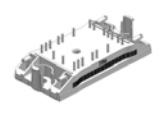
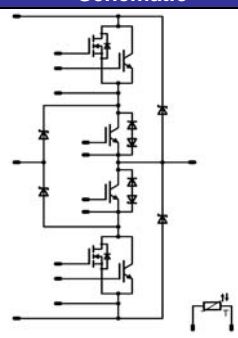


flowNPC 0	600V/75A & 70A PS*
<div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"> <p style="text-align: center; background-color: #000080; color: white; margin: 0;"><b>Features</b></p> <ul style="list-style-type: none"> <li>*PS: 70A parallel switch (60A PT and 99mΩ)</li> <li>neutral point clamped inverter</li> <li>reactive power capability</li> <li>low inductance layout</li> </ul> </div> <div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"> <p style="text-align: center; background-color: #000080; color: white; margin: 0;"><b>Target Applications</b></p> <ul style="list-style-type: none"> <li>solar inverter</li> <li>UPS</li> </ul> </div> <div style="border: 1px solid black; padding: 5px;"> <p style="text-align: center; background-color: #000080; color: white; margin: 0;"><b>Types</b></p> <ul style="list-style-type: none"> <li>FZ06NPA070FP01</li> </ul> </div>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 5px;"> <p style="text-align: center; background-color: #000080; color: white; margin: 0;"><b>flow0 12mm housing</b></p>  </div> <div style="border: 1px solid black; padding: 5px;"> <p style="text-align: center; background-color: #000080; color: white; margin: 0;"><b>Schematic</b></p>  </div>

### Maximum Ratings

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

Parameter	Symbol	Condition	Value	Unit
<b>Buck IGBT</b>				
Collector-emitter break down voltage	V <sub>CE</sub>		600	V
DC collector current	I <sub>C</sub>	T <sub>j</sub> =T <sub>jmax</sub> T <sub>h</sub> =80°C T <sub>c</sub> =80°C	44 59	A
Repetitive peak collector current	I <sub>Cpulse</sub>	t <sub>p</sub> limited by T <sub>jmax</sub>	240	A
Power dissipation per IGBT	P <sub>tot</sub>	T <sub>j</sub> =T <sub>jmax</sub> T <sub>h</sub> =80°C T <sub>c</sub> =80°C	71 108	W
Gate-emitter peak voltage	V <sub>GE</sub>		±20	V
Short circuit ratings	t <sub>SC</sub> V <sub>CC</sub>	T <sub>j</sub> ≤150°C V <sub>GE</sub> =15V	5 390	μs V
Maximum Junction Temperature	T <sub>jmax</sub>		150	°C
<b>Buck Diode</b>				
Peak Repetitive Reverse Voltage	V <sub>RRM</sub>	T <sub>j</sub> =25°C	600	V
DC forward current	I <sub>F</sub>	T <sub>j</sub> =T <sub>jmax</sub> T <sub>h</sub> =80°C T <sub>c</sub> =80°C	21 28	A
Repetitive peak forward current	I <sub>FRM</sub>	t <sub>p</sub> limited by T <sub>jmax</sub> T <sub>c</sub> =100°C	120	A
Power dissipation per Diode	P <sub>tot</sub>	T <sub>j</sub> =T <sub>jmax</sub> T <sub>h</sub> =80°C T <sub>c</sub> =80°C	41 62	W
Maximum Junction Temperature	T <sub>jmax</sub>		150	°C

## Maximum Ratings

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

Parameter	Symbol	Condition	Value	Unit
<b>Buck MOSFET</b>				
Drain to source breakdown voltage	$V_{DS}$		600	V
DC drain current	$I_D$	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	16 21	A
Pulsed drain current	$I_{Dpulse}$	$t_p$ limited by $T_{jmax}$ $T_c=25^{\circ}\text{C}$	93	A
Power dissipation	$P_{tot}$	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	54 97	W
Gate-source peak voltage	$V_{gs}$		$\pm 20$	V
Maximum Junction Temperature	$T_{jmax}$		150	$^{\circ}\text{C}$

### Boost IGBT

Collector-emitter break down voltage	$V_{CE}$		600	V
DC collector current	$I_C$	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	57 75	A
Repetitive peak collector current	$I_{Cpuls}$	$t_p$ limited by $T_{jmax}$	225	A
Power dissipation per IGBT	$P_{tot}$	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	85 129	W
Gate-emitter peak voltage	$V_{GE}$		$\pm 20$	V
Short circuit ratings	$t_{SC}$ $V_{CC}$	$T_j \leq 150^{\circ}\text{C}$ $V_{GE}=15\text{V}$	6 360	$\mu\text{s}$ V
Maximum Junction Temperature	$T_{jmax}$		175	$^{\circ}\text{C}$

### Boost Inverse Diode

Peak Repetitive Reverse Voltage	$V_{RRM}$	$T_c=25^{\circ}\text{C}$	600	V
DC forward current	$I_F$	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	2	A
Power dissipation per Diode	$P_{tot}$	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	21	W
Maximum Junction Temperature	$T_{jmax}$		150	$^{\circ}\text{C}$

### Boost Diode

Peak Repetitive Reverse Voltage	$V_{RRM}$	$T_j=25^{\circ}\text{C}$	1200	V
DC forward current	$I_F$	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	20 28	A
Repetitive peak forward current	$I_{FRM}$	$t_p$ limited by $T_{jmax}$	70	A
Power dissipation per Diode	$P_{tot}$	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	34 52	W
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
-----------	--------	-----------	-------	------

### Thermal Properties

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

### Insulation Properties

Insulation voltage	$V_{\text{is}}$	$t=2\text{s}$	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 $I_b$ [A]	$T_j$	Min	Typ	Max						
<b>Buck IGBT *</b>														
Gate emitter threshold voltage	$V_{GE(th)}$	$V_{CE}=V_{GE}$			0.00025	$T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	4.5	5.2	7	V				
Collector-emitter saturation voltage	$V_{CE(sat)}$		15		70	$T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	1.45	2.32 2.09	2.5	V				
Collector-emitter cut-off current incl. Diode	$I_{CES}$		0	600		$T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$			250	$\mu\text{A}$				
Gate-emitter leakage current	$I_{GES}$		$\pm 20$	0		$T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$			300	nA				
Integrated Gate resistor	$R_{gint}$							none		$\Omega$				
Input capacitance **	$C_{ies}$	f=1MHz	0	25		$T_j=25^\circ\text{C}$		4+4,7		nF				
Output capacitance	$C_{oss}$										200	400		pF
Reverse transfer capacitance	$C_{rss}$													
Gate charge **	$Q_{Gate}$		$\pm 15$			$T_j=25^\circ\text{C}$		225+70		nC				
Thermal resistance chip to heatsink per chip	$R_{th,JH}$	Thermal grease thickness $\leq 50\mu\text{m}$ $\lambda = 1 \text{ W/mK}$						0.99		K/W				
* see dynamic characteristic at <b>Buck MosFET</b> **additional value stands for built-in capacitor														
<b>Buck Diode</b>														
Diode forward voltage	$V_F$				30	$T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$		3.18 2.37	3.3	V				
Peak reverse recovery current	$I_{RRM}$	Rgon=8 $\Omega$		350	40	$T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$		81		A				
Reverse recovery time	$t_{rr}$							13						
Reverse recovered charge	$Q_{rr}$							22						
Peak rate of fall of recovery current	$di(rec)/max/dt$							0.48						
Reverse recovered energy	$E_{rec}$							1.09						
								24887						
Thermal resistance chip to heatsink per chip	$R_{th,JH}$	Thermal grease thickness $\leq 50\mu\text{m}$ $\lambda = 1 \text{ W/mK}$						0.097		mWs				
								0.164		K/W				
<b>Buck MOSFET</b>														
Static drain to source ON resistance	$R_{ds(on)}$		10		18	$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		109 219		m $\Omega$				
Gate threshold voltage	$V_{(GS)th}$				$V_{DS}=V_{GS}$	$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$	2.1	3	3.9	V				
Gate to Source Leakage Current	$I_{gss}$		20	0		$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$			200	nA				
Zero Gate Voltage Drain Current	$I_{dss}$		0	600		$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$			15	nA				
Turn On Delay Time	$t_{d(ON)}$	Rgon=8 $\Omega$ ** Rgoff=8 $\Omega$ **	$\pm 15$	350	40	$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		131		ns				
Rise Time	$t_r$							129						
Turn off delay time	$t_{d(OFF)}$							8						
								9						
Fall time	$t_f$							228						
								230						
Turn-on energy loss per pulse	$E_{on}$							8						
		3												
Turn-off energy loss per pulse	$E_{off}$	0.102												
		0.325												
Total gate charge	$Q_g$	0.094												
		0.202												
Gate to source charge	$Q_{gs}$		$\pm 15$	350	40	$T_j=25^\circ\text{C}$		60	80	nC				
Gate to drain charge	$Q_{gd}$							14						
Input capacitance	$C_{iss}$	f=1MHz	0	100		$T_j=25^\circ\text{C}$		2800		pF				
Output capacitance	$C_{oss}$							130						
Thermal resistance chip to heatsink per chip	$R_{th,JH}$	Thermal grease thickness $\leq 50\mu\text{m}$ $\lambda = 1 \text{ W/mK}$						1.29		K/W				

\*\* see schematic of the Gate-complex at characteristic figures

**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			
<b>Boost IGBT</b>											
Gate emitter threshold voltage	$V_{GE(th)}$	$V_{CE}=V_{GE}$			0.0012	$T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	5	5.8	6.5	V	
Collector-emitter saturation voltage	$V_{CE(sat)}$		15		70	$T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$	1	1.49 1.60	2.1	V	
Collector-emitter cut-off incl diode	$I_{CES}$		0	600		$T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$			0.03	mA	
Gate-emitter leakage current	$I_{GES}$		20	0		$T_j=25^\circ\text{C}$ $T_j=150^\circ\text{C}$			650	nA	
Integrated Gate resistor	$R_{gint}$							none		$\Omega$	
Turn-on delay time	$t_{d(on)}$	$R_{gon}=8\ \Omega$ $R_{goff}=8\ \Omega$	$\pm 15$	350	40	$T_j=25^\circ\text{C}$		37		ns	
Rise time	$t_r$					$T_j=150^\circ\text{C}$		35			
Turn-off delay time	$t_{d(off)}$					$T_j=25^\circ\text{C}$		13			
Fall time	$t_f$					$T_j=150^\circ\text{C}$		16			
Turn-on energy loss per pulse	$E_{on}$					$T_j=25^\circ\text{C}$		459			
Turn-off energy loss per pulse	$E_{off}$	$T_j=150^\circ\text{C}$		500							
Input capacitance	$C_{iss}$					$T_j=25^\circ\text{C}$		0.807		mWs	
Output capacitance	$C_{oss}$	$f=1\text{MHz}$	0	25		$T_j=150^\circ\text{C}$		1.110			
Reverse transfer capacitance	$C_{rss}$					$T_j=25^\circ\text{C}$		1.354		pF	
Gate charge	$Q_{Gate}$		15	480	75	$T_j=150^\circ\text{C}$		1.708			
Thermal resistance chip to heatsink per chip	$R_{th,JH}$	Thermal grease thickness $\leq 50\mu\text{m}$ $\lambda = 1\ \text{W/mK}$							4620		
<b>Boost Inverse Diode</b>											
Diode forward voltage	$V_F$				20	$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		9.07 9.43		V	
Thermal resistance chip to heatsink per chip	$R_{th,JH}$	Thermal grease thickness $\leq 50\mu\text{m}$ $\lambda = 1\ \text{W/mK}$							4.36	KW	
<b>Boost Diode</b>											
Diode forward voltage	$V_F$				30	$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$	1.5	2.44 2.01	3.5	V	
Reverse leakage current	$I_r$			1200		$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$			100	$\mu\text{A}$	
Peak reverse recovery current	$I_{RRM}$	$R_{gon}=8\ \Omega$	$\pm 15$	350	40	$T_j=25^\circ\text{C}$		80		A	
Reverse recovery time	$t_{rr}$					$T_j=125^\circ\text{C}$		100			
Reverse recovered charge	$Q_{rr}$					$T_j=25^\circ\text{C}$		33			
Peak rate of fall of recovery current	$di(\text{rec})_{\text{max}}/dt$					$T_j=125^\circ\text{C}$		109			
Reverse recovery energy	$E_{rec}$					$T_j=25^\circ\text{C}$		2.74			
Thermal resistance chip to heatsink per chip	$R_{th,JH}$	Thermal grease thickness $\leq 50\mu\text{m}$ $\lambda = 1\ \text{W/mK}$				$T_j=125^\circ\text{C}$		6.02		$\mu\text{C}$	
						$T_j=25^\circ\text{C}$		11226		$\text{A}/\mu\text{s}$	
						$T_j=125^\circ\text{C}$		8793		$\text{mWs}$	
						$T_j=25^\circ\text{C}$		0.607			
						$T_j=125^\circ\text{C}$		1.520			
								2.04		KW	
<b>Thermistor</b>											
Rated resistance*	$R_{25}$	Tol. $\pm 13\%$				$T_j=25^\circ\text{C}$		19.1	22	24.9	$\text{k}\Omega$
	$R_{100}$	Tol. $\pm 5\%$				$T_j=100^\circ\text{C}$		1411	1486	1560	$\Omega$
Power dissipation	P					$T_j=25^\circ\text{C}$			210		mW
B-value	$B_{(25/100)}$	Tol. $\pm 3\%$				$T_j=25^\circ\text{C}$			4000		K

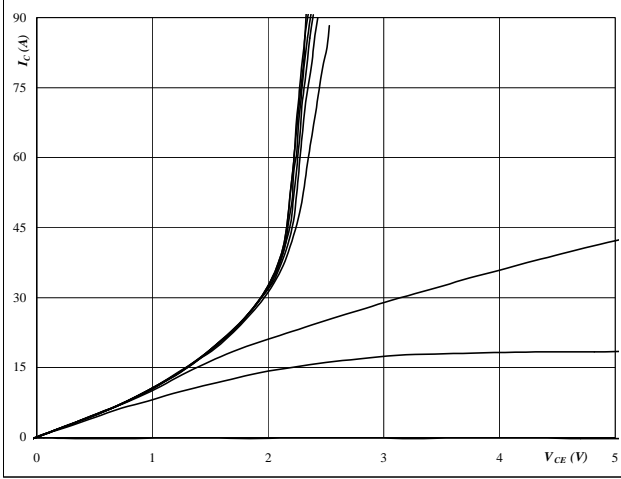
\* see details on Thermistor charts on Figure 2.

## Buck

**Figure 1** MOSFET

**Typical output characteristics**

$I_C = f(V_{CE})$

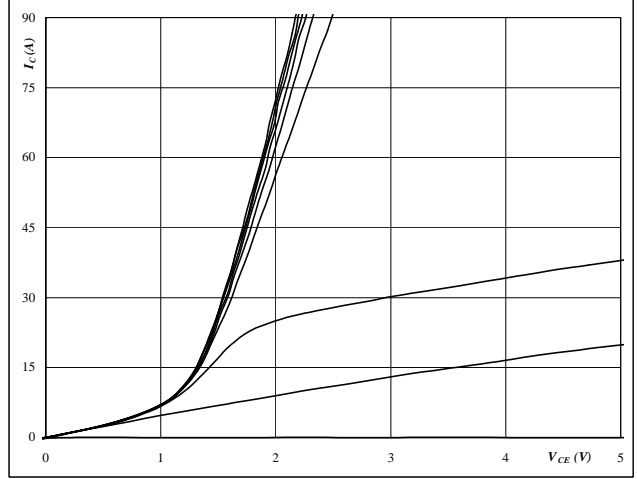


**At**  
 $t_p = 250 \mu s$   
 $T_j = 25 \text{ }^\circ C$   
 $V_{GE}$  from 3 V to 19 V in steps of 2 V

**Figure 2** MOSFET

**Typical output characteristics**

$I_C = f(V_{CE})$

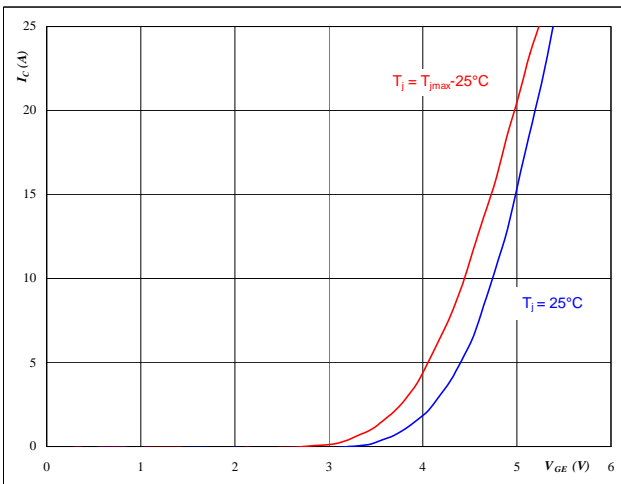


**At**  
 $t_p = 250 \mu s$   
 $T_j = 125 \text{ }^\circ C$   
 $V_{GE}$  from 3 V to 19 V in steps of 2 V

**Figure 3** MOSFET

**Typical transfer characteristics**

$I_C = f(V_{GE})$

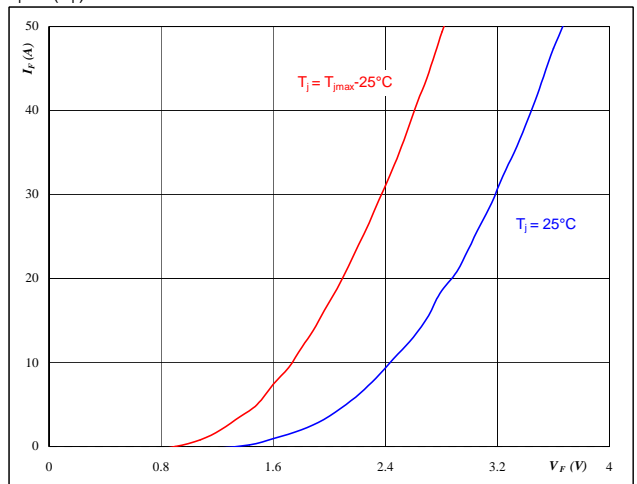


**At**  
 $t_p = 250 \mu s$   
 $V_{CE} = 10 V$

**Figure 4** FRED

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

$I_F = f(V_F)$

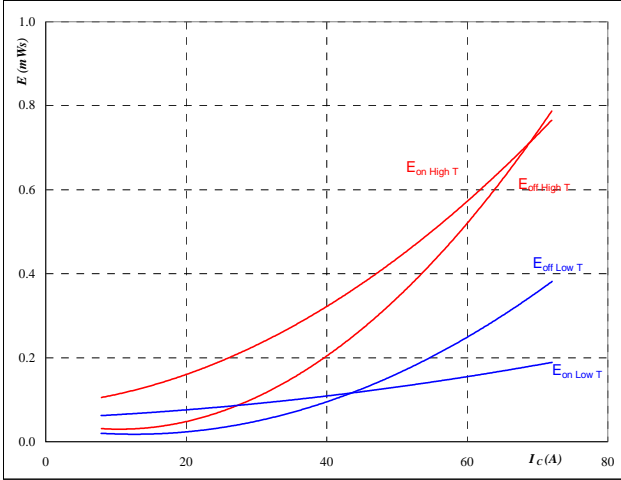


**At**  
 $t_p = 250 \mu s$

## Buck

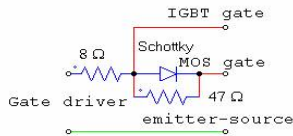
**Figure 5** MOSFET

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



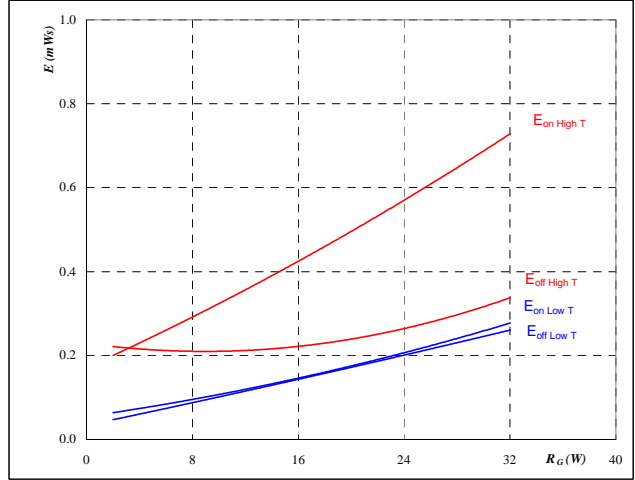
With an inductive load at

$T_J = 25/125$  °C  
 $V_{CE} = 350$  V  
 $V_{GE} = \pm 15$  V  
 $R_{gon} = 8$  Ω  
 $R_{goff} = 8$  Ω



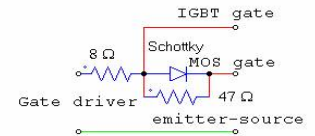
**Figure 6** MOSFET

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



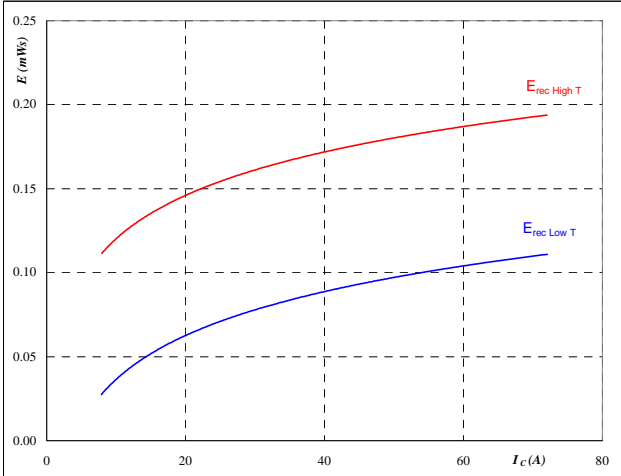
With an inductive load at

$T_J = 25/125$  °C  
 $V_{CE} = 350$  V  
 $V_{GE} = \pm 15$  V  
 $I_C = 40$  A



**Figure 7** FRED

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

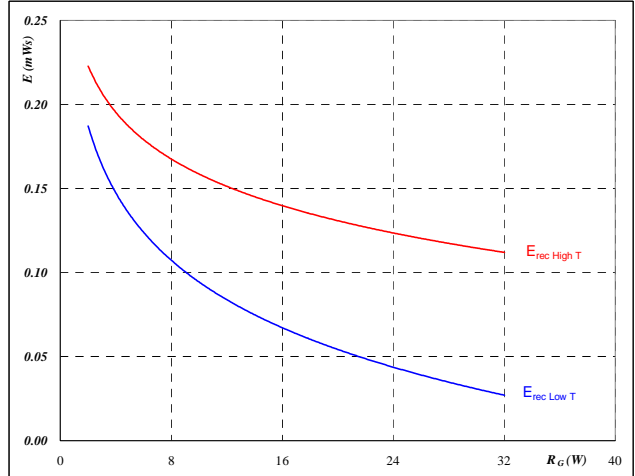


With an inductive load at

$T_J = 25/125$  °C  
 $V_{CE} = 350$  V  
 $V_{GE} = \pm 15$  V  
 $R_{gon} = 8$  Ω

**Figure 8** FRED

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



With an inductive load at

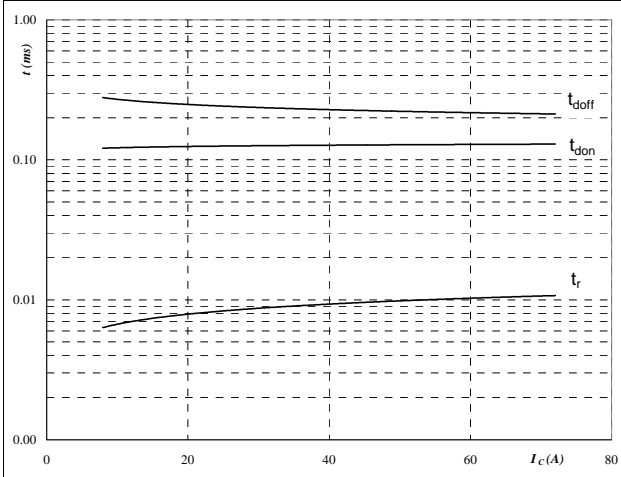
$T_J = 25/125$  °C  
 $V_{CE} = 350$  V  
 $V_{GE} = \pm 15$  V  
 $I_C = 40$  A

## Buck

**Figure 9** MOSFET

Typical switching times as a function of collector current

$$t = f(I_C)$$



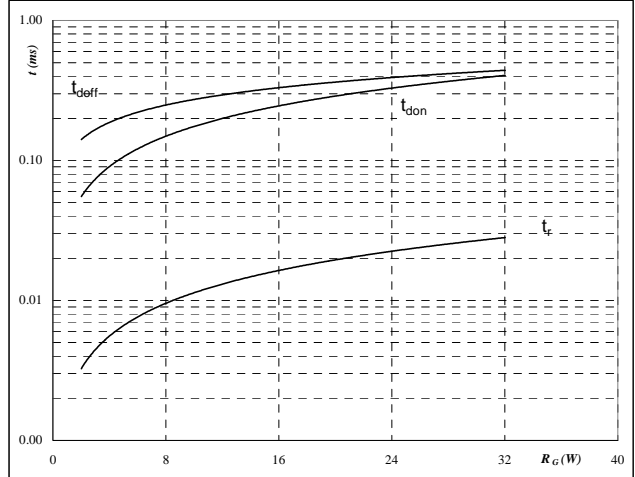
With an inductive load at

$T_j =$	125	°C
$V_{CE} =$	350	V
$V_{GE} =$	±15	V
$R_{gon} =$	8	Ω
$R_{goff} =$	8	Ω

**Figure 10** MOSFET

Typical switching times as a function of gate resistor

$$t = f(R_G)$$



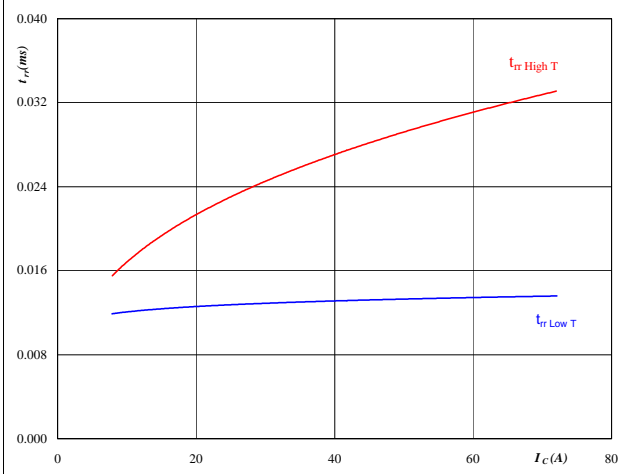
With an inductive load at

$T_j =$	125	°C
$V_{CE} =$	350	V
$V_{GE} =$	±15	V
$I_C =$	40	A

**Figure 11** FRED

Typical reverse recovery time as a function of collector current

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



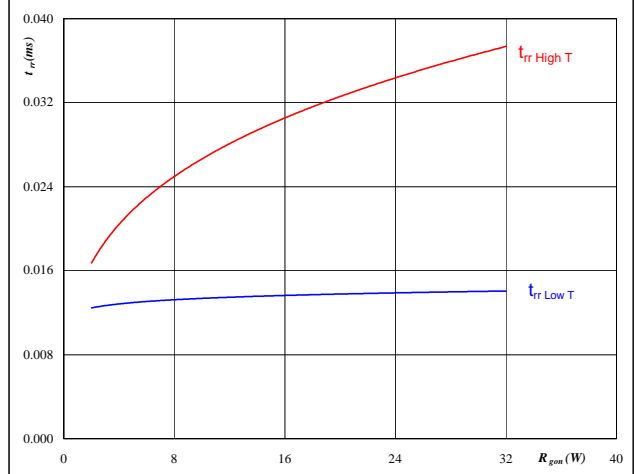
At

$T_j =$	25/125	°C
$V_{CE} =$	350	V
$V_{GE} =$	±15	V
$R_{gon} =$	8	Ω

**Figure 12** FRED

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

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



At

$T_j =$	25/125	°C
$V_R =$	350	V
$I_F =$	40	A
$V_{GE} =$	±15	V

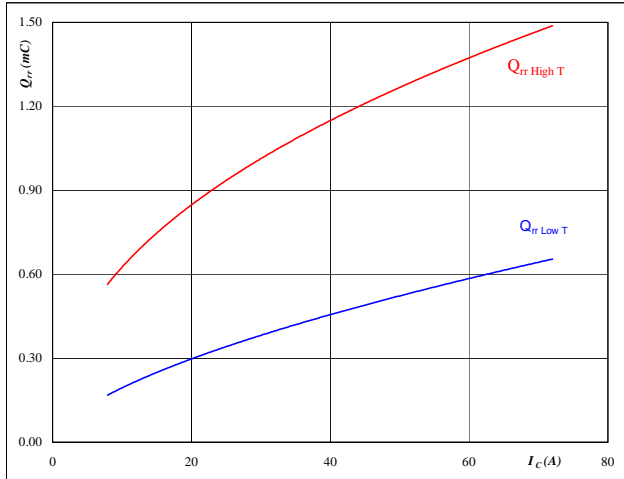


## Buck

**Figure 13** FRED

Typical reverse recovery charge as a function of collector current

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

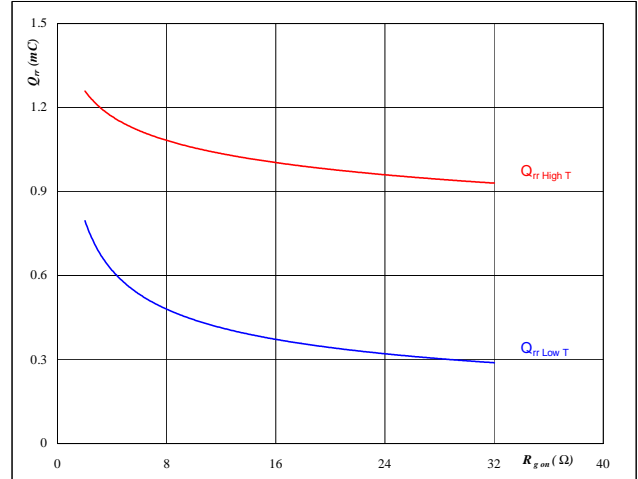


**At**  
 $T_j = 25/125$  °C  
 $V_{CE} = 350$  V  
 $V_{GE} = \pm 15$  V  
 $R_{gon} = 8$   $\Omega$

**Figure 14** FRED

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

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

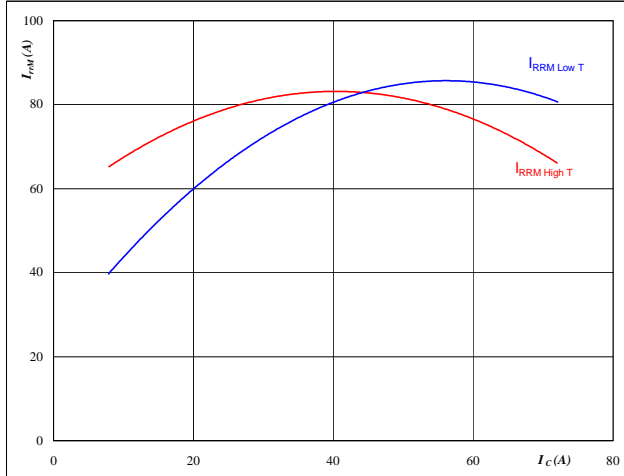


**At**  
 $T_j = 25/125$  °C  
 $V_R = 350$  V  
 $I_F = 40$  A  
 $V_{GE} = \pm 15$  V

**Figure 15** FRED

Typical reverse recovery current as a function of collector current

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

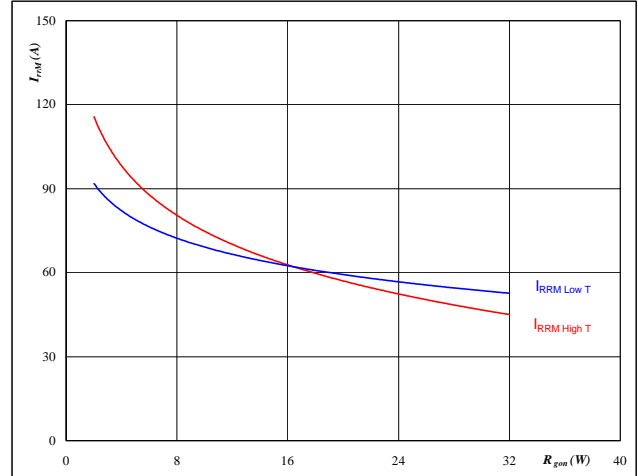


**At**  
 $T_j = 25/125$  °C  
 $V_{CE} = 350$  V  
 $V_{GE} = \pm 15$  V  
 $R_{gon} = 8$   $\Omega$

**Figure 16** FRED

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

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

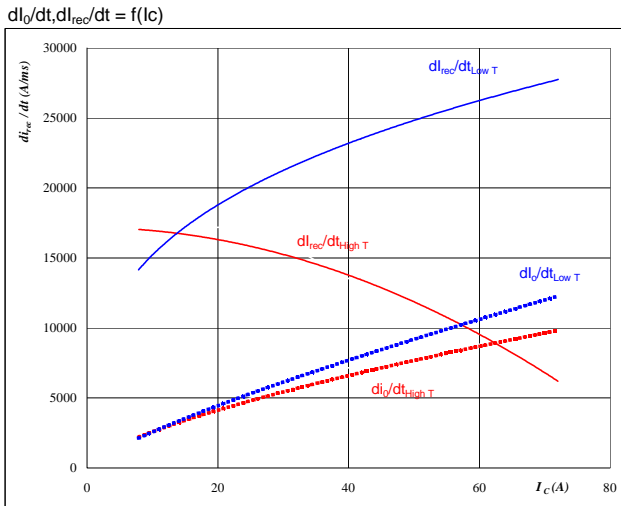


**At**  
 $T_j = 25/125$  °C  
 $V_R = 350$  V  
 $I_F = 40$  A  
 $V_{GE} = \pm 15$  V

## Buck

**Figure 17** FRED

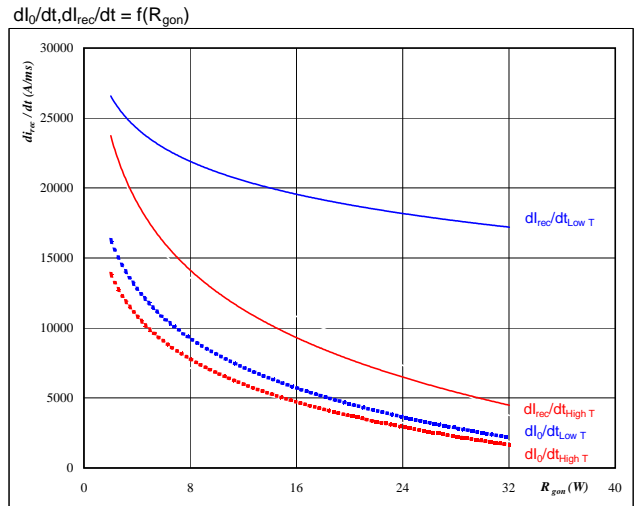
Typical rate of fall of forward and reverse recovery current as a function of collector current



**At**  
 $T_j = 25/125$  °C  
 $V_{CE} = 350$  V  
 $V_{GE} = \pm 15$  V  
 $R_{gon} = 8$  Ω

**Figure 18** FRED

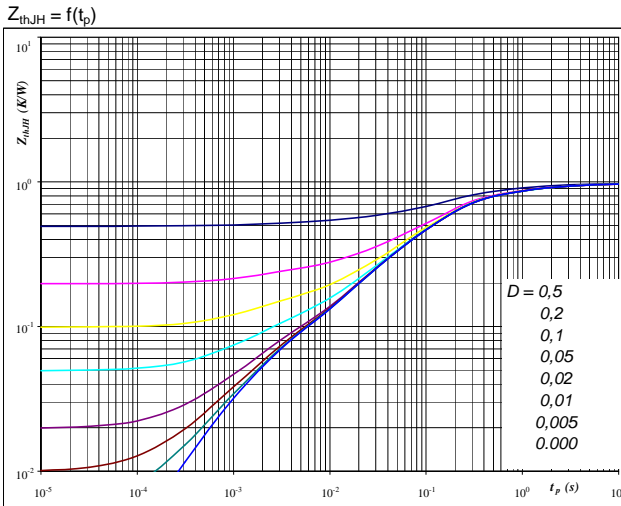
Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor



**At**  
 $T_j = 25/125$  °C  
 $V_R = 350$  V  
 $I_F = 40$  A  
 $V_{GE} = \pm 15$  V

**Figure 19** IGBT

IGBT transient thermal impedance as a function of pulse width



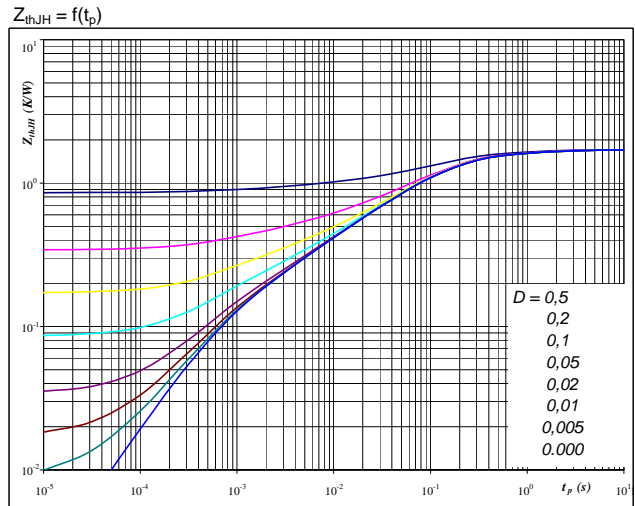
**At**  
 $D = t_p / T$   
 $R_{thJH} = 0.99$  K/W

IGBT thermal model values

R (C/W)	Tau (s)
0.06	9.7E+00
0.18	9.9E-01
0.56	1.6E-01
0.14	2.4E-02
0.05	1.6E-03

**Figure 20** FRED

FRED transient thermal impedance as a function of pulse width



**At**  
 $D = t_p / T$   
 $R_{thJH} = 1.72$  K/W

FRED thermal model values

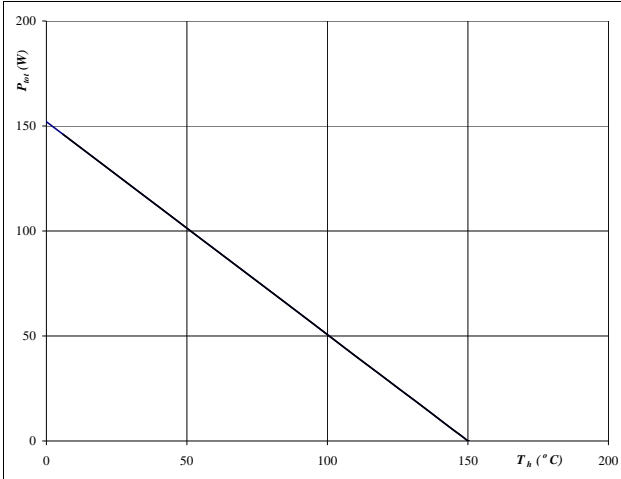
R (C/W)	Tau (s)
0.04	7.9E+00
0.21	8.8E-01
0.82	1.3E-01
0.39	3.0E-02
0.17	4.1E-03
0.09	6.3E-04

## Buck

**Figure 21** IGBT

**Power dissipation as a function of heatsink temperature**

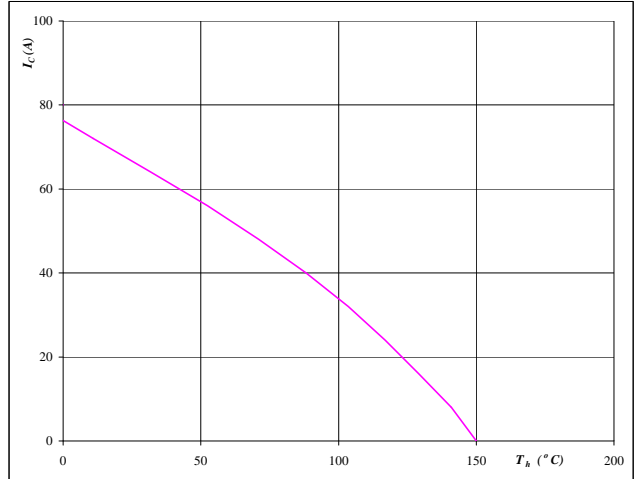
$$P_{tot} = f(T_h)$$


**At**  
 $T_j = 150$  °C

**Figure 22** IGBT

**Collector current as a function of heatsink temperature**

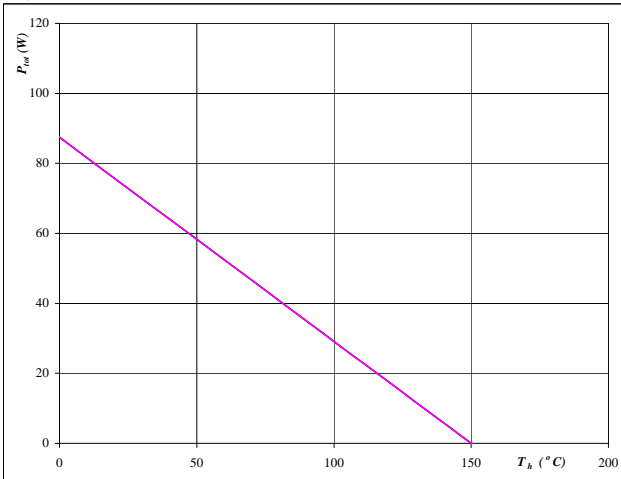
$$I_C = f(T_h)$$


**At**  
 $T_j = 150$  °C  
 $V_{GE} = 15$  V

**Figure 23** FRED

**Power dissipation as a function of heatsink temperature**

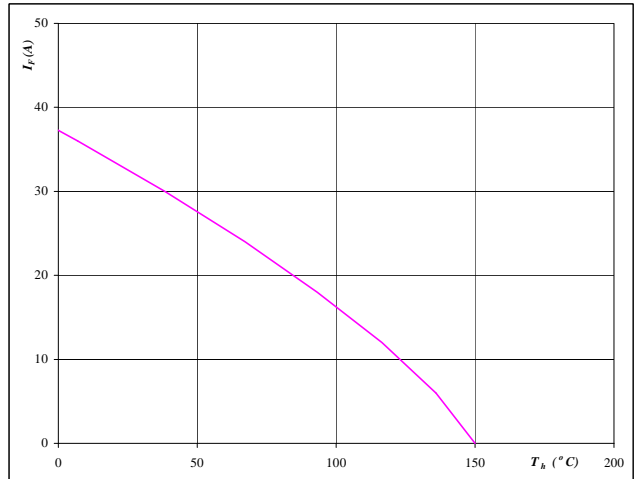
$$P_{tot} = f(T_h)$$


**At**  
 $T_j = 150$  °C

**Figure 24** FRED

**Forward current as a function of heatsink temperature**

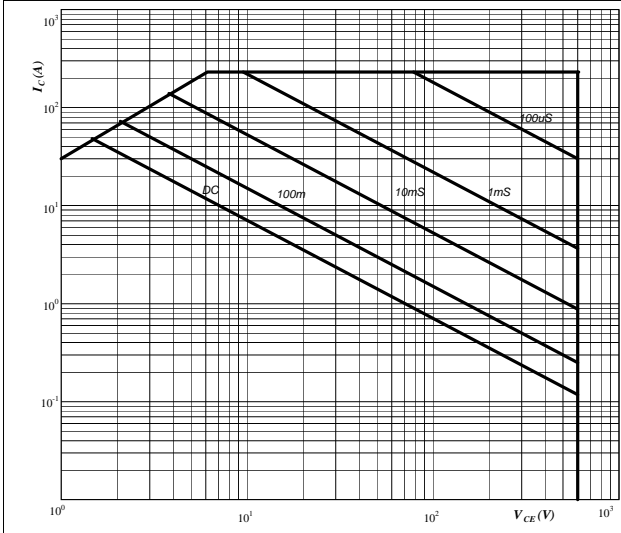
$$I_F = f(T_h)$$


**At**  
 $T_j = 150$  °C

## Buck

**Figure 25** IGBT

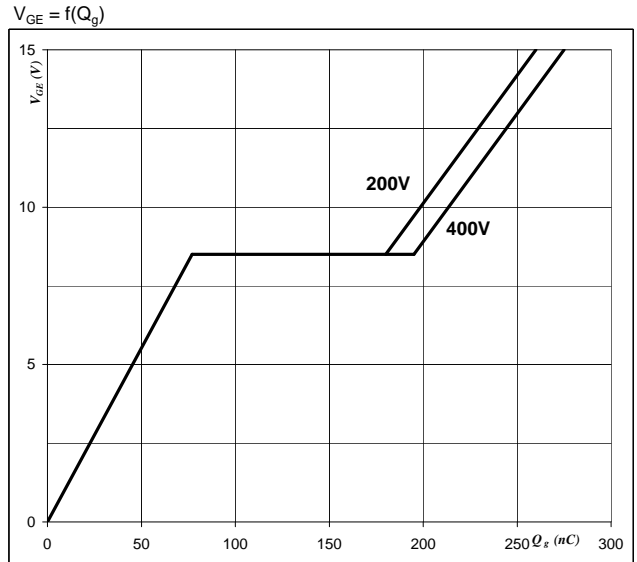
**Safe operating area as a function of collector-emitter voltage**  
 $I_C = f(V_{CE})$



**At**  
D = single pulse  
Th = 80 °C  
V<sub>GE</sub> = ±15 V  
T<sub>j</sub> = T<sub>jmax</sub> °C

**Figure 26** IGBT

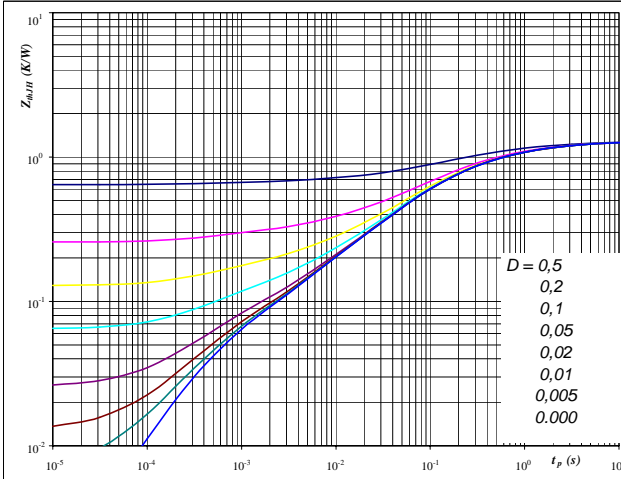
**Gate voltage vs Gate charge**



**At**  
I<sub>G(REF)</sub> = 1mA, R<sub>L</sub> = 15Ω

**Figure 27** MOSFET

**MOSFET transient thermal impedance as a function of pulse width**  
 $Z_{thJH} = f(t_p)$



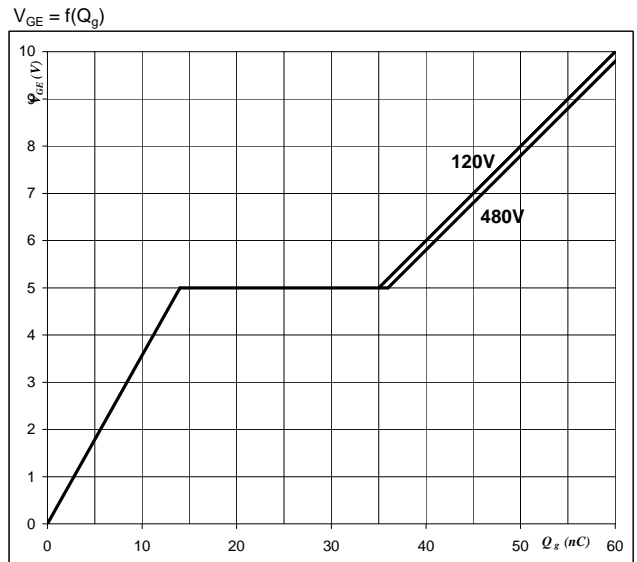
**At**  
D = t<sub>p</sub> / T  
R<sub>thJH</sub> = 1.29 K/W

MOSFET thermal model values

R (C/W)	Tau (s)
0.09	9.2E+00
0.27	1.3E+00
0.53	2.1E-01
0.27	4.0E-02
0.08	4.8E-03
0.05	4.7E-04

**Figure 28** MOSFET

**Gate voltage vs Gate charge**



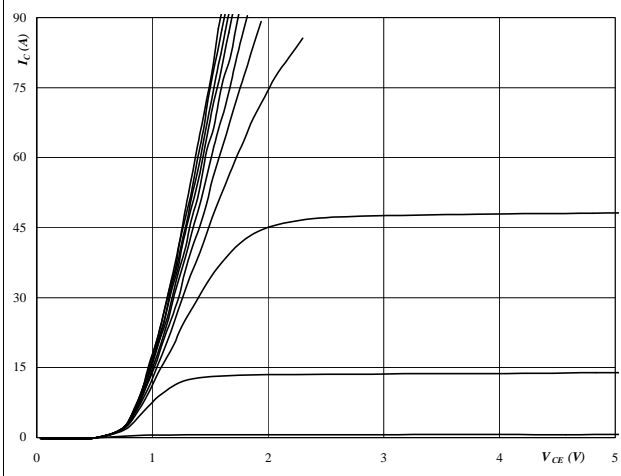
**At**  
I<sub>C</sub> = 18 A

## Boost

**Figure 1** IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$

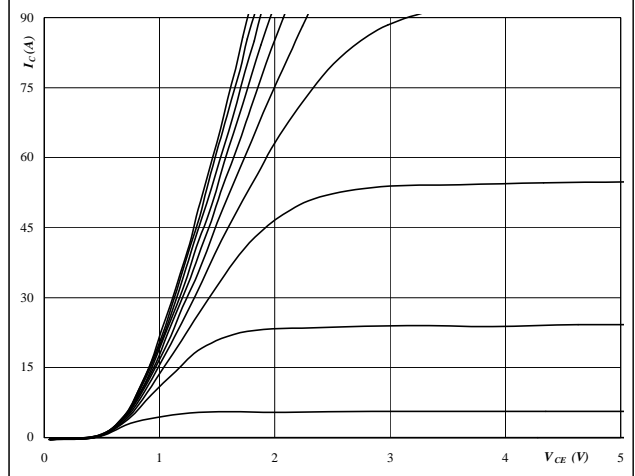


At  
 $t_p = 250 \mu s$   
 $T_j = 25 \text{ } ^\circ C$   
 $V_{GE}$  from 7 V to 17 V in steps of 1 V

**Figure 2** IGBT

**Typical output characteristics**

$I_C = f(V_{CE})$

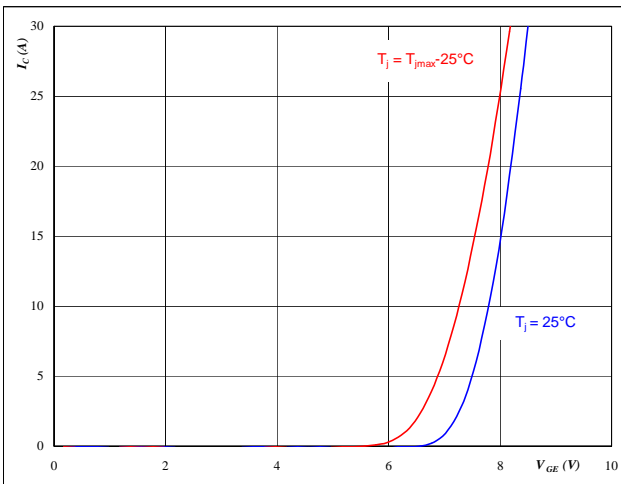


At  
 $t_p = 250 \mu s$   
 $T_j = 125 \text{ } ^\circ C$   
 $V_{GE}$  from 6 V to 16 V in steps of 1 V

**Figure 3** IGBT

**Typical transfer characteristics**

$I_C = f(V_{GE})$

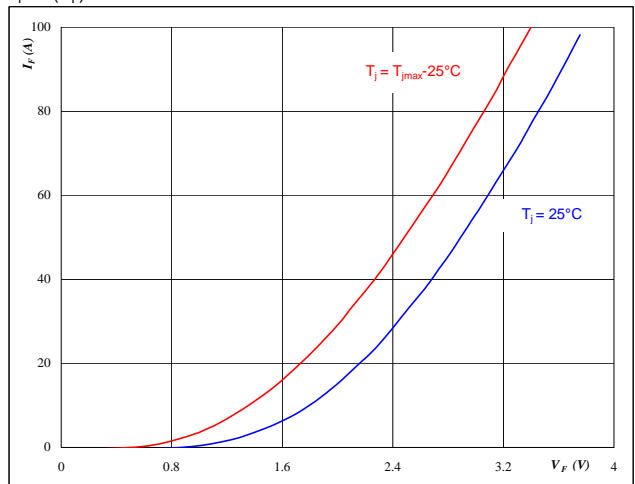


At  
 $t_p = 250 \mu s$   
 $V_{CE} = 10 V$

**Figure 4** FRED

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

$I_F = f(V_F)$



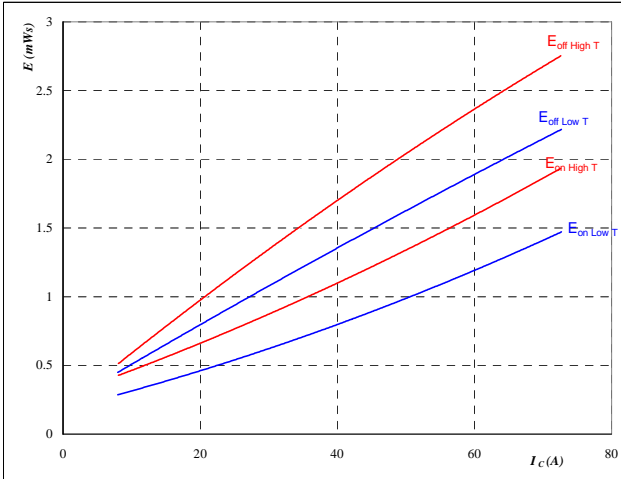
At  
 $t_p = 250 \mu s$

## Boost

Figure 5 IGBT

Typical switching energy losses  
as a function of collector current

$$E = f(I_C)$$



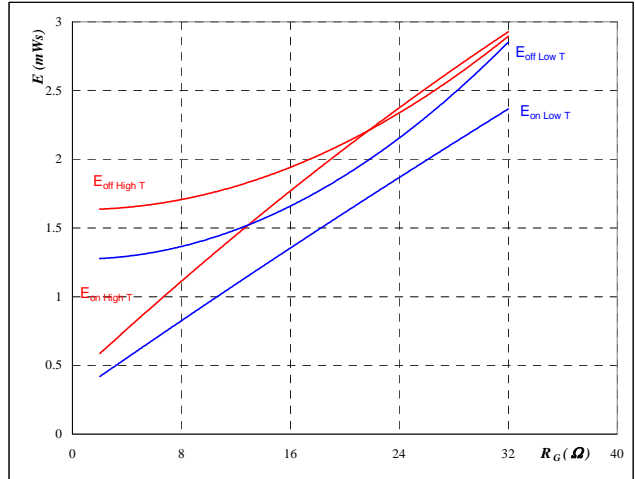
With an inductive load at

$T_J =$	25/125	°C
$V_{CE} =$	350	V
$V_{GE} =$	15	V
$R_{gon} =$	8	Ω
$R_{goff} =$	8	Ω

Figure 6 IGBT

Typical switching energy losses  
as a function of gate resistor

$$E = f(R_G)$$



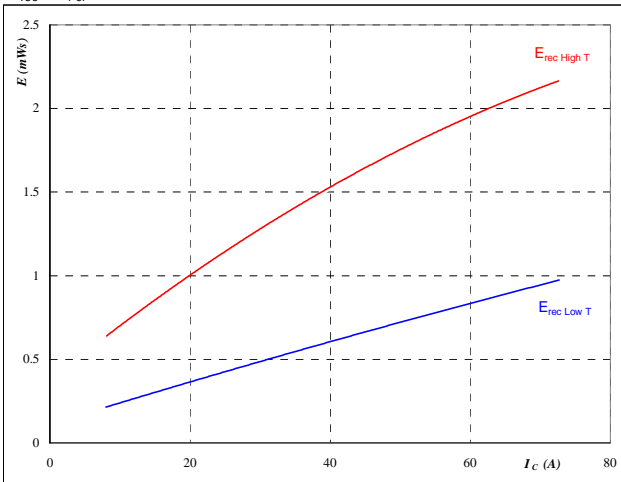
With an inductive load at

$T_J =$	25/125	°C
$V_{CE} =$	350	V
$V_{GE} =$	15	V
$I_C =$	40	A

Figure 7 IGBT

Typical reverse recovery energy loss  
as a function of collector current

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



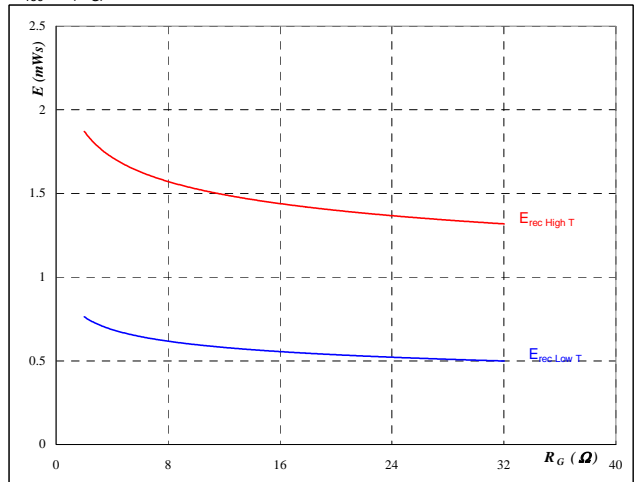
With an inductive load at

$T_J =$	25/125	°C
$V_{CE} =$	350	V
$V_{GE} =$	15	V
$R_{gon} =$	8	Ω

Figure 8 IGBT

Typical reverse recovery energy loss  
as a function of gate resistor

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



With an inductive load at

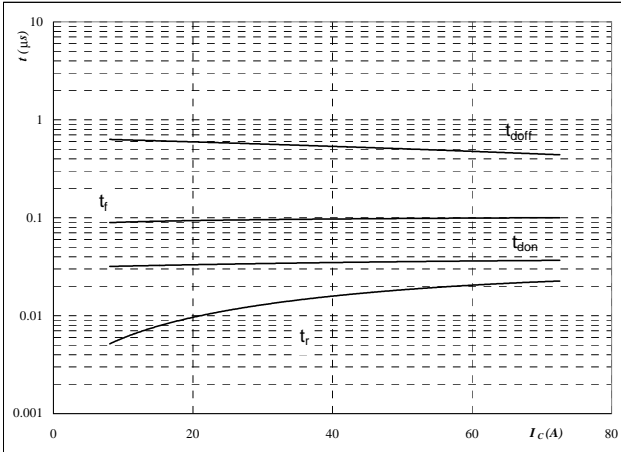
$T_J =$	25/125	°C
$V_{CE} =$	350	V
$V_{GE} =$	15	V
$I_C =$	40	A

## Boost

**Figure 9** IGBT

**Typical switching times as a function of collector current**

$$t = f(I_C)$$



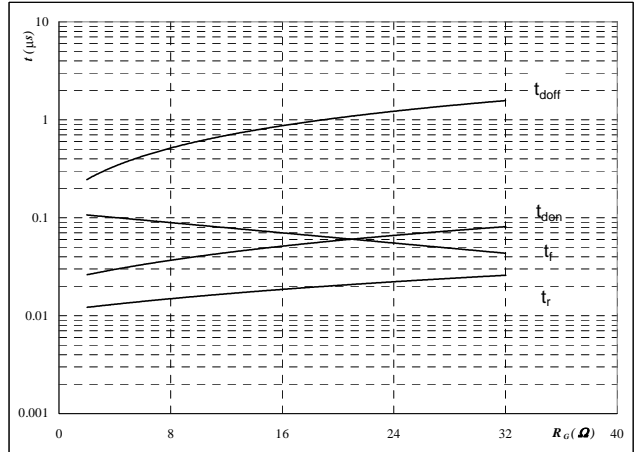
With an inductive load at

$T_j =$	125	°C
$V_{CE} =$	350	V
$V_{GE} =$	15	V
$R_{gon} =$	8	Ω
$R_{goff} =$	8	Ω

**Figure 10** IGBT

**Typical switching times as a function of gate resistor**

$$t = f(R_G)$$



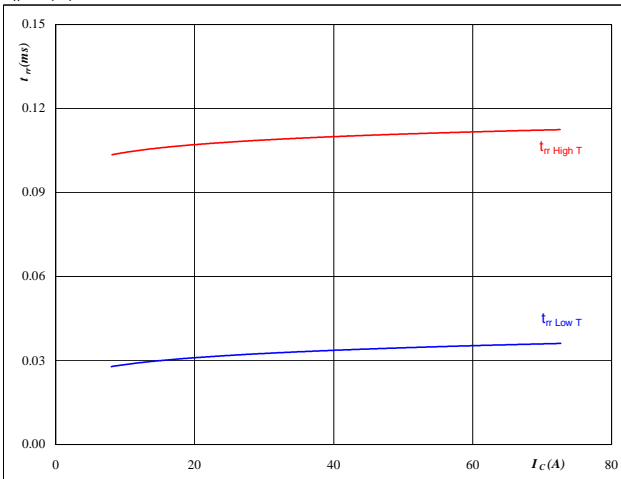
With an inductive load at

$T_j =$	125	°C
$V_{CE} =$	350	V
$V_{GE} =$	15	V
$I_C =$	40	A

**Figure 11** FRED

**Typical reverse recovery time as a function of collector current**

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

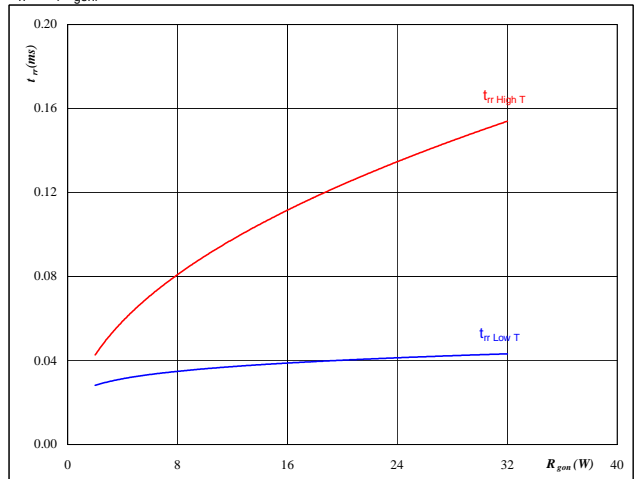

**At**

$T_j =$	25/125	°C
$V_{CE} =$	350	V
$V_{GE} =$	15	V
$R_{gon} =$	8	Ω

**Figure 12** FRED

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

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


**At**

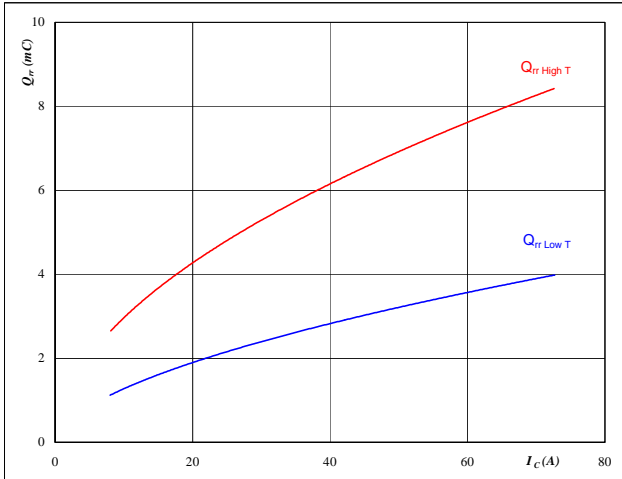
$T_j =$	25/125	°C
$V_R =$	350	V
$I_F =$	40	A
$V_{GE} =$	15	V

## Boost

**Figure 13** FRED

Typical reverse recovery charge as a function of collector current

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

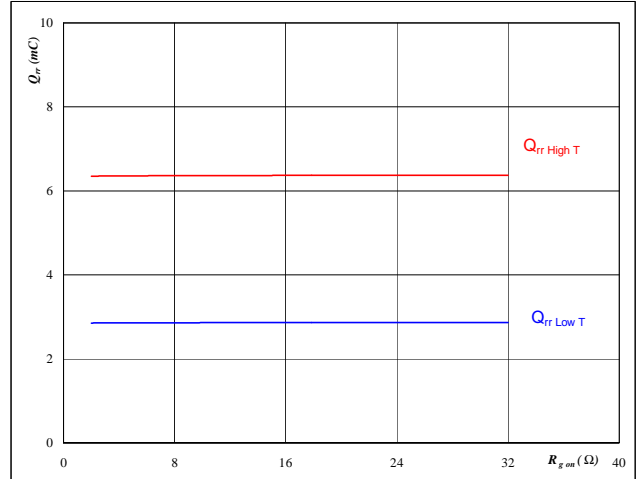


**At**  
 $T_j = 25/125$  °C  
 $V_{CE} = 350$  V  
 $V_{GE} = 15$  V  
 $R_{gon} = 8$  Ω

**Figure 14** FRED

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

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

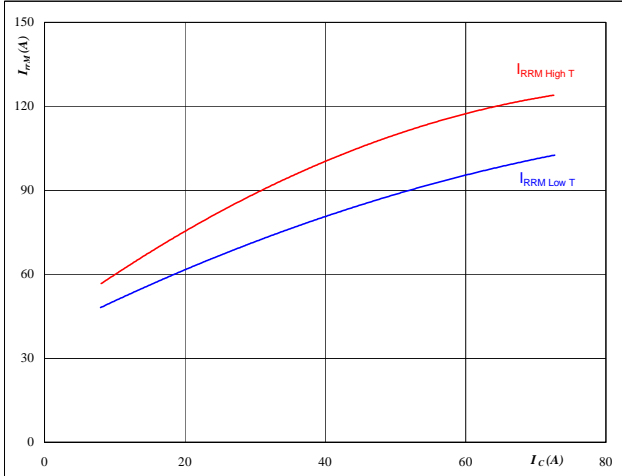


**At**  
 $T_j = 25/125$  °C  
 $V_R = 350$  V  
 $I_F = 40$  A  
 $V_{GE} = 15$  V

**Figure 15** FRED

Typical reverse recovery current as a function of collector current

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

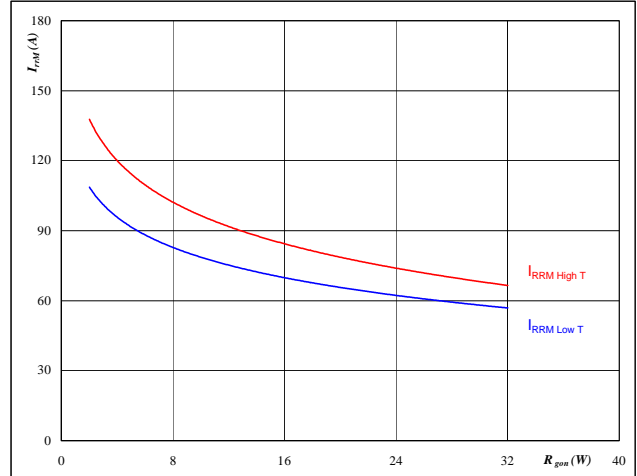


**At**  
 $T_j = 25/125$  °C  
 $V_{CE} = 350$  V  
 $V_{GE} = 15$  V  
 $R_{gon} = 8$  Ω

**Figure 16** FRED

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

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



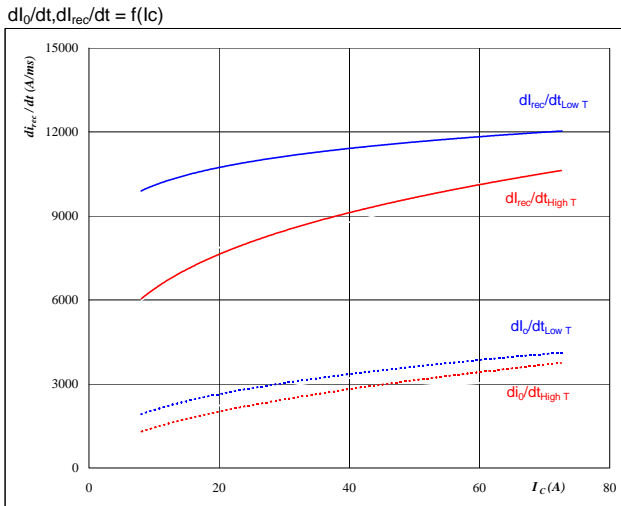
**At**  
 $T_j = 25/125$  °C  
 $V_R = 350$  V  
 $I_F = 40$  A  
 $V_{GE} = 15$  V



## Boost

**Figure 17** FRED

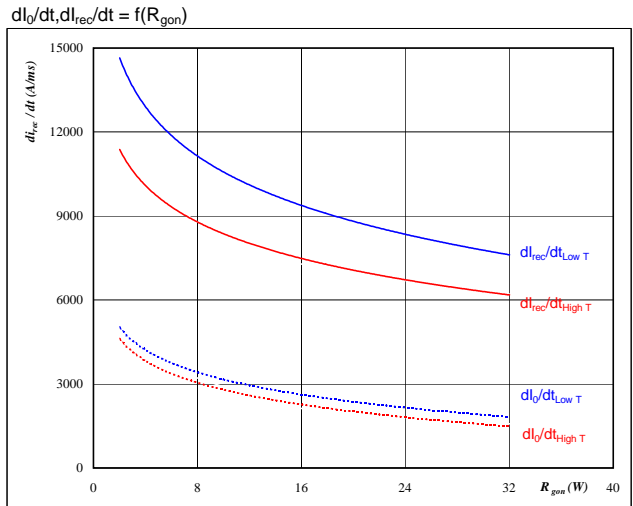
Typical rate of fall of forward and reverse recovery current as a function of collector current



**At**  
 $T_j = 25/125 \text{ } ^\circ\text{C}$   
 $V_{CE} = 350 \text{ V}$   
 $V_{GE} = 15 \text{ V}$   
 $R_{gon} = 8 \text{ } \Omega$

**Figure 18** FRED

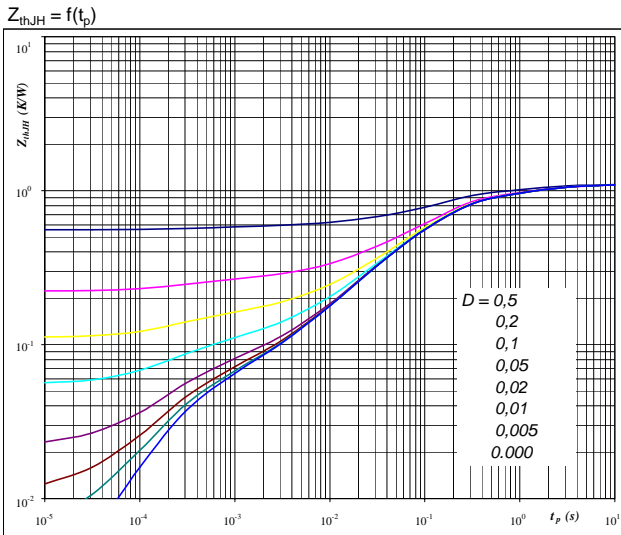
Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor



**At**  
 $T_j = 25/125 \text{ } ^\circ\text{C}$   
 $V_R = 350 \text{ V}$   
 $I_F = 40 \text{ A}$   
 $V_{GE} = 15 \text{ V}$

**Figure 19** IGBT

IGBT transient thermal impedance as a function of pulse width



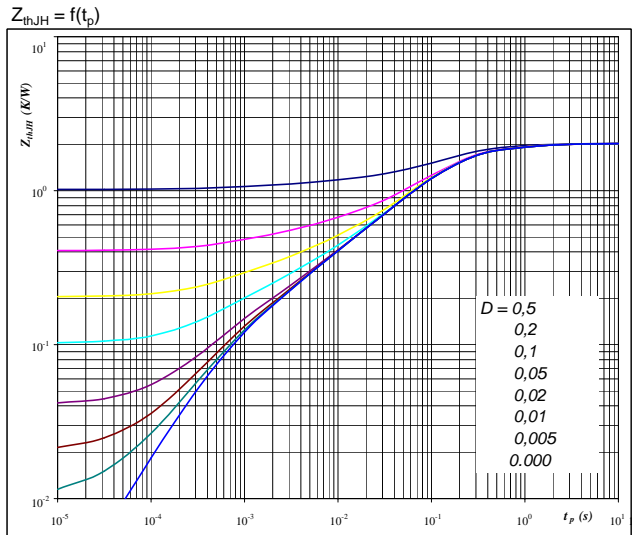
**At**  
 $D = t_p / T$   
 $R_{thJH} = 1.11 \text{ K/W}$

IGBT thermal model values

R (C/W)	Tau (s)
0.06	9.9E+00
0.22	1.2E+00
0.59	1.4E-01
0.17	2.2E-02
0.03	2.7E-03
0.04	2.7E-04

**Figure 20** FRED

FRED transient thermal impedance as a function of pulse width



**At**  
 $D = t_p / T$   
 $R_{thJH} = 2.04 \text{ K/W}$

FRED thermal model values

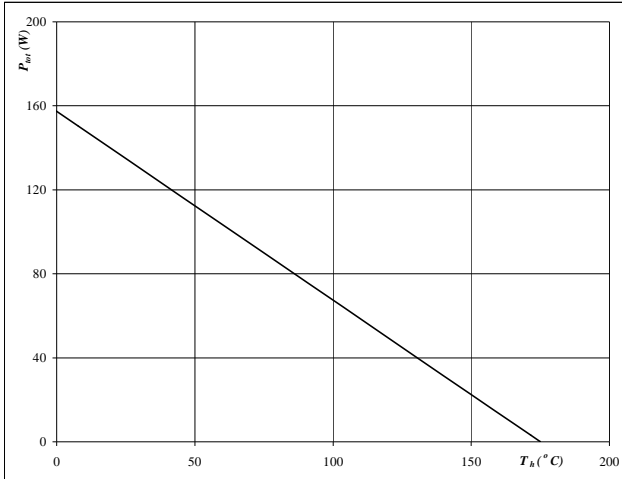
R (C/W)	Tau (s)
0.04	9.8E+00
0.21	1.0E+00
1.12	1.5E-01
0.42	3.7E-02
0.17	4.4E-03
0.08	6.1E-04

## Boost

**Figure 21** IGBT

**Power dissipation as a function of heatsink temperature**

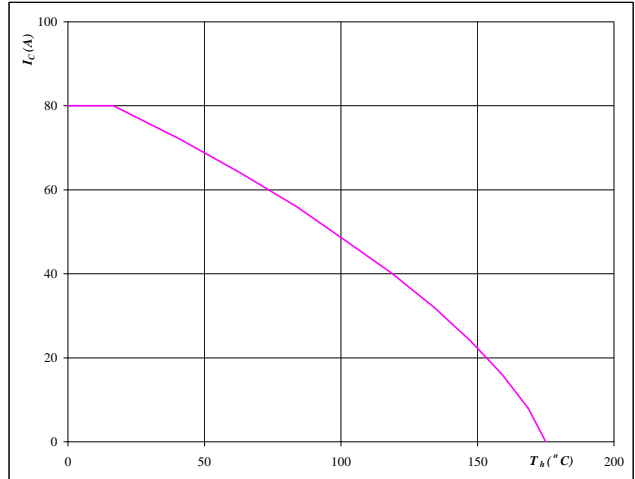
$$P_{tot} = f(T_h)$$


**At**  
 $T_j = 175$  °C

**Figure 22** IGBT

**Collector current as a function of heatsink temperature**

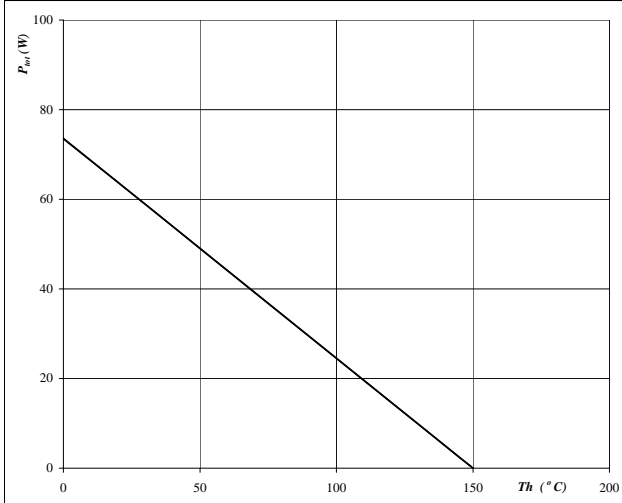
$$I_C = f(T_h)$$


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

**Figure 23** FRED

**Power dissipation as a function of heatsink temperature**

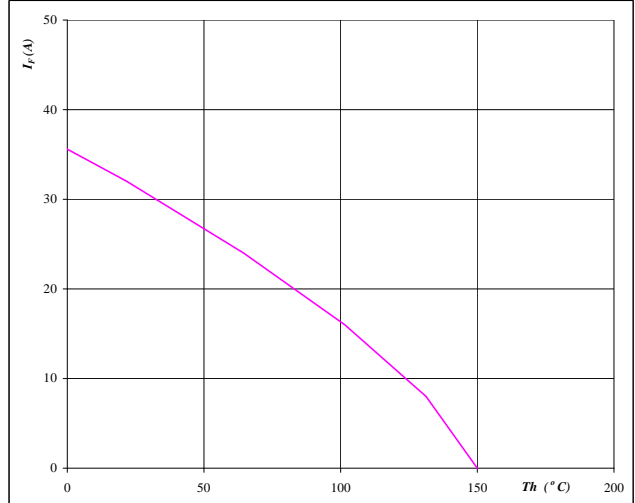
$$P_{tot} = f(T_h)$$


**At**  
 $T_j = 150$  °C

**Figure 24** FRED

**Forward current as a function of heatsink temperature**

$$I_F = f(T_h)$$

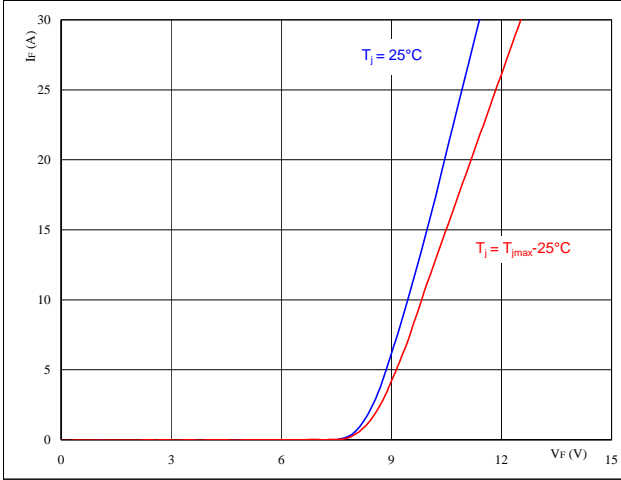

**At**  
 $T_j = 150$  °C

## Boost

**Figure 25** Boost Inverse Diode

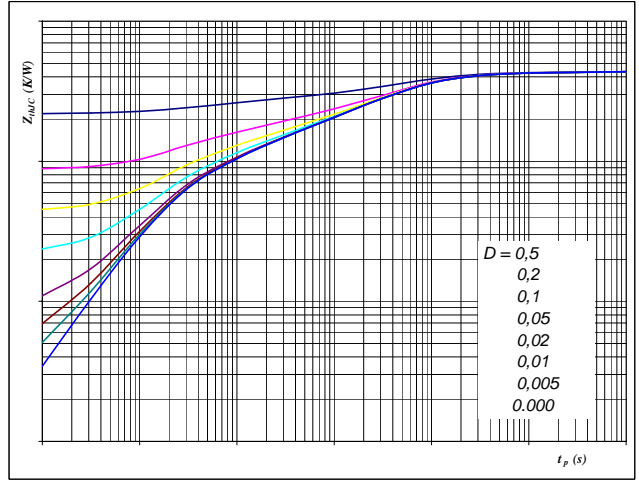
**Typical diode forward current as a function of forward voltage**

$$I_F = f(V_F)$$


**At**  
 $t_p = 250 \mu s$ 
**Figure 26** Boost Inverse Diode

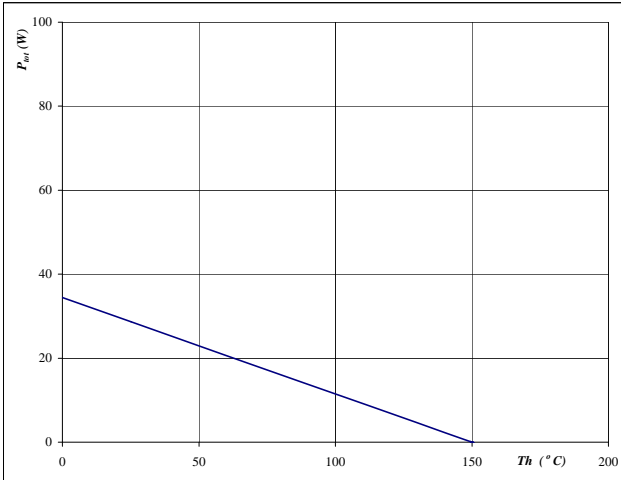
**Diode transient thermal impedance as a function of pulse width**

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


**At**  
 $D = t_p / T$   
 $R_{thJH} = 4.36 \text{ K/W}$ 
**Figure 27** Boost Inverse Diode

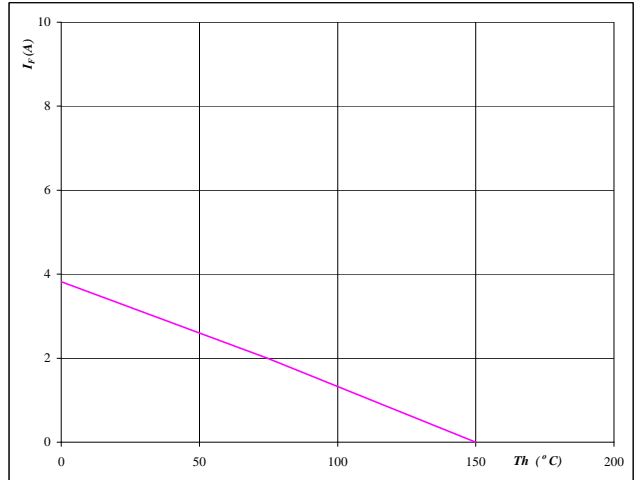
**Power dissipation as a function of heatsink temperature**

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


**At**  
 $T_j = 150 \text{ °C}$ 
**Figure 28** Boost Inverse Diode

**Forward current as a function of heatsink temperature**

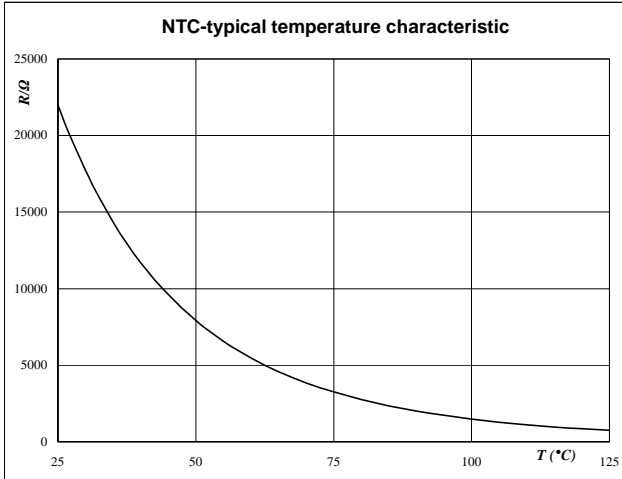
$$I_F = f(T_h)$$


**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_soll [Ω]	R_min [Ω]	R_max [Ω]	ΔR/R [+-%]
-50	1458070,6	1069249,3	1846891,9	26,7
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
<b>100</b>	<b>1486,1</b>	<b>1411,8</b>	<b>1560,4</b>	<b>5</b>
150	400,2	364,8	435,7	8,8

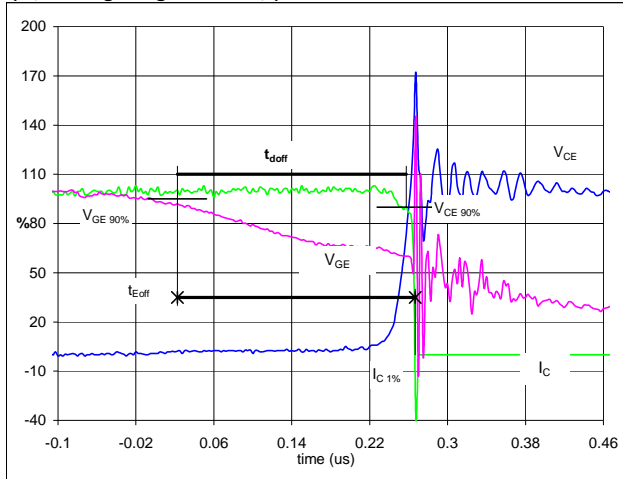
## Switching Definitions BUCK MOSFET

General conditions

$T_j$	=	125 °C	$R_{gon\ MOSFET}$	=	0 $\Omega$
$R_{gon\ IGBT}$	=	8 $\Omega$	$R_{goff\ MOSFET}$	=	47 $\Omega$
$R_{goff\ IGBT}$	=	8 $\Omega$			

**Figure 1** Output inverter IGBT

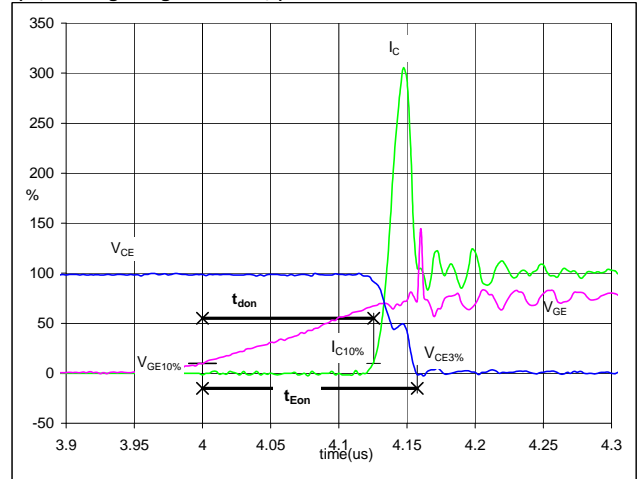
Turn-off Switching Waveforms & definition of  $t_{doff}$ ,  $t_{Eoff}$   
( $t_{Eoff}$  = integrating time for  $E_{off}$ )



$V_{GE} (0\%) =$	-15	V
$V_{GE} (100\%) =$	15	V
$V_C (100\%) =$	350	V
$I_C (100\%) =$	40	A
$t_{doff} =$	0.23	$\mu s$
$t_{Eoff} =$	0.24	$\mu s$

**Figure 2** Output inverter IGBT

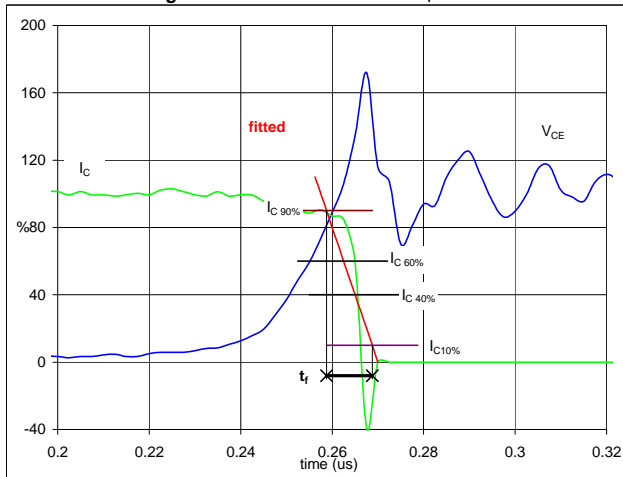
Turn-on Switching Waveforms & definition of  $t_{don}$ ,  $t_{Eon}$   
( $t_{Eon}$  = integrating time for  $E_{on}$ )



$V_{GE} (0\%) =$	-15	V
$V_{GE} (100\%) =$	15	V
$V_C (100\%) =$	350	V
$I_C (100\%) =$	40	A
$t_{don} =$	0.13	$\mu s$
$t_{Eon} =$	0.16	$\mu s$

**Figure 3** Output inverter IGBT

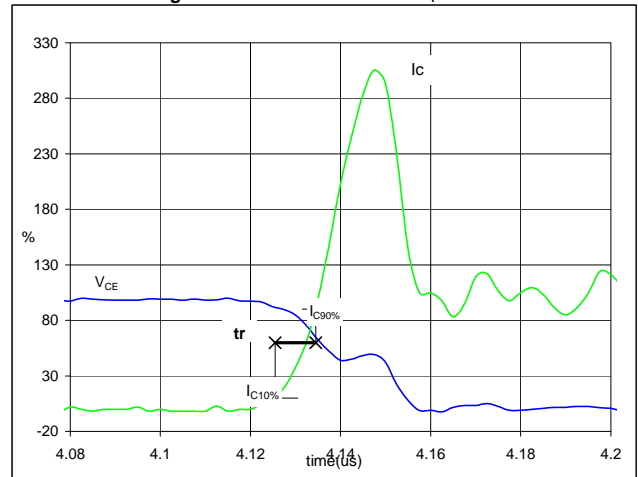
Turn-off Switching Waveforms & definition of  $t_f$



$V_C (100\%) =$	350	V
$I_C (100\%) =$	40	A
$t_f =$	0.00	$\mu s$

**Figure 4** Output inverter IGBT

Turn-on Switching Waveforms & definition of  $t_r$

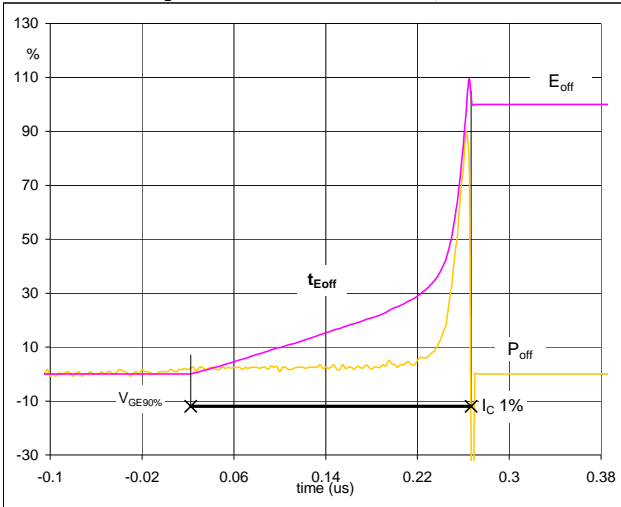


$V_C (100\%) =$	350	V
$I_C (100\%) =$	40	A
$t_r =$	0.01	$\mu s$

## Switching Definitions BUCK MOSFET

Figure 5 Output inverter IGBT

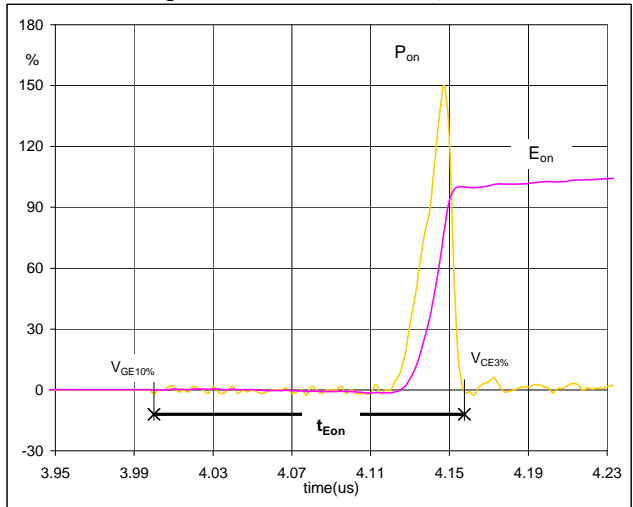
Turn-off Switching Waveforms & definition of  $t_{Eoff}$



$P_{off} (100\%) = 13.94 \text{ kW}$   
 $E_{off} (100\%) = 0.20 \text{ mJ}$   
 $t_{Eoff} = 0.24 \text{ }\mu\text{s}$

Figure 6 Output inverter IGBT

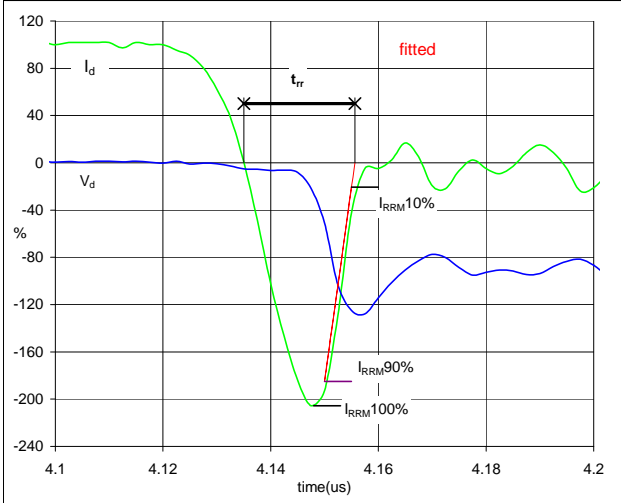
Turn-on Switching Waveforms & definition of  $t_{Eon}$



$P_{on} (100\%) = 13.94 \text{ kW}$   
 $E_{on} (100\%) = 0.33 \text{ mJ}$   
 $t_{Eon} = 0.16 \text{ }\mu\text{s}$

Figure 7 Output inverter IGBT

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

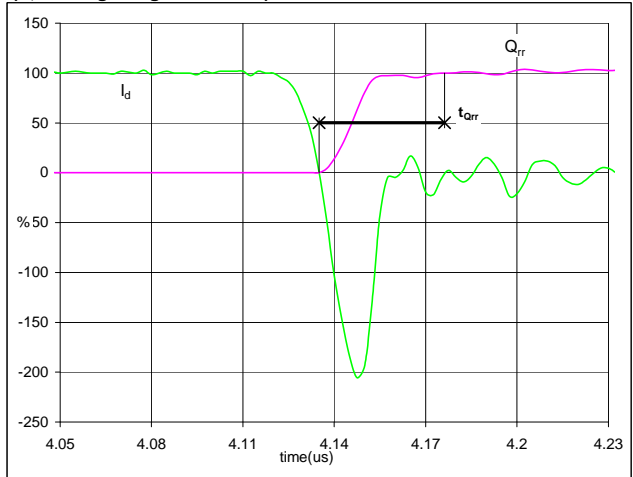


$V_d (100\%) = 350 \text{ V}$   
 $I_d (100\%) = 40 \text{ A}$   
 $I_{RRM} (100\%) = -82 \text{ A}$   
 $t_{rr} = 0.02 \text{ }\mu\text{s}$

Figure 8 Output inverter FRED

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

( $t_{Qrr}$  = integrating time for  $Q_{rr}$ )



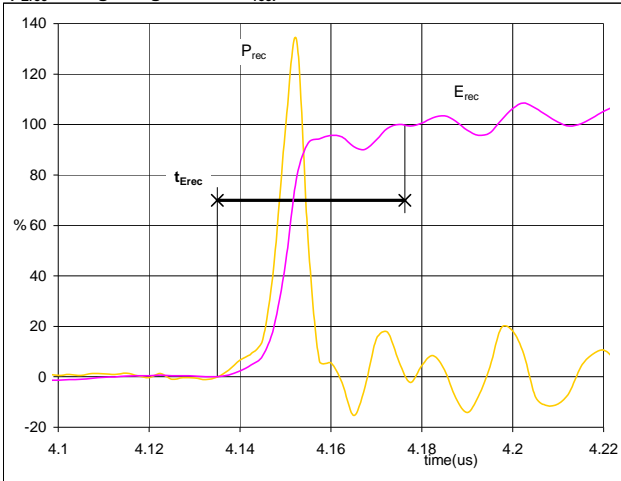
$I_d (100\%) = 40 \text{ A}$   
 $Q_{rr} (100\%) = 1.09 \text{ }\mu\text{C}$   
 $t_{Qrr} = 0.04 \text{ }\mu\text{s}$

## Switching Definitions BUCK MOSFET

Figure 9 Output inverter FRED

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

( $t_{Erec}$  = integrating time for  $E_{rec}$ )

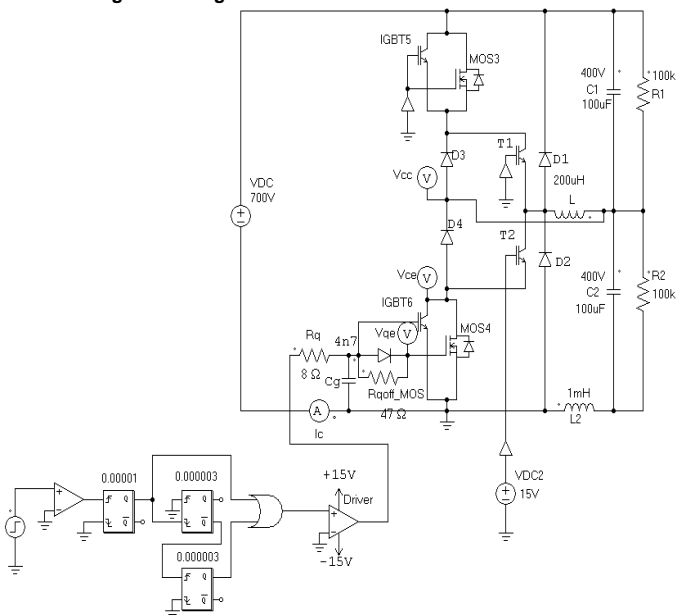


$P_{rec}$ (100%) =	13.94	kW
$E_{rec}$ (100%) =	0.16	mJ
$t_{Erec}$ =	0.04	$\mu$ s

## Measurement circuits

Figure 11

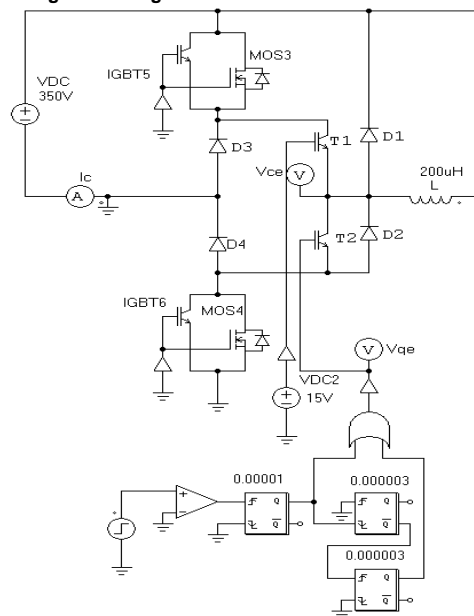
BUCK stage switching measurement circuit



$C_g$  is included in the module

Figure 12

BOOST stage switching measurement circuit

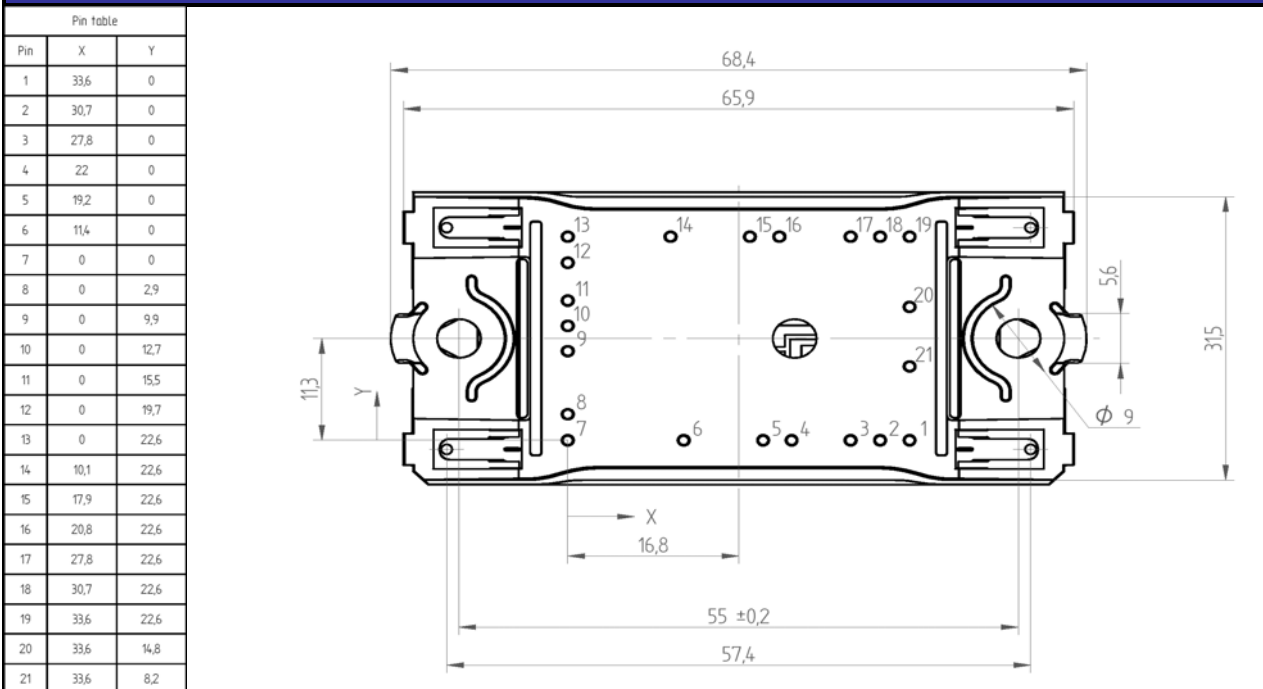


## Ordering Code and Marking - Outline - Pinout

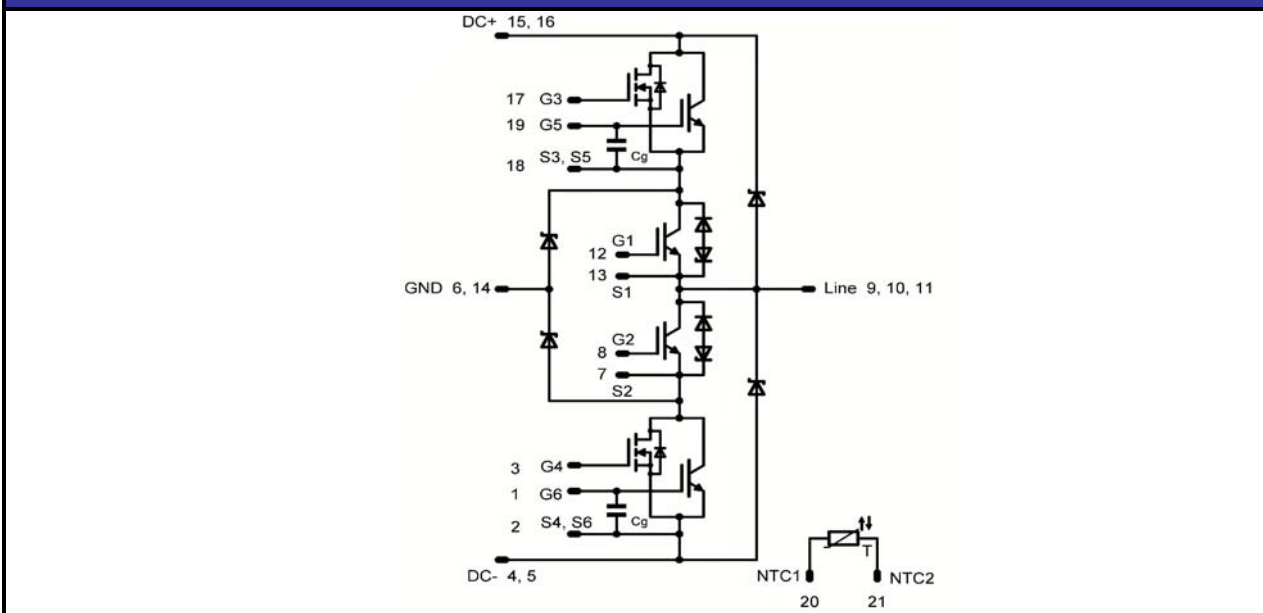
### Ordering Code & Marking

Version	Ordering Code	in DataMatrix as	in packaging barcode as
without thermal paste 12mm housing	10-FZ06NPA070FP01-P969F10	P969F10	P969F10

### 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.
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