


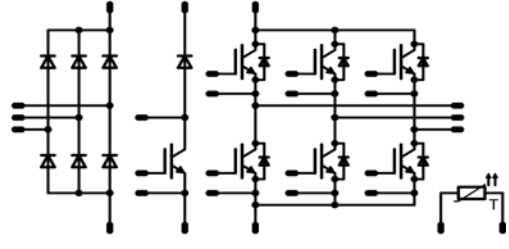
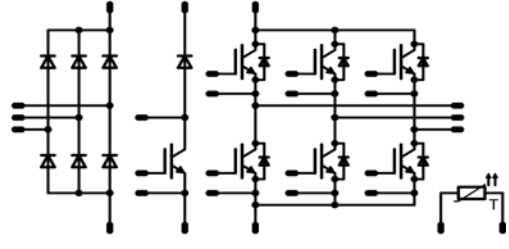
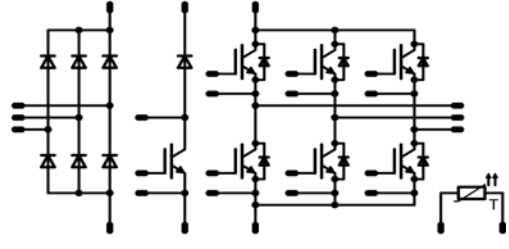


<b>MiniSKiiP® 3 PIM</b>	<b>1200V/100A</b>				
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### Maximum Ratings

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

Parameter	Symbol	Condition	Value	Unit
<b>Input Rectifier Diode</b>				
Repetitive peak reverse voltage	$V_{RRM}$		1600	V
DC forward current	$I_{FAV}$	DC current $T_n=80^{\circ}\text{C}$	74	A
Surge forward current	$I_{FSM}$	$t_p=10\text{ms}$ $T_j=25^{\circ}\text{C}$	500	A
I2t-value	$I^2t$		1250	$\text{A}^2\text{s}$
Power dissipation per Diode	$P_{tot}$	$T_j=T_{jmax}$ $T_n=80^{\circ}\text{C}$	75	W
Maximum Junction Temperature	$T_{jmax}$		150	$^{\circ}\text{C}$
<b>Inverter Transistor</b>				
Collector-emitter break down voltage	$V_{CE}$		1200	V
DC collector current	$I_C$	$T_j=T_{jmax}$ $T_n=80^{\circ}\text{C}$	67	A
Repetitive peak collector current	$I_{Cpulse}$	$t_p$ limited by $T_{jmax}$	300	A
Power dissipation per IGBT	$P_{tot}$	$T_j=T_{jmax}$ $T_n=80^{\circ}\text{C}$	127	W
Gate-emitter peak voltage	$V_{GE}$		$\pm 20$	V
Short circuit ratings	$t_{SC}$ $V_{CC}$	$T_j=150^{\circ}\text{C}$ $V_{GE}=15\text{V}$	10 800	$\mu\text{s}$ 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

Repetitive peak reverse voltage	$V_{RRM}$		1200	V
DC forward current	$I_F$	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$	51	A
Repetitive peak forward current	$I_{FRM}$	$t_p$ limited by $T_{jmax}$	300	A
Power dissipation per Diode	$P_{tot}$	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$	90	W
Maximum Junction Temperature	$T_{jmax}$		175	$^{\circ}\text{C}$

### Brake Transistor

Collector-emitter break down voltage	$V_{CE}$		1200	V
DC collector current	$I_C$	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$	66	A
Repetitive peak collector current	$I_{Cpuls}$	$t_p$ limited by $T_{jmax}$	300	A
Power dissipation per IGBT	$P_{tot}$	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$	127	W
Gate-emitter peak voltage	$V_{GE}$		$\pm 20$	V
Short circuit ratings	$t_{SC}$ $V_{CC}$	$T_j=150^{\circ}\text{C}$ $V_{GE}=15\text{V}$	10 800	$\mu\text{s}$ V
Maximum Junction Temperature	$T_{jmax}$		175	$^{\circ}\text{C}$

### Brake Diode

Repetitive peak reverse voltage	$V_{RRM}$		1200	V
DC forward current	$I_F$	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$	51	A
Repetitive peak forward current	$I_{FRM}$	$t_p$ limited by $T_{jmax}$	300	A
Power dissipation per Diode	$P_{tot}$	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$	90	W
Maximum Junction Temperature	$T_{jmax}$		175	$^{\circ}\text{C}$

### Thermal Properties

Storage temperature	$T_{stg}$		-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

**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>Input Rectifier Diode</b>										
Forward voltage	$V_F$				35	$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$	0.8	0.97 0.88	1.35	V
Threshold voltage (for power loss calc. only)	$V_{td}$					$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		0.85 0.71		V
Slope resistance (for power loss calc. only)	$r_t$					$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		0.0035 0.0047		$\Omega$
Reverse current	$I_r$			1500		$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$			0.1 1.1	mA
Thermal resistance chip to heatsink per chip	$R_{thJH}$	Thermal grease thickness $\leq 50\mu\text{m}$						0.93		K/W
Thermal resistance chip to case per chip	$R_{thJC}$	$\lambda=1\text{W/mK}$						N/A		
<b>Inverter Transistor</b>										
Gate emitter threshold voltage	$V_{GE(th)}$	$V_{CE}=V_{GE}$			0.0038	$T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	5	5.8	6.5	V
Collector-emitter saturation voltage	$V_{CE(sat)}$		15		100	$T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	1.6	1.92 2.33	2.2	V
Collector-emitter cut-off current incl. Diode	$I_{CES}$		0	1200		$T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$			0.12	mA
Gate-emitter leakage current	$I_{GES}$		20	0		$T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$			600	nA
Integrated Gate resistor	$R_{gint}$							7.5		$\Omega$
Turn-on delay time	$t_{d(on)}$	$R_{goff}=4\Omega$ $R_{gon}=4\Omega$	$\pm 15$	600	100	$T_j=25^\circ\text{C}$		204		ns
Rise time	$t_r$					$T_j=150^\circ\text{C}$		216		
Turn-off delay time	$t_{d(off)}$					$T_j=25^\circ\text{C}$		35		
						$T_j=150^\circ\text{C}$		42		
Fall time	$t_f$					$T_j=25^\circ\text{C}$		296		
Turn-on energy loss per pulse	$E_{on}$	$T_j=25^\circ\text{C}$		384						
		$T_j=150^\circ\text{C}$		78						
Turn-off energy loss per pulse	$E_{off}$	$T_j=25^\circ\text{C}$		112						
		$T_j=150^\circ\text{C}$		7.83						
Input capacitance	$C_{ies}$							6150		pF
Output capacitance	$C_{oss}$	$f=1\text{MHz}$	0	25		$T_j=25^\circ\text{C}$		405		
Reverse transfer capacitance	$C_{rss}$							345		
Gate charge	$Q_{Gate}$		$\pm 15$			$T_j=25^\circ\text{C}$		800		nC
Thermal resistance chip to heatsink per chip	$R_{thJH}$	Thermal grease thickness $\leq 50\mu\text{m}$						0.75		K/W
Thermal resistance chip to case per chip	$R_{thJC}$	$\lambda=1\text{W/mK}$						N/A		
<b>Inverter Diode</b>										
Diode forward voltage	$V_F$				100	$T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	1.5	2.47 2.46	2.7	V
Peak reverse recovery current	$I_{RRM}$	$R_{gon}=4\Omega$	$\pm 15$	600	100	$T_j=25^\circ\text{C}$		68.3		A
Reverse recovery time	$t_{rr}$					$T_j=150^\circ\text{C}$		91.3		
						$T_j=25^\circ\text{C}$		267		
Reverse recovered charge	$Q_{rr}$					$T_j=150^\circ\text{C}$		455		
						$T_j=25^\circ\text{C}$		5.69		
Peak rate of fall of recovery current	$di(\text{rec})_{\text{max}}/dt$					$T_j=25^\circ\text{C}$		2761		A/ $\mu\text{s}$
Reverse recovered energy	$E_{rec}$	$T_j=150^\circ\text{C}$				$T_j=25^\circ\text{C}$		1.87		mWs
		$T_j=25^\circ\text{C}$				$T_j=150^\circ\text{C}$		5.42		
Thermal resistance chip to heatsink per chip	$R_{thJH}$	Thermal grease thickness $\leq 50\mu\text{m}$						1.05		K/W
Thermal resistance chip to case per chip	$R_{thJC}$	$\lambda=1\text{W/mK}$						N/A		

**Characteristic Values**

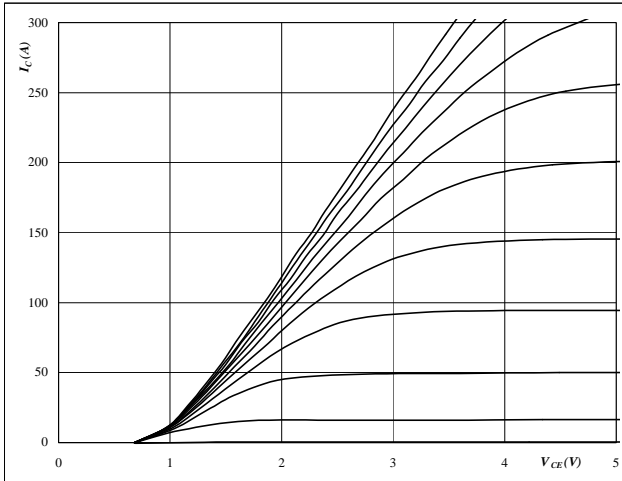
Parameter	Symbol	Conditions					Value			Unit
		$V_{GE}[V]$ or $V_{GS}[V]$	$V_r[V]$ or $V_{CE}[V]$ or $V_{DS}[V]$	$I_c[A]$ or $I_F[A]$ or $I_D[A]$	$T_j$	Min	Typ	Max		
<b>Brake Transistor</b>										
Gate emitter threshold voltage	$V_{GE(th)}$	$V_{CE}=V_{GE}$			0.0038	$T_j=25^\circ C$ $T_j=150^\circ C$	5	5.8	6.5	V
Collector-emitter saturation voltage	$V_{CE(sat)}$		15		100	$T_j=25^\circ C$ $T_j=150^\circ C$	1.6	1.92 2.33	2.2	V
Collector-emitter cut-off incl diode	$I_{CES}$		0	1200		$T_j=25^\circ C$ $T_j=150^\circ C$			0.12	mA
Gate-emitter leakage current	$I_{GES}$		20	0		$T_j=25^\circ C$ $T_j=150^\circ C$			600	nA
Integrated Gate resistor	$R_{gint}$							7.5		$\Omega$
Turn-on delay time	$t_{d(on)}$	Rgoff=4 $\Omega$ Rgon=4 $\Omega$	$\pm 15$	600	100	$T_j=25^\circ C$		198		ns
Rise time	$t_r$					$T_j=150^\circ C$		215		
Turn-off delay time	$t_{d(off)}$					$T_j=25^\circ C$		44		
Fall time	$t_f$					$T_j=150^\circ C$		54		
Turn-on energy loss per pulse	$E_{on}$					$T_j=25^\circ C$		292		
Turn-off energy loss per pulse	$E_{off}$		$T_j=150^\circ C$	378		$T_j=25^\circ C$		73.5		mWs
Input capacitance	$C_{ies}$					$T_j=150^\circ C$		113.4		
Output capacitance	$C_{oss}$	f=1MHz	0	25		$T_j=25^\circ C$		10.3		pF
Reverse transfer capacitance	$C_{rss}$					$T_j=150^\circ C$		15.2		
Gate charge	$Q_{Gate}$		$\pm 15$			$T_j=25^\circ C$		5.67		nC
Thermal resistance chip to heatsink per chip	$R_{thJH}$	Thermal grease thickness $\leq 50\mu m$ $\lambda=1W/mK$						8.97		
Thermal resistance chip to case per chip	$R_{thJC}$							N/A		K/W
<b>Brake Diode</b>										
Diode forward voltage	$V_F$				100	$T_j=25^\circ C$ $T_j=150^\circ C$	1.5	2.47 2.45	2.7	V
Reverse leakage current	$I_r$			1200		$T_j=25^\circ C$ $T_j=150^\circ C$			120 10500	$\mu A$
Peak reverse recovery current	$I_{RRM}$	Rgon=4 $\Omega$	$\pm 15$	600	100	$T_j=25^\circ C$		37.8		A
Reverse recovery time	$t_{rr}$					$T_j=150^\circ C$		53.3		
Reverse recovered charge	$Q_{rr}$					$T_j=25^\circ C$		304		
Peak rate of fall of recovery current	$di(rec)max/dt$					$T_j=150^\circ C$		599		
Reverse recovery energy	$E_{rec}$					$T_j=25^\circ C$		5.01		
			$T_j=150^\circ C$	14.17		$T_j=25^\circ C$		477		$A/\mu s$
						$T_j=150^\circ C$		93		
Thermal resistance chip to heatsink per chip	$R_{thJH}$	Thermal grease thickness $\leq 50\mu m$ $\lambda=1W/mK$						1.56		mWs
Thermal resistance chip to case per chip	$R_{thJC}$							4.92		
								1.05		K/W
								N/A		
<b>Thermistor</b>										
Rated resistance	R					$T_j=25^\circ C$ $T_j=150^\circ C$	0.97	1 2.23	1.03	k $\Omega$
Temperature coefficient	a					$T_j=25^\circ C$		0.76		%/K
Recommended measuring current	I					$T_j=25^\circ C$		1	3	mA

## Output Inverter

Figure 1 Output inverter IGBT

Typical output characteristics

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

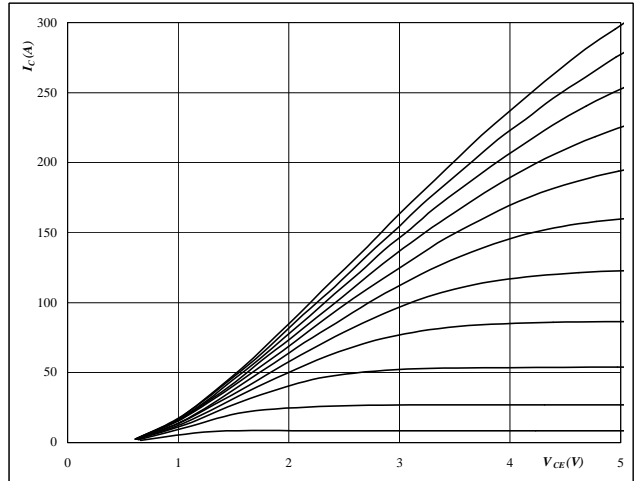


At  
 $t_p = 250 \mu s$   
 $T_j = 25 \text{ } ^\circ C$   
 $V_{GE}$  from 7 V to 17 V in steps of 1 V

Figure 2 Output inverter IGBT

Typical output characteristics

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

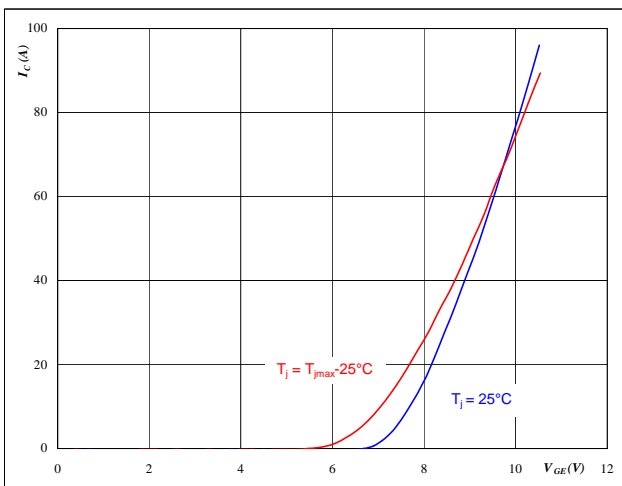


At  
 $t_p = 250 \mu s$   
 $T_j = 150 \text{ } ^\circ C$   
 $V_{GE}$  from 7 V to 17 V in steps of 1 V

Figure 3 Output inverter IGBT

Typical transfer characteristics

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

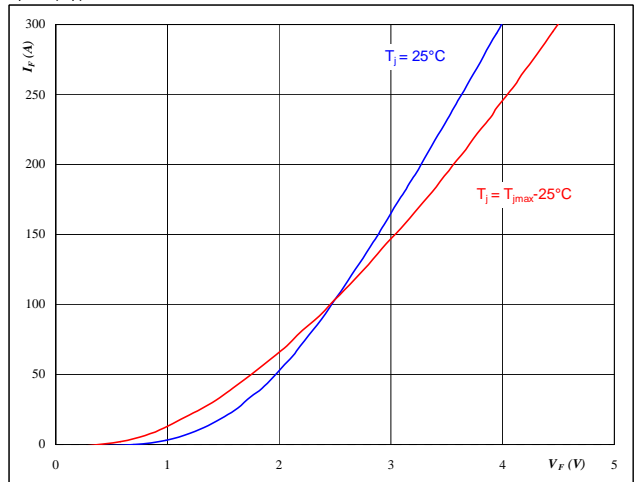


At  
 $t_p = 250 \mu s$   
 $V_{CE} = 10 V$

Figure 4 Output inverter FRED

Typical diode forward current as a function of forward voltage

$$I_F = f(V_F)$$

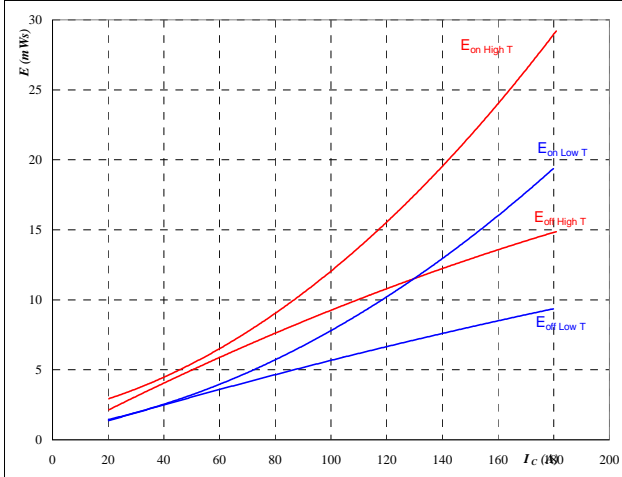


At  
 $t_p = 250 \mu s$

## Output Inverter

Figure 5 Output inverter IGBT

Typical switching energy losses  
as a function of collector current  
 $E = f(I_C)$

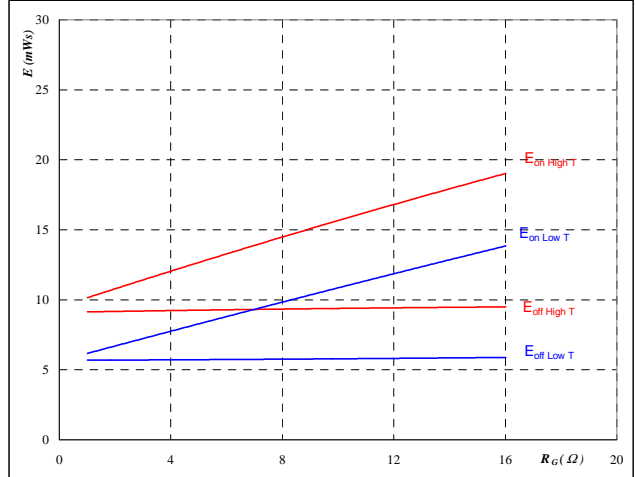


With an inductive load at

$T_j = 25/150 \text{ } ^\circ\text{C}$   
 $V_{CE} = 600 \text{ V}$   
 $V_{GE} = \pm 15 \text{ V}$   
 $R_{gon} = 4 \text{ } \Omega$   
 $R_{goff} = 4 \text{ } \Omega$

Figure 6 Output inverter IGBT

Typical switching energy losses  
as a function of gate resistor  
 $E = f(R_G)$

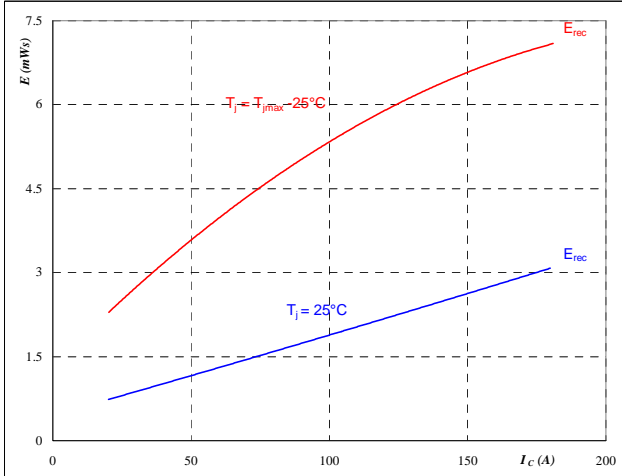


With an inductive load at

$T_j = 25/150 \text{ } ^\circ\text{C}$   
 $V_{CE} = 600 \text{ V}$   
 $V_{GE} = \pm 15 \text{ V}$   
 $I_C = 100 \text{ A}$

Figure 7 Output inverter IGBT

Typical reverse recovery energy loss  
as a function of collector current  
 $E_{rec} = f(I_C)$

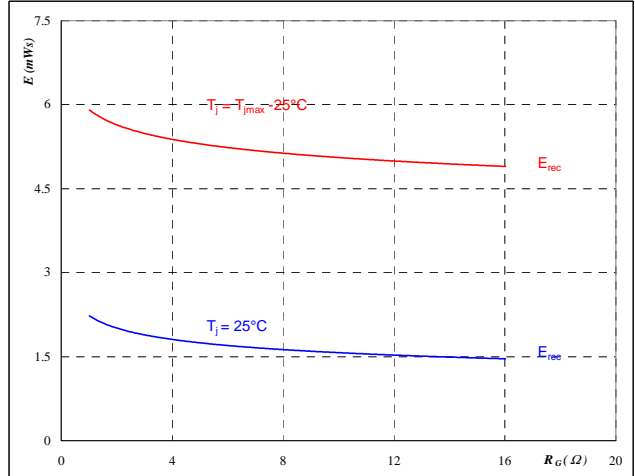


With an inductive load at

$T_j = 25/150 \text{ } ^\circ\text{C}$   
 $V_{CE} = 600 \text{ V}$   
 $V_{GE} = \pm 15 \text{ V}$   
 $R_{gon} = 4 \text{ } \Omega$

Figure 8 Output inverter IGBT

Typical reverse recovery energy loss  
as a function of gate resistor  
 $E_{rec} = f(R_G)$



With an inductive load at

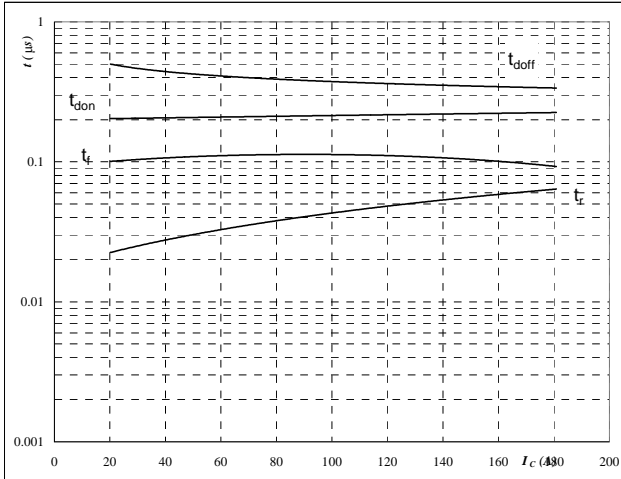
$T_j = 25/150 \text{ } ^\circ\text{C}$   
 $V_{CE} = 600 \text{ V}$   
 $V_{GE} = \pm 15 \text{ V}$   
 $I_C = 100 \text{ A}$

## Output Inverter

Figure 9 Output inverter IGBT

Typical switching times as a function of collector current

$$t = f(I_C)$$



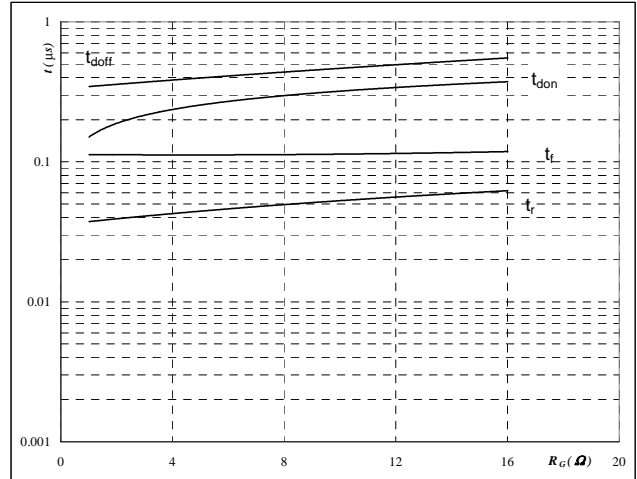
With an inductive load at

$T_j =$	150	°C
$V_{CE} =$	600	V
$V_{GE} =$	±15	V
$R_{gon} =$	4	Ω
$R_{goff} =$	4	Ω

Figure 10 Output inverter IGBT

Typical switching times as a function of gate resistor

$$t = f(R_G)$$



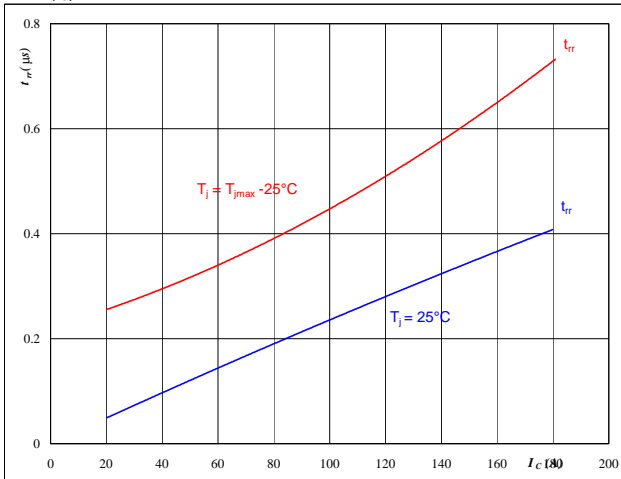
With an inductive load at

$T_j =$	150	°C
$V_{CE} =$	600	V
$V_{GE} =$	±15	V
$I_C =$	100	A

Figure 11 Output inverter FRED

Typical reverse recovery time as a function of collector current

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



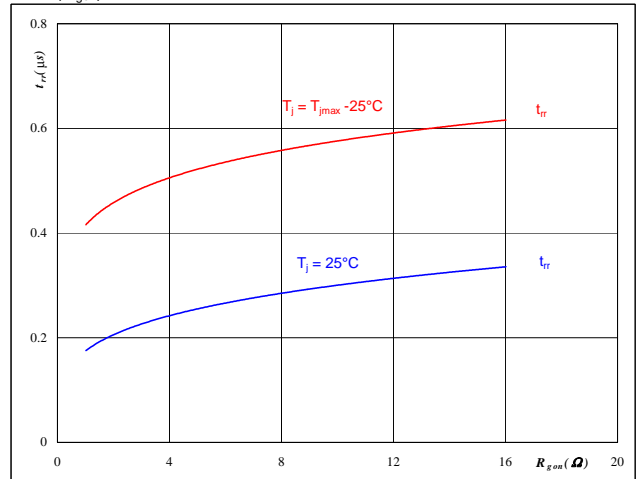
At

$T_j =$	25/150	°C
$V_{CE} =$	600	V
$V_{GE} =$	±15	V
$R_{gon} =$	4	Ω

Figure 12 Output inverter FRED

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

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



At

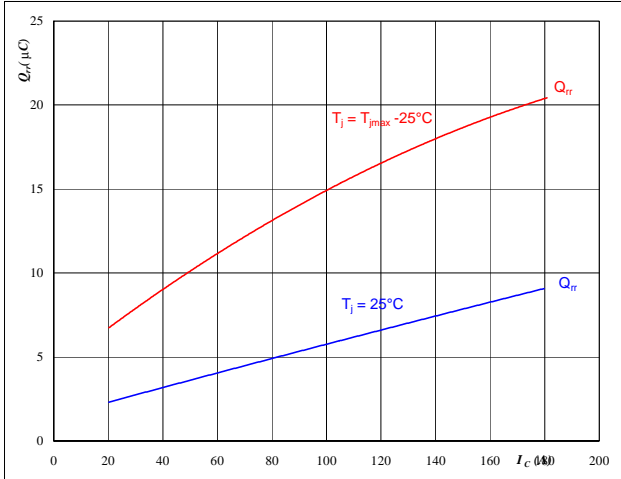
$T_j =$	25/150	°C
$V_R =$	600	V
$I_F =$	100	A
$V_{GE} =$	±15	V

## Output Inverter

Figure 13 Output inverter FRED

Typical reverse recovery charge as a function of collector current

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



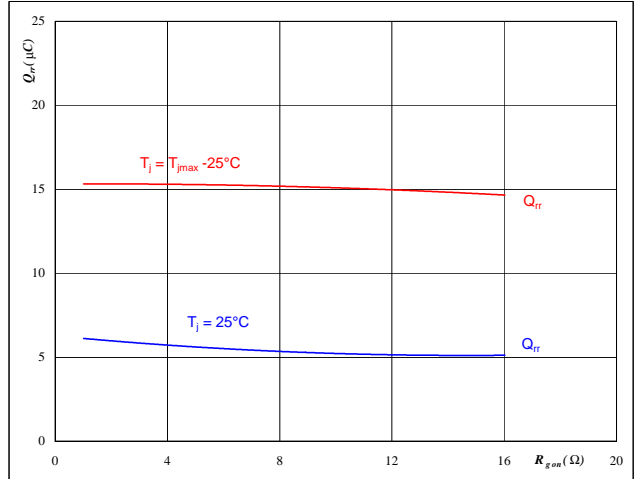
**At**

$T_j =$	25/150	$^\circ\text{C}$
$V_{CE} =$	600	V
$V_{GE} =$	$\pm 15$	V
$R_{gon} =$	4	$\Omega$

Figure 14 Output inverter FRED

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

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



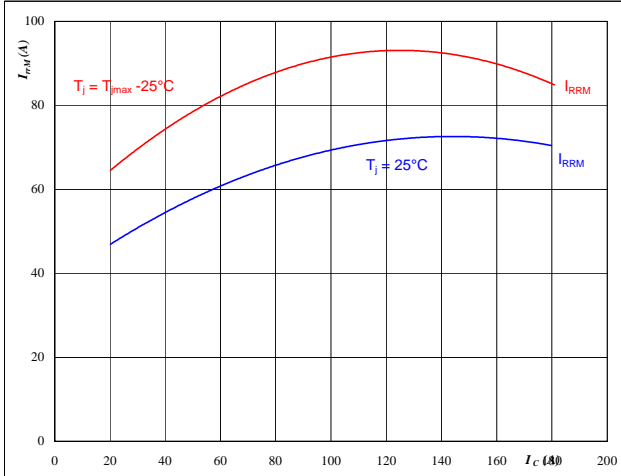
**At**

$T_j =$	25/150	$^\circ\text{C}$
$V_R =$	600	V
$I_F =$	100	A
$V_{GE} =$	$\pm 15$	V

Figure 15 Output inverter FRED

Typical reverse recovery current as a function of collector current

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



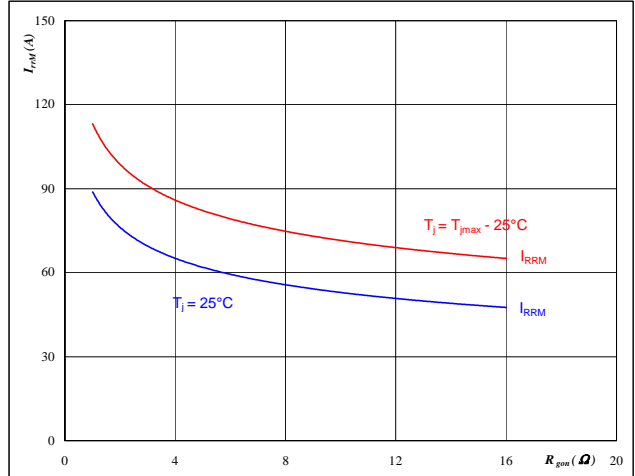
**At**

$T_j =$	25/150	$^\circ\text{C}$
$V_{CE} =$	600	V
$V_{GE} =$	$\pm 15$	V
$R_{gon} =$	4	$\Omega$

Figure 16 Output inverter FRED

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

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



**At**

$T_j =$	25/150	$^\circ\text{C}$
$V_R =$	600	V
$I_F =$	100	A
$V_{GE} =$	$\pm 15$	V

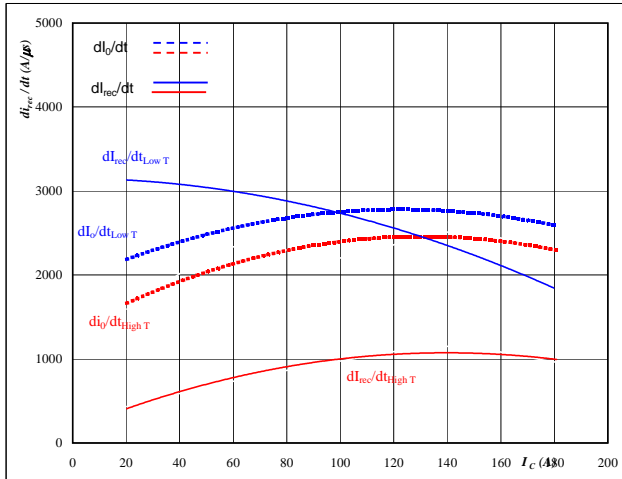


### Output Inverter

Figure 17 Output inverter FRED

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

$dI_o/dt, dI_{rec}/dt = f(I_c)$

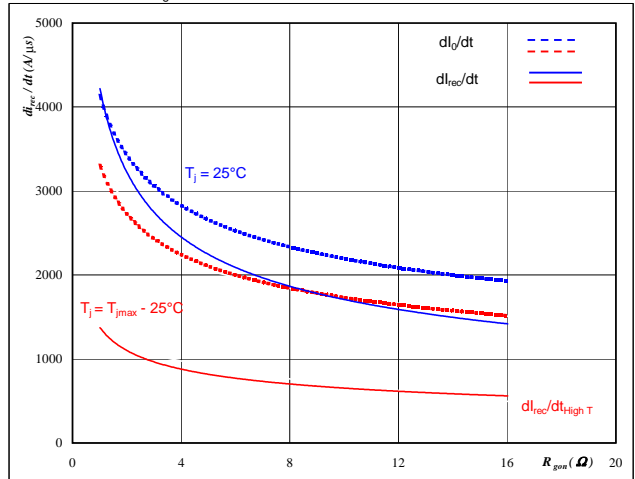


At  
 $T_j = 25/150 \text{ } ^\circ\text{C}$   
 $V_{CE} = 600 \text{ V}$   
 $V_{GE} = \pm 15 \text{ V}$   
 $R_{gon} = 4 \text{ } \Omega$

Figure 18 Output inverter FRED

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

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

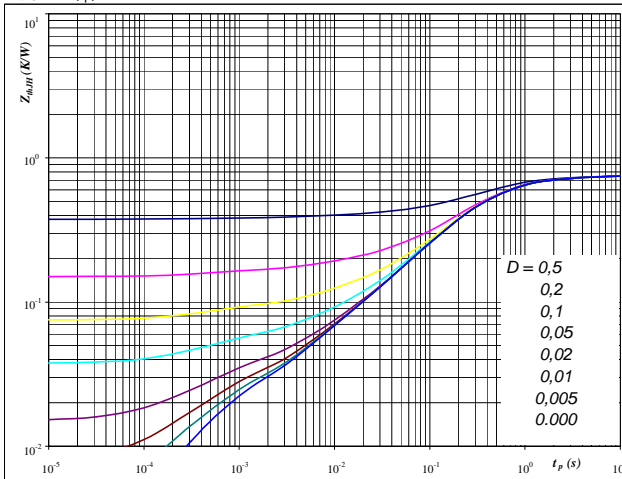


At  
 $T_j = 25/150 \text{ } ^\circ\text{C}$   
 $V_R = 600 \text{ V}$   
 $I_F = 100 \text{ A}$   
 $V_{GE} = \pm 15 \text{ V}$

Figure 19 Output inverter IGBT

IGBT transient thermal impedance as a function of pulse width

$Z_{thJH} = f(t_p)$



At  
 $D = t_p / T$   
 $R_{thJH} = 0.75 \text{ K/W}$

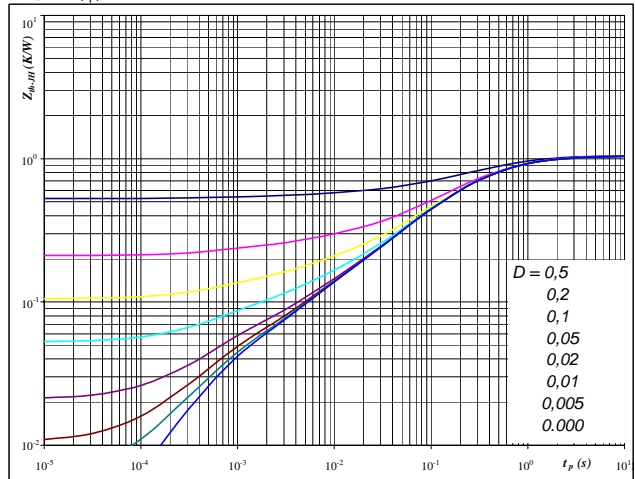
IGBT thermal model values

R (C/W)	Tau (s)
0.11	2.2E+00
0.42	3.8E-01
0.16	1.0E-01
0.04	9.2E-03
0.02	4.7E-04

Figure 20 Output inverter FRED

FRED transient thermal impedance as a function of pulse width

$Z_{thJH} = f(t_p)$



At  
 $D = t_p / T$   
 $R_{thJH} = 1.05 \text{ K/W}$

FRED thermal model values

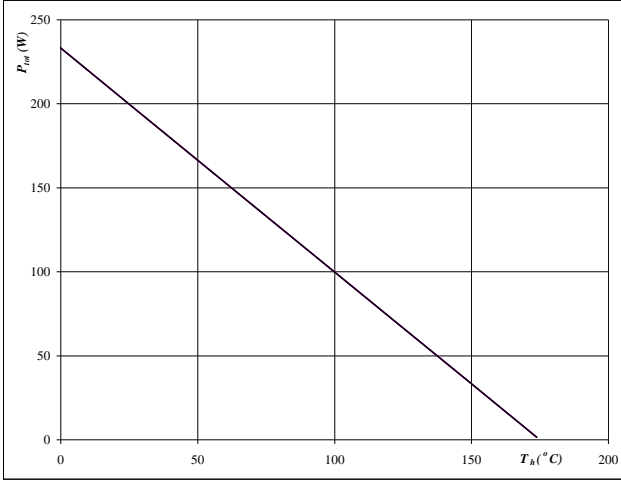
R (C/W)	Tau (s)
0.04	9.3E+00
0.21	1.1E+00
0.52	2.5E-01
0.19	5.4E-02
0.06	6.3E-03
0.03	6.4E-04

## Output Inverter

Figure 21 Output inverter IGBT

Power dissipation as a function of heatsink temperature

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

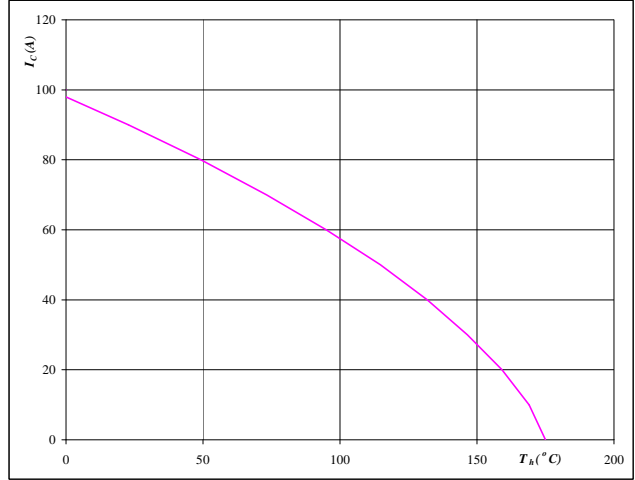


At  $T_j = 175$  °C  
— single heating  
— overall heating

Figure 22 Output inverter IGBT

Collector current as a function of heatsink temperature

$$I_C = f(T_h)$$

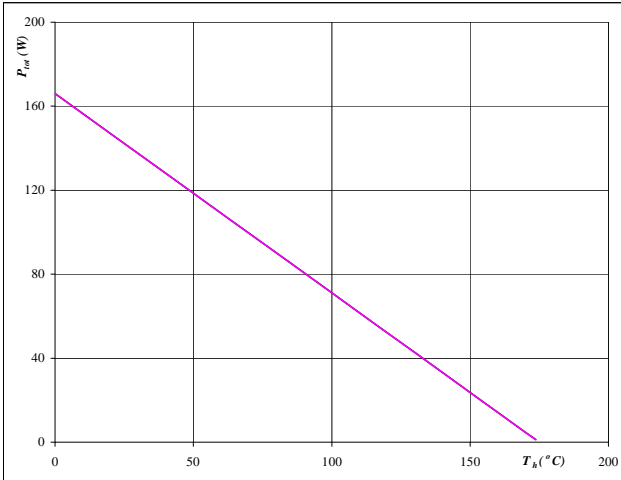


At  $T_j = 175$  °C  
 $V_{GE} = 15$  V

Figure 23 Output inverter FRED

Power dissipation as a function of heatsink temperature

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

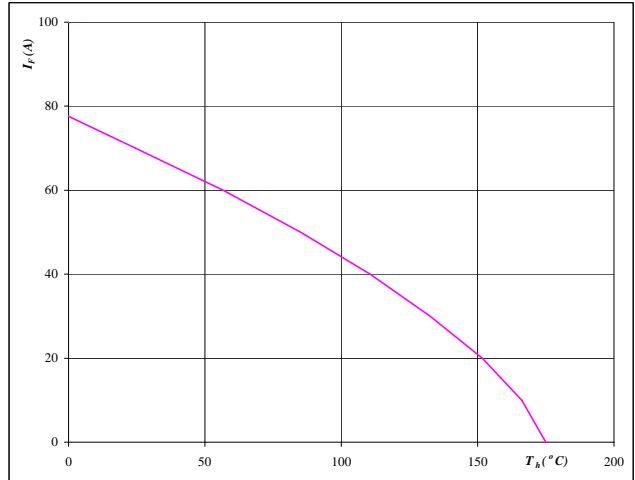


At  $T_j = 175$  °C  
— single heating  
— overall heating

Figure 24 Output inverter FRED

Forward current as a function of heatsink temperature

$$I_F = f(T_h)$$

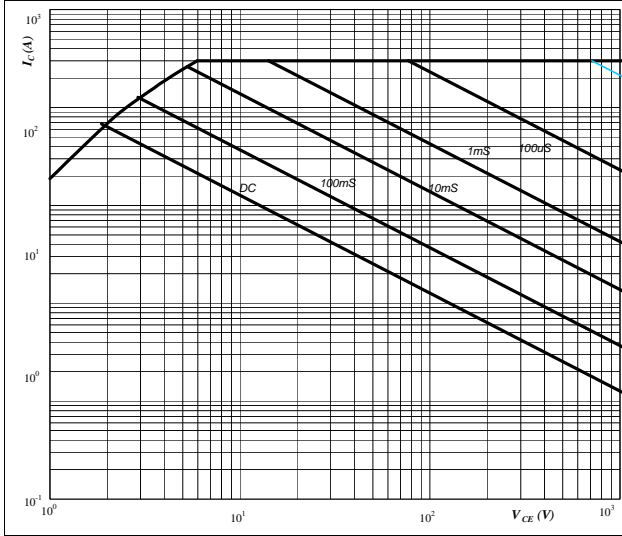


At  $T_j = 175$  °C

## Output Inverter

Figure 25 Output inverter IGBT

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

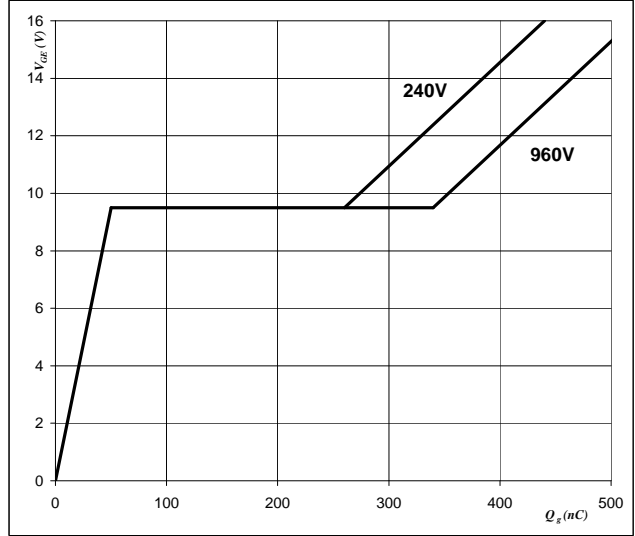


At  
D = single pulse  
 $T_h = 80 \text{ } ^\circ\text{C}$   
 $V_{GE} = \pm 15 \text{ V}$   
 $T_j = T_{jmax} \text{ } ^\circ\text{C}$

Figure 26 Output inverter IGBT

Gate voltage vs Gate charge

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



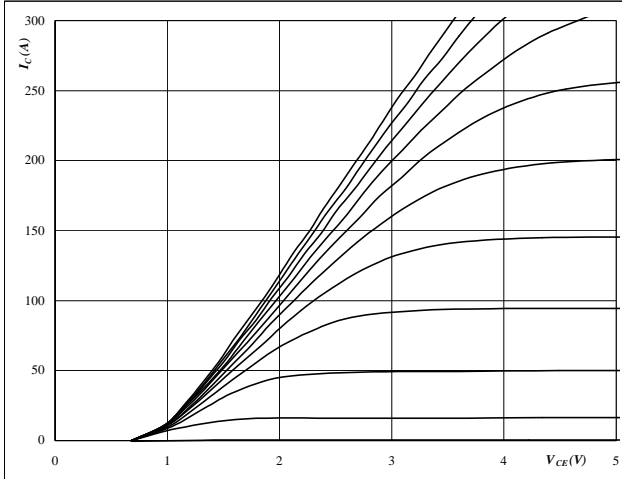
At  
 $I_C = 100 \text{ A}$

# Brake

**Figure 1** Brake IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$

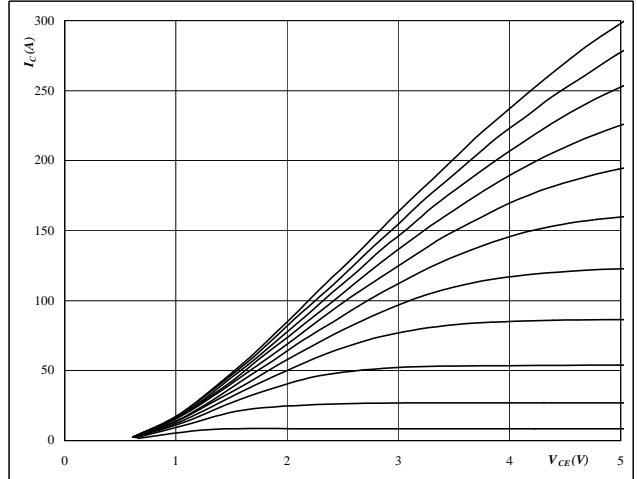


**At**  
 $t_p = 250 \mu s$   
 $T_j = 25 \text{ } ^\circ C$   
 $V_{GE}$  from 7 V to 17 V in steps of 1 V

**Figure 2** Brake IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$

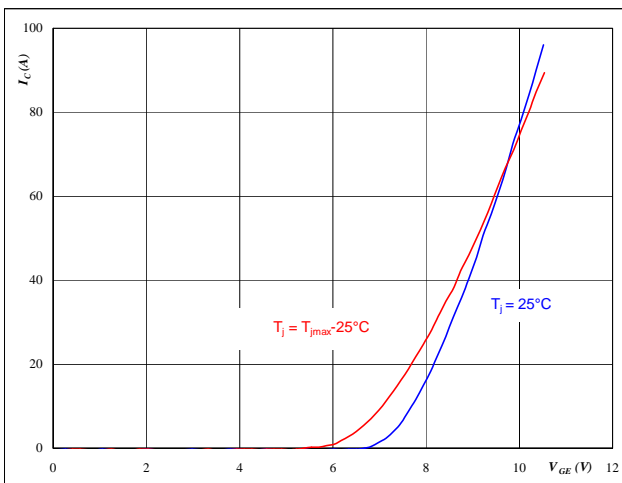


**At**  
 $t_p = 250 \mu s$   
 $T_j = 150 \text{ } ^\circ C$   
 $V_{GE}$  from 7 V to 17 V in steps of 1 V

**Figure 3** Brake IGBT

**Typical transfer characteristics**

$I_C = f(V_{GE})$

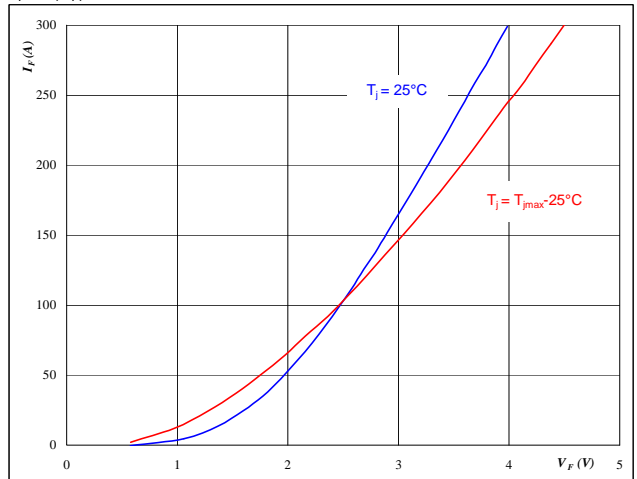


**At**  
 $t_p = 250 \mu s$   
 $V_{CE} = 10 V$

**Figure 4** Brake FRED

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

$I_F = f(V_F)$

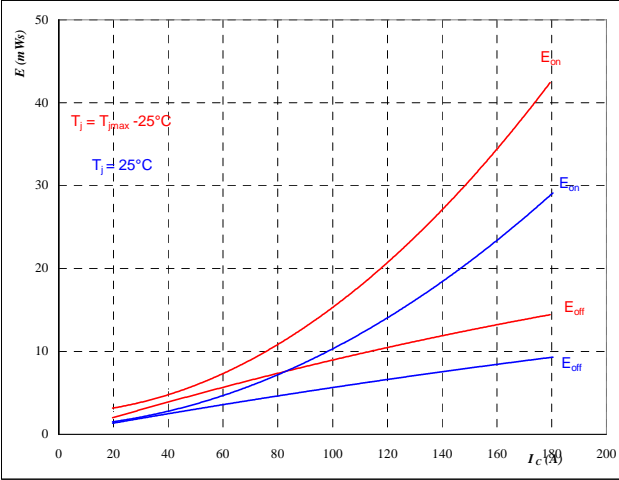


**At**  
 $t_p = 250 \mu s$

# Brake

Figure 5 Brake IGBT

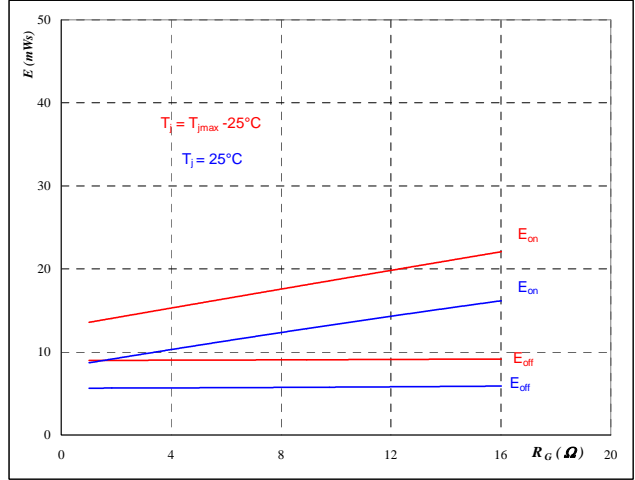
Typical switching energy losses  
as a function of collector current  
 $E = f(I_C)$



With an inductive load at  
 $T_j = 25/150 \text{ } ^\circ\text{C}$   
 $V_{CE} = 600 \text{ V}$   
 $V_{GE} = \pm 15 \text{ V}$   
 $R_{gon} = 4 \text{ } \Omega$   
 $R_{goff} = 4 \text{ } \Omega$

Figure 6 Brake IGBT

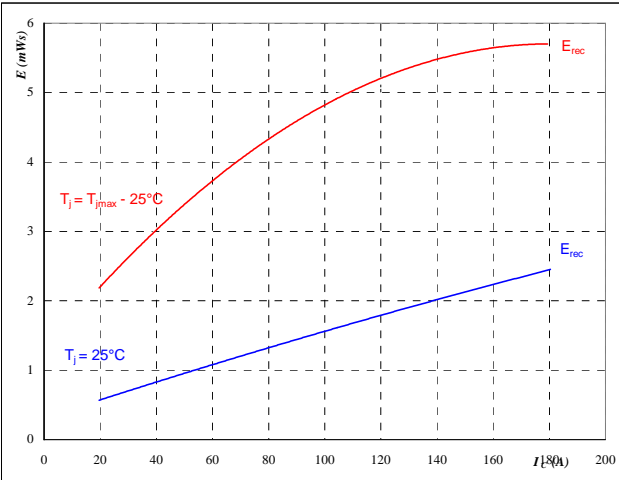
Typical switching energy losses  
as a function of gate resistor  
 $E = f(R_G)$



With an inductive load at  
 $T_j = 25/150 \text{ } ^\circ\text{C}$   
 $V_{CE} = 600 \text{ V}$   
 $V_{GE} = \pm 15 \text{ V}$   
 $I_C = 100 \text{ A}$

Figure 7 Brake IGBT

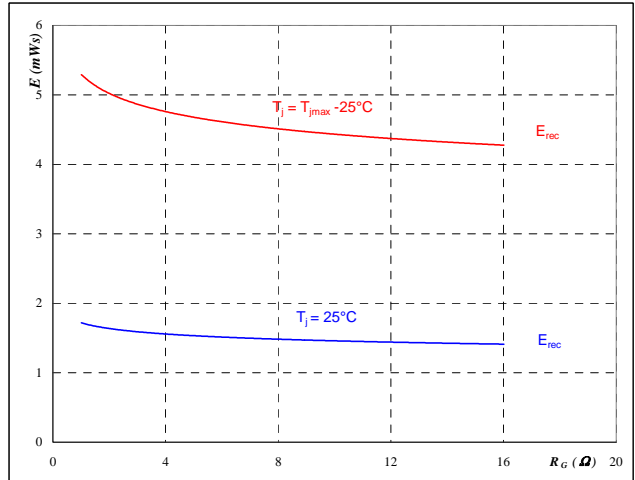
Typical reverse recovery energy loss  
as a function of collector current  
 $E_{rec} = f(I_C)$



With an inductive load at  
 $T_j = 25/150 \text{ } ^\circ\text{C}$   
 $V_{CE} = 600 \text{ V}$   
 $V_{GE} = \pm 15 \text{ V}$   
 $R_{gon} = 4 \text{ } \Omega$

Figure 8 Brake IGBT

Typical reverse recovery energy loss  
as a function of gate resistor  
 $E_{rec} = f(R_G)$



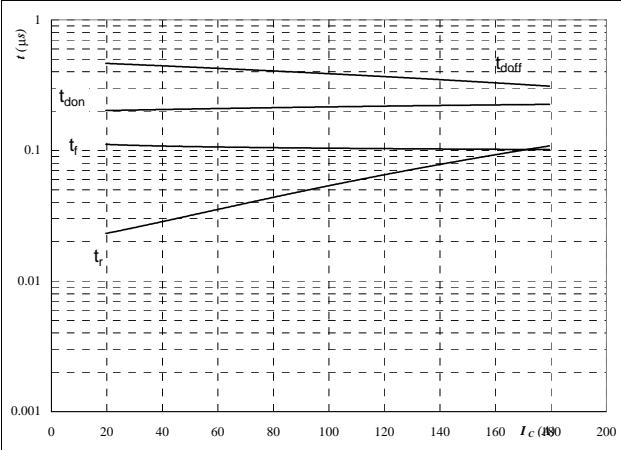
With an inductive load at  
 $T_j = 25/150 \text{ } ^\circ\text{C}$   
 $V_{CE} = 600 \text{ V}$   
 $V_{GE} = \pm 15 \text{ V}$   
 $I_C = 100 \text{ A}$

### Brake

Figure 9 Brake IGBT

Typical switching times as a function of collector current

$t = f(I_C)$



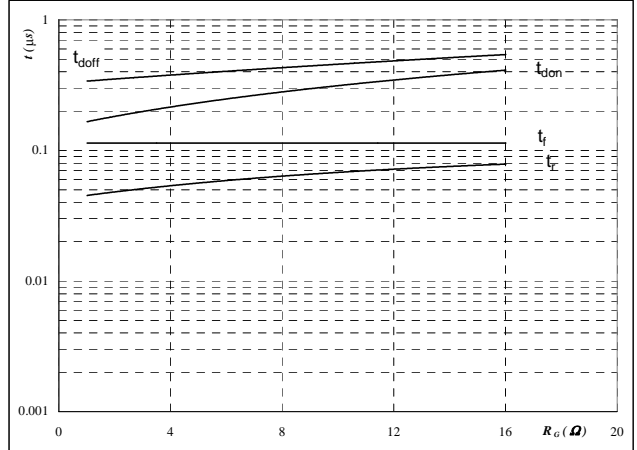
With an inductive load at

- $T_J = 25/150$  °C
- $V_{CE} = 600$  V
- $V_{GE} = \pm 15$  V
- $R_{gon} = 4$  Ω
- $R_{goff} = 4$  Ω

Figure 10 Brake IGBT

Typical switching times as a function of gate resistor

$t = f(R_G)$



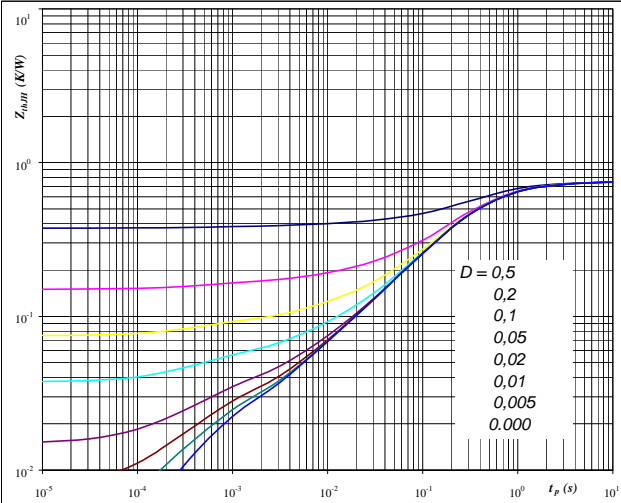
With an inductive load at

- $T_J = 25/150$  °C
- $V_{CE} = 600$  V
- $V_{GE} = \pm 15$  V
- $I_C = 100$  A

Figure 11 Brake IGBT

IGBT transient thermal impedance as a function of pulse width

$Z_{thJH} = f(t_p)$

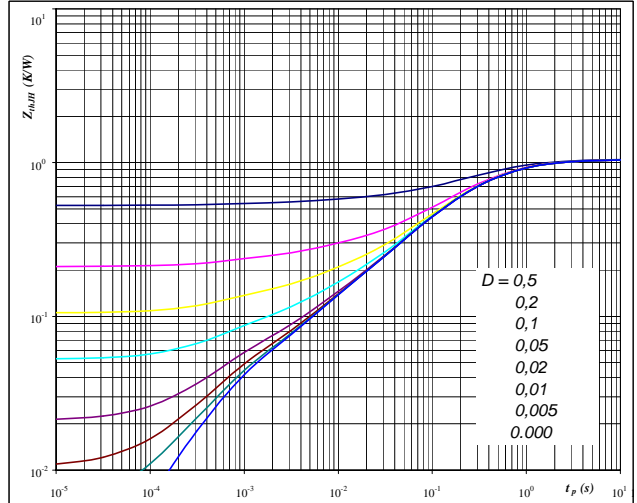


- At
- $D = t_p / T$
  - $R_{thJH} = 0.75$  K/W

Figure 12 Brake FRED

FRED transient thermal impedance as a function of pulse width

$Z_{thJH} = f(t_p)$



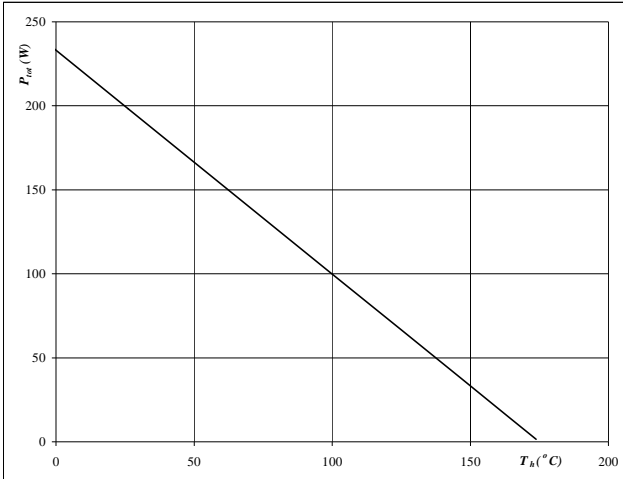
- At
- $D = t_p / T$
  - $R_{thJH} = 1.05$  K/W

# Brake

Figure 13 Brake IGBT

Power dissipation as a function of heatsink temperature

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

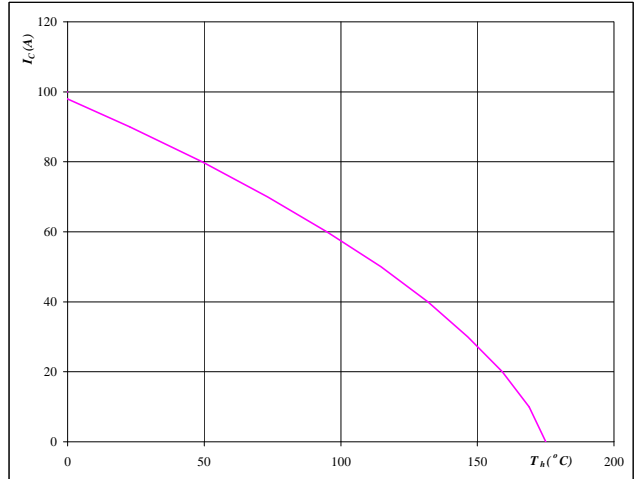


At  
 $T_j = 175 \text{ °C}$

Figure 14 Brake IGBT

Collector current as a function of heatsink temperature

$$I_C = f(T_h)$$

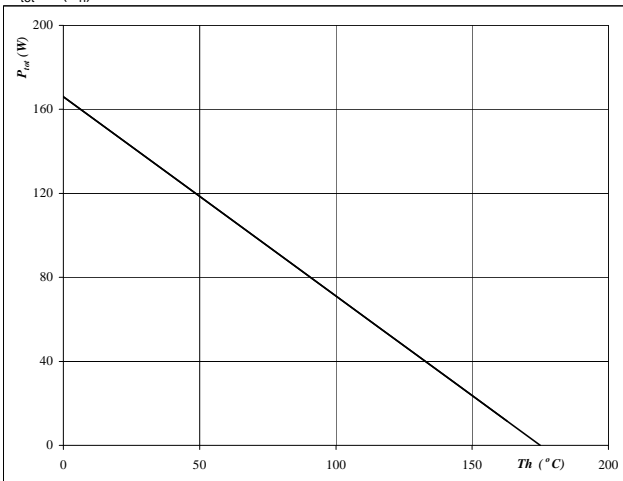


At  
 $T_j = 175 \text{ °C}$   
 $V_{GE} = 15 \text{ V}$

Figure 15 Brake FRED

Power dissipation as a function of heatsink temperature

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

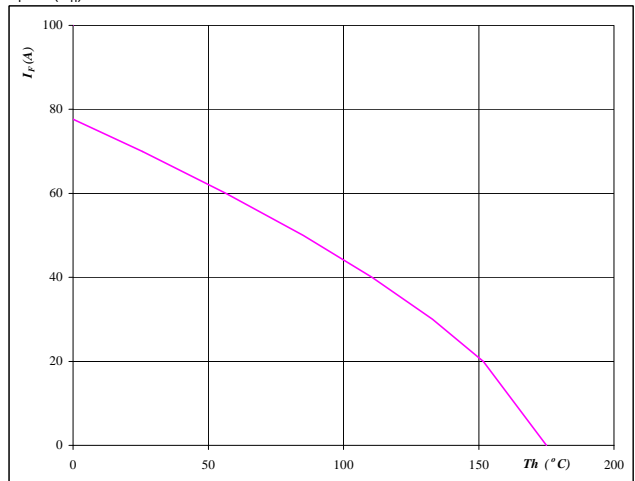


At  
 $T_j = 175 \text{ °C}$

Figure 16 Brake FRED

Forward current as a function of heatsink temperature

$$I_F = f(T_h)$$



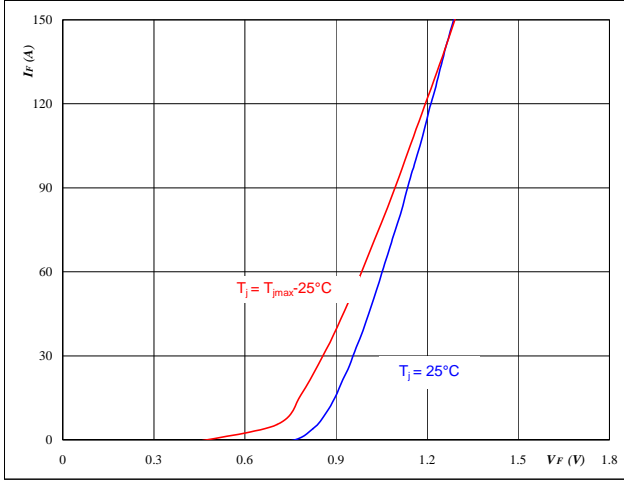
At  
 $T_j = 175 \text{ °C}$

# Input Rectifier Bridge

Figure 1 Rectifier diode

Typical diode forward current as a function of forward voltage

$I_F = f(V_F)$

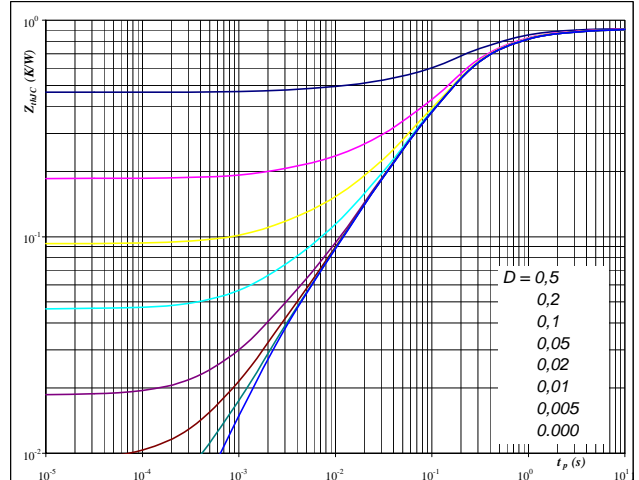


At  
 $t_p = 250 \mu s$

Figure 2 Rectifier diode

Diode transient thermal impedance as a function of pulse width

$Z_{thJH} = f(t_p)$

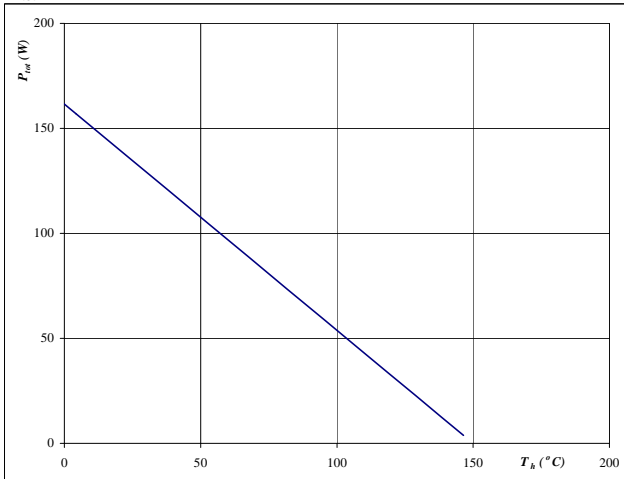


At  
 $D = t_p / T$   
 $R_{thJH} = 0.928 \text{ K/W}$

Figure 3 Rectifier diode

Power dissipation as a function of heatsink temperature

$P_{tot} = f(T_h)$

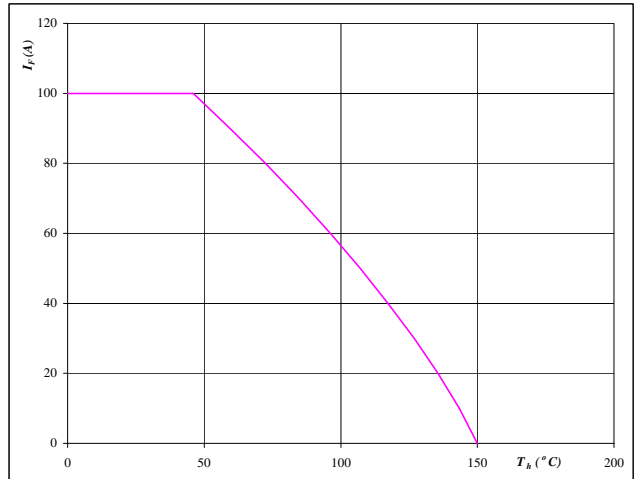


At  
 $T_j = 150 \text{ °C}$

Figure 4 Rectifier diode

Forward current as a function of heatsink temperature

$I_F = f(T_h)$



At  
 $T_j = 150 \text{ °C}$

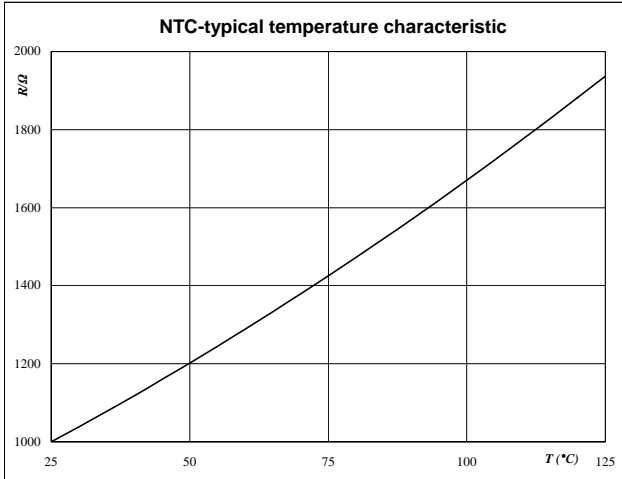


## Thermistor

Figure 1 Thermistor

Typical NTC characteristic  
as a function of temperature

$$R_T = f(T)$$

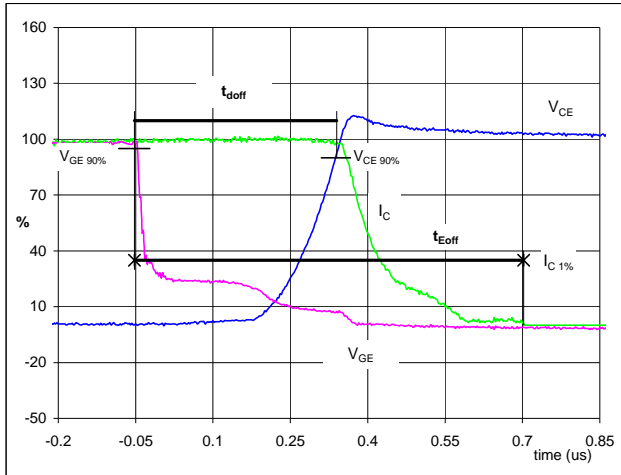


## Switching Definitions Output Inverter

General conditions	
$T_j$	= 150 °C
$R_{gon}$	= 4 Ω
$R_{goff}$	= 4 Ω

Figure 1 Output inverter IGBT

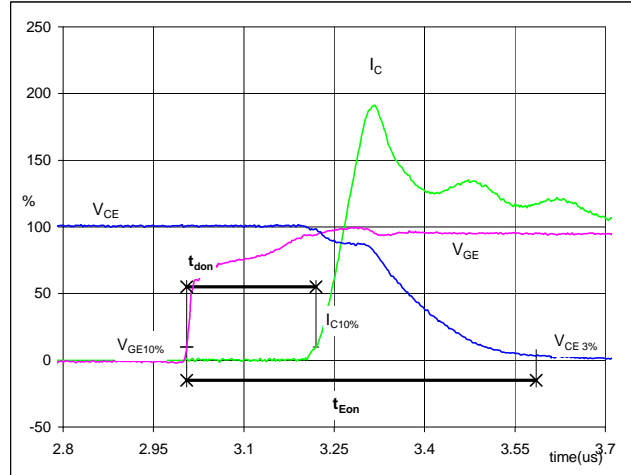
Turn-off Switching Waveforms & definition of  $t_{doff}$ ,  $t_{Eoff}$   
( $t_{Eoff}$  = integrating time for  $E_{off}$ )



$V_{GE}(0\%) =$	-15	V
$V_{GE}(100\%) =$	15	V
$V_C(100\%) =$	600	V
$I_C(100\%) =$	100	A
$t_{doff} =$	0.38	μs
$t_{Eoff} =$	0.75	μs

Figure 2 Output inverter IGBT

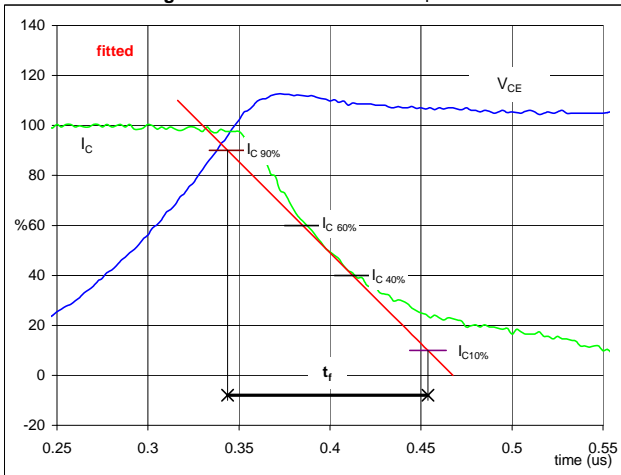
Turn-on Switching Waveforms & definition of  $t_{don}$ ,  $t_{Eon}$   
( $t_{Eon}$  = integrating time for  $E_{on}$ )



$V_{GE}(0\%) =$	-15	V
$V_{GE}(100\%) =$	15	V
$V_C(100\%) =$	600	V
$I_C(100\%) =$	100	A
$t_{don} =$	0.22	μs
$t_{Eon} =$	0.58	μs

Figure 3 Output inverter IGBT

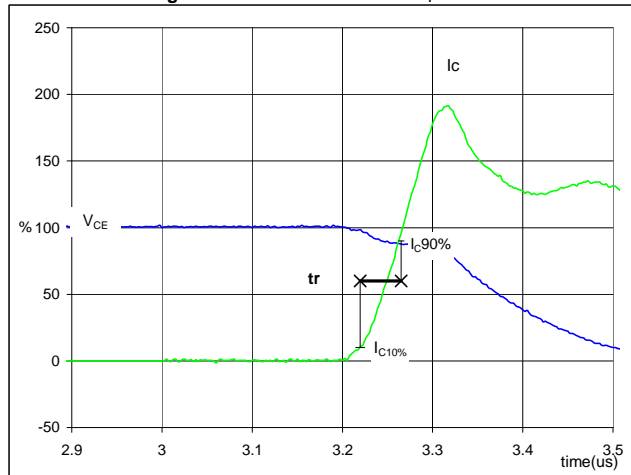
Turn-off Switching Waveforms & definition of  $t_f$



$V_C(100\%) =$	600	V
$I_C(100\%) =$	100	A
$t_f =$	0.11	μs

Figure 4 Output inverter IGBT

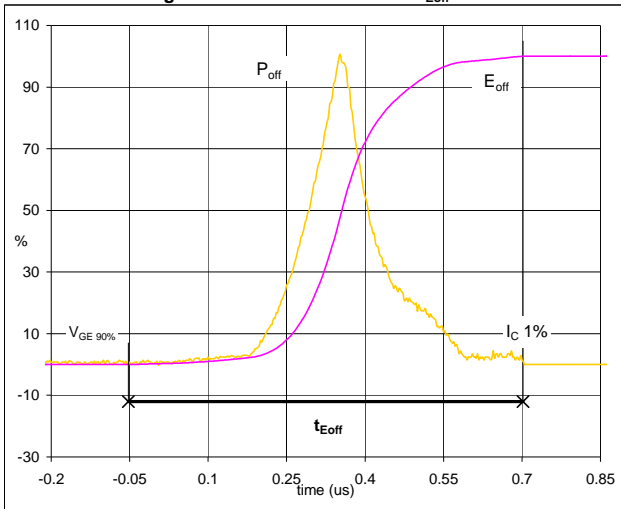
Turn-on Switching Waveforms & definition of  $t_r$



$V_C(100\%) =$	600	V
$I_C(100\%) =$	100	A
$t_r =$	0.04	μs

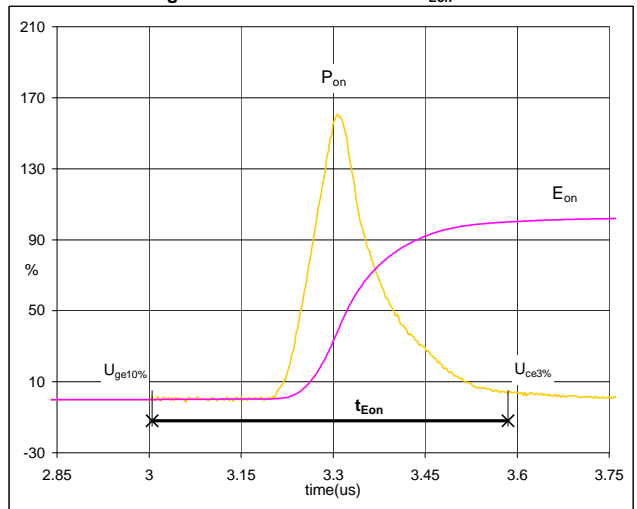
## Switching Definitions Output Inverter

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



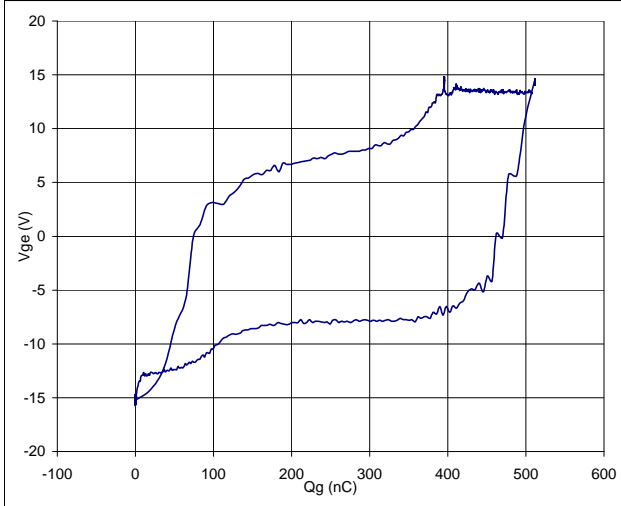
$P_{off}(100\%) = 60.10$  kW  
 $E_{off}(100\%) = 9.25$  mJ  
 $t_{Eoff} = 0.75$   $\mu$ s

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



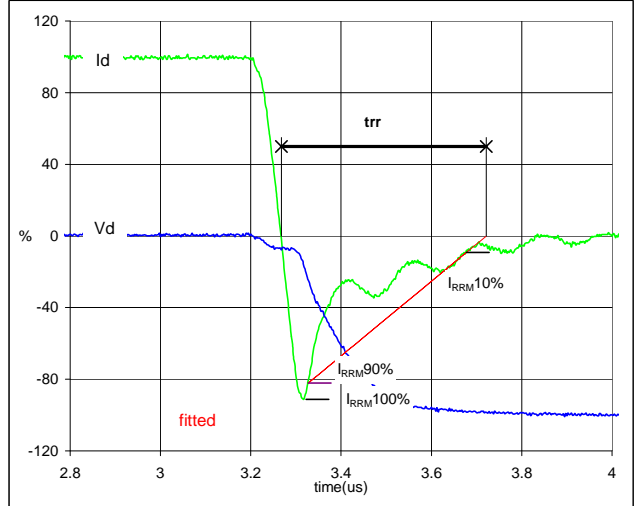
$P_{on}(100\%) = 60.10$  kW  
 $E_{on}(100\%) = 12.12$  mJ  
 $t_{Eon} = 0.58$   $\mu$ s

**Figure 7** Output inverter FRED  
**Gate voltage vs Gate charge (measured)**



$V_{GEoff} = -15$  V  
 $V_{GEon} = 15$  V  
 $V_C(100\%) = 600$  V  
 $I_C(100\%) = 100$  A  
 $Q_g = 597.46$  nC

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

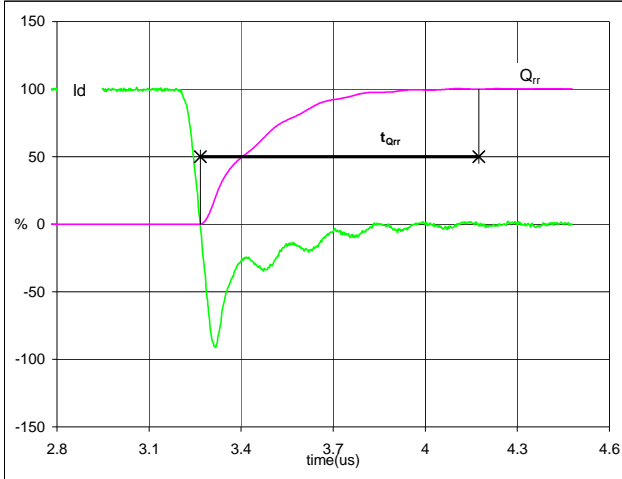


$V_d(100\%) = 600$  V  
 $I_d(100\%) = 100$  A  
 $I_{RRM}(100\%) = -91$  A  
 $t_{rr} = 0.46$   $\mu$ s

## Switching Definitions Output Inverter

Figure 9 Output inverter FRED

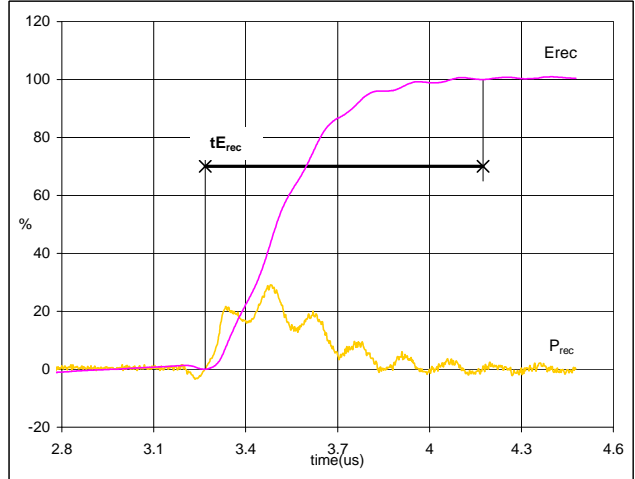
Turn-on Switching Waveforms & definition of  $t_{Qrr}$   
( $t_{Qrr}$  = integrating time for  $Q_{rr}$ )



$I_d$ (100%) =	100	A
$Q_{rr}$ (100%) =	15.08	$\mu\text{C}$
$t_{Qrr}$ =	0.91	$\mu\text{s}$

Figure 10 Output inverter FRED

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



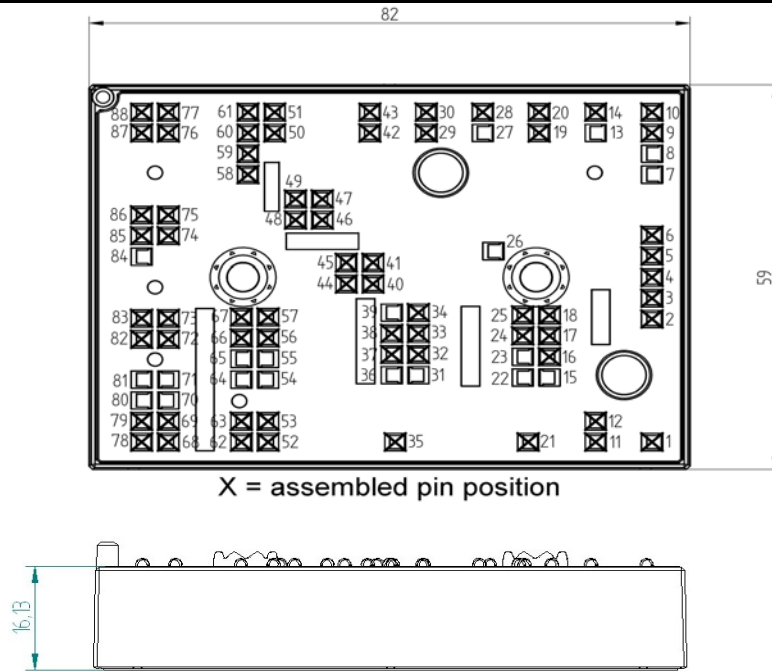
$P_{rec}$ (100%) =	60.10	kW
$E_{rec}$ (100%) =	5.42	mJ
$t_{E_{rec}}$ =	0.91	$\mu\text{s}$

Ordering Code and Marking - Outline - Pinout

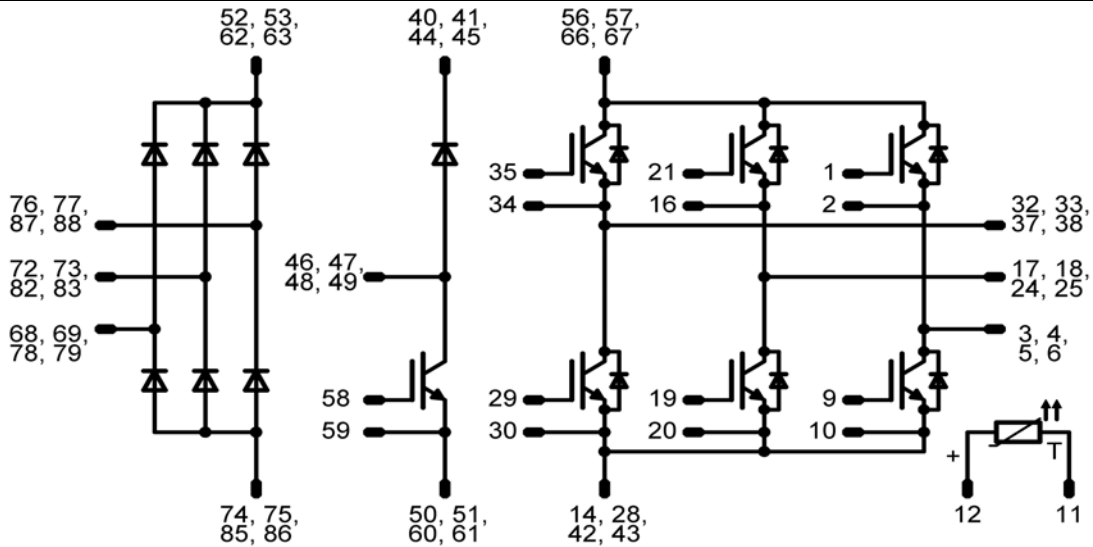
Ordering Code & Marking

Version	Ordering Code	in DataMatrix as	in packaging barcode as
with std lid (black V23990-K12-T-PM)	V23990-K420-A40-/0A/-PM	K420A40	K420A40-/0A/
with std lid (black V23990-K12-T-PM) and P12	V23990-K420-A40-/1A/-PM	K420A40	K420A40-/1A/
with thin lid (white V23990-K13-T-PM)	V23990-K420-A40-/0B/-PM	K420A40	K420A40-/0B/
with thin lid (white V23990-K13-T-PM) and P12	V23990-K420-A40-/1B/-PM	K420A40	K420A40-/1B/

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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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.