



flow MNPC 1

1200 V / 160 A

Features

- mixed voltage NPC topology
- reactive power capability
- low inductance layout
- Split output
- enhanced LVRT capability

Target Applications

- solar inverter
- UPS
- Active frontend

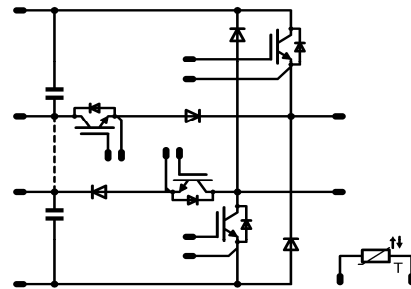
Types

- 10-FY12NMA160SH01-M820F18
- 10-PY12NMA160SH01-M820F18Y

flow 1 12mm housing



Schematic



Maximum Ratings

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

Parameter	Symbol	Condition	Value	Unit
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Halfbridge IGBT Inverse Diode

Repetitive peak reverse voltage	V_{RRM}		1200	V	
Forward current	I_{FAV}	DC current	$T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	14 19	A
Repetitive peak forward current	I_{FSM}	$t_p=10\text{ms}$	$T_j=25^{\circ}\text{C}$	14	A
Power dissipation	P_{tot}	$T_j=T_{jmax}$	$T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	31 47	W
Maximum Junction Temperature	T_{jmax}		150	$^{\circ}\text{C}$	

Halfbridge IGBT

Collector-emitter break down voltage	V_{CES}		1200	V	
DC collector current	I_C	$T_j=T_{jmax}$	$T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	117 151	A
Pulsed collector current	I_{CRM}	t_p limited by T_{jmax}		480	A
Turn off safe operating area		$T_j \leq 150^{\circ}\text{C}$ $V_{CE} \leq V_{CES}$		480	A
Power dissipation	P_{tot}	$T_j=T_{jmax}$	$T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	260 394	W
Gate-emitter peak voltage	V_{GE}		± 20	V	
Short circuit ratings	t_{SC} V_{CC}	$T_j \leq 150^{\circ}\text{C}$ $V_{GE} = 15\text{V}$		10 800	μs V
Maximum Junction Temperature	T_{jmax}		175	$^{\circ}\text{C}$	

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

Parameter	Symbol	Condition	Value	Unit
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NP Diode

Peak Repetitive Reverse Voltage	V_{RRM}		700	V
DC forward current	I_F	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	53 72	A
Power dissipation	P_{tot}	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	63 96	W
Maximum Junction Temperature	T_{jmax}		150	$^{\circ}\text{C}$

NP IGBT

Collector-emitter break down voltage	V_{CES}		650	V
DC collector current	I_C	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	76 101	A
Pulsed collector current	I_{CRM}	t_p limited by T_{jmax}	450	A
Turn off safe operating area		$T_j \leq 150^{\circ}\text{C}$ $V_{CE} \leq V_{CES}$	450	A
Power dissipation	P_{tot}	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	96 145	W
Gate-emitter peak voltage	V_{GE}		± 20	V
Short circuit ratings	t_{SC} V_{CC}	$T_j \leq 150^{\circ}\text{C}$ $V_{GE} = 15\text{V}$	6 360	μs V
Maximum Junction Temperature	T_{jmax}		175	$^{\circ}\text{C}$

NP Inverse Diode

Peak Repetitive Reverse Voltage	V_{RRM}		650	V
DC forward current	I_F	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	15 21	A
Repetitive peak forward current	I_{FRM}	t_p limited by T_{jmax}	30	A
Power dissipation	P_{tot}	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	28 42	W
Maximum Junction Temperature	T_{jmax}		175	$^{\circ}\text{C}$

Halfbridge Diode

Peak Repetitive Reverse Voltage	V_{RRM}		1200	V
DC forward current	I_F	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	31 46	A
Repetitive peak forward current	I_{FRM}	t_p limited by T_{jmax}	140	A
Power dissipation	P_{tot}	$T_j=T_{jmax}$ $T_h=80^{\circ}\text{C}$ $T_c=80^{\circ}\text{C}$	61 92	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
DC link Capacitor				
Max.DC voltage	V_{MAX}	$T_C=25^{\circ}\text{C}$	630	V
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=2s DC voltage	4000	V
Creepage distance			min 12,7	mm
Clearance			min 8,06	mm

Characteristic Values

Parameter	Symbol	Conditions					Value			Unit
		V_{GE} [V] or V_{GS} [V]	V_r [V] or V_{DS} [V]	V_{CE} [V] or V_{DS} [V]	I_c [A] or I_F [A] or I_D [A]	T_j	Min	Typ	Max	

Halfbridge IGBT Inverse Diode

Forward voltage	V_F				7	$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		1,97 1,65	2,7	V
Reverse current	I_r			1200		$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$			0,25	mA
Thermal resistance chip to heatsink	$R_{th(j-s)}$	Thermal grease thickness $\leq 50\mu\text{m}$ $\lambda = 1 \text{ W/mK}$						2,24		K/W

Halfbridge IGBT

Gate emitter threshold voltage	$V_{GE(th)}$	VCE=VGE			0,006	$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$	5	5,80	6,5	V
Collector-emitter saturation voltage	V_{CESat}		15		160	$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$	1	2,02 2,37	2,70	V
Collector-emitter cut-off current incl. Diode	I_{CES}		0	1200		$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$			0,25	mA
Gate-emitter leakage current	I_{GES}		20	0		$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$			480	nA
Integrated Gate resistor	R_{gint}							none		Ω
Turn-on delay time	$t_{d(on)}$	Rgoff=4 Ω Rgon=4 Ω	± 15	350	100	$T_j=25^\circ\text{C}$		127		ns
Rise time	t_r					$T_j=25^\circ\text{C}$		26		
Turn-off delay time	$t_{d(off)}$					$T_j=25^\circ\text{C}$		30		
Fall time	t_f					$T_j=25^\circ\text{C}$		219		
						$T_j=125^\circ\text{C}$		274		
Turn-on energy loss per pulse	E_{on}					$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		1,52 2,60		mWs
Turn-off energy loss per pulse	E_{off}					$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		2,69 4,19		mWs
Input capacitance	C_{ies}							9200		pF
Output capacitance	C_{oss}	f=1MHz	0	25		$T_j=25^\circ\text{C}$		600		
Reverse transfer capacitance	C_{rss}							540		
Gate charge	Q_G		± 15	960	160	$T_j=25^\circ\text{C}$		740		nC
Thermal resistance chip to heatsink	$R_{th(j-s)}$	Thermal grease thickness $\leq 50\mu\text{m}$ $\lambda = 1 \text{ W/mK}$						0,37		K/W

NP Diode

Diode forward voltage	V_F				150	$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$	1	2,00 1,88	2,6	V
Reverse leakage current	I_r			700		$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$			50	μA
Peak reverse recovery current	I_{RRM}	Rgon=4 Ω	± 15	350	100	$T_j=25^\circ\text{C}$		86		A
Reverse recovery time	t_{rr}					$T_j=25^\circ\text{C}$		113		
Reverse recovered charge	Q_{rr}					$T_j=25^\circ\text{C}$		57		
						$T_j=125^\circ\text{C}$		109		
						$T_j=25^\circ\text{C}$		2,93		
Peak rate of fall of recovery current	$(di_{rr}/dt)_{max}$					$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		3683 1519		A/ μs
Reverse recovered energy	E_{rec}					$T_j=25^\circ\text{C}$ $T_j=125^\circ\text{C}$		0,53 1,38		mWs
Thermal resistance chip to heatsink	$R_{th(j-s)}$	Thermal grease thickness $\leq 50\mu\text{m}$ $\lambda = 1 \text{ W/mK}$						1,11		K/W

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	

NP IGBT

Gate emitter threshold voltage	$V_{GE(th)}$	$V_{CE}=V_{GE}$			0,008	$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$	5	5,8	6,5	V
Collector-emitter saturation voltage	V_{CEsat}		15		150	$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$	1,05	1,48 1,62	1,85	V
Collector-emitter cut-off incl diode	I_{CES}		0	650		$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$			0,05	mA
Gate-emitter leakage current	I_{GES}		20	0		$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$			700	nA
Integrated Gate resistor	R_{gint}							none		Ω
Turn-on delay time	$t_{d(on)}$	Rgoff=4 Ω Rgon=4 Ω	± 15	350	100	$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$		170		ns
Rise time	t_r					$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$		29 31		
Turn-off delay time	$t_{d(off)}$					$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$		235 265		
Fall time	t_f					$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$		54 71		
Turn-on energy loss per pulse	E_{on}					$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$		1,29 1,70		
Turn-off energy loss per pulse	E_{off}	$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$		2,88 3,95						mWs
Input capacitance	C_{ies}	f=1MHz	0	25		$T_j=25^\circ\text{C}$		9240		pF
Output capacitance	C_{oss}							276		
Reverse transfer capacitance	C_{rss}							274		
Thermal resistance chip to heatsink	$R_{th(j-s)}$	Thermal grease thickness \leq 50um $\lambda = 1 \text{ W/mK}$						0,99		K/W

NP Inverse Diode

Diode forward voltage	V_F				15	$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$	1,23	1,89 1,79	2,20	V
Thermal resistance chip to heatsink	$R_{th(j-s)}$	Thermal grease thickness \leq 50um $\lambda = 1 \text{ W/mK}$						3,43		K/W

Halfbridge Diode

Diode forward voltage	V_F				150	$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$		2,46 2,07	3,5	V
Reverse leakage current	I_r			1200		$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$			200	μA
Peak reverse recovery current	I_{RRM}	Rgon=4 Ω	± 15	350	100	$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$		83 116		A
Reverse recovery time	t_{rr}					$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$		113 136		
Reverse recovered charge	Q_{rr}					$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$		6,17 12,86		
Peak rate of fall of recovery current	$(di_{rr}/dt)_{max}$					$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$		2952 3586		
Reverse recovery energy	E_{rec}					$T_j=25^\circ\text{C}$ $T_i=125^\circ\text{C}$		1,66 3,63		
Thermal resistance chip to heatsink	$R_{th(j-s)}$	Thermal grease thickness \leq 50um $\lambda = 1 \text{ W/mK}$						1,15		K/W

DC link Capacitor

C value	C						80	100	120	nF
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Thermistor

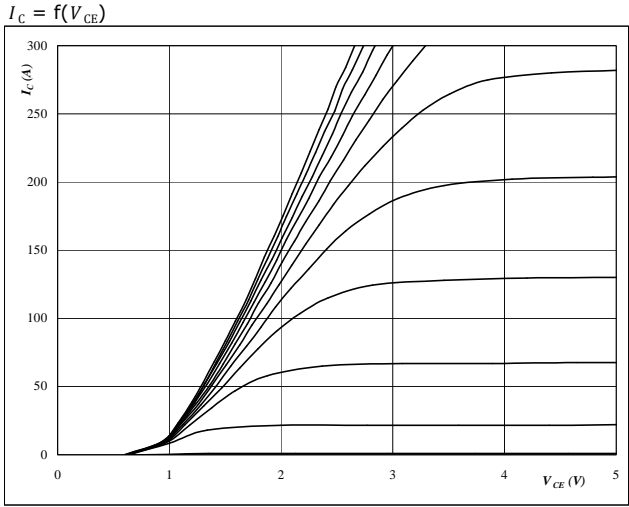
Rated resistance	R					T=25 $^\circ\text{C}$		21511		Ω
Deviation of R100	$\Delta_{R/R}$	R100=1486 Ω				T=100 $^\circ\text{C}$	-4,5		+4,5	%
Power dissipation	P					T=25 $^\circ\text{C}$		210		mW
Power dissipation constant						T=25 $^\circ\text{C}$		3,5		mW/K
B-value	B(25/50)					T=25 $^\circ\text{C}$		3884		K
B-value	B(25/100)					T=25 $^\circ\text{C}$		3964		K
Vincotech NTC Reference									F	



Half Bridge

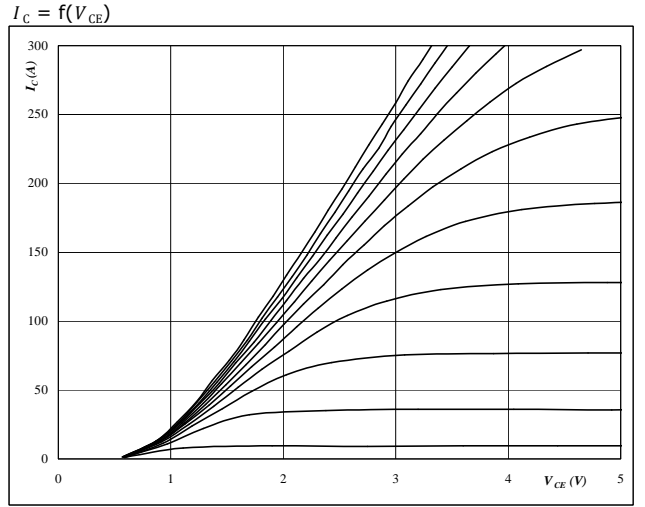
Half Bridge IGBT and Neutral Point FWD

Figure 1 IGBT
Typical output characteristics



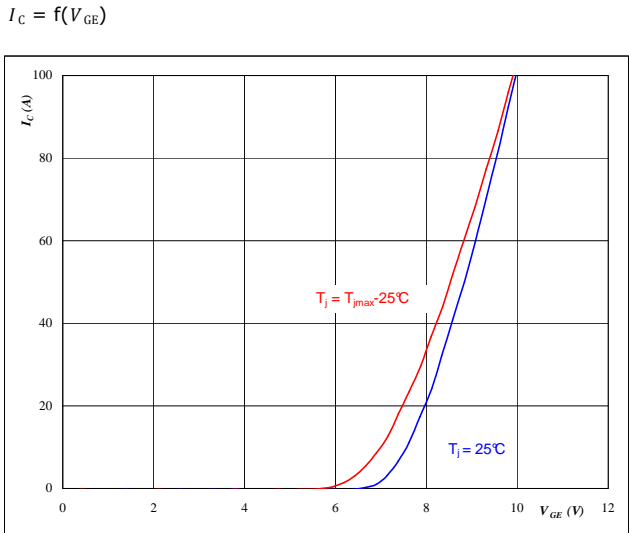
At
 $t_p = 250 \mu s$
 $T_j = 25 \text{ }^\circ C$
 V_{GE} from 7 V to 17 V in steps of 1 V

Figure 2 IGBT
Typical output characteristics



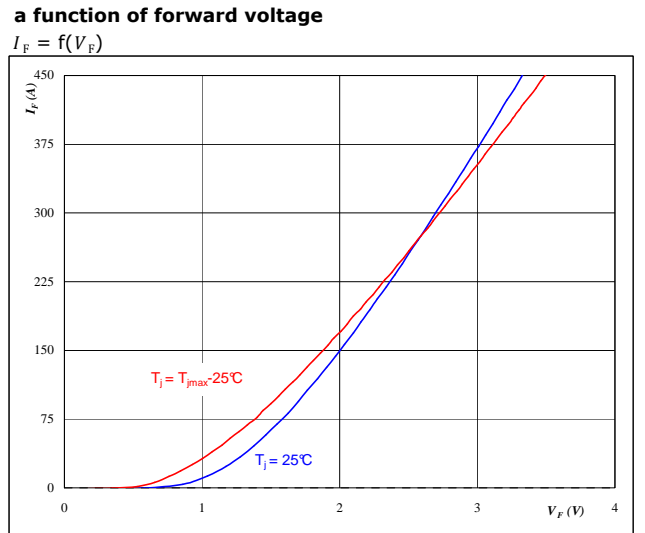
At
 $t_p = 250 \mu s$
 $T_j = 125 \text{ }^\circ C$
 V_{GE} from 7 V to 17 V in steps of 1 V

Figure 3 IGBT
Typical transfer characteristics



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

Figure 4 FWD
Typical diode forward current as a function of forward voltage



At
 $t_p = 250 \mu s$



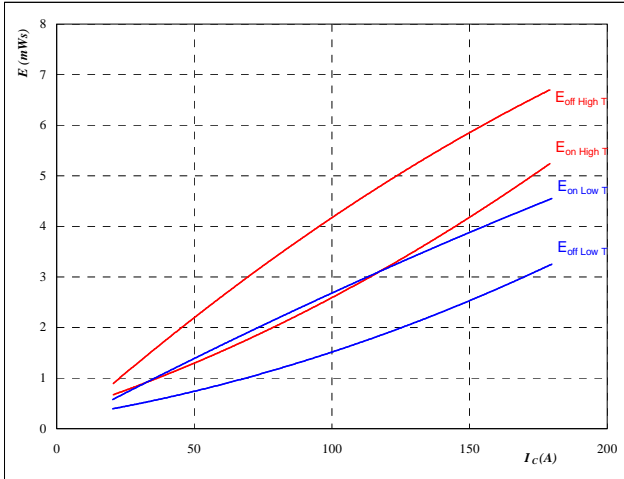
Half Bridge

Half Bridge IGBT and Neutral Point FWD

Figure 5 IGBT

Typical switching energy losses
as a function of collector current

$$E = f(I_c)$$



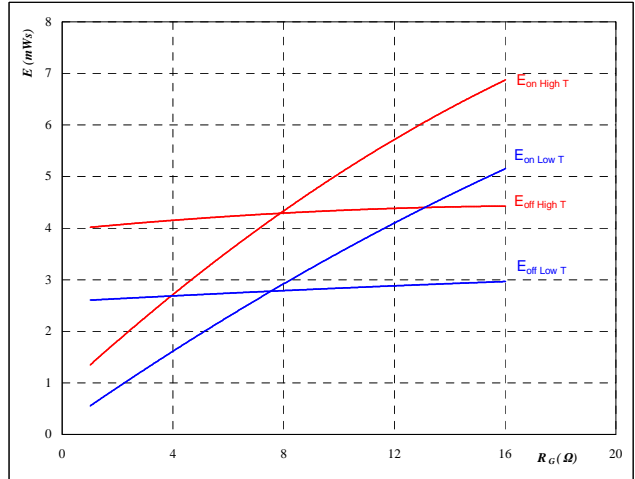
With an inductive load at

- $T_j = 25/125 \text{ } ^\circ\text{C}$
- $V_{CE} = 350 \text{ V}$
- $V_{GE} = \pm 15 \text{ V}$
- $R_{gon} = 4 \text{ } \Omega$
- $R_{goff} = 4 \text{ } \Omega$

Figure 6 IGBT

Typical switching energy losses
as a function of gate resistor

$$E = f(R_g)$$



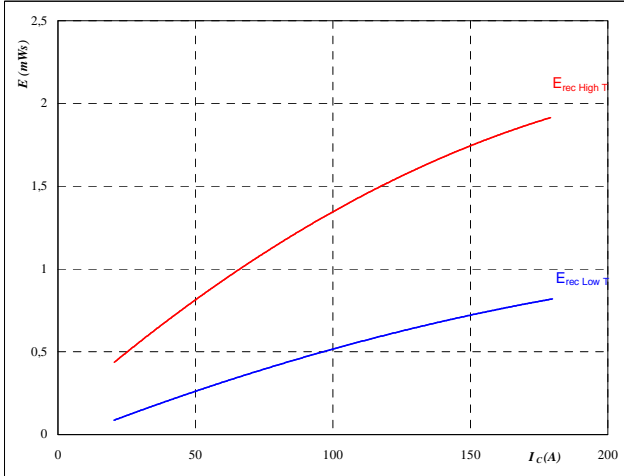
With an inductive load at

- $T_j = 25/125 \text{ } ^\circ\text{C}$
- $V_{CE} = 350 \text{ V}$
- $V_{GE} = \pm 15 \text{ V}$
- $I_c = 100 \text{ A}$

Figure 7 FWD

Typical reverse recovery energy loss
as a function of collector current

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



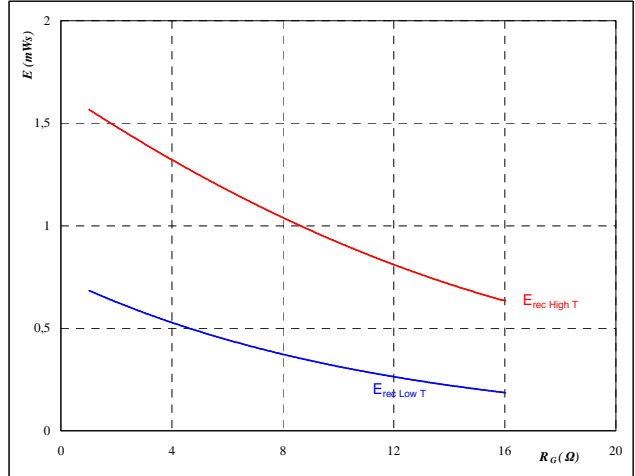
With an inductive load at

- $T_j = 25/125 \text{ } ^\circ\text{C}$
- $V_{CE} = 350 \text{ V}$
- $V_{GE} = \pm 15 \text{ V}$
- $R_{gon} = 4 \text{ } \Omega$

Figure 8 FWD

Typical reverse recovery energy loss
as a function of gate resistor

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



With an inductive load at

- $T_j = 25/125 \text{ } ^\circ\text{C}$
- $V_{CE} = 350 \text{ V}$
- $V_{GE} = \pm 15 \text{ V}$
- $I_c = 100 \text{ A}$



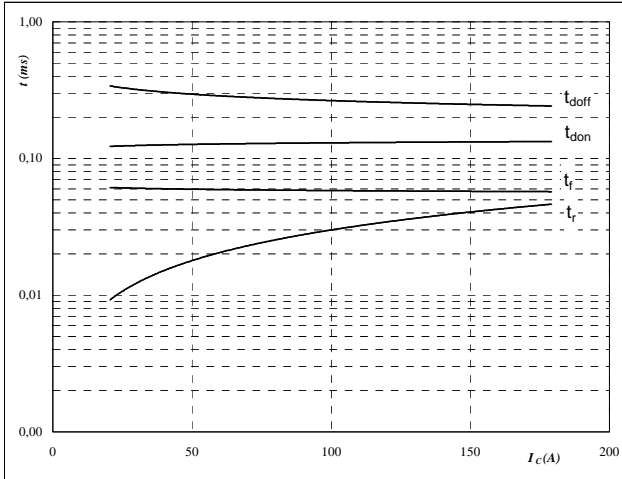
Half Bridge

Half Bridge IGBT and Neutral Point FWD

Figure 9 IGBT

Typical switching times as a function of collector current

$t = f(I_C)$



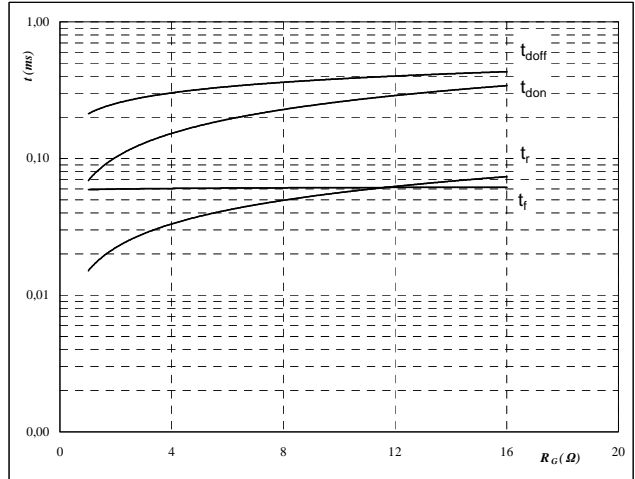
With an inductive load at

- $T_j = 125 \text{ } ^\circ\text{C}$
- $V_{CE} = 350 \text{ V}$
- $V_{GE} = \pm 15 \text{ V}$
- $R_{gon} = 4 \text{ } \Omega$
- $R_{goff} = 4 \text{ } \Omega$

Figure 10 IGBT

Typical switching times as a function of gate resistor

$t = f(R_G)$



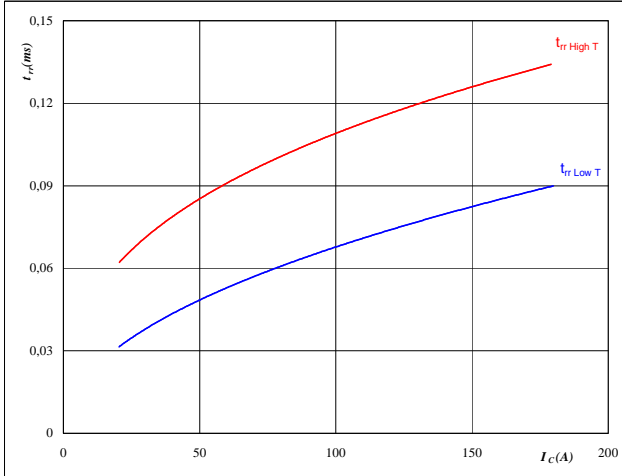
With an inductive load at

- $T_j = 125 \text{ } ^\circ\text{C}$
- $V_{CE} = 350 \text{ V}$
- $V_{GE} = \pm 15 \text{ V}$
- $I_C = 100 \text{ A}$

Figure 11 FWD

Typical reverse recovery time as a function of collector current

$t_{rr} = f(I_C)$



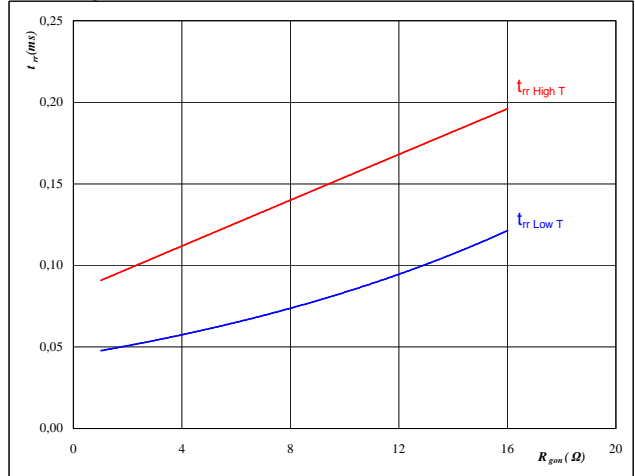
At

- $T_j = 25/125 \text{ } ^\circ\text{C}$
- $V_{CE} = 350 \text{ V}$
- $V_{GE} = \pm 15 \text{ V}$
- $R_{gon} = 4 \text{ } \Omega$

Figure 12 FWD

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

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



At

- $T_j = 25/125 \text{ } ^\circ\text{C}$
- $V_R = 350 \text{ V}$
- $I_F = 100 \text{ A}$
- $V_{GE} = \pm 15 \text{ V}$



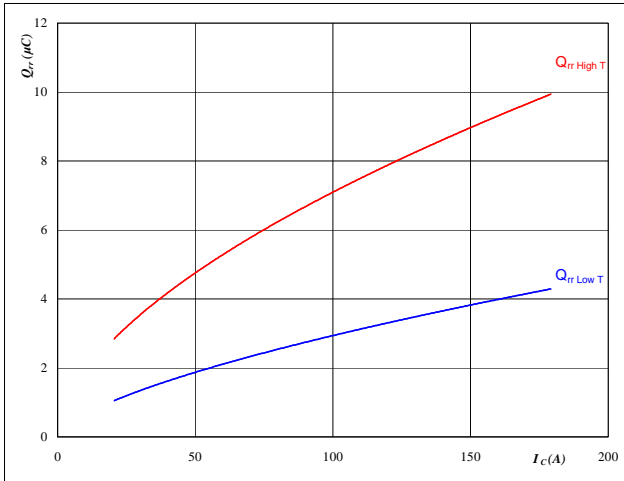
Half Bridge

Half Bridge IGBT and Neutral Point FWD

Figure 13 FWD

Typical reverse recovery charge as a function of collector current

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

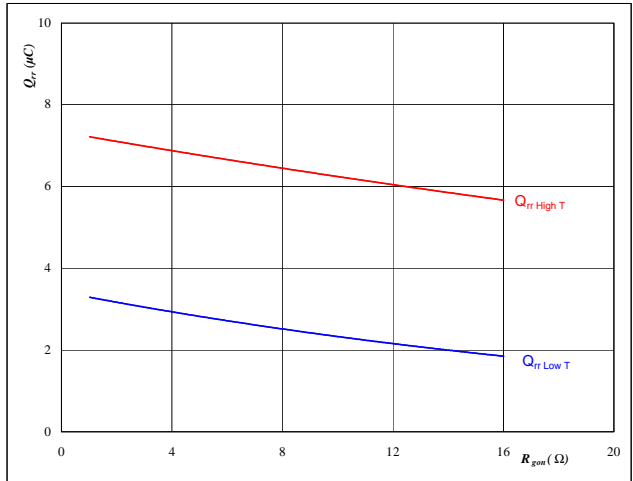


At
 $T_j = 25/125$ °C
 $V_{CE} = 350$ V
 $V_{GE} = \pm 15$ V
 $R_{gon} = 4$ Ω

Figure 14 FWD

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

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

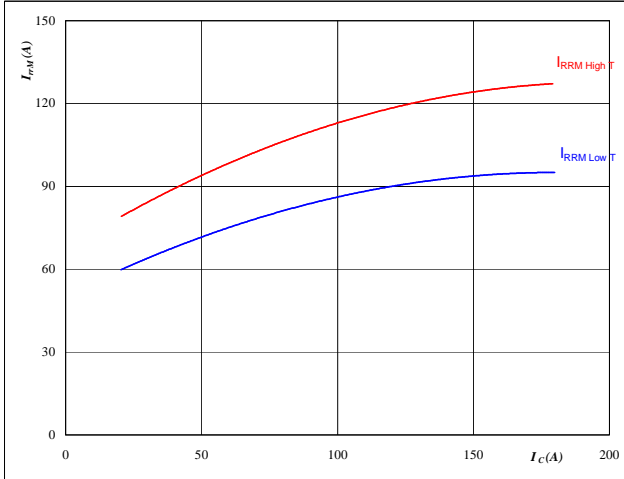


At
 $T_j = 25/125$ °C
 $V_R = 350$ V
 $I_F = 100$ A
 $V_{GE} = \pm 15$ V

Figure 15 FWD

Typical reverse recovery current as a function of collector current

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

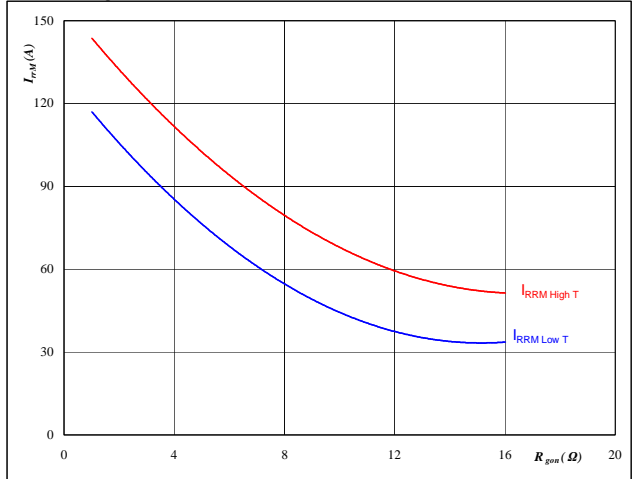


At
 $T_j = 25/125$ °C
 $V_{CE} = 350$ V
 $V_{GE} = \pm 15$ V
 $R_{gon} = 4$ Ω

Figure 16 FWD

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

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



At
 $T_j = 25/125$ °C
 $V_R = 350$ V
 $I_F = 100$ A
 $V_{GE} = \pm 15$ V



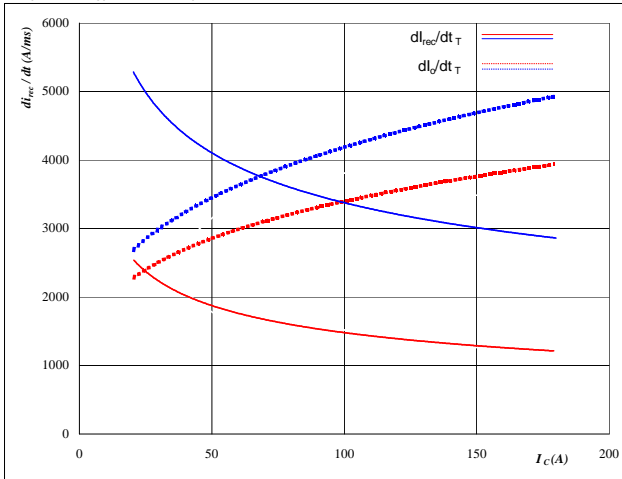
Half Bridge

Half Bridge IGBT and Neutral Point FWD

Figure 17 FWD

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

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

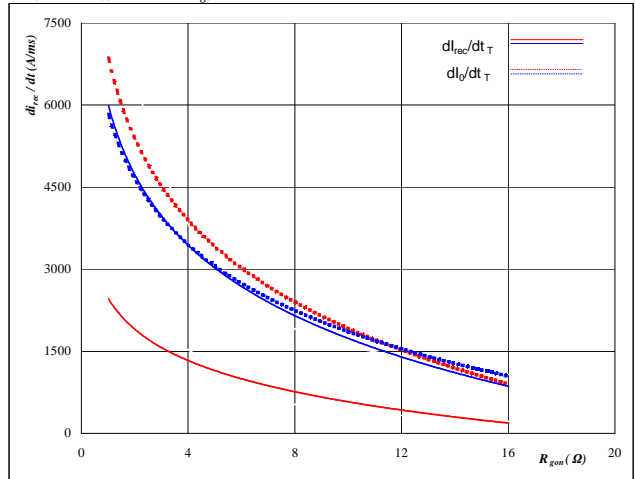


At
 $T_j = 25/125 \text{ } ^\circ\text{C}$
 $V_{CE} = 350 \text{ V}$
 $V_{GE} = \pm 15 \text{ V}$
 $R_{gon} = 4 \text{ } \Omega$

Figure 18 FWD

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

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

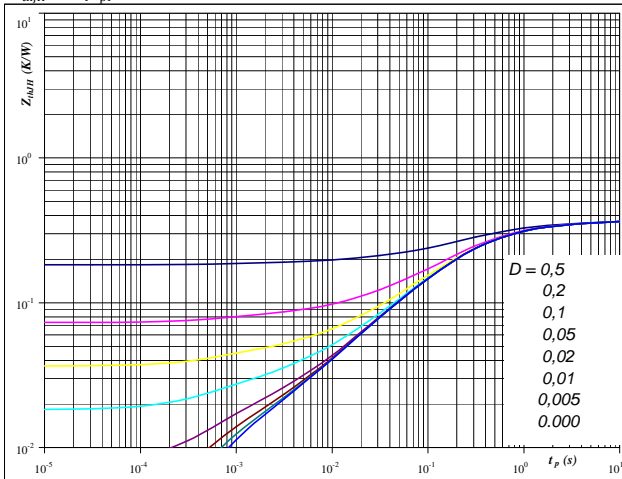


At
 $T_j = 25/125 \text{ } ^\circ\text{C}$
 $V_R = 350 \text{ V}$
 $I_F = 100 \text{ A}$
 $V_{GE} = \pm 15 \text{ V}$

Figure 19 IGBT

IGBT transient thermal impedance as a function of pulse width

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



At
 $D = t_p / T$
 $R_{thjH} = 0,37 \text{ K/W}$

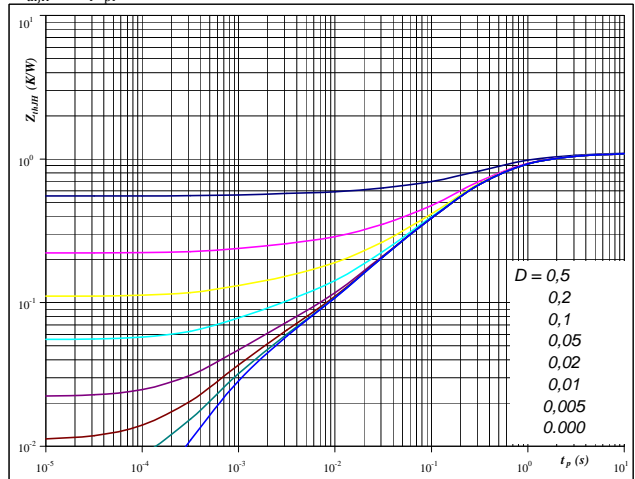
IGBT thermal model values

R (K/W)	Tau (s)
0,06	2,4E+00
0,15	4,0E-01
0,12	1,0E-01
0,03	1,3E-02
0,01	8,4E-04

Figure 20 FWD

FWD transient thermal impedance as a function of pulse width

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



At
 $D = t_p / T$
 $R_{thjH} = 1,11 \text{ K/W}$

FWD thermal model values

R (K/W)	Tau (s)
0,07	6,8E+00
0,25	1,2E+00
0,57	2,8E-01
0,12	6,0E-02
0,06	1,3E-02
0,03	1,1E-03



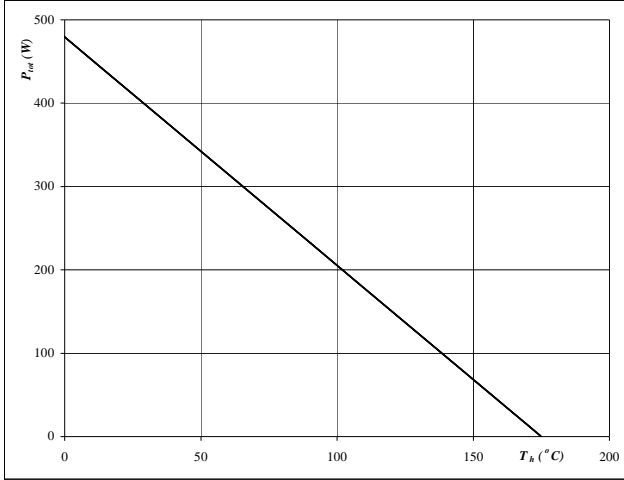
Half Bridge

Half Bridge IGBT and Neutral Point FWD

Figure 21 IGBT

Power dissipation as a function of heatsink temperature

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

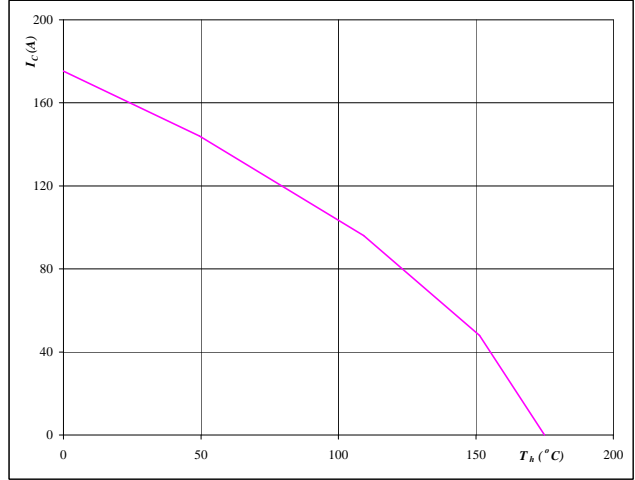


At
T_j = 175 °C

Figure 22 IGBT

Collector current as a function of heatsink temperature

$$I_c = f(T_h)$$

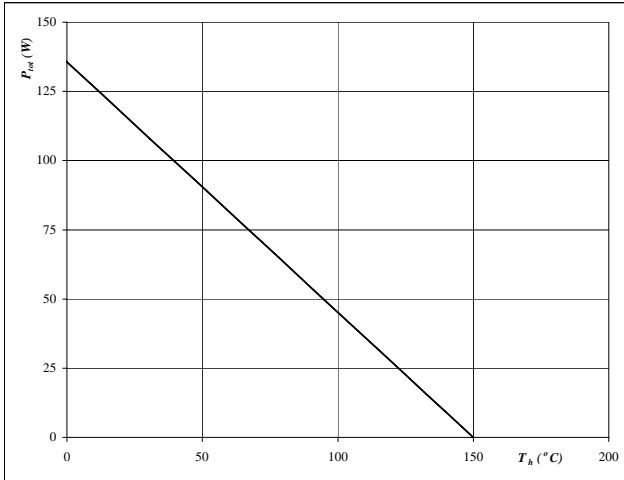


At
T_j = 175 °C
V_{GE} = 15 V

Figure 23 FWD

Power dissipation as a function of heatsink temperature

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

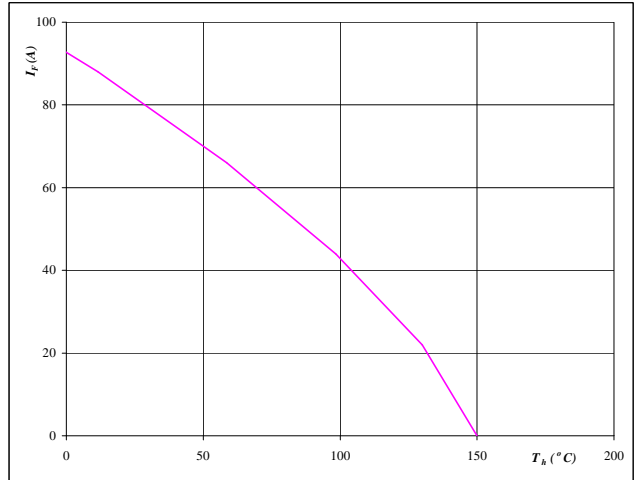


At
T_j = 150 °C

Figure 24 FWD

Forward current as a function of heatsink temperature

$$I_F = f(T_h)$$



At
T_j = 150 °C



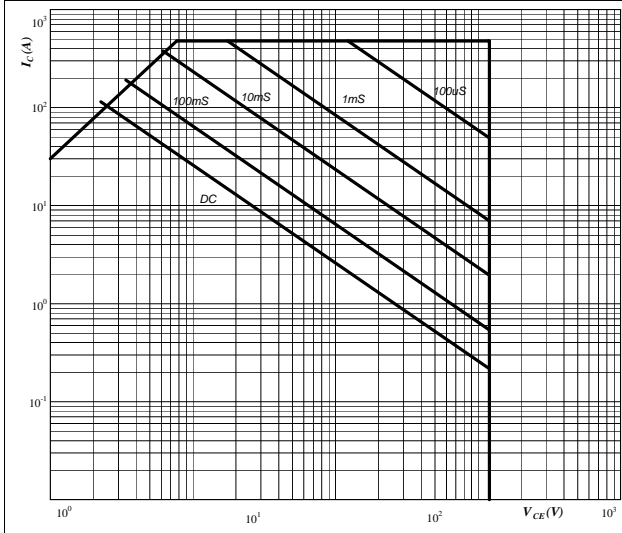
Half Bridge

Half Bridge IGBT and Neutral Point FWD

Figure 25 IGBT

Safe operating area as a function of collector-emitter voltage

$I_C = f(V_{CE})$

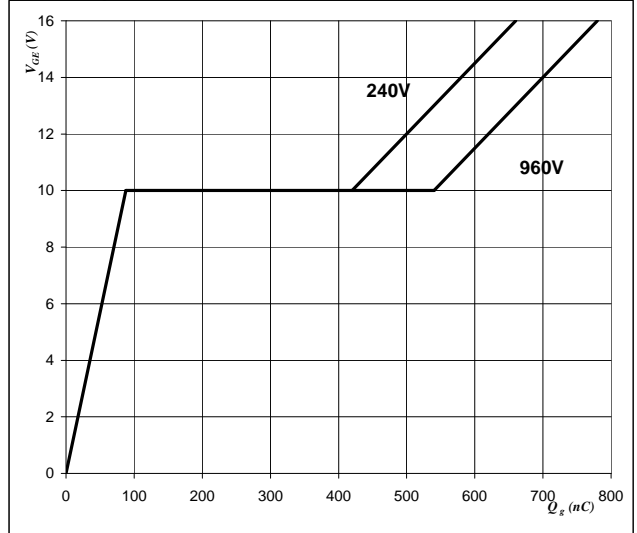


At
 $D =$ single pulse
 $T_h =$ 80 °C
 $V_{GE} =$ ±15 V
 $T_j = T_{jmax}$ °C

Figure 26 IGBT

Gate voltage vs Gate charge

$V_{GE} = f(Q_g)$



At
 $I_C =$ 160 A



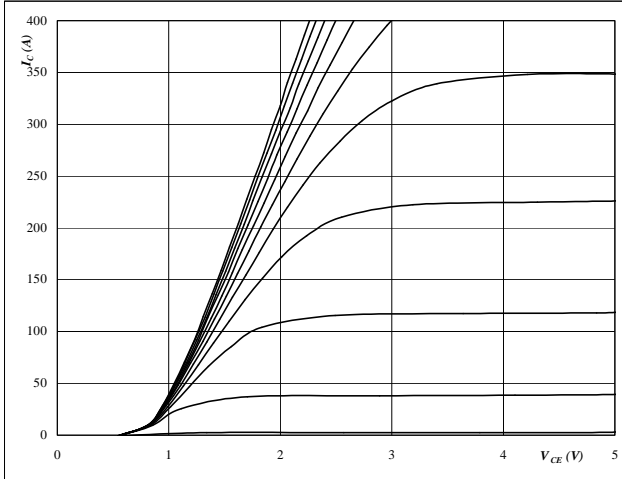
Neutral Point

Neutral Point IGBT and Half Bridge FWD

Figure 1 IGBT

Typical output characteristics

$I_C = f(V_{CE})$

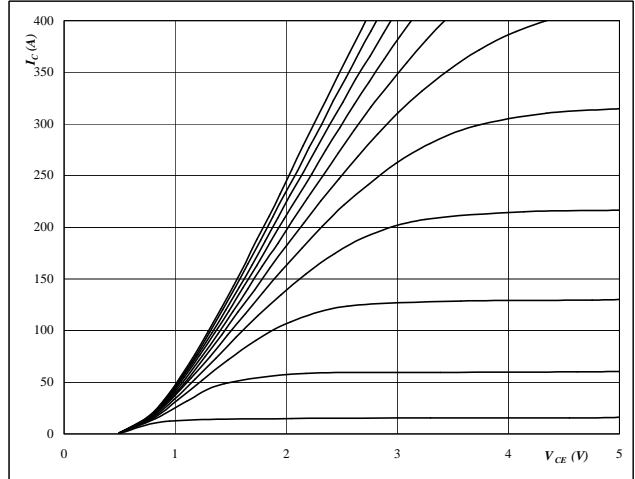


At
 $t_p = 250 \mu s$
 $T_j = 25 \text{ } ^\circ C$
 V_{GE} from 7 V to 17 V in steps of 1 V

Figure 2 IGBT

Typical output characteristics

$I_C = f(V_{CE})$

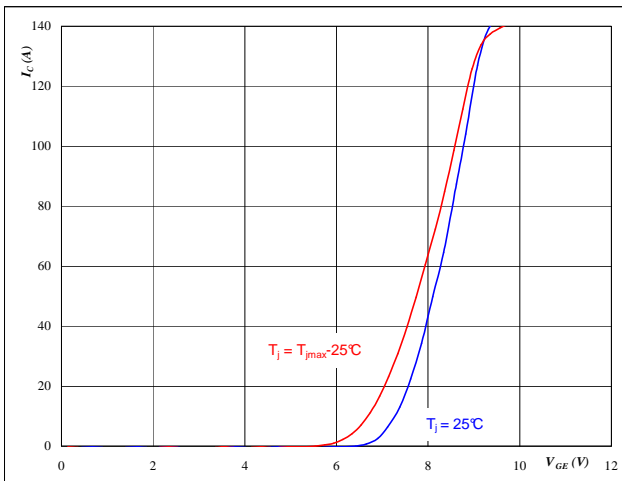


At
 $t_p = 250 \mu s$
 $T_j = 125 \text{ } ^\circ C$
 V_{GE} from 7 V to 17 V in steps of 1 V

Figure 3 IGBT

Typical transfer characteristics

$I_C = f(V_{GE})$

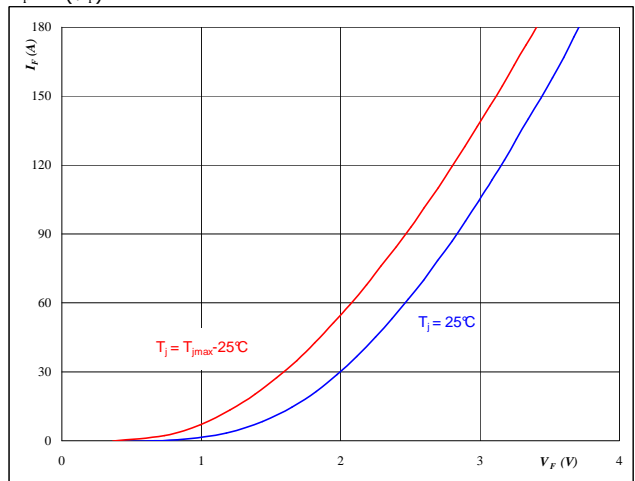


At
 $t_p = 250 \mu s$
 $V_{CE} = 10 V$

Figure 4 FWD

Typical diode forward current as a function of forward voltage

$I_F = f(V_F)$



At
 $t_p = 250 \mu s$



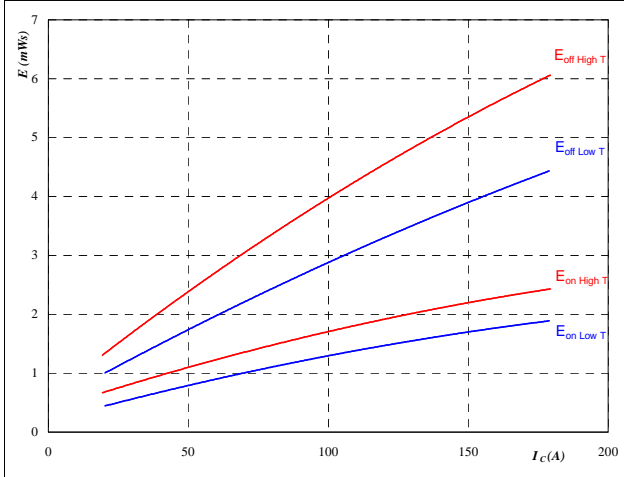
Neutral Point

Neutral Point IGBT and Half Bridge FWD

Figure 5 IGBT

Typical switching energy losses
as a function of collector current

$E = f(I_C)$



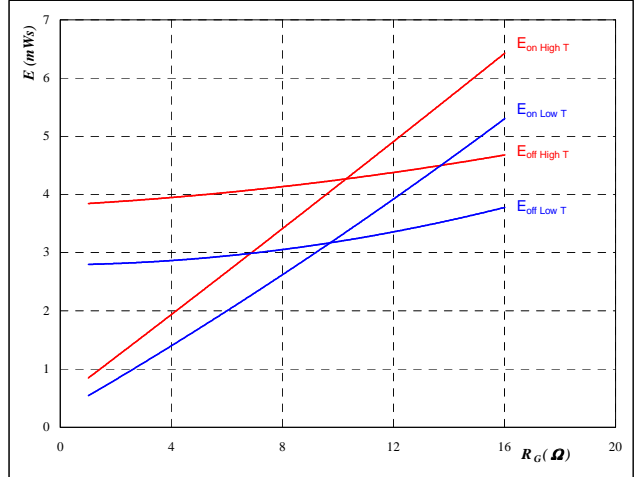
With an inductive load at

- $T_j = 25/125 \text{ } ^\circ\text{C}$
- $V_{CE} = 350 \text{ V}$
- $V_{GE} = \pm 15 \text{ V}$
- $R_{gon} = 4 \text{ } \Omega$
- $R_{goff} = 4 \text{ } \Omega$

Figure 6 IGBT

Typical switching energy losses
as a function of gate resistor

$E = f(R_G)$



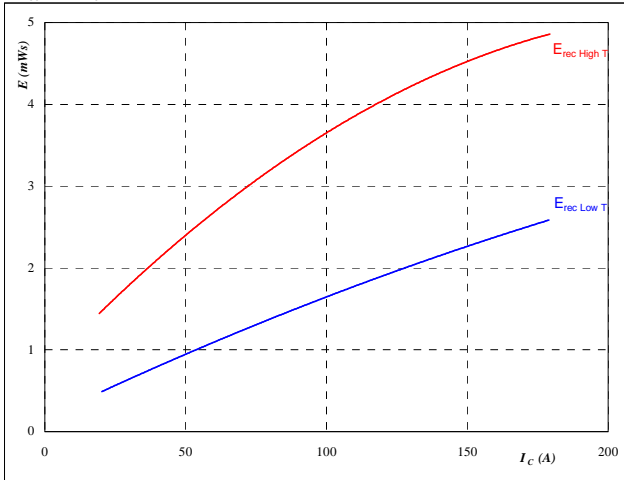
With an inductive load at

- $T_j = 25/125 \text{ } ^\circ\text{C}$
- $V_{CE} = 350 \text{ V}$
- $V_{GE} = \pm 15 \text{ V}$
- $I_C = 100 \text{ A}$

Figure 7 FWD

Typical reverse recovery energy loss
as a function of collector current

$E_{rec} = f(I_C)$



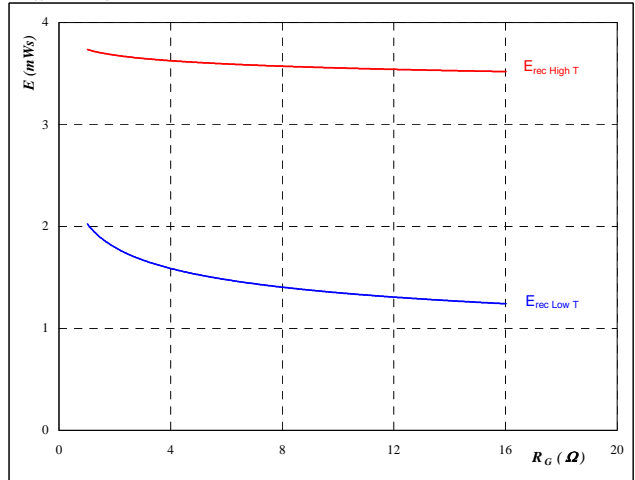
With an inductive load at

- $T_j = 25/125 \text{ } ^\circ\text{C}$
- $V_{CE} = 350 \text{ V}$
- $V_{GE} = \pm 15 \text{ V}$
- $R_{gon} = 4 \text{ } \Omega$

Figure 8 FWD

Typical reverse recovery energy loss
as a function of gate resistor

$E_{rec} = f(R_G)$



With an inductive load at

- $T_j = 25/125 \text{ } ^\circ\text{C}$
- $V_{CE} = 350 \text{ V}$
- $V_{GE} = \pm 15 \text{ V}$
- $I_C = 100 \text{ A}$

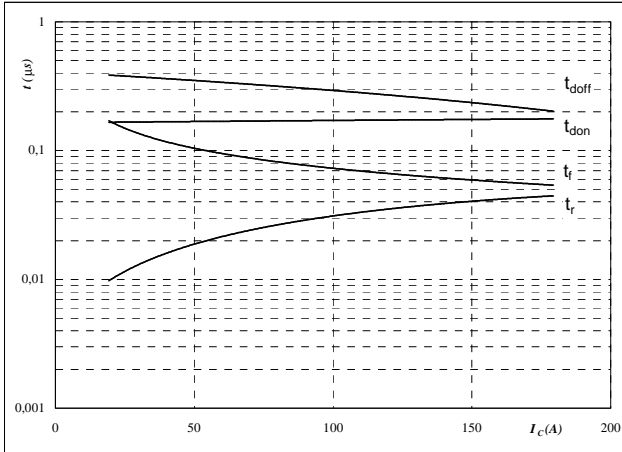
Neutral Point

Neutral Point IGBT and Half Bridge FWD

Figure 9 IGBT

Typical switching times as a function of collector current

$$t = f(I_C)$$



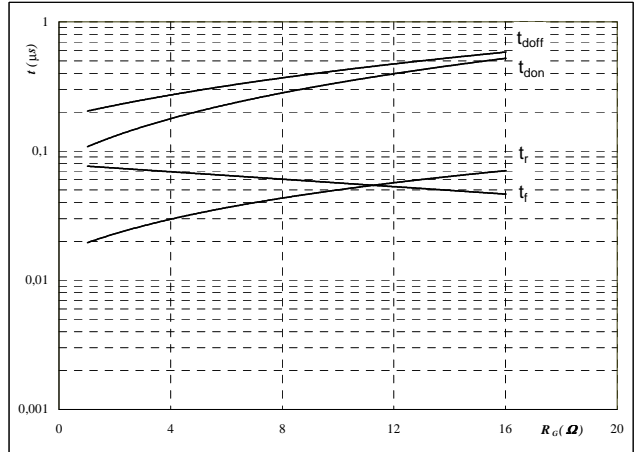
With an inductive load at

$T_j = 125 \text{ } ^\circ\text{C}$
 $V_{CE} = 350 \text{ V}$
 $V_{GE} = \pm 15 \text{ V}$
 $R_{gon} = 4 \text{ } \Omega$
 $R_{goff} = 4 \text{ } \Omega$

Figure 10 IGBT

Typical switching times as a function of gate resistor

$$t = f(R_G)$$



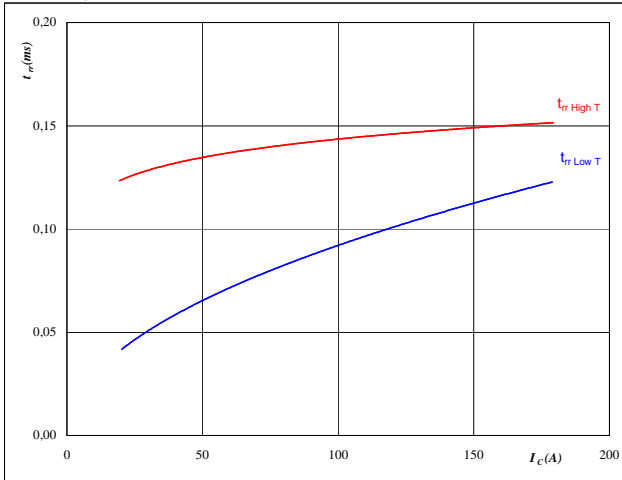
With an inductive load at

$T_j = 125 \text{ } ^\circ\text{C}$
 $V_{CE} = 350 \text{ V}$
 $V_{GE} = \pm 15 \text{ V}$
 $I_C = 100 \text{ A}$

Figure 11 FWD

Typical reverse recovery time as a function of collector current

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



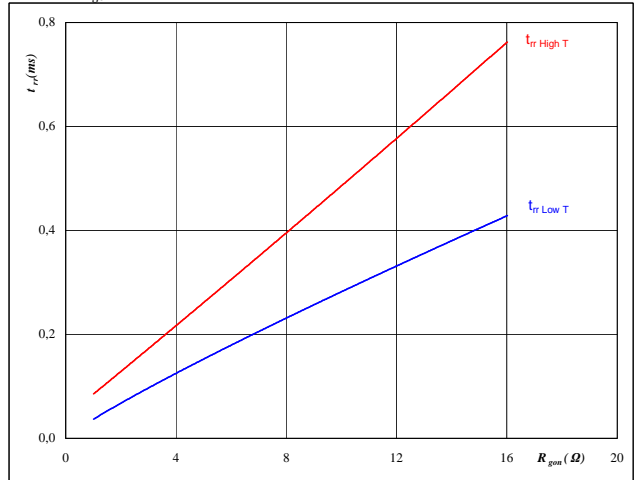
At

$T_j = 25/125 \text{ } ^\circ\text{C}$
 $V_{CE} = 350 \text{ V}$
 $V_{GE} = \pm 15 \text{ V}$
 $R_{gon} = 4 \text{ } \Omega$

Figure 12 FWD

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

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



At

$T_j = 25/125 \text{ } ^\circ\text{C}$
 $V_R = 350 \text{ V}$
 $I_F = 100 \text{ A}$
 $V_{GE} = \pm 15 \text{ V}$



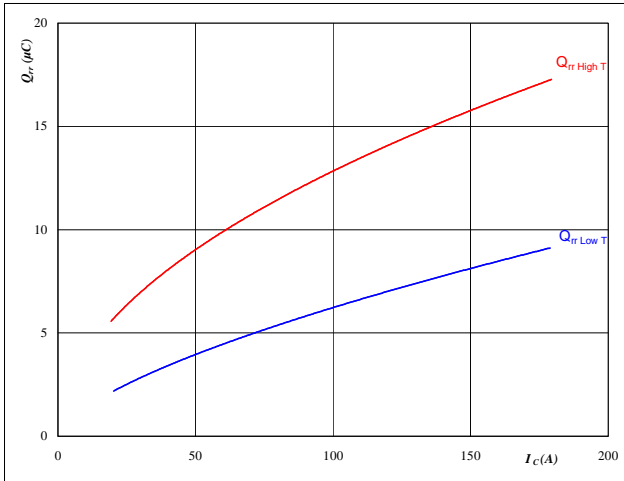
Neutral Point

Neutral Point IGBT and Half Bridge FWD

Figure 13 FWD

Typical reverse recovery charge as a function of collector current

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

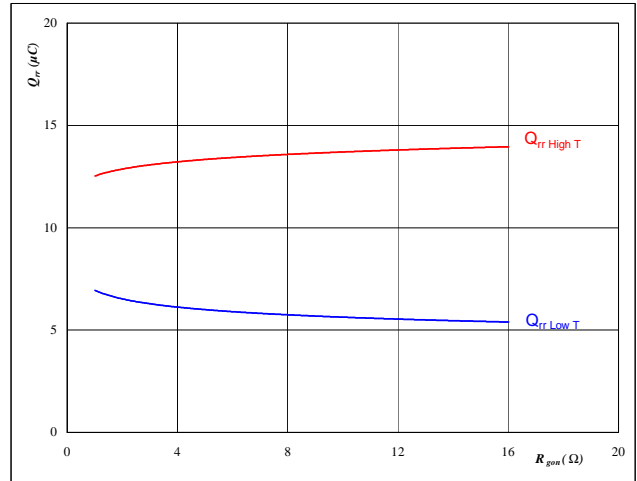


At
 $T_j = 25/125$ °C
 $V_{CE} = 350$ V
 $V_{GE} = \pm 15$ V
 $R_{gon} = 4$ Ω

Figure 14 FWD

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

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

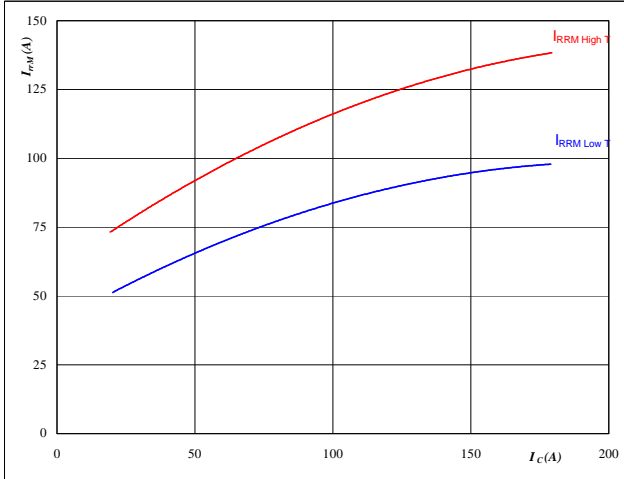


At
 $T_j = 25/125$ °C
 $V_R = 350$ V
 $I_F = 100$ A
 $V_{GE} = \pm 15$ V

Figure 15 FWD

Typical reverse recovery current as a function of collector current

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

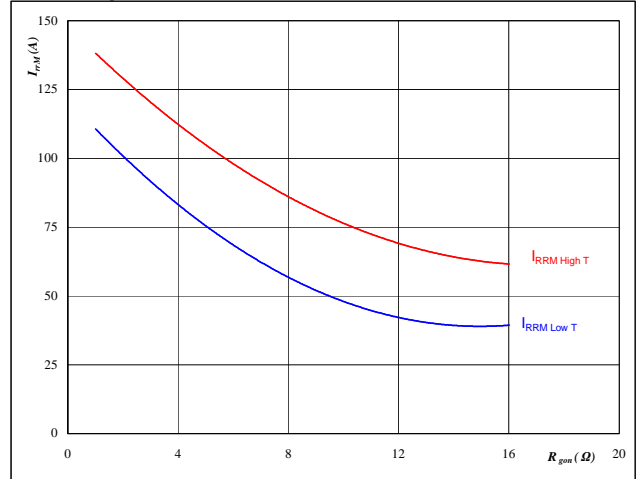


At
 $T_j = 25/125$ °C
 $V_{CE} = 350$ V
 $V_{GE} = \pm 15$ V
 $R_{gon} = 4$ Ω

Figure 16 FWD

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

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



At
 $T_j = 25/125$ °C
 $V_R = 350$ V
 $I_F = 100$ A
 $V_{GE} = \pm 15$ V



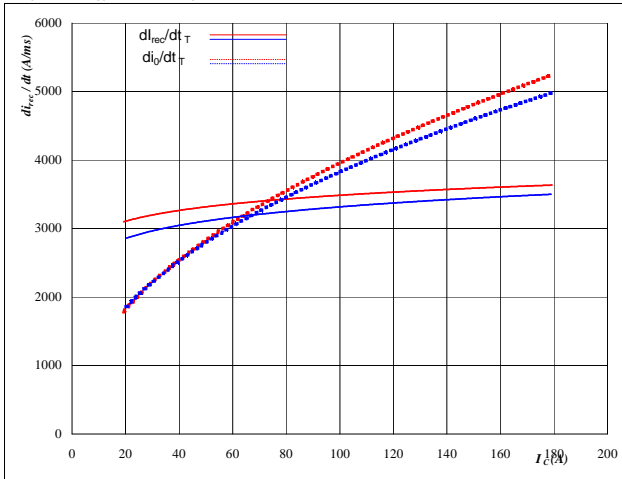
Neutral Point

Neutral Point IGBT and Half Bridge FWD

Figure 17 FWD

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

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

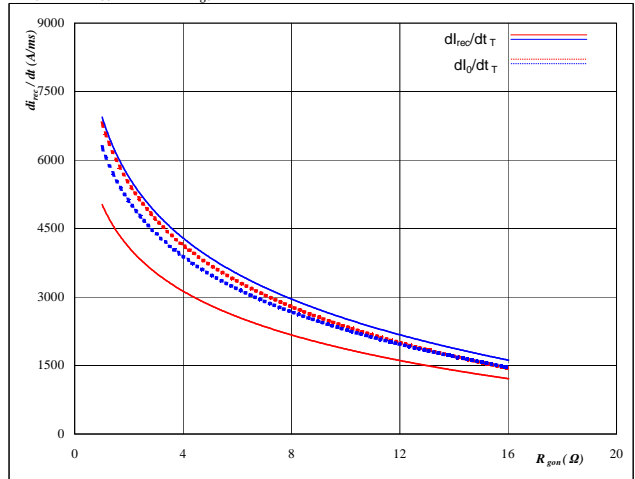


At
 $T_j = 25/125 \text{ } ^\circ\text{C}$
 $V_{CE} = 350 \text{ V}$
 $V_{GE} = \pm 15 \text{ V}$
 $R_{gon} = 4 \text{ } \Omega$

Figure 18 FWD

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

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

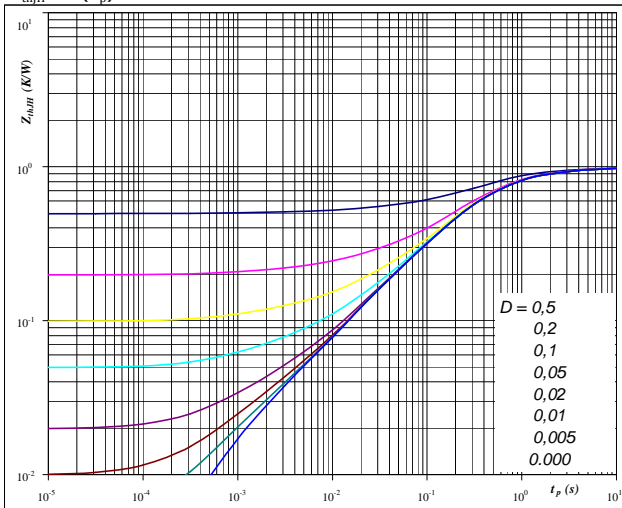


At
 $T_j = 25/125 \text{ } ^\circ\text{C}$
 $V_R = 350 \text{ V}$
 $I_F = 100 \text{ A}$
 $V_{GE} = \pm 15 \text{ V}$

Figure 19 IGBT

IGBT transient thermal impedance as a function of pulse width

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



At
 $D = t_p / T$
 $R_{thjH} = 0,99 \text{ K/W}$

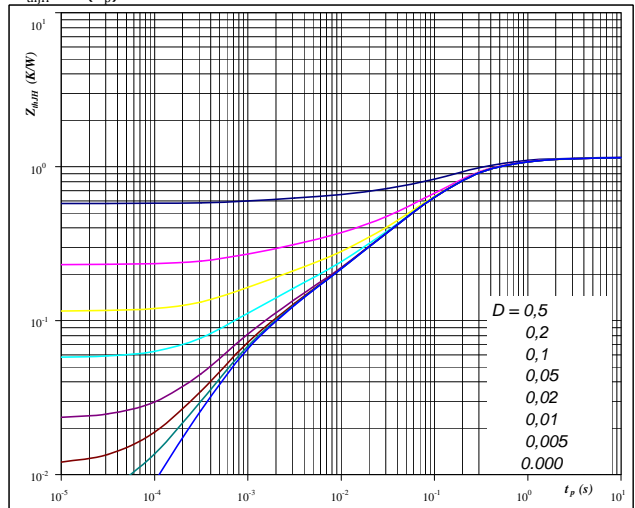
IGBT thermal model values

R (K/W)	Tau (s)
0,08	6,3E+00
0,24	1,1E+00
0,52	2,8E-01
0,09	6,6E-02
0,05	1,3E-02
0,02	1,2E-03

Figure 20 FWD

FWD transient thermal impedance as a function of pulse width

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



At
 $D = t_p / T$
 $R_{thjH} = 1,15 \text{ K/W}$

FWD thermal model values

R (K/W)	Tau (s)
0,05	4,9E+00
0,13	8,2E-01
0,59	1,8E-01
0,22	4,7E-02
0,10	7,8E-03
0,07	9,8E-04



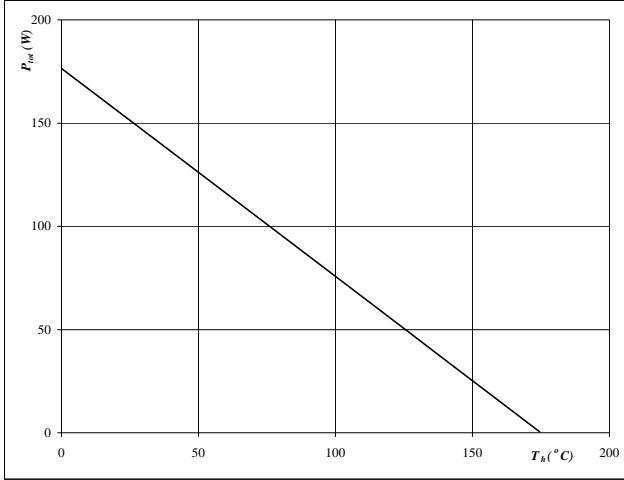
Neutral Point

Neutral Point IGBT and Half Bridge FWD

Figure 21 IGBT

Power dissipation as a function of heatsink temperature

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

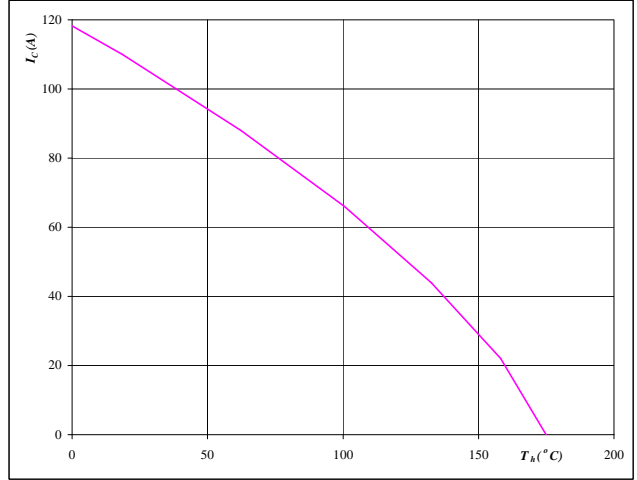


At
T_j = 175 °C

Figure 22 IGBT

Collector current as a function of heatsink temperature

$$I_C = f(T_h)$$

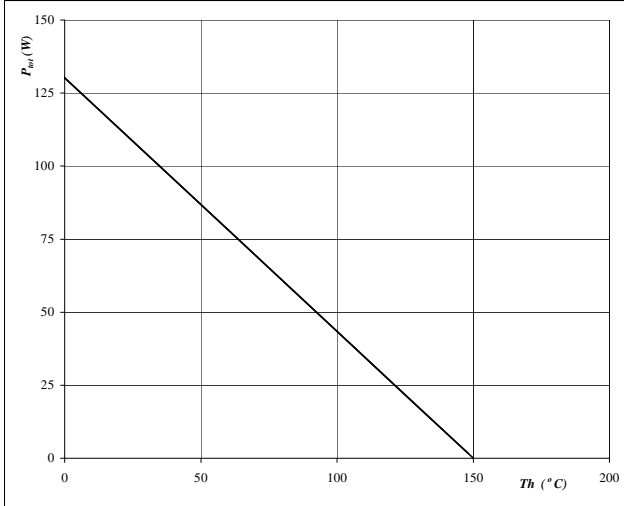


At
T_j = 175 °C
V_{GE} = 15 V

Figure 23 FWD

Power dissipation as a function of heatsink temperature

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

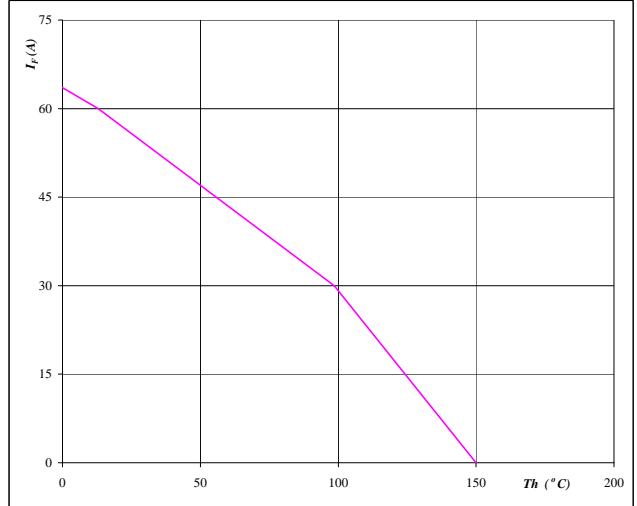


At
T_j = 150 °C

Figure 24 FWD

Forward current as a function of heatsink temperature

$$I_F = f(T_h)$$



At
T_j = 150 °C

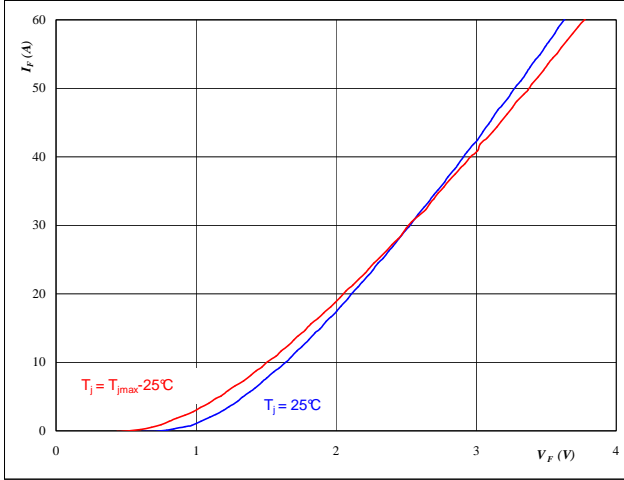


NP IGBT Inverse Diode

Figure 25 NP IGBT Inverse Diode

Typical diode forward current as a function of forward voltage

$I_F = f(V_F)$

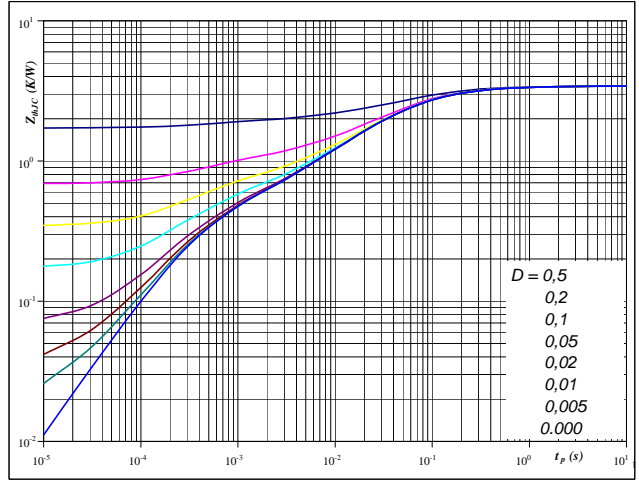


At
 $t_p = 250 \mu s$

Figure 26 NP IGBT Inverse Diode

Diode transient thermal impedance as a function of pulse width

$Z_{th(jc)} = f(t_p)$

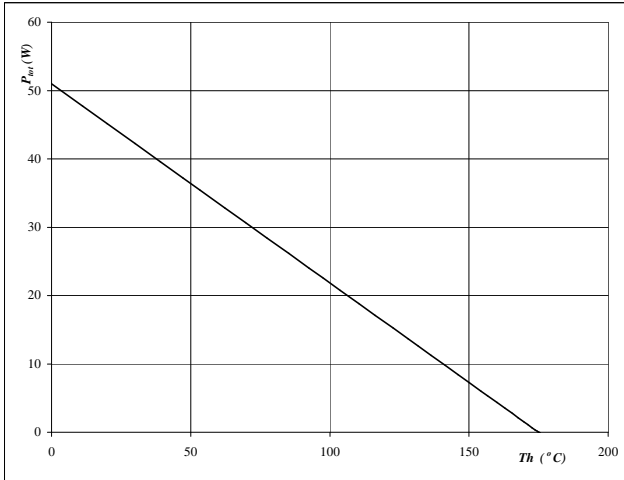


At
 $D = t_p / T$
 $R_{th(jc)} = 3,43 \text{ K/W}$

Figure 27 NP IGBT Inverse Diode

Power dissipation as a function of heatsink temperature

$P_{tot} = f(T_h)$

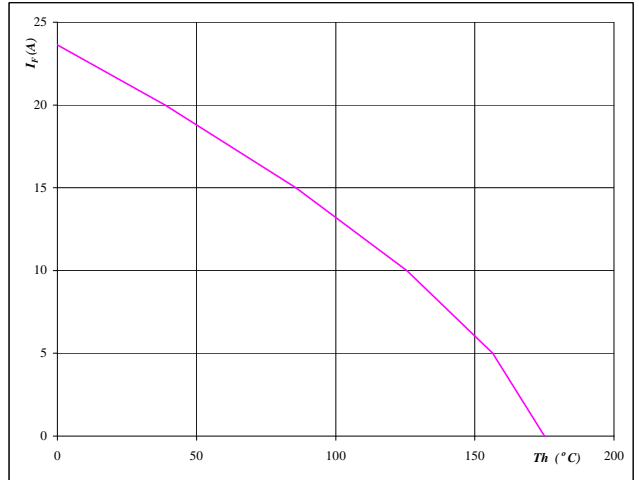


At
 $T_j = 175 \text{ °C}$

Figure 28 NP IGBT Inverse Diode

Forward current as a function of heatsink temperature

$I_F = f(T_h)$



At
 $T_j = 175 \text{ °C}$

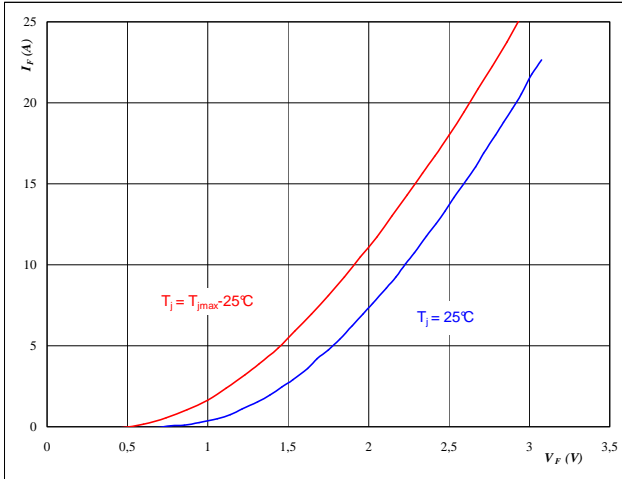


Half Bridge Inverse Diode

Figure 1 Half Bridge Inverse Diode

Typical diode forward current as a function of forward voltage

$I_F = f(V_F)$

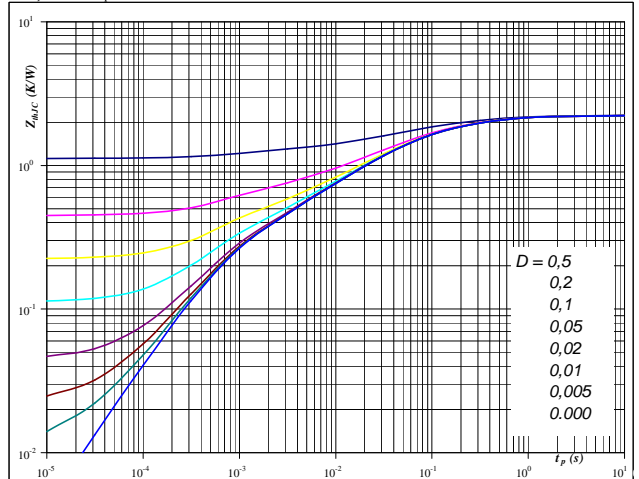


At
 $t_p = 250 \mu s$

Figure 2 Half Bridge Inverse Diode

Diode transient thermal impedance as a function of pulse width

$Z_{th(H)} = f(t_p)$

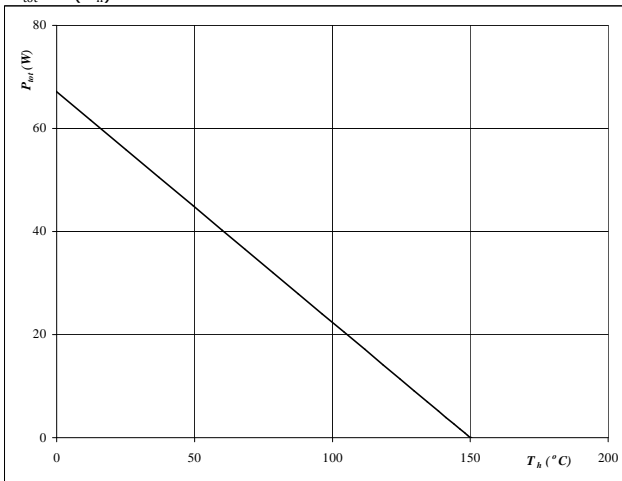


At
 $D = t_p / T$
 $R_{th(H)} = 2,24 \text{ K/W}$

Figure 3 Half Bridge Inverse Diode

Power dissipation as a function of heatsink temperature

$P_{tot} = f(T_h)$

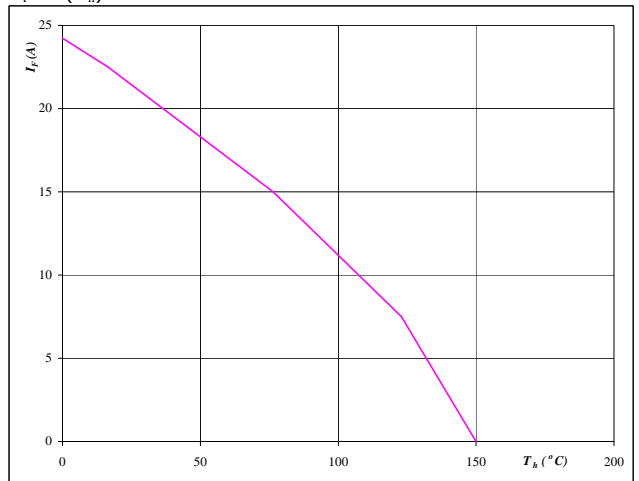


At
 $T_j = 150 \text{ } ^\circ C$

Figure 4 Half Bridge Inverse Diode

Forward current as a function of heatsink temperature

$I_F = f(T_h)$



At
 $T_j = 150 \text{ } ^\circ C$

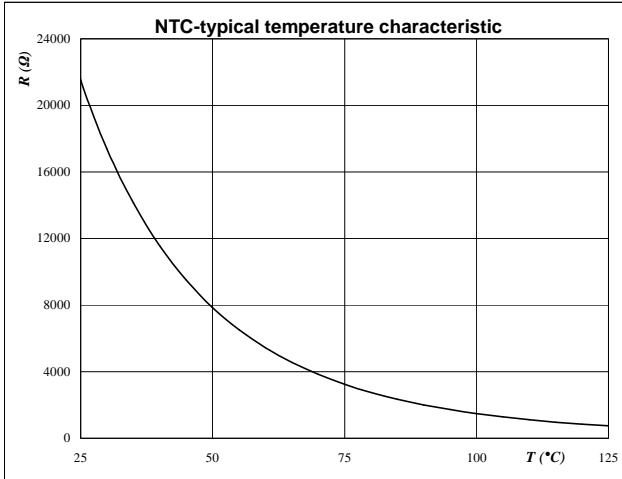


Thermistor

Figure 1 Thermistor

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

$$R_T = f(T)$$





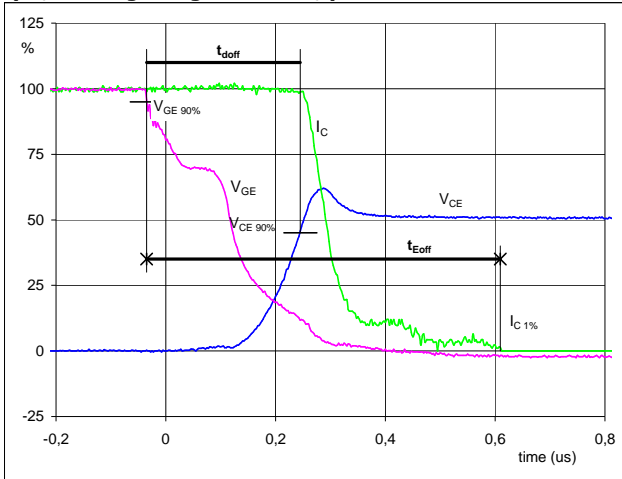
Switching Definitions Half Bridge

General conditions

T_j	=	125 °C
R_{gon}	=	4 Ω
R_{goff}	=	4 Ω

Figure 1 Half Bridge IGBT

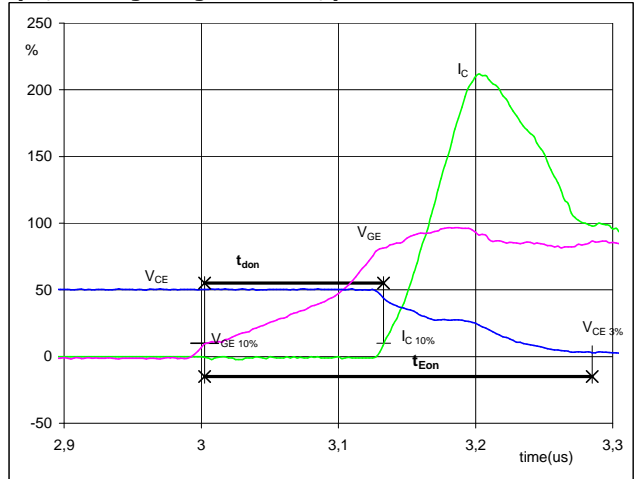
Turn-off Switching Waveforms & definition of t_{doff} t_{Eoff}
 (t_{Eoff} = integrating time for E_{off})



$V_{GE} (0\%) =$	-15	V
$V_{GE} (100\%) =$	15	V
$V_C (100\%) =$	700	V
$I_C (100\%) =$	100	A
$t_{doff} =$	0,27	μs
$t_{Eoff} =$	0,64	μs

Figure 2 Half Bridge IGBT

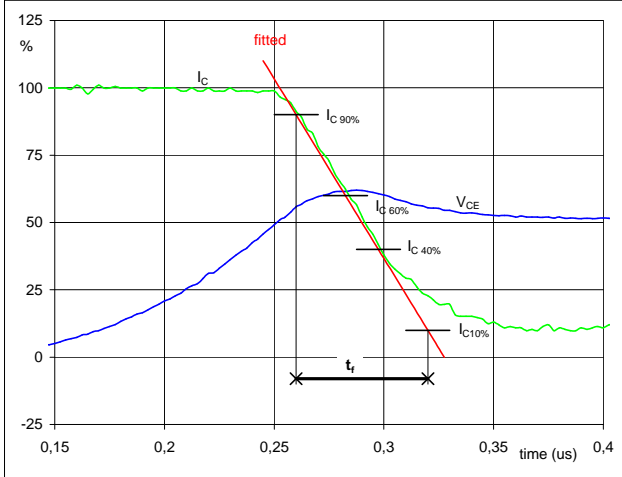
Turn-on Switching Waveforms & definition of t_{don} t_{Eon}
 (t_{Eon} = integrating time for E_{on})



$V_{GE} (0\%) =$	-15	V
$V_{GE} (100\%) =$	15	V
$V_C (100\%) =$	700	V
$I_C (100\%) =$	100	A
$t_{don} =$	0,13	μs
$t_{Eon} =$	0,28	μs

Figure 3 Half Bridge IGBT

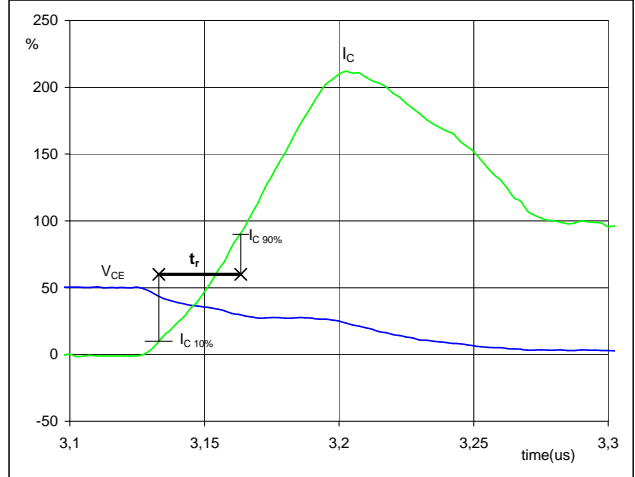
Turn-off Switching Waveforms & definition of t_f



$V_C (100\%) =$	700	V
$I_C (100\%) =$	100	A
$t_f =$	0,06	μs

Figure 4 Half Bridge IGBT

Turn-on Switching Waveforms & definition of t_r

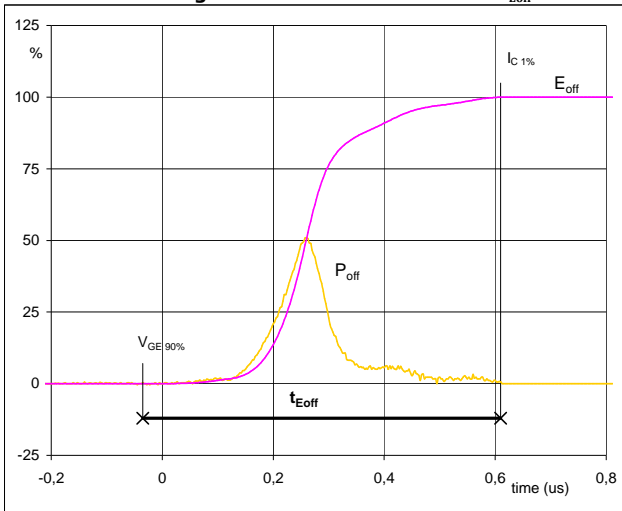


$V_C (100\%) =$	700	V
$I_C (100\%) =$	100	A
$t_r =$	0,03	μs



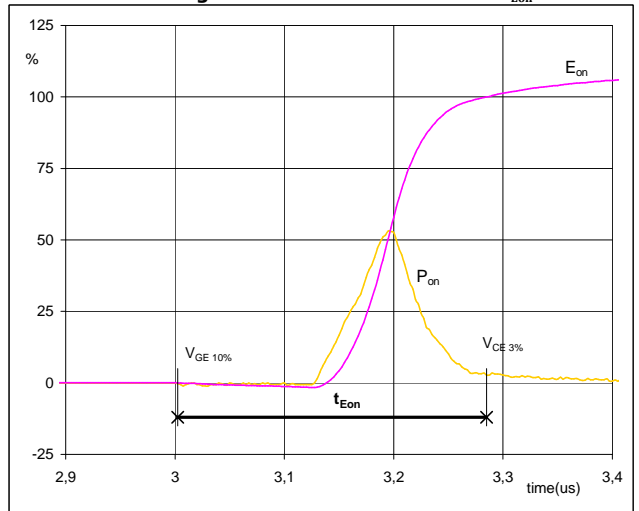
Switching Definitions Half Bridge

Figure 5 Half Bridge IGBT
 Turn-off Switching Waveforms & definition of t_{Eoff}



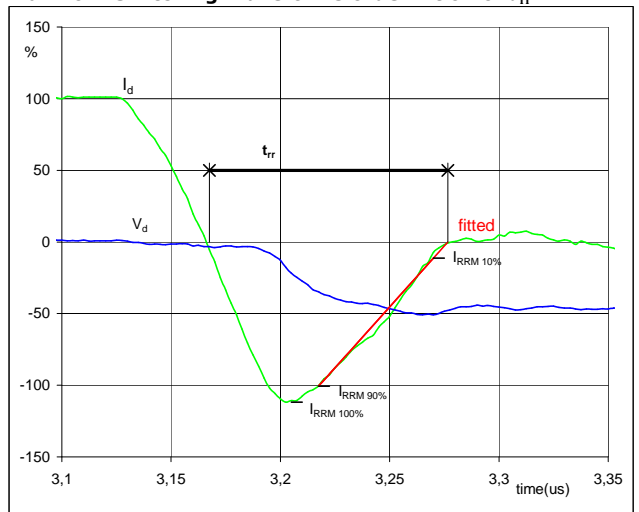
$P_{off} (100\%) = 70,11 \text{ kW}$
 $E_{off} (100\%) = 4,19 \text{ mJ}$
 $t_{Eoff} = 0,64 \text{ }\mu\text{s}$

Figure 6 Half Bridge IGBT
 Turn-on Switching Waveforms & definition of t_{Eon}



$P_{on} (100\%) = 70,11 \text{ kW}$
 $E_{on} (100\%) = 2,60 \text{ mJ}$
 $t_{Eon} = 0,28 \text{ }\mu\text{s}$

Figure 7 NP FWD
 Turn-off Switching Waveforms & definition of t_{rr}



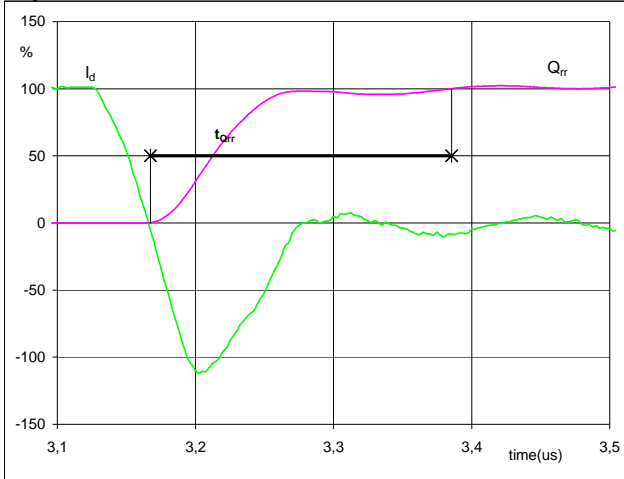
$V_d (100\%) = 700 \text{ V}$
 $I_d (100\%) = 100 \text{ A}$
 $I_{RRM} (100\%) = -113 \text{ A}$
 $t_{rr} = 0,11 \text{ }\mu\text{s}$



Switching Definitions Half Bridge

Figure 8 NP FWD

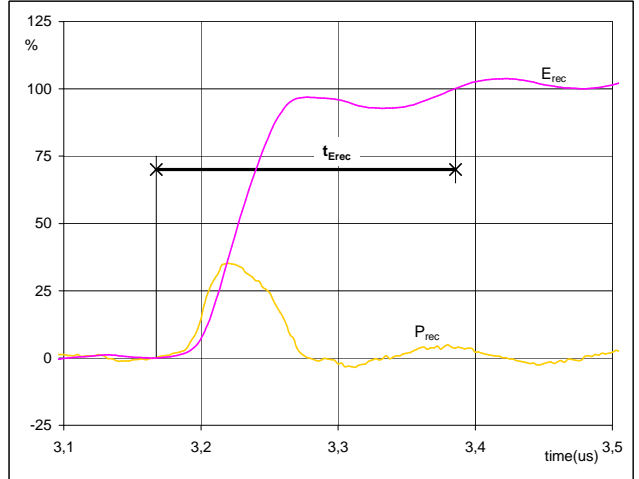
Turn-on Switching Waveforms & definition of t_{Qrr}
(t_{Qrr} = integrating time for Q_{rr})



I_d (100%) =	100	A
Q_{rr} (100%) =	7,16	μC
t_{Qrr} =	0,22	μs

Figure 9 NP FWD

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

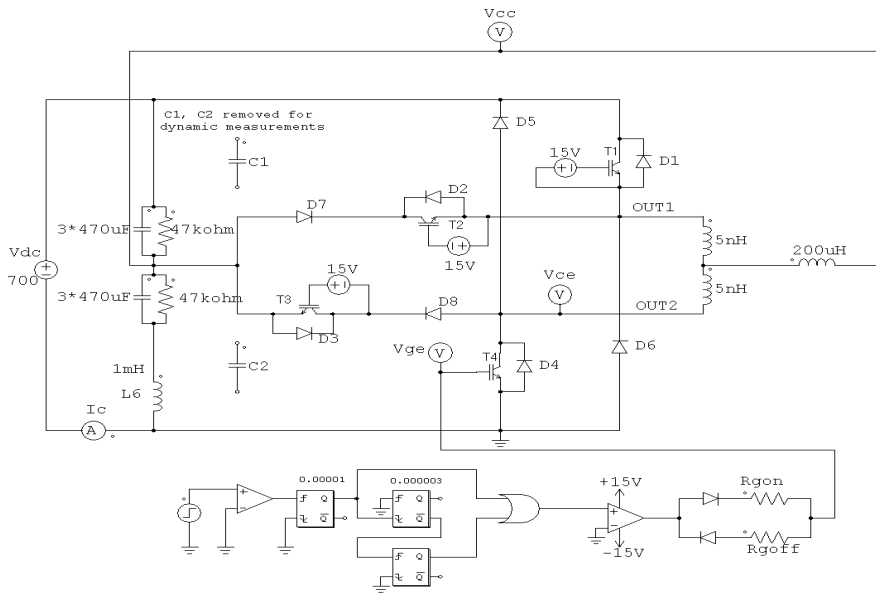


P_{rec} (100%) =	70,11	kW
E_{rec} (100%) =	1,38	mJ
t_{Erec} =	0,22	μs

Measurement circuits

Figure 10

BUCK stage switching measurement circuit



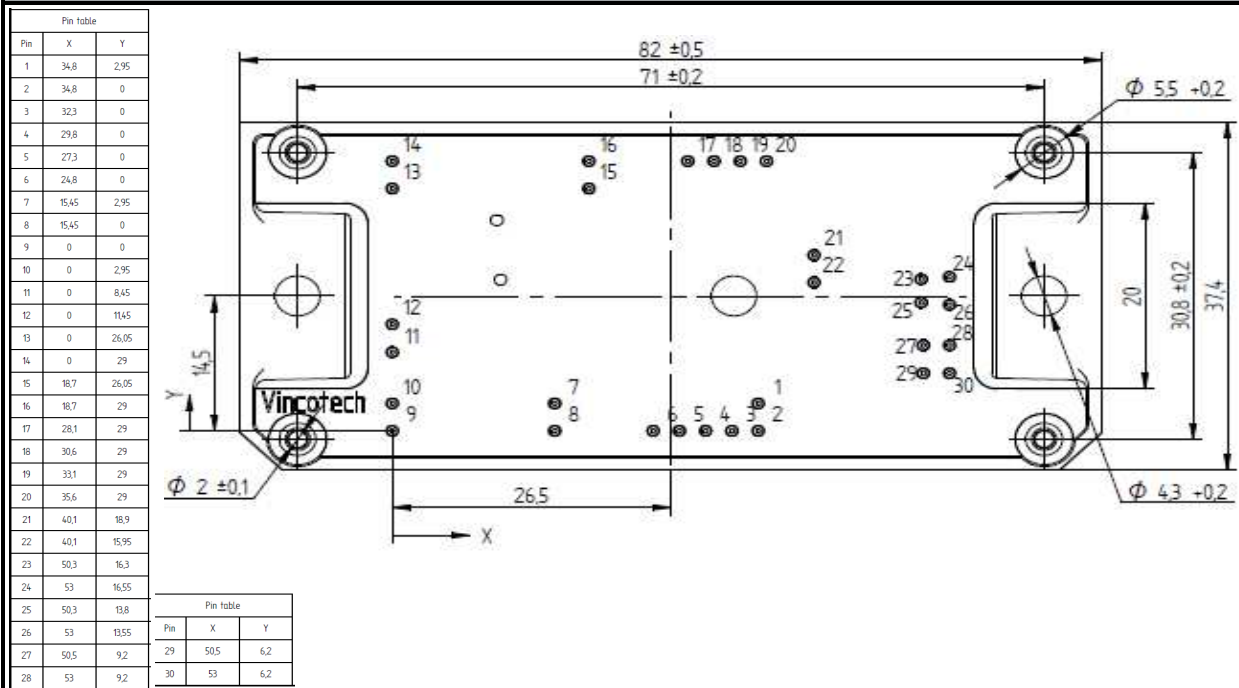


Ordering Code and Marking - Outline - Pinout

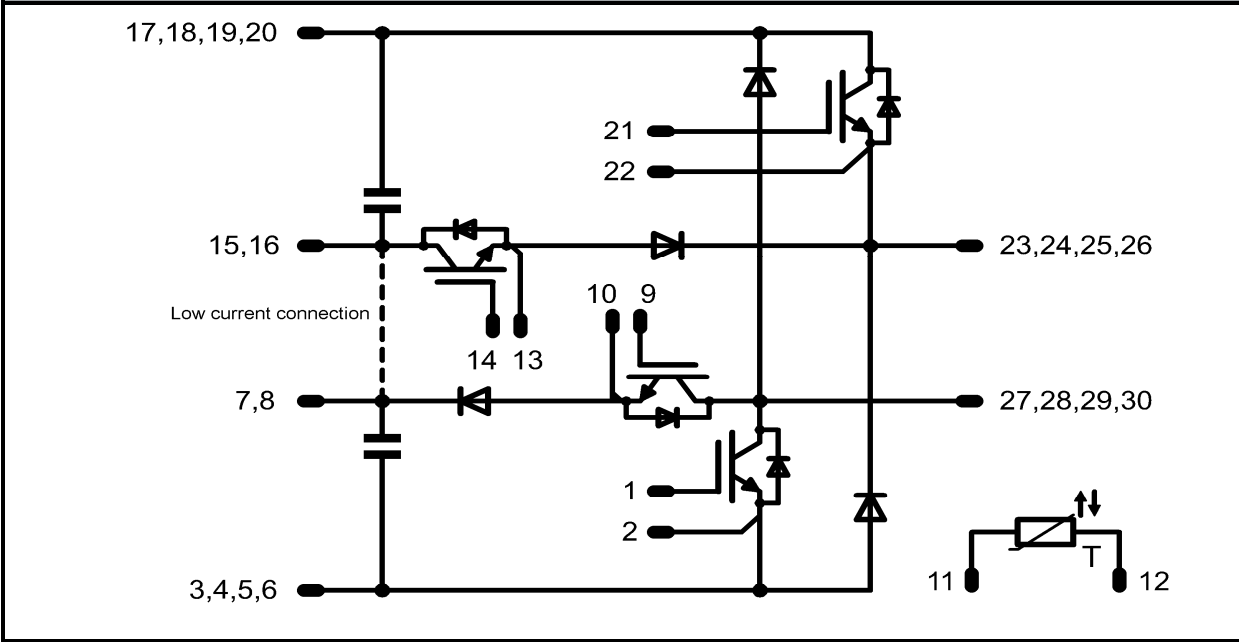
Ordering Code & Marking

Version	Ordering Code	in DataMatrix as	in packaging barcode as
without thermal paste with solder pins	10-FY12NMA160SH01-M820F18	M820F	M820-F
without thermal paste with pressfit pins	10-PY12NMA160SH01-M820F18Y	M820FY	M820-FY

Outline



Pinout



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