage				V_{RRM}				
Turn-off time				t_q	125, 160, 200, 250, 320, 400, 500 μ s			
V_{DRM}, V_{RRM}, V	1000	1100	1200	1300	1400	1500	1600	1800
Voltage code	10	11	12	13	14	15	16	18
$T_j, ^\circ C$	-60...+125							

MAXIMUM ALLOWABLE RATINGS

Symbols and parameters		Units	Values	Test conditions	
ON-STATE					
I_{TAV}	Maximum allowable mean on-state current	A	500 592	$T_c=93\text{ }^{\circ}\text{C}$, Double side cooled $T_c=85\text{ }^{\circ}\text{C}$, Double side cooled 180° half-sine wave; 50 Hz	
I_{TRMS}	RMS on-state current	A	785	$T_c=93\text{ }^{\circ}\text{C}$, Double side cooled 180° half-sine wave; 50 Hz	
I_{TSM}	Surge on-state current	kA	7.0 8.0	$T_j=T_{j\text{ max}}$ $T_j=25\text{ }^{\circ}\text{C}$	180° half-sine wave; $t_p=10\text{ ms}$; single pulse; $V_D=V_R=0\text{ V}$; Gate pulse: $I_G=2\text{ A}$; $t_{GP}=50\text{ }\mu\text{s}$; $di_G/dt\geq 1\text{ A}/\mu\text{s}$
			7.5 8.5	$T_j=T_{j\text{ max}}$ $T_j=25\text{ }^{\circ}\text{C}$	180° half-sine wave; $t_p=8.3\text{ ms}$; single pulse; $V_D=V_R=0\text{ V}$; Gate pulse: $I_G=2\text{ A}$; $t_{GP}=50\text{ }\mu\text{s}$; $di_G/dt\geq 1\text{ A}/\mu\text{s}$
I^2t	Safety factor	$A^2s\cdot 10^3$	240 320	$T_j=T_{j\text{ max}}$ $T_j=25\text{ }^{\circ}\text{C}$	180° half-sine wave; $t_p=10\text{ ms}$; single pulse; $V_D=V_R=0\text{ V}$; Gate pulse: $I_G=2\text{ A}$; $t_{GP}=50\text{ }\mu\text{s}$; $di_G/dt\geq 1\text{ A}/\mu\text{s}$
			230 290	$T_j=T_{j\text{ max}}$ $T_j=25\text{ }^{\circ}\text{C}$	180° half-sine wave; $t_p=8.3\text{ ms}$; single pulse; $V_D=V_R=0\text{ V}$; Gate pulse: $I_G=2\text{ A}$; $t_{GP}=50\text{ }\mu\text{s}$; $di_G/dt\geq 1\text{ A}/\mu\text{s}$
BLOCKING					
V_{DRM}, V_{RRM}	Repetitive peak off-state and Repetitive peak reverse voltages	V	1000...1800	$T_{j\text{ min}} < T_j < T_{j\text{ max}}$; 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...1900	$T_{j\text{ min}} < T_j < T_{j\text{ max}}$; 180° half-sine wave; single pulse; Gate open	
V_D, V_R	Direct off-state and Direct reverse voltages	V	$0.6\cdot V_{DRM}$ $0.6\cdot V_{RRM}$	$T_j=T_{j\text{ max}}$; Gate open	

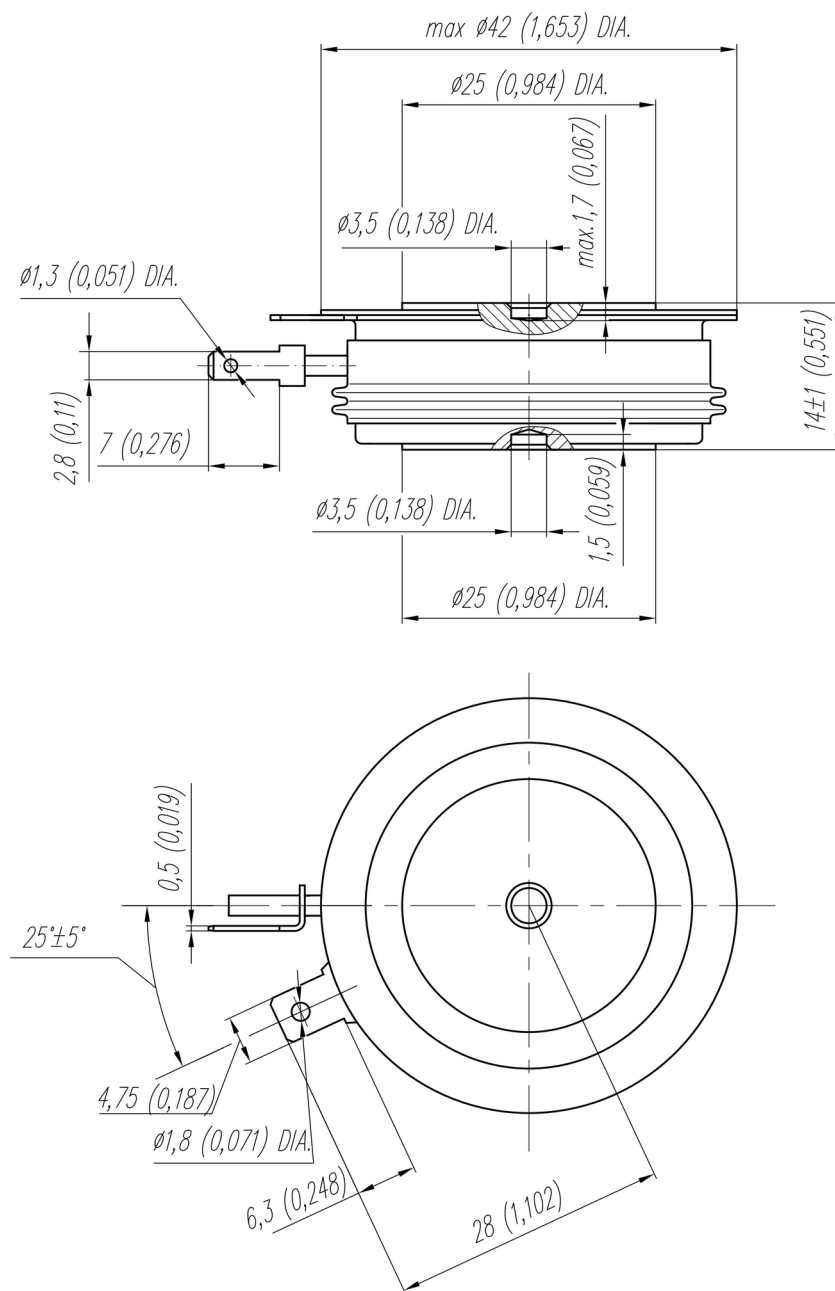
TRIGGERING				
I_{FGM}	Peak forward gate current	A	6	$T_j = T_{j\max}$
V_{RGM}	Peak reverse gate voltage	V	5	
P_G	Gate power dissipation	W	3	$T_j = T_{j\max}$ for DC gate current
SWITCHING				
$(di_T/dt)_{crit}$	Critical rate of rise of on-state current non-repetitive ($f=1$ Hz)	A/ μ s	1000	$T_j = T_{j\max}$; $V_D = 0.67 \cdot V_{DRM}$; $I_{TM} = 1700$ A; Gate pulse: $I_G = 2$ A; $t_{GP} = 50$ μ s; $di_G/dt \geq 2$ A/ μ s
THERMAL				
T_{stg}	Storage temperature	$^{\circ}$ C	-60...+50	
T_j	Operating junction temperature	$^{\circ}$ C	-60...+125	
MECHANICAL				
F	Mounting force	kN	9.0...11.0	
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} =1570 A	
V _{T(TO)}	On-state threshold voltage, max	V	0.919	T _j =T _{j max} ;	
r _T	On-state slope resistance, max	mΩ	0.529	0.5 π I _{TAV} < I _T < 1.5 π I _{TAV}	
I _L	Latching current, max	mA	700	T _j =25 °C; V _D =12 V; Gate pulse: I _G =2 A; t _{GP} =50 μs; di _G /dt≥1 A/μs	
I _H	Holding current, max	mA	300	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	70	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·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	0.60	T _j =T _{j max} ; V _D =0.67·V _{DRM} ; Direct gate current	
I _{GD}	Gate non-trigger direct current, min	mA	35.00		
SWITCHING					
t _{gd}	Delay time, max	μs	1.25	T _j =25 °C; V _D =1000 V; I _{TM} =I _{TAV} ; di/dt=200 A/μs;	
t _{gt}	Turn-on time, max	μs	4.00	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 =100V; V _D =0.67·V _{DRM}	
Q _{rr}	Recovered charge, max	μC	750	T _j =T _{j max} ; I _{TM} =500 A;	
t _{rr}	Reverse recovery time, max	μs	15	di _R /dt=-10 A/μs;	
I _{rr}	Reverse recovery current, max	A	100	V _R =100 V	

THERMAL					
R _{thjc}	Thermal resistance, junction to case, max	°C/W	0.040	Direct current	Double side cooled
R _{thjc-A}			0.088		Anode side cooled
R _{thjc-K}			0.072		Cathode side cooled
R _{thck}	Thermal resistance, case to heatsink, max	°C/W	0.008	Direct current	
MECHANICAL					
m	Weight, max	g	95		
D _s	Surface creepage distance	mm (inch)	10.30 (0.405)		
D _a	Air strike distance	mm (inch)	6.30 (0.248)		

PART NUMBERING GUIDE							NOTES																	
T	233	500	18	A2	X2	N	1) Critical rate of rise of off-state voltage <table><tr><td>Symbol of Group</td><td>P2</td><td>K2</td><td>E2</td><td>A2</td><td>T1</td><td>P1</td><td>M1</td></tr><tr><td>$(dv_D/dt)_{crit}$, V/μs</td><td>200</td><td>320</td><td>500</td><td>1000</td><td>1600</td><td>2000</td><td>2500</td></tr></table>		Symbol of Group	P2	K2	E2	A2	T1	P1	M1	$(dv_D/dt)_{crit}$, V/μs	200	320	500	1000	1600	2000	2500
Symbol of Group	P2	K2	E2	A2	T1	P1			M1															
$(dv_D/dt)_{crit}$, V/μs	200	320	500	1000	1600	2000	2500																	
1	2	3	4	5	6	7																		
1. Phase Control Thyristor							2) Turn-off time ($dv_D/dt=50$ V/μs) <table><tr><td>Symbol of Group</td><td>X2</td><td>T2</td><td>P2</td><td>M2</td><td>K2</td><td>H2</td><td>E2</td></tr><tr><td>t_{qr}, μs</td><td>125</td><td>160</td><td>200</td><td>250</td><td>320</td><td>400</td><td>500</td></tr></table>		Symbol of Group	X2	T2	P2	M2	K2	H2	E2	t_{qr} , μs	125	160	200	250	320	400	500
Symbol of Group	X2	T2	P2	M2	K2	H2			E2															
t_{qr} , μs	125	160	200	250	320	400			500															
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																								



All dimensions in millimeters (inches)

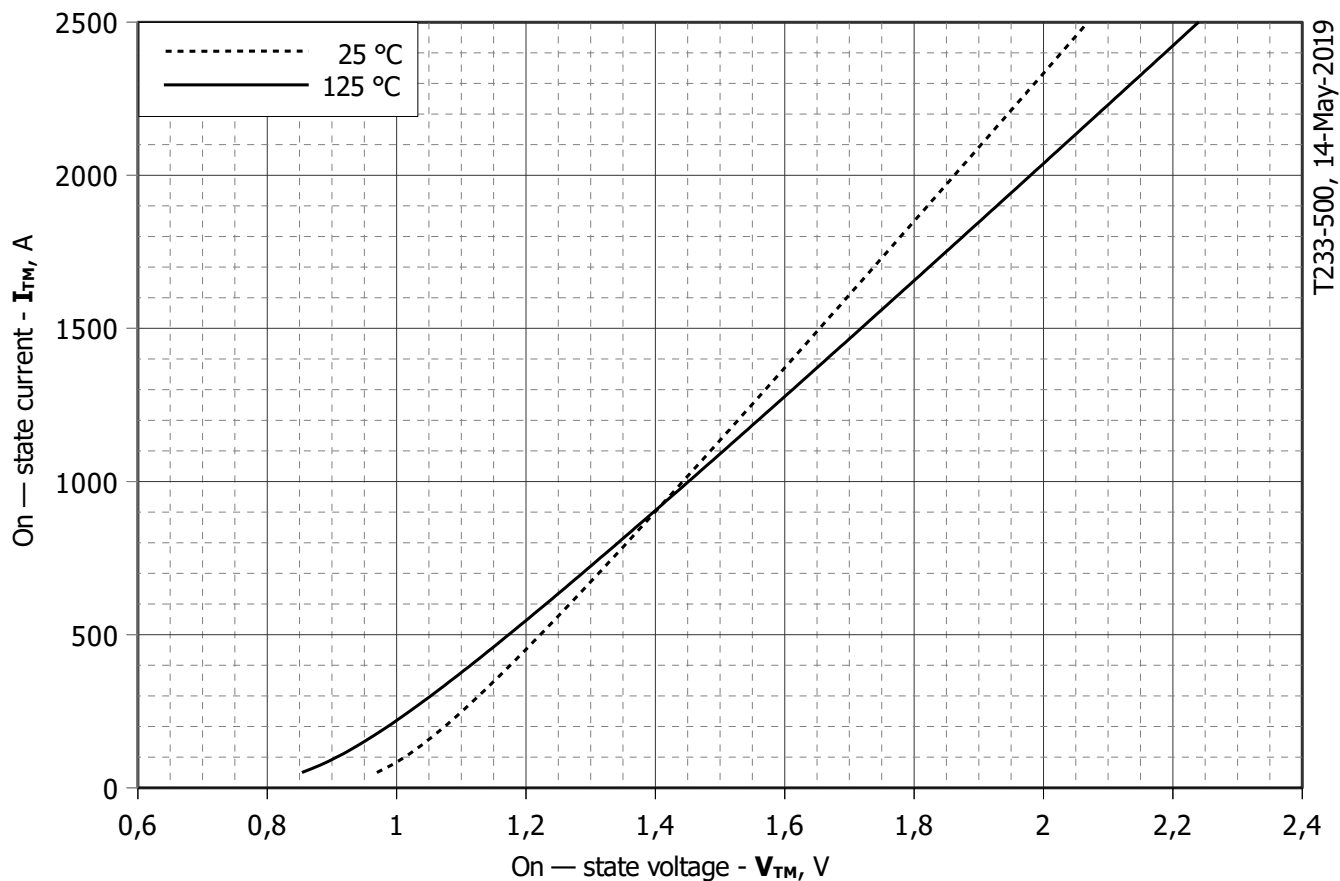


Fig 1 – On-state characteristics of Limit device

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	
	$T_j = 25^\circ\text{C}$	$T_j = T_{j\max}$
A	0.81206000	0.65641000
B	0.00040593	0.00050753
C	0.03645500	0.04506900
D	-0.00086613	-0.00075974

On-state characteristic model (see Fig. 1)

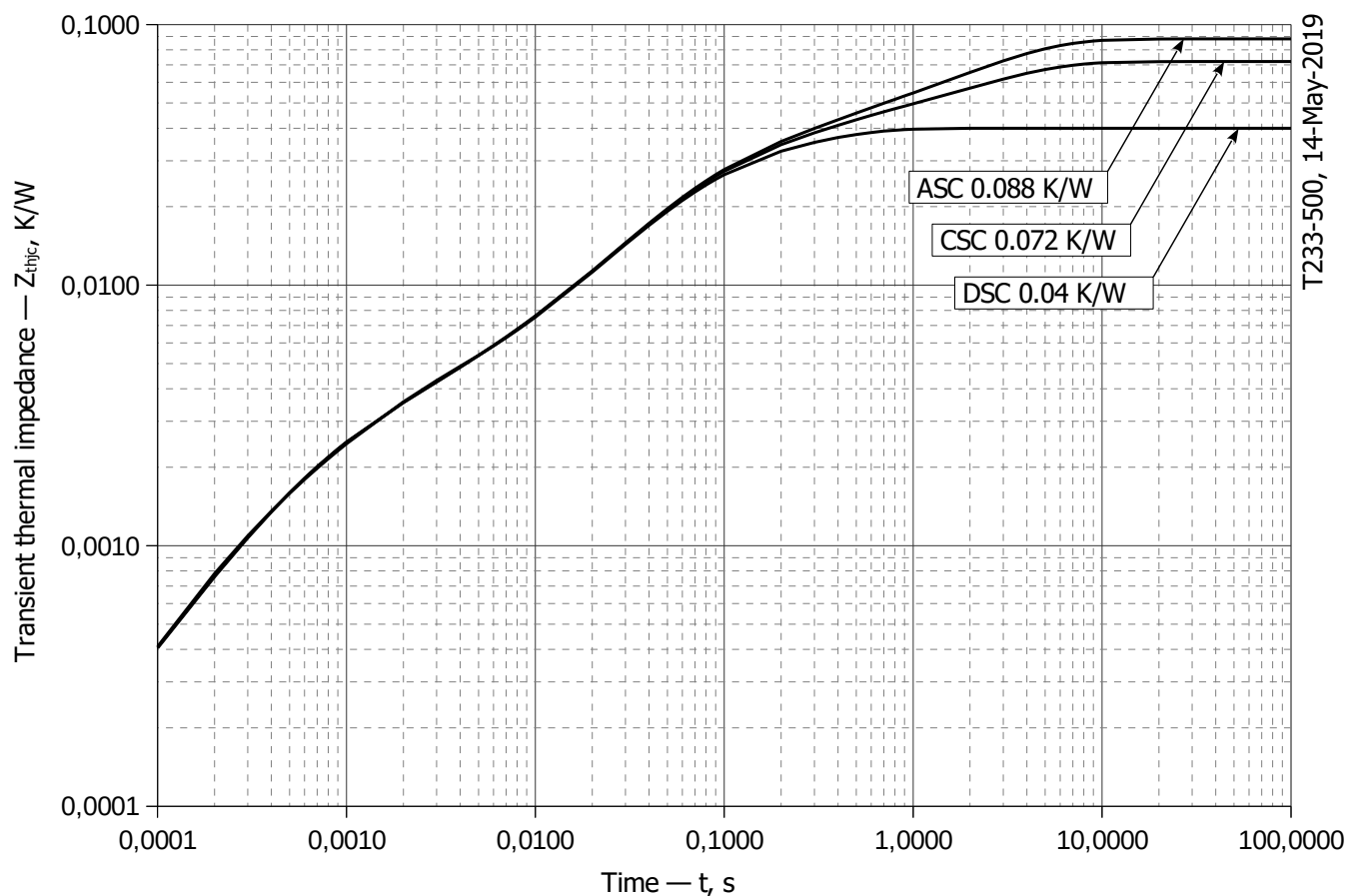


Fig 2 – Transient thermal impedance Z_{thjc} vs. time t

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 constant of r_{th} term.

DC Double side cooled

i	1	2	3	4	5	6
R_i , K/W	0.01423	0.01906	0.003576	0.002535	-4.666e-005	0.0006479
τ_i , s	0.265	0.05901	0.03499	0.001252	0.000001	0.0002488

DC Anode side cooled

i	1	2	3	4	5	6
R_i , K/W	0.04804	0.001789	0.01342	0.02147	0.001374	0.001945
τ_i , s	2.651	0.4195	0.2622	0.05451	0.002585	0.0005847

DC Cathode side cooled

i	1	2	3	4	5	6
R_i , K/W	0.03216	0.01306	0.002934	0.02064	0.001493	0.001786
τ_i , s	2.647	0.2831	0.1455	0.05284	0.002255	0.0005519

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

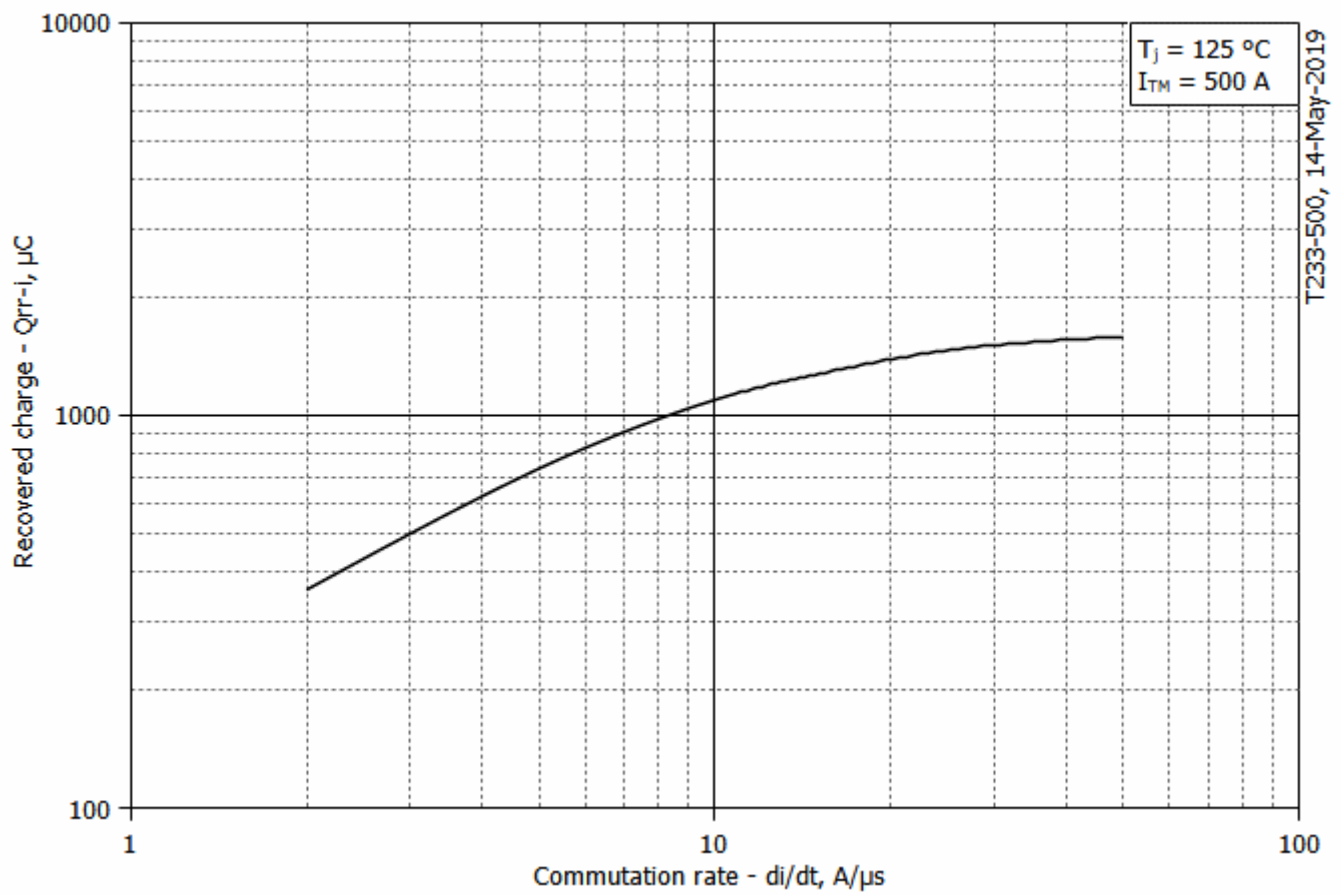


Fig 3 – Maximum recovered charge Q_{rr-i} (integral) vs. commutation rate di_R/dt

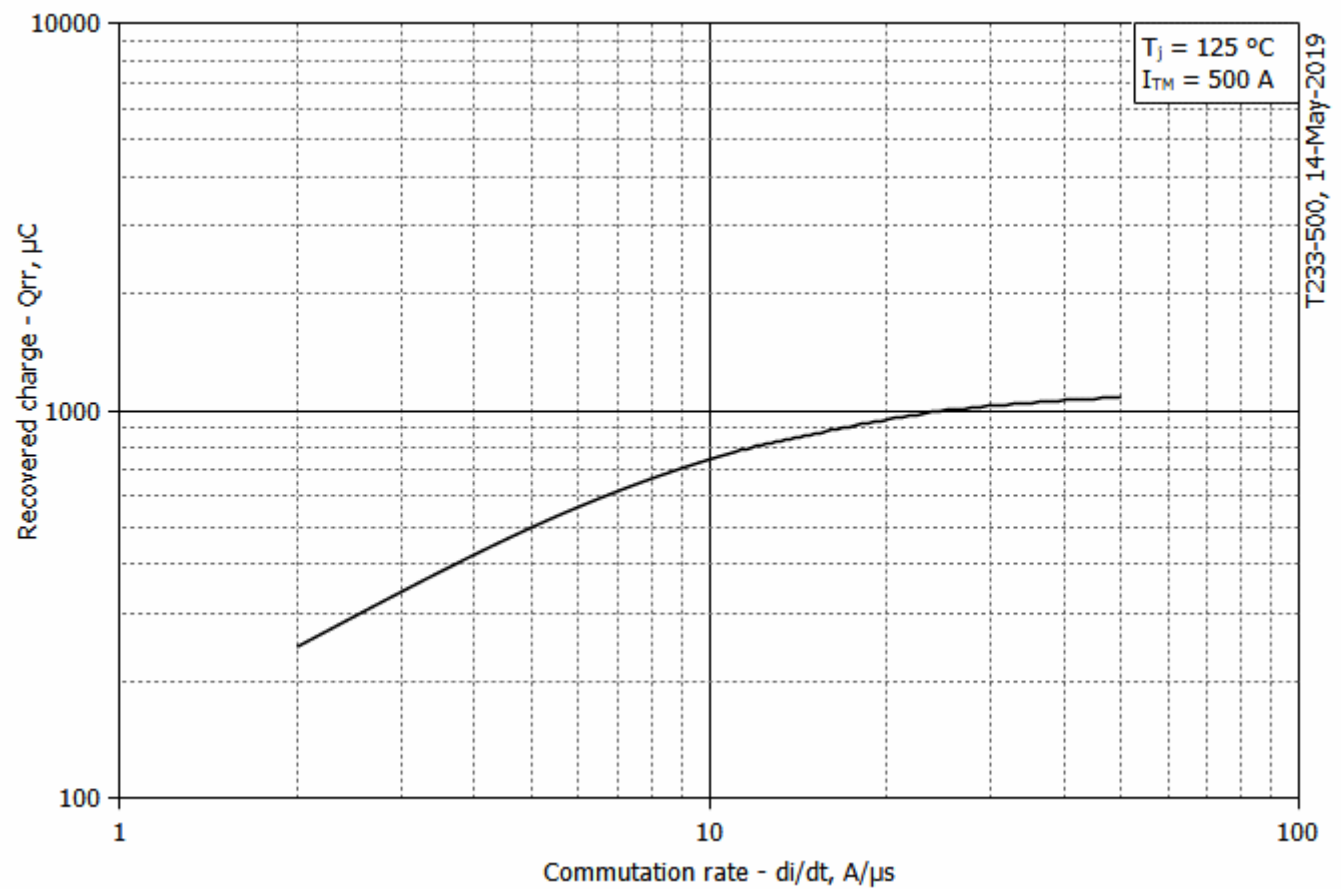


Fig 4 – Maximum recovered charge Q_{rr} vs. commutation rate di_R/dt (25% chord)

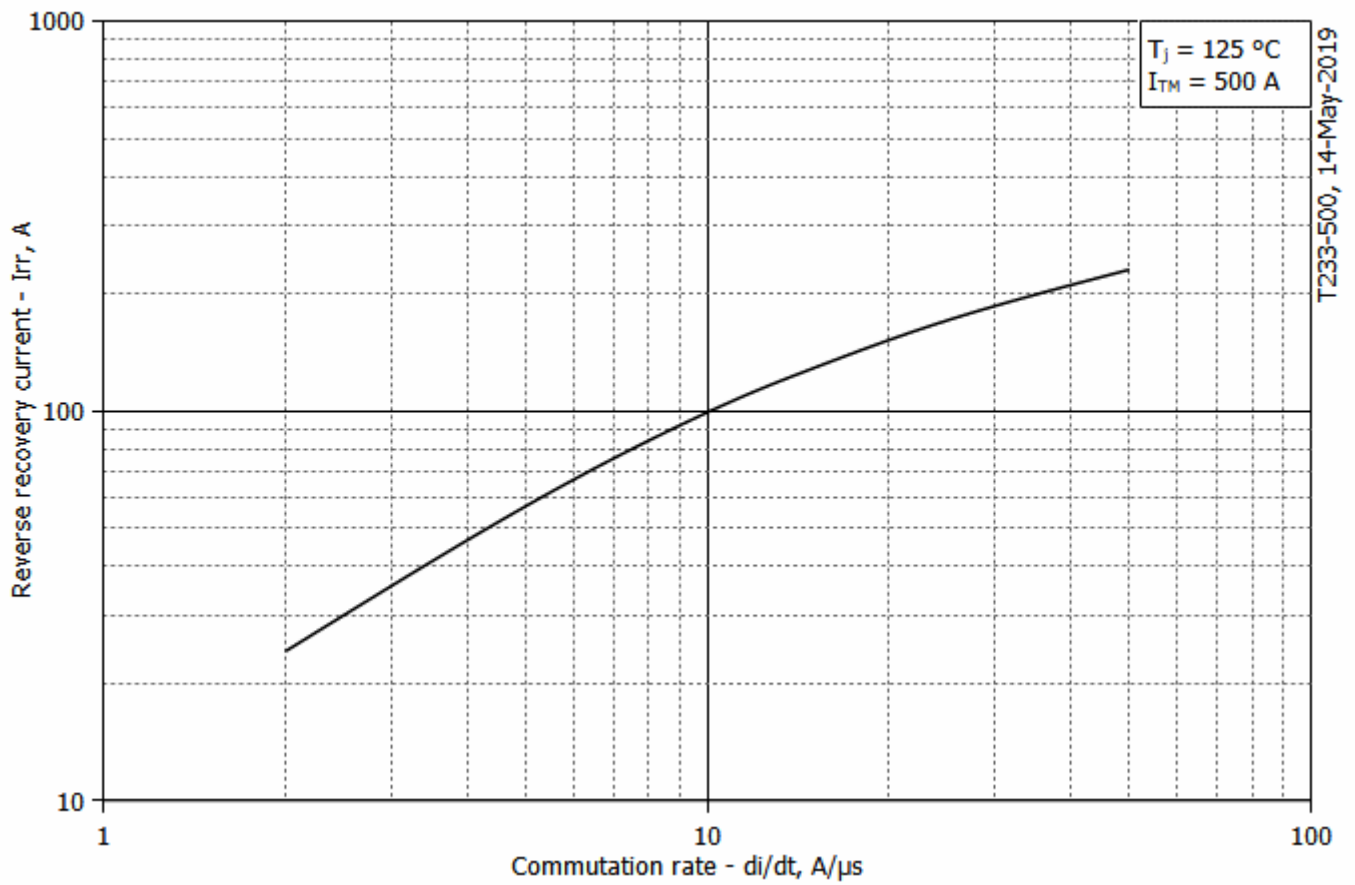


Fig 5 – Maximum reverse recovery current I_{rr} vs. commutation rate di_R/dt

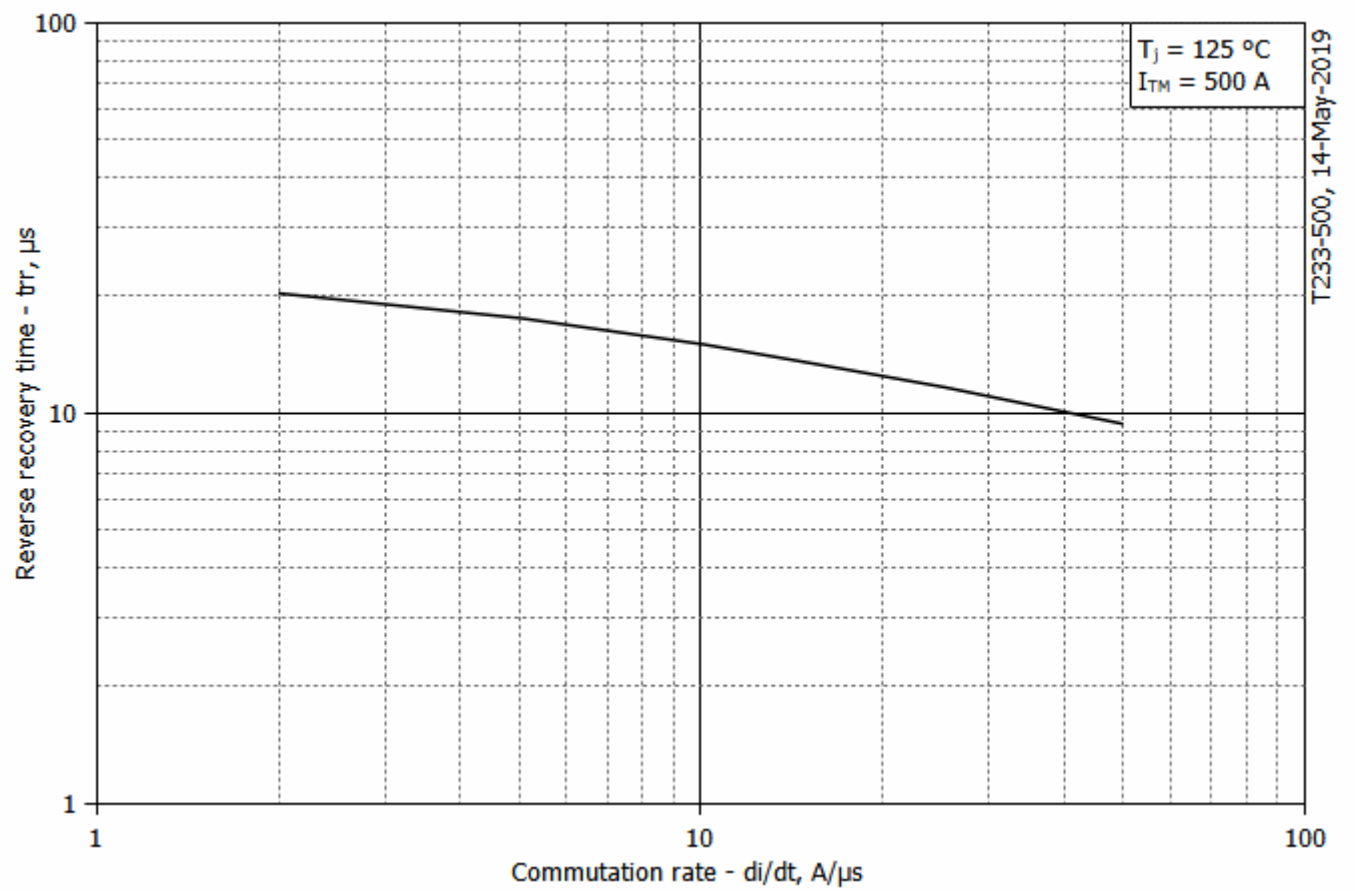
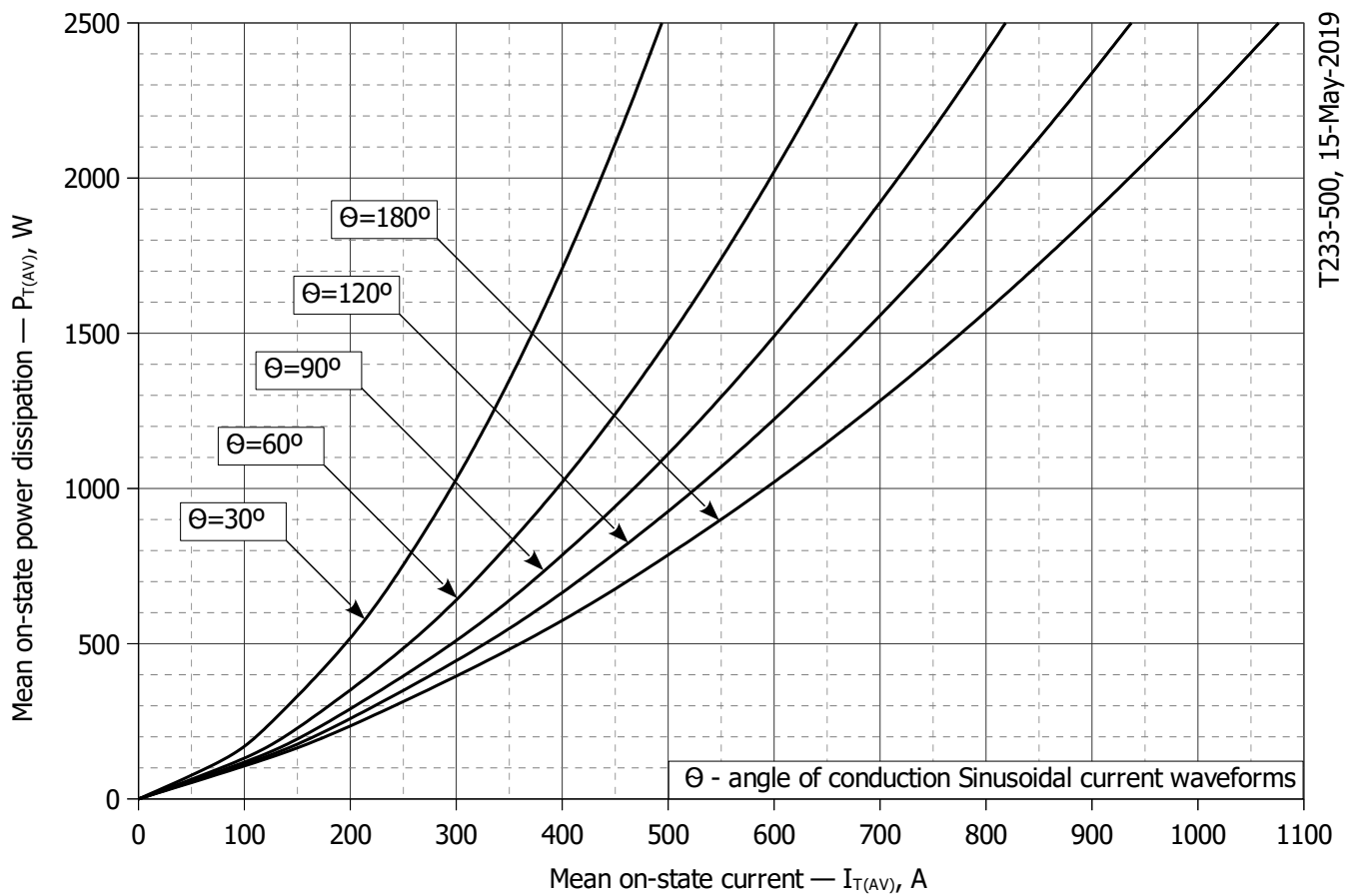
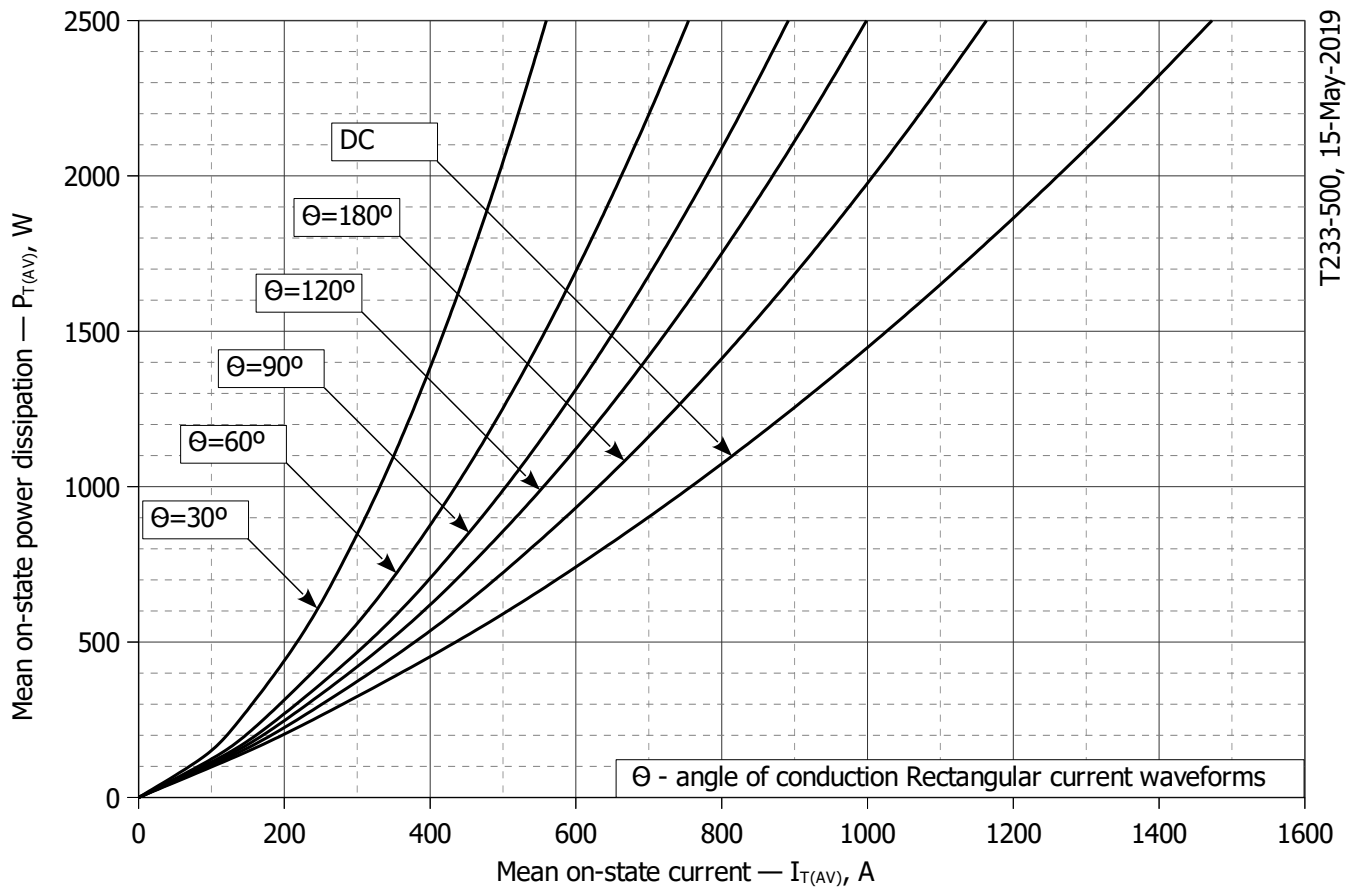


Fig 6 – Maximum recovery time t_{rr} vs. commutation rate di_R/dt (25% chord)



T233-500, 15-May-2019

Fig. 7 - Mean on-state power dissipation P_{TAV} vs. mean on-state current I_{TAV} for sinusoidal current waveforms at different conduction angles ($f=50\text{Hz}$, DSC)



T233-500, 15-May-2019

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 ($f=50\text{Hz}$, DSC)

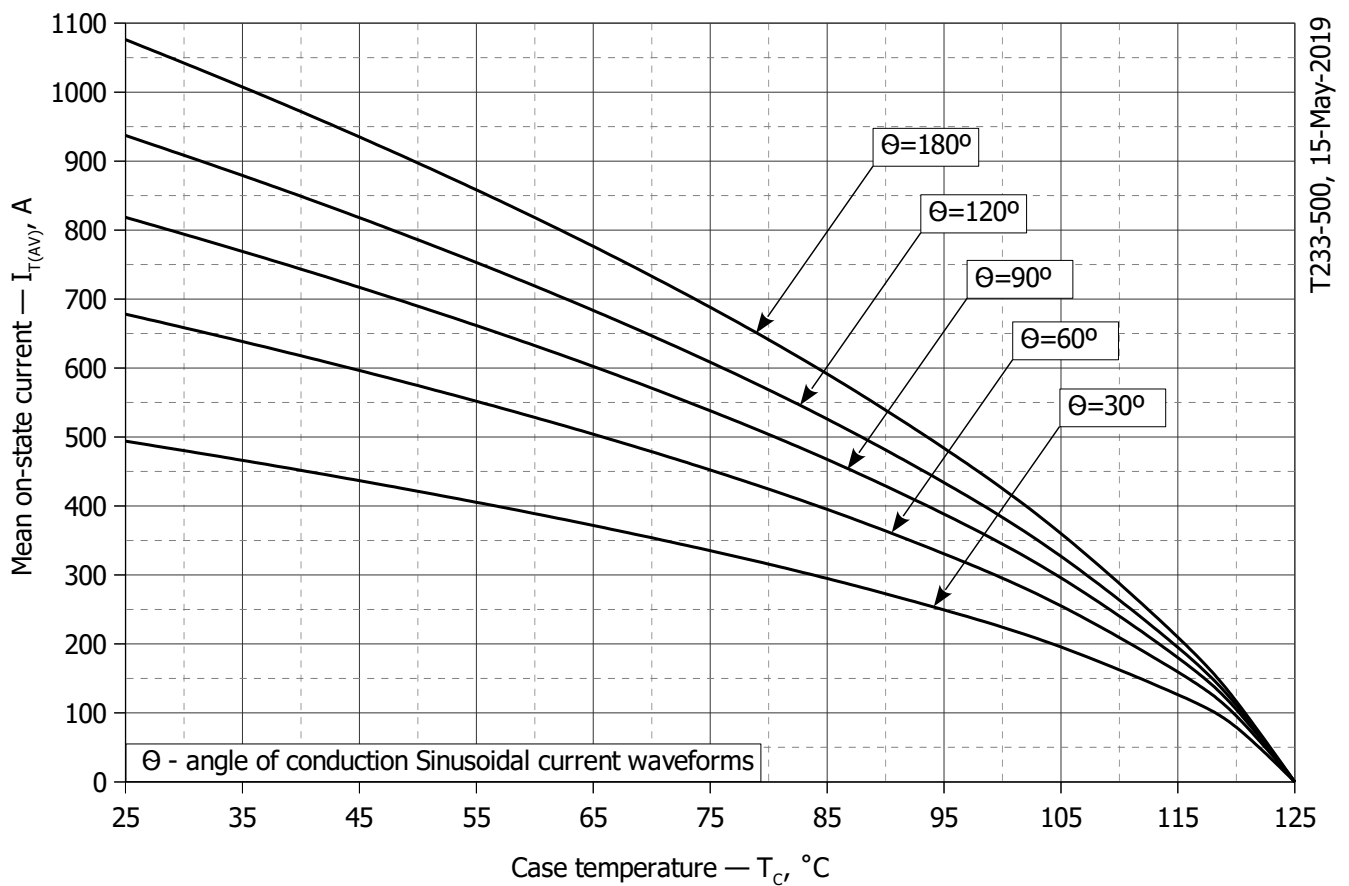


Fig. 9 – Mean on-state current I_{TAV} vs. case temperature T_c for sinusoidal current waveforms at different conduction angles ($f=50\text{Hz}$, DSC)

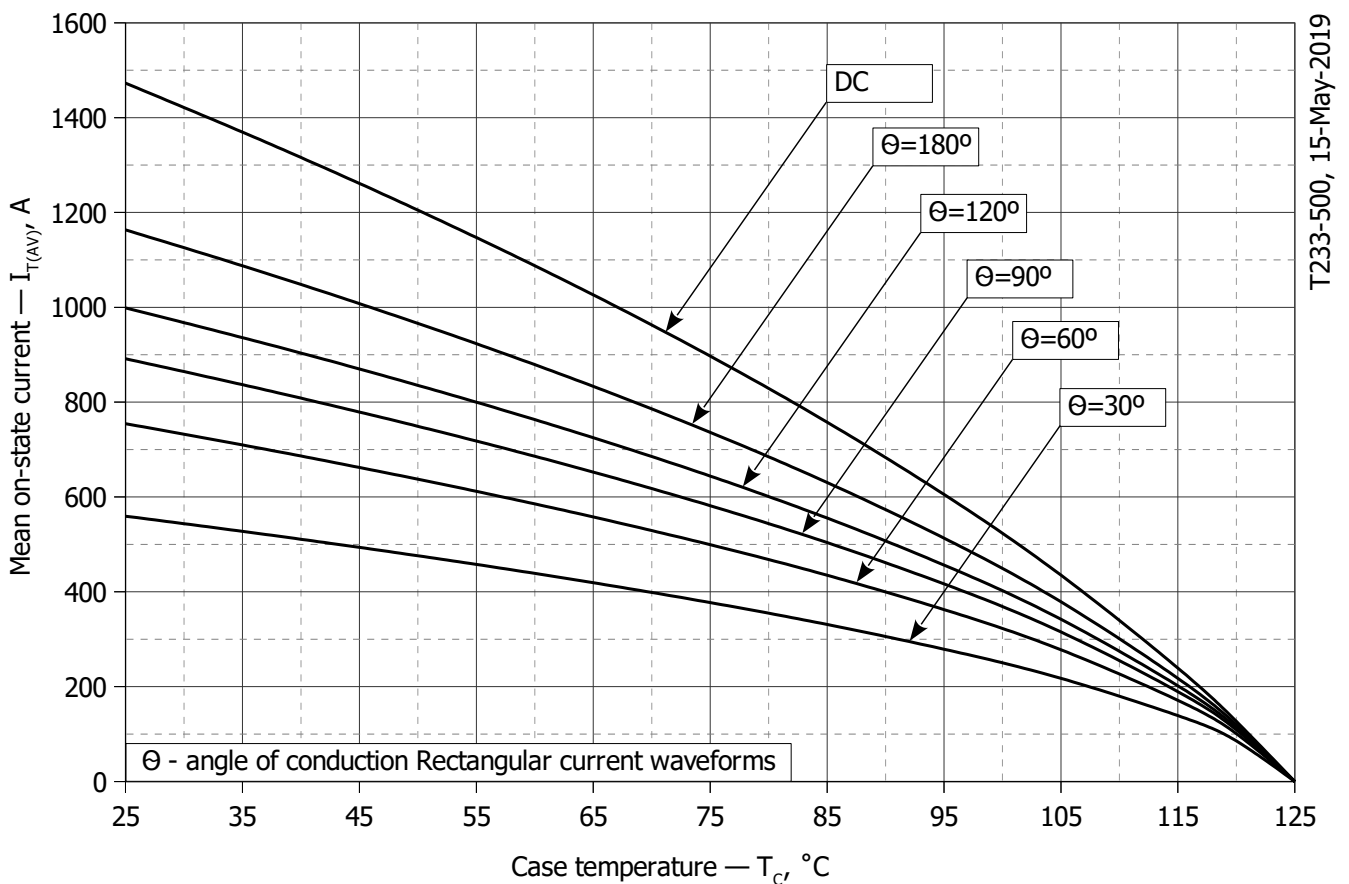


Fig. 10 - Mean on-state current I_{TAV} vs. case temperature T_c for rectangular current waveforms at different conduction angles and for DC ($f=50\text{Hz}$, DSC)

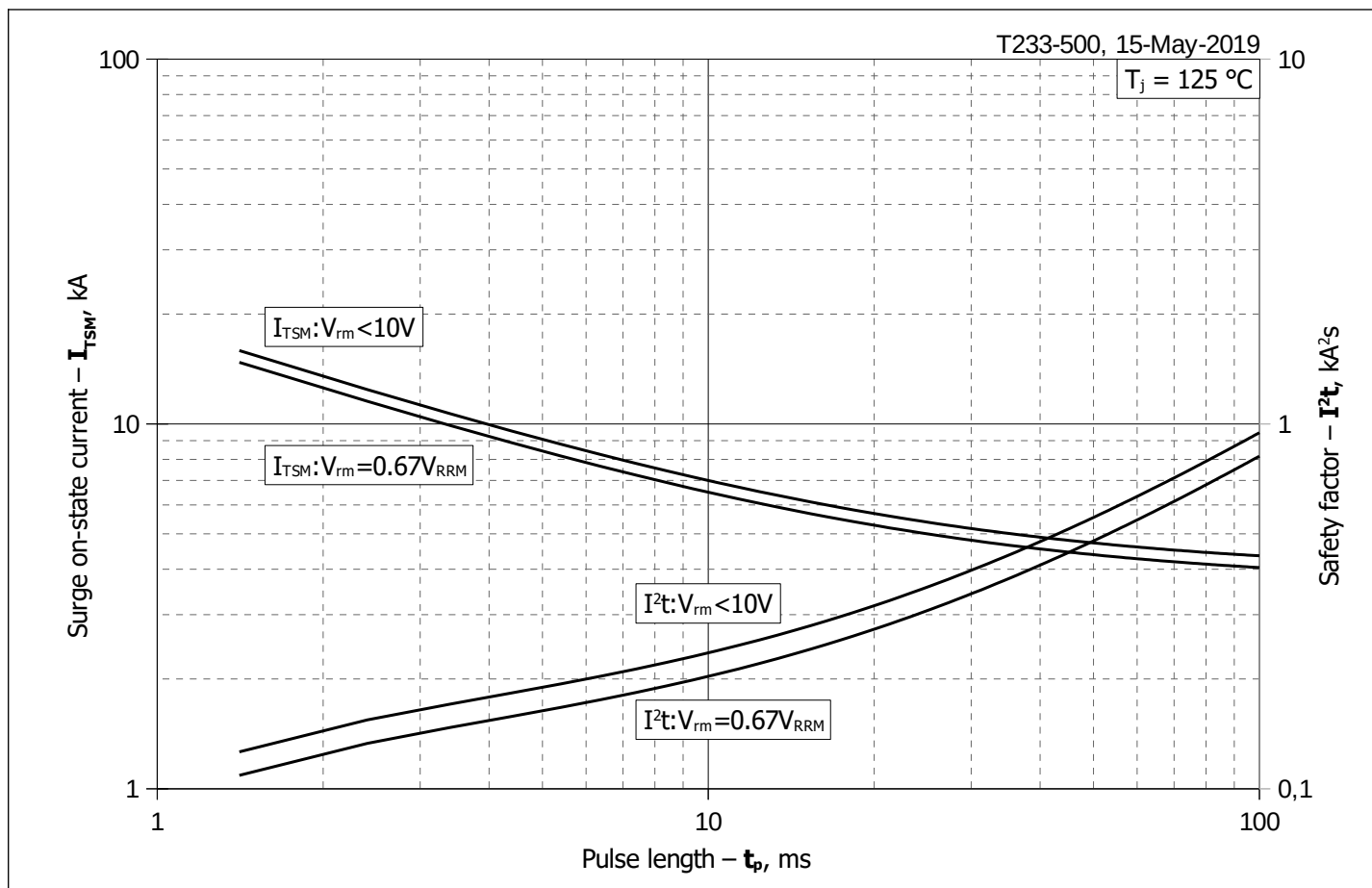


Fig. 11 – Maximum surge on-state current I_{TSM} and safety factor I^2t vs. pulse length t_p

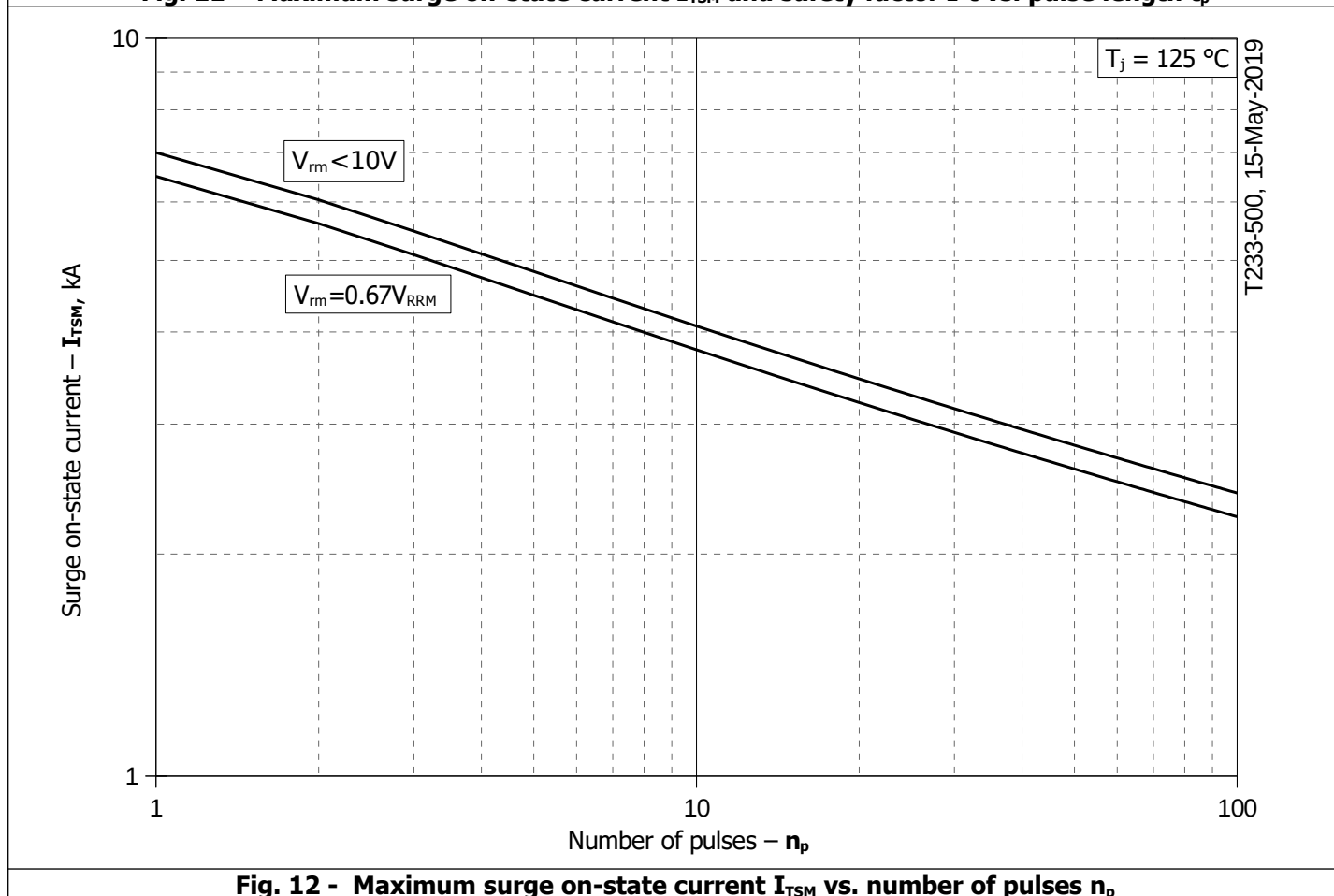


Fig. 12 - Maximum surge on-state current I_{TSM} vs. number of pulses n_p