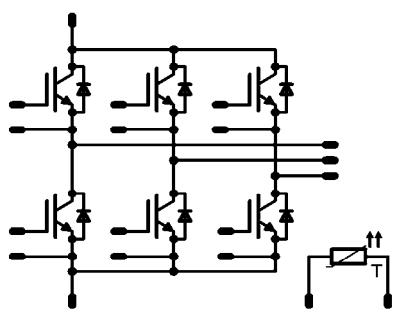


MiniSKiiP® 2 PACK		600V/50A
<p>Features</p> <ul style="list-style-type: none"> • SixPack (inverter) topology • Solder less interconnection • Designed for motor drives up to 7 kW • Fully compatible with Semikron pedant 27AC066V1 • Temperature sensor • Standard (6.5mm) and thin (2.8mm) lids, 16mm housing • Optional with pre-applied thermal grease 		<p>MiniSKiiP® 2 Housing</p> 
<p>Target Applications</p> <ul style="list-style-type: none"> • Industrial Motor Drives • Power Generation • UPS 		<p>Schematic</p> 
<p>Types</p> <ul style="list-style-type: none"> • V23990-K232-F-PM 		

Maximum Ratings

T_j=25°C, unless otherwise specified

Parameter	Symbol	Condition	Value	Unit
T1,T2,T3,T4,T5,T6				
Collector-emitter break down voltage	V _{CE}		600	V
DC collector current	I _C	T _j =T _j max T _h =80°C T _c =80°C	50 50	A
Repetitive peak collector current	I _{Cpulse}	t _p limited by T _j max	150	A
Turn off safe operating area		VCE ≤ 1200V, T _j ≤ Top max	200	A
Power dissipation per IGBT	P _{tot}	T _j =T _j max T _h =80°C T _c =80°C	100 152	W
Gate-emitter peak voltage	V _{GE}		±20	V
Short circuit ratings	t _{SC} V _{CC}	T _j ≤150°C V _{GE} =15V	6 360	μs V
Maximum Junction Temperature	T _j max		175	°C

Maximum Ratings

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

Parameter	Symbol	Condition	Value	Unit
D1,D2,D3,D4,D5,D6				
Peak Repetitive Reverse Voltage	V_{RRM}	$T_j=25^\circ\text{C}$	600	V
DC forward current	I_F	$T_j=T_j\text{max}$ $T_h=80^\circ\text{C}$ $T_c=80^\circ\text{C}$	41 55	A
Repetitive peak forward current	I_{FRM}	t_p limited by $T_j\text{max}$	81 109	A
Power dissipation per Diode	P_{tot}	$T_j=T_j\text{max}$ $T_h=80^\circ\text{C}$ $T_c=80^\circ\text{C}$	59 89	W
Maximum Junction Temperature	$T_j\text{max}$		175	$^\circ\text{C}$

Thermal Properties

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

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

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

T1,T2,T3,T4,T5,T6

Gate emitter threshold voltage	$V_{GE(th)}$	$V_{CE}=V_{GE}$			0,0008	$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$	5	5,8	6,5	V
Collector-emitter saturation voltage	$V_{CE(sat)}$		15		50	$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		1,49 1,69		V
Collector-emitter cut-off current incl. Diode	I_{CES}		0	612		$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$			0,2	mA
Gate-emitter leakage current	I_{GES}		20	0		$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$			700	nA
Integrated Gate resistor	R_{gint}							none		Ω
Turn-on delay time	$t_{d(on)}$	$R_{goff}=8 \Omega$ $R_{gon}=8 \Omega$	± 15	300	50	$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$	100 100			ns
Rise time	t_r					$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$	16 17			
Turn-off delay time	$t_{d(off)}$					$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$	151 172			
Fall time	t_f					$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$	96 167			
Turn-on energy loss per pulse	E_{on}					$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$	0,55 0,72			mWs
Turn-off energy loss per pulse	E_{off}					$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$	1,28 1,62			
Input capacitance	C_{ies}	$f=1\text{MHz}$	± 15	25		$T_j=25^\circ\text{C}$		3140		pF
Output capacitance	C_{oss}							200		
Reverse transfer capacitance	C_{rss}							93		
Gate charge	Q_{Gate}					$T_j=25^\circ\text{C}$		315		nC
Thermal resistance chip to heatsink per chip	R_{thJH}	Thermal grease thickness≤50um $\lambda = 1 \text{ W/mK}$						0,95		K/W

D1,D2,D3,D4,D5,D6

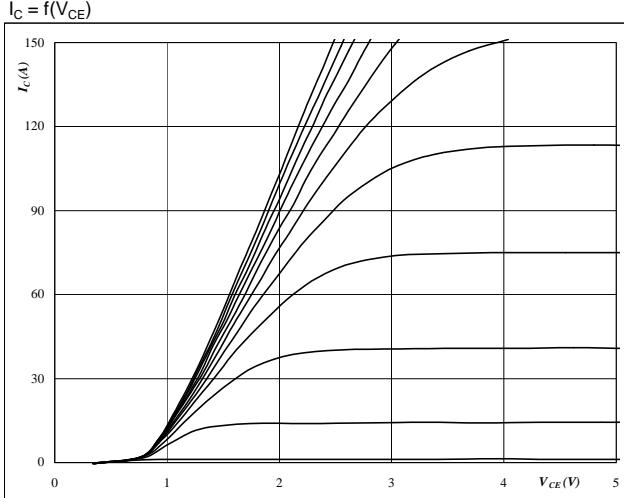
Diode forward voltage	V_F				37	$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$	1	1,47 1,54	2,5	V
Peak reverse recovery current	I_{RRM}	$R_{goff}=8 \Omega$	± 15	300	50	$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		73 84		A
Reverse recovery time	t_{rr}					$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		48 157		ns
Reverse recovered charge	Q_{rr}					$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		3,22 4,89		μC
Peak rate of fall of recovery current	$di(rec)\max /dt$					$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		3872 3958		$\text{A}/\mu\text{s}$
Reverse recovered energy	E_{rec}					$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		0,75 1,18		mWs
Thermal resistance chip to heatsink per chip	R_{thJH}	Thermal grease thickness≤50um $\lambda = 1 \text{ W/mK}$						1,61		K/W

Thermistor

Rated resistance	R					$T=25^\circ\text{C}$		1000		Ω
Deviation of R100	$\Delta R/R$	$R_{100}=1670 \Omega$				$T=100^\circ\text{C}$	-3		3	%
R100	P					$T=100^\circ\text{C}$		1670,313		Ω
Power dissipation constant						$T=25^\circ\text{C}$				mW/K
A-value	$B(25/50)$	Tol. %				$T=25^\circ\text{C}$		7,635*10-3		$1/\text{K}$
B-value	$B(25/100)$	Tol. %				$T=25^\circ\text{C}$		1,731*10-5		$1/\text{K}^2$
Vincotech NTC Reference									E	

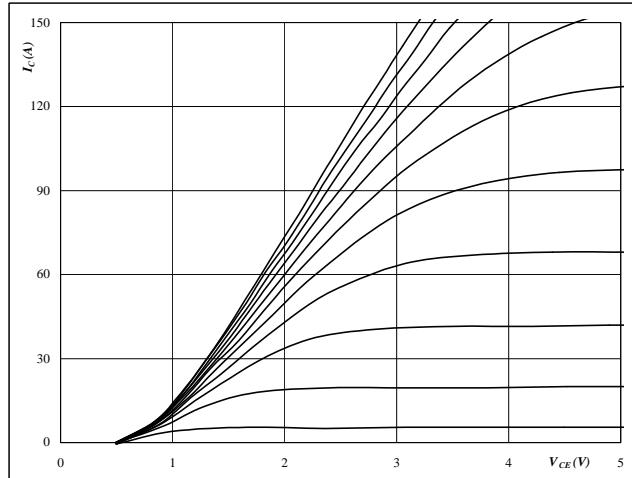
T1,T2,T3,T4,T5,T6/D1,D2,D3,D4,D5,D6

Figure 1
Typical output characteristics
 $I_C = f(V_{CE})$



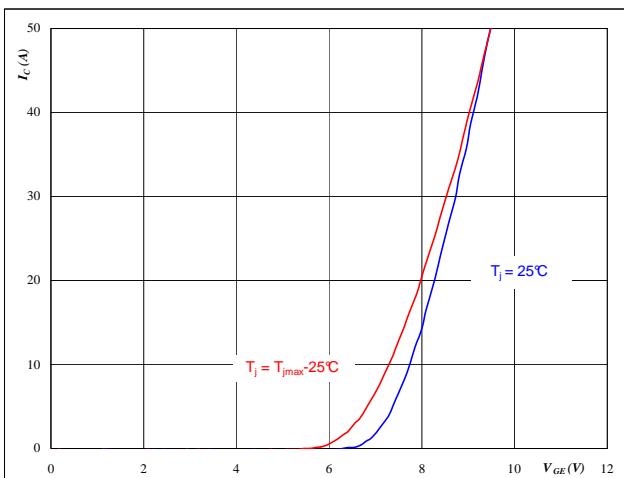
At
 $t_p = 250 \mu s$
 $T_j = 25^\circ C$
 V_{GE} from 7 V to 17 V in steps of 1 V

Figure 2
Typical output characteristics
 $I_C = f(V_{CE})$



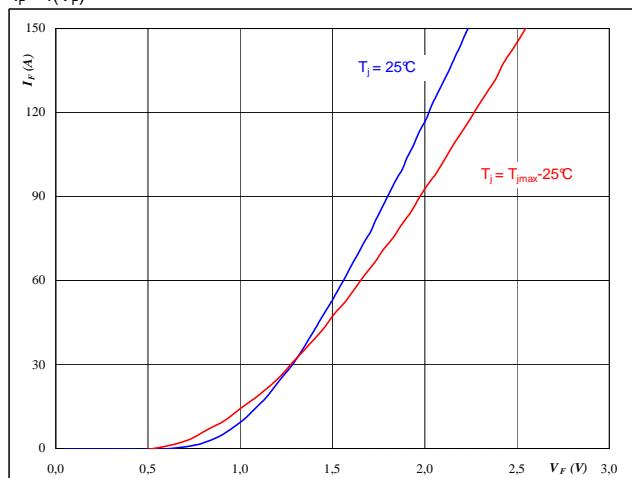
At
 $t_p = 250 \mu s$
 $T_j = 125^\circ C$
 V_{GE} from 7 V to 17 V in steps of 1 V

Figure 3
Typical transfer characteristics
 $I_C = f(V_{GE})$



At
 $T_j = 25/125^\circ C$
 $t_p = 250 \mu s$
 $V_{CE} = 10 V$

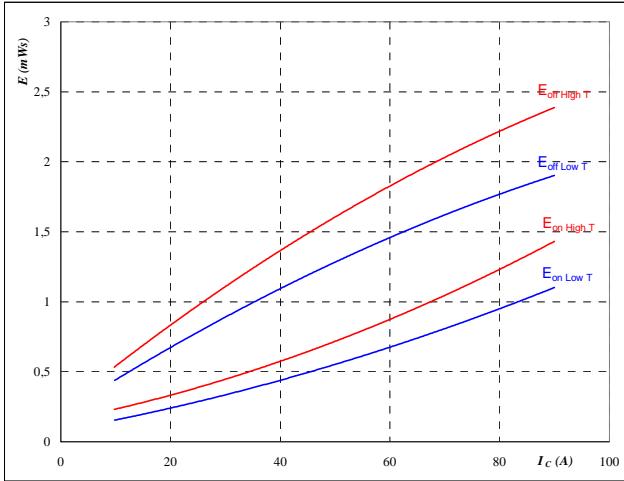
Figure 4
Typical diode forward current as a function of forward voltage
 $I_F = f(V_F)$



At
 $t_p = 250 \mu s$

T1,T2,T3,T4,T5,T6/D1,D2,D3,D4,D5,D6
Figure 5
T1,T2,T3,T4,T5,T6 IGBT
**Typical switching energy losses
as a function of collector current**

$$E = f(I_C)$$

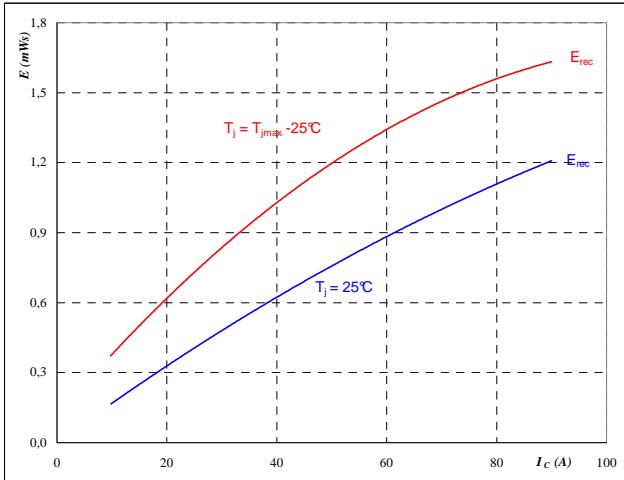


With an inductive load at

$$\begin{aligned} T_j &= 25/125 \quad ^\circ C \\ V_{CE} &= 300 \quad V \\ V_{GE} &= \pm 15 \quad V \\ R_{gon} &= 8 \quad \Omega \\ R_{goff} &= 8 \quad \Omega \end{aligned}$$

Figure 7
D1,D2,D3,D4,D5,D6 FWD
**Typical reverse recovery energy loss
as a function of collector current**

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

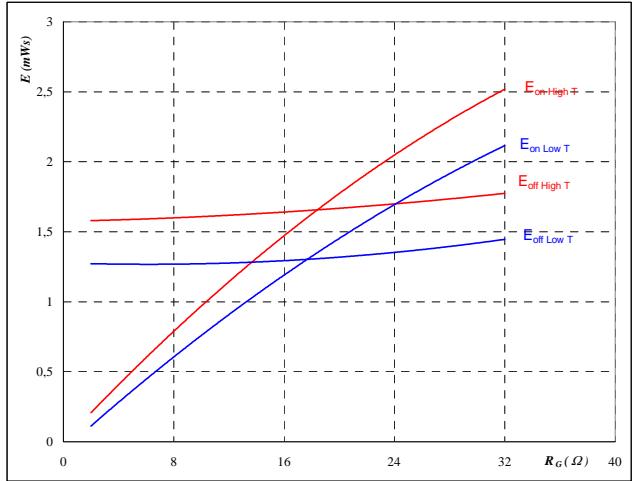


With an inductive load at

$$\begin{aligned} T_j &= 25/125 \quad ^\circ C \\ V_{CE} &= 300 \quad V \\ V_{GE} &= \pm 15 \quad V \\ R_{gon} &= 8 \quad \Omega \end{aligned}$$

Figure 6
T1,T2,T3,T4,T5,T6 IGBT
**Typical switching energy losses
as a function of gate resistor**

$$E = f(R_G)$$

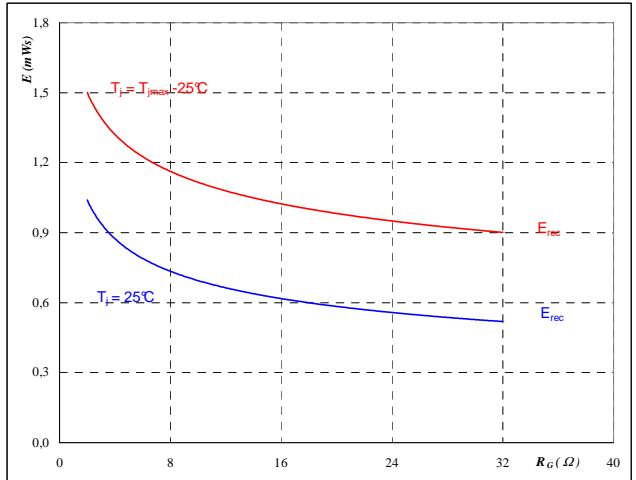


With an inductive load at

$$\begin{aligned} T_j &= 25/125 \quad ^\circ C \\ V_{CE} &= 300 \quad V \\ V_{GE} &= \pm 15 \quad V \\ I_C &= 50 \quad A \end{aligned}$$

Figure 8
D1,D2,D3,D4,D5,D6 FWD
**Typical reverse recovery energy loss
as a function of gate resistor**

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



With an inductive load at

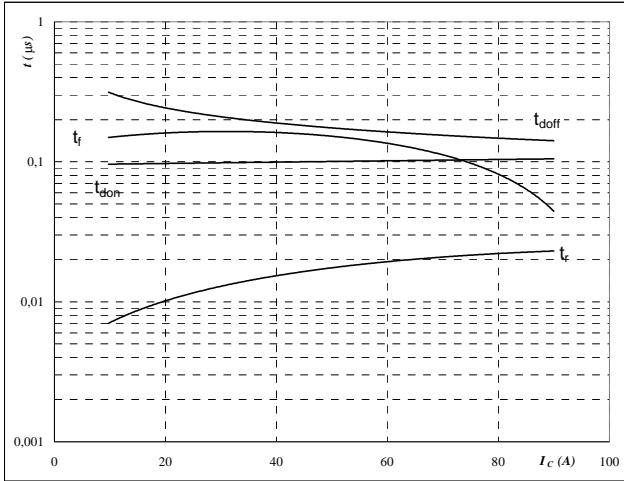
$$\begin{aligned} T_j &= 25/125 \quad ^\circ C \\ V_{CE} &= 300 \quad V \\ V_{GE} &= \pm 15 \quad V \\ I_C &= 50 \quad A \end{aligned}$$

T1,T2,T3,T4,T5,T6/D1,D2,D3,D4,D5,D6

Figure 9
T1,T2,T3,T4,T5,T6 IGBT

Typical switching times as a function of collector current

$t = f(I_C)$



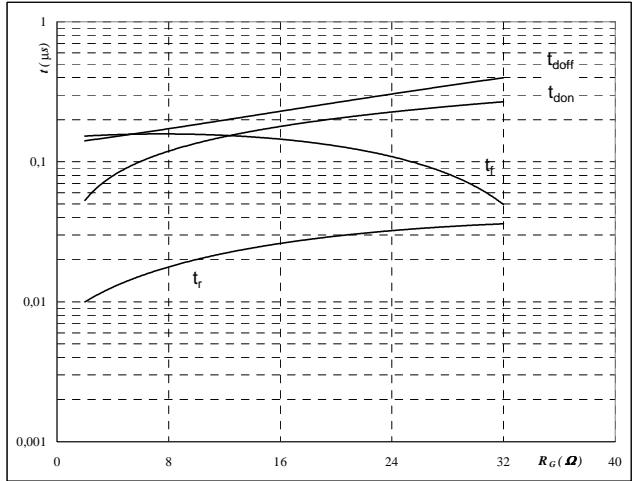
With an inductive load at

T _j =	125	°C
V _{CE} =	300	V
V _{GE} =	±15	V
R _{gon} =	8	Ω
R _{goff} =	8	Ω

Figure 10
T1,T2,T3,T4,T5,T6 IGBT

Typical switching times as a function of gate resistor

$t = f(R_G)$



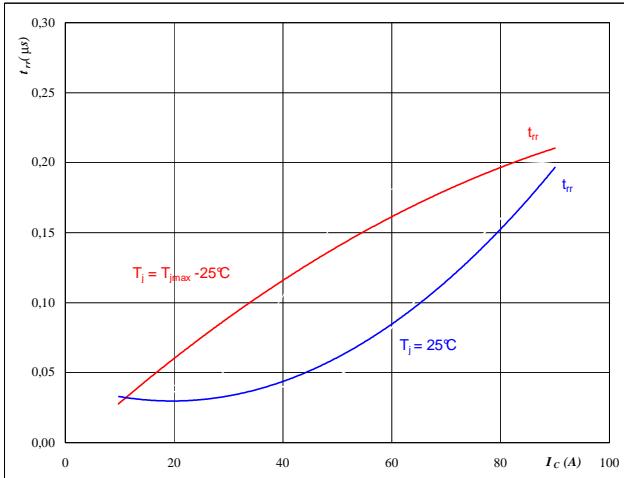
With an inductive load at

T _j =	125	°C
V _{CE} =	300	V
V _{GE} =	±15	V
I _C =	50	A

Figure 11
D1,D2,D3,D4,D5,D6 FWD

Typical reverse recovery time as a function of collector current

$t_{rr} = f(I_C)$



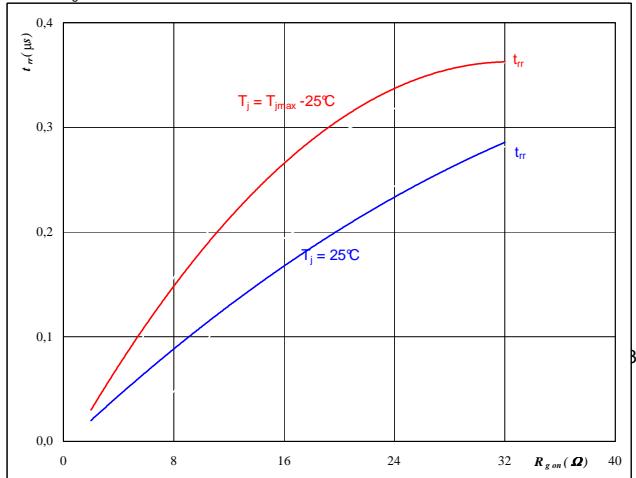
At

T _j =	25/125	°C
V _{CE} =	300	V
V _{GE} =	±15	V
R _{gon} =	8	Ω

Figure 12
D1,D2,D3,D4,D5,D6 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 =	300	V
I _F =	50	A
V _{GE} =	±15	V

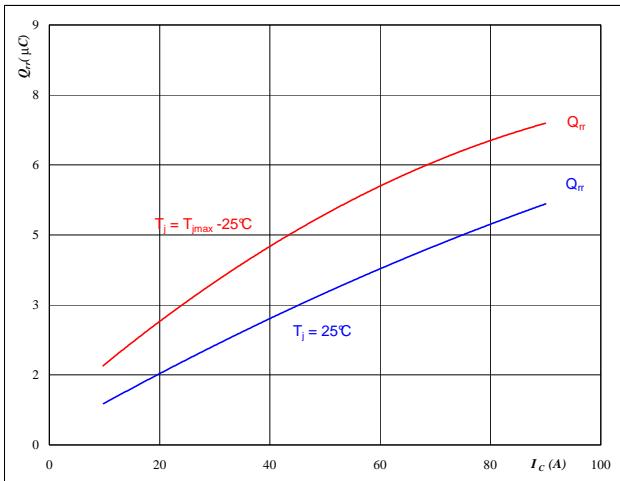
T1,T2,T3,T4,T5,T6/D1,D2,D3,D4,D5,D6

Figure 13

D1,D2,D3,D4,D5,D6 FWD

Typical reverse recovery charge as a function of collector current

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


At

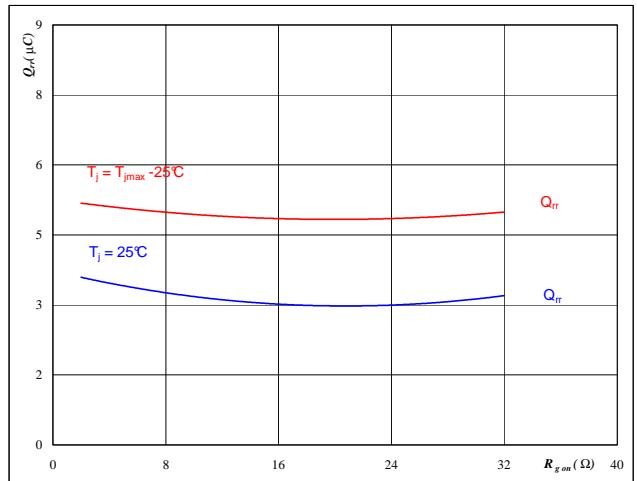
$$\begin{aligned} T_j &= 25/125 \quad ^\circ\text{C} \\ V_{CE} &= 300 \quad \text{V} \\ V_{GE} &= \pm 15 \quad \text{V} \\ R_{gon} &= 8 \quad \Omega \end{aligned}$$

Figure 14

D1,D2,D3,D4,D5,D6 FWD

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

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


At

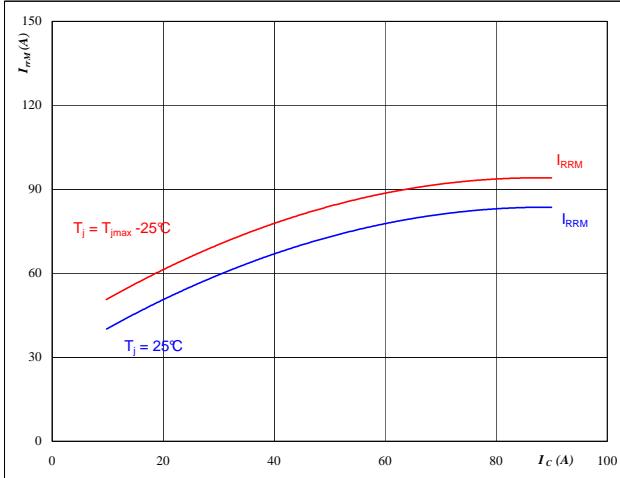
$$\begin{aligned} T_j &= 25/125 \quad ^\circ\text{C} \\ V_R &= 300 \quad \text{V} \\ I_F &= 50 \quad \text{A} \\ V_{GE} &= \pm 15 \quad \text{V} \end{aligned}$$

Figure 15

D1,D2,D3,D4,D5,D6 FWD

Typical reverse recovery current as a function of collector current

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


At

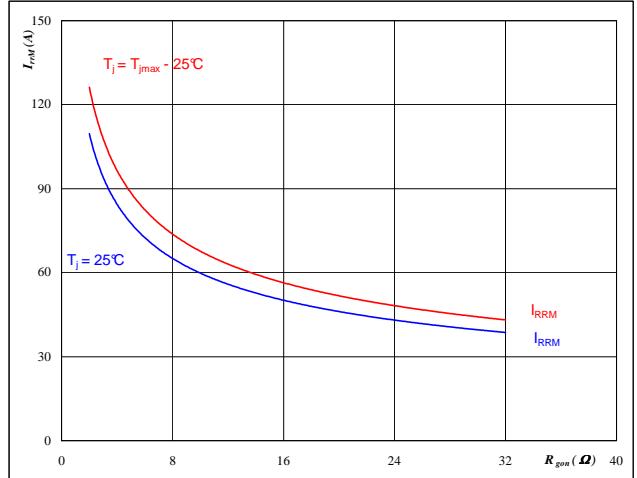
$$\begin{aligned} T_j &= 25/125 \quad ^\circ\text{C} \\ V_{CE} &= 300 \quad \text{V} \\ V_{GE} &= \pm 15 \quad \text{V} \\ R_{gon} &= 8 \quad \Omega \end{aligned}$$

Figure 16

D1,D2,D3,D4,D5,D6 FWD

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

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


At

$$\begin{aligned} T_j &= 25/125 \quad ^\circ\text{C} \\ V_R &= 300 \quad \text{V} \\ I_F &= 50 \quad \text{A} \\ V_{GE} &= \pm 15 \quad \text{V} \end{aligned}$$

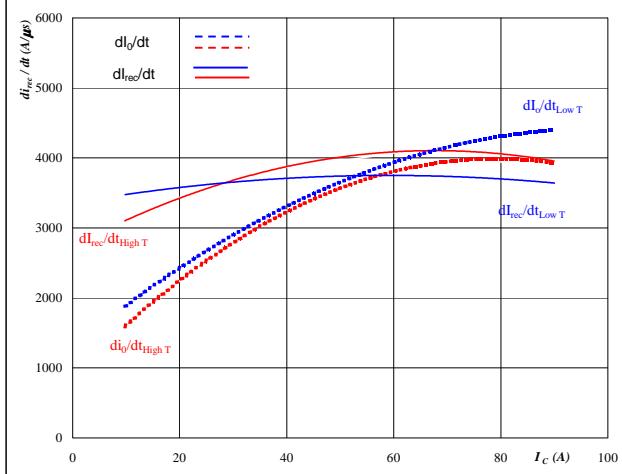
T1,T2,T3,T4,T5,T6/D1,D2,D3,D4,D5,D6

Figure 17

D1,D2,D3,D4,D5,D6 FWD

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

$$dI_0/dt, dI_{rec}/dt = f(I_C)$$


At

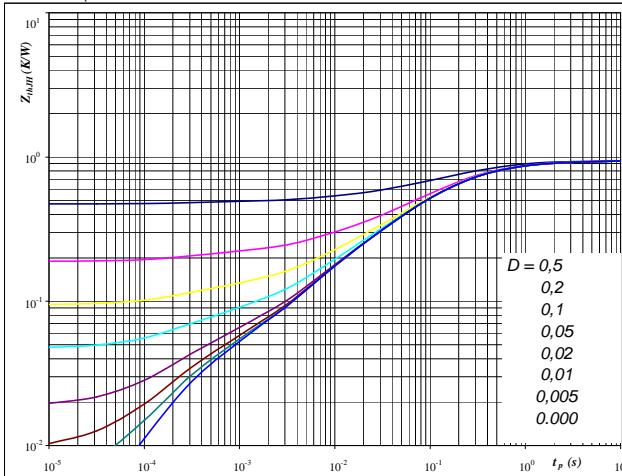
$$\begin{aligned} T_j &= 25/125 \quad ^\circ\text{C} \\ V_{CE} &= 300 \quad \text{V} \\ V_{GE} &= \pm 15 \quad \text{V} \\ R_{gon} &= 8 \quad \Omega \end{aligned}$$

Figure 19

T1,T2,T3,T4,T5,T6 IGBT

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

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


At

$$\begin{aligned} D &= t_p / T \\ R_{thJH} &= 0,95 \quad \text{K/W} \end{aligned}$$

IGBT thermal model values
Thermal grease

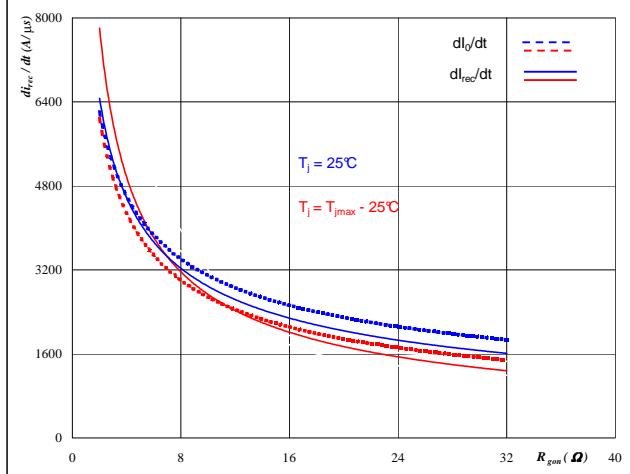
R (C/W)	Tau (s)
0,02	9,1E+00
0,13	1,2E+00
0,45	2,0E-01
0,23	3,8E-02
0,08	5,7E-03
0,03	3,2E-04

Figure 18

D1,D2,D3,D4,D5,D6 FWD

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

$$dI_0/dt, dI_{rec}/dt = f(R_{gon})$$


At

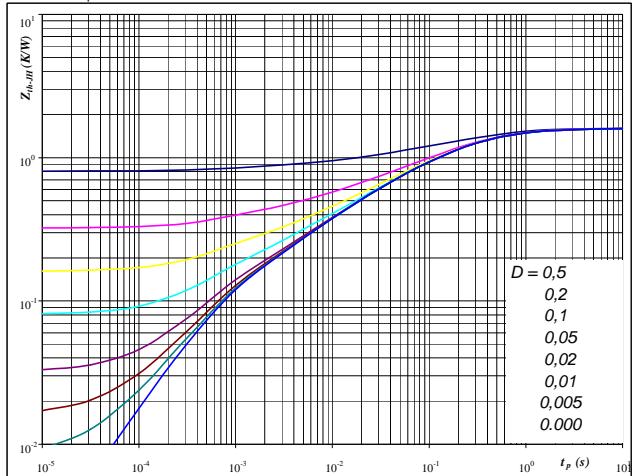
$$\begin{aligned} T_j &= 25/125 \quad ^\circ\text{C} \\ V_R &= 300 \quad \text{V} \\ I_F &= 50 \quad \text{A} \\ V_{GE} &= \pm 15 \quad \text{V} \end{aligned}$$

Figure 20

D1,D2,D3,D4,D5,D6 FWD

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

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


At

$$\begin{aligned} D &= t_p / T \\ R_{thJH} &= 1,61 \quad \text{K/W} \end{aligned}$$

FWD thermal model values
Thermal grease

R (C/W)	Tau (s)
0,04	9,2E+00
0,22	1,0E+00
0,66	2,1E-01
0,38	4,0E-02
0,19	7,0E-03
0,11	7,5E-04

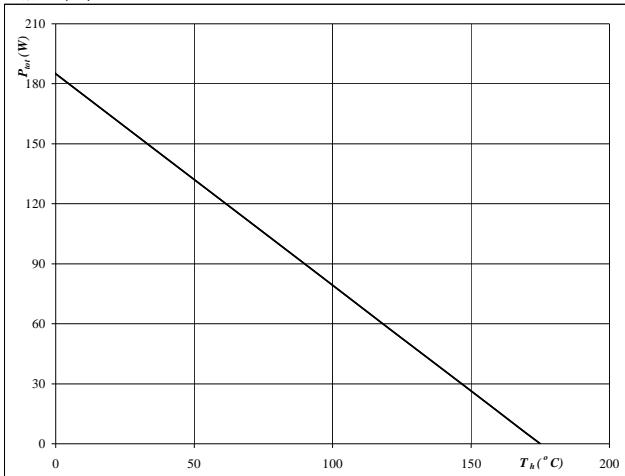
T1,T2,T3,T4,T5,T6/D1,D2,D3,D4,D5,D6

Figure 21

T1,T2,T3,T4,T5,T6 IGBT

Power dissipation as a function of heatsink temperature

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


At

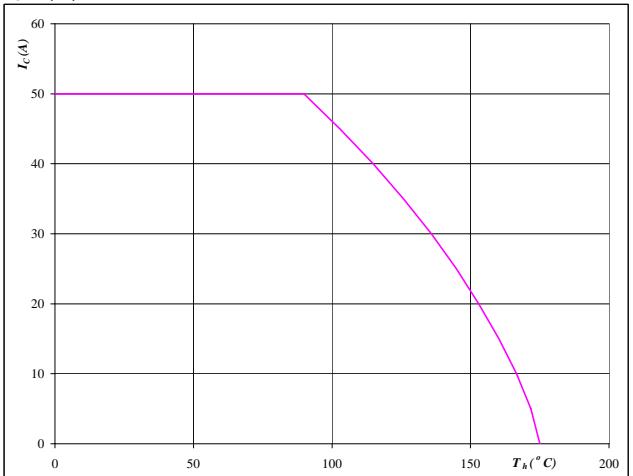
T_j = 175 °C

Figure 22

T1,T2,T3,T4,T5,T6 IGBT

Collector current as a function of heatsink temperature

$$I_C = f(T_h)$$


At

T_j = 175 °C

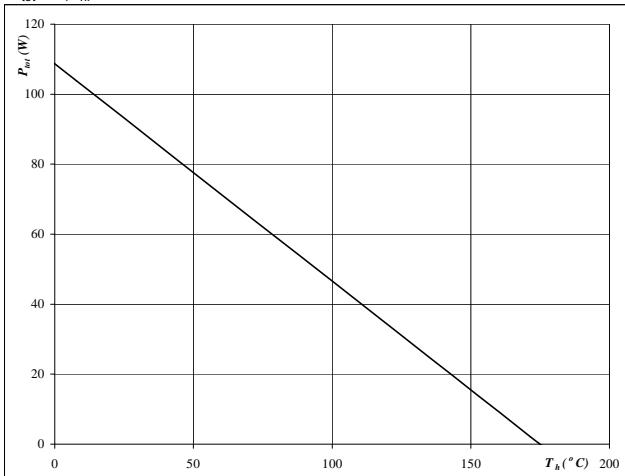
V_{GE} = 15 V

Figure 23

D1,D2,D3,D4,D5,D6 FWD

Power dissipation as a function of heatsink temperature

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


At

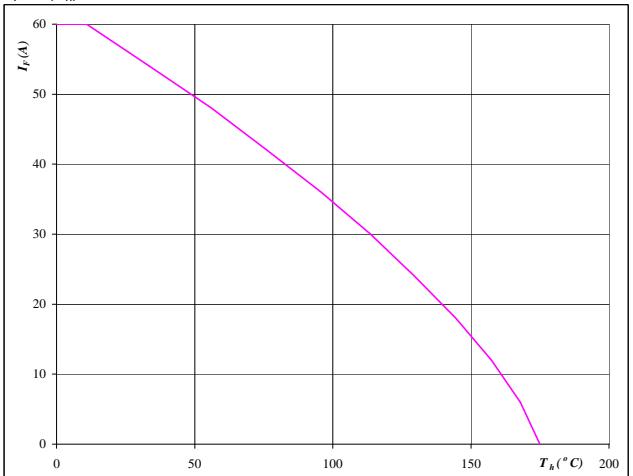
T_j = 175 °C

Figure 24

D1,D2,D3,D4,D5,D6 FWD

Forward current as a function of heatsink temperature

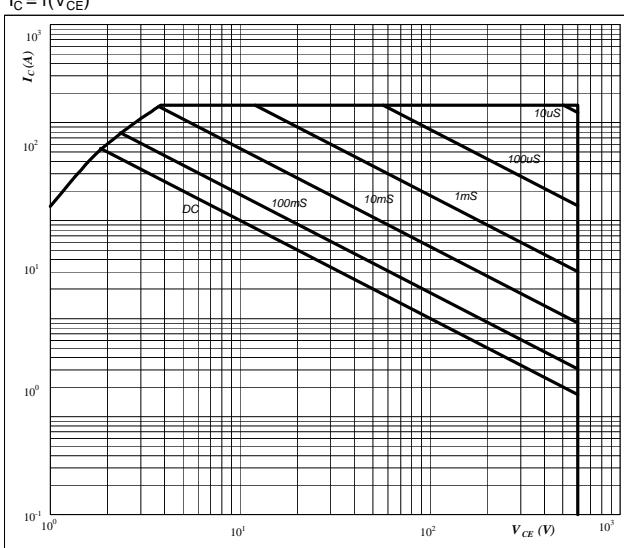
$$I_F = f(T_h)$$


At

T_j = 175 °C

T1,T2,T3,T4,T5,T6/D1,D2,D3,D4,D5,D6

Figure 25
Safe operating area as a function
of collector-emitter voltage
 $I_C = f(V_{CE})$

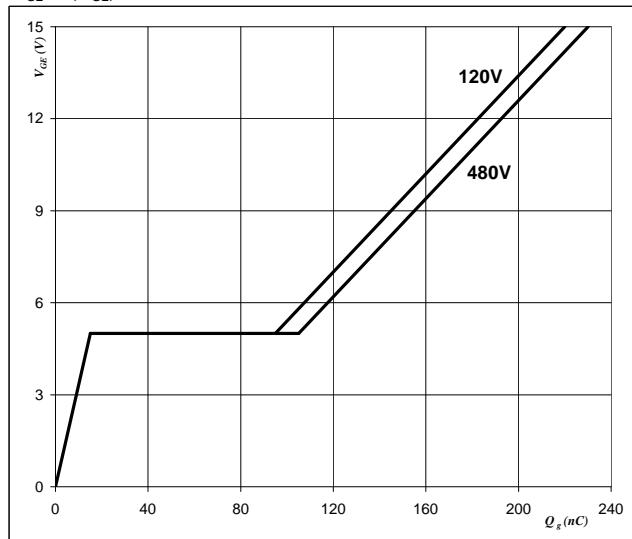


At
 $D =$ single pulse
 $T_h =$ 80 °C
 $V_{GE} =$ ±15 V
 $T_j =$ T_{jmax} °C

T1,T2,T3,T4,T5,T6 IGBT

Figure 26
Gate voltage vs Gate charge

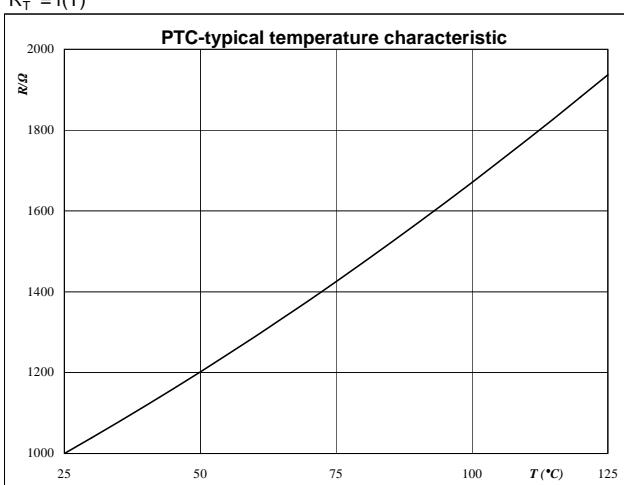
$$V_{GE} = f(Q_{GE})$$



At
 $I_C =$ 50 A

Thermistor

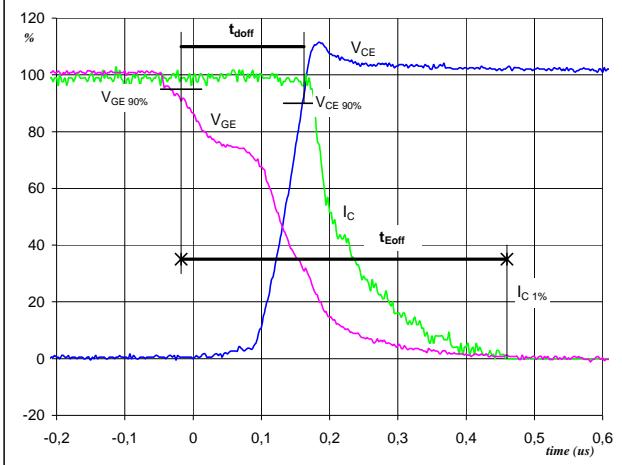
Figure 1
Typical PTC characteristic
as a function of temperature
 $R_T = f(T)$



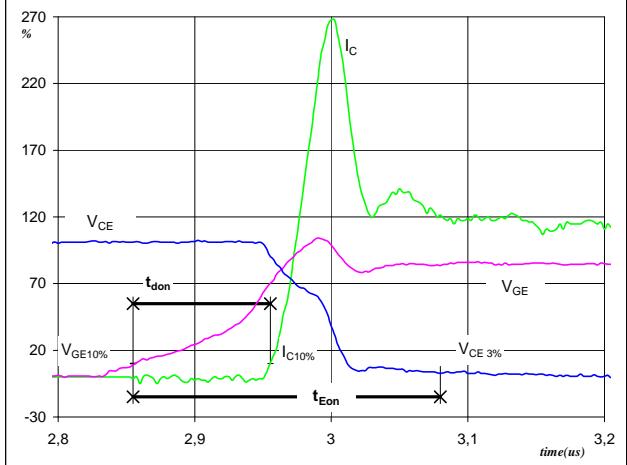
Switching Definitions Output Inverter

General conditions

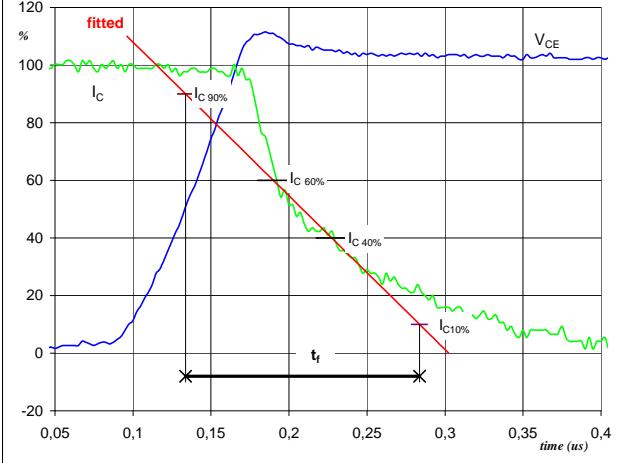
T_j	=	125 °C
R_{gon}	=	8 Ω
R_{goff}	=	8 Ω

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


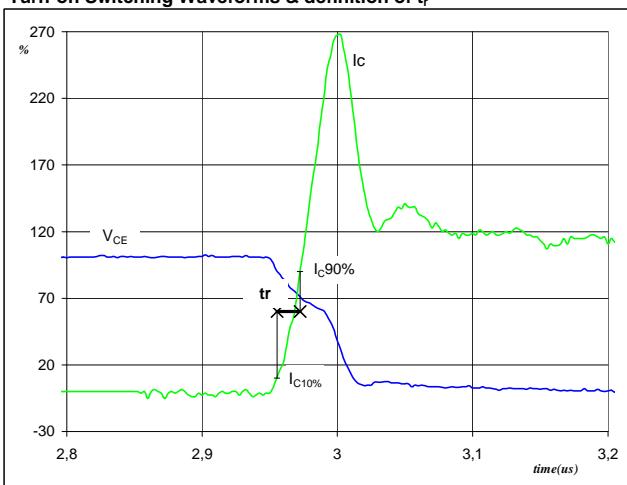
$V_{GE}(0\%) = -15$ V
 $V_{GE}(100\%) = 15$ V
 $V_C(100\%) = 300$ V
 $I_C(100\%) = 50$ A
 $t_{doff} = 0,17$ μs
 $t_{Eoff} = 0,48$ μs

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


$V_{GE}(0\%) = -15$ V
 $V_{GE}(100\%) = 15$ V
 $V_C(100\%) = 300$ V
 $I_C(100\%) = 50$ A
 $t_{don} = 0,10$ μs
 $t_{Eon} = 0,23$ μs

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


$V_C(100\%) = 300$ V
 $I_C(100\%) = 50$ A
 $t_f = 0,17$ μs

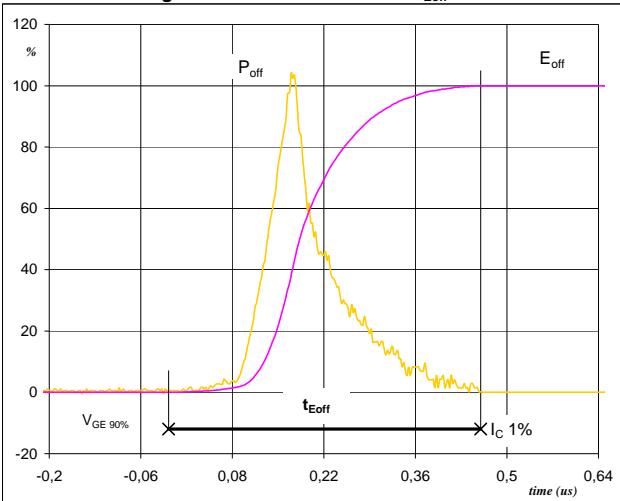
Figure 4
Output inverter IGBT
Turn-on Switching Waveforms & definition of t_r


$V_C(100\%) = 300$ V
 $I_C(100\%) = 50$ A
 $t_r = 0,02$ μs

Switching Definitions Output Inverter

Figure 5

Output inverter IGBT

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


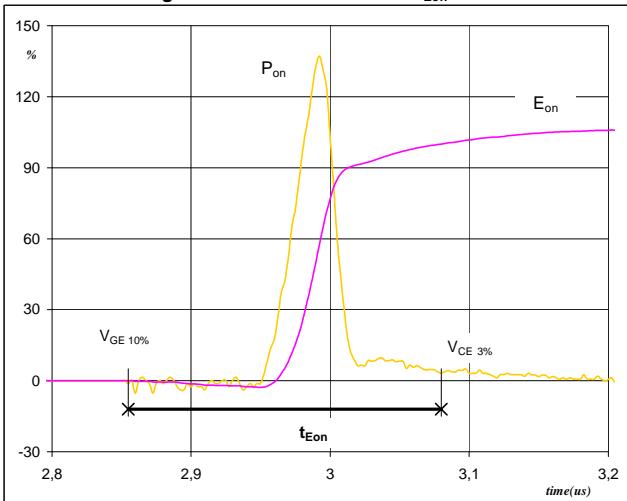
$P_{off} (100\%) = 14,94 \text{ kW}$

$E_{off} (100\%) = 1,62 \text{ mJ}$

$t_{Eoff} = 0,48 \mu\text{s}$

Figure 6

Output inverter IGBT

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


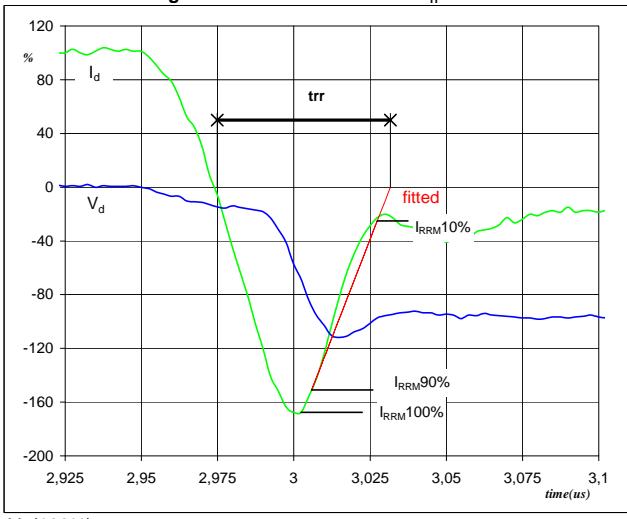
$P_{on} (100\%) = 14,94 \text{ kW}$

$E_{on} (100\%) = 0,72 \text{ mJ}$

$t_{Eon} = 0,23 \mu\text{s}$

Figure 7

Output inverter FWD

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


$V_d (100\%) = 300 \text{ V}$

$I_d (100\%) = 50 \text{ A}$

$I_{RRM} (100\%) = 84 \text{ A}$

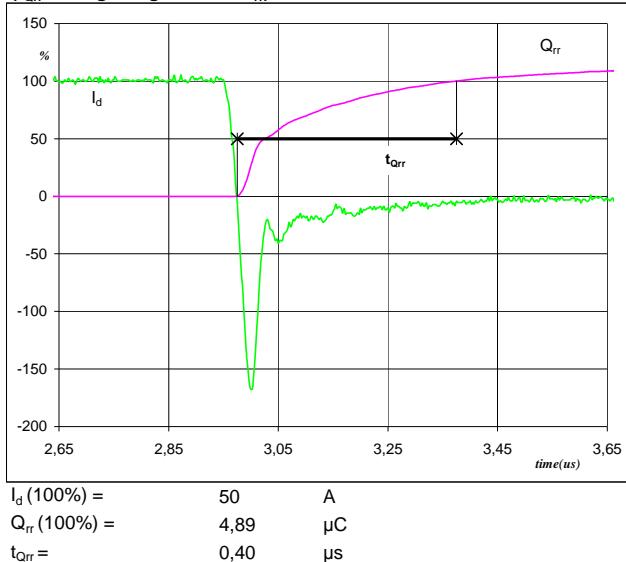
$t_{rr} = 0,16 \mu\text{s}$

Switching Definitions Output Inverter

Figure 8

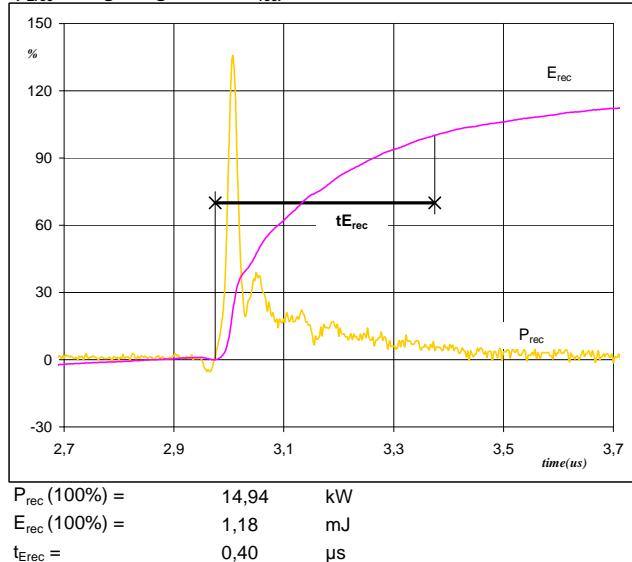
Output inverter FWD

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


Figure 9

Output inverter FWD

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

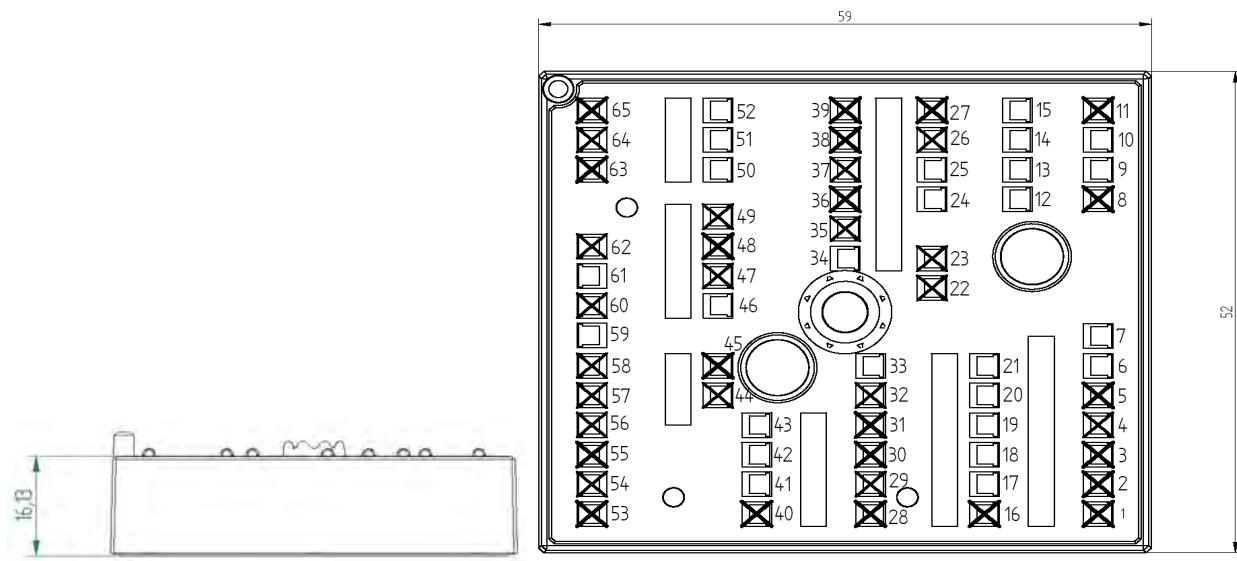


Ordering Code and Marking - Outline - Pinout

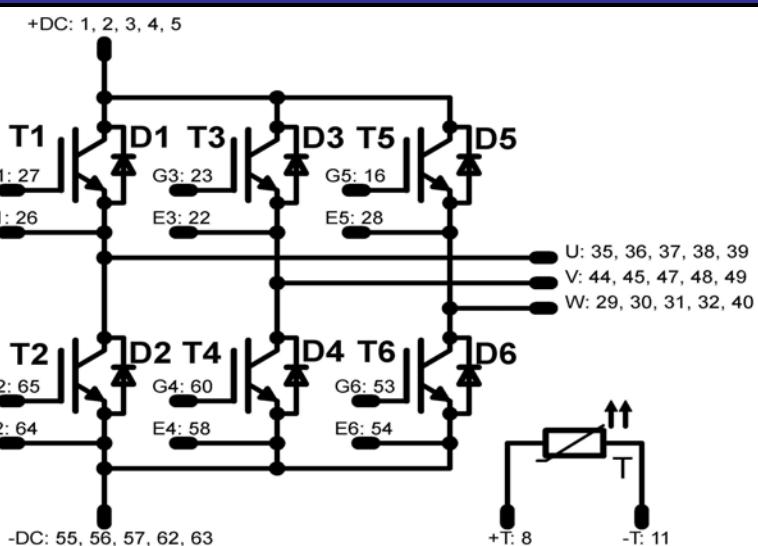
Ordering Code & Marking

Version	Ordering Code	in DataMatrix as	in packaging barcode as
with std lid (black V23990-K22-T-PM)	V23990-K232-A-/0A/-PM	K232A	K232A-/0A/
with std lid (black V23990-K22-T-PM) and P12	V23990-K232-A-/1A/-PM	K232A	K232A-/1A/
with thin lid (white V23990-K23-T-PM)	V23990-K232-A-/0B/-PM	K232A	K232A-/0B/
with thin lid (white V23990-K23-T-PM) and P12	V23990-K232-A-/1B/-PM	K232A	K232A-/1B/

Outline



Pinout



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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.