***flow* 90PIM 1 600V/20A**

V23990-P634-A-02-14

Maximum Ratings / Höchstzulässige Werte — P634-A

Parameter	Condition		Symbol	Datasheet values max.	Unit
Input Rectifier Bridge					
Gleichrichter					
Repetitive peak reverse voltage			V_{RRM}	1600	V
Periodische Rückw. Spitzensperrspannung					
Forward current per diode	DC current	T_h=80°C;	I_{FAV}	30	A
Dauergrenzstrom		Tc=80°C		30	
Surge forward current	t_p=10ms	T_j=25°C	I_{FSM}	200	A
Stoßstrom Grenzwert					
I^2t-value	t_p=10ms	T_j=25°C	I^2t	200	A2s
Grenzlastintegral					
Power dissipation per Diode	T_j=150°C	T_h=80°C	P_{tot}	42	W
Verlustleistung pro Diode		T_c=80°C		64	
max. Chip temperature			T_{jmax}	**150**	°C
max. Chiptemperatur					
Transistor Inverter					
Transistor Wechselrichter					
Collector-emitter break down voltage			V_{CE}	600	V
Kollektor-Emitter-Sperrspannung					
DC collector current	T_j=175°C	T_h=80°C,	I_C	24	A
Kollektor-Dauergleichstrom		T_c=80°C		30	
Repetitive peak collector current	tp limited by Tj max		I_{cpuls}	60	A
Periodischer Kollektorspitzenstrom					
Power dissipation per IGBT	T_j=175°C	T_h=80°C	P_{tot}	50	W
Verlustleistung pro IGBT		T_c=80°C		75	
Gate-emitter peak voltage			V_{GE}	±20	V
Gate-Emitter-Spitzenspannung					
SC withstand time*	Tj≤150°C	V_{GE}=15V	t_{SC}	6	us
Kurzschlußverhalten*	V_{CC}=360V				
max. Chip temperature			T_{jmax}	**175**	°C
max. Chiptemperatur					
Diode Inverter					
Diode Wechselrichter					
DC forward current	T_j=175°C	T_h=80°C,	I_F	23	A
Dauergleichstrom		T_c=80°C		30	
Repetitive peak forward current	tp limited by Tj max		I_{FRM}	60	A
Periodischer Spitzenstrom					
Power dissipation per Diode	T_j=175°C	T_h=80°C	P_{tot}	39	W
Verlustleistung pro Diode		T_c=80°C		60	
max. Chip temperature			T_{jmax}	**175**	°C
max. Chiptemperatur					

flow 90PIM 1 600V/20A

Maximum Ratings / Höchstzulässige Werte					**P634-A**	
Parameter	**Condition**		**Symbol**	**Datasheet values** **max.**	**Unit**
Transistor BRC **Transistor Wechselrichter**					
Collector-emitter break down voltage Kollektor-Emitter-Sperrspannung			V_{CE}	600	V
DC collector current Kollektor-Dauergleichstrom	T_j=150°C T_j=150°C	T_h=80°C	I_C	15 15	A
Repetitive peak collector current Periodischer Kollektorspitzenstrom	t_p=1ms	T_h=80°C	I_{cpuls}	45	A
Power dissipation per IGBT Verlustleistung pro IGBT	T_j=150°C	T_h=80°C	P_{tot}	42 64	W
Gate-emitter peak voltage Gate-Emitter-Spitzenspannung			V_{GE}	±20	V
SC withstand time Kurzschlußverhalten	Tj≤150°C VCE=600/1200 V	VGE=15V	t_{SC}	6	us
max. Chip temperature max. Chiptemperatur			T_{jmax}	**175**	°C
Diode BRC **Diode BRC**					
DC forward current Dauergleichstrom	T_j=150°C T_j=150°C	T_h=80°C	I_F	10 10	A
Repetitive peak forward current Periodischer Spitzenstrom	t_p=1ms	T_h=80°C	I_{FRM}	30	A
Power dissipation per Diode Verlustleistung pro Diode	T_j=150°C	T_h=80°C	P_{tot}	31 38	W
max. Chip temperature max. Chiptemperatur			T_{jmax}	**175**	°C
Thermal properties **Thermische Eigenschaften**					
Storage temperature Lagertemperatur			T_{stg}	-40…+125	°C
Operation temperature Betriebstemperatur			T_{op}	-40…+125	°C
Insulation properties **Modulisolation**					
Insulation voltage Isolationsspannung		t=1min	V_{is}	4000	Vdc
Creepage distance Kriechstrecke				min 12,7	mm
Clearance Luftstrecke				min 12,7	mm

Additional notes and remarks: ** Allowed number of short circuits must be less than 1000 times, and time duration between short circuits should be more than 1 second!*

Characteristic values/ Charateristische Werte

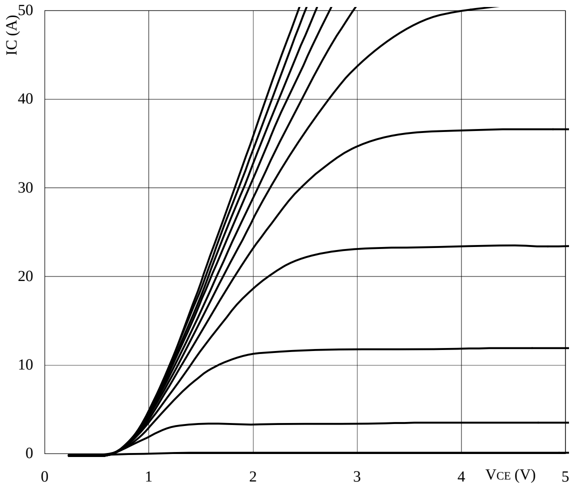
Description	Symbol	Conditions					Datasheet values			Unit
		T(C°)	Other conditions (Rgon-Rgoff)	VGE(V) VGS(V)	VCE(V) VDS(V)	IC(A) IF(A) Id(A)	Min	Typ	Max	
Input Rectifier Bridge										
Gleichrichter										
Forward voltage	V_F	Tj=25°C				30		1,23	1,5	V
Durchlaßpannung		Tj=125°C						1,22		
Threshold voltage (for power loss calc. only)	V_{to}	Tj=25°C				30		0,9		V
Schleusenspannung		Tj=150°C						0,79		
Slope resistance (for power loss calc. only)	r_t	Tj=25°C						0,011		Ohm
Ersatzwiderstand		Tj=150°C				30		0,014		
Reverse current	I_r	Tj=25°C			1500				0,01	mA
Sperrstrom		Tj=150°C								
Thermal resistance chip to heatsink per chip	R_{thJH}		Thermal grease					1,67		K/W
Wärmewiderstand Chip-Kühlkörper pro Chip			thickness≤50um							
Thermal resistance chip to case per chip	R_{thJC}		Warmeleitpaste					1,1022		
Wärmewiderstand Chip-Gehause pro Chip			Dicke≤50um λ = 0,61 W/mK							
Transistor Inverter										
Transistor Wechselrichter										
Gate emitter threshold voltage	$V_{GE(th)}$	Tj=25°C	VCE=VGE			0,00029	4,5	5,8	7	
Gate-Schwellenspannung		Tj=125°C								
Collector-emitter saturation voltage	$V_{CE(sat)}$	Tj=25°C		15		20		1,57	2,1	V
Kollektor-Emitter Sättigungsspannung		Tj=125°C						1,73		
Collector-emitter cut-off	I_{CES}	Tj=25°C		0	600				0,11	mA
Kollektor-Emitter Reststrom		Tj=125°C								
Gate-emitter leakage current	I_{GES}	Tj=25°C		20	0				350	nA
Gate-Emitter Reststrom		Tj=125°C								
Integrated Gate resistor	R_{gint}							none		Ohm
Integrirter Gate Widerstand										
Turn-on delay time	$t_{d(on)}$	Tj=25°C	Rgoff=8 Ω							ns
Einschaltverzögerungszeit		Tj=125°C	Rgon=16 Ω	15	300	20		17		
Rise time	t_r	Tj=25°C	Rgoff=8 Ω							ns
Anstiegszeit		Tj=125°C	Rgon=16 Ω	15	300	20		18		
Turn-off delay time	$t_{d(off)}$	Tj=25°C	Rgoff=8 Ω							ns
Abschaltverzögerungszeit		Tj=125°C	Rgon=16 Ω	15	300	20		182		
Fall time	t_f	Tj=25°C	Rgoff=8 Ω							ns
Fallzeit		Tj=125°C	Rgon=16 Ω	15	300	20		95		
Turn-on energy loss per pulse	E_{on}	Tj=25°C	Rgoff=8 Ω							mWs
Einschaltverlustenergie pro Puls		Tj=125°C	Rgon=16 Ω	15	300	20		0,521		
Turn-off energy loss per pulse	E_{off}	Tj=25°C	Rgoff=8 Ω							mWs
Abschaltverlustenergie pro Puls		Tj=125°C	Rgon=16 Ω	15	300	20		0,608		
SC withstand time	t_{SC}									us
Kurzschlußverhalten										
Input capacitance	C_{ies}	Tj=25°C	f=1MHz	0	25			1,1		nF
Eingangskapazität		Tj=125°C								
Output capacitance	C_{oss}	Tj=25°C	f=1MHz	0	25			0,071		nF
Ausgangskapazität		Tj=125°C								
Reverse transfer capacitance	C_{rss}	Tj=25°C	f=1MHz	0	25			0,032		nF
Rückwirkungskapazität		Tj=125°C								
Gate charge	Q_{Gate}	Tj=25°C						tbd		nC
Gate Ladung		Tj=125°C								
Thermal resistance chip to heatsink per chip	R_{thJH}		Thermal grease					1,92		K/W
Wärmewiderstand Chip-Kühlkörper pro Chip			thickness≤50um							
Thermal resistance chip to case per chip	R_{thJC}		Warmeleitpaste					1,27		K/W
Wärmewiderstand Chip-Gehause pro Chip			Dicke≤50um λ = 0,61 W/mK							
Diode Inverter										
Diode Wechselrichter										
Diode forward voltage	V_F	Tj=25°C				20		1,75	2,1	V
Durchlaßspannung		Tj=125°C						1,67		
Peak reverse recovery current	I_{RM}	Tj=25°C								A
Rückstromspitze		Tj=125°C	diF/dt = 507 A/us	0	300	20		15,17		
Reverse recovery time	t_{rr}	Tj=25°C								ns
Sperreverzögerungszeit		Tj=125°C	diF/dt = 507 A/us	0	300	20		224,8		
Reverse recovered charge	Q_{rr}	Tj=25°C								uC
Sperrverzögerungsladung		Tj=125°C	diF/dt = 507 A/us	0	300	20		1,29		
Reverse recovered energy	Erec	Tj=25°C								mWs
Sperrverzögerungsenergie		Tj=125°C	diF/dt = 507 A/us	0	300	20		0,247		
Thermal resistance chip to heatsink per chip	R_{thJH}		Thermal grease					2,41		K/W
Wärmewiderstand Chip-Kühlkörper pro Chip			thickness≤50um							
Thermal resistance chip to case per chip	R_{thJC}		Warmeleitpaste					1,59		K/W
Wärmewiderstand Chip-Gehause pro Chip			Dicke≤50um λ = 0,61 W/mK							

Characteristic values/ Charateristische Werte

Description	Symbol	Conditions					Datasheet values			Unit
		T(C°)	Other conditions (Rgon-Rgoff)	VGE(V) VGS(V)	VCE(V) VDS(V)	IC(A) IF(A) Id(A)	Min	Typ	Max	
Transistor BRC										
Transistor BRC										
Gate emitter threshold voltage	$V_{GE(th)}$	Tj=25°C	VCE=VGE			0,00021	4,5	5,8	7	V
Gate-Schwellenspannung		Tj=125°C								
Collector-emitter saturation voltage	$V_{CE(sat)}$	Tj=25°C		15		15		1,53	2,1	V
Kollektor-Emitter Sättigungsspannung		Tj=125°C						1,73		
Collector-emitter cut-off	I_{CES}	Tj=25°C		0	600				0,04	mA
Kollektor-Emitter Reststrom		Tj=125°C								
Gate-emitter leakage current	I_{GES}	Tj=25°C		20	0				350	nA
Gate-Emitter Reststrom		Tj=125°C								
Integrated Gate resistor	R_{gint}									Ohm
Integrirter Gate Widerstand										
Turn-on delay time	$t_{d(on)}$	Tj=25°C	Rgon=16Ω	15	300	15				ns
Einschaltverzögerungszeit		Tj=125°C	Rgoff=8Ω					15,8		
Rise time	t_r	Tj=25°C	Rgon=16Ω	15	300	15				ns
Anstiegszeit		Tj=125°C	Rgoff=8Ω					15,2		
Turn-off delay time	$t_{d(off)}$	Tj=25°C	Rgon=16Ω	15	300	15				ns
Abschaltverzögerungszeit		Tj=125°C	Rgoff=8Ω					154,2		
Fall time	t_f	Tj=25°C	Rgon=16Ω	15	300	15				ns
Fallzeit		Tj=125°C	Rgoff=8Ω					94,7		
Turn-on energy loss per pulse	E_{on}	Tj=25°C	Rgon=16Ω	15	300	15				uWs
Einschaltverlustenergie pro Puls		Tj=125°C	Rgoff=8Ω					0,34		
Turn-off energy loss per pulse	E_{off}	Tj=25°C	Rgon=16Ω	15	300	15				uWs
Abschaltverlustenergie pro Puls		Tj=125°C	Rgoff=8Ω					0,39		
SC withstand time	t_{SC}									us
Kurzschlußverhalten										
Input capacitance	C_{iss}	Tj=25°C	f=1MHz	0	25			0,86		nF
Eingangskapazität		Tj=125°C								
Output capacitance	C_{oss}	Tj=25°C	f=1MHz	0	25			0,055		nF
Ausgangskapazität		Tj=125°C								
Reverse transfer capacitance	Cies	Tj=25°C	f=1MHz	0	25			0,024		nF
Rückwirkungskapazität		Tj=125°C								
Gate charge	Qgate	Tj=25°C						tbd		nC
Gate Ladung		Tj=125°C								
Thermal resistance chip to heatsink per chip	R_{thJH}		Thermal grease thickness≤50um					2,24		K/W
Wärmewiderstand Chip-Kühlkörper pro Chip			Warmeleitpaste Dicke≤50um λ = 0,61 W/mK					1,4784		
Diode BRC										
Diode BRC										
Diode forward voltage	V_F	Tj=25°C				10		1,64	2,2	V
Durchlaßspannung		Tj=125°C						1,57		
Reverse current	I_r	Tj=25°C	Rgon=16Ω	15	300	10			0,06	uA
Sperrstrom		Tj=125°C								
Reverse recovery time	t_{rr}	Tj=25°C	Rgon=16Ω	15	300	10				ns
Sperreverzögerungszeit		Tj=125°C						273,7		
Reverse recovered charge	Q_{rr}	Tj=25°C	Rgon=16Ω	15	300	10				uC
Sperrverzögerungsladung		Tj=125°C						0,98		
Reverse recovery energy	E_{rec}	Tj=25°C	Rgon=16Ω	15	300	10				uWs
Sperrverzögerungsenergie		Tj=125°C								
Thermal resistance chip to heatsink per chip	R_{thJH}		Thermal grease thickness≤50um					3,05		K/W
Wärmewiderstand Chip-Kühlkörper pro Chip			Warmeleitpaste Dicke≤50um λ = 0,61 W/mK							
NTC-Thermistor										
NTC-Widerstand										
Rated resistance	R_{25}	Tj=25°C	Tol. ±5%				20,9	22	23,1	kOhm
Nennwiderstand										
Deviation of R100	$D_{R/R}$	Tc=100°C	R100=1503Ω					2,9		%/K
Abweichung von R100										
Power dissipation given Epcos-Typ	P	Tj=25°C						210		mW
Verlustleistung Epcos-Typ angeben										
B-value	$B_{(25/100)}$	Tj=25°C	Tol. ±3%					3980		K
B-Wert										

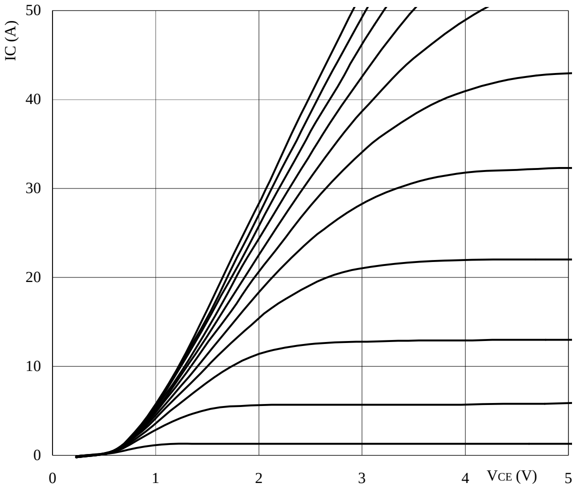
Output inverter

Figure 1. **Typical output characteristics**
Output inverter IGBT
Ic= f(VCE)



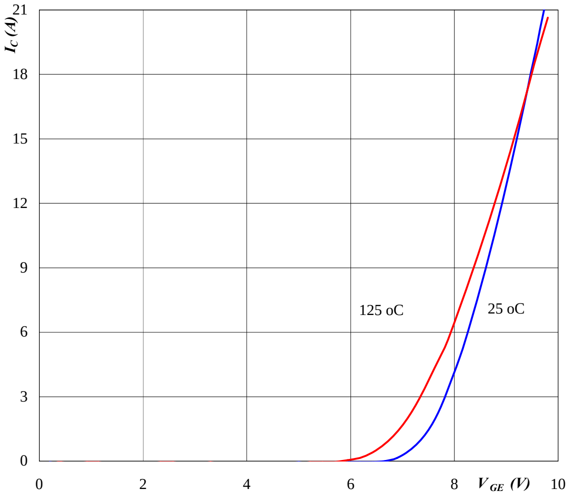
parameter: tp = 250 us Tj = 25 °C
VGE parameter: from: 7 V to 17 V
in 1 V steps

Figure 2. **Typical output characteristics**
Output inverter IGBT
Ic= f(VCE)



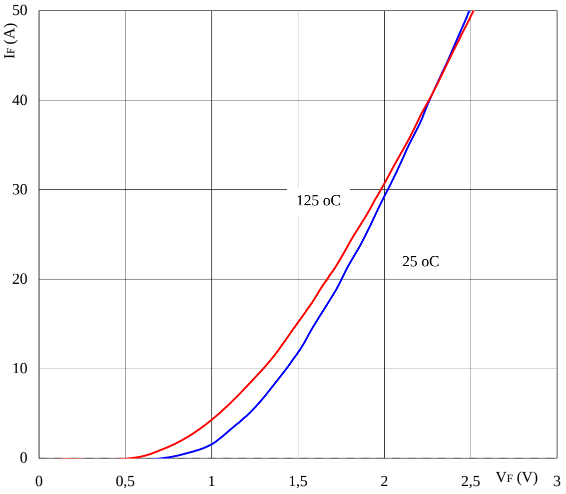
parameter: tp = 250 us Tj = 125 °C
VGE parameter: from: 7 V to 17 V
in 1 V steps

Figure 3. **Typical transfer characteristics**
Output inverter IGBT
Ic= f(VGE)



parameter: tp = 250 us VCE = 10 V

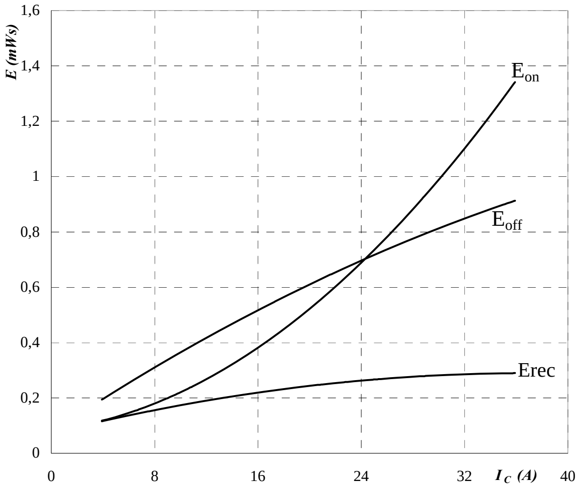
Figure 4. **Typical diode forward current as a function of forward voltage**
Output inverter FRED IF=f(VF)



parameter: tp = 250 us

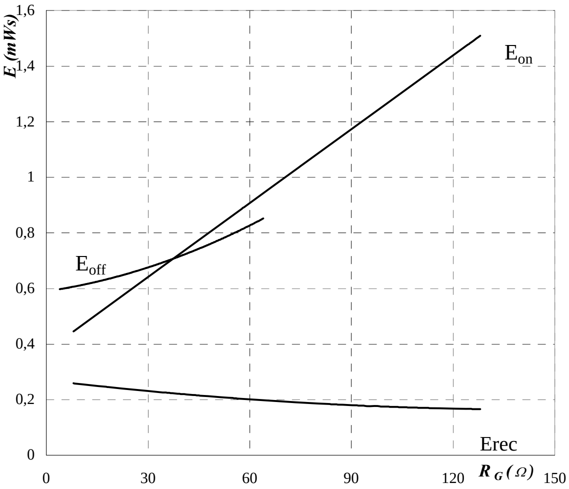
Output inverter

Figure 5. Typical switching energy losses as a function of collector current
Output inverter IGBT
E = f (Ic)



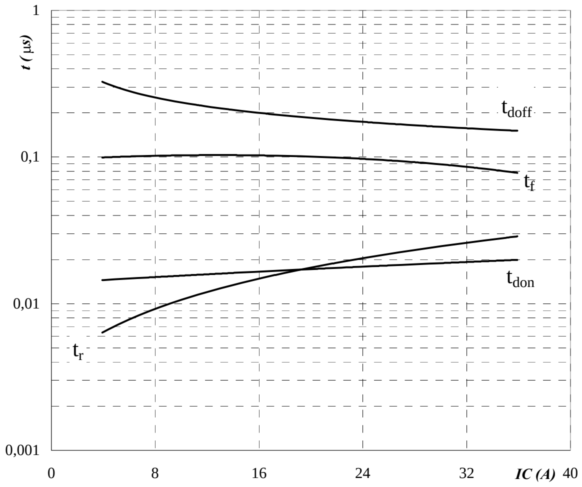
inductive load, Tj = 125 °C
VCE = 300 V
VGE= 15 V
Rgon= 16 Ω
Rgoff= 8 Ω

Figure 6. Typical switching energy losses as a function of gate resistor
Output inverter IGBT
E = f (RG)



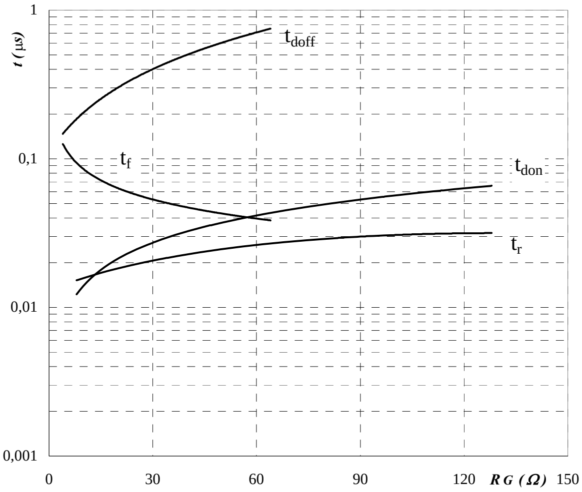
inductive load, Tj = 125 °C
VCE = 300 V
VGE= 15 V
Ic = 20 A

Figure 7. Typical switching times as a function of collector current
Output inverter IGBT
t = f (Ic)



inductive load, Tj = 125 °C
VCE = 300 V
VGE= 15 V
Rgon= 16 Ω
Rgoff= 8 Ω

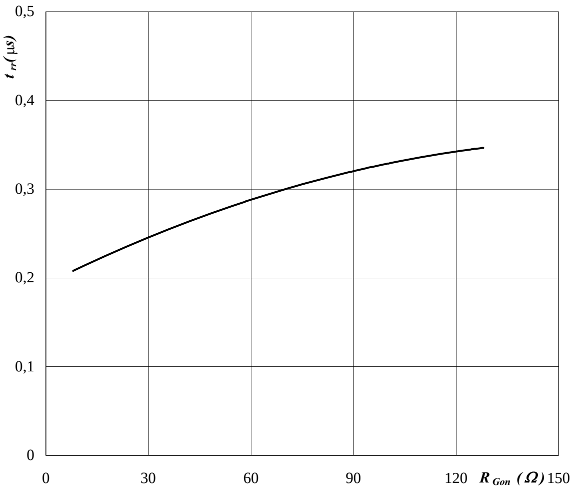
Figure 8. Typical switching times as a function of gate resistor
Output inverter IGBT
t = f (RG)



inductive load, Tj = 125 °C
VCE = 300 V
VGE= 15 V
Ic = 20 A

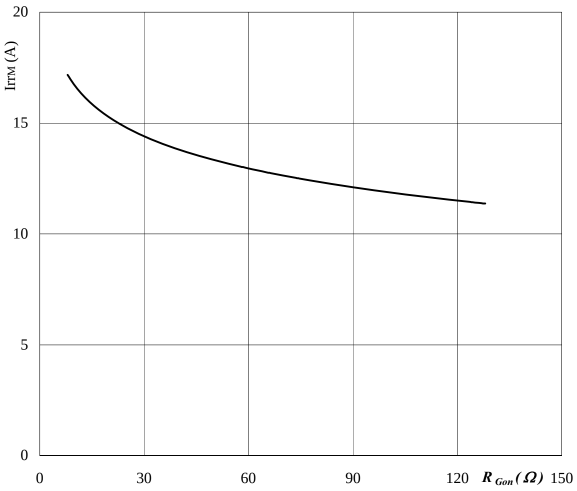
Output inverter

Figure 9. **Typical reverse recovery time as a function of IGBT turn on gate resistor**
Output inverter FRED diode
t_{rr} = f (Rgon)



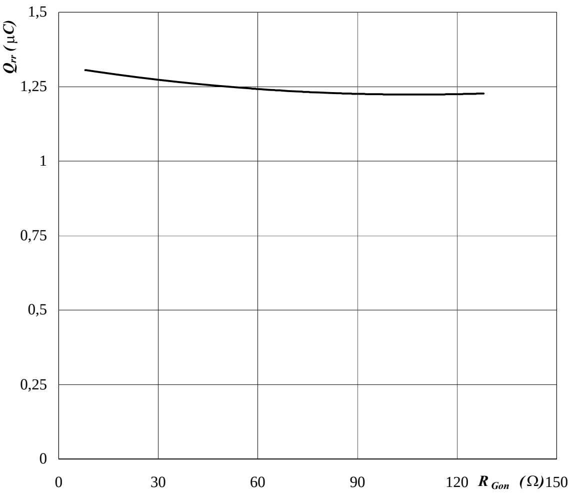
T_j = 125 °C
V_R = 300 V
I_F= 20 A
V_{GE}= 15 V

Figure 10. **Typical reverse recovery current as a function of IGBT turn on gate resistor**
Output inverter FRED diode
I_{RRM} = f (Rgon)



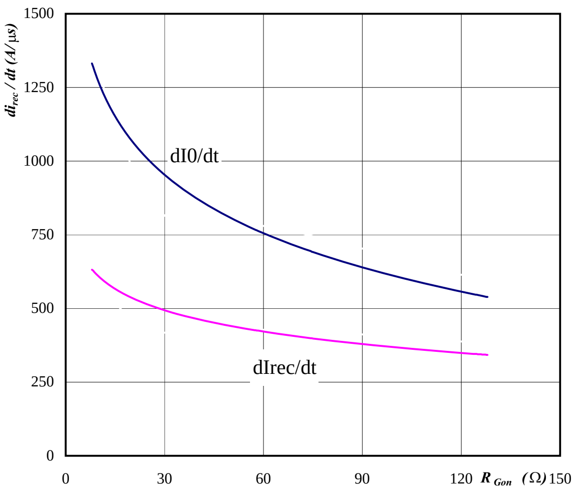
T_j = 125 °C
V_R = 300 V
I_F= 20 A
V_{GE}= 15 V

Figure 11. **Typical reverse recovery charge as a function of IGBT turn on gate resistor**
Output inverter FRED diode
Q_{rr} = f (Rgon)



T_j = 125 °C
V_R = 300 V
I_F= 20 A
V_{GE}= 15 V

Figure 12. **Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor**
Output inverter FRED diode
dI0/dt,dIrec/dt= f (Rgon)

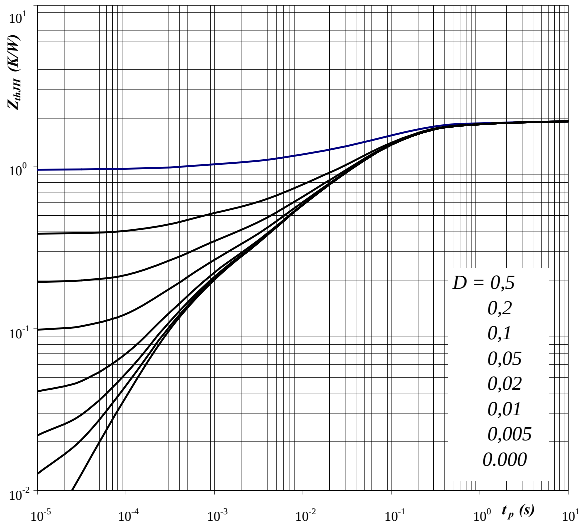


T_j = 125 °C
V_R = 300 V
I_F= 20 A
V_{GE}= 15 V

Output inverter

Figure 13. IGBT transient thermal impedance as a function of pulse width

$Z_{th}JH = f(t_p)$



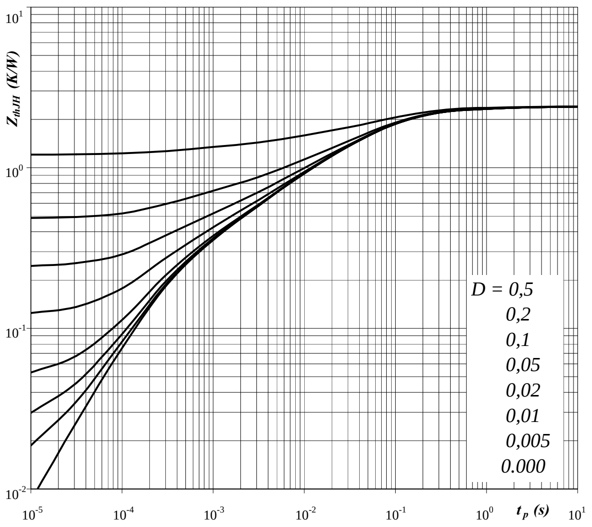
Parameter: D = tp / T RthJH= 1,92 K/W

IGBT thermal model values

R (C/W)	Tau (s)
0,07	4,7E+00
0,18	5,9E-01
0,86	1,0E-01
0,44	2,4E-02
0,23	4,4E-03
0,14	4,2E-04

Figure 14. FRED transient thermal impedance as a function of pulse width

$Z_{th}JH = f(t_p)$



Parameter: D = tp / T RthJH= 2,41 K/W

FRED thermal model values

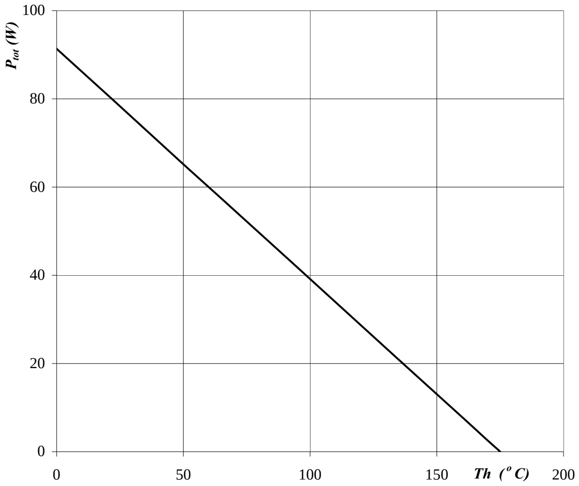
R (C/W)	Tau (s)
0,09	3,5E+00
0,25	3,8E-01
1,02	7,3E-02
0,51	1,5E-02
0,32	2,9E-03
0,22	3,2E-04

Output inverter

Figure 15. Power dissipation as a function of heatsink temperature

Output inverter IGBT

$P_{tot} = f(Th)$

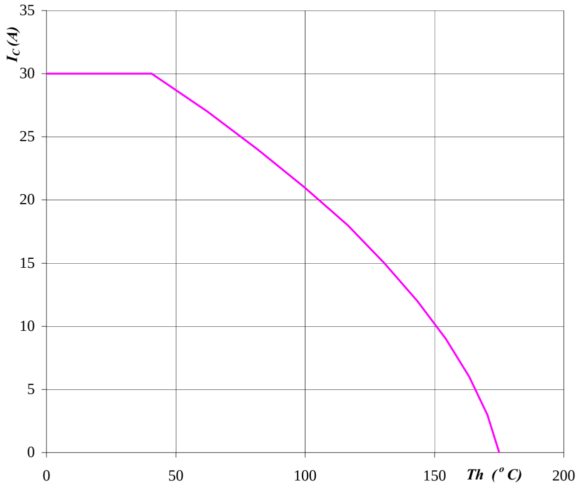


parameter: Tj= 175 ºC

Figure 16. Collector current as a function of heatsink temperature

Output inverter IGBT

$I_C = f(Th)$



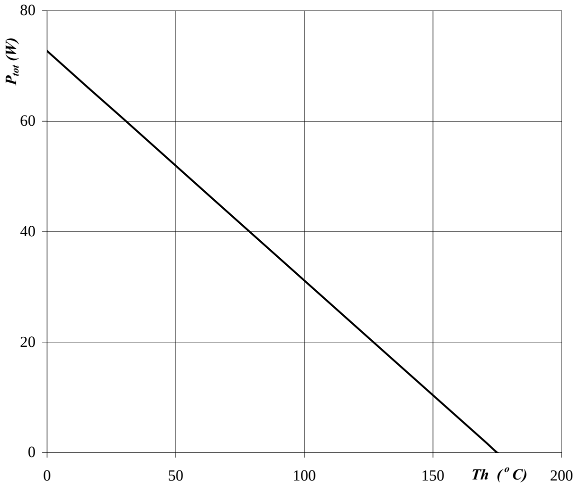
parameter: Tj= 175 ºC

V_{GE}= 15 V

Figure 17. Power dissipation as a function of heatsink temperature

Output inverter FRED

$P_{tot} = f(Th)$

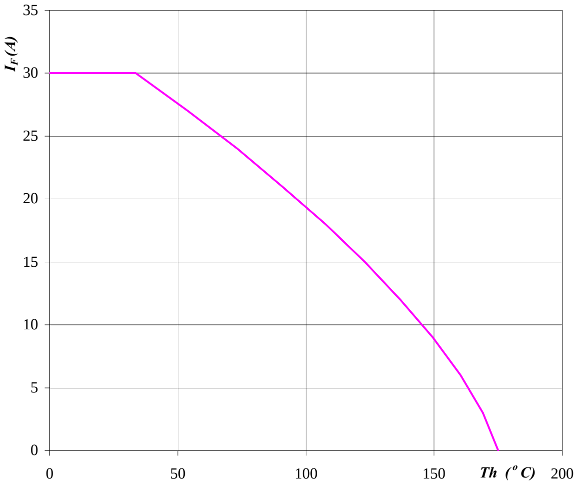


parameter: Tj= 175 ºC

Figure 18. Forward current as a function of heatsink temperature

Output inverter FRED

$I_F = f(Th)$



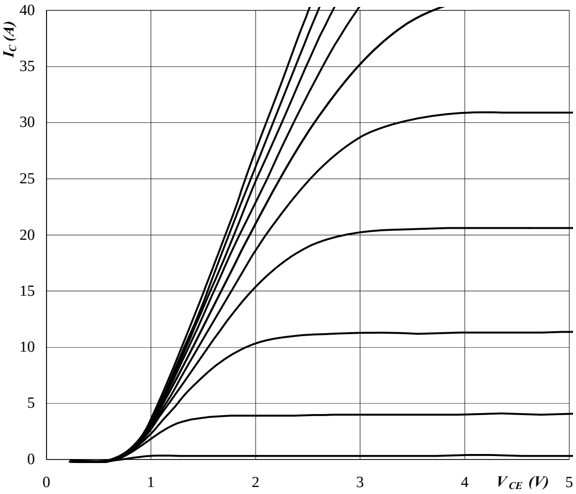
parameter: Tj= 175 ºC

Brake

Figure 1. Typical output characteristics

Brake IGBT

Ic= f(VCE)

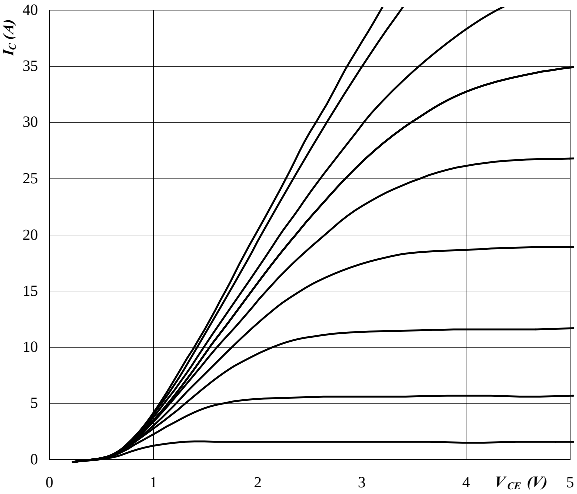


parameter: tp = 250 us Tj = 25 °C
VGE parameter: from: 7 V to 17 V
in 1 V steps

Figure 2. Typical output characteristics

Brake IGBT

Ic= f(VCE)

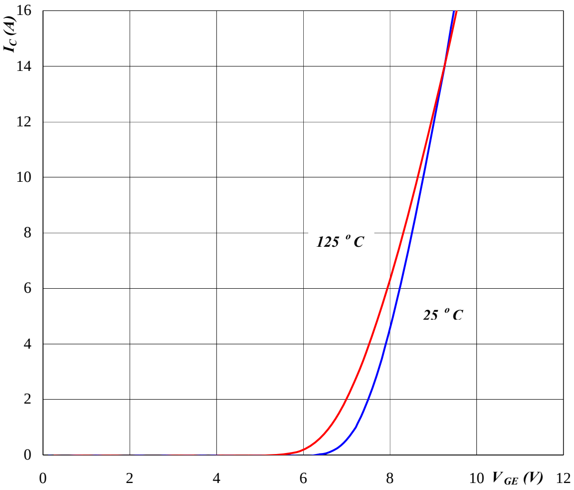


parameter: tp = 250 us Tj = 125 °C
VGE parameter: from: 7 V to 17 V
in 1 V steps

Figure 3. Typical transfer characteristics

Brake IGBT

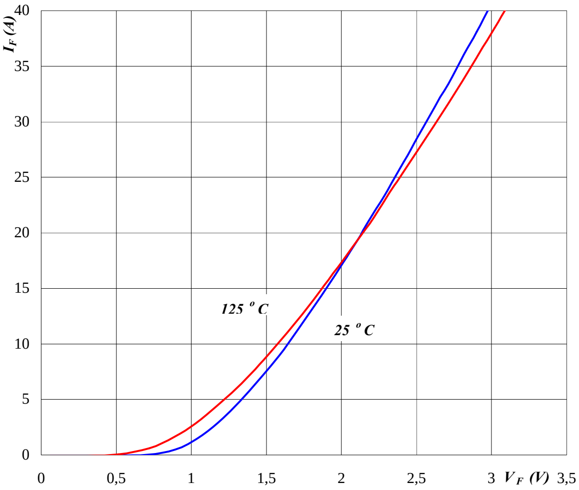
Ic= f(VGE)



parameter: tp = 250 us VCE = 10 V

Figure 4. Typical diode forward current as a function of forward voltage

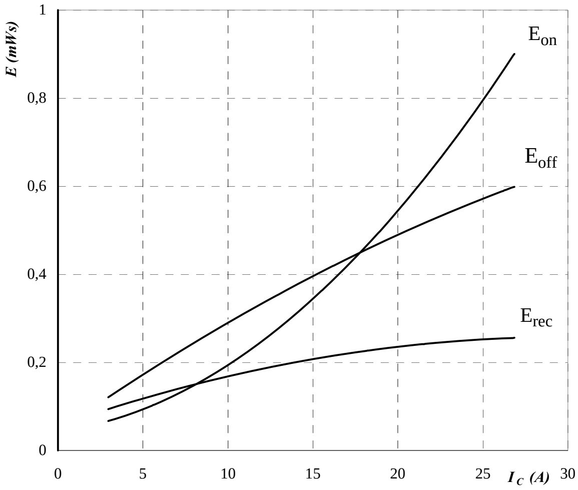
Brake FRED IF=f(VF)



parameter: tp = 250 us

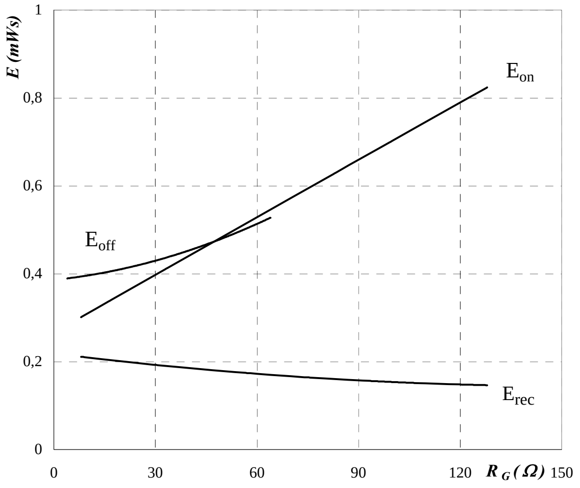
Brake

Figure 5. **Typical switching energy losses as a function of collector current**
Brake IGBT
E = f (Ic)



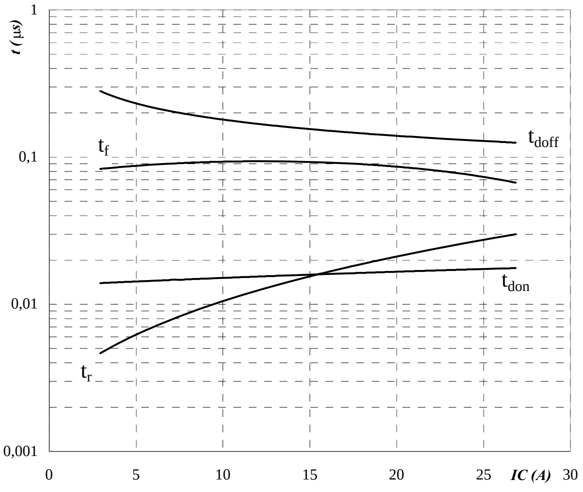
inductive load, Tj = 125 °C
V_{CE} = 300 V
V_{GE}= 15 V
Rgon = 16 Ω
Rgoff = 8 Ω

Figure 6. **Typical switching energy losses as a function of gate resistor**
Brake IGBT
E = f (R_G)



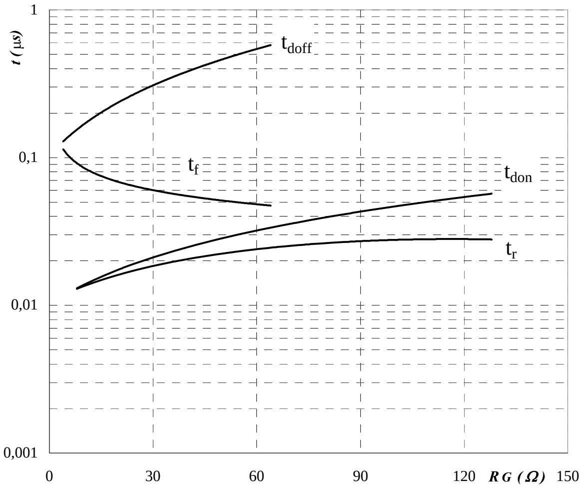
inductive load, Tj = 125 °C
V_{CE} = 300 V
V_{GE}= 15 V
Ic = 15 A

Figure 7. **Typical switching times as a function of collector current**
Brake IGBT
t = f (Ic)



inductive load, Tj = 125 °C
V_{CE} = 300 V
V_{GE}= 15 V
Rgon = 16 Ω
Rgoff = 8 Ω

Figure 8. **Typical switching times as a function of gate resistor**
Brake IGBT
t = f (R_G)

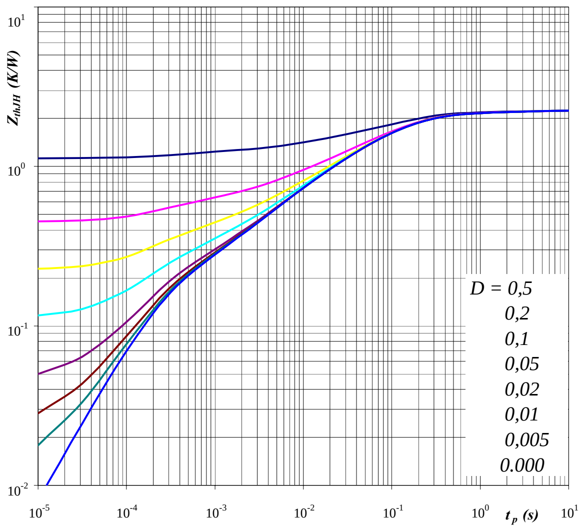


inductive load, Tj = 125 °C
V_{CE} = 300 V
V_{GE}= 15 V
Ic = 15 A

Brake

Figure9. IGBT transient thermal impedance as a function of pulse width

$Z_{thJH} = f(tp)$

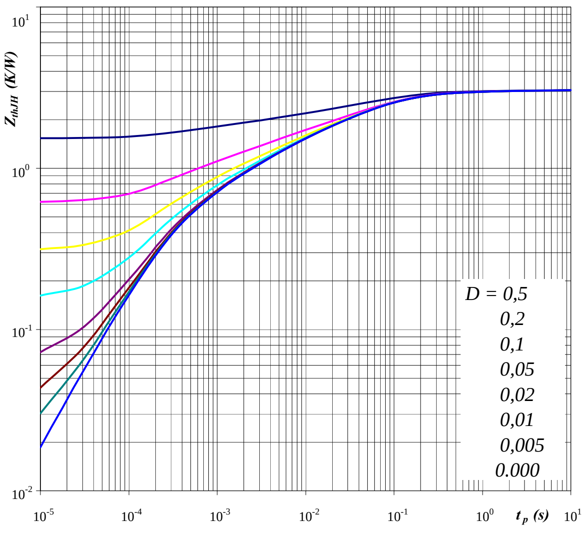


Parameter: D = tp / T

RthJH= 2,24 K/W

Figure 10. FRED transient thermal impedance as a function of pulse width

$Z_{thJH} = f(tp)$



Parameter: D = tp / T

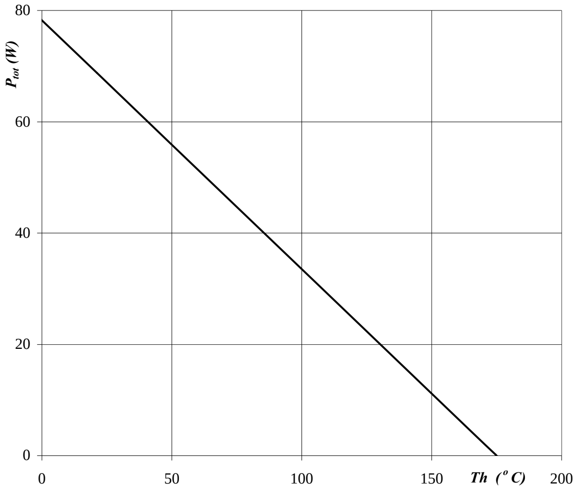
RthJH= 3,05 K/W

Brake

Figure 11. **Power dissipation as a function of heatsink temperature**

Brake IGBT

$P_{tot} = f(T_h)$

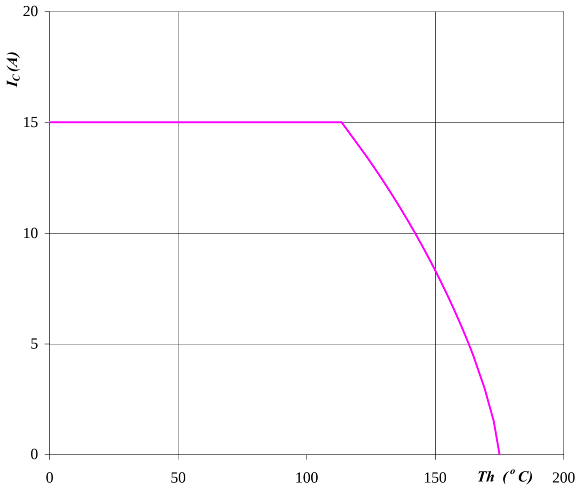


parameter: Tj= 175 °C

Figure 12. **Collector current as a function of heatsink temperature**

Brake IGBT

$I_C = f(T_h)$



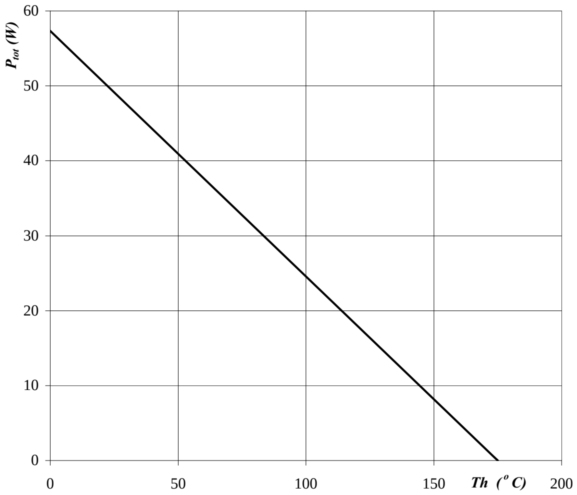
parameter: Tj= 175 °C

V_{GE}= 15 V

Figure 13. **Power dissipation as a function of heatsink temperature**

Brake FRED

$P_{tot} = f(T_h)$

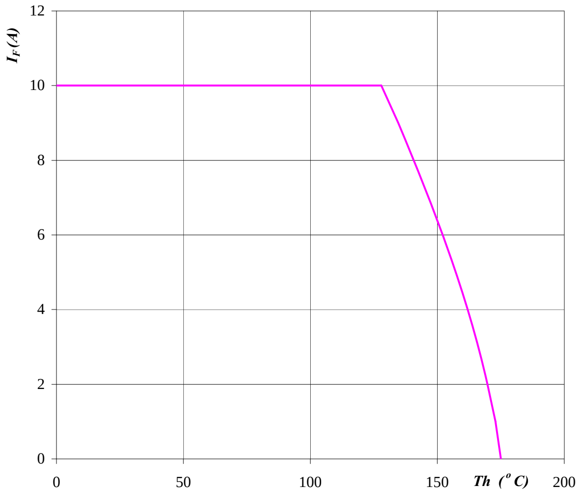


parameter: Tj= 175 °C

Figure 14. **Forward current as a function of heatsink temperature**

Brake FRED

$I_F = f(T_h)$



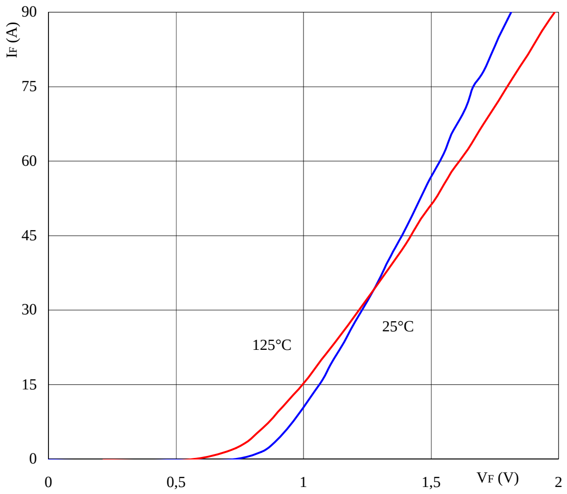
parameter: Tj= 175 °C

Input rectifier bridge

Figure 1. Typical diode forward current as a function of forward voltage

Rectifier diode

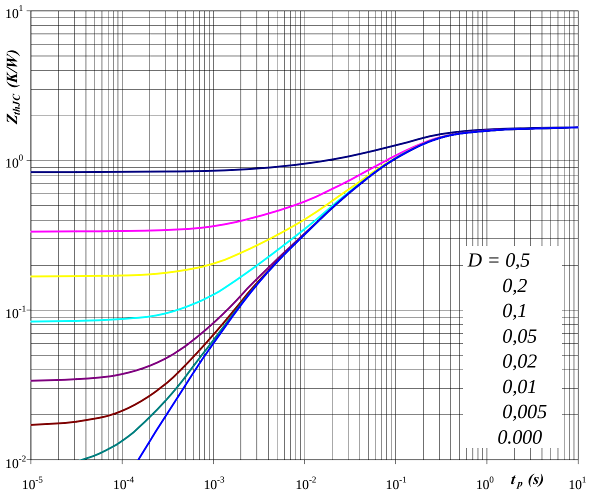
$I_F=f(V_F)$



parameter: tp = 250 us

Figure 2. Diode transient thermal impedance as a function of pulse width

$Z_{th}JH = f(tp)$



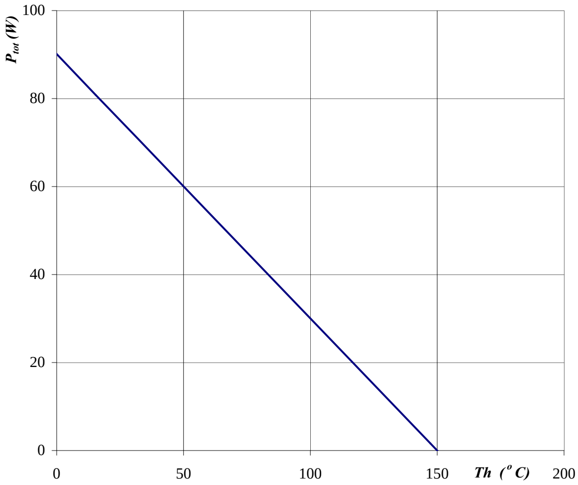
Parameter: D = tp / T

RthJH= 1,67 K/W

Figure 3. Power dissipation as a function of heatsink temperature

Rectifier diode

$P_{tot} = f\ (Th)$

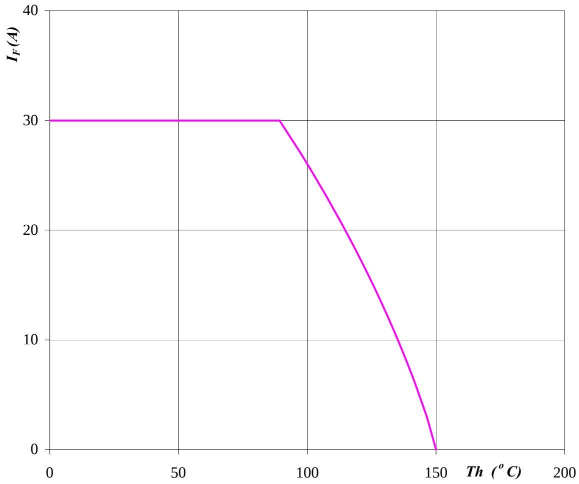


parameter: Tj= 150 ºC

Figure 4. Forward current as a function of heatsink temperature

Rectifier diode

$I_F = f\ (Th)$

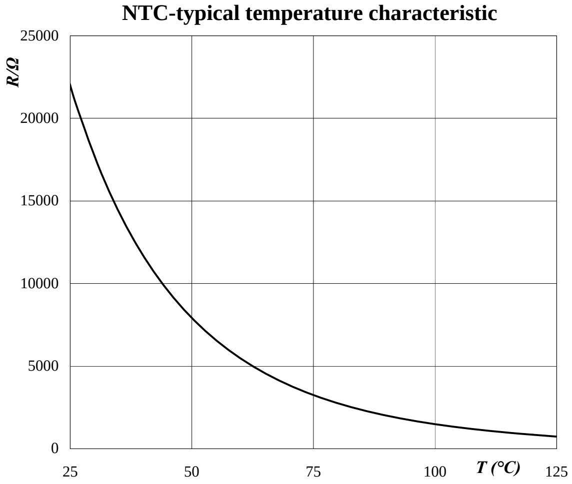


parameter: Tj= 150 ºC

Thermistor

Figure 1. **Typical NTC characteristic as afunction of temperature**

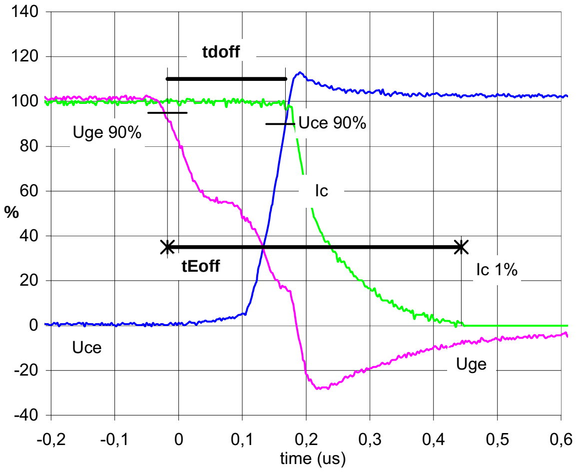
R_T = f (T)



Switching definitions

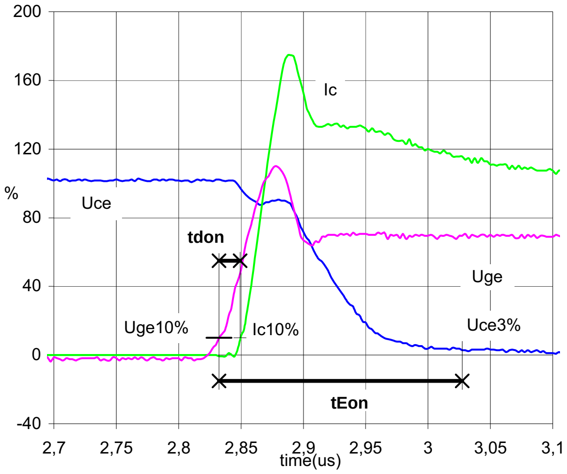
General conditions: Tj= 125 °C Rgon= 16 Ω Rgoff= 8,0 Ω

Figure 1. Turn-off Switching Waveforms & definition of tdoff, t_{Eoff} (t_{Eoff} = integrating time for E_{off})
Output inverter IGBT



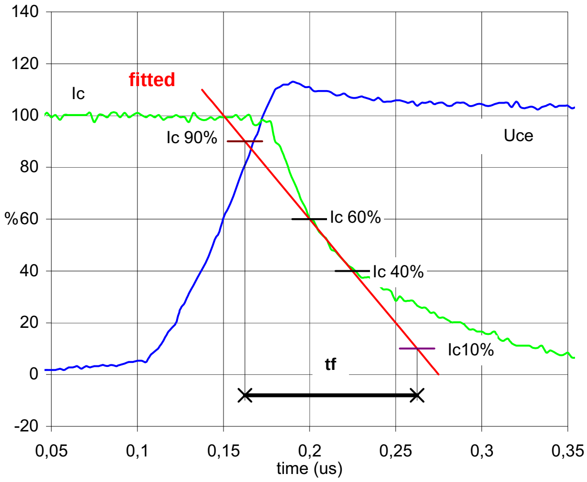
Uge(0%)= 0 V
Uge(100%)= 15 V
Uc(100%)= 300 V
Ic(100%)= 20 A
tdoff= 0,18 us
t_{Eoff}= 0,46 us

Figure 2. Turn-on Switching Waveforms & definition of t_{don}, t_{Eon} (t_{Eon} = integrating time for E_{on})
Output inverter IGBT



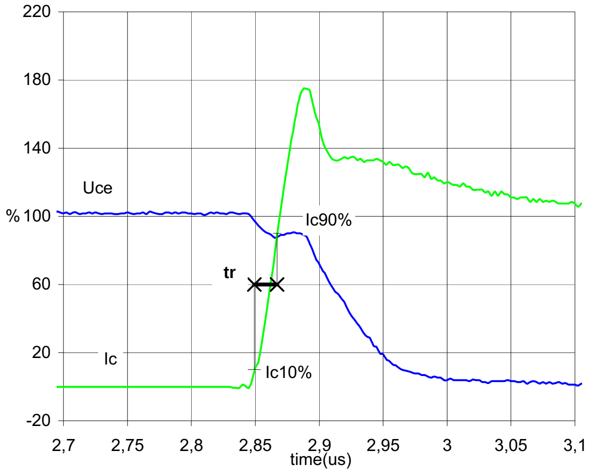
Uge(0%)= 0 V
Uge(100%)= 15 V
Uc(100%)= 300 V
Ic(100%)= 20 A
tdon= 0,02 us
t_{Eon}= 0,19 us

Figure 3. Turn-off Switching Waveforms & definition of t_f
Output inverter IGBT



Uc(100%)= 300 V
Ic(100%)= 20 A
t_f= 0,095 us

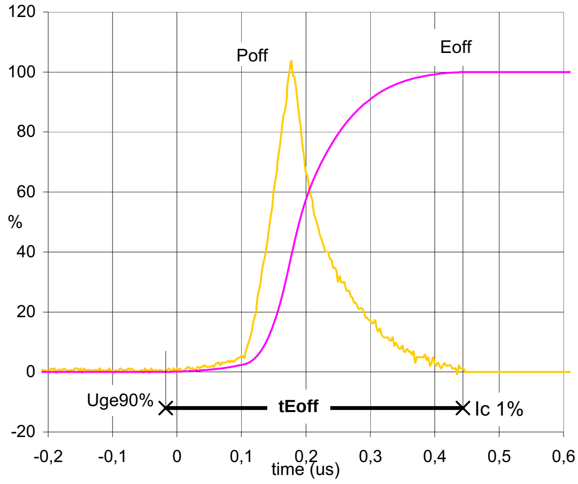
Figure 4. Turn-on Switching Waveforms & definition of t_r
Output inverter IGBT



Uc(100%)= 300 V
Ic(100%)= 20 A
t_r= 0,018 us

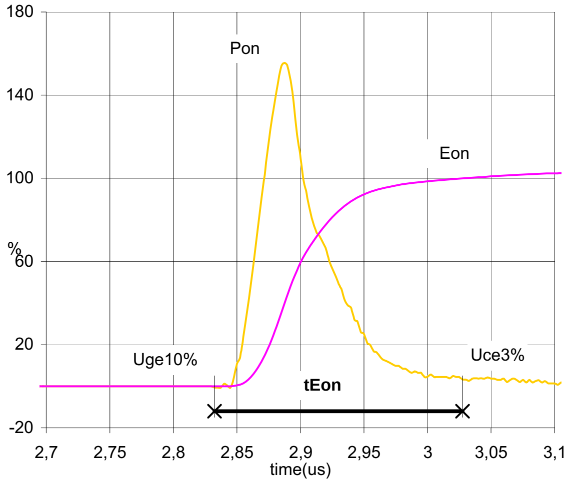
Switching definitions

Figure 5. **Turn-off Switching Waveforms & definition of t_{Eoff}**
Output inverter IGBT



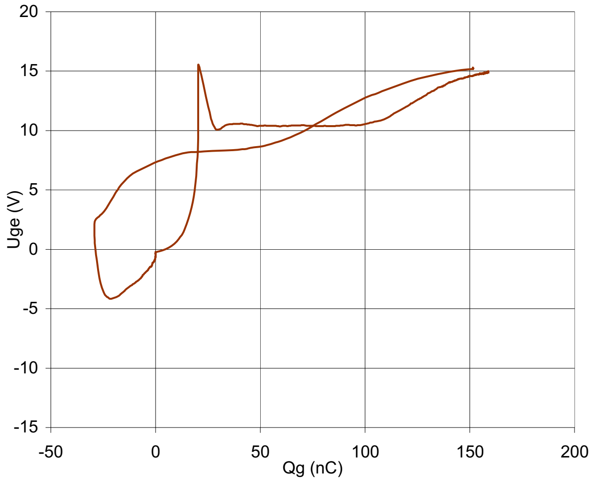
Poff(100%)=	5,99 kW
Eoff(100%)=	0,61 mJ
t_{Eoff}=	0,46 us

Figure 6. **Turn-on Switching Waveforms & definition of t_{Eon}**
Output inverter IGBT



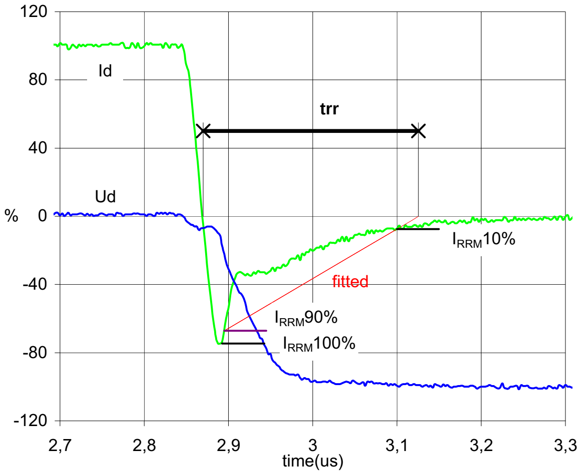
Pon(100%)=	5,99 kW
Eon(100%)=	0,52 mJ
t_{Eon}=	0,19 us

Figure 7. **Gate voltage vs Gate charge**
Output inverter IGBT



Ugeoff=	0 V
Ugeon=	15 V
Uc(100%)=	300 V
Ic(100%)=	20 A
Qg=	158,8 nC

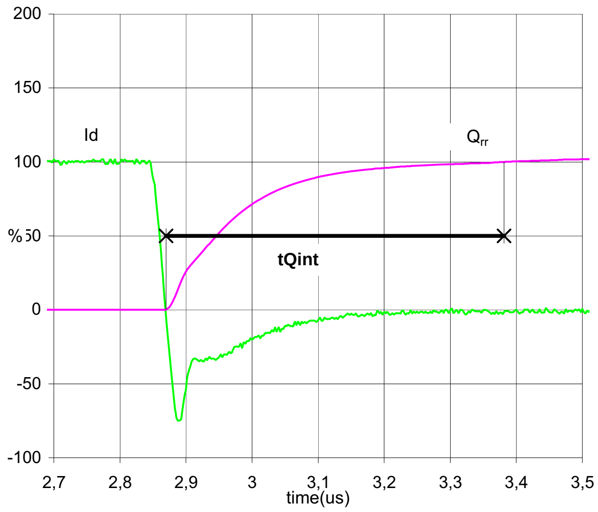
Figure 8. **Turn-off Switching Waveforms & definition of t_{rr}**
Output inverter FRED



Ud(100%)=	300 V
Id(100%)=	20 A
I_{RRM}(100%)=	15,2 A
trr=	0,22 us

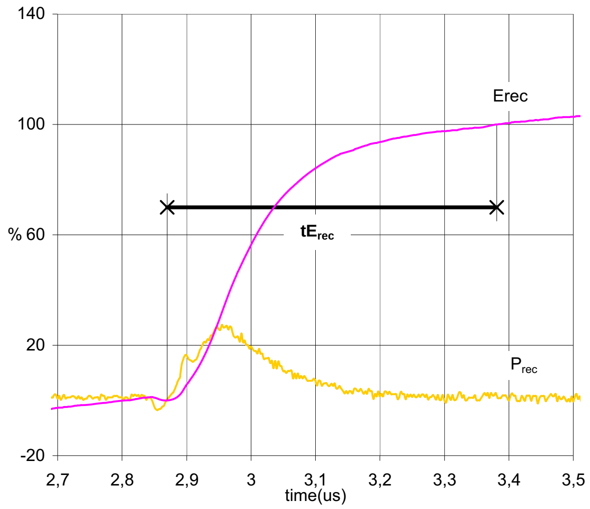
Switching definitions

Figure 9. Turn-on Switching Waveforms & definition of t_{Qrr}
(tQrr= integrating time for Qrr)
Output inverter FRED



Id(100%)= 20 A
Qrr(100%)= 1,29 uC
tQint= 0,51 us

Figure 10. Turn-on Switching Waveforms & definition of t_{Erec}
(t_{Erec}= integrating time for E_{rec})
Output inverter FRED



Prec(100%)= 5,99 kW
Erec(100%)= 0,25 mJ
tErec= 0,51 us