

flowPIM 0 + PFC 2nd

600V/20A

Features

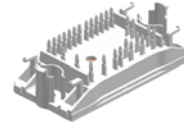
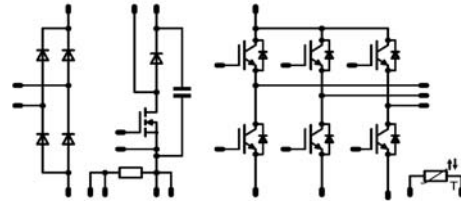
- Clip in PCB mounting
- Trench Fieldstop IGBT's for low saturation losses
- Latest generation superjunction MOSFET for PFC

Target Applications

- Industrial Drives
- Embedded Drives

Types

- 10-F006PPA020SB01-M685B10

flowPIM0+PFC 2nd

Schematic


Maximum Ratings

 $T_j=25^{\circ}\text{C}$, unless otherwise specified

Parameter	Symbol	Condition	Value	Unit	
Input Rectifier Diode					
Repetitive peak reverse voltage	V_{RRM}		1600	V	
DC forward current	I_{FAV}	$T_j=T_{jmax}$	$T_h=80^{\circ}\text{C}$	26	A
			$T_c=80^{\circ}\text{C}$	36	
Surge forward current	I_{FSM}	$t_p=10\text{ms}$	$T_j=150^{\circ}\text{C}$	200	A
I2t-value	I^2t			200	A^2s
Power dissipation per Diode	P_{tot}	$T_j=T_{jmax}$	$T_h=80^{\circ}\text{C}$	32	W
			$T_c=80^{\circ}\text{C}$	48	
Maximum Junction Temperature	T_{jmax}		150	$^{\circ}\text{C}$	

Maximum Ratings

 $T_j=25^{\circ}\text{C}$, unless otherwise specified

Parameter	Symbol	Condition	Value	Unit
PFC MOSFET				
Drain to source breakdown voltage	V_{DS}		600	V
DC drain current	I_D	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	20 24	A
Pulsed drain current	I_{Dpulse}	$T_j=25^{\circ}\text{C}$	159	A
Avalanche energy, single pulse	E_{AS}	$I_D=9,3\text{A}$ $V_{DD}=50\text{V}$ $T_j=25^{\circ}\text{C}$	1135	mJ
Avalanche energy, repetitive	E_{AR}	$I_D=9,3\text{A}$ $V_{DD}=50\text{V}$ $T_j=25^{\circ}\text{C}$	1,72	mJ
Avalanche current, repetitive	I_{AR}		9,3	A
MOSFET dv/dt ruggedness	dv/dt	$V_{DS}=0\dots480\text{V}$	50	V/ns
Power dissipation	P_{tot}	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	64 97	W
Gate-source peak voltage	V_{GS}		± 20	V
Reverse diode dv/dt	dv/dt	$V_{DS}=0\dots400\text{V}$, $I_{SD} \leq I_D$ $T_j=25^{\circ}\text{C}$	15	V/ns
Maximum Junction Temperature	T_{jmax}		150	$^{\circ}\text{C}$

PFC Diode

Peak Repetitive Reverse Voltage	V_{RRM}	$T_j=25^{\circ}\text{C}$	600	V
DC forward current	I_F	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	23 30	A
Repetitive peak forward current	I_{FRM}	t_p limited by T_{jmax}	99	A
Power dissipation	P_{tot}	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	36 54	W
Maximum Junction Temperature	T_{jmax}		150	$^{\circ}\text{C}$

PFC Shunt

DC forward current	I_F	$T_c=25^{\circ}\text{C}$	55	A
Power dissipation per Shunt	P_{tot}	$T_c=25^{\circ}\text{C}$	3	W

Inverter Transistor

Collector-emitter break down voltage	V_{CE}		600	V
DC collector current	I_C	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	20 27	A
Pulsed collector current	I_{Cpulse}	t_p limited by T_{jmax}	60	A
Turn off safe operating area		$V_{CE} \leq 600\text{V}$, $T_j \leq T_{op max}$	60	A
Power dissipation per IGBT	P_{tot}	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	41 62	W
Gate-emitter peak voltage	V_{GE}		± 20	V
Short circuit ratings	t_{SC} V_{CC}	$T_j \leq 150^{\circ}\text{C}$ $V_{GE}=15\text{V}$	6 360	μs V
Maximum Junction Temperature	T_{jmax}		175	$^{\circ}\text{C}$

Maximum Ratings

 $T_j=25^{\circ}\text{C}$, unless otherwise specified

Parameter	Symbol	Condition	Value	Unit
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Inverter Diode

Peak Repetitive Reverse Voltage	V_{RRM}	$T_j=25^{\circ}\text{C}$	600	V	
DC forward current	I_F	$T_j=T_{jmax}$	$T_h=80^{\circ}\text{C}$	26	A
			$T_c=80^{\circ}\text{C}$	34	
Repetitive peak forward current	I_{FRM}	t_p limited by T_{jmax}	60	A	
Power dissipation per Diode	P_{tot}	$T_j=T_{jmax}$	$T_h=80^{\circ}\text{C}$	40	W
			$T_c=80^{\circ}\text{C}$	60	
Maximum Junction Temperature	T_{jmax}		175	$^{\circ}\text{C}$	

DC link Capacitor

Max.DC voltage	V_{MAX}	$T_c=25^{\circ}\text{C}$	500	V
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Thermal Properties

Storage temperature	T_{slg}		-40...+125	$^{\circ}\text{C}$
Operation temperature under switching condition	T_{op}		-40...+($T_{jmax} - 25$)	$^{\circ}\text{C}$

Insulation Properties

Insulation voltage	V_{is}	$t=2\text{s}$ DC voltage	4000	V
Creepage distance			min 12,7	mm
Clearance			min 12,7	mm
Comparative tracking index	CTI		>200	

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		
Input Rectifier Diode										
Forward voltage	V_F			25	$T_j=25^\circ C$ $T_j=125^\circ C$		1,20 1,17			V
Threshold voltage (for power loss calc. only)	V_{td}			25	$T_j=25^\circ C$ $T_j=125^\circ C$		0,92 0,81			V
Slope resistance (for power loss calc. only)	r_t			25	$T_j=25^\circ C$ $T_j=125^\circ C$		11 14			m Ω
Reverse current	I_r		1600		$T_j=25^\circ C$ $T_j=125^\circ C$			0,05		mA
Thermal resistance chip to heatsink per chip	R_{thJH}	Thermal grease thickness \leq 50um $\lambda = 1$ W/mK					2,20			K/W

PFC MOSFET

Static drain to source ON resistance	$R_{DS(on)}$		10		15	$T_j=25^\circ C$ $T_j=125^\circ C$		70 140		m Ω
Gate threshold voltage	$V_{(GS)th}$				0,00172	$T_j=25^\circ C$ $T_j=125^\circ C$	2,4	3	3,6	V
Gate to Source Leakage Current	I_{GSS}		20	0		$T_j=25^\circ C$ $T_j=125^\circ C$			100	nA
Zero Gate Voltage Drain Current	I_{DSS}		0	600		$T_j=25^\circ C$ $T_j=125^\circ C$			5	nA
Turn On Delay Time	$t_{d(ON)}$	Rgoff=8 Ω Rgon=8 Ω	± 15	400	21	$T_j=25^\circ C$		24		ns
Rise Time	t_r					$T_j=125^\circ C$		23		
Turn off delay time	$t_{d(OFF)}$					$T_j=25^\circ C$		10		
Fall time	t_f					$T_j=125^\circ C$		11		
Turn-on energy loss per pulse	E_{on}					$T_j=25^\circ C$		228		
Turn-off energy loss per pulse	E_{off}					$T_j=125^\circ C$		237		
Total gate charge	Q_{GE}					$T_j=25^\circ C$		13		
Gate to source charge	Q_{GS}					$T_j=125^\circ C$		11		
Gate to drain charge	Q_{GD}	$T_j=25^\circ C$		0,22						
Input capacitance	C_{iss}	f=1MHz	0	100		$T_j=25^\circ C$		3800		pF
Output capacitance	C_{oss}					$T_j=125^\circ C$		215		
Gate resistance	r_G							0,85		
Thermal resistance chip to heatsink per chip	R_{thJH}	Thermal grease thickness \leq 50um $\lambda = 1$ W/mK					1,09			K/W

PFC Diode

Forward voltage	V_F				24	$T_j=25^\circ C$ $T_j=125^\circ C$		1,40 1,55	1,7	V
Reverse leakage current	I_{rm}			600		$T_j=25^\circ C$ $T_j=125^\circ C$			480	μA
Peak recovery current	I_{RRM}	Rgon=8 Ω	± 15	400	21	$T_j=25^\circ C$		7		A
Reverse recovery time	t_{rr}					$T_j=125^\circ C$		6		
Reverse recovery charge	Q_{rr}					$T_j=25^\circ C$		12		
Reverse recovered energy	E_{rec}					$T_j=125^\circ C$		13		
Peak rate of fall of recovery current	$di(rec)max/dt$					$T_j=25^\circ C$		0,14		
						$T_j=125^\circ C$		0,13		
Thermal resistance chip to heatsink per chip	R_{thJH}	Thermal grease thickness \leq 50um $\lambda = 1$ W/mK					1,96			K/W

PFC Shunt

R1 value	R							10		m Ω
Temperature coefficient	t_c	20 $^\circ C$ to 60 $^\circ C$							30	ppm/K
Internal heat resistance	R_{thi}								10	K/W
Inductance	L								3	nH

Characteristic Values

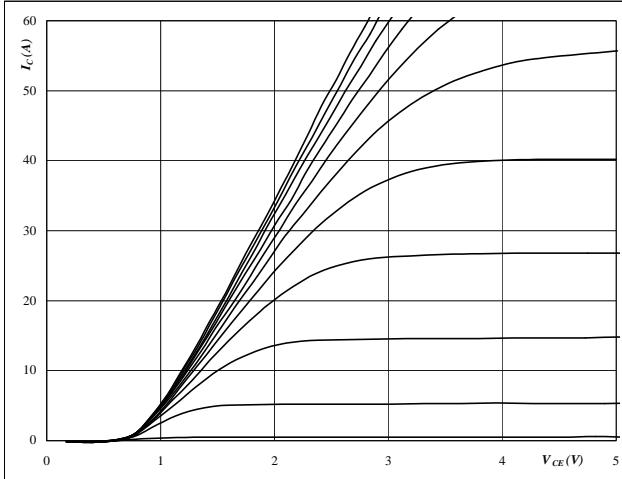
Parameter	Symbol	Conditions					Value			Unit
		$V_{GE}[V]$ or $V_{GS}[V]$	$V_r[V]$ or $V_{CE}[V]$ or $V_{DS}[V]$	$I_c[A]$ or $I_F[A]$ or $I_b[A]$	T_j	Min	Typ	Max		
Inverter Transistor										
Gate emitter threshold voltage	$V_{GE(th)}$	$V_{CE}=V_{GE}$			0,00029	$T_j=25^\circ C$ $T_j=125^\circ C$	5	5,6	6,5	V
Collector-emitter saturation voltage	$V_{CE(sat)}$		15		20	$T_j=25^\circ C$ $T_j=125^\circ C$	1,1	1,58 1,76	1,9	V
Collector-emitter cut-off current incl. Diode	I_{CES}		0	600		$T_j=25^\circ C$ $T_j=125^\circ C$			1,1	mA
Gate-emitter leakage current	I_{GES}		20	0		$T_j=25^\circ C$ $T_j=125^\circ C$			300	nA
Integrated Gate resistor	R_{gint}							noen		Ω
Turn-on delay time	$t_{d(on)}$	$R_{goff}=16 \Omega$ $R_{gon}=16 \Omega$	± 15	400	20	$T_j=25^\circ C$		67	ns	
Rise time	t_r					$T_j=125^\circ C$		67		
Turn-off delay time	$t_{d(off)}$					$T_j=25^\circ C$		27		
Fall time	t_f					$T_j=125^\circ C$		29		
Turn-on energy loss per pulse	E_{on}					$T_j=25^\circ C$		126		
Turn-off energy loss per pulse	E_{off}	$T_j=125^\circ C$		145						
Input capacitance	C_{ies}					$T_j=25^\circ C$		1100	pF	
Output capacitance	C_{oss}	$f=1MHz$	0	25		$T_j=25^\circ C$		71		
Reverse transfer capacitance	C_{rss}					$T_j=25^\circ C$		32		
Gate charge	Q_{Gate}		± 15	480	20	$T_j=25^\circ C$		120	nC	
Thermal resistance chip to heatsink per chip	R_{thJH}	Thermal grease thickness $\leq 50\mu m$ $\lambda = 1 W/mK$						2,32	K/W	
Inverter Diode										
Diode forward voltage	V_F				30	$T_j=25^\circ C$ $T_j=125^\circ C$	1,25	1,64 1,66	1,95	V
Peak reverse recovery current	I_{RRM}	$R_{gon}=16 \Omega$	± 15	400	20	$T_j=25^\circ C$		10	ns	
Reverse recovery time	t_{rr}					$T_j=125^\circ C$		13		
Reverse recovered charge	Q_{rr}					$T_j=25^\circ C$		204		
Peak rate of fall of recovery current	$di(rec)max/dt$					$T_j=125^\circ C$		257		
Reverse recovered energy	E_{rec}					$T_j=25^\circ C$		1,13		
Thermal resistance chip to heatsink per chip	R_{thJH}	Thermal grease thickness $\leq 50\mu m$ $\lambda = 1 W/mK$						2,40	K/W	
DC link Capacitor										
C value	C							100	nF	
Thermistor										
Rated resistance	R					$T_j=25^\circ C$		22000	Ω	
Deviation of R100	$\Delta R/R$	$R_{100}=1486 \Omega$				$T_c=100^\circ C$	-5		5	%
Power dissipation	P					$T_c=100^\circ C$		210	mW	
Power dissipation constant						$T_j=25^\circ C$		3,5	mW/K	
B-value	$B_{(25/50)}$	Tol. $\pm 3\%$				$T_j=25^\circ C$			K	
B-value	$B_{(25/100)}$	Tol. $\pm 3\%$				$T_j=25^\circ C$		4000	K	
Vincotech NTC Reference						$T_j=25^\circ C$			A	

Output Inverter

Figure 1 Output inverter IGBT

Typical output characteristics

$I_C = f(V_{CE})$

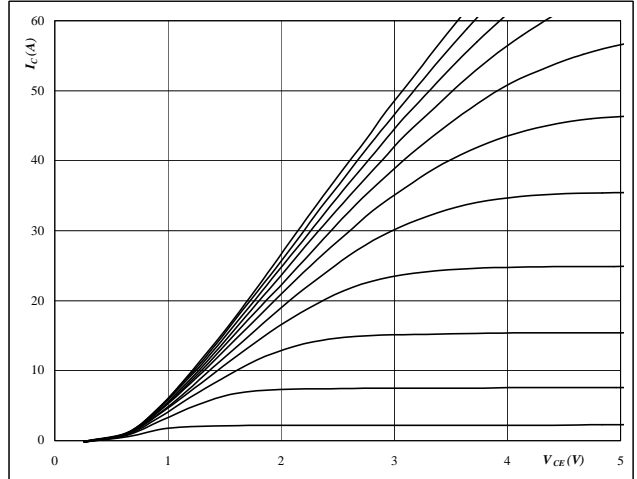


At
 $t_p = 250 \mu s$
 $T_J = 25 \text{ }^\circ C$
 V_{GE} from 7 V to 17 V in steps of 1 V

Figure 2 Output inverter IGBT

Typical output characteristics

$I_C = f(V_{CE})$

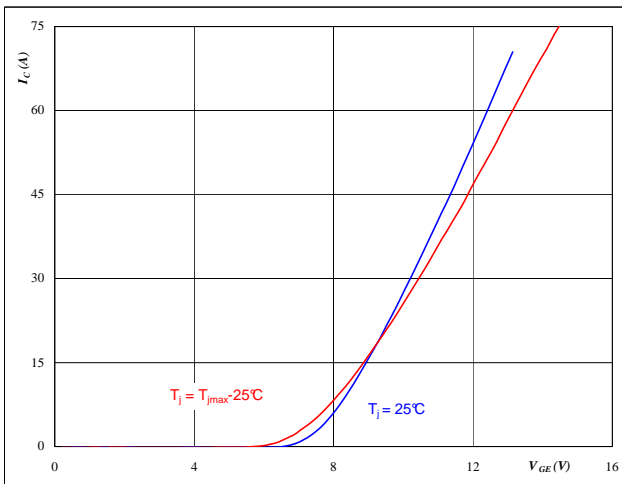


At
 $t_p = 250 \mu s$
 $T_J = 125 \text{ }^\circ C$
 V_{GE} from 7 V to 17 V in steps of 1 V

Figure 3 Output inverter IGBT

Typical transfer characteristics

$I_C = f(V_{GE})$

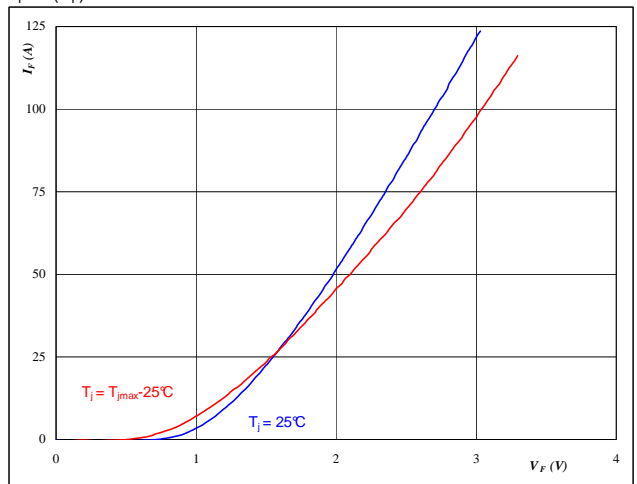


At
 $t_p = 250 \mu s$
 $V_{CE} = 10 V$

Figure 4 Output inverter FWD

Typical diode forward current as a function of forward voltage

$I_F = f(V_F)$



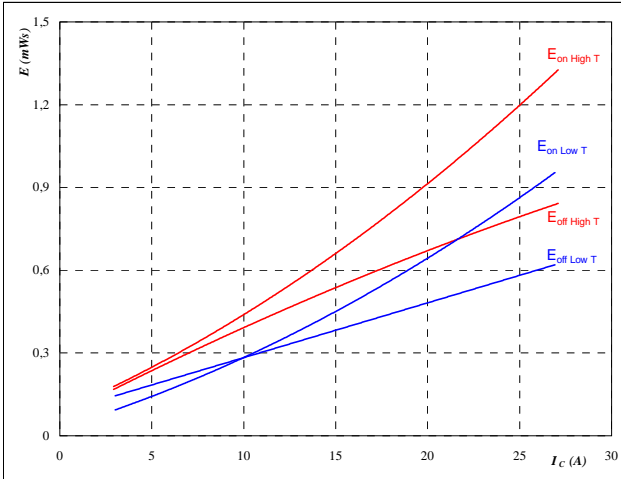
At
 $t_p = 250 \mu s$

Output Inverter

Figure 5 Output inverter IGBT

Typical switching energy losses as a function of collector current

$$E = f(I_C)$$



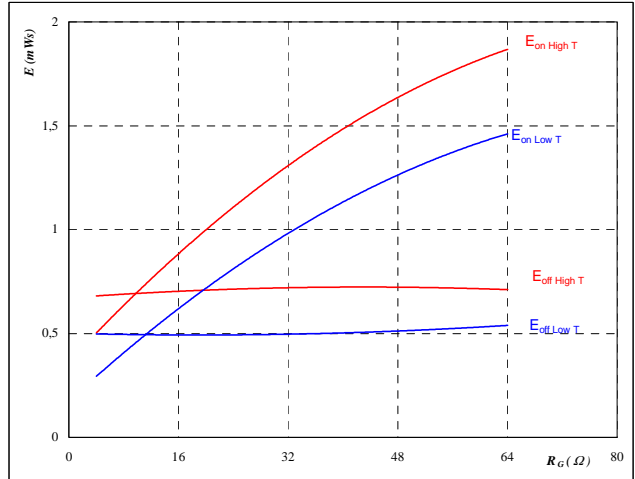
With an inductive load at

$T_J =$	25/125	°C
$V_{CE} =$	400	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

$$E = f(R_G)$$



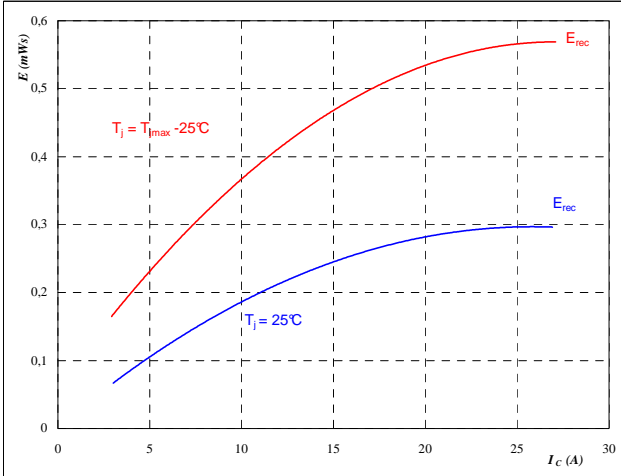
With an inductive load at

$T_J =$	25/125	°C
$V_{CE} =$	400	V
$V_{GE} =$	±15	V
$I_C =$	20	A

Figure 7 Output inverter FWD

Typical reverse recovery energy loss as a function of collector current

$$E_{rec} = f(I_C)$$



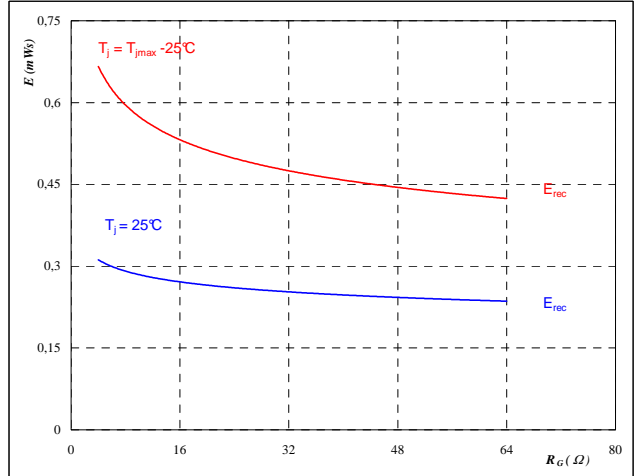
With an inductive load at

$T_J =$	25/125	°C
$V_{CE} =$	400	V
$V_{GE} =$	±15	V
$R_{gon} =$	16	Ω

Figure 8 Output inverter FWD

Typical reverse recovery energy loss as a function of gate resistor

$$E_{rec} = f(R_G)$$



With an inductive load at

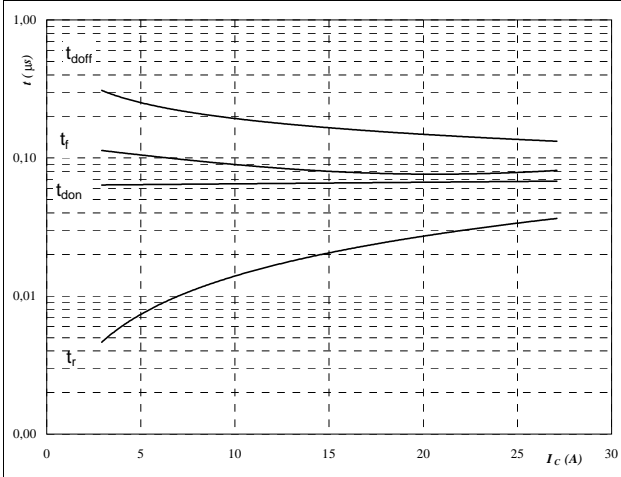
$T_J =$	25/125	°C
$V_{CE} =$	400	V
$V_{GE} =$	±15	V
$I_C =$	20	A

Output Inverter

Figure 9 Output inverter IGBT

Typical switching times as a function of collector current

$$t = f(I_C)$$



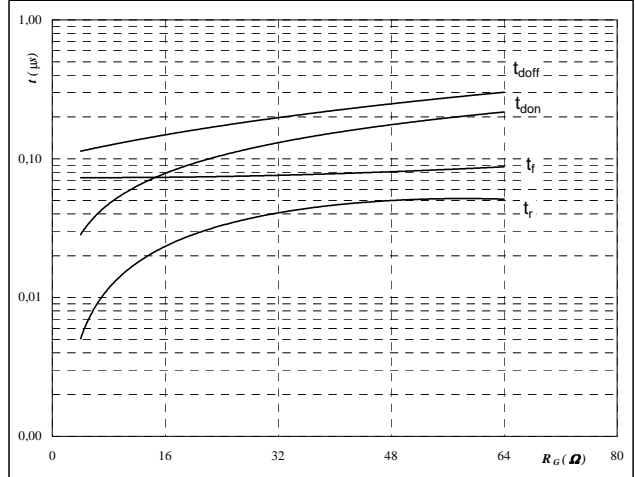
With an inductive load at

$T_j =$	125	°C
$V_{CE} =$	400	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

$$t = f(R_G)$$



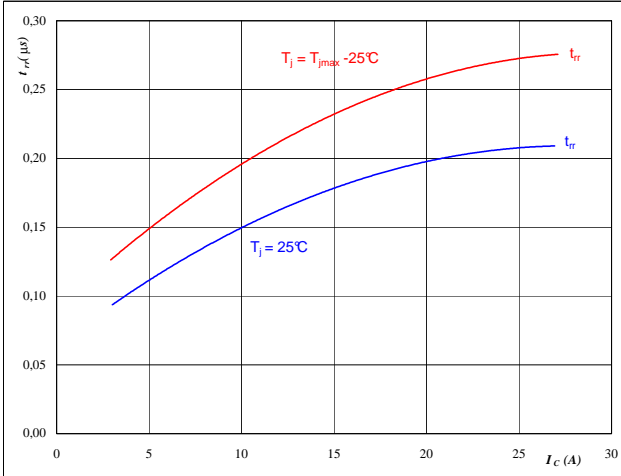
With an inductive load at

$T_j =$	125	°C
$V_{CE} =$	400	V
$V_{GE} =$	±15	V
$I_C =$	20	A

Figure 11 Output inverter FWD

Typical reverse recovery time as a function of collector current

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



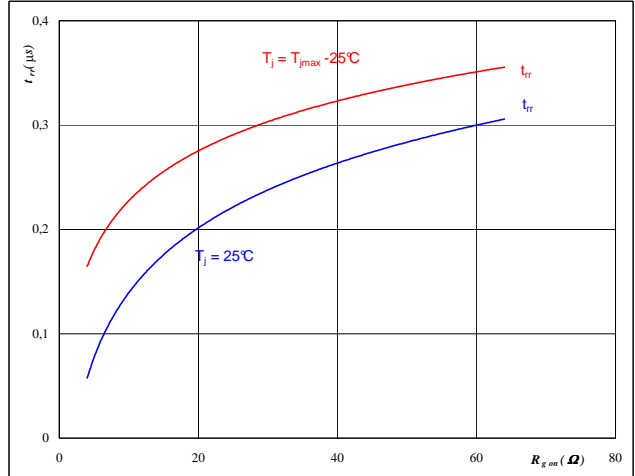
At

$T_j =$	25/125	°C
$V_{CE} =$	400	V
$V_{GE} =$	±15	V
$R_{gon} =$	16	Ω

Figure 12 Output inverter FWD

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

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



At

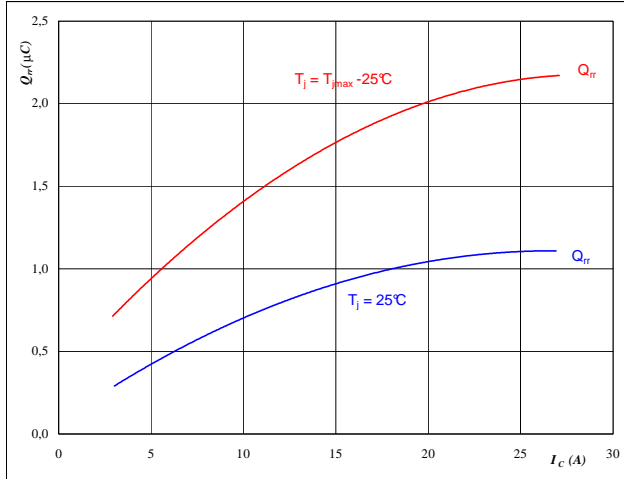
$T_j =$	25/125	°C
$V_R =$	400	V
$I_F =$	20	A
$V_{GE} =$	±15	V

Output Inverter

Figure 13 Output inverter FWD

Typical reverse recovery charge as a function of collector current

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



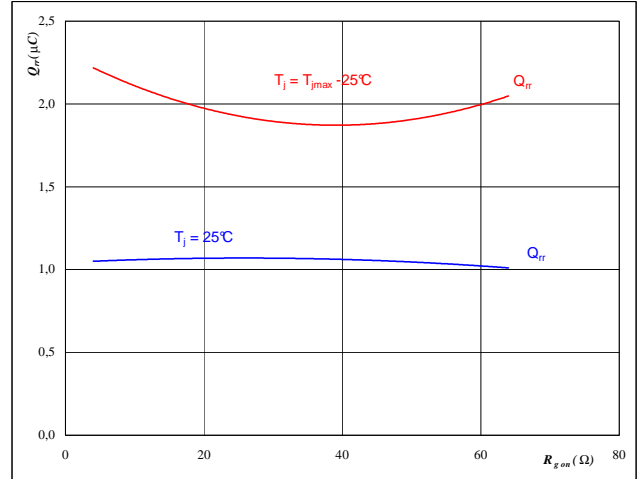
At

$T_j =$	25/125	°C
$V_{CE} =$	400	V
$V_{GE} =$	±15	V
$R_{gon} =$	16	Ω

Figure 14 Output inverter FWD

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

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



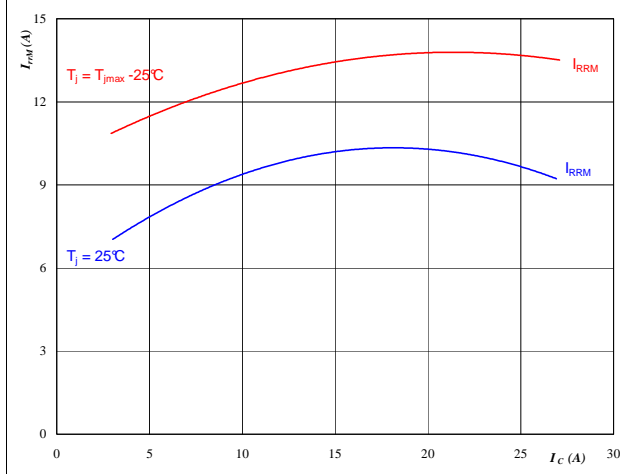
At

$T_j =$	25/125	°C
$V_R =$	400	V
$I_F =$	20	A
$V_{GE} =$	±15	V

Figure 15 Output inverter FWD

Typical reverse recovery current as a function of collector current

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



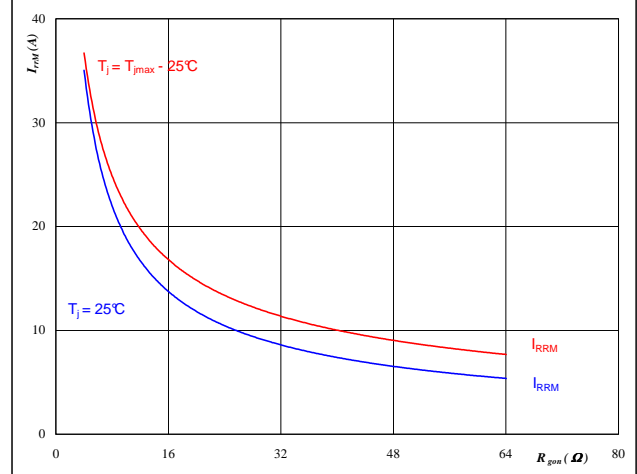
At

$T_j =$	25/125	°C
$V_{CE} =$	400	V
$V_{GE} =$	±15	V
$R_{gon} =$	16	Ω

Figure 16 Output inverter FWD

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

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



At

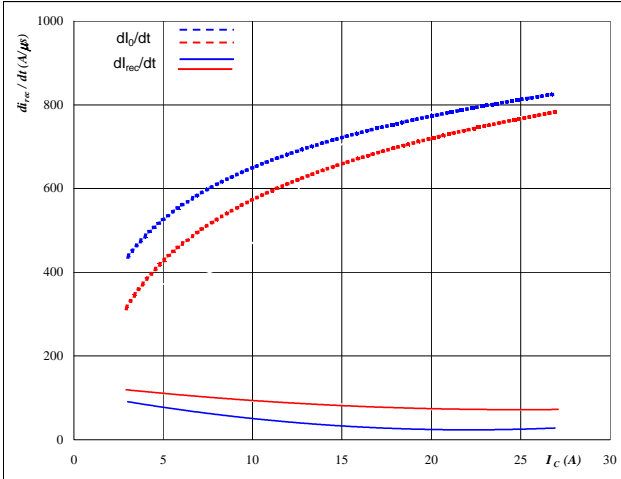
$T_j =$	25/125	°C
$V_R =$	400	V
$I_F =$	20	A
$V_{GE} =$	±15	V

Output Inverter

Figure 17 Output inverter FWD

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

$$dI_f/dt, dI_{rec}/dt = f(I_C)$$

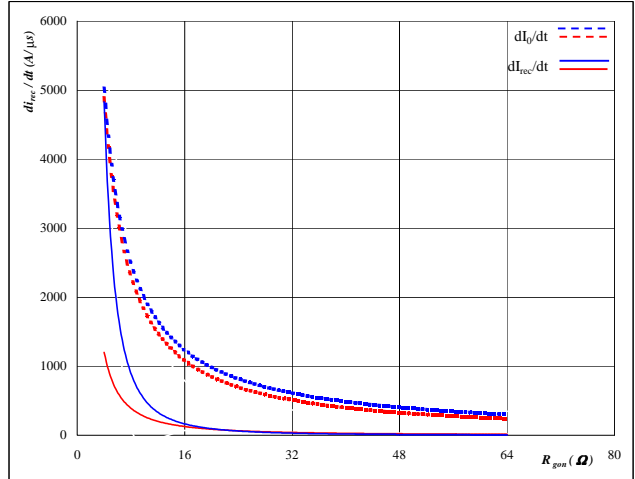


At
 $T_j = 25/125 \text{ } ^\circ\text{C}$
 $V_{CE} = 400 \text{ V}$
 $V_{GE} = \pm 15 \text{ V}$
 $R_{gon} = 16 \text{ } \Omega$

Figure 18 Output inverter FWD

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

$$dI_f/dt, dI_{rec}/dt = f(R_{gon})$$

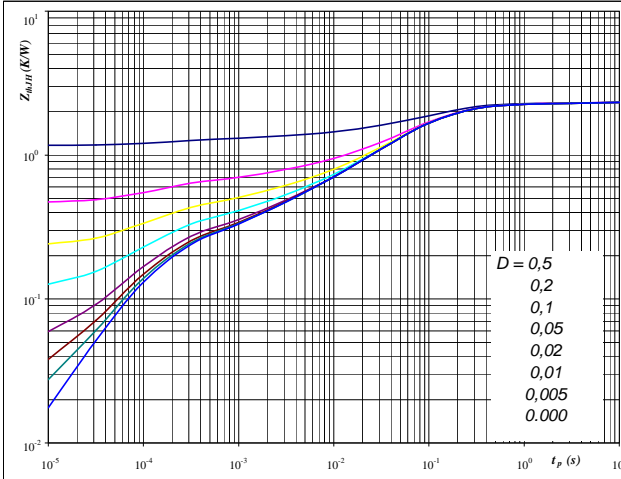


At
 $T_j = 25/125 \text{ } ^\circ\text{C}$
 $V_R = 400 \text{ V}$
 $I_F = 20 \text{ A}$
 $V_{GE} = \pm 15 \text{ V}$

Figure 19 Output inverter IGBT

IGBT transient thermal impedance as a function of pulse width

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



At
 $D = t_p / T$
 $R_{thJH} = 2,32 \text{ K/W}$ $R_{thJH} = 1,88 \text{ K/W}$

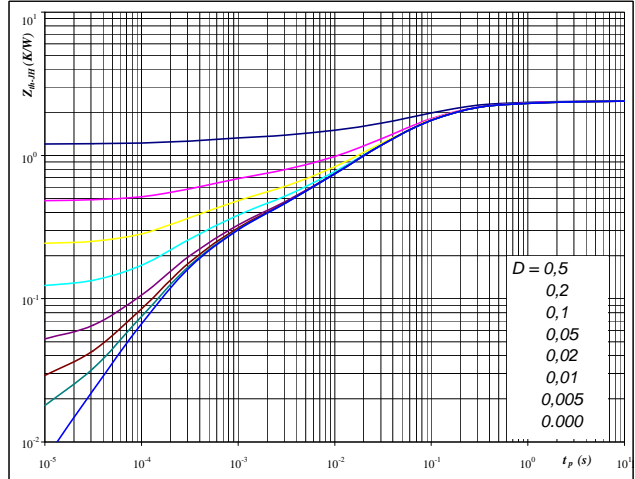
IGBT thermal model values

Thermal grease		Phase change interface	
R (C/W)	Tau (s)	R (C/W)	Tau (s)
0,07	4,4E+00	0,06	3,6E+00
0,30	3,8E-01	0,24	3,1E-01
1,26	8,1E-02	1,02	6,6E-02
0,34	1,2E-02	0,27	9,6E-03
0,14	1,4E-03	0,12	1,1E-03
0,21	1,3E-04	0,17	1,0E-04

Figure 20 Output inverter FWD

FWD transient thermal impedance as a function of pulse width

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



At
 $D = t_p / T$
 $R_{thJH} = 2,40 \text{ K/W}$ $R_{thJH} = 1,94 \text{ K/W}$

FWD thermal model values

Thermal grease		Phase change interface	
R (C/W)	Tau (s)	R (C/W)	Tau (s)
0,07	4,6E+00	0,06	3,7E+00
0,27	4,8E-01	0,22	3,9E-01
1,13	8,5E-02	0,92	6,9E-02
0,52	2,0E-02	0,42	1,6E-02
0,20	2,8E-03	0,16	2,3E-03
0,21	3,3E-04	0,17	2,7E-04

Output Inverter

Figure 21 Output inverter IGBT

Power dissipation as a function of heatsink temperature

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

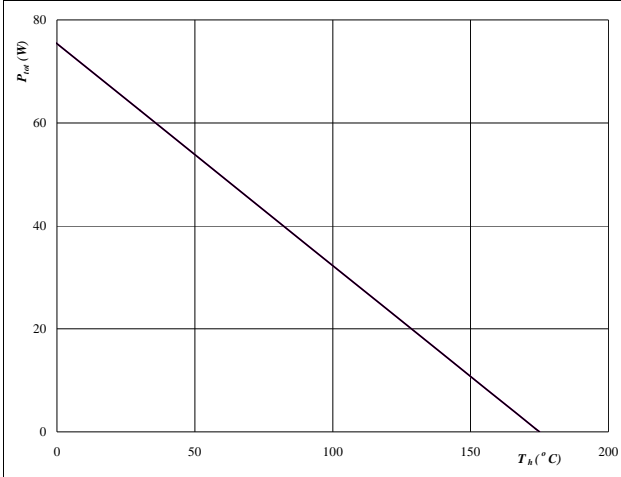

At
 T_j = 175 °C

Figure 22 Output inverter IGBT

Collector current as a function of heatsink temperature

$$I_C = f(T_h)$$

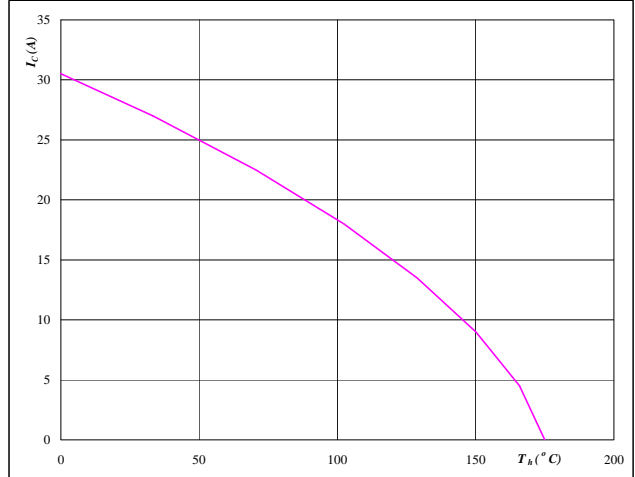

At
 T_j = 175 °C
 V_{GE} = 15 V

Figure 23 Output inverter FWD

Power dissipation as a function of heatsink temperature

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

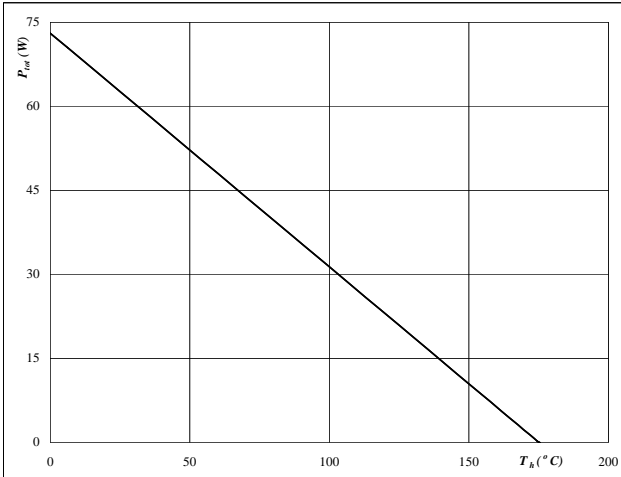
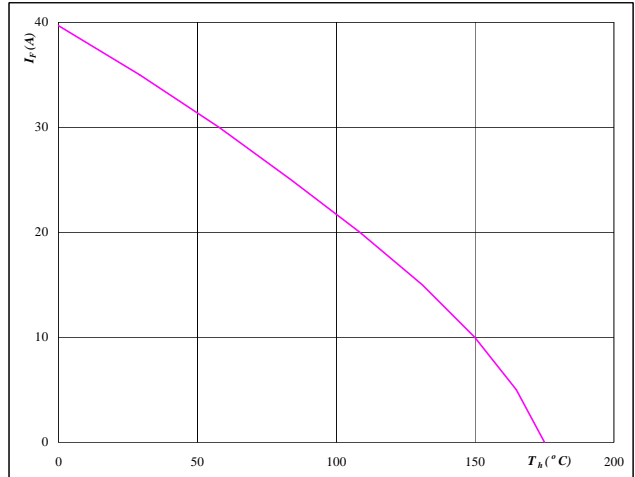

At
 T_j = 175 °C

Figure 24 Output inverter FWD

Forward current as a function of heatsink temperature

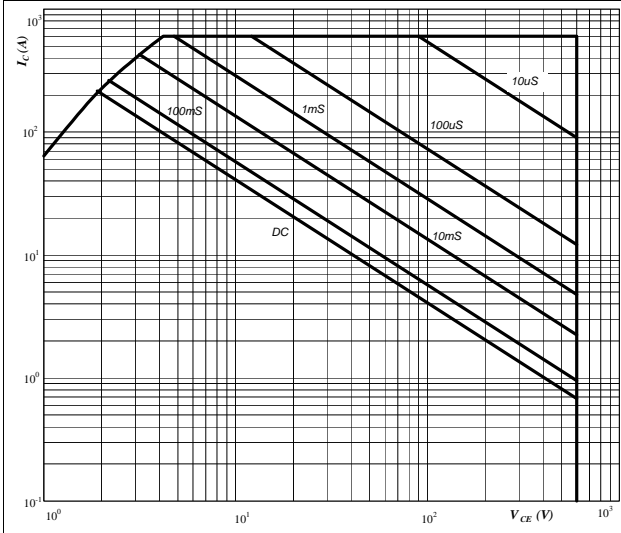
$$I_F = f(T_h)$$


At
 T_j = 175 °C

Output Inverter

Figure 25 Output inverter IGBT

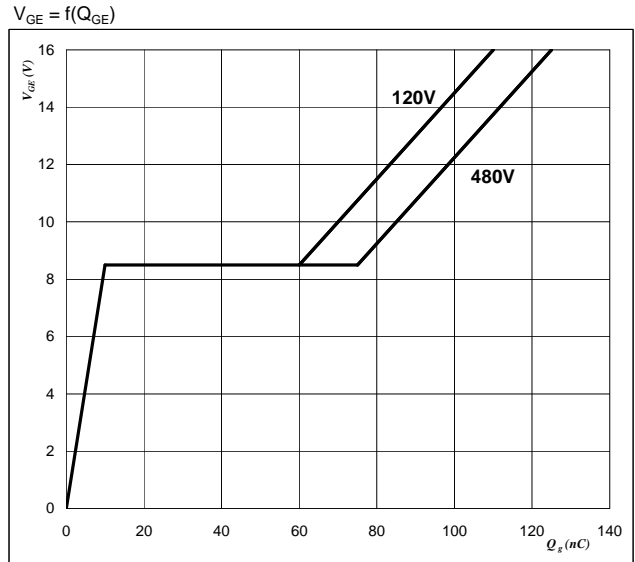
Safe operating area as a function of collector-emitter voltage
 $I_C = f(V_{CE})$



At
 D = single pulse
 $T_h = 80$ °C
 $V_{GE} = \pm 15$ V
 $T_j = T_{jmax}$ °C

Figure 26 Output inverter IGBT

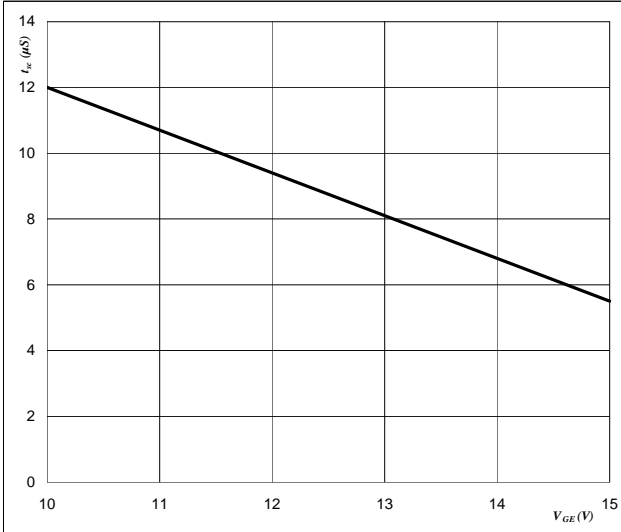
Gate voltage vs Gate charge



At
 $I_C = 20$ A

Figure 27 Output inverter IGBT

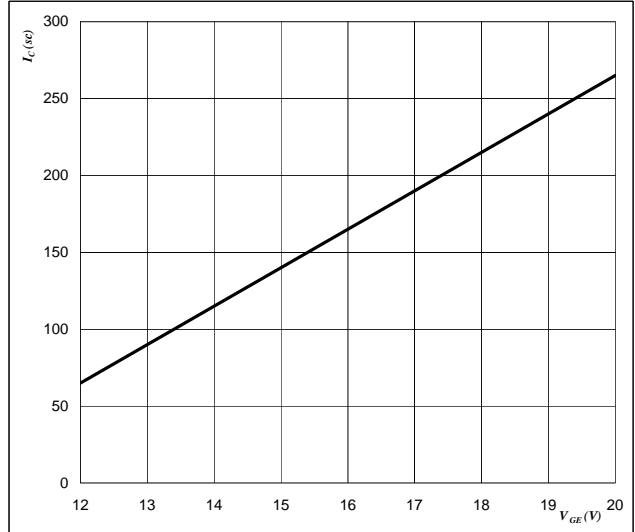
Short circuit withstand time as a function of gate-emitter voltage
 $t_{sc} = f(V_{GE})$



At
 $V_{CE} = 600$ V
 $T_j \leq 175$ °C

Figure 28 Output inverter IGBT

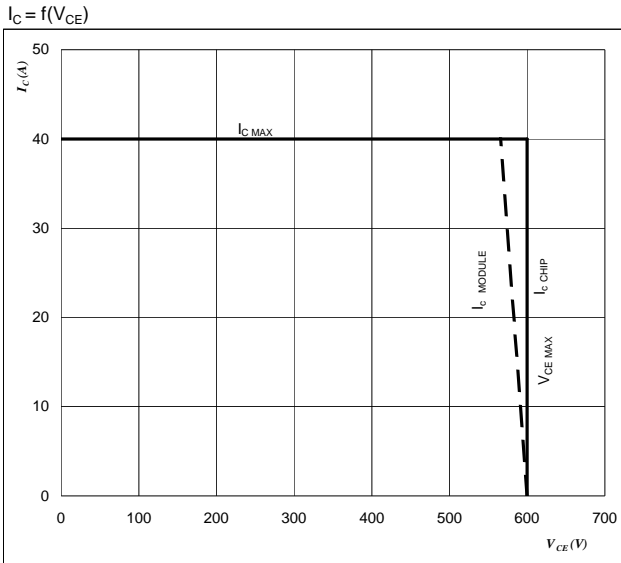
Typical short circuit collector current as a function of gate-emitter voltage
 $V_{GE} = f(Q_{GE})$



At
 $V_{CE} \leq 600$ V
 $T_j = 175$ °C

Output Inverter

Figure 29 IGBT

Reverse bias safe operating area

At

$$T_j = T_{j\text{max}} - 25 \quad ^\circ\text{C}$$

$$U_{\text{ccmin}} = U_{\text{ccplus}}$$

Switching mode : 3 level switching

PFC
Figure 1 PFC MOSFET

Typical output characteristics

$I_D = f(V_{DS})$

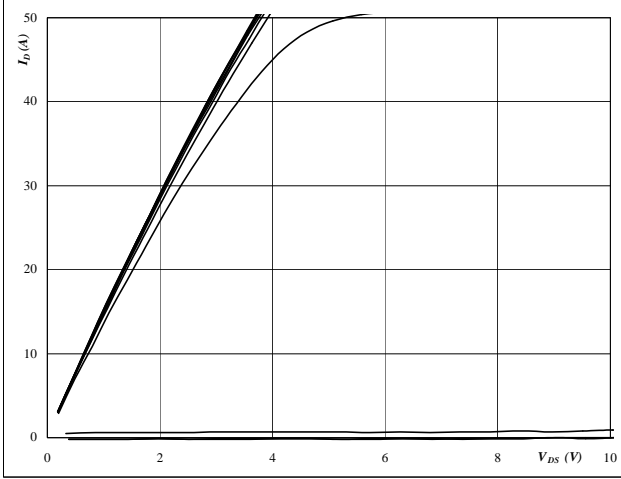

At
 $t_p = 250 \mu s$
 $T_j = 25 \text{ }^\circ C$
 V_{GS} from 0 V to 20 V in steps of 2 V

Figure 2 PFC MOSFET

Typical output characteristics

$I_D = f(V_{DS})$

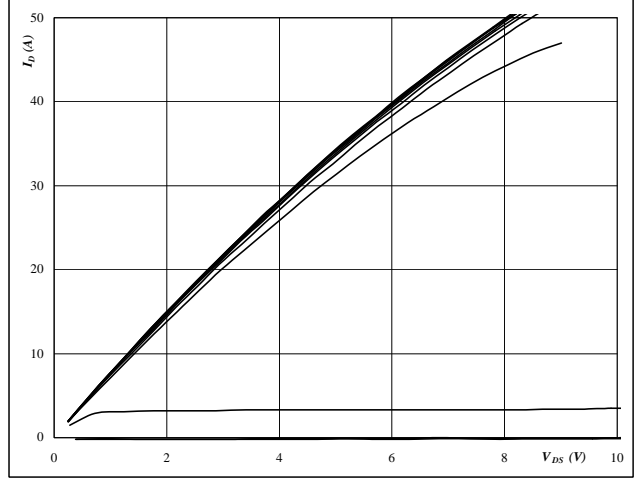
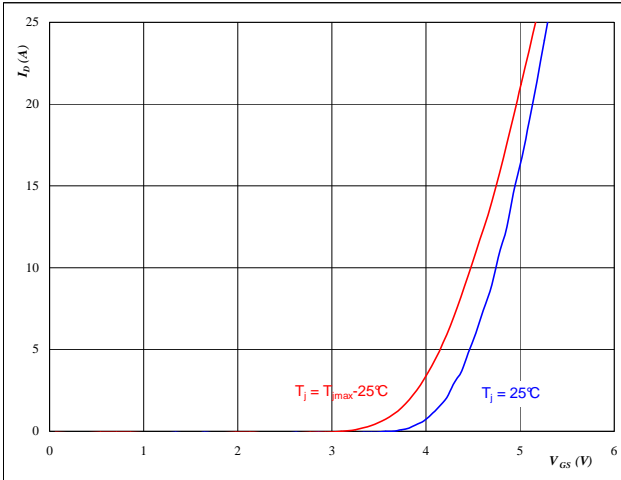

At
 $t_p = 250 \mu s$
 $T_j = 125 \text{ }^\circ C$
 V_{GS} from 0 V to 20 V in steps of 2 V

Figure 3 PFC MOSFET

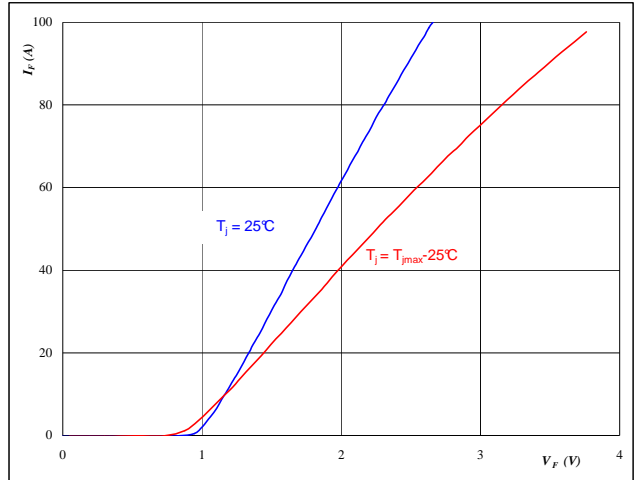
Typical transfer characteristics

$I_D = f(V_{GS})$


At
 $t_p = 250 \mu s$
 $V_{DS} = 10 \text{ V}$
Figure 4 PFC FWD

Typical diode forward current as a function of forward voltage

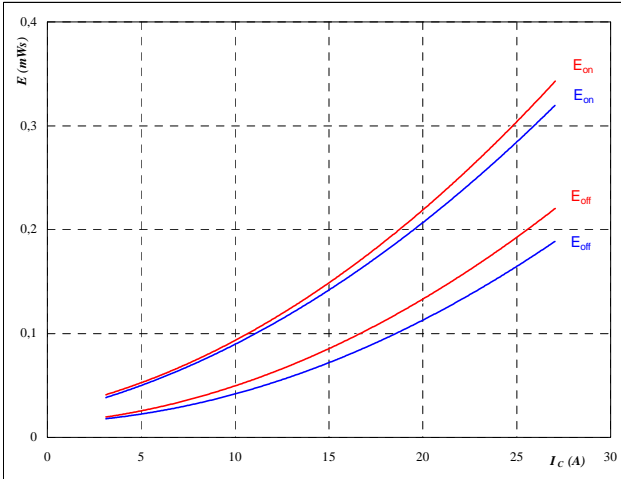
$I_F = f(V_F)$


At
 $t_p = 250 \mu s$

PFC
Figure 5 PFC MOSFET

Typical switching energy losses as a function of collector current

$$E = f(I_D)$$



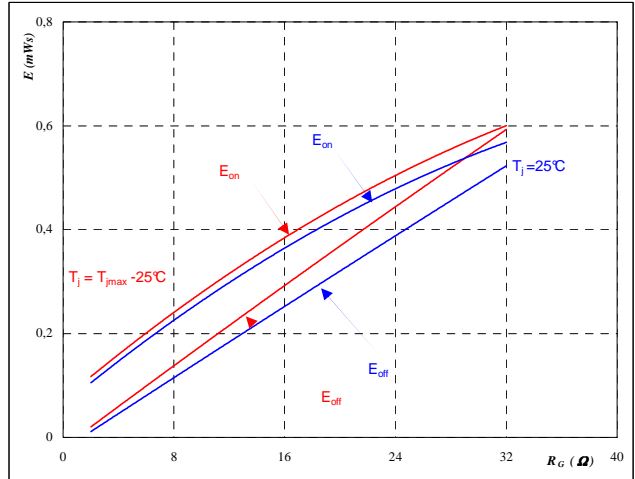
With an inductive load at

$T_j =$	25/125	°C
$V_{DS} =$	400	V
$V_{GS} =$	10	V
$R_{gon} =$	8	Ω
$R_{goff} =$	8	Ω

Figure 6 PFC MOSFET

Typical switching energy losses as a function of gate resistor

$$E = f(R_G)$$



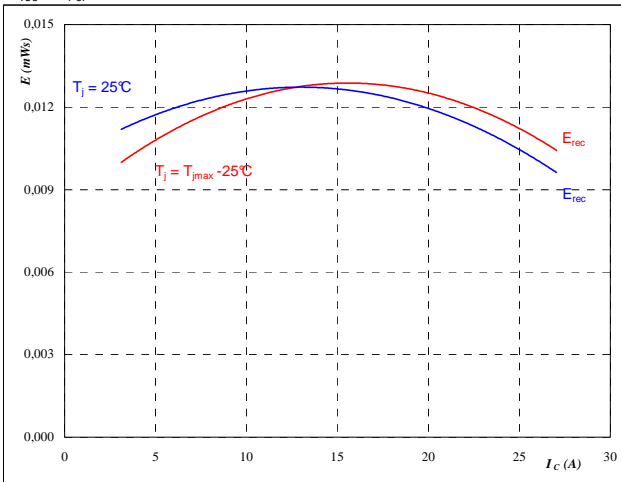
With an inductive load at

$T_j =$	25/125	°C
$V_{DS} =$	400	V
$V_{GS} =$	10	V
$I_D =$	21	A

Figure 7 PFC MOSFET

Typical reverse recovery energy loss as a function of collector (drain) current

$$E_{rec} = f(I_C)$$



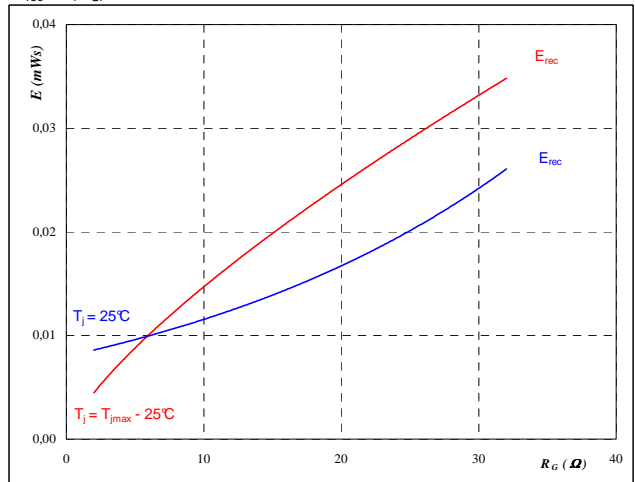
With an inductive load at

$T_j =$	25/125	°C
$V_{DS} =$	400	V
$V_{GS} =$	10	V
$R_{gon} =$	8	Ω
$R_{goff} =$	8	Ω

Figure 8 PFC MOSFET

Typical reverse recovery energy loss as a function of gate resistor

$$E_{rec} = f(R_G)$$



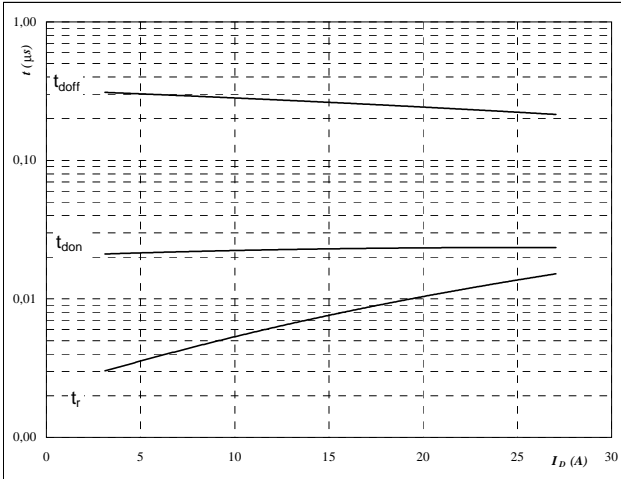
With an inductive load at

$T_j =$	25/125	°C
$V_{DS} =$	400	V
$V_{GS} =$	10	V
$I_D =$	21	A

PFC
Figure 9 PFC MOSFET

Typical switching times as a function of collector current

$t = f(I_D)$



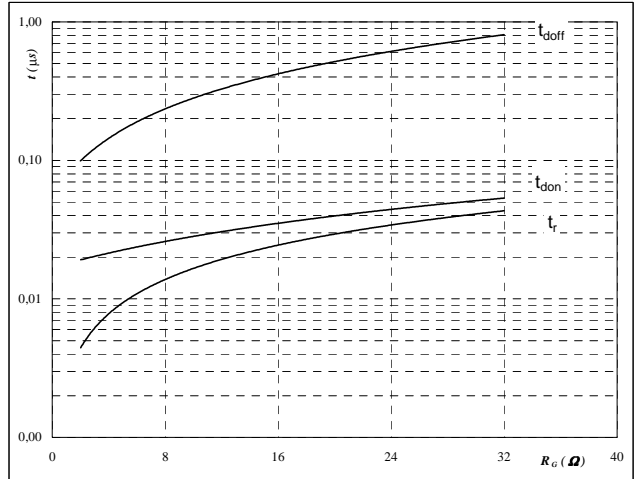
With an inductive load at

$T_j =$	125	°C
$V_{DS} =$	400	V
$V_{GS} =$	10	V
$R_{gon} =$	8	Ω
$R_{goff} =$	8	Ω

Figure 10 PFC MOSFET

Typical switching times as a function of gate resistor

$t = f(R_G)$



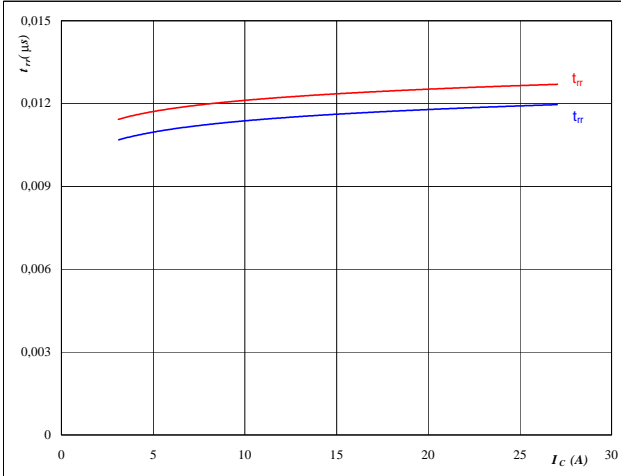
With an inductive load at

$T_j =$	125	°C
$V_{DS} =$	400	V
$V_{GS} =$	10	V
$I_C =$	21	A

Figure 11 PFC FWD

Typical reverse recovery time as a function of collector current

$t_{rr} = f(I_C)$

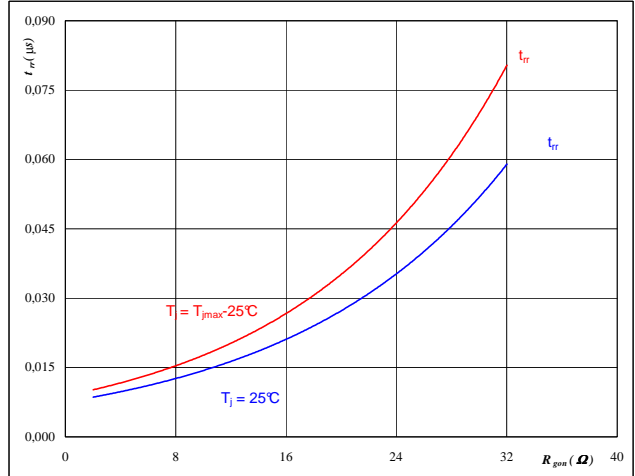

At

$T_j =$	25/125	°C
$V_{CE} =$	400	V
$V_{GE} =$	10	V
$R_{gon} =$	8	Ω

Figure 12 PFC FWD

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

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

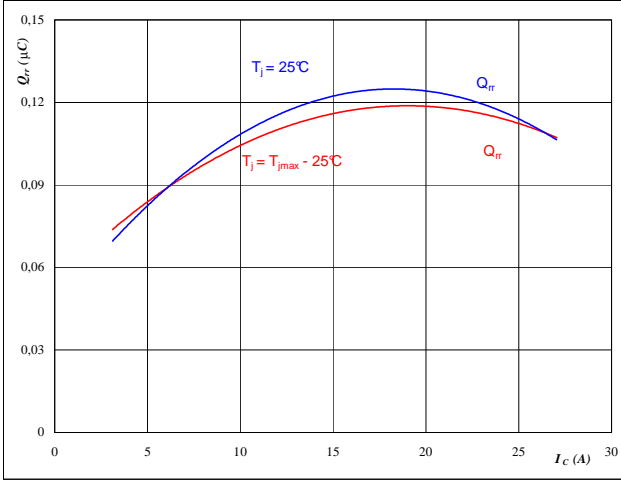

At

$T_j =$	25/125	°C
$V_R =$	400	V
$I_F =$	21	A
$V_{GS} =$	10	V

PFC
Figure 13 PFC FWD

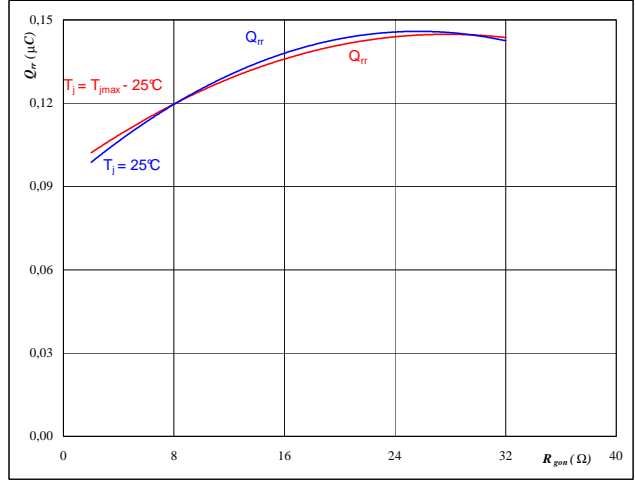
Typical reverse recovery charge as a function of collector current

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


At
 $T_j = 25/125 \text{ } ^\circ\text{C}$
 $V_{CE} = 400 \text{ V}$
 $V_{GE} = 10 \text{ V}$
 $R_{gon} = 8 \text{ } \Omega$
Figure 14 PFC FWD

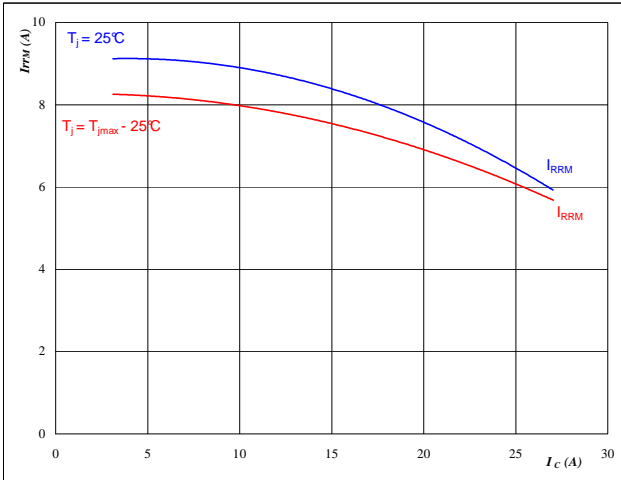
Typical reverse recovery charge as a function of IGBT turn on gate resistor

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


At
 $T_j = 25/125 \text{ } ^\circ\text{C}$
 $V_R = 400 \text{ V}$
 $I_F = 21 \text{ A}$
 $V_{GS} = 10 \text{ V}$
Figure 15 PFC FWD

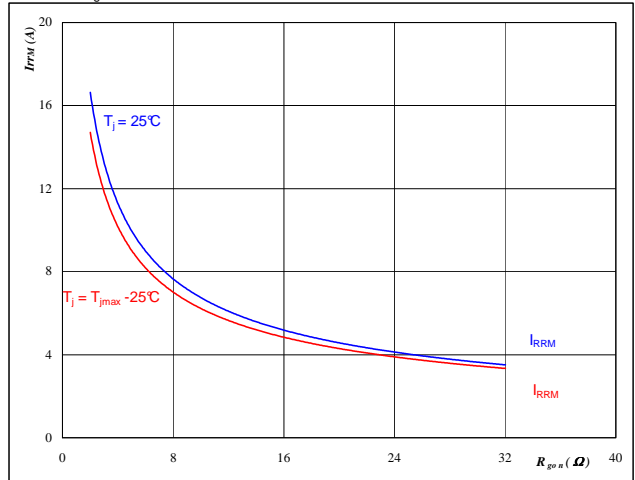
Typical reverse recovery current as a function of collector current

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


At
 $T_j = 25/125 \text{ } ^\circ\text{C}$
 $V_{CE} = 400 \text{ V}$
 $V_{GE} = 10 \text{ V}$
 $R_{gon} = 8 \text{ } \Omega$
Figure 16 PFC FWD

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

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

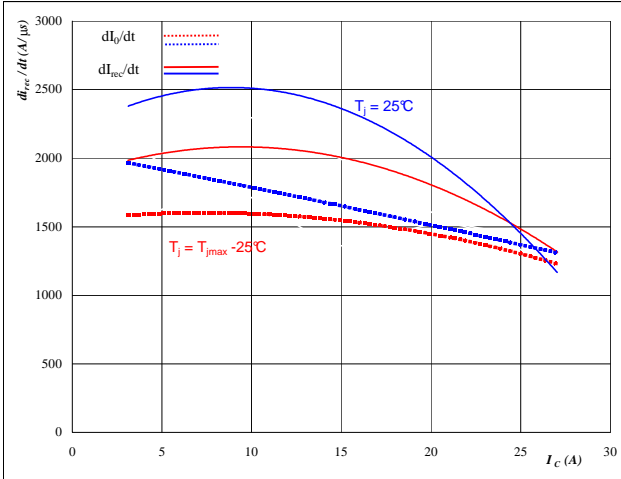

At
 $T_j = 25/125 \text{ } ^\circ\text{C}$
 $V_R = 400 \text{ V}$
 $I_F = 21 \text{ A}$
 $V_{GS} = 10 \text{ V}$

PFC

Figure 17 PFC FWD

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

$dI_F/dt, dI_{rec}/dt = f(I_C)$

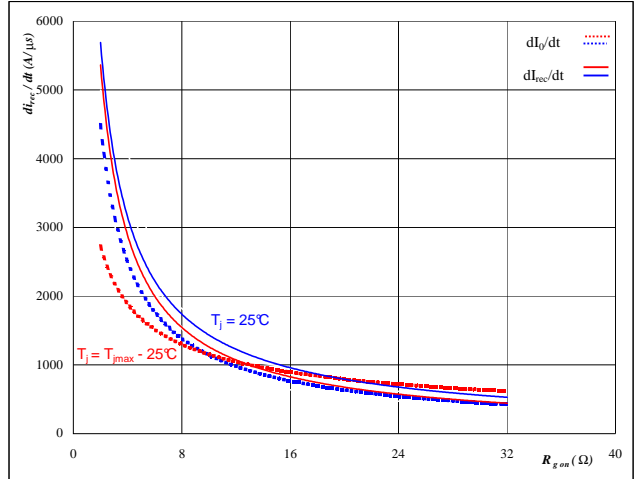


At
 $T_j = 25/125 \text{ } ^\circ\text{C}$
 $V_{CE} = 400 \text{ V}$
 $V_{GE} = 10 \text{ V}$
 $R_{gon} = 8,01 \text{ } \Omega$

Figure 18 PFC FWD

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

$dI_F/dt, dI_{rec}/dt = f(R_{gon})$

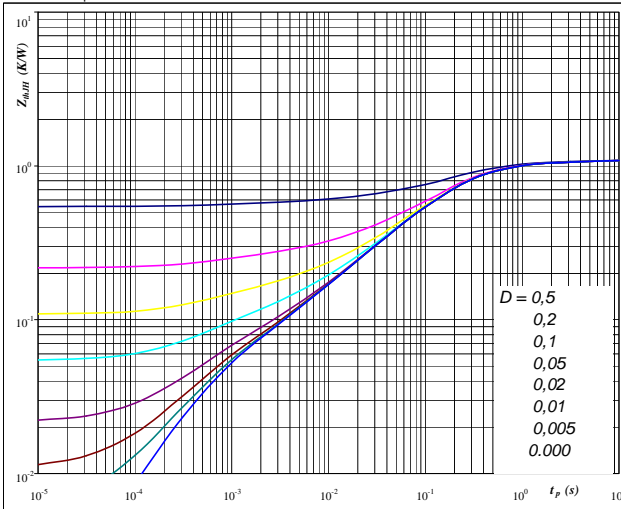


At
 $T_j = 25/125 \text{ } ^\circ\text{C}$
 $V_R = 400 \text{ V}$
 $I_F = 21 \text{ A}$
 $V_{GS} = 10 \text{ V}$

Figure 19 PFC MOSFET

IGBT/MOSFET transient thermal impedance as a function of pulse width

$Z_{thJH} = f(t_p)$



At
 $D = t_p / T$
 $R_{thJH} = 1,09 \text{ K/W}$ $R_{thJH} = 0,88 \text{ K/W}$

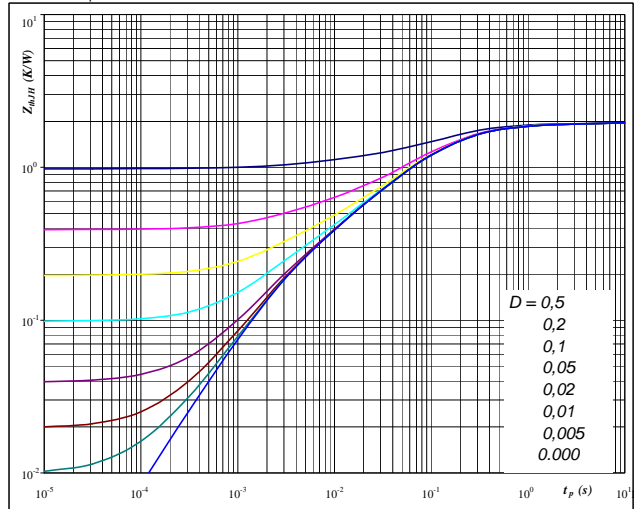
IGBT thermal model values

Thermal grease		Phase change interface	
R (C/W)	Tau (s)	R (C/W)	Tau (s)
0,06	3,95E+00	0,05	3,20E+00
0,28	4,91E-01	0,23	3,98E-01
0,53	1,37E-01	0,43	1,11E-01
0,13	2,28E-02	0,11	1,85E-02
0,05	3,27E-03	0,04	2,66E-03
0,03	5,12E-04	0,03	4,15E-04

Figure 20 PFC FWD

FWD transient thermal impedance as a function of pulse width

$Z_{thJH} = f(t_p)$



At
 $D = t_p / T$
 $R_{thJH} = 1,96 \text{ K/W}$ $R_{thJH} = 1,59 \text{ K/W}$

FWD thermal model values

Thermal grease		Phase change interface	
R (C/W)	Tau (s)	R (C/W)	Tau (s)
0,10	3,09E+00	0,08	2,51E+00
0,50	3,43E-01	0,41	2,78E-01
0,95	8,40E-02	0,77	6,81E-02
0,26	1,66E-02	0,21	1,35E-02
0,16	2,77E-03	0,13	2,24E-03

PFC
Figure 21 PFC MOSFET

Power dissipation as a function of heatsink temperature

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

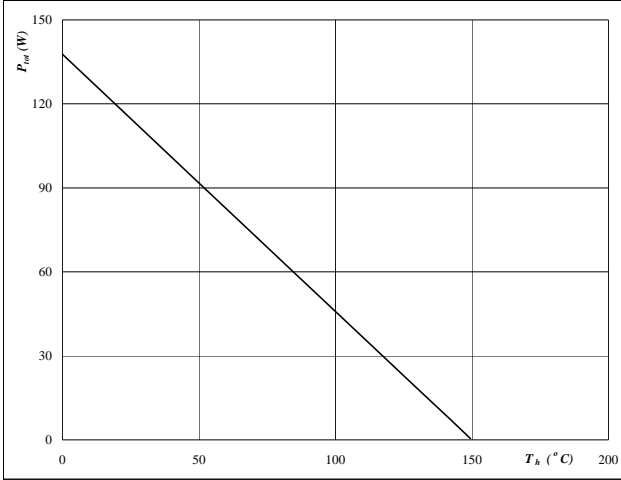

At
 $T_j = 150$ °C

Figure 22 PFC MOSFET

Collector/Drain current as a function of heatsink temperature

$$I_C = f(T_h)$$

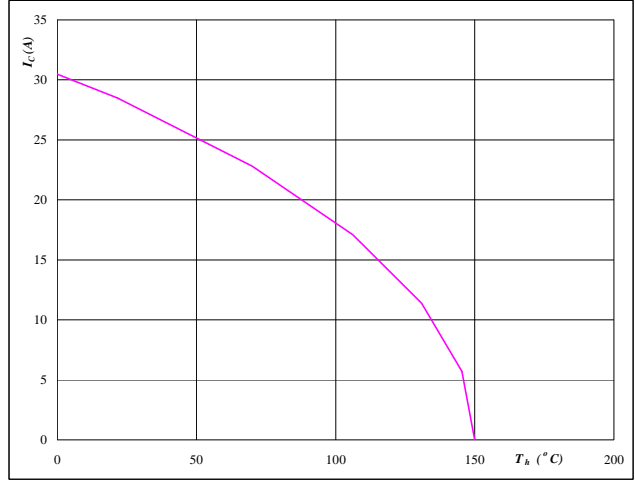

At
 $T_j = 150$ °C
 $V_{GS} = 10$ V

Figure 23 PFC FWD

Power dissipation as a function of heatsink temperature

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

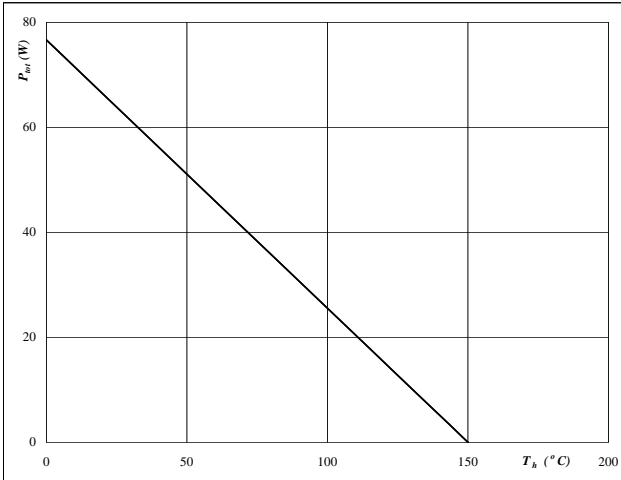
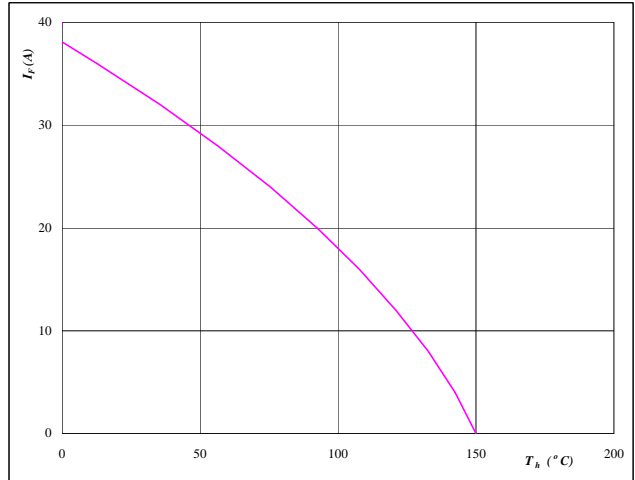

At
 $T_j = 150$ °C

Figure 24 PFC FWD

Forward current as a function of heatsink temperature

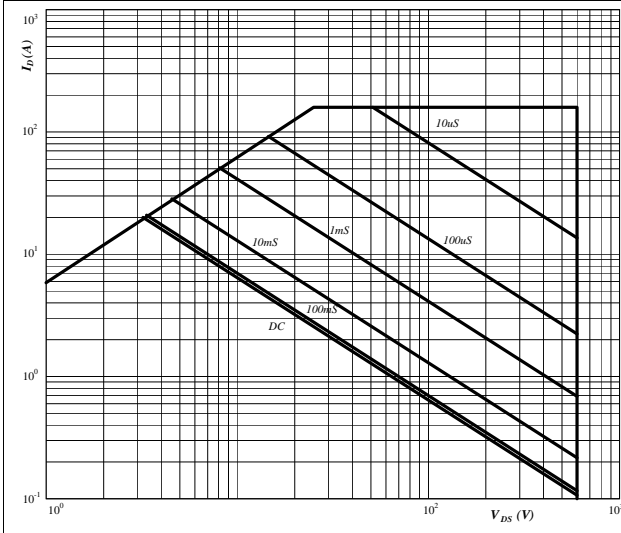
$$I_F = f(T_h)$$


At
 $T_j = 150$ °C

PFC
Figure 25 PFC MOSFET

Safe operating area as a function of drain-source voltage

$$I_D = f(V_{DS})$$

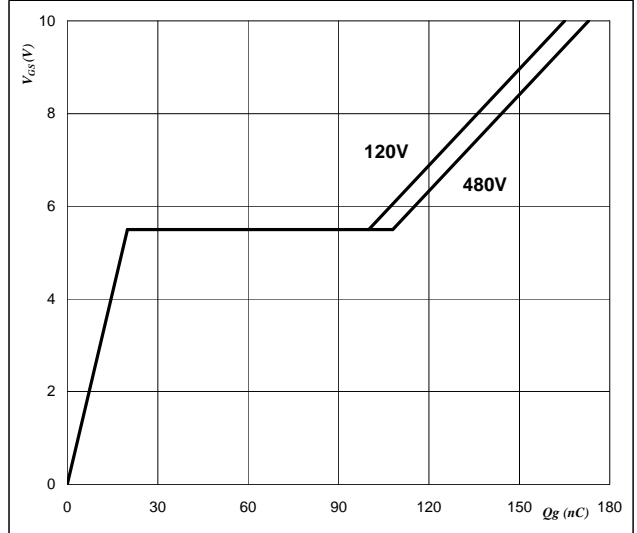


At
 D = single pulse
 $T_h = 80 \text{ } ^\circ\text{C}$
 $V_{GS} = 10 \text{ V}$
 $T_j = T_{jmax} \text{ } ^\circ\text{C}$

Figure 26 PFC MOSFET

Gate voltage vs Gate charge

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

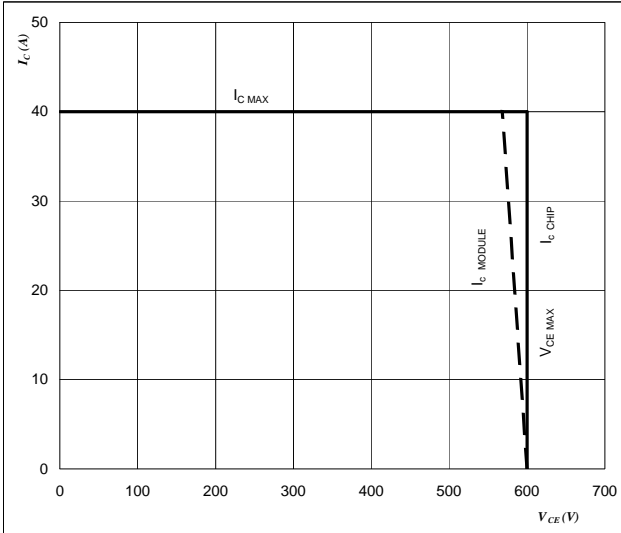


At
 $I_D = 21 \text{ A}$

Figure 29 IGBT

Reverse bias safe operating area

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



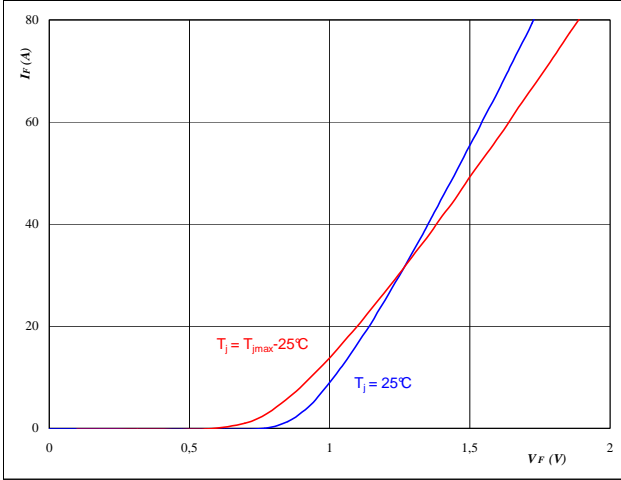
At
 $T_j = T_{jmax} - 25 \text{ } ^\circ\text{C}$
 $U_{ocminus} = U_{ocplus}$
 Switching mode : 3phase SPWM

Input Rectifier Bridge

Figure 1 Rectifier diode

Typical diode forward current as a function of forward voltage

$$I_F = f(V_F)$$

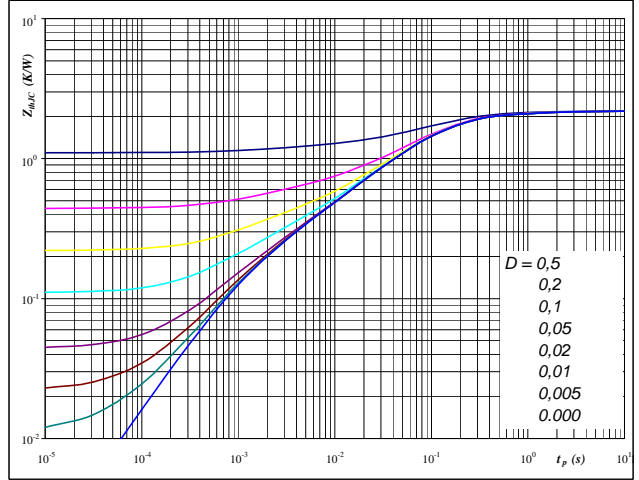


At
 $t_p = 250 \mu s$

Figure 2 Rectifier diode

Diode transient thermal impedance as a function of pulse width

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

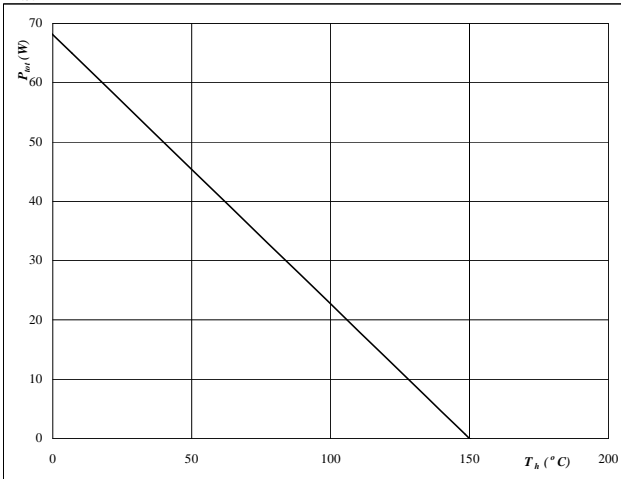


At
 $D = t_p / T$
 $R_{thJH} = 2,20 \text{ K/W}$

Figure 3 Rectifier diode

Power dissipation as a function of heatsink temperature

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

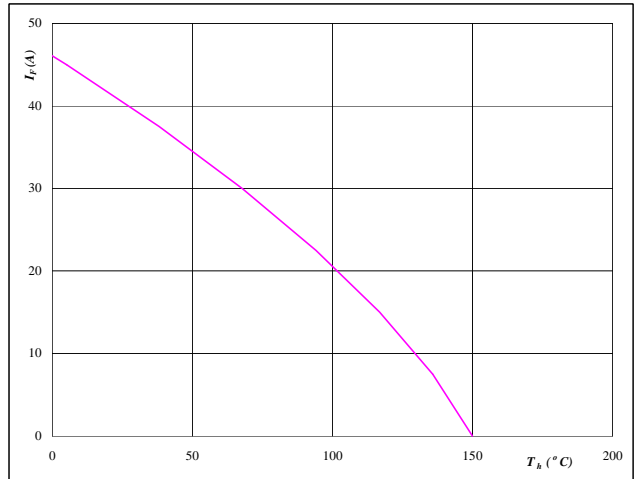


At
 $T_j = 150 \text{ °C}$

Figure 4 Rectifier diode

Forward current as a function of heatsink temperature

$$I_F = f(T_h)$$

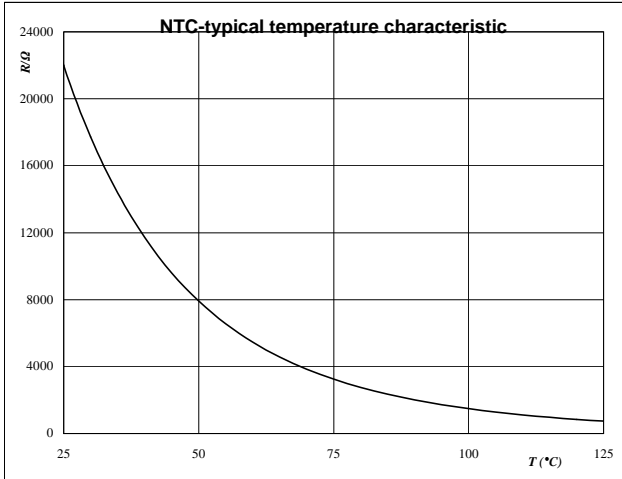


At
 $T_j = 150 \text{ °C}$

Thermistor

Figure 1 Thermistor

Typical NTC characteristic
 as a function of temperature

 $R_T = f(T)$

Figure 2 Thermistor

Typical NTC resistance values

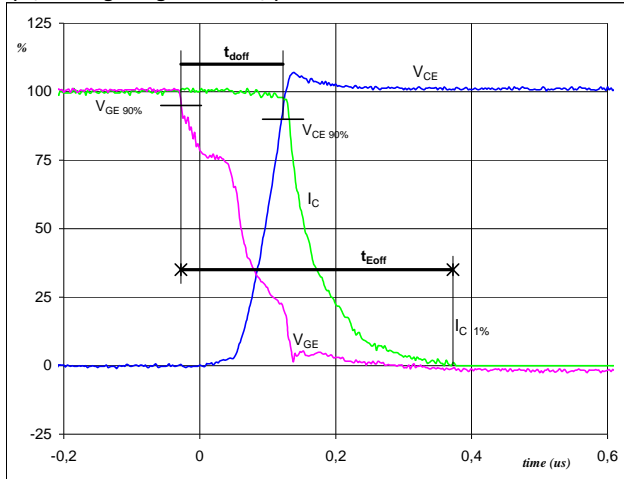
$$R(T) = R_{25} \cdot e^{\left(B_{25/100} \left(\frac{1}{T} - \frac{1}{T_{25}} \right) \right)} \quad [\Omega]$$

T [°C]	R _{nom} [Ω]	R _{min} [Ω]	R _{max} [Ω]	ΔR/R [±%]
-55	2089434,5	1506495,4	2672373,6	27,9
0	71804,2	59724,4	83884	16,8
10	43780,4	37094,4	50466,5	15,3
20	27484,6	23684,6	31284,7	13,8
25	22000	19109,3	24890,7	13,1
30	17723,3	15512,2	19934,4	12,5
60	5467,9	4980,6	5955,1	8,9
70	3848,6	3546	4151,1	7,9
80	2757,7	2568,2	2947,1	6,9
90	2008,9	1889,7	2128,2	5,9
100	1486,1	1411,8	1560,4	5
150	400,2	364,8	435,7	8,8

Switching Definitions Output Inverter

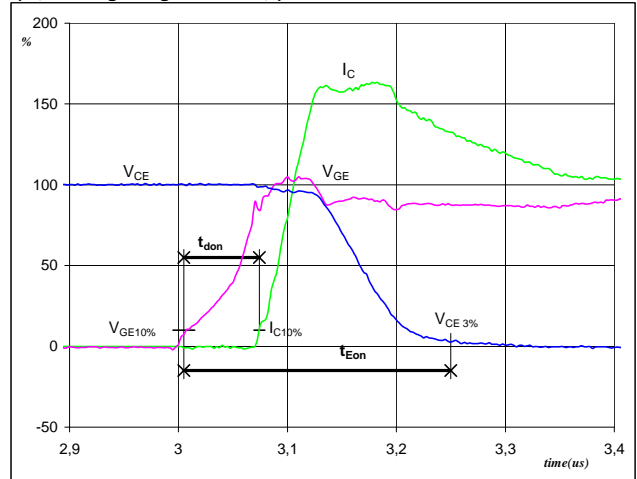
General conditions	
T_j	= 125 °C
R_{gon}	= 16 Ω
R_{goff}	= 16 Ω

Figure 1 Output inverter IGBT

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


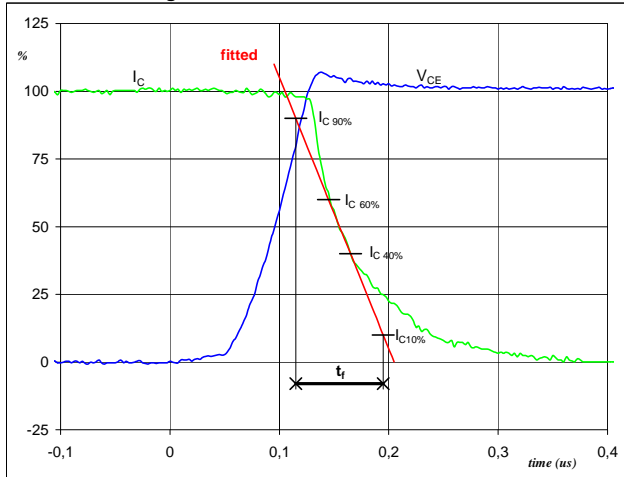
$V_{GE}(0\%) =$	-15	V
$V_{GE}(100\%) =$	15	V
$V_C(100\%) =$	400	V
$I_C(100\%) =$	21	A
$t_{doff} =$	0,15	μs
$t_{Eoff} =$	0,40	μs

Figure 2 Output inverter IGBT

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


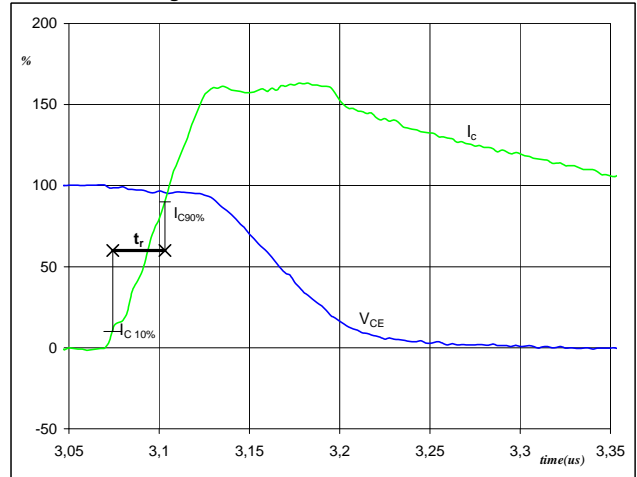
$V_{GE}(0\%) =$	-15	V
$V_{GE}(100\%) =$	15	V
$V_C(100\%) =$	400	V
$I_C(100\%) =$	21	A
$t_{don} =$	0,07	μs
$t_{Eon} =$	0,24	μs

Figure 3 Output inverter IGBT

Turn-off Switching Waveforms & definition of t_f


$V_C(100\%) =$	400	V
$I_C(100\%) =$	21	A
$t_f =$	0,08	μs

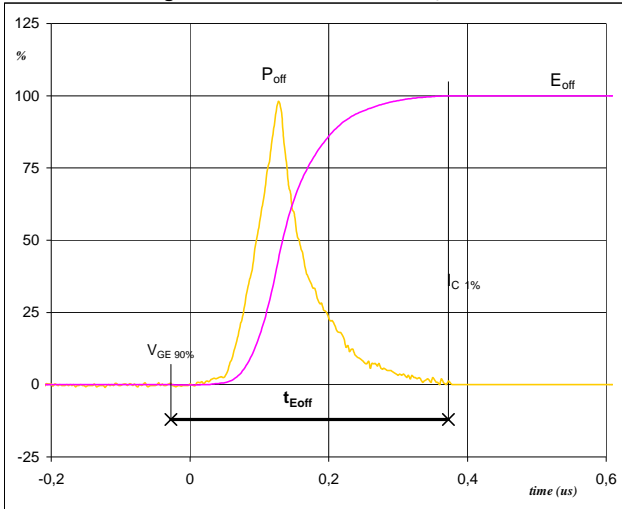
Figure 4 Output inverter IGBT

Turn-on Switching Waveforms & definition of t_r


$V_C(100\%) =$	400	V
$I_C(100\%) =$	21	A
$t_r =$	0,03	μs

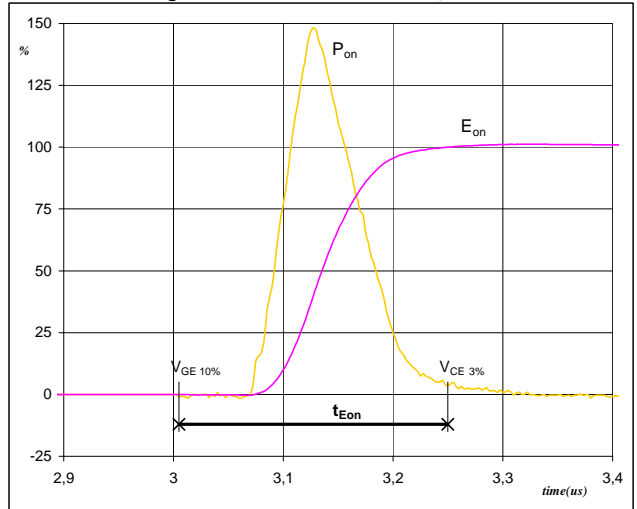
Switching Definitions Output Inverter

Figure 5 Output inverter IGBT

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


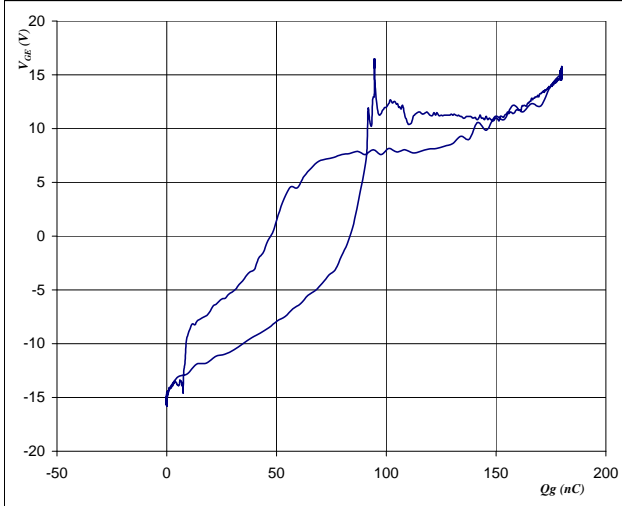
$P_{off}(100\%) = 8,37$ kW
 $E_{off}(100\%) = 0,71$ mJ
 $t_{Eoff} = 0,40$ μ s

Figure 6 Output inverter IGBT

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


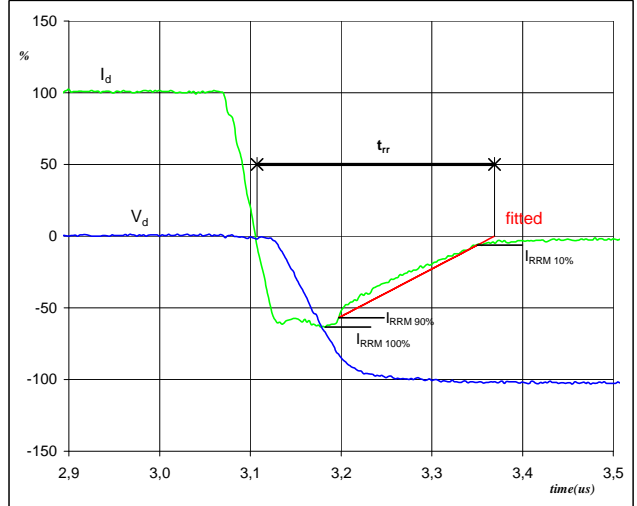
$P_{on}(100\%) = 8,37$ kW
 $E_{on}(100\%) = 0,96$ mJ
 $t_{Eon} = 0,24$ μ s

Figure 7 Output inverter IGBT

Gate voltage vs Gate charge (measured)


$V_{GEoff} = -15$ V
 $V_{GEon} = 15$ V
 $V_C(100\%) = 400$ V
 $I_C(100\%) = 21$ A
 $Q_g = 179,93$ nC

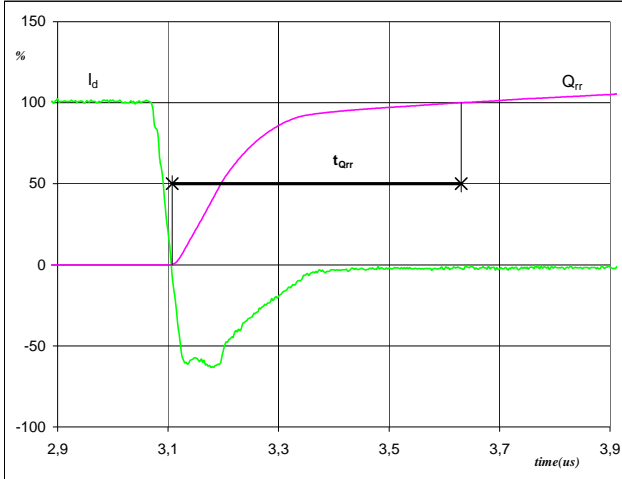
Figure 8 Output inverter FWD

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


$V_d(100\%) = 400$ V
 $I_d(100\%) = 21$ A
 $I_{RRM}(100\%) = -13$ A
 $t_{rr} = 0,26$ μ s

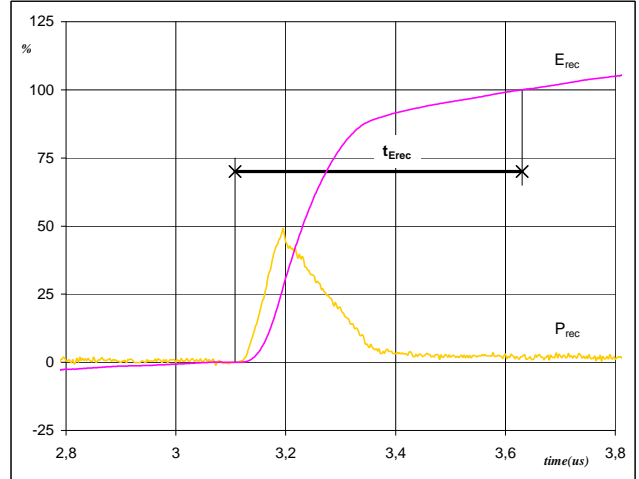
Switching Definitions Output Inverter

Figure 9 Output inverter FWD

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


I_d (100%) =	21	A
Q_{rr} (100%) =	2,01	μC
t_{Qrr} =	0,52	μs

Figure 10 Output inverter FWD

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


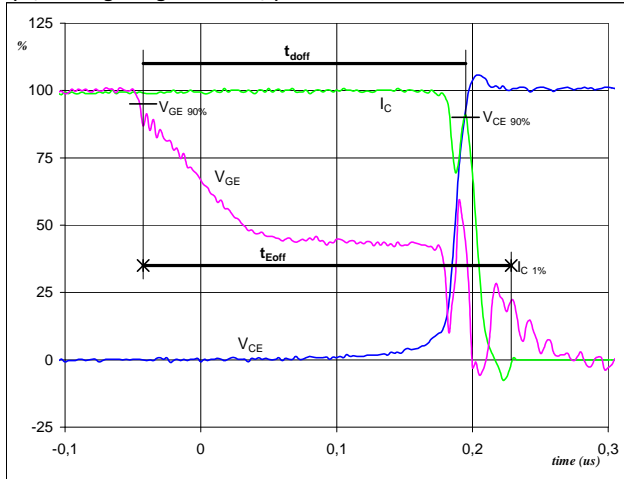
P_{rec} (100%) =	8,37	kW
E_{rec} (100%) =	0,54	mJ
t_{Erec} =	0,52	μs

Switching Definitions PFC

General conditions

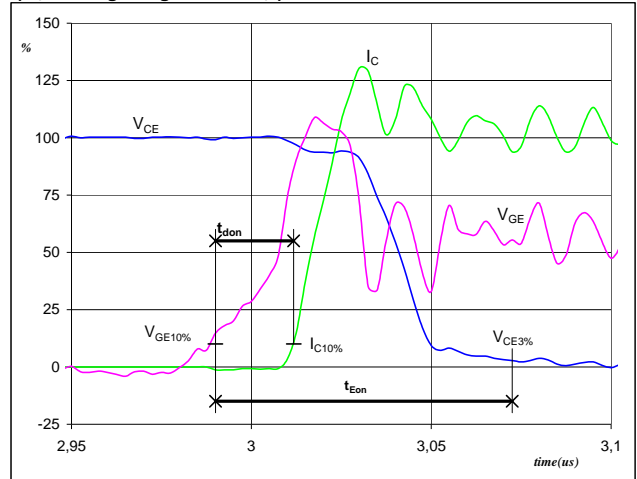
T_j	=	125 °C
R_{gon}	=	8 Ω
R_{goff}	=	8 Ω

Figure 1 PFC MOSFET

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


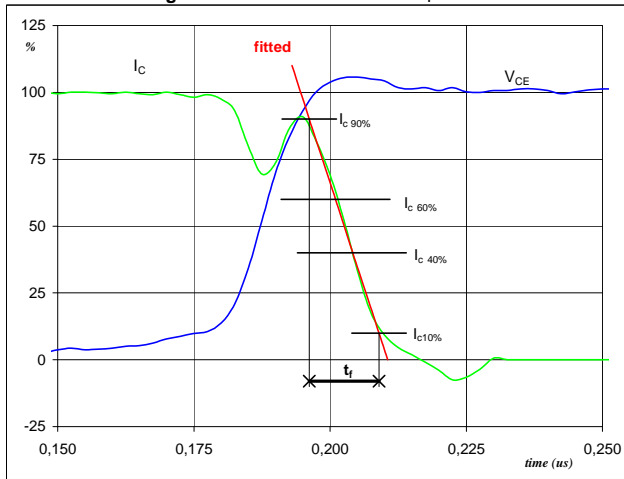
V_{GE} (0%) =	0	V
V_{GE} (100%) =	10	V
V_C (100%) =	400	V
I_C (100%) =	21	A
t_{doff} =	0,24	μs
t_{Eoff} =	0,27	μs

Figure 2 PFC MOSFET

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


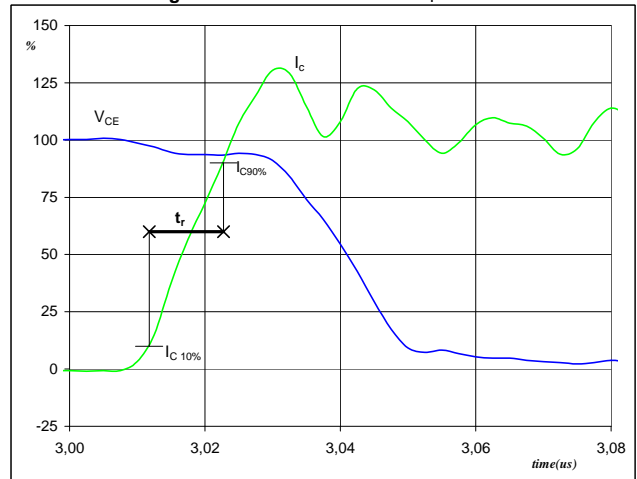
V_{GE} (0%) =	0	V
V_{GE} (100%) =	10	V
V_C (100%) =	400	V
I_C (100%) =	21	A
t_{don} =	0,02	μs
t_{Eon} =	0,08	μs

Figure 3 PFC MOSFET

Turn-off Switching Waveforms & definition of t_f


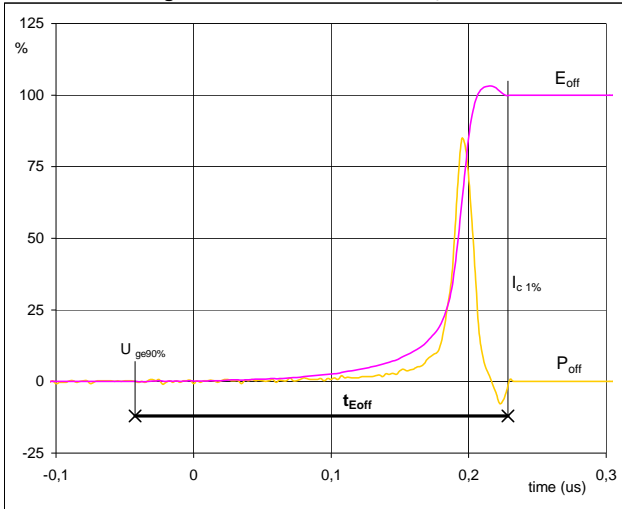
V_C (100%) =	400	V
I_C (100%) =	21	A
t_f =	0,0110	μs

Figure 4 PFC MOSFET

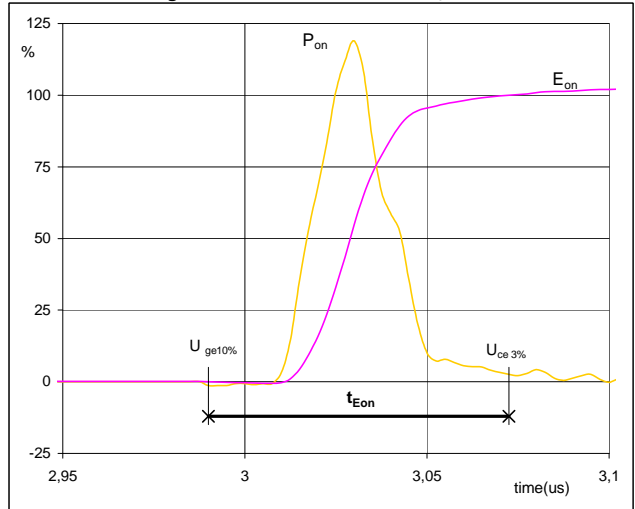
Turn-on Switching Waveforms & definition of t_r


V_C (100%) =	400	V
I_C (100%) =	21	A
t_r =	0,0110	μs

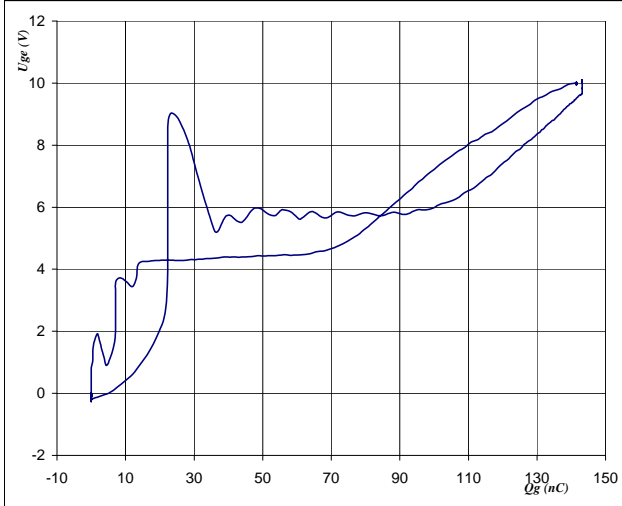
Switching Definitions PFC

Figure 5 PFC MOSFET
Turn-off Switching Waveforms & definition of t_{Eoff}


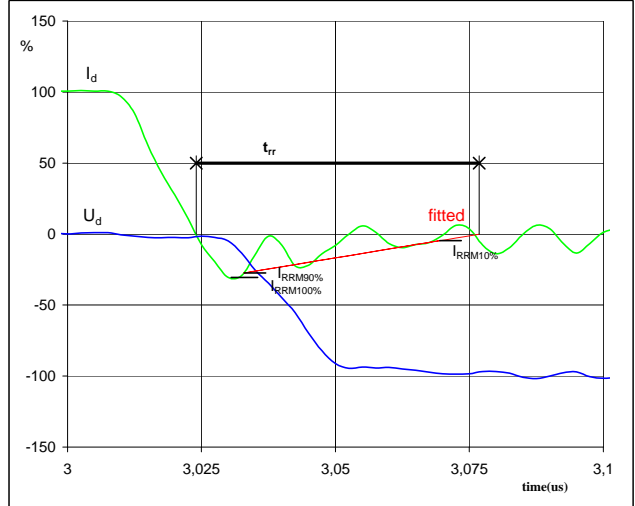
$P_{off} (100\%) = 8,4 \text{ kW}$
 $E_{off} (100\%) = 0,14 \text{ mJ}$
 $t_{Eoff} = 0,27 \text{ } \mu\text{s}$

Figure 6 PFC MOSFET
Turn-on Switching Waveforms & definition of t_{Eon}


$P_{on} (100\%) = 8,4 \text{ kW}$
 $E_{on} (100\%) = 0,23 \text{ mJ}$
 $t_{Eon} = 0,0825 \text{ } \mu\text{s}$

Figure 7 PFC MOSFET
Gate voltage vs Gate charge (measured)


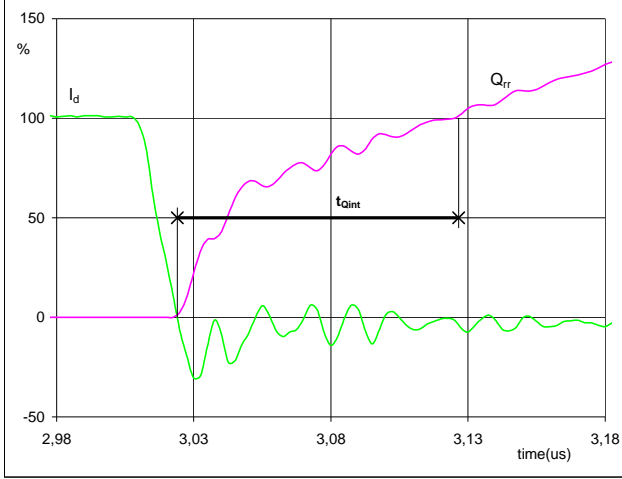
$V_{GEoff} = 0 \text{ V}$
 $V_{GEon} = 10 \text{ V}$
 $V_C (100\%) = 400 \text{ V}$
 $I_C (100\%) = 21 \text{ A}$
 $Q_g = 143,16 \text{ nC}$

Figure 8 PFC FWD
Turn-off Switching Waveforms & definition of t_{rr}


$V_d (100\%) = 400 \text{ V}$
 $I_d (100\%) = 21 \text{ A}$
 $I_{RRM} (100\%) = -6 \text{ A}$
 $t_{rr} = 0,01 \text{ } \mu\text{s}$

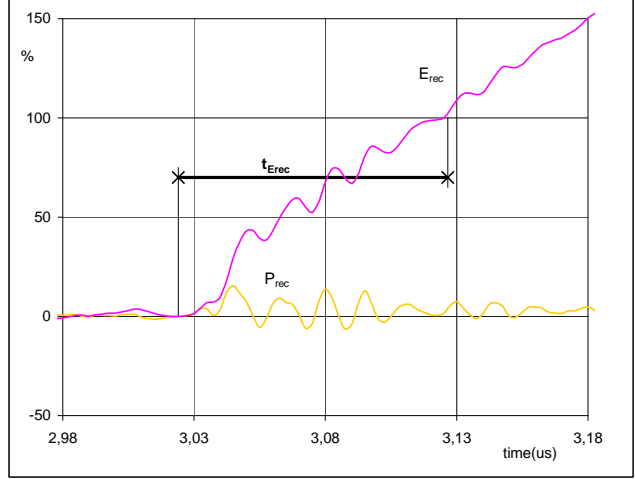
Switching Definitions PFC

Figure 9 PFC FWD

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


I_d (100%) =	21	A
Q_{rr} (100%) =	0,13	μC
t_{Qint} =	0,10	μs

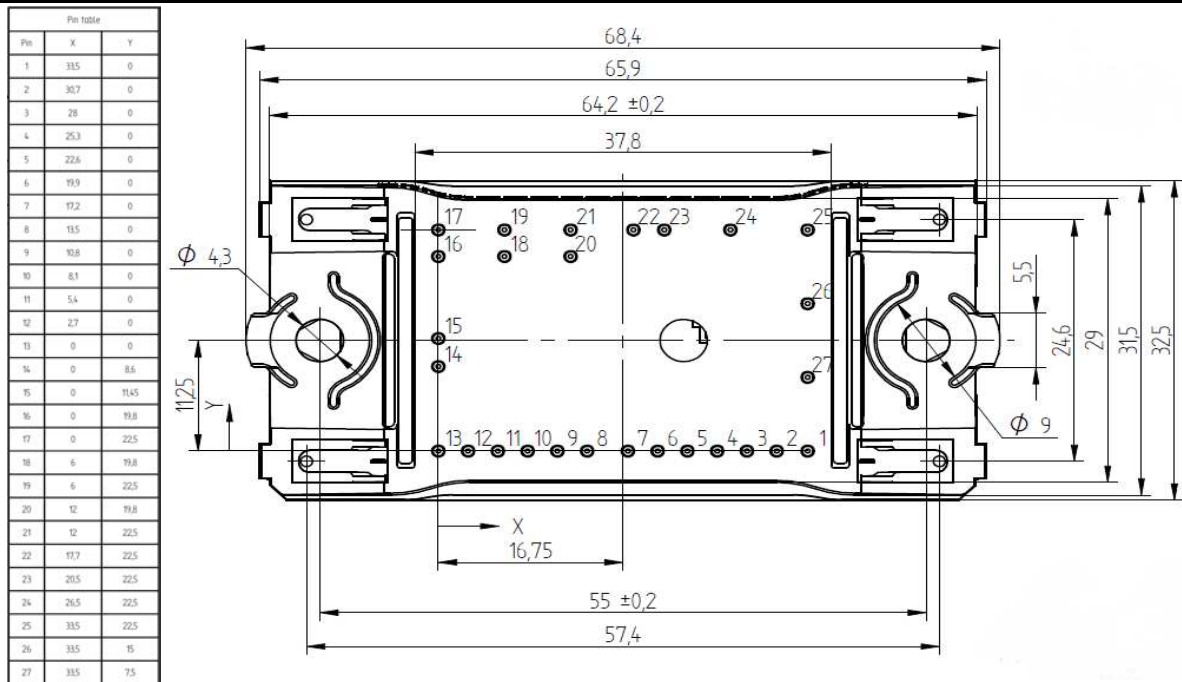
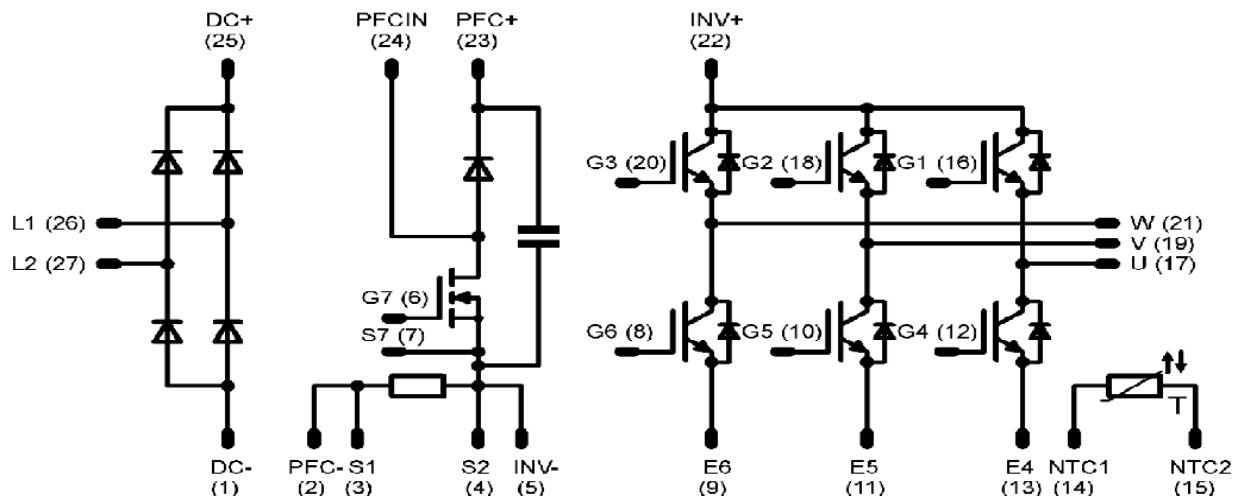
Figure 10 PFC FWD

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


P_{rec} (100%) =	8,40	kW
E_{rec} (100%) =	0,03	mJ
t_{Erec} =	0,10	μs

Ordering Code and Marking - Outline - Pinout
Ordering Code & Marking

Version	Ordering Code	in DataMatrix as	in packaging barcode as
without thermal paste 17mm housing	10-F006PPA020SB01-M685B10	M685B10	M685B10

Outline

Pinout


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.

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