V23990-P840-A4x/C4x-PM

preliminary datasheet

***flow* PIM 0 3rd Gen** **1200V/15A**

Features

- Tyco 2 clip-in housing in 12 and 17mm height
- Trench Fieldstop IGBT's 4 technology
- Optional w/o BRC

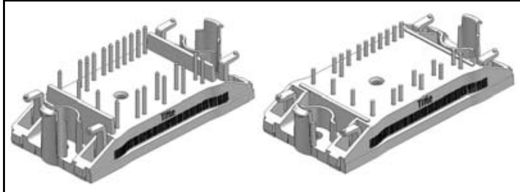
Target Applications

- Industrial Drives
- Embedded Generation

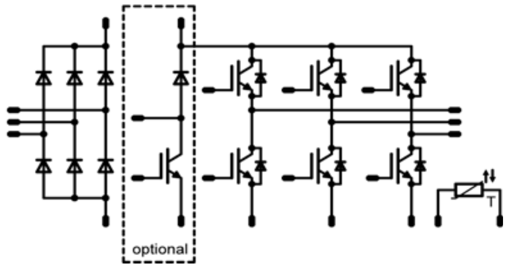
Types

- V23990-P840-A49-PM 17mm height
- V23990-P840-A48-PM 12mm height
- V23990-P840-C49-PM 17mm height; w/o BRC
- V23990-P840-C48-PM 12mm height; w/o BRC

flow 0 housing



Schematic



Maximum Ratings

Tj=25°C, unless otherwise specified

Parameter	Symbol	Condition		Value	Unit
Input Rectifier Diode					
Repetitive peak reverse voltage	V_{RRM}	I_R=0.05mA	T_j=25°C	1600	V
Forward current per diode	I_{FAV}	DC current	T_h=80°C T_c=80°C	28	A
Surge forward current	I_{FSM}	t_p=10ms 180°sine	T_j=$T_j$max	220	A
I2t-value	I^2t			200	A2s
Power dissipation per Diode	P_{tot}	T_j=$T_j$max	T_h=80°C T_c=80°C	33	W
Maximum Junction Temperature	$T_j$max			150	°C

Maximum Ratings

Tj=25°C, unless otherwise specified

Parameter	Symbol	Condition		Value	Unit
Transistor Inverter					
Collector-emitter voltage	V_{CE}			1200	V
DC collector current	I_C	T_j=$T_j$max	T_h=80°C T_c=80°C	18	A
Repetitive peak collector current	I_{Cpuls}	tp limited by $T_j$max		45	A
Power dissipation per IGBT	P_{tot}	T_j=$T_j$max	T_h=80°C T_c=80°C	52	W
Gate-emitter peak voltage	V_{GE}			±20	V
Short circuit ratings*	t_{SC} V_{CC}	T_j=150°C	V_{GE}=15V	10 800	µs V
Maximum Junction Temperature	$T_j$max			175	°C

* It is recommended to not exceed 1000 short circuit situations in the lifetime of the module and to allow at least 1s between short circuits

Parameter	Symbol	Condition		Value	Unit
Diode Inverter					
Peak Repetitive Reverse Voltage	V_{RRM}			1200	V
DC forward current	I_F	T_j=$T_j$max	T_h=80°C T_c=80°C	18	A
Repetitive peak forward current	I_{FRM}	tp limited by $T_j$max		30	A
Power dissipation per Diode	P_{tot}	T_j=$T_j$max	T_h=80°C T_c=80°C	38	W
Maximum Junction Temperature	$T_j$max			175	°C

Maximum Ratings

Tj=25°C, unless otherwise specified

Parameter	Symbol	Condition		Value	Unit
Transistor BRC					
Collector-emitter voltage	V_{CE}			1200	V
DC collector current	I_C	T_j=$T_j$max	T_h=80°C T_c=80°C	10	A
Repetitive peak collector current	I_{cpuls}	tp limited by $T_j$max	T_h=80°C	24	A
Power dissipation per IGBT	P_{tot}	T_j=$T_j$max	T_h=80°C T_c=80°C	40	W
Gate-emitter peak voltage	V_{GE}			±20	V
Short circuit ratings*	t_{SC} V_{CC}	T_j=150°C V_{GE}=15V		10 800	µs V
Maximum Junction Temperature	$T_j$max			175	°C

* It is recommended to not exceed 1000 short circuit situations in the lifetime of the module and to allow at least 1s between short circuits

Parameter	Symbol	Condition		Value	Unit
Diode BRC					
Peak Repetitive Reverse Voltage	V_{RRM}			1200	V
DC forward current	I_F	T_j=$T_j$max	T_h=80°C T_c=80°C	10	A
Repetitive peak forward current	I_{FRM}	tp limited by $T_j$max	T_h=80°C	18	A
Power dissipation per Diode	P_{tot}	T_j=$T_j$max	T_h=80°C T_c=80°C	22	W
Maximum Junction Temperature	$T_j$max			150	°C

Parameter	Symbol	Condition	Value	Unit
Thermal properties				
Storage temperature	T_{stg}		-40…+125	°C
Operation junction temperature	T_{jop}		-40…Tjmax-25°C	°C

Parameter	Symbol	Condition	Value	Unit
Insulation properties				
Insulation voltage	V_{is}	t=1min	4000	Vdc
Creepage distance			min 12,7	mm
Clearance			min 12,7	mm

Characteristic Values

Parameter	Symbol	Conditions					Value			Unit
			V_{GE}(V) or V_{GS}(V)	V_r(V) or V_{CE}(V) or V_{DS}(V)	I_C(A) or I_F(A) or I_D(A)	T(°C)	Min	Typ	Max	
Input Rectifier Diode										
Forward voltage	V_F				30	Tj=25°C Tj=125°C		1,22 1,19	1,9	V
Threshold voltage (for power loss calc. only)	V_{to}					Tj=25°C Tj=125°C		0,93 0,81	 0,83	V
Slope resistance (for power loss calc. only)	r_t					Tj=25°C Tj=125°C		0,01 0,01	 0,02	Ohm
Reverse current	I_r			1500		Tj=25°C Tj=125°C			0,01	mA
Thermal resistance chip to heatsink per chip	R_{thJH}	Thermal grease thickness≤50um λ = 0,61 W/mK						2,16		K/W
Thermal resistance chip to case per chip	R_{thJC}									K/W
Transistor Inverter										
Gate emitter threshold voltage	$V_{GE(th)}$	VCE=VGE			0.5m	Tj=25°C Tj=125°C	5	5,8	6,5	V
Collector-emitter saturation voltage	$V_{CE(sat)}$		15		15	Tj=25°C Tj=125°C		1,94 2,26	2,4	V
Collector-emitter cut-off current incl. Diode	I_{CES}		0	1200		Tj=25°C Tj=125°C			0,01	mA
Gate-emitter leakage current	I_{GES}		20	0		Tj=25°C Tj=125°C			200	nA
Integrated Gate resistor	R_{gint}							none		Ohm
Turn-on delay time	$t_{d(on)}$	Rgon=16Ohm Rgoff=16Ohm	±15	600	15	Tj=25°C Tj=125°C		 60,4		ns
Rise time	t_r					Tj=25°C Tj=125°C		 19		ns
Turn-off delay time	$t_{d(off)}$					Tj=25°C Tj=125°C		 239		ns
Fall time	t_f					Tj=25°C Tj=125°C		 105		ns
Turn-on energy loss per pulse	E_{on}					Tj=25°C Tj=125°C		 1,25		mWs
Turn-off energy loss per pulse	E_{off}					Tj=25°C Tj=125°C		 1,24		mWs
Input capacitance	C_{ies}	f=1MHz	0	25		Tj=25°C		0,9		nF
Output capacitance	C_{oss}							0,08		nF
Reverse transfer capacitance	C_{rss}							0,055		nF
Gate charge	Q_{Gate}		±15			Tj=25°C		124		nC
Thermal resistance chip to heatsink per chip	R_{thJH}	Thermal grease thickness≤50um λ = 0,61 W/mK						1,83		K/W
Thermal resistance chip to case per chip	R_{thJC}									K/W
Diode Inverter										
Diode forward voltage	V_F				15	Tj=25°C Tj=125°C	1,35	1,9 1,91	2,35	V
Reverse leakage current	I_{rm}								3,5	mA
Peak reverse recovery current	I_{RRM}	Rgon=16Ohm	±15	600	15	Tj=25°C Tj=125°C		 16,06		A
Reverse recovery time	t_{rr}					Tj=25°C Tj=125°C		 433		ns
Reverse recovered charge	Q_{rr}					Tj=25°C Tj=125°C		 2,75		mC
Peak rate of fall of recovery current	di(rec)max /dt							109		A/ms
Reverse recovered energy	Erec					Tj=25°C Tj=125°C		 1,16		mWs
Thermal resistance chip to heatsink per chip	R_{thJH}	Thermal grease thickness≤50um λ = 0,61 W/mK						2,52		K/W
Thermal resistance chip to case per chip	R_{thJC}									K/W

Characteristic Values

Parameter	Symbol	Conditions					Value			Unit
			V_{GE}(V) or V_{GS}(V)	V_r(V) or V_{CE}(V) or V_{DS}(V)	I_C(A) or I_F(A) or I_D(A)	T(°C)	Min	Typ	Max	
Transistor BRC										
Gate emitter threshold voltage	$V_{GE(th)}$	VCE=VGE			0.3m	Tj=25°C Tj=125°C	5	5,8	6,5	V
Collector-emitter saturation voltage	$V_{CE(sat)}$		15		8	Tj=25°C Tj=125°C		1,87 2,22	2,25	V
Collector-emitter cut-off	I_{CES}		0	1200		Tj=25°C Tj=125°C			0,05	mA
Gate-emitter leakage current	I_{GES}		20	0		Tj=25°C Tj=125°C			200	nA
Integrated Gate resistor	R_{gint}							none		Ohm
Turn-on delay time	$t_{d(on)}$					Tj=25°C Tj=125°C		71,8		ns
Rise time	t_r					Tj=25°C Tj=125°C		23,6		ns
Turn-off delay time	$t_{d(off)}$	Rgon=32Ohm Rgoff=32Ohm	±15	600	8	Tj=25°C Tj=125°C		228,2		ns
Fall time	t_f					Tj=25°C Tj=125°C		104		ns
Turn-on energy loss per pulse	E_{on}					Tj=25°C Tj=125°C		0,71		mWs
Turn-off energy loss per pulse	E_{off}					Tj=25°C Tj=125°C		0,62		mWs
Input capacitance	C_{ies}							0,49		nF
Output capacitance	C_{oss}	f=1MHz	0	25		Tj=25°C		0,05		nF
Reverse transfer capacitance	C_{rss}							0,03		nF
Gate charge	Q_{Gate}		±15			Tj=25°C				nC
Thermal resistance chip to heatsink per chip	R_{thJH}	Thermal grease thickness≤50um λ = 0,61 W/mK						2,36		K/W
Thermal resistance chip to case per chip	R_{thJC}									K/W

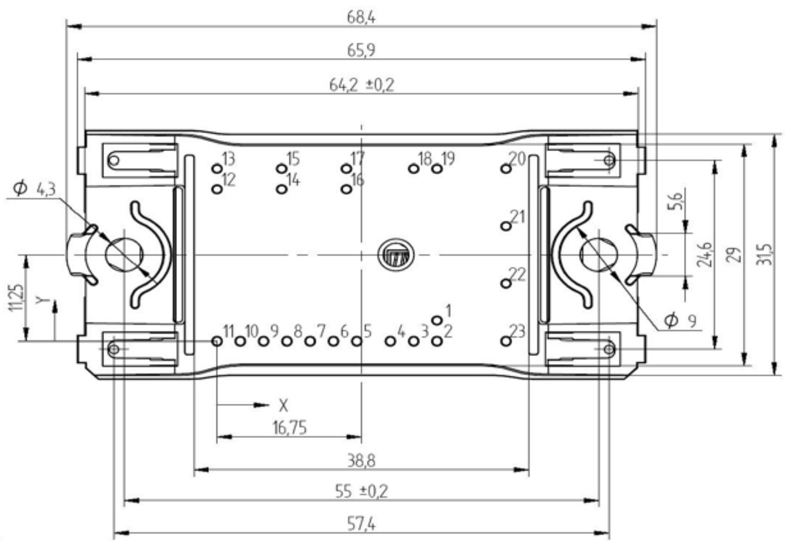
Parameter	Symbol	Conditions	V_{GE}(V) or V_{GS}(V)	V_r(V) or V_{CE}(V) or V_{DS}(V)	I_C(A) or I_F(A) or I_D(A)	T(°C)	Min	Typ	Max	Unit
Diode BRC										
Diode forward voltage	V_F				8	Tj=25°C Tj=125°C	0,8	1,67 1,61	2,2	V
Reverse leakage current	I_r					Tj=25°C Tj=125°C			250	mA
Peak reverse recovery current	I_{RRM}					Tj=25°C Tj=125°C		9,87		A
Reverse recovery time	t_{rr}	Rgon=32Ohm				Tj=25°C Tj=125°C		427		ns
Reverse recovered charge	Q_{rr}		±15	600	8	Tj=25°C Tj=125°C		1,64		mC
Peak rate of fall of recovery current	di(rec)max /dt					Tj=25°C Tj=125°C		73		A/ms
Reverse recovery energy	E_{rec}					Tj=25°C Tj=125°C		0,69		mWs
Thermal resistance chip to heatsink per chip	R_{thJH}	Thermal grease thickness≤50um λ = 0,61 W/mK						3,15		K/W
Thermal resistance chip to case per chip	R_{thJC}									K/W

Parameter	Symbol	Conditions	V_{GE}(V) or V_{GS}(V)	V_r(V) or V_{CE}(V) or V_{DS}(V)	I_C(A) or I_F(A) or I_D(A)	T(°C)	Min	Typ	Max	Unit
Thermistor										
Rated resistance	R_{25}	Tol. ±5%				Tj=25°C	20,9	22	23,1	kOhm
Deviation of R100	$D_{R/R}$	R100=1503Ohm				Tc=100°C		2,9		%/K
Power dissipation given Epcos-Typ	P					Tj=25°C		210		mW
B-value	$B_{(25/100)}$	Tol. ±3%				Tj=25°C		3980		K

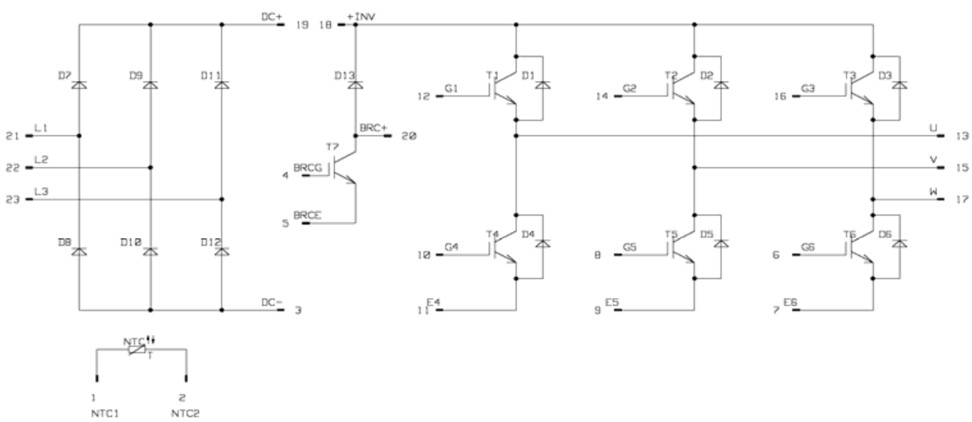
Package Outline and Pinout

Outline

Pin table		
Pin	X	Y
1	25,5	2,7
2	25,5	0
3	22,8	0
4	20,1	0
5	16,2	0
6	13,5	0
7	10,8	0
8	8,1	0
9	5,4	0
10	2,7	0
11	0	0
12	0	19,8
13	0	22,5
14	7,5	19,8
15	7,5	22,5
16	15	19,8
17	15	22,5
18	22,8	22,5
19	25,5	22,5
20	33,5	22,5
21	33,5	15
22	33,5	7,5
23	33,5	0



Pinout



This drawing contains the maximum configuration.
Depending upon types, some components may be left. See in part list.

PRODUCT STATUS DEFINITIONS

Datasheet Status	Product Status	Definition
Target	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice. The data contained is exclusively intended for technically trained staff.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data may be published at a later date. Vincotech reserves the right to make changes at any time without notice in order to improve design. The data contained is exclusively intended for technically trained staff.
Final	Full Production	This datasheet contains final specifications. Vincotech reserves the right to make changes at any time without notice in order to improve design. The data contained is exclusively intended for technically trained staff.

DISCLAIMER

The information given in this datasheet describes the type of component and does not repesent assured characteristics.
For tested values please contact Vincotech.
Vincotech reserves the right to make changes without further notice to any products herein to improve reliability, function or design.
Vincotech does not assume any liability arising out of the application or use of any product or circuit described herein; neither does it convey any license under its patent rights, nor the rights of others.

LIFE SUPPORT POLICY

Vincotech products are not authorised for use as critical components in life support devices or systems without the express written approval of Vincotech.

As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, or (c) whose failure to perform when properly used in accordance with instructions for use provided in labelling can be reasonably expected to result in significant injury to the user.

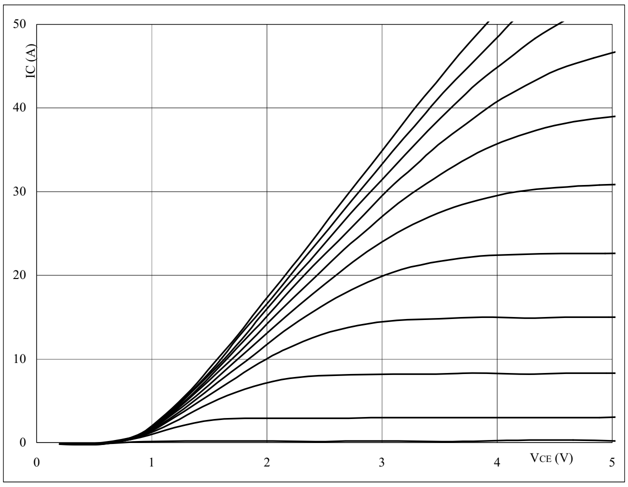
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

Output Inverter

Figure 1 Output inverter IGBT

Typical output characteristics

$I_C = f(V_{CE})$



At

t_p = 250 μs

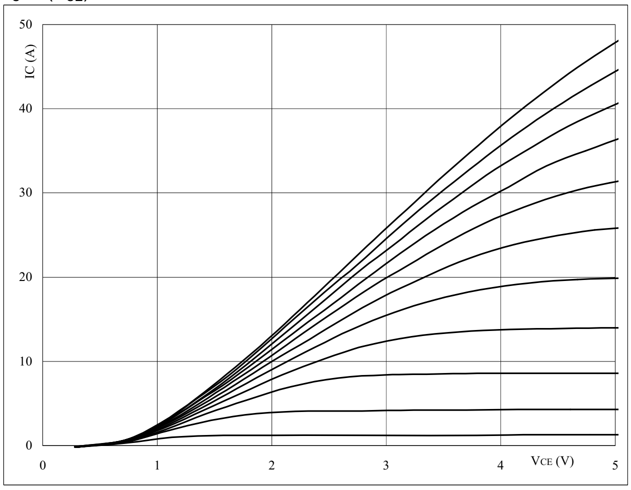
T_j = 25 °C

VGE from 7 V to 17 V in steps of 1 V

Figure 2 Output inverter IGBT

Typical output characteristics

$I_C = f(V_{CE})$



At

t_p = 250 μs

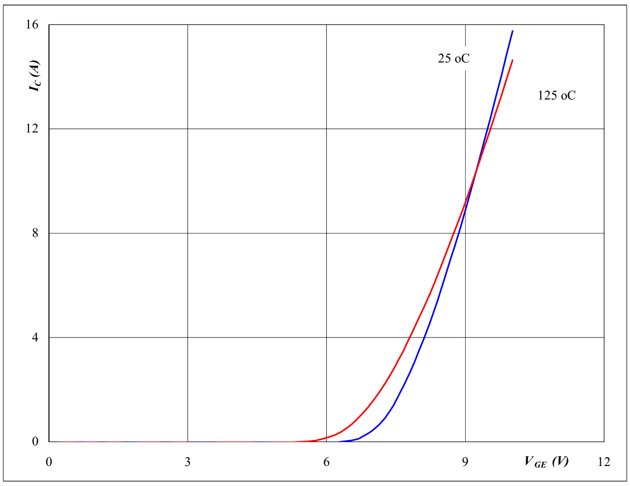
T_j = 125 °C

VGE from 7 V to 17 V in steps of 1 V

Figure 3 Output inverter IGBT

Typical transfer characteristics

$Ic = f(V_{GE})$



At

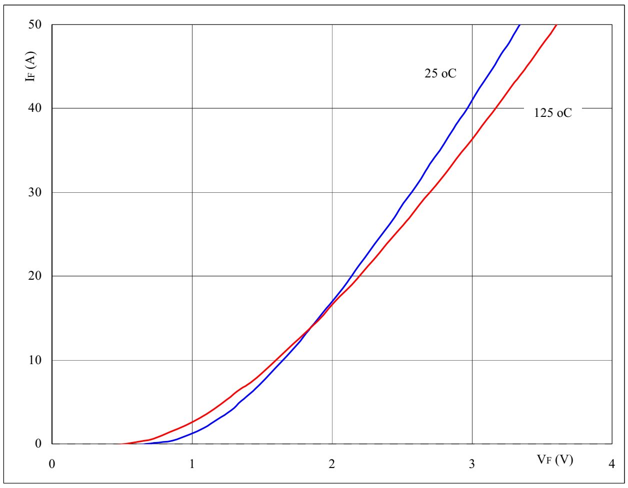
t_p = 250 μs

V_{CE} = 10 V

Figure 4 Output inverter FRED

Typical diode forward current as a function of forward voltage

$I_F = f(V_F)$



At

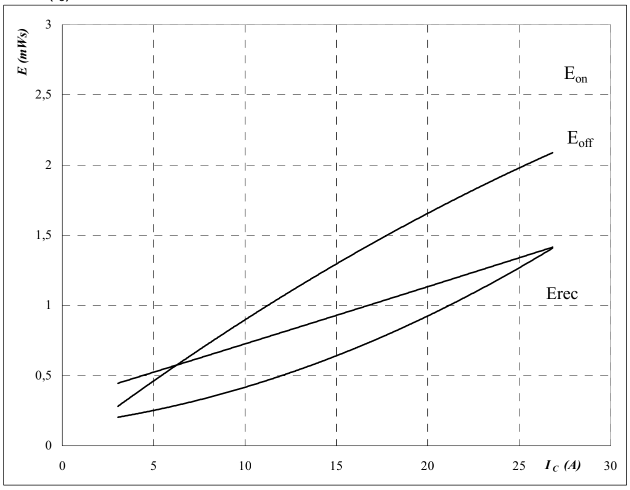
t_p = 250 μs

Output Inverter

Figure 5 Output inverter IGBT

Typical switching energy losses as a function of collector current

E = f(I_c)



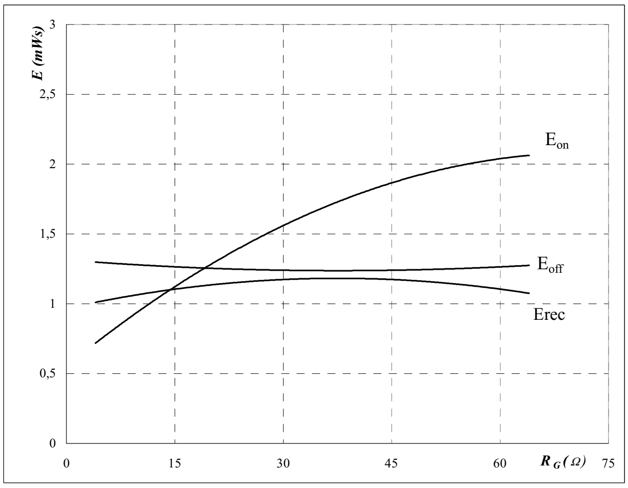
With an inductive load at

T_j =	125	°C
V_{CE} =	600	V
V_{GE} =	±15	V
R_{gon} =	4	Ω
R_{goff} =	4	Ω

Figure 6 Output inverter IGBT

Typical switching energy losses as a function of gate resistor

E = f(R_G)



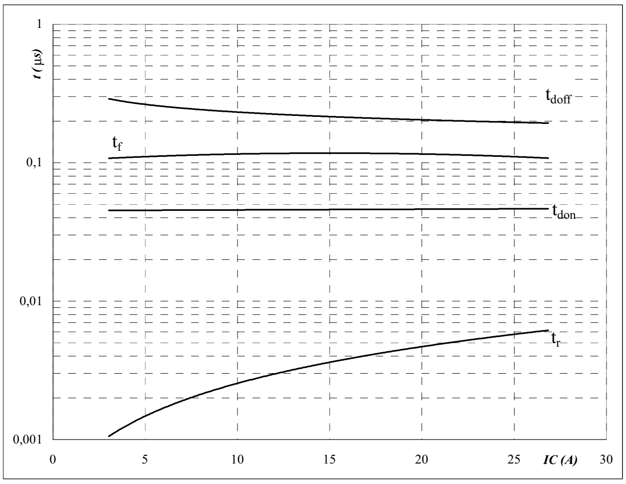
With an inductive load at

T_j =	125	°C
V_{CE} =	600	V
V_{GE} =	±15	V
I_C =	15	A

Figure 7 Output inverter IGBT

Typical switching times as a function of collector current

t = f(I_C)



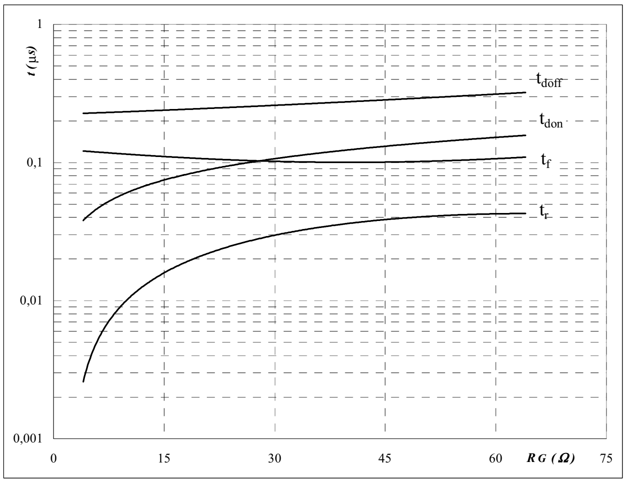
With an inductive load at

T_j =	125	°C
V_{CE} =	600	V
V_{GE} =	±15	V
R_{gon} =	4	Ω
R_{goff} =	4	Ω

Figure 8 Output inverter IGBT

Typical switching times as a function of gate resistor

t = f(R_G)



With an inductive load at

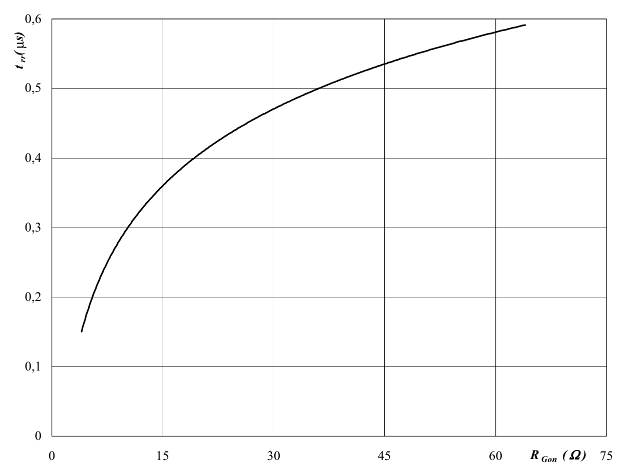
T_j =	125	°C
V_{CE} =	600	V
V_{GE} =	±15	V
I_C =	15	A

Output Inverter

Figure 9 Output inverter FRED diode

Typical reverse recovery time as a function of IGBT turn on gate resistor

$t_{rr} = f(R_{gon})$

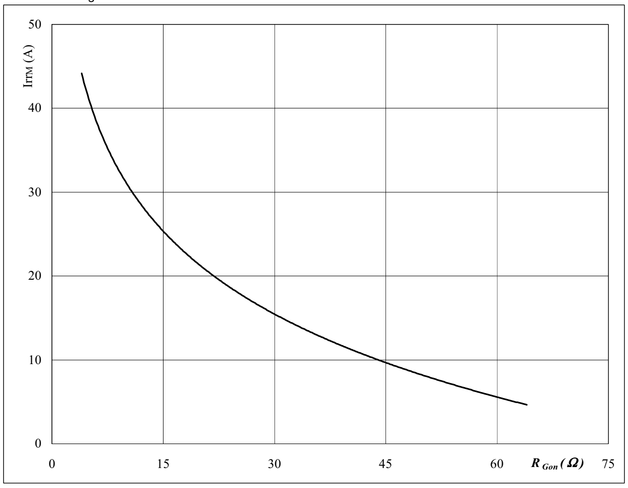


At		
T_j =	125	°C
V_R =	600	V
I_F =	15	A
V_{GE} =	±15	V

Figure 10 Output inverter FRED diode

Typical reverse recovery current as a function of IGBT turn on gate resistor

$I_{RRM} = f(R_{gon})$

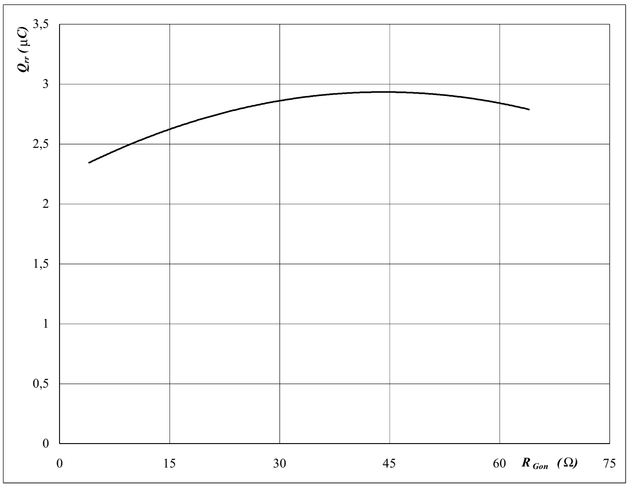


At		
T_j =	125	°C
V_R =	600	V
I_F =	15	A
V_{GE} =	±15	V

Figure 11 Output inverter FRED diode

Typical reverse recovery charge as a function of IGBT turn on gate resistor

$Q_{rr} = f(R_{gon})$

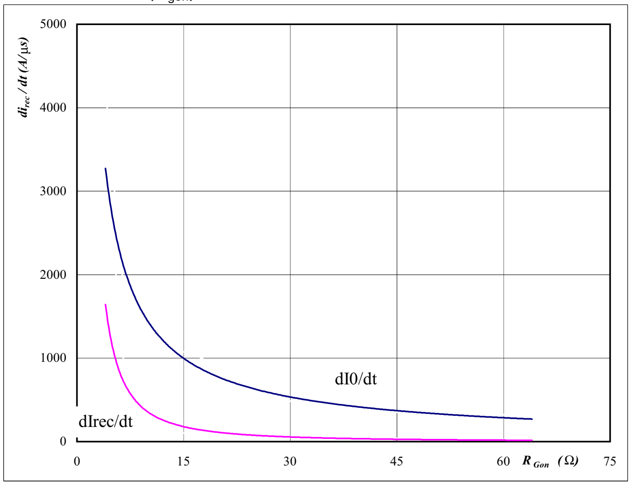


At		
T_j =	125	°C
V_R =	600	V
I_F =	15	A
V_{GE} =	±15	V

Figure 12 Output inverter FRED diode

Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor

$dI0/dt, dIrec/dt = f(R_{gon})$



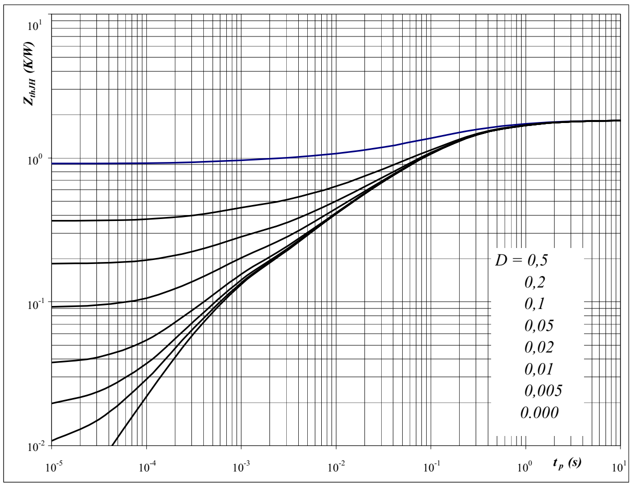
At		
T_j =	125	°C
V_R =	600	V
I_F =	15	A
V_{GE} =	±15	V

Output Inverter

Figure 13	Output inverter IGBT

IGBT transient thermal impedance
as a function of pulse width

Z_{thJH} = f(tp)



With
D = tp / T
R_{thJH} = 1,83 K/W

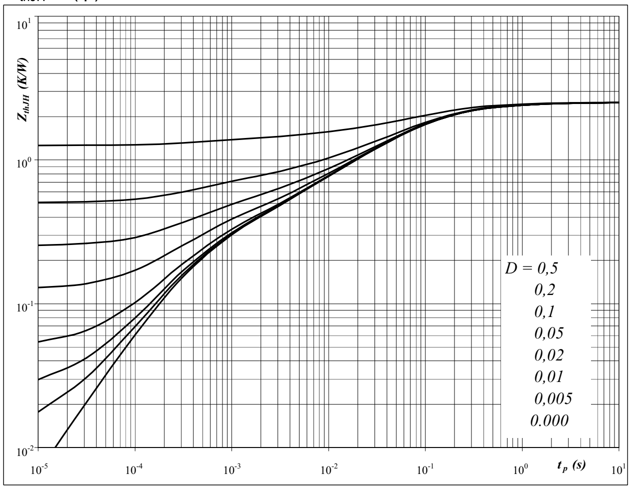
IGBT thermal model values

R (C/W)	Tau (s)
0,06	5,6E+00
0,28	8,7E-01
0,77	1,7E-01
0,42	3,4E-02
0,19	6,2E-03
0,10	5,5E-04

Figure 14	Output inverter FRED diode

FRED transient thermal impedance
as a function of pulse width

Z_{thJH} = f(tp)



With
D = tp / T
R_{thJH} = 2,52 K/W

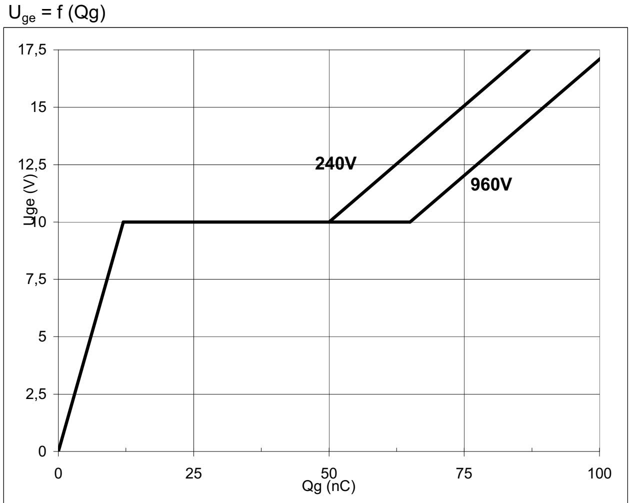
FRED thermal model values

R (C/W)	Tau (s)
0,05	9,6E+00
0,26	8,2E-01
1,04	1,2E-01
0,69	2,6E-02
0,27	3,4E-03
0,21	3,8E-04

Figure 15	Output inverter IGBT

Gate voltage vs Gate charge
Output inverter IGBT

U_{ge} = f (Qg)



At

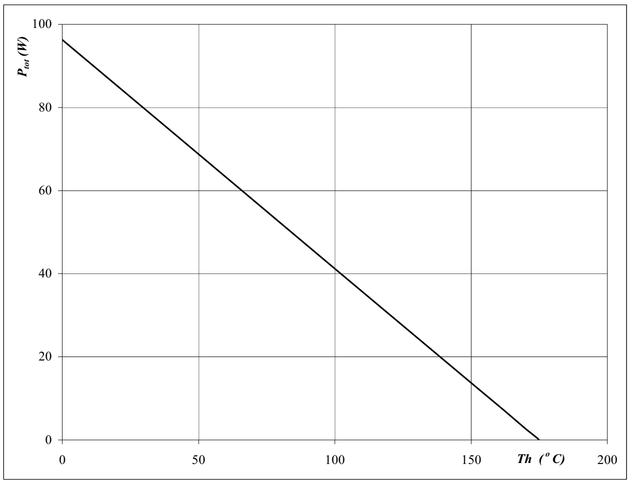
V_{CE} (80%) =	960	V
V_{CE} (20%) =	240	V
V_{GE} =	15	V
I_C (100%) =	15	A
Q_g =	93	nC

Output Inverter

Figure 16 Output inverter IGBT

Power dissipation as a function of heatsink temperature

$P_{tot} = f(T_h)$



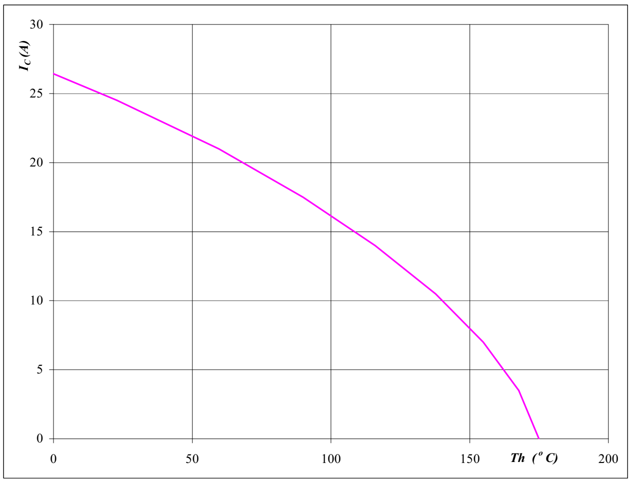
At

T_j = 175 °C

Figure 17 Output inverter IGBT

Collector current as a function of heatsink temperature

$I_C = f(T_h)$



At

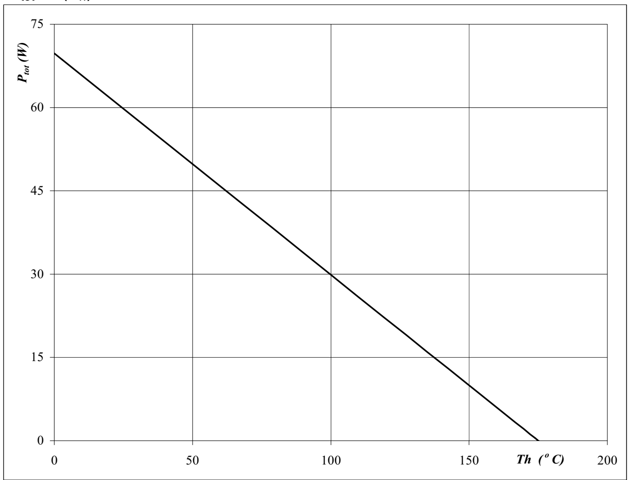
T_j = 175 °C

V_{GE} = 15 V

Figure 18 Output inverter FRED

Power dissipation as a function of heatsink temperature

$P_{tot} = f(T_h)$



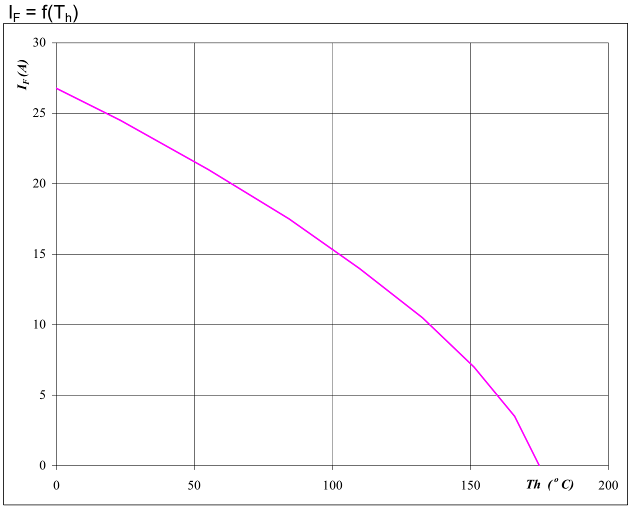
At

T_j = 175 °C

Figure 19 Output inverter FRED

Forward current as a function of heatsink temperature

$I_F = f(T_h)$



At

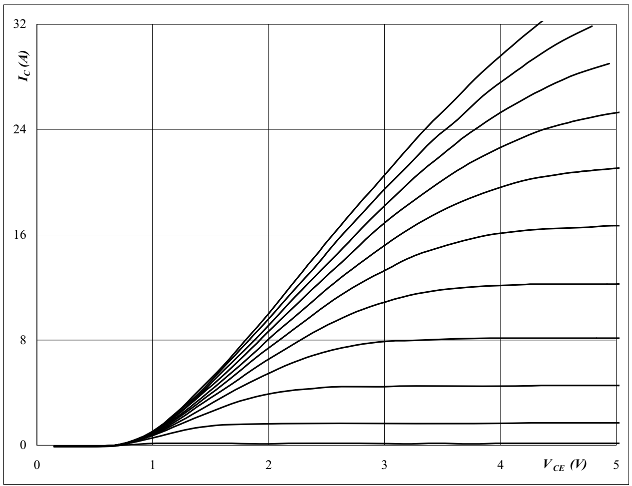
T_j = 175 °C

Brake

Figure 1 Brake IGBT

Typical output characteristics

$I_C = f(V_{CE})$



At

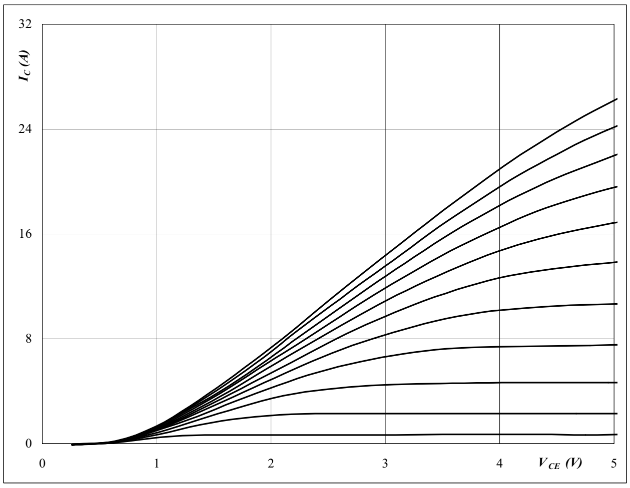
t_p =	250	µs
T_j =	25	°C

VGE from 7 V to 17 V in steps of 1 V

Figure 2 Brake IGBT

Typical output characteristics

$I_C = f(V_{CE})$



At

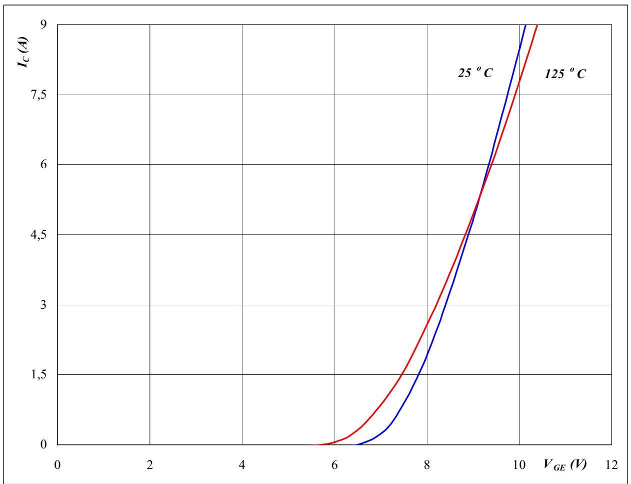
t_p =	250	µs
T_j =	125	°C

VGE from 7 V to 17 V in steps of 1 V

Figure 3 Brake IGBT

Typical transfer characteristics

$I_C = f(V_{GE})$



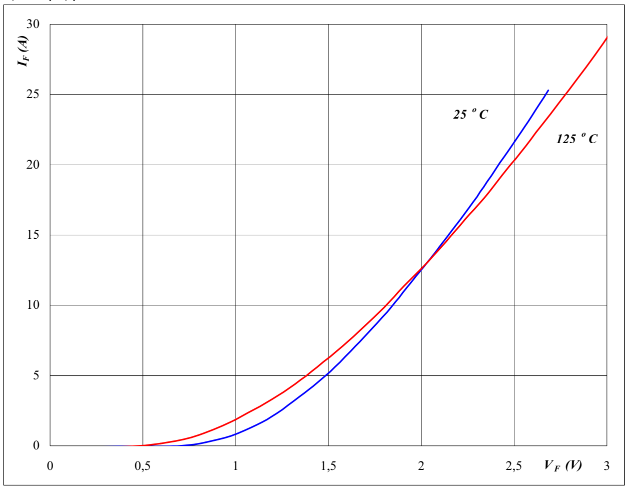
At

t_p =	250	µs
V_{CE} =	10	V

Figure 4 Brake FRED

Typical diode forward current as a function of forward voltage

$I_F = f(V_F)$



At

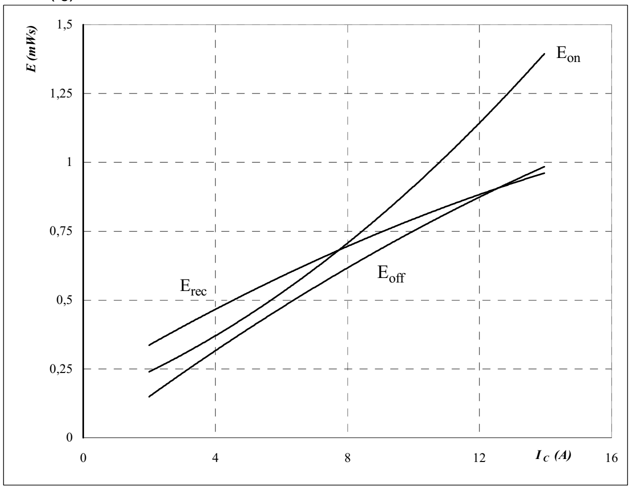
t_p =	250	µs

Brake

Figure 5 Brake IGBT

Typical switching energy losses as a function of collector current

$E = f(I_C)$



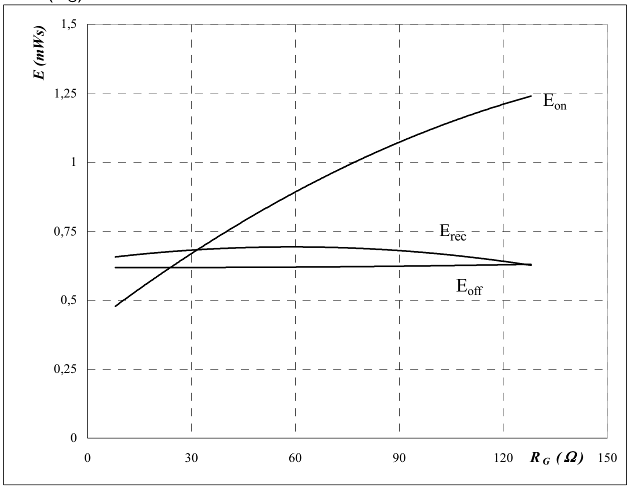
With an inductive load at

T_j =	125	°C
V_{CE} =	600	V
V_{GE} =	±15	V
R_{gon} =	32	Ω
R_{goff} =	32	Ω

Figure 6 Brake IGBT

Typical switching energy losses as a function of gate resistor

$E = f(R_G)$



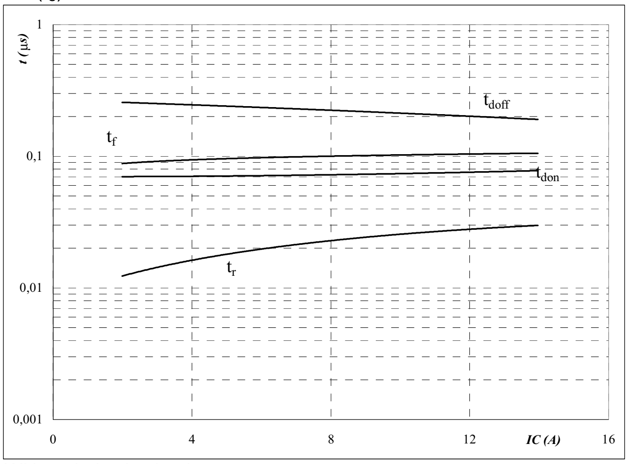
With an inductive load at

T_j =	125	°C
V_{CE} =	600	V
V_{GE} =	±15	V
I_C =	8	A

Figure 7 Brake IGBT

Typical switching times as a function of collector current

$t = f(I_C)$



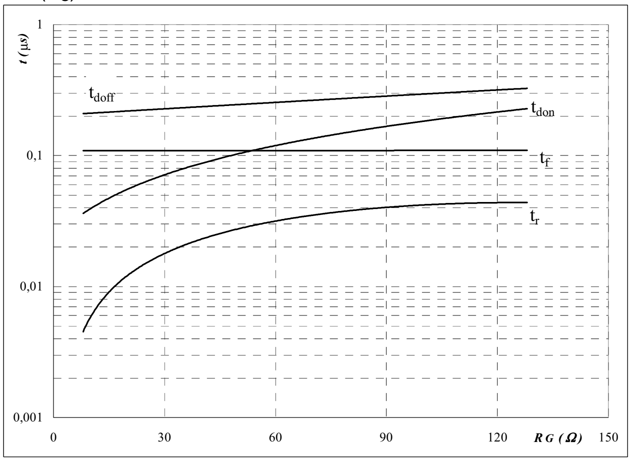
With an inductive load at

T_j =	125	°C
V_{CE} =	600	V
V_{GE} =	±15	V
R_{gon} =	32	Ω
R_{goff} =	32	Ω

Figure 8 Brake IGBT

Typical switching times as a function of gate resistor

$t = f(R_G)$



With an inductive load at

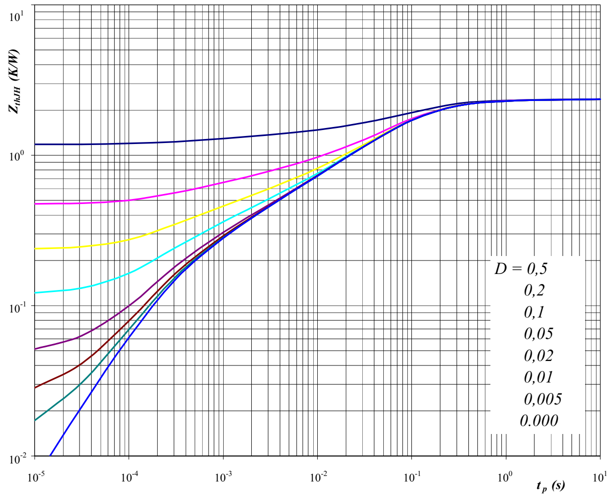
T_j =	125	°C
V_{CE} =	600	V
V_{GE} =	±15	V
I_C =	8	A

Brake

Figure 9

IGBT transient thermal impedance
as a function of pulse width

$Z_{thJH} = f(t_p)$

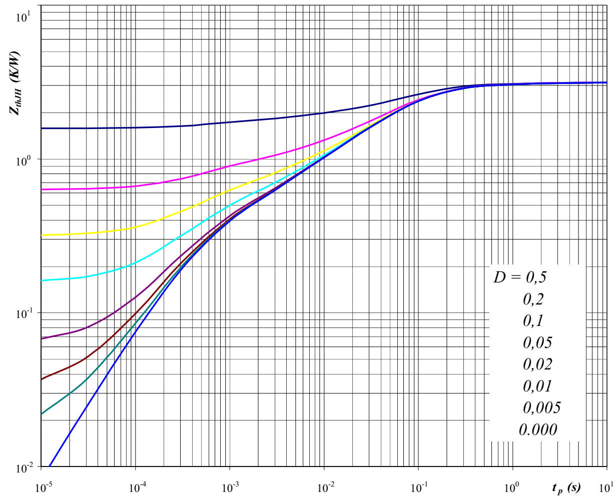


With
D = tp / T
R_{thJH} = 2,36 K/W

Figure 10

FRED transient thermal impedance
as a function of pulse width

$Z_{thJH} = f(t_p)$



With
D = tp / T
R_{thJH} = 3,15 K/W

Brake

Figure 11 Brake IGBT

Power dissipation as a function of heatsink temperature

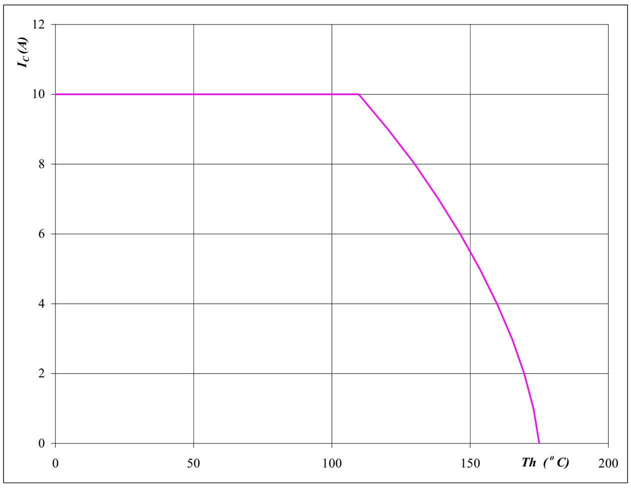
$P_{tot} = f(T_h)$

At
T_j = 175 ºC

Figure 12 Brake IGBT

Collector current as a function of heatsink temperature

$I_C = f(T_h)$

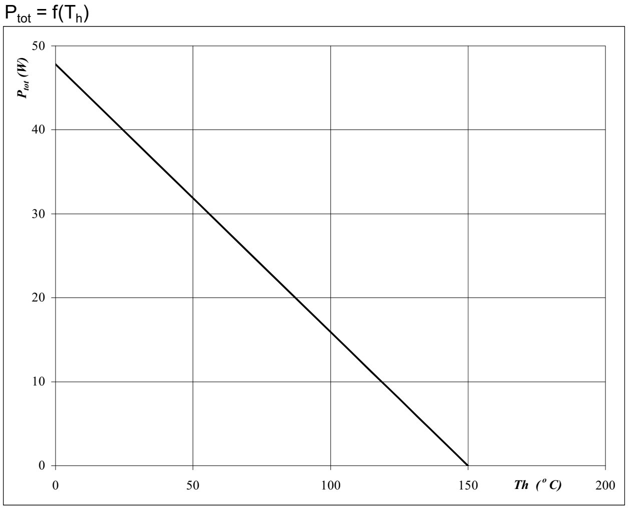


At
T_j = 175 ºC
V_{GE} = 15 V

Figure 13 Brake FRED

Power dissipation as a function of heatsink temperature

$P_{tot} = f(T_h)$

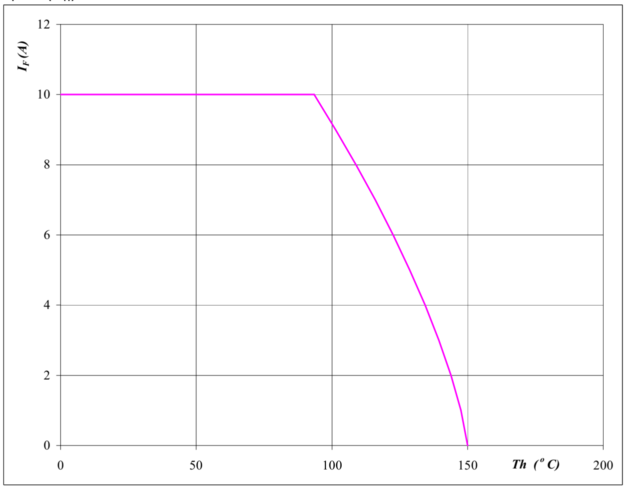


At
T_j = 150 ºC

Figure 14 Brake FRED

Forward current as a function of heatsink temperature

$I_F = f(T_h)$



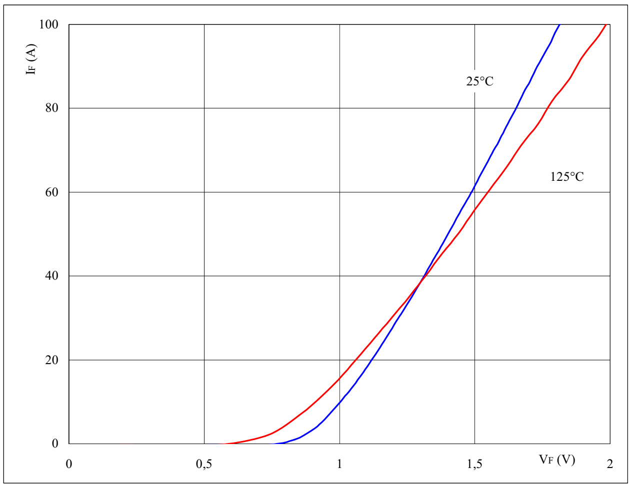
At
T_j = 150 ºC

Input Rectifier Bridge

Figure 1 Rectifier diode

Typical diode forward current as a function of forward voltage

$I_F = f(V_F)$

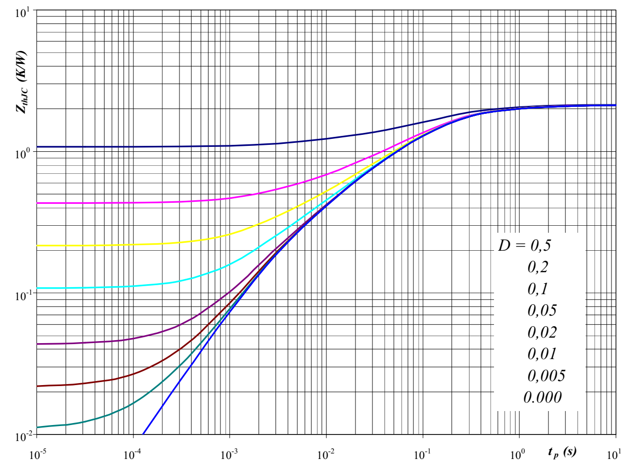


At
t_p = 250 µs

Figure 2 Rectifier diode

Diode transient thermal impedance as a function of pulse width

$Z_{thJH} = f(t_p)$

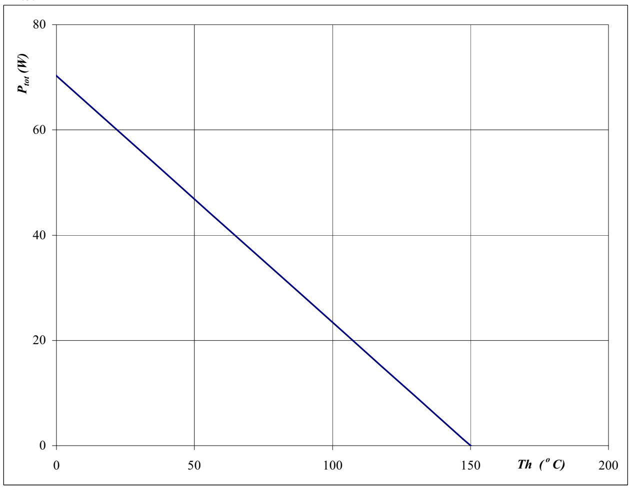


With
D = tp / T
R_{thJH} = 2,16 K/W

Figure 3 Rectifier diode

Power dissipation as a function of heatsink temperature

$P_{tot} = f(T_h)$

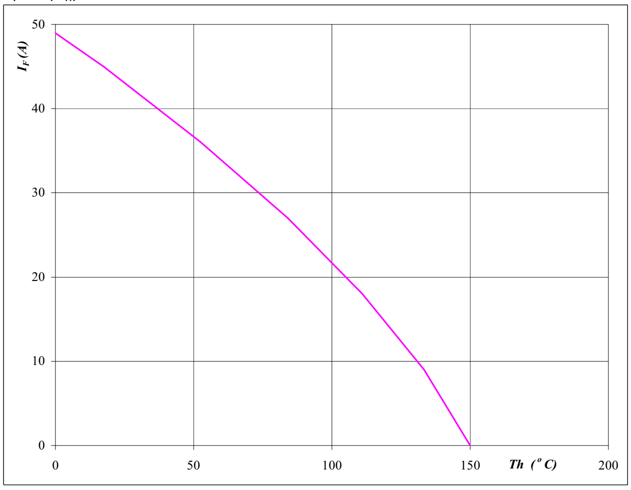


At
T_j = 150 ºC

Figure 4 Rectifier diode

Forward current as a function of heatsink temperature

$I_F = f(T_h)$

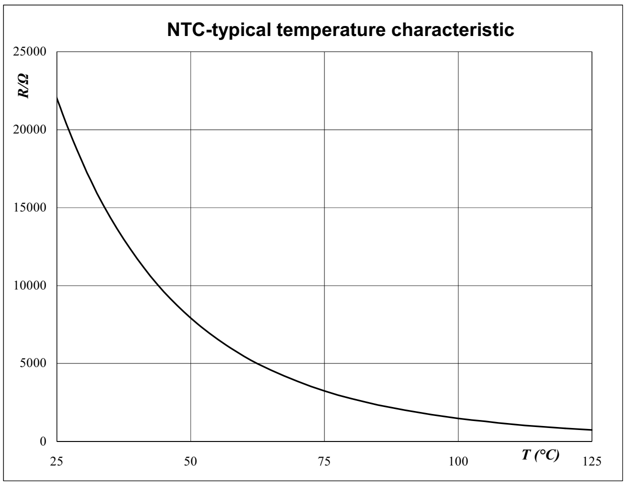


At
T_j = 150 ºC

Thermistor

Figure 1	Thermistor

Typical NTC characteristic
as a function of temperature
R_T = f (T)



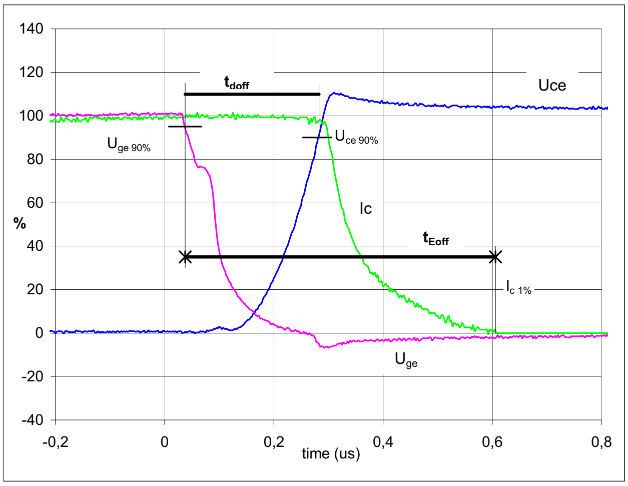
Switching Definitions Output Inverter

General conditions

T_j	=	125,2 °C
R_{gon}	=	16 Ω
R_{goff}	=	16 Ω

Figure 1 Output inverter IGBT

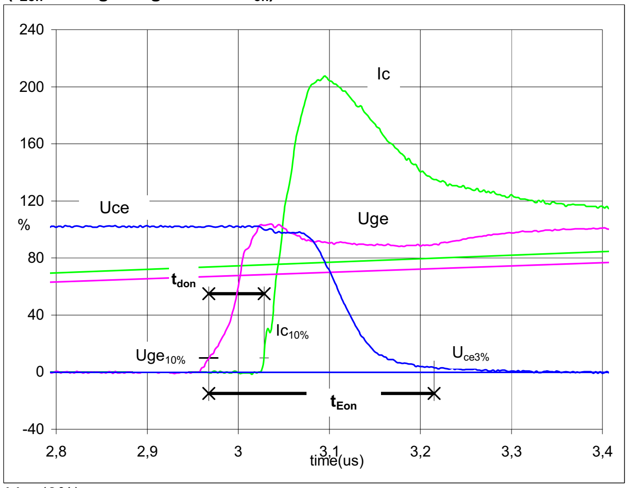
Turn-off Switching Waveforms & definition of tdoff, tEoff
(t_{Eoff} = integrating time for E_{off})



V_{GE} (0%) =	-15	V
V_{GE} (100%) =	15	V
V_C (100%) =	600	V
I_C (100%) =	15	A
t_{doff} =	0,24	µs
t_{Eoff} =	0,57	µs

Figure 2 Output inverter IGBT

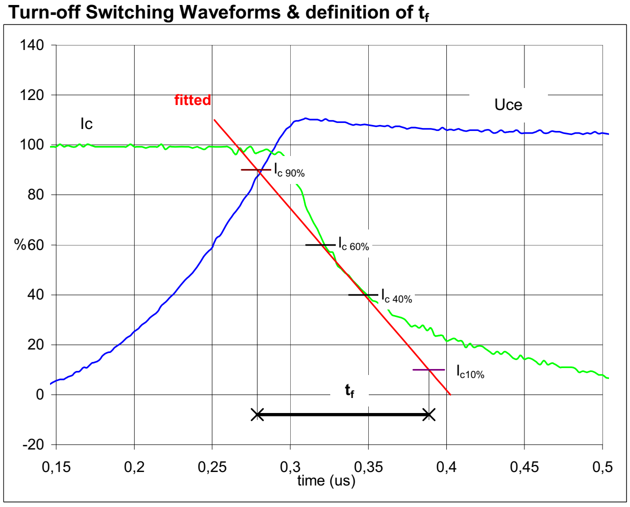
Turn-on Switching Waveforms & definition of tdon, tEon
(t_{Eon} = integrating time for E_{on})



V_{GE} (0%) =	-15	V
V_{GE} (100%) =	15	V
V_C (100%) =	600	V
I_C (100%) =	15	A
t_{don} =	0,06	µs
t_{Eon} =	0,25	µs

Figure 3 Output inverter IGBT

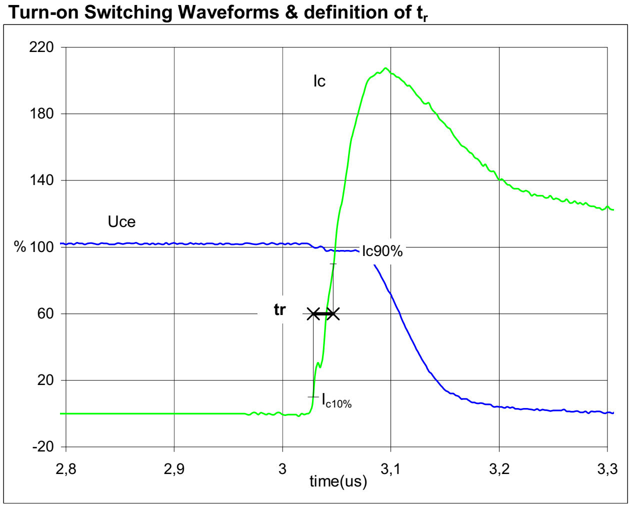
Turn-off Switching Waveforms & definition of t_f



V_C (100%) =	600	V
I_C (100%) =	15	A
t_f =	0,106	µs

Figure 4 Output inverter IGBT

Turn-on Switching Waveforms & definition of t_r

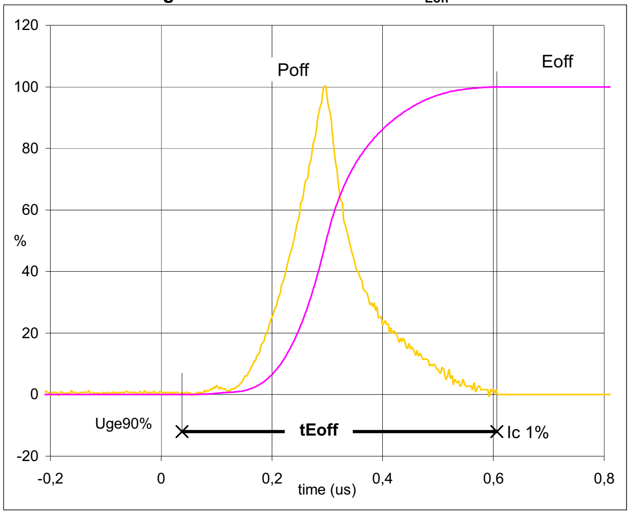


V_C (100%) =	600	V
I_C (100%) =	15	A
t_r =	0,019	µs

Switching Definitions Output Inverter

Figure 5 Output inverter IGBT

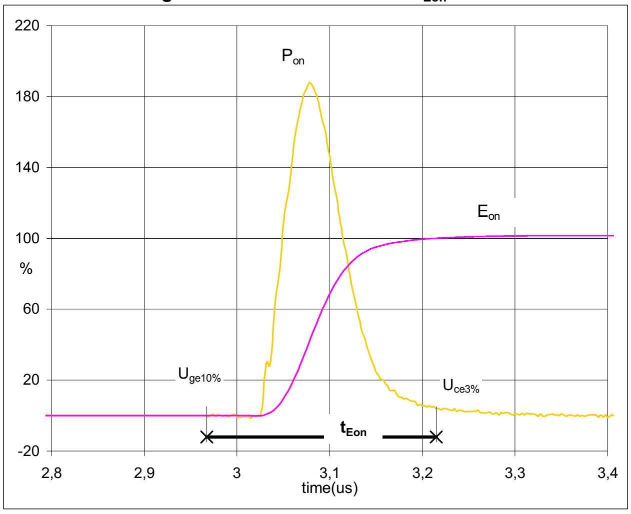
Turn-off Switching Waveforms & definition of t_{Eoff}



P_{off} (100%) =	9,00	kW
E_{off} (100%) =	1,24	mJ
t_{Eoff} =	0,57	µs

Figure 6 Output inverter IGBT

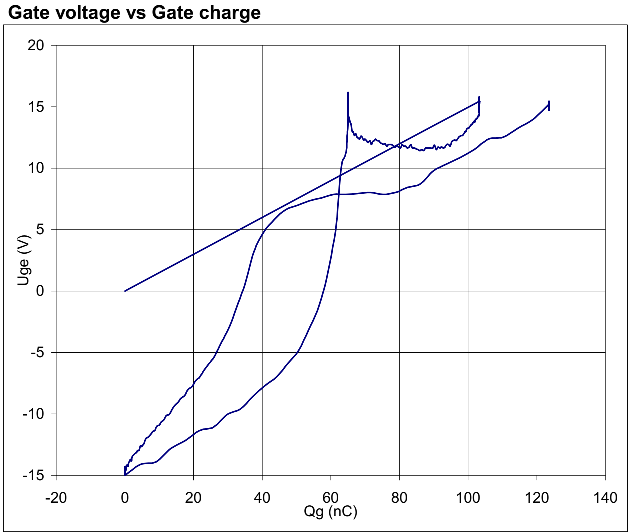
Turn-on Switching Waveforms & definition of t_{Eon}



P_{on} (100%) =	9,00	kW
E_{on} (100%) =	1,25	mJ
t_{Eon} =	0,25	µs

Figure 7 Output inverter IGBT

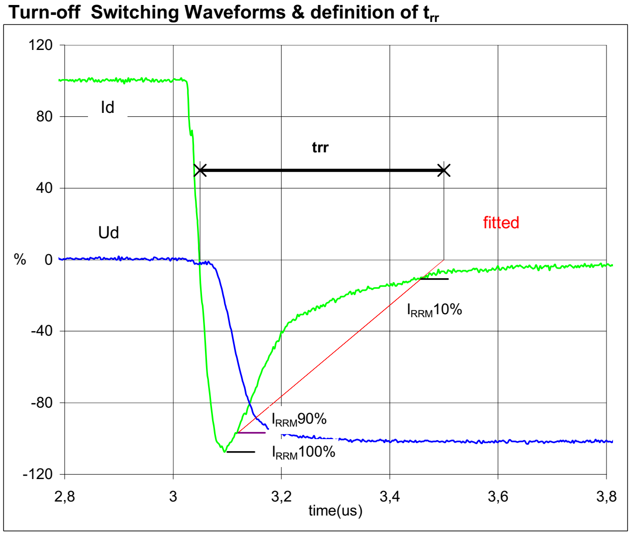
Gate voltage vs Gate charge



V_{GEoff} =	-15	V
V_{GEon} =	15	V
V_C (100%) =	600	V
I_C (100%) =	15	A
Q_g =	123,54	nC

Figure 8 Output inverter FRED

Turn-off Switching Waveforms & definition of t_{rr}

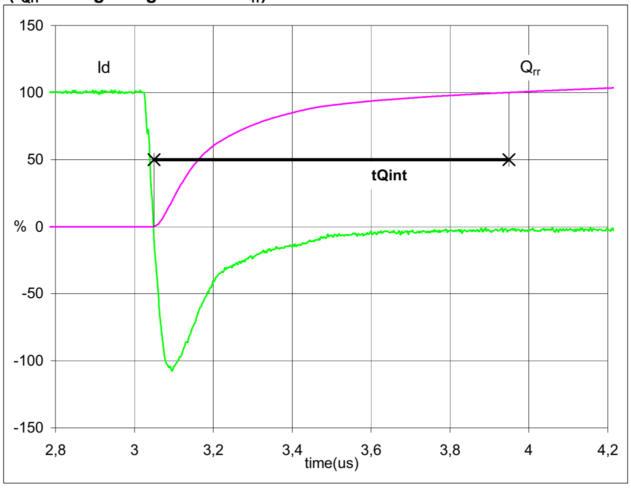


V_d (100%) =	600	V
I_d (100%) =	15	A
I_{RRM} (100%) =	-16	A
t_{rr} =	0,43	µs

Switching Definitions Output Inverter

Figure 9 Output inverter FRED

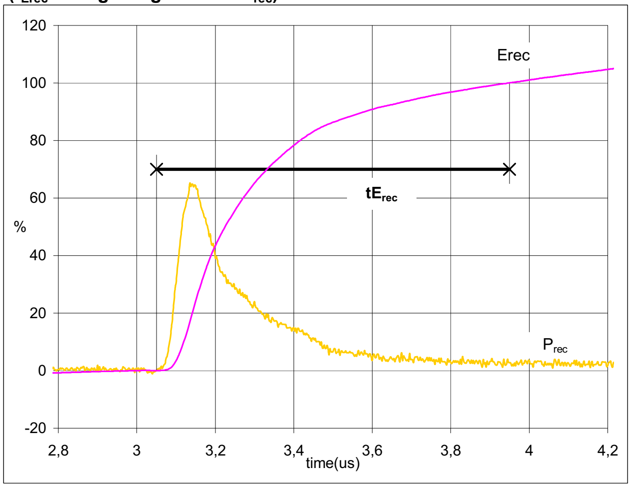
Turn-on Switching Waveforms & definition of t_{Qrr}
(t_{Qrr} = integrating time for Q_{rr})



I_d (100%) =	15	A
Q_{rr} (100%) =	2,75	µC
t_{Qint} =	0,90	µs

Figure 10 Output inverter FRED

Turn-on Switching Waveforms & definition of t_{Erec}
(t_{Erec} = integrating time for E_{rec})



P_{rec} (100%) =	9,00	kW
E_{rec} (100%) =	1,157	mJ
t_{Erec} =	0,90	µs