

flowPACK 0 3rd gen

1200V/35A

**Features**

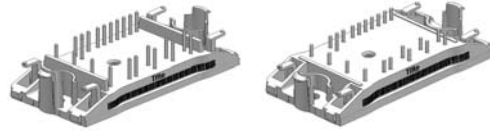
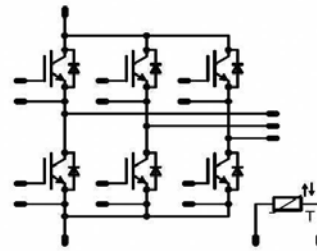
- 2 clip housing in 12mm and 17mm height
- Trench Fieldstop IGBT<sup>4</sup> technology
- Compact and low inductance design
- Built-in NTC

**Target Applications**

- Motor Drives
- Power Generation
- UPS

**Types**

- V23990-P860-F49-PM: 17mm height
- V23990-P860-F48-PM: 12mm height

**flow0 housing**

**Schematic**


## Maximum Ratings

 T<sub>j</sub>=25°C, unless otherwise specified

Parameter	Symbol	Condition	Value	Unit
<b>Inverter Transistor</b>				
Collector-emitter voltage	V <sub>CE</sub>		1200	V
DC collector current	I <sub>C</sub>	T <sub>j</sub> =T <sub>jmax</sub> T <sub>h</sub> =80°C T <sub>c</sub> =80°C	34	A
Repetitive peak collector current	I <sub>Cpulse</sub>	t <sub>p</sub> limited by T <sub>jmax</sub>	105	A
Power dissipation per IGBT	P <sub>tot</sub>	T <sub>j</sub> =T <sub>jmax</sub> T <sub>h</sub> =80°C T <sub>c</sub> =80°C	80	W
Gate-emitter peak voltage	V <sub>GE</sub>		±20	V
Short circuit ratings*	t <sub>SC</sub> V <sub>CC</sub>	T <sub>j</sub> ≤150°C V <sub>GE</sub> =15V	10 800	μs V
Maximum Junction Temperature	T <sub>jmax</sub>		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

**Inverter Diode**

Peak Repetitive Reverse Voltage	V <sub>RRM</sub>	T <sub>j</sub> =25°C	1200	V
DC forward current	I <sub>F</sub>	T <sub>j</sub> =T <sub>jmax</sub> T <sub>h</sub> =80°C T <sub>c</sub> =80°C	35	A
Repetitive peak forward current	I <sub>FRM</sub>	t <sub>p</sub> limited by T <sub>jmax</sub>	70	A
Power dissipation per Diode	P <sub>tot</sub>	T <sub>j</sub> =T <sub>jmax</sub> T <sub>h</sub> =80°C T <sub>c</sub> =80°C	61	W
Maximum Junction Temperature	T <sub>jmax</sub>		175	°C

**Thermal properties**

Storage temperature	T <sub>stg</sub>		-40.....+125	°C
Operation junction temperature	T <sub>op</sub>		-40.....+T <sub>jmax</sub> -25	°C

## Maximum Ratings

T<sub>j</sub>=25°C, unless otherwise specified

Parameter	Symbol	Condition	Value	Unit
<b>Insulation properties</b>				
Insulation voltage	V <sub>is</sub>	t=2s DC voltage	4000	V
Creepage distance			min.12,7	mm
Clearance			min.12,7	mm

**Characteristic Values**

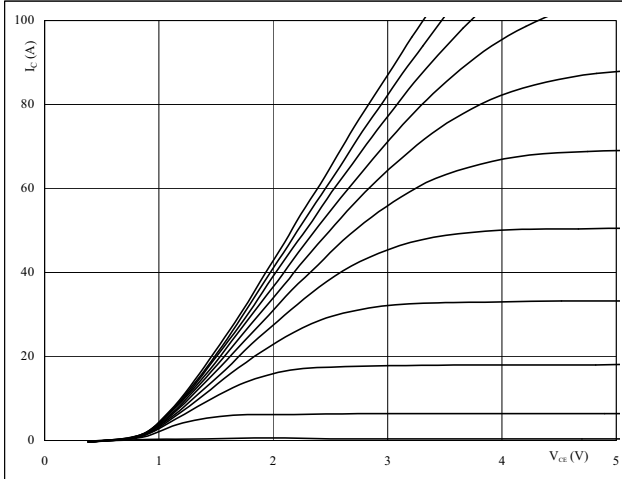
Parameter	Symbol	Conditions					Value			Unit
		$V_{GE} [V]$ or $V_{GS} [V]$	$V_r [V]$ or $V_{CE} [V]$ or $V_{DS} [V]$	$I_c [A]$ or $I_F [A]$ or $I_D [A]$	$T_j$	Min	Typ	Max		
<b>Inverter Transistor</b>										
Gate emitter threshold voltage	$V_{GE(th)}$	VCE=VGE			0,0012	T <sub>J</sub> =25°C T <sub>J</sub> =150°C	5	5,8	6,5	V
Collector-emitter saturation voltage	$V_{CE(sat)}$		15		35	T <sub>J</sub> =25°C T <sub>J</sub> =150°C		1,9 2,33	2,3	V
Collector-emitter cut-off current incl. Diode	$I_{CES}$		0	1200		T <sub>J</sub> =25°C T <sub>J</sub> =150°C			15	μA
Gate-emitter leakage current	$I_{GES}$		20	0		T <sub>J</sub> =25°C T <sub>J</sub> =150°C			200	nA
Integrated Gate resistor	$R_{gint}$							none		Ω
Turn-on delay time	$t_{d(on)}$	R <sub>gon</sub> =16Ω R <sub>goff</sub> =16Ω	±15	600	35	T <sub>J</sub> =25°C		85	ns	
Rise time	$t_r$					T <sub>J</sub> =150°C		88		
Turn-off delay time	$t_{d(off)}$					T <sub>J</sub> =25°C		22		
Fall time	$t_f$					T <sub>J</sub> =150°C		26		
Turn-on energy loss per pulse	$E_{on}$					T <sub>J</sub> =25°C		199		
Turn-off energy loss per pulse	$E_{off}$	T <sub>J</sub> =150°C		259		T <sub>J</sub> =25°C		73	mWs	
Input capacitance	$C_{ies}$					T <sub>J</sub> =150°C		1950		
Output capacitance	$C_{oss}$	f=1MHz	0	25		T <sub>J</sub> =25°C		155	pF	
Reverse transfer capacitance	$C_{rss}$							115		
Gate charge	$Q_{Gate}$		15	960	35	T <sub>J</sub> =25°C		197		nC
Thermal resistance chip to heatsink per chip	$R_{thJH}$	Thermal grease thickness≤50um λ = 0,61 W/mK						1,19		K/W
<b>Inverter Diode</b>										
Diode forward voltage	$V_F$				35	T <sub>J</sub> =25°C T <sub>J</sub> =150°C		1,79 1,76	2,3	V
Reverse leakage current	$I_R$					T <sub>J</sub> =25°C T <sub>J</sub> =150°C			15	μA
Peak reverse recovery current	$I_{RRM}$	R <sub>gon</sub> =16Ω	±15	600	35	T <sub>J</sub> =25°C		30,4	ns	
Reverse recovery time	$t_{rr}$					T <sub>J</sub> =150°C		34,5		
Reverse recovered charge	$Q_{rr}$					T <sub>J</sub> =25°C		298		
Peak rate of fall of recovery current	$di(rec)max/dt$					T <sub>J</sub> =150°C		493		
Reverse recovered energy	$E_{rec}$					T <sub>J</sub> =25°C		3,79		
Thermal resistance chip to heatsink per chip	$R_{thJH}$	Thermal grease thickness≤50um				T <sub>J</sub> =150°C		7,00		μC
								122		A/μs
								105		
								2,806		mWs
								1,55		K/Wn
<b>Thermistor</b>										
Rated resistance	$R_{25}$	Tol. ±5%				T <sub>J</sub> =25°C	20,9	22	23,1	kΩ
Deviation of R100	$\Delta R/R$	R100=1486Ω				T <sub>J</sub> =100°C		2,9		%/K
Power dissipation	$P$					T <sub>J</sub> =25°C		210		mW
B-value	$B_{(25/100)}$	Tol. ±3%				T <sub>J</sub> =25°C		4000		K

## Output Inverter

**Figure 1** Output inverter IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$

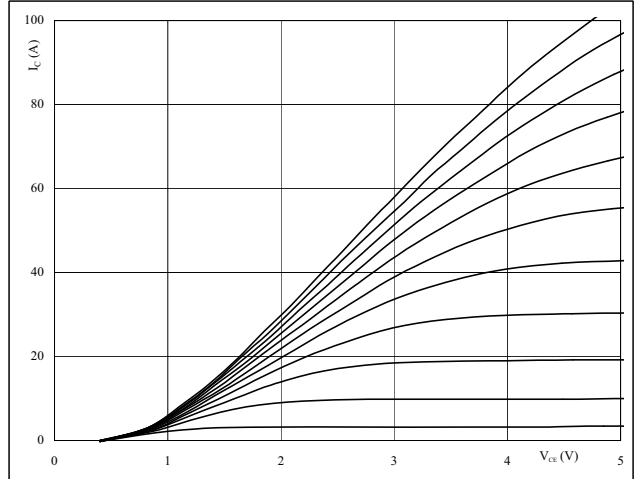


$t_p = 250 \mu s$   
 $T_j = 25 \text{ } ^\circ C$   
 $V_{GE}$  from 7 V to 17 V in steps of 1 V

**Figure 2** Output inverter IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$

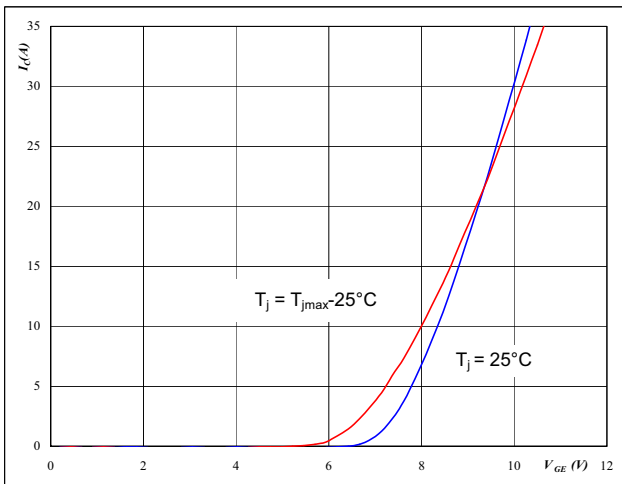


$t_p = 250 \mu s$   
 $T_j = 150 \text{ } ^\circ C$   
 $V_{GE}$  from 7 V to 17 V in steps of 1 V

**Figure 3** Output inverter IGBT

**Typical transfer characteristics**

$I_C = f(V_{GE})$

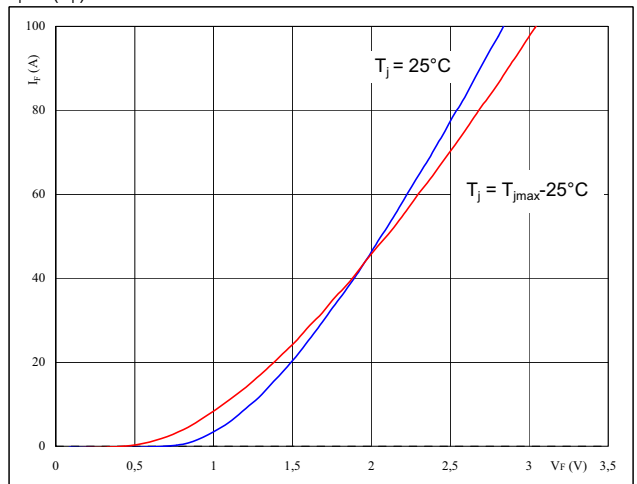


$t_p = 250 \mu s$   
 $V_{CE} = 10 V$

**Figure 4** Output inverter FRED

**Typical diode forward current as a function of forward voltage**

$I_F = f(V_F)$



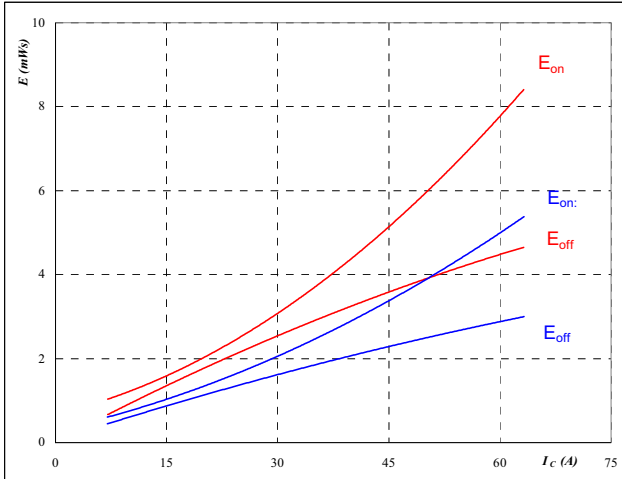
$t_p = 250 \mu s$

## Output Inverter

**Figure 5** Output inverter IGBT

**Typical switching energy losses as a function of collector current**

$E = f(I_C)$



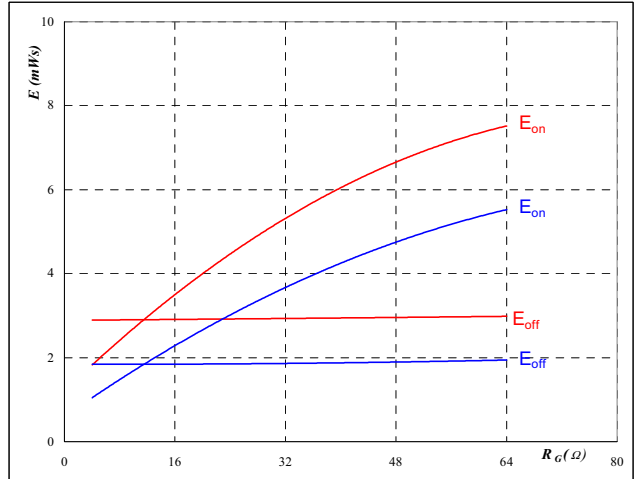
inductive load

$T_J =$	25/150	°C
$V_{CE} =$	600	V
$V_{GE} =$	±15	V
$R_{gon} =$	16	Ω
$R_{goff} =$	16	Ω

**Figure 6** Output inverter IGBT

**Typical switching energy losses as a function of gate resistor**

$E = f(R_G)$



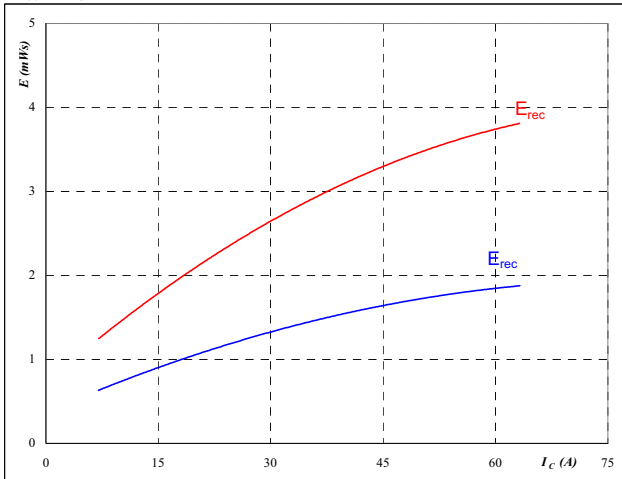
inductive load

$T_J =$	25/150	°C
$V_{CE} =$	600	V
$V_{GE} =$	±15	V
$I_C =$	35	A

**Figure 7** Output inverter IGBT

**Typical reverse recovery energy loss as a function of collector current**

$E_{rec} = f(I_C)$



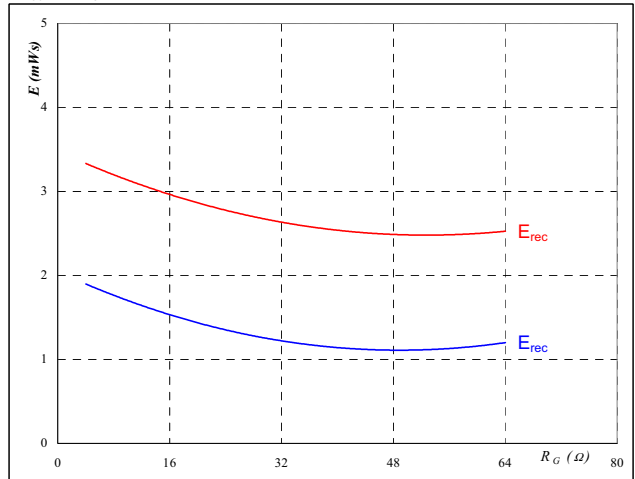
inductive load

$T_J =$	25/150	°C
$V_{CE} =$	600	V
$V_{GE} =$	±15	V
$R_{gon} =$	16	Ω

**Figure 8** Output inverter IGBT

**Typical reverse recovery energy loss as a function of gate resistor**

$E_{rec} = f(R_G)$



inductive load

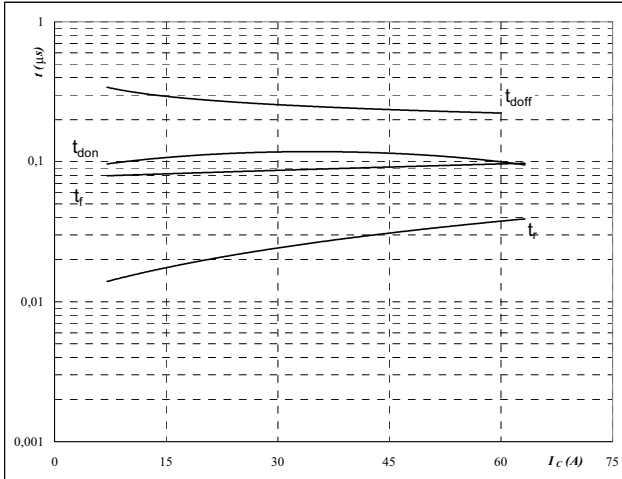
$T_J =$	25/150	°C
$V_{CE} =$	600	V
$V_{GE} =$	±15	V
$I_C =$	35	A

## Output Inverter

**Figure 9** Output inverter IGBT

Typical switching times as a function of collector current

$$t = f(I_C)$$



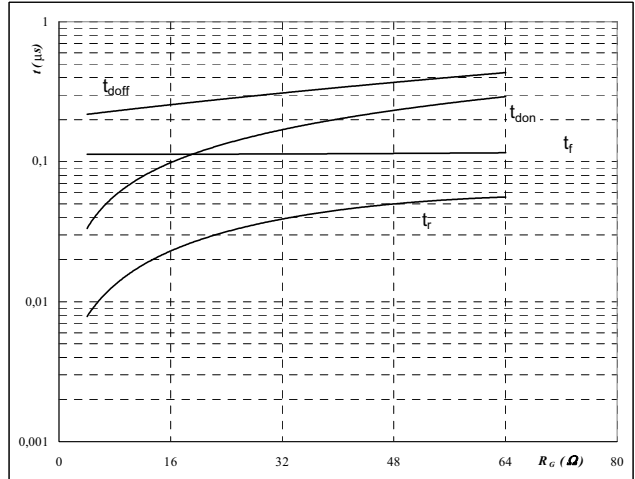
inductive load

$T_J =$	150	°C
$V_{CE} =$	600	V
$V_{GE} =$	±15	V
$R_{gon} =$	16	Ω
$R_{goff} =$	16	Ω

**Figure 10** Output inverter IGBT

Typical switching times as a function of gate resistor

$$t = f(R_G)$$



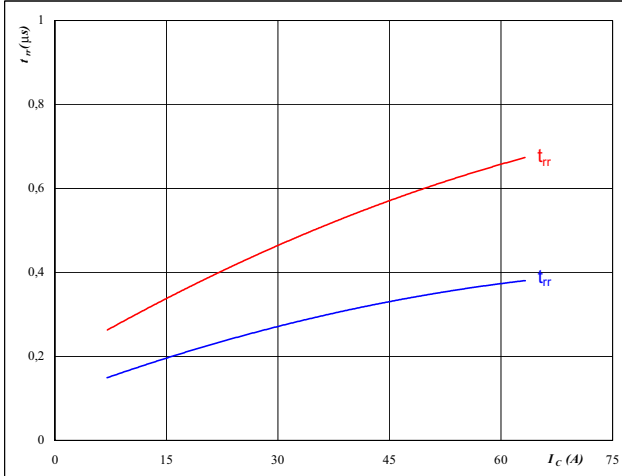
inductive load

$T_J =$	150	°C
$V_{CE} =$	600	V
$V_{GE} =$	±15	V
$I_C =$	35	A

**Figure 11** Output inverter FRED

Typical reverse recovery time as a function of collector current

$$t_{rr} = f(I_C)$$

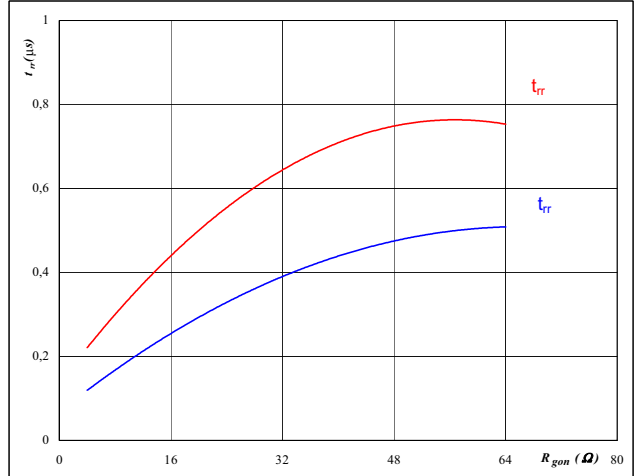


$T_J =$	25/150	°C
$V_{CE} =$	600	V
$V_{GE} =$	±15	V
$R_{gon} =$	16	Ω

**Figure 12** Output inverter FRED

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

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



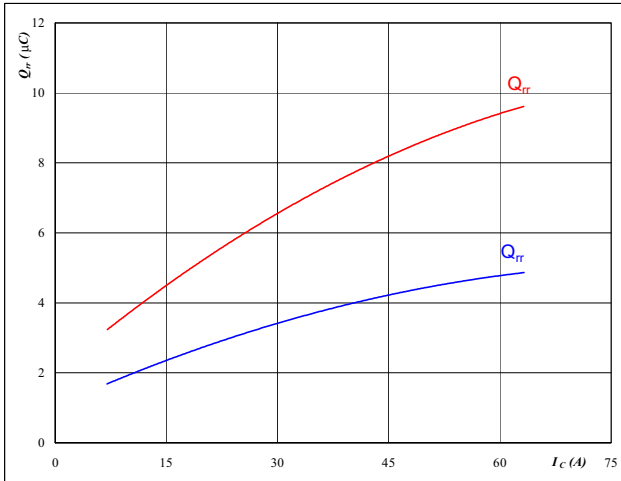
$T_J =$	25/150	°C
$V_R =$	600	V
$I_F =$	35	A
$V_{GE} =$	±15	V

## Output Inverter

Figure 13 Output inverter FRED

Typical reverse recovery charge as a function of collector current

$$Q_{rr} = f(I_C)$$

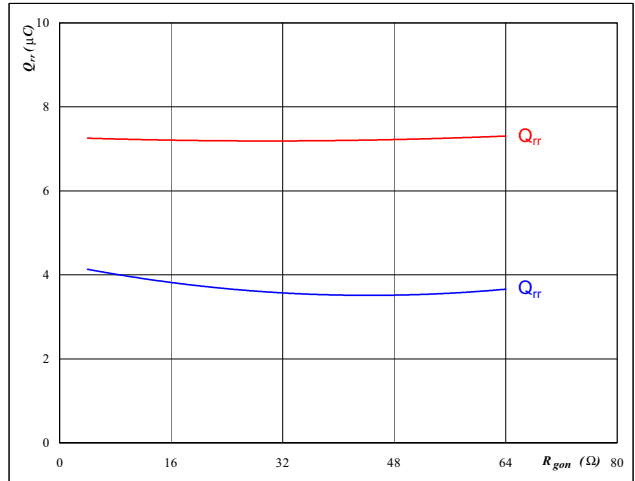


$T_J = 25/150$  °C  
 $V_{CE} = 600$  V  
 $V_{GE} = \pm 15$  V  
 $R_{gon} = 16$   $\Omega$

Figure 14 Output inverter FRED

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

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

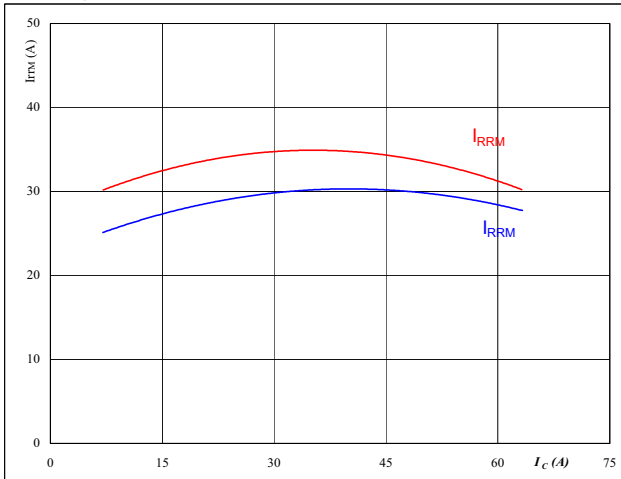


$T_J = 25/150$  °C  
 $V_R = 600$  V  
 $I_F = 35$  A  
 $V_{GE} = \pm 15$  V

Figure 15 Output inverter FRED

Typical reverse recovery current as a function of collector current

$$I_{RRM} = f(I_C)$$

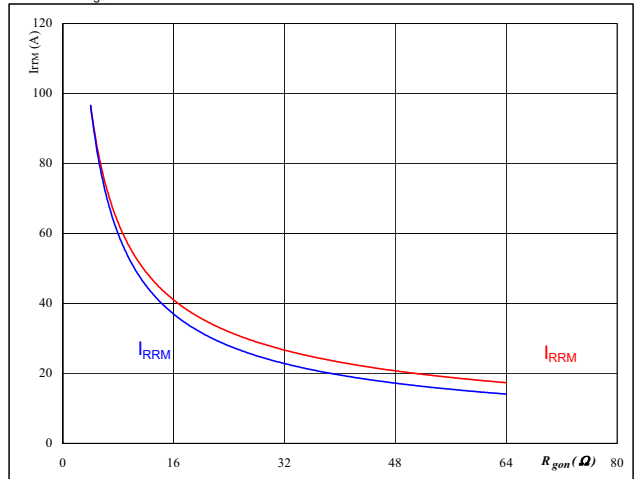


$T_J = 25/150$  °C  
 $V_{CE} = 600$  V  
 $V_{GE} = \pm 15$  V  
 $R_{gon} = 16$   $\Omega$

Figure 16 Output inverter FRED

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

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



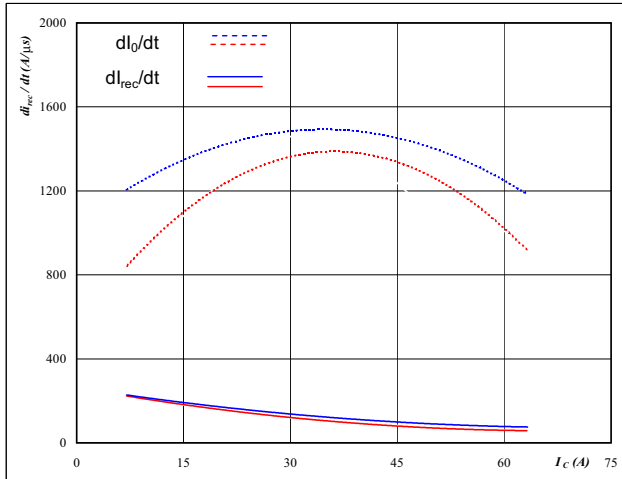
$T_J = 25/150$  °C  
 $V_R = 600$  V  
 $I_F = 35$  A  
 $V_{GE} = \pm 15$  V

## Output Inverter

**Figure 17** Output inverter FRED

**Typical rate of fall of forward and reverse recovery current as a function of collector current**

$$di_o/dt, di_{rec}/dt = f(I_C)$$

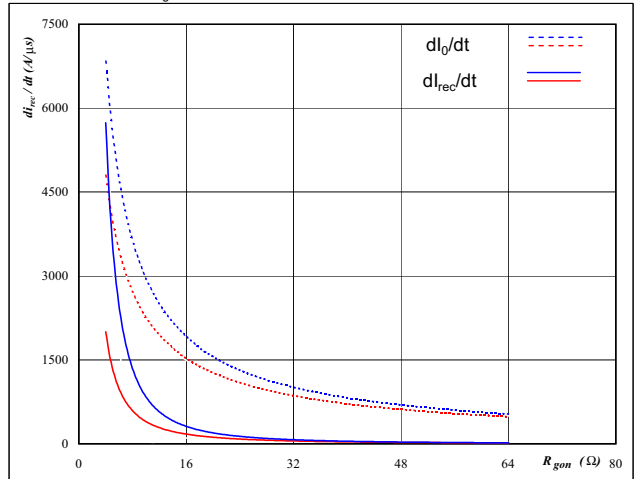


$T_j = 25/150$  °C  
 $V_{CE} = 600$  V  
 $V_{GE} = \pm 15$  V  
 $R_{gon} = 16$  Ω

**Figure 18** Output inverter FRED

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

$$di_o/dt, di_{rec}/dt = f(R_{gon})$$

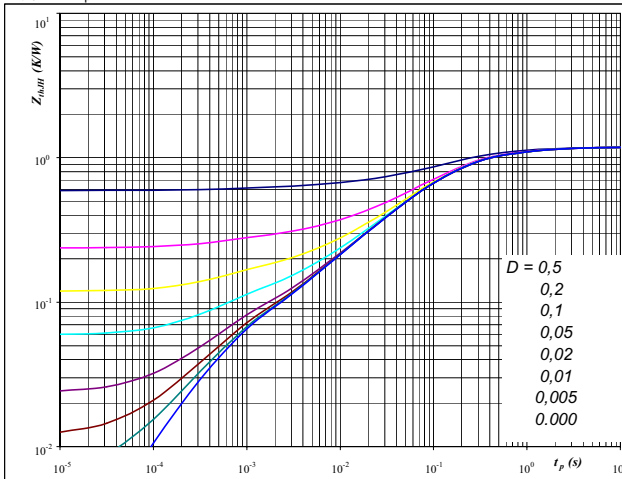


$T_j = 25/150$  °C  
 $V_R = 600$  V  
 $I_F = 35$  A  
 $V_{GE} = \pm 15$  V

**Figure 19** Output inverter IGBT

**IGBT transient thermal impedance as a function of pulse width**

$$Z_{thJH} = f(t_p)$$



$D = t_p / T$   
 $R_{thJH} = 1,19$  K/W

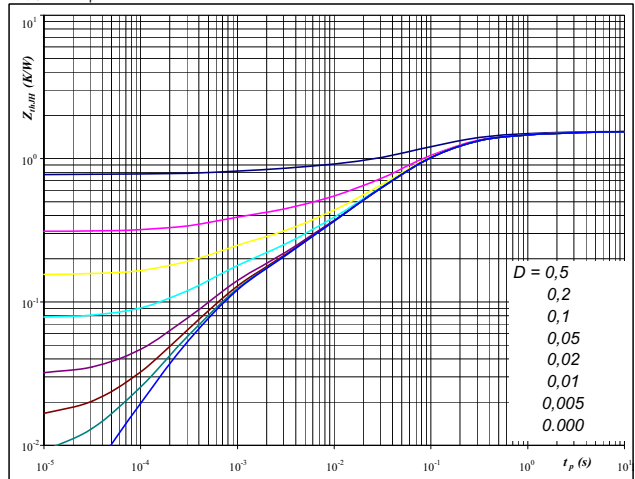
IGBT thermal model values

R (C/W)	Tau (s)
0,03	6,8E+00
0,16	1,0E+00
0,60	1,6E-01
0,25	4,0E-02
0,09	7,1E-03
0,05	5,9E-04

**Figure 20** Output inverter FRED

**FRED transient thermal impedance as a function of pulse width**

$$Z_{thJH} = f(t_p)$$



$D = t_p / T$   
 $R_{thJH} = 1,55$  K/W

FRED thermal model values

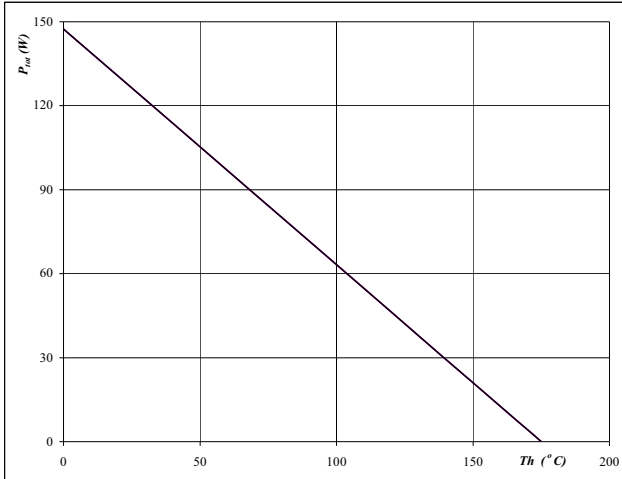
R (C/W)	Tau (s)
0,03	9,8E+00
0,16	9,8E-01
0,65	1,4E-01
0,47	4,0E-02
0,14	6,0E-03
0,10	6,2E-04

## Output Inverter

Figure 21 Output inverter IGBT

Power dissipation as a function of heatsink temperature

$$P_{tot} = f(T_h)$$

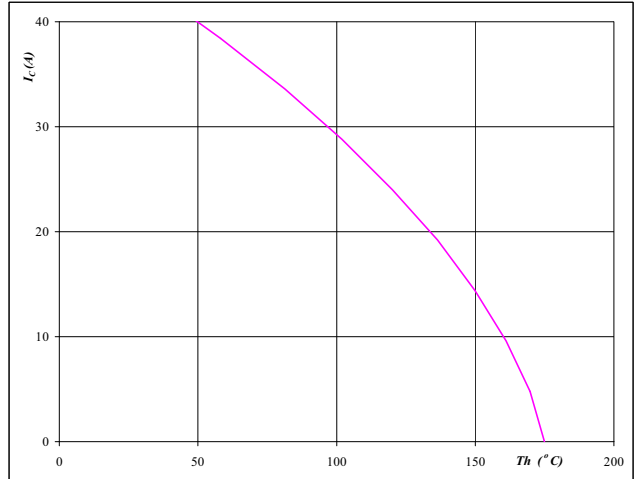


$T_j = 175 \text{ } ^{\circ}C$

Figure 22 Output inverter IGBT

Collector current as a function of heatsink temperature

$$I_C = f(T_h)$$

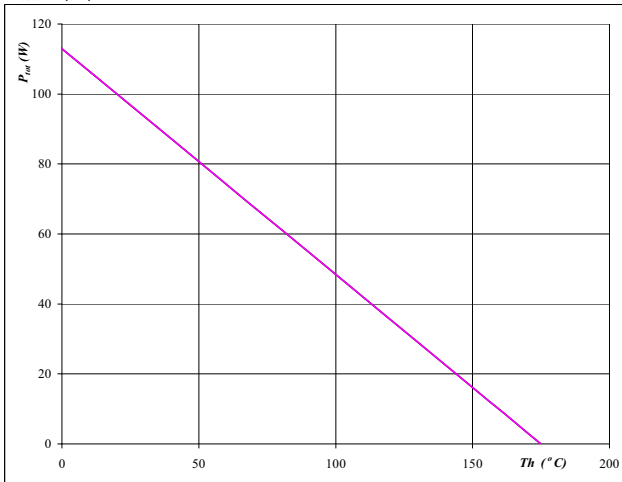


$T_j = 175 \text{ } ^{\circ}C$   
 $V_{GE} = 15 \text{ V}$

Figure 23 Output inverter FRED

Power dissipation as a function of heatsink temperature

$$P_{tot} = f(T_h)$$

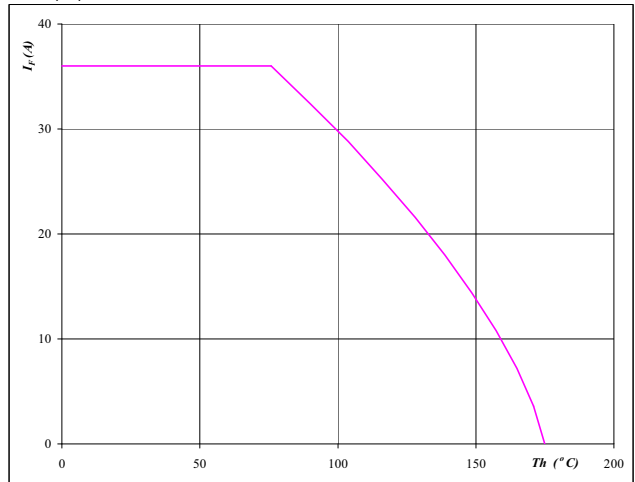


$T_j = 175 \text{ } ^{\circ}C$

Figure 24 Output inverter FRED

Forward current as a function of heatsink temperature

$$I_F = f(T_h)$$



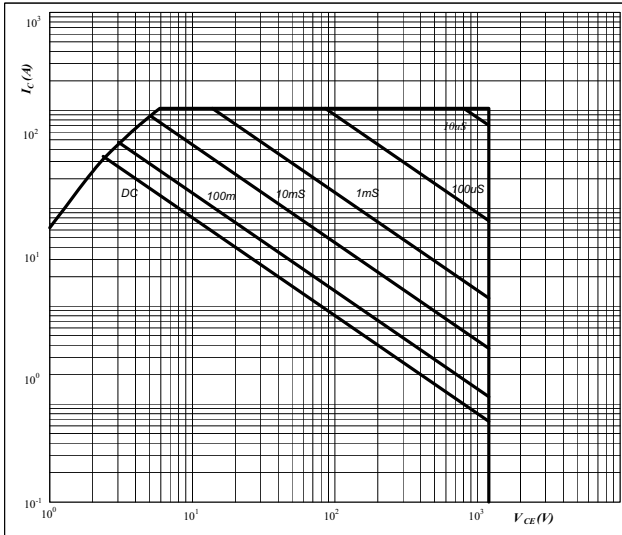
$T_j = 175 \text{ } ^{\circ}C$

## Output Inverter

**Figure 25** Output inverter IGBT

**Safe operating area as a function of collector-emitter voltage**

$$I_C = f(V_{CE})$$

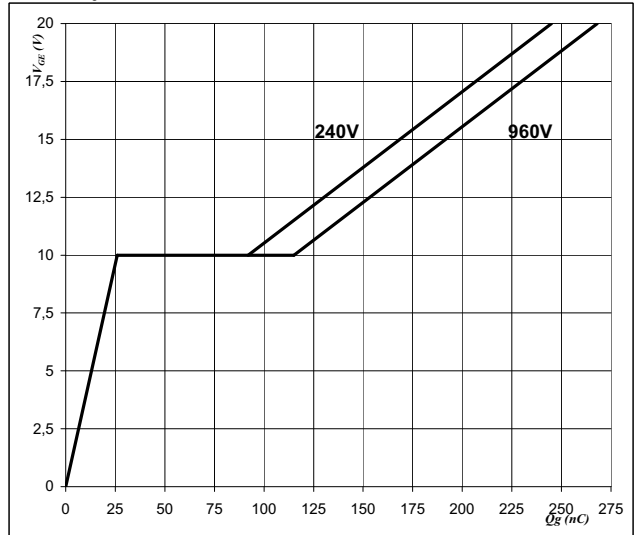


D = single pulse  
 $T_h = 80 \text{ } ^\circ\text{C}$   
 $V_{GE} = \pm 15 \text{ V}$   
 $T_j = T_{jmax} \text{ } ^\circ\text{C}$

**Figure 26** Output inverter IGBT

**Gate voltage vs Gate charge**

$$V_{GE} = f(Q_g)$$



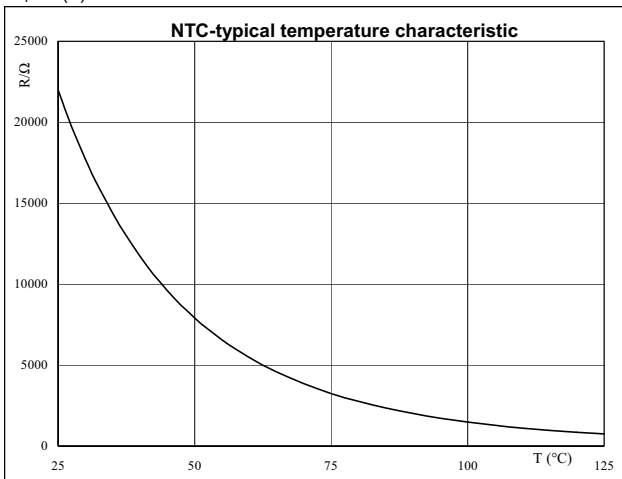
$I_C = 35 \text{ A}$

## Thermistor

**Figure 1** Thermistor

**Typical NTC characteristic as a function of temperature**

$$R_T = f(T)$$

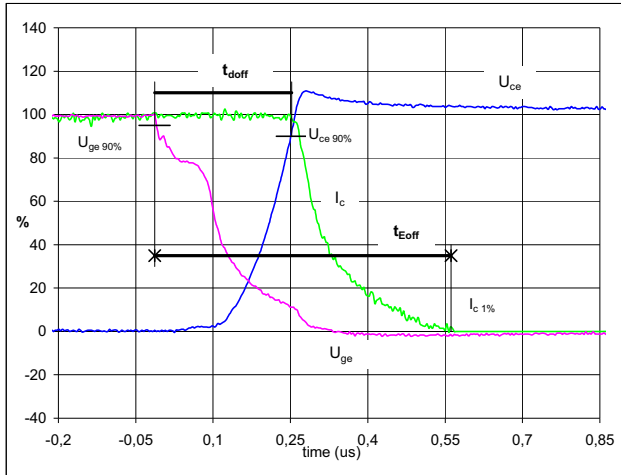


## Switching Definitions Output Inverter

General conditions	
$T_j$	= 150 °C
$R_{gon}$	= 16 $\Omega$
$R_{goff}$	= 16 $\Omega$

Figure 1 Output inverter IGBT

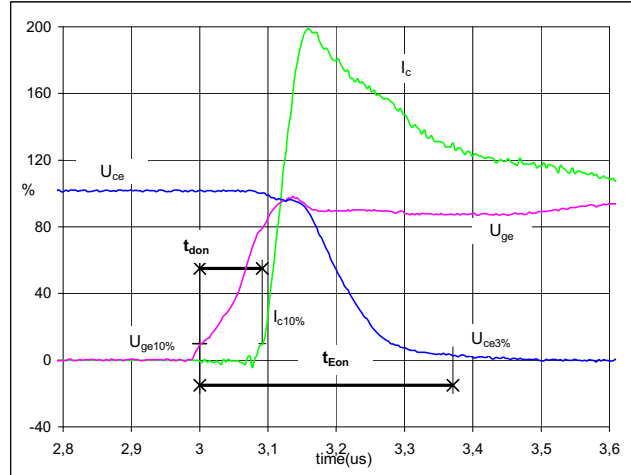
Turn-off Switching Waveforms & definition of  $t_{doff}$ ,  $t_{Eoff}$   
( $t_{Eoff}$  = integrating time for  $E_{off}$ )



$V_{GE}(0\%)$	=	-15	V
$V_{GE}(100\%)$	=	15	V
$V_C(100\%)$	=	600	V
$I_C(100\%)$	=	35	A
$t_{doff}$	=	0,26	$\mu s$
$t_{Eoff}$	=	0,57	$\mu s$

Figure 2 Output inverter IGBT

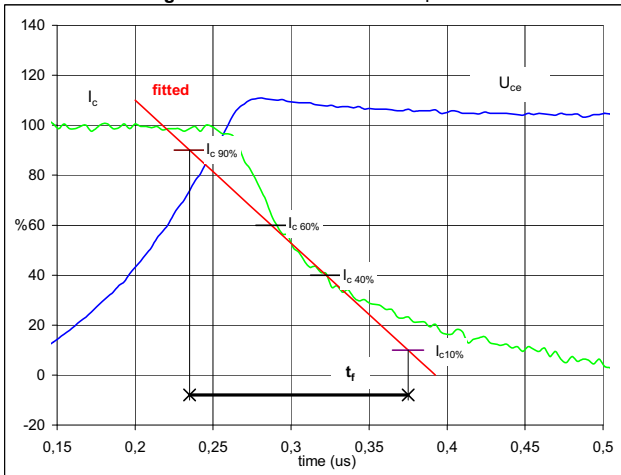
Turn-on Switching Waveforms & definition of  $t_{don}$ ,  $t_{Eon}$   
( $t_{Eon}$  = integrating time for  $E_{on}$ )



$V_{GE}(0\%)$	=	-15	V
$V_{GE}(100\%)$	=	15	V
$V_C(100\%)$	=	600	V
$I_C(100\%)$	=	35	A
$t_{don}$	=	0,09	$\mu s$
$t_{Eon}$	=	0,37	$\mu s$

Figure 3 Output inverter IGBT

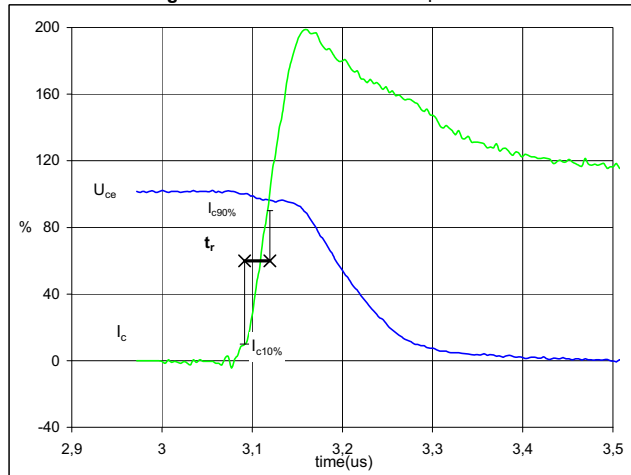
Turn-off Switching Waveforms & definition of  $t_f$



$V_C(100\%)$	=	600	V
$I_C(100\%)$	=	35	A
$t_f$	=	0,12	$\mu s$

Figure 4 Output inverter IGBT

Turn-on Switching Waveforms & definition of  $t_r$

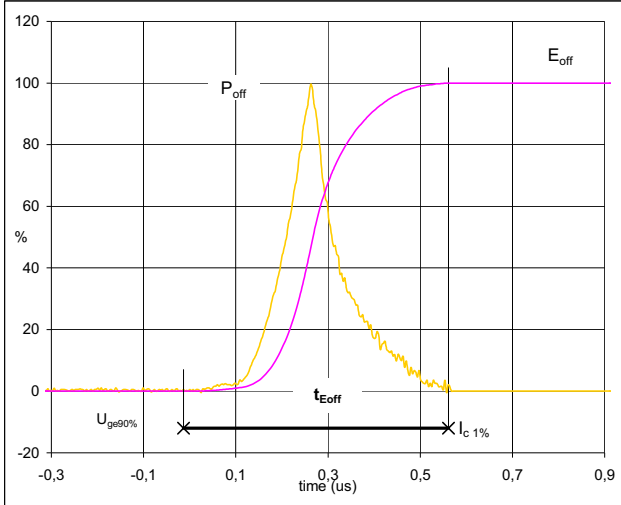


$V_C(100\%)$	=	600	V
$I_C(100\%)$	=	35	A
$t_r$	=	0,03	$\mu s$

## Switching Definitions Output Inverter

Figure 5 Output inverter IGBT

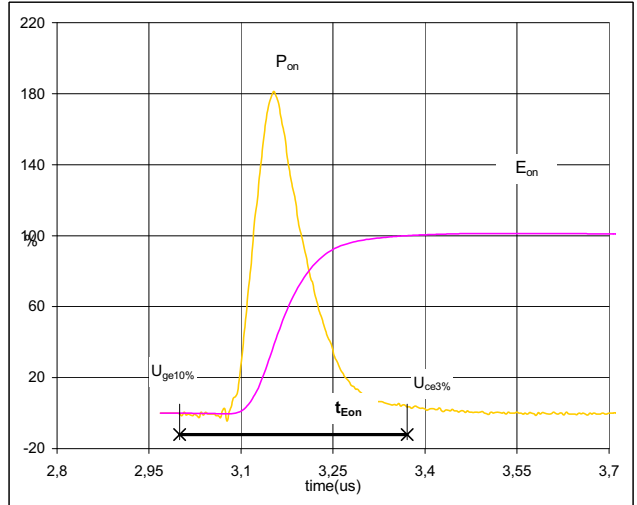
Turn-off Switching Waveforms & definition of  $t_{Eoff}$



$P_{off}(100\%) = 21,08 \text{ kW}$   
 $E_{off}(100\%) = 2,91 \text{ mJ}$   
 $t_{Eoff} = 0,57 \text{ μs}$

Figure 6 Output inverter IGBT

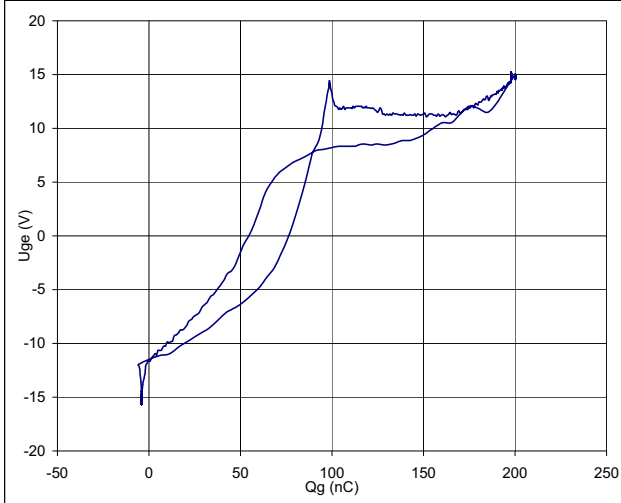
Turn-on Switching Waveforms & definition of  $t_{Eon}$



$P_{on}(100\%) = 21,08 \text{ kW}$   
 $E_{on}(100\%) = 3,71 \text{ mJ}$   
 $t_{Eon} = 0,37 \text{ μs}$

Figure 7 Output inverter FRED

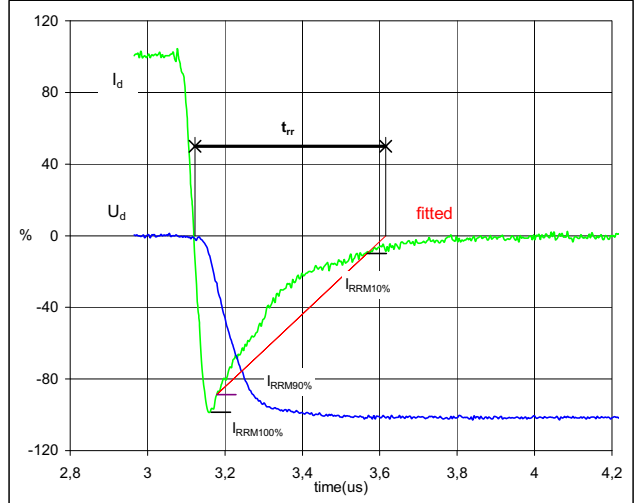
Gate voltage vs Gate charge (measured)



$V_{GEoff} = -15 \text{ V}$   
 $V_{GEon} = 15 \text{ V}$   
 $V_C(100\%) = 600 \text{ V}$   
 $I_C(100\%) = 35 \text{ A}$   
 $Q_g = 1132 \text{ nC}$

Figure 8 Output inverter IGBT

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

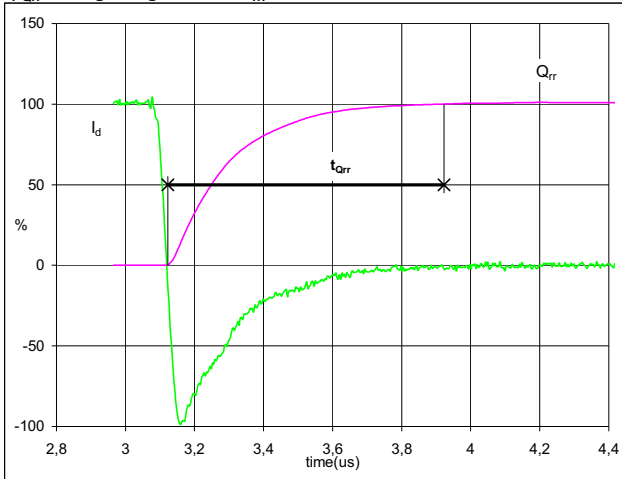


$V_d(100\%) = 600 \text{ V}$   
 $I_d(100\%) = 35 \text{ A}$   
 $I_{RRM}(100\%) = -34 \text{ A}$   
 $t_{rr} = 0,49 \text{ μs}$

## Switching Definitions Output Inverter

**Figure 9** Output inverter FRED

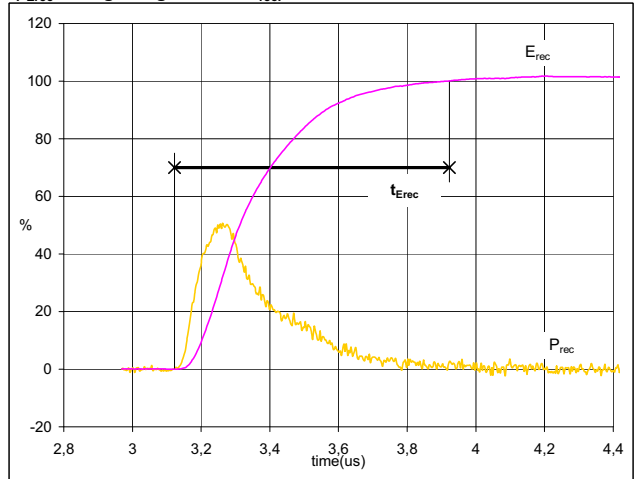
Turn-on Switching Waveforms & definition of  $t_{Qrr}$   
( $t_{Qrr}$  = integrating time for  $Q_{rr}$ )



$I_d$ (100%) =	35	A
$Q_{rr}$ (100%) =	7,00	$\mu\text{C}$
$t_{Qrr}$ =	0,80	$\mu\text{s}$

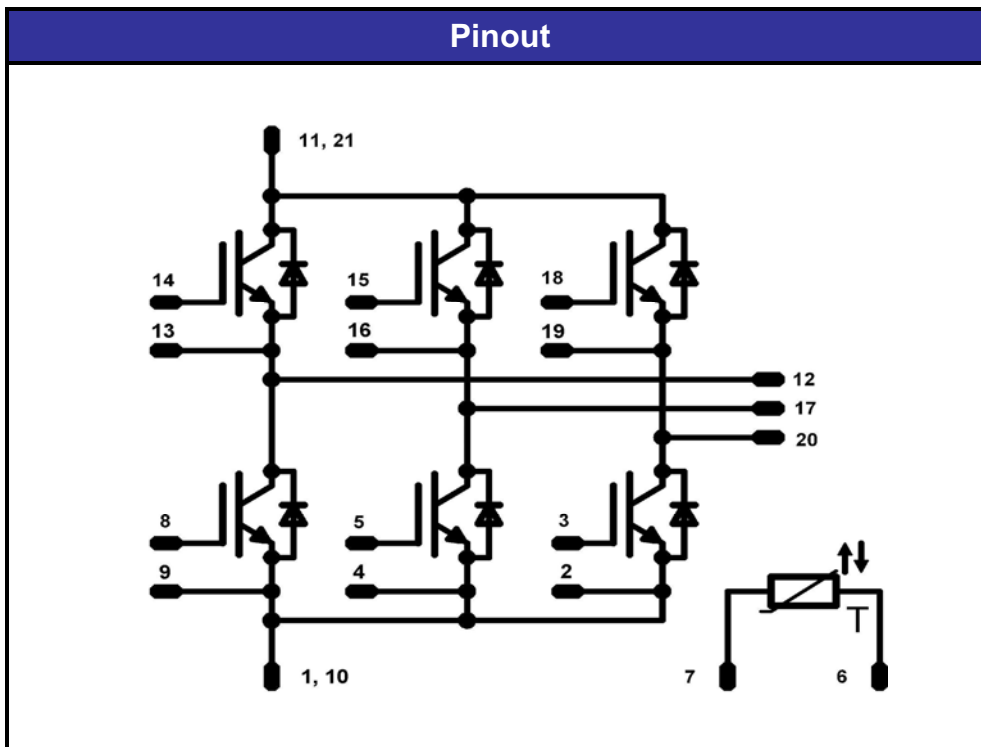
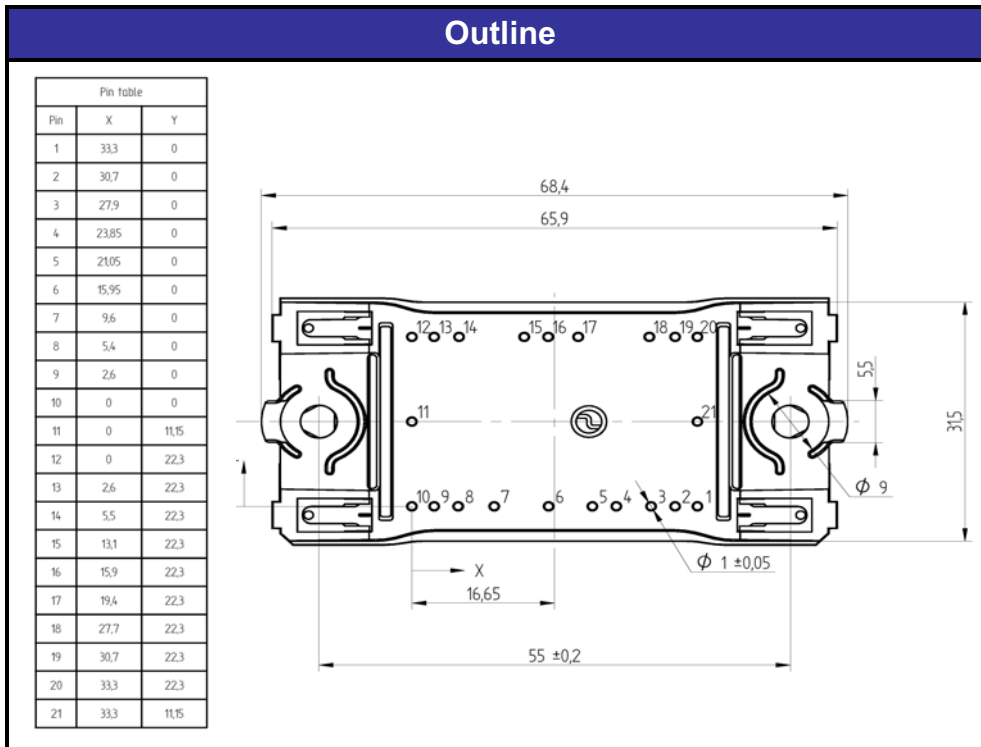
**Figure 10** Output inverter FRED

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



$P_{rec}$ (100%) =	21,08	kW
$E_{rec}$ (100%) =	2,81	mJ
$t_{Erec}$ =	0,80	$\mu\text{s}$

### Package Outline and Pinout



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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.
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