



<i>flowANPC 1 split</i>	1500 V / 9 mΩ
<div style="background-color: #eee; padding: 2px; text-align: center; font-weight: bold; margin-bottom: 5px;">Features</div> <ul style="list-style-type: none"> Split Advanced NPC topology Ultra-high switching frequency with SiC MOSFETs Split topology for better thermal performance No x-conduction at high frequencies 	<div style="background-color: #eee; padding: 2px; text-align: center; font-weight: bold; margin-bottom: 5px;">flow 1 12 mm housing</div> <div style="display: flex; justify-content: space-around; align-items: center;"> </div> <div style="display: flex; justify-content: space-around; margin-top: 5px;"> LC59F88T LC69F88T </div>
<div style="background-color: #eee; padding: 2px; text-align: center; font-weight: bold; margin-bottom: 5px;">Target applications</div> <ul style="list-style-type: none"> Solar Inverters 	<div style="background-color: #eee; padding: 2px; text-align: center; font-weight: bold; margin-bottom: 5px;">Schematic</div> <div style="display: flex; justify-content: space-around; align-items: center;"> </div> <div style="display: flex; justify-content: space-around; margin-top: 5px;"> LC59F88T LC69F88T </div>
<div style="background-color: #eee; padding: 2px; text-align: center; font-weight: bold; margin-bottom: 5px;">Types</div> <ul style="list-style-type: none"> 10-PG12NAB009CS04-LC59F88T 10-PG12NAC009CS04-LC69F88T 	

Maximum Ratings

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

Parameter	Symbol	Condition	Value	Unit
AC Switch				
Drain-source voltage	V_{DSS}		1200	V
Drain current	I_D	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	141	A
Peak drain current	I_{DM}	t_p limited by T_{jmax}	800	A
Total power dissipation	P_{tot}	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	346	W
Gate-source voltage	V_{GSS}		-10/+20	V
Maximum Junction Temperature	T_{jmax}		175	°C



Maximum Ratings

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

Parameter	Symbol	Condition	Value	Unit
AC Diode				
Peak repetitive reverse voltage	V_{RRM}		1200	V
Continuous (direct) forward current	I_F	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	85	A
Repetitive peak forward current	I_{FRM}		252	A
Total power dissipation	P_{tot}	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	243	W
Maximum junction temperature	T_{jmax}		175	°C
Neutral Point Switch				
Collector-emitter voltage	V_{CES}		1200	V
Collector current	I_C	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	149	A
Repetitive peak collector current	I_{CRM}	t_p limited by T_{jmax}	300	A
Total power dissipation	P_{tot}	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	287	W
Gate-emitter voltage	V_{GES}		±20	V
Short circuit ratings	t_{SC}	$V_{GE} = 15\text{ V}$ $V_{CE} = 800\text{ V}$ $T_j = 150\text{ °C}$	9,5	µs
Maximum junction temperature	T_{jmax}		175	°C
DC-Link Diode				
Peak repetitive reverse voltage	V_{RRM}		1200	V
Continuous (direct) forward current	I_F	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	86	A
Repetitive peak forward current	I_{FRM}		200	A
Total power dissipation	P_{tot}	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	158	W
Maximum junction temperature	T_{jmax}		175	°C



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Maximum Ratings

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

Parameter	Symbol	Condition	Value	Unit
Neutral Point Switch Prot. Diode				
Peak repetitive reverse voltage	V_{RRM}		1200	V
Continuous (direct) forward current	I_F	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	21	A
Surge (non-repetitive) forward current	I_{FSM}	50 Hz Single Half Sine Wave $t_p = 10\text{ ms}$ $T_j = 25\text{ °C}$	65	A
Surge current capability	I^2t		21	A ² s
Total power dissipation	P_{tot}	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	70	W
Maximum junction temperature	T_{jmax}		175	°C

DC-Link Switch

Collector-emitter voltage	V_{CES}		1200	V
Collector current	I_C	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	149	A
Repetitive peak collector current	I_{CRM}	t_p limited by T_{jmax}	300	A
Total power dissipation	P_{tot}	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	287	W
Gate-emitter voltage	V_{GES}		±20	V
Short circuit ratings	t_{SC}	$V_{GE} = 15\text{ V}$ $V_{CE} = 800\text{ V}$ $T_j = 150\text{ °C}$	9,5	µs
Maximum junction temperature	T_{jmax}		175	°C

Neutral Point Diode

Peak repetitive reverse voltage	V_{RRM}		1200	V
Continuous (direct) forward current	I_F	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	111	A
Repetitive peak forward current	I_{FRM}		300	A
Total power dissipation	P_{tot}	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	183	W
Maximum junction temperature	T_{jmax}		175	°C



Maximum Ratings

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

Parameter	Symbol	Condition	Value	Unit
DC-Link Switch Prot. Diode				
Peak repetitive reverse voltage	V_{RRM}		1200	V
Continuous (direct) forward current	I_F	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	86	A
Repetitive peak forward current	I_{FRM}		200	A
Total power dissipation	P_{tot}	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	158	W
Maximum junction temperature	T_{jmax}		175	°C

Capacitor (GS)

Maximum DC voltage	V_{MAX}		25	V
Operation Temperature	T_{op}		-55...+125	°C

Module Properties

Thermal Properties

Storage temperature	T_{stg}		-40...+125	°C
Operation temperature under switching condition	T_{top}		-40...($T_{jmax} - 25$)	°C

Isolation Properties

Isolation voltage	V_{isol}	DC Test Voltage* $t_p = 2\text{ s}$	6000	V
Creepage distance			min. 12,7	mm
Clearance			8,33	mm
Comparative Tracking Index	CTI		≥ 600	

*100 % tested in production



Vincotech

10-PG12NAB009CS04-LC59F88T
10-PG12NAC009CS04-LC69F88T
 datasheet

Characteristic Values

Parameter	Symbol	Conditions					Value			Unit
		V_{GE} [V]	V_{CE} [V]	I_C [A]	T_j [°C]	Min	Typ	Max		

AC Switch

Static

Parameter	Symbol	Conditions	V_{GE} [V]	V_{GS} [V]	V_{CE} [V]	V_{DS} [V]	I_C [A]	I_D [A]	I_F [A]	T_j [°C]	Min	Typ	Max	Unit
Drain-source on-state resistance	$r_{DS(on)}$		15				100	25 125 150				7 9 10	12	mΩ
Gate-source threshold voltage	$V_{GS(th)}$	$V_{GS} = V_{DS}$					0,05	25			3,5	4,5	5,7	V
Gate to Source Leakage Current	I_{GSS}		-10/+20	0				25					600	nA
Zero Gate Voltage Drain Current	I_{DSS}		0	1200				25				10	1000	μA
Internal gate resistance	r_g	$f = 1\text{MHz}$										0,8		Ω
Gate charge	Q_g											310		nC
Gate to source charge	Q_{GS}		-5/+15	800	100	25						115		
Gate to drain charge	Q_{GD}											55		
Short-circuit input capacitance	C_{iss}	$f = 1\text{MHz}$	0	800				25				10000		pF
Reverse transfer capacitance	C_{rss}											65		

Reverse Diode Static

Parameter	Symbol	Conditions	V_{GE} [V]	V_{GS} [V]	V_{CE} [V]	V_{DS} [V]	I_C [A]	I_D [A]	I_F [A]	T_j [°C]	Min	Typ	Max	Unit
Diode forward voltage	V_{SD}		-5				100	25				4,1	5	V

Thermal

Parameter	Symbol	Conditions	V_{GE} [V]	V_{GS} [V]	V_{CE} [V]	V_{DS} [V]	I_C [A]	I_D [A]	I_F [A]	T_j [°C]	Min	Typ	Max	Unit
Thermal resistance junction to sink	$R_{th(j-s)}$	$\lambda_{paste} = 3,4\text{ W/mK}$ (PSX)										0,27		K/W

AC Diode

Static

Parameter	Symbol	Conditions	V_{GE} [V]	V_{GS} [V]	V_{CE} [V]	V_{DS} [V]	I_C [A]	I_D [A]	I_F [A]	T_j [°C]	Min	Typ	Max	Unit
Forward voltage	V_F						60	25 125				1,63 2,04	1,7	V
Reverse leakage current	I_R					1200		25					1200	μA

Thermal

Parameter	Symbol	Conditions	V_{GE} [V]	V_{GS} [V]	V_{CE} [V]	V_{DS} [V]	I_C [A]	I_D [A]	I_F [A]	T_j [°C]	Min	Typ	Max	Unit
Thermal resistance junction to sink	$R_{th(j-s)}$	$\lambda_{paste} = 3,4\text{ W/mK}$ (PSX)										0,39		K/W



Characteristic Values

Parameter	Symbol	Conditions					Value			Unit
		V_{GS} [V]	V_{GE} [V]	V_{DS} [V]	I_D [A]	T_j [°C]	Min	Typ	Max	

AC Real Open configuration

Switch Dynamic

Parameter	Symbol	Conditions	V_{GS} [V]	V_{GE} [V]	V_{DS} [V]	I_D [A]	T_j [°C]	Min	Typ	Max	Unit
Turn-on delay time	$t_{d(on)}$	$R_{gon} = 2 \Omega$ $R_{goff} = 2 \Omega$	-5 / 16	600	100	100	25		50		ns
							125		43		
							150		46		
Rise time	t_r						25		14		
							125		12		
							150		13		
Turn-off delay time	$t_{d(off)}$			25		68					
				125		72					
				150		74					
Fall time	t_f			25		21					
				125		27					
				150		27					
Turn-on energy (per pulse)	E_{on}	$Q_{rFWD} = 0,4 \mu C$ $Q_{rFWD} = 0,6 \mu C$ $Q_{rFWD} = 0,8 \mu C$					25		0,904		mWs
							125		0,680		
							150		0,515		
Turn-off energy (per pulse)	E_{off}						25		0,601		mWs
							125		0,687		
							150		0,702		

Diode Dynamic

Parameter	Symbol	Conditions	V_{GS} [V]	V_{GE} [V]	V_{DS} [V]	I_D [A]	T_j [°C]	Min	Typ	Max	Unit				
Peak recovery current	I_{RRM}	$di/dt = 6405 A/\mu s$ $di/dt = 9762 A/\mu s$ $di/dt = 8361 A/\mu s$	-5 / 16	600	100	100	25		32		A				
							125		47						
							150		44						
Reverse recovery time	t_{rr}								25		21				ns
									125		19				
									150		21				
Recovered charge	Q_r			25		0,414				μC					
				125		0,625									
				150		0,803									
Reverse recovered energy	E_{rec}			25		0,243				mWs					
				125		0,322									
				150		0,470									
Peak rate of fall of recovery current	$(di_{rr}/dt)_{max}$			25		3040				A/ μs					
				125		5917									
				150		4230									



Characteristic Values

Parameter	Symbol	Conditions					Value			Unit
		V_{GE} [V]	V_{CE} [V]	I_C [A]	T_j [°C]	Min	Typ	Max		

AC Reactive Open configuration

Switch Dynamic

Parameter	Symbol	Conditions	V_{GE} [V]	V_{CE} [V]	I_C [A]	T_j [°C]	Min	Typ	Max	Unit
Turn-on delay time	$t_{d(on)}$	$R_{gon} = 2 \Omega$ $R_{goff} = 2 \Omega$	-5 / 16	600	100	25		48		ns
						125		46		
						150		47		
Rise time	t_r	$R_{gon} = 2 \Omega$ $R_{goff} = 2 \Omega$	-5 / 16	600	100	25		13		ns
						125		13		
						150		13		
Turn-off delay time	$t_{d(off)}$	$R_{gon} = 2 \Omega$ $R_{goff} = 2 \Omega$	-5 / 16	600	100	25		74		ns
						125		77		
						150		78		
Fall time	t_f	$R_{gon} = 2 \Omega$ $R_{goff} = 2 \Omega$	-5 / 16	600	100	25		22		ns
						125		19		
						150		20		
Turn-on energy (per pulse)	E_{on}	$Q_{FWD} = 1 \mu C$ $Q_{FWD} = 1,2 \mu C$ $Q_{FWD} = 1,1 \mu C$	-5 / 16	600	100	25		0,983		mWs
						125		0,786		
						150		0,772		
Turn-off energy (per pulse)	E_{off}	$Q_{FWD} = 1 \mu C$ $Q_{FWD} = 1,2 \mu C$ $Q_{FWD} = 1,1 \mu C$	-5 / 16	600	100	25		0,369		mWs
						125		0,609		
						150		0,506		

Diode Dynamic

Parameter	Symbol	Conditions	V_{GE} [V]	V_{CE} [V]	I_C [A]	T_j [°C]	Min	Typ	Max	Unit
Peak recovery current	I_{RRM}	$di/dt = 8701 A/\mu s$ $di/dt = 9380 A/\mu s$ $di/dt = 7898 A/\mu s$	-5 / 16	600	100	25		55		A
						125		68		
						150		63		
Reverse recovery time	t_{rr}	$di/dt = 8701 A/\mu s$ $di/dt = 9380 A/\mu s$ $di/dt = 7898 A/\mu s$	-5 / 16	600	100	25		26		ns
						125		27		
						150		26		
Recovered charge	Q_r	$di/dt = 8701 A/\mu s$ $di/dt = 9380 A/\mu s$ $di/dt = 7898 A/\mu s$	-5 / 16	600	100	25		1,02		μC
						125		1,19		
						150		1,09		
Reverse recovered energy	E_{rec}	$di/dt = 8701 A/\mu s$ $di/dt = 9380 A/\mu s$ $di/dt = 7898 A/\mu s$	-5 / 16	600	100	25		0,555		mWs
						125		0,666		
						150		0,649		
Peak rate of fall of recovery current	$(di_{rr}/dt)_{max}$	$di/dt = 8701 A/\mu s$ $di/dt = 9380 A/\mu s$ $di/dt = 7898 A/\mu s$	-5 / 16	600	100	25		5747		A/ μs
						125		5808		
						150		6338		



Characteristic Values

Parameter	Symbol	Conditions					Value			Unit
		V_{GS} [V]	V_{GE} [V]	V_{DS} [V]	I_D [A]	T_j [°C]	Min	Typ	Max	

Neutral Point Switch

Static

Parameter	Symbol	$V_{GE} = V_{CE}$	V_{GS} [V]	V_{CE} [V]	I_C [A]	T_j [°C]	Min	Typ	Max	Unit
Gate-emitter threshold voltage	$V_{GE(th)}$				0,015	25	5,4	6	6,6	V
Collector-emitter saturation voltage	V_{CEsat}		15		150	25 125 150		1,57 1,80 1,86	1,85	V
Collector-emitter cut-off current	I_{CES}		0	1200		25			100	µA
Gate-emitter leakage current	I_{GES}		20	0		25			500	nA
Internal gate resistance	r_g							3		Ω
Input capacitance	C_{ies}							30000		pF
Output capacitance	C_{oes}		0	10		25		880		
Reverse transfer capacitance	C_{res}							320		
Gate charge	Q_g		15	600	150	25		1000		nC

Thermal

Parameter	Symbol	Value	Unit
Thermal resistance junction to sink	$R_{th(j-s)}$	$\lambda_{paste} = 3,4 \text{ W/mK}$ (PSX)	0,33 K/W

Dynamic

Parameter	Symbol	$R_{gon} = 2 \Omega$ $R_{goff} = 2 \Omega$	V_{GS} [V]	V_{CE} [V]	I_D [A]	T_j [°C]	Min	Typ	Max	Unit
Turn-on delay time	$t_{d(on)}$		±15	600	100	25 125 150		335		ns
Rise time	t_r						25 125 150	38 47 49		
Turn-off delay time	$t_{d(off)}$						25 125 150	304 351 363		
Fall time	t_f						25 125 150	101 139 142		
Turn-on energy (per pulse)	E_{on}	$Q_{tFWD} = 10,4 \mu\text{C}$ $Q_{tFWD} = 15 \mu\text{C}$ $Q_{tFWD} = 16,2 \mu\text{C}$				25 125 150		8,92 11,15 11,85		mWs
Turn-off energy (per pulse)	E_{off}					25 125 150		7,89 10,42 10,95		



Characteristic Values

Parameter	Symbol	Conditions					Value			Unit
		V_{GE} [V]	V_{CE} [V]	I_C [A]	T_j [°C]	Min	Typ	Max		

DC-Link Diode

Static

Parameter	Symbol	V_{GE} [V]	V_{CE} [V]	I_C [A]	T_j [°C]	Min	Typ	Max	Unit
Forward voltage	V_F			100	25 125 150		1,82 1,96 1,97	2,1	V
Reverse leakage current	I_R		1200		25			40	μA

Thermal

Parameter	Symbol	Conditions	Value	Unit
Thermal resistance junction to sink	$R_{th(j-s)}$	$\lambda_{paste} = 3,4$ W/mK (PSX)	0,60	K/W

Dynamic

Parameter	Symbol	V_{GE} [V]	V_{CE} [V]	I_C [A]	T_j [°C]	Min	Typ	Max	Unit
Peak recovery current	I_{RRM}				25 125 150		83 86 88		A
Reverse recovery time	t_{rr}				25 125 150		310 419 453		ns
Recovered charge	Q_r			±15	600	100	10,40 15,02 16,24		μC
Reverse recovered energy	E_{rec}				25 125 150		3,99 5,95 6,43		mWs
Peak rate of fall of recovery current	$(di_{rr}/dt)_{max}$				25 125 150		507 513 504		A/μs

Neutral Point Switch Prot. Diode

Static

Parameter	Symbol	V_{GE} [V]	V_{CE} [V]	I_C [A]	T_j [°C]	Min	Typ	Max	Unit
Forward voltage	V_F			15	25 125		2,37 2,47	2,71	V
Reverse leakage current	I_R		1200		25 150			60 1800	μA

Thermal

Parameter	Symbol	Conditions	Value	Unit
Thermal resistance junction to sink	$R_{th(j-s)}$	$\lambda_{paste} = 3,4$ W/mK (PSX)	1,35	K/W



Characteristic Values

Parameter	Symbol	Conditions					Value			Unit
		V_{GS} [V]	V_{GE} [V]	V_{DS} [V]	I_D [A]	T_j [°C]	Min	Typ	Max	

DC-Link Switch

Static

Gate-emitter threshold voltage	$V_{GE(th)}$	$V_{GE} = V_{CE}$				0,015	25	5,4	6	6,6	V
Collector-emitter saturation voltage	V_{CEsat}		15			150	25 125 150		1,57 1,80 1,86	1,85	V
Collector-emitter cut-off current	I_{CES}		0	1200			25			100	µA
Gate-emitter leakage current	I_{GES}		20	0			25			500	nA
Internal gate resistance	r_g								3		Ω
Input capacitance	C_{ies}								30000		pF
Output capacitance	C_{oes}		0	10		25			880		
Reverse transfer capacitance	C_{res}								320		
Gate charge	Q_g		15	600	150	25			1000		nC

Thermal

Thermal resistance junction to sink	$R_{th(j-s)}$	$\lambda_{paste} = 3,4 \text{ W/mK}$ (PSX)							0,33		K/W
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Dynamic

Turn-on delay time	$t_{d(on)}$	$R_{gon} = 2 \Omega$ $R_{goff} = 2 \Omega$	±15	600	100	25		317		ns
Rise time	t_r					125		335		
						150		350		
						25		36		
Turn-off delay time	$t_{d(off)}$					125		41		
		150		45						
		25		306						
Fall time	t_f	125		351						
		150		368						
		25		97						
Turn-on energy (per pulse)	E_{on}	$Q_{t-FWD} = 12,8 \mu\text{C}$ $Q_{t-FWD} = 20,8 \mu\text{C}$ $Q_{t-FWD} = 22,3 \mu\text{C}$				25		9,56		mWs
						125		13,18		
						150		13,42		
Turn-off energy (per pulse)	E_{off}					25		7,12		
						125		9,90		
						150		11,12		



Vincotech

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10-PG12NAC009CS04-LC69F88T
 datasheet

Characteristic Values

Parameter	Symbol	Conditions					Value			Unit
		V_{GE} [V]	V_{CE} [V]	I_C [A]	T_j [°C]	Min	Typ	Max		

Neutral Point Diode

Static

Parameter	Symbol	V_{GS} [V]	V_{DS} [V]	I_D [A]	T_j [°C]	Min	Typ	Max	Unit
Forward voltage	V_F			150	25 125 150		1,80 1,90 1,90	2,1	V
Reverse leakage current	I_R		1200		25			40	μA

Thermal

Parameter	Symbol	Conditions	Value	Unit
Thermal resistance junction to sink	$R_{th(j-s)}$	$\lambda_{paste} = 3,4$ W/mK (PSX)	0,52	K/W

Dynamic

Parameter	Symbol	dI/dt	I_D [A]	V_{GS} [V]	V_{DS} [V]	T_j [°C]	Min	Typ	Max	Unit
Peak recovery current	I_{RRM}		±15	600	100	25 125 150		117 120 118		A
Reverse recovery time	t_{rr}					25 125 150		268 406 454		ns
Recovered charge	Q_r	$dI/dt = 2578$ A/μs $dI/dt = 2565$ A/μs $dI/dt = 2545$ A/μs				25 125 150		12,79 20,79 22,27		μC
Reverse recovered energy	E_{rec}					25 125 150		4,36 7,63 8,66		mWs
Peak rate of fall of recovery current	$(di_{rr}/dt)_{max}$					25 125 150		865 626 632		A/μs

DC-Link Switch Prot. Diode

Static

Parameter	Symbol	V_{GS} [V]	V_{DS} [V]	I_D [A]	T_j [°C]	Min	Typ	Max	Unit
Forward voltage	V_F			100	25 125 150		1,82 1,96 1,97	2,1	V
Reverse leakage current	I_R		1200		25			40	μA

Thermal

Parameter	Symbol	Conditions	Value	Unit
Thermal resistance junction to sink	$R_{th(j-s)}$	$\lambda_{paste} = 3,4$ W/mK (PSX)	0,60	K/W

Capacitor (GS)

Parameter	Symbol	Conditions	Value	Unit
Capacitance	C		10	nF
Tolerance			-10	+10
Dissipation factor		$f = 1$ kHz		0,1



Vincotech

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 datasheet

Characteristic Values

Parameter	Symbol	Conditions					Value			Unit
		V_{GE} [V] V_{GS} [V]	V_{CE} [V] V_{DS} [V]	I_C [A] I_D [A]	I_F [A]	T_j [°C]	Min	Typ	Max	

Thermistor

Rated resistance	R					25		22		kΩ
Deviation of R_{100}	$\Delta_{R/R}$	$R_{100} = 1484 \Omega$				100	-5		5	%
Power dissipation	P					25		5		mW
Power dissipation constant						25		1,5		mW/K
B-value	$B_{(25/50)}$	Tol. ± 1 %				25		3962		K
B-value	$B_{(25/100)}$	Tol. ± 1 %				25		4000		K
Vincotech NTC Reference									I	

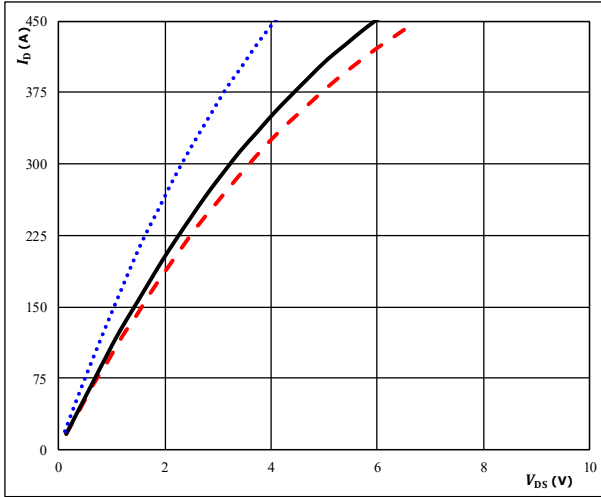


AC Switch Characteristics

figure 1. MOSFET

Typical output characteristics

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

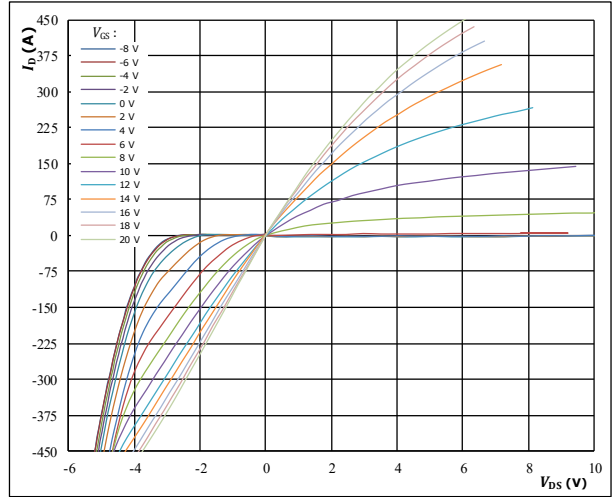


$t_p = 250 \mu\text{s}$
 $V_{GS} = 18 \text{ V}$
 $T_j: 25 \text{ }^\circ\text{C}$ (dotted blue line)
 $125 \text{ }^\circ\text{C}$ (solid black line)
 $150 \text{ }^\circ\text{C}$ (dashed red line)

figure 2. MOSFET

Typical output characteristics

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

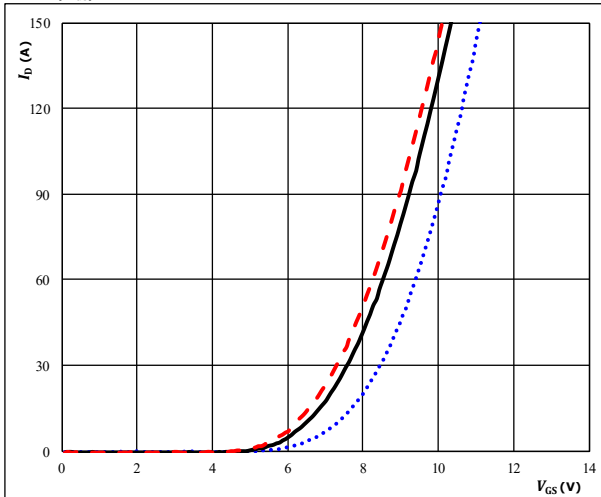


$t_p = 250 \mu\text{s}$
 $T_j = 150 \text{ }^\circ\text{C}$
 V_{GS} from 0 V to 20 V in steps of 2 V

figure 3. MOSFET

Typical transfer characteristics

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

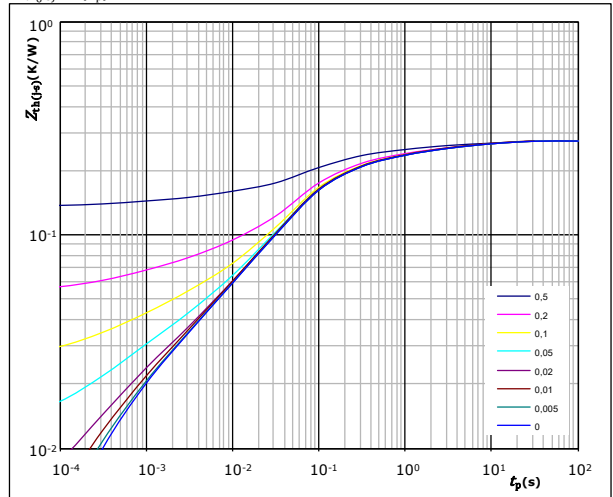


$t_p = 250 \mu\text{s}$
 $V_{DS} = 10 \text{ V}$
 $T_j: 25 \text{ }^\circ\text{C}$ (dotted blue line)
 $125 \text{ }^\circ\text{C}$ (solid black line)
 $150 \text{ }^\circ\text{C}$ (dashed red line)

figure 4. MOSFET

Transient thermal impedance as a function of pulse width

$$Z_{th(f-s)} = f(t_p)$$



$D = t_p / T$
 $R_{th(f-s)} = 0,27 \text{ K/W}$
 MOSFET thermal model values

R (K/W)	τ (s)
3,03E-02	4,54E+00
4,28E-02	4,89E-01
6,79E-02	9,05E-02
9,74E-02	2,77E-02
2,42E-02	2,00E-03
1,17E-02	2,18E-04

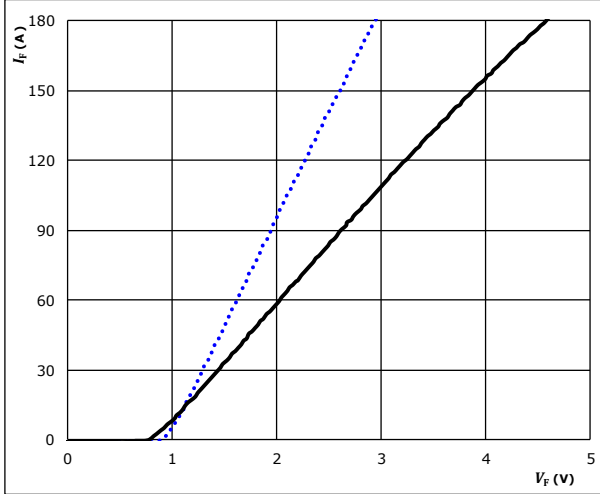


AC Diode Characteristics

figure 1. **FWD**

Typical forward characteristics

$$I_F = f(V_F)$$

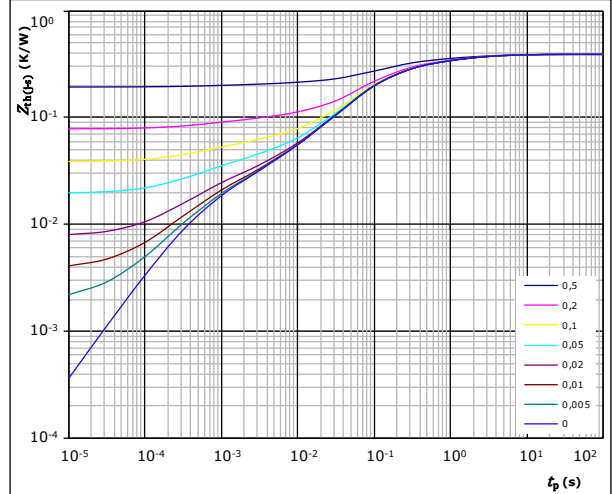


$t_p =$ 250 μ s $T_j:$ 25 °C
125 °C —————

figure 2. **FWD**

Transient thermal impedance as a function of pulse width

$$Z_{th(j-s)} = f(t_p)$$



$D =$ t_p / T
 $R_{th(j-s)} =$ 0,39 K/W

FWD thermal model values

R (K/W)	τ (s)
1,95E-02	6,94E+00
6,79E-02	1,61E+00
1,06E-01	3,11E-01
1,67E-01	8,72E-02
1,08E-02	6,83E-03
8,63E-03	2,04E-03
1,10E-02	5,15E-04

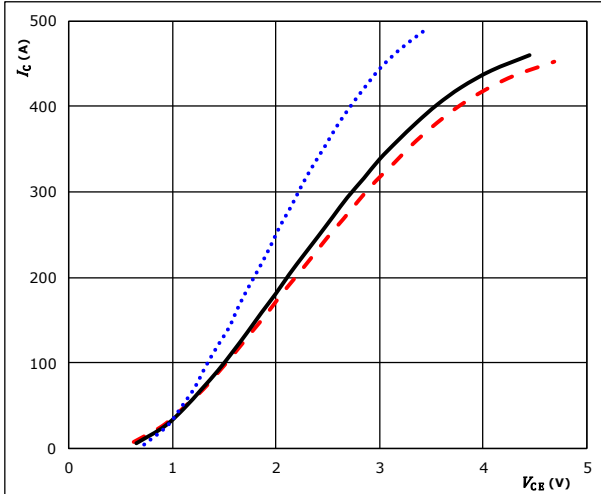


Neutral Point Switch Characteristics

figure 1. IGBT

Typical output characteristics

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

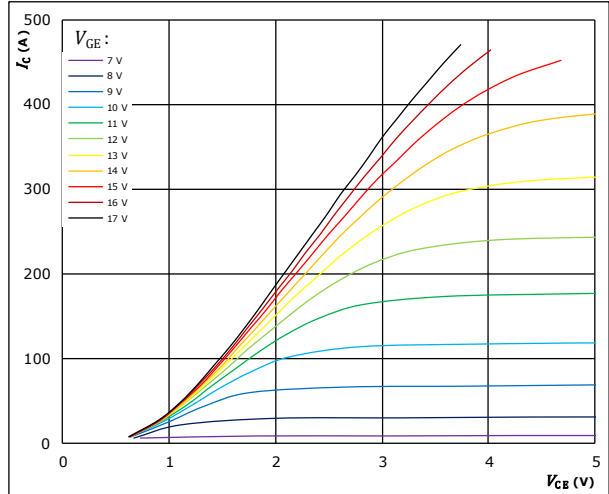


$t_p = 250 \mu s$
 $V_{GE} = 15 V$
 $T_j: 25 \text{ } ^\circ C$ (dotted blue)
 $125 \text{ } ^\circ C$ (solid black)
 $150 \text{ } ^\circ C$ (dashed red)

figure 2. IGBT

Typical output characteristics

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

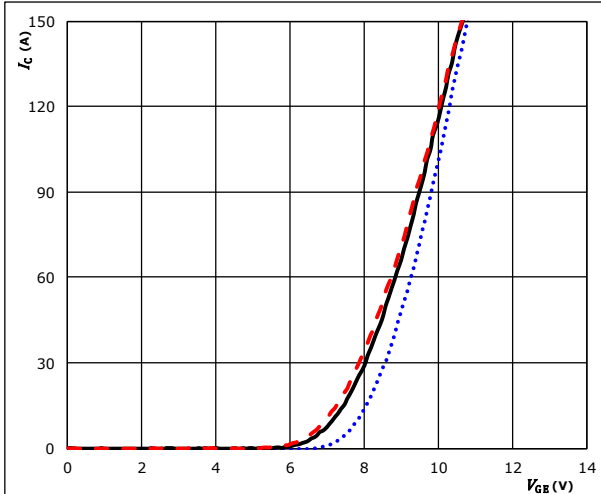


$t_p = 250 \mu s$
 $T_j = 150 \text{ } ^\circ C$
 V_{GE} from 7 V to 17 V in steps of 1 V

figure 3. IGBT

Typical transfer characteristics

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

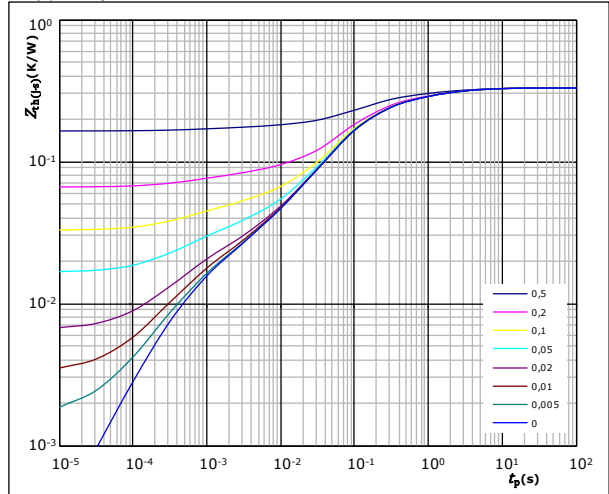


$t_p = 250 \mu s$
 $V_{CE} = 10 V$
 $T_j: 25 \text{ } ^\circ C$ (dotted blue)
 $125 \text{ } ^\circ C$ (solid black)
 $150 \text{ } ^\circ C$ (dashed red)

figure 4. IGBT

Transient thermal impedance as function of pulse duration

$$Z_{th(j-s)} = f(t_p)$$



$D = t_p / T$
 $R_{th(j-s)} = 0,33 \text{ K/W}$
 IGBT thermal model values

$R \text{ (K/W)}$	$\tau \text{ (s)}$
1,65E-02	5,88E+00
5,75E-02	1,37E+00
8,96E-02	2,63E-01
1,41E-01	7,38E-02
9,17E-03	5,78E-03
7,30E-03	1,73E-03
9,30E-03	4,36E-04



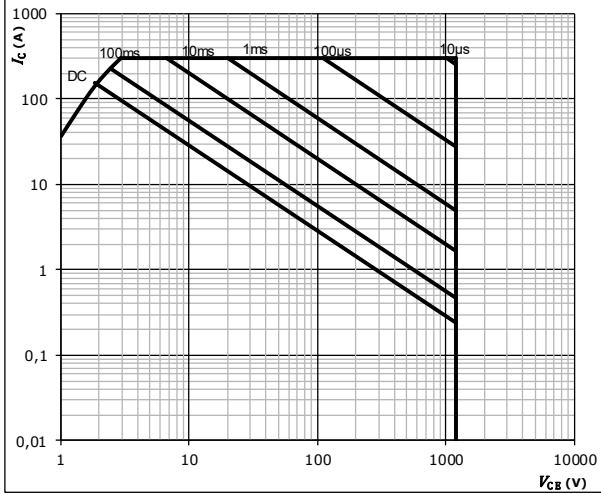
Vincotech

Neutral Point Switch Characteristics

figure 5. IGBT

Safe operating area

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



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



DC-Link Diode Characteristics

figure 1. FWD

Typical forward characteristics

$$I_F = f(V_F)$$

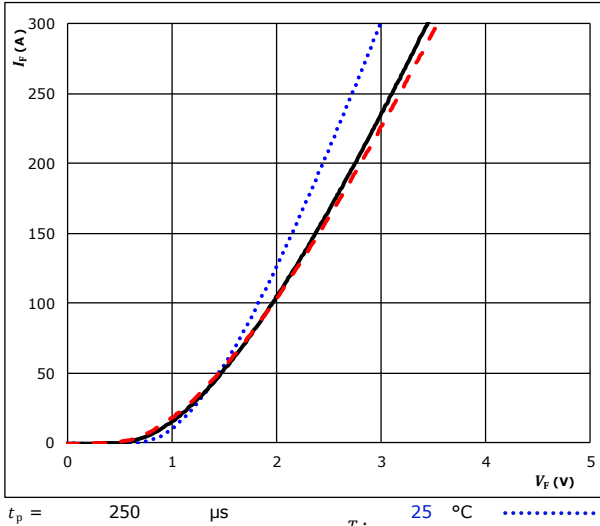
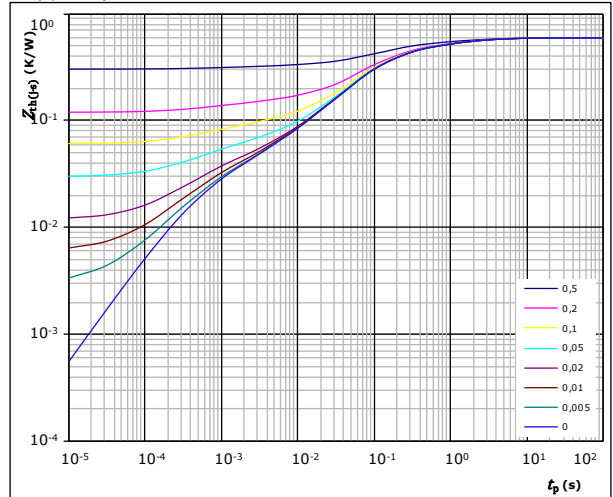


figure 2. FWD

Transient thermal impedance as a function of pulse width

$$Z_{th(j-s)} = f(t_p)$$



$$D = \frac{t_p}{T}$$

$$R_{th(j-s)} = 0,60 \text{ K/W}$$

FWD thermal model values

R (K/W)	τ (s)
2,99E-02	1,07E+01
1,04E-01	2,48E+00
1,63E-01	4,77E-01
2,56E-01	1,34E-01
1,66E-02	1,05E-02
1,33E-02	3,13E-03
1,69E-02	7,91E-04

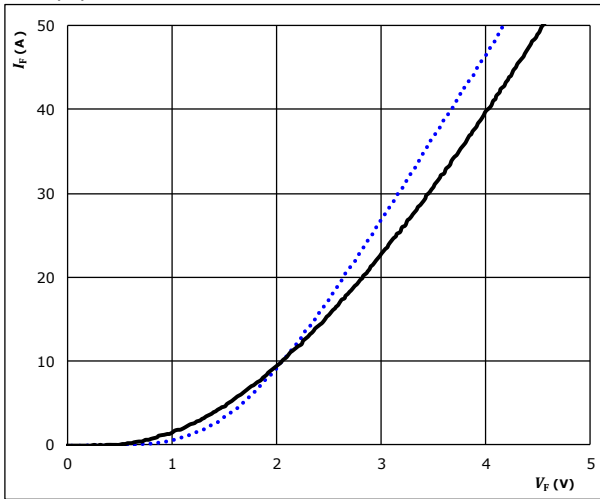


Neutral Point Switch Prot. Diode Characteristics

figure 1. FWD

Typical forward characteristics

$$I_F = f(V_F)$$

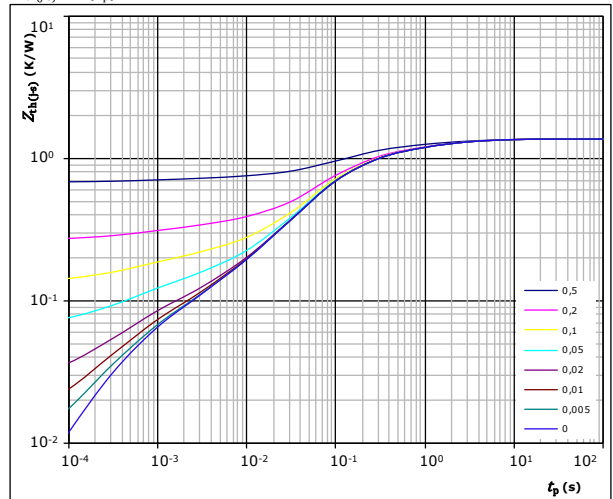


$t_p = 250 \mu s$
 $T_j: 25 \text{ } ^\circ\text{C}$ (dotted blue line)
 $125 \text{ } ^\circ\text{C}$ (solid black line)

figure 2. FWD

Transient thermal impedance as a function of pulse width

$$Z_{th(j-s)} = f(t_p)$$



$D = t_p / T$
 $R_{th(j-s)} = 1,35 \text{ K/W}$

FWD thermal model values

R (K/W)	τ (s)
6,72E-02	2,40E+01
2,35E-01	5,58E+00
3,66E-01	1,07E+00
5,76E-01	3,01E-01
3,74E-02	2,36E-02
2,98E-02	7,04E-03
3,80E-02	1,78E-03

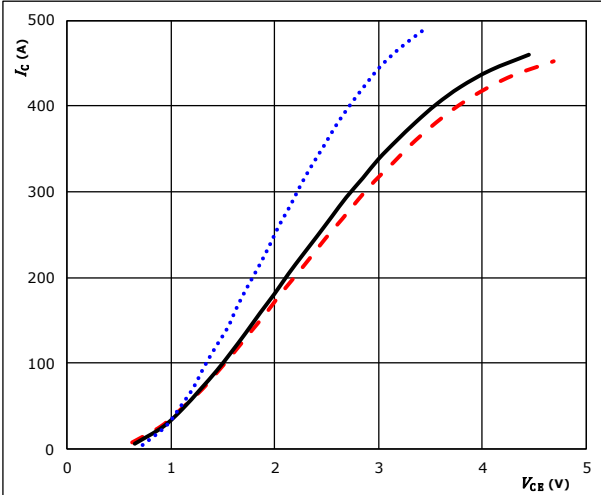


DC-Link Switch Characteristics

figure 1. IGBT

Typical output characteristics

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

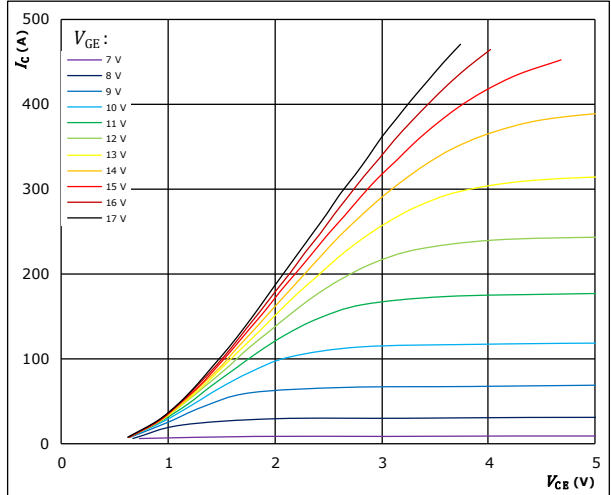


$t_p = 250 \mu s$
 $V_{GE} = 15 V$
 $T_j: 25 \text{ } ^\circ C$ (dotted blue)
 $125 \text{ } ^\circ C$ (solid black)
 $150 \text{ } ^\circ C$ (dashed red)

figure 2. IGBT

Typical output characteristics

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

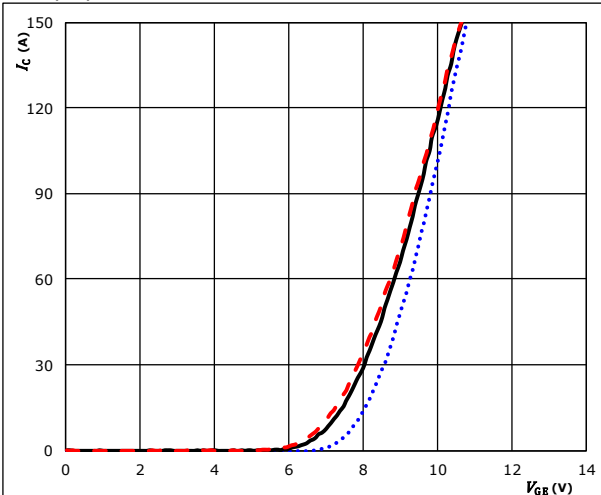


$t_p = 250 \mu s$
 $T_j = 150 \text{ } ^\circ C$
 V_{GE} from 7 V to 17 V in steps of 1 V

figure 3. IGBT

Typical transfer characteristics

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

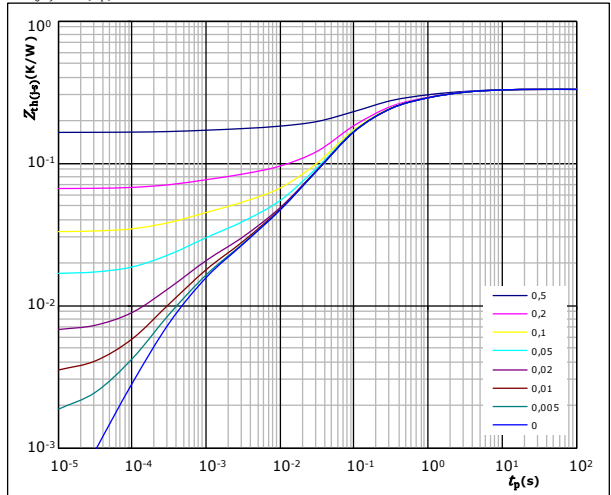


$t_p = 250 \mu s$
 $V_{CE} = 10 V$
 $T_j: 25 \text{ } ^\circ C$ (dotted blue)
 $125 \text{ } ^\circ C$ (solid black)
 $150 \text{ } ^\circ C$ (dashed red)

figure 4. IGBT

Transient thermal impedance as function of pulse duration

$$Z_{th(j-s)} = f(t_p)$$



$$D = t_p / T$$

$$R_{th(j-s)} = 0,33 \text{ K/W}$$

IGBT thermal model values

R (K/W)	τ (s)
1,65E-02	5,88E+00
5,75E-02	1,37E+00
8,96E-02	2,63E-01
1,41E-01	7,38E-02
9,17E-03	5,78E-03
7,30E-03	1,73E-03
9,30E-03	4,36E-04



Vincotech

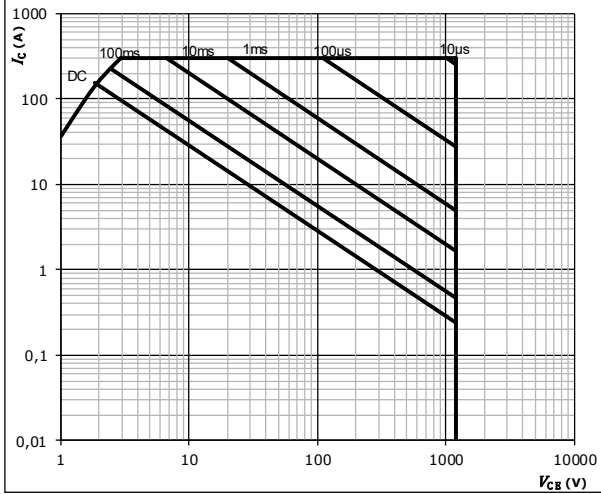
10-PG12NAB009CS04-LC59F88T
10-PG12NAC009CS04-LC69F88T
datasheet

DC-Link Switch Characteristics

figure 5. IGBT

Safe operating area

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



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

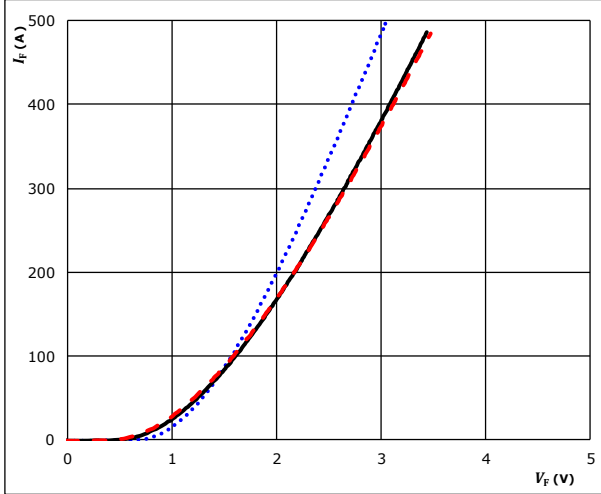


Neutral Point Diode Characteristics

figure 1. FWD

Typical forward characteristics

$$I_F = f(V_F)$$

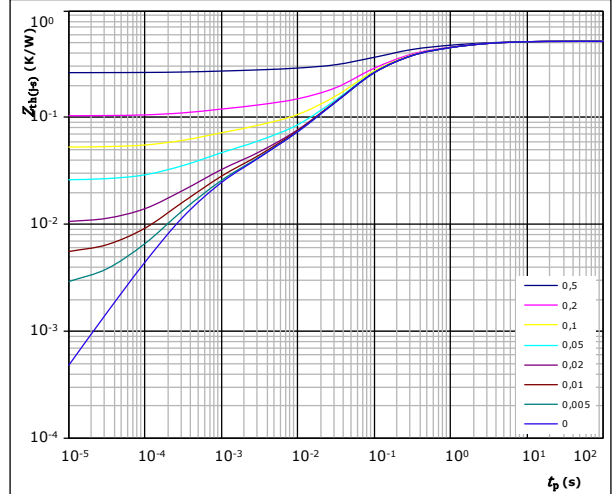


$t_p = 250 \mu s$
 T_j : 25 °C
 125 °C ———
 150 °C - - - -

figure 2. FWD

Transient thermal impedance as a function of pulse width

$$Z_{th(j-s)} = f(t_p)$$



$D = t_p / T$
 $R_{th(j-s)} = 0,52 \text{ K/W}$

FWD thermal model values

R (K/W)	τ (s)
2,59E-02	9,26E+00
9,06E-02	2,15E+00
1,41E-01	4,14E-01
2,22E-01	1,16E-01
1,44E-02	9,10E-03
1,15E-02	2,72E-03
1,46E-02	6,86E-04



DC-Link Switch Prot. Diode Characteristics

figure 1. FWD

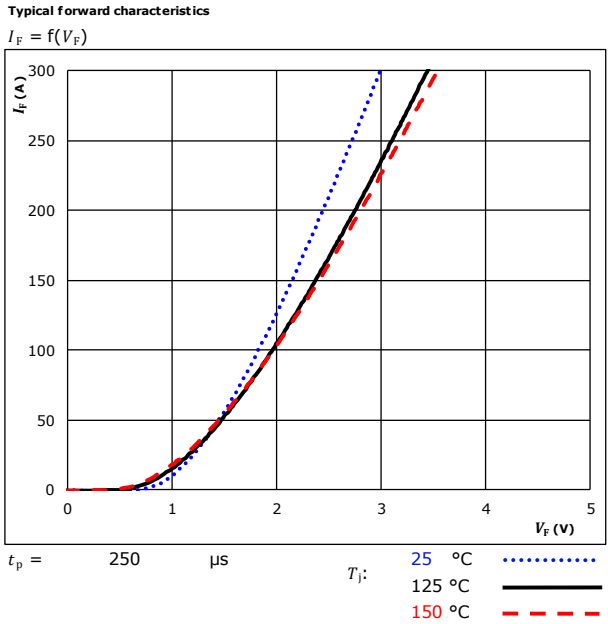
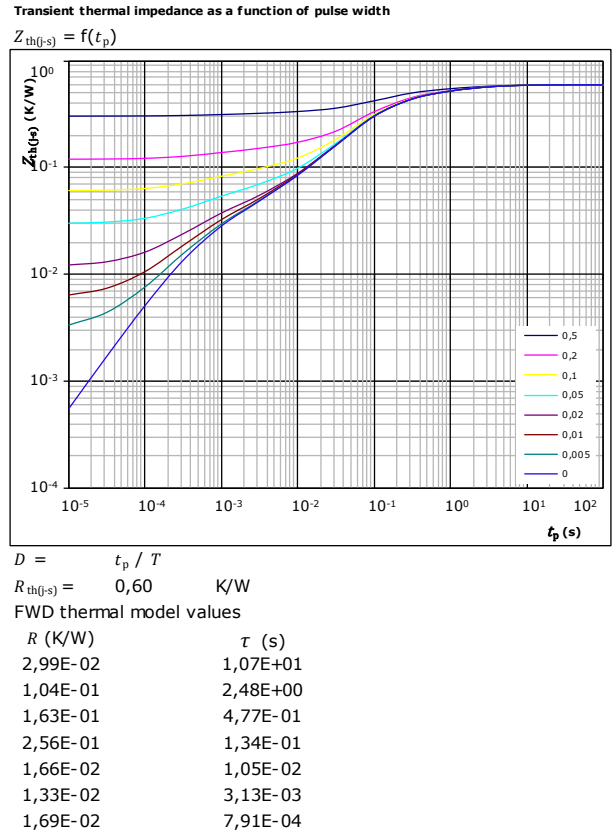
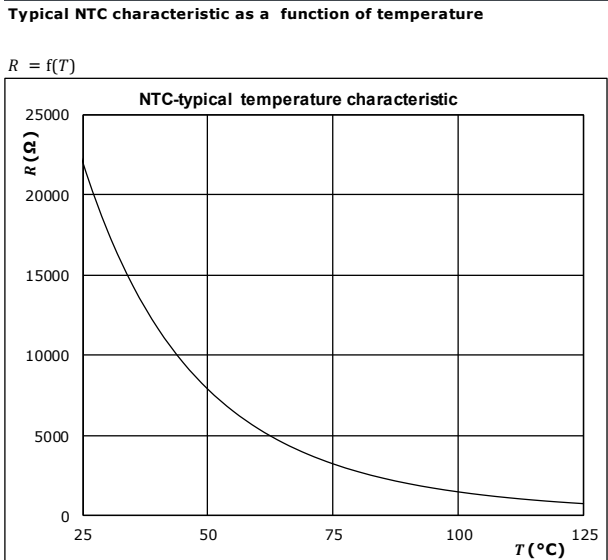


figure 2. FWD



Thermistor Characteristics

figure 1. Thermistor



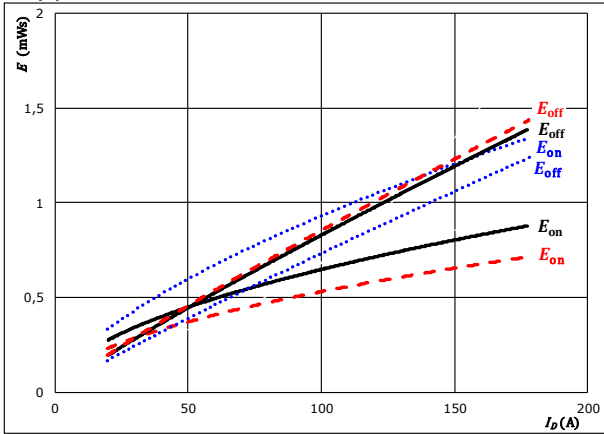


AC Real Open Switching Characteristics

figure 1. MOSFET

Typical switching energy losses as a function of drain current

$$E = f(I_D)$$



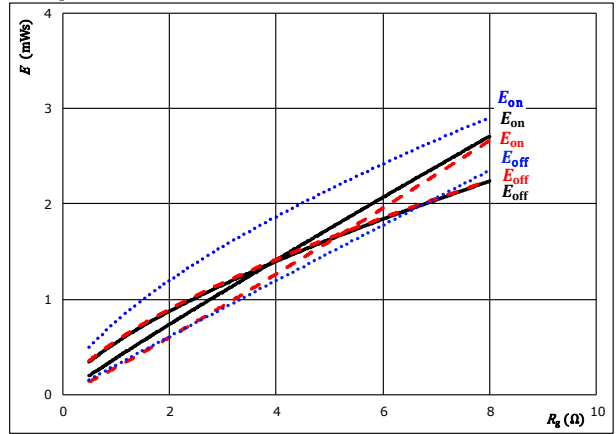
With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $R_{gon} = 2$ Ω
 $R_{goff} = 2$ Ω

T_j : 25 °C (dotted blue), 125 °C (solid black), 150 °C (dashed red)

figure 2. MOSFET

Typical switching energy losses as a function of gate resistor

$$E = f(R_g)$$



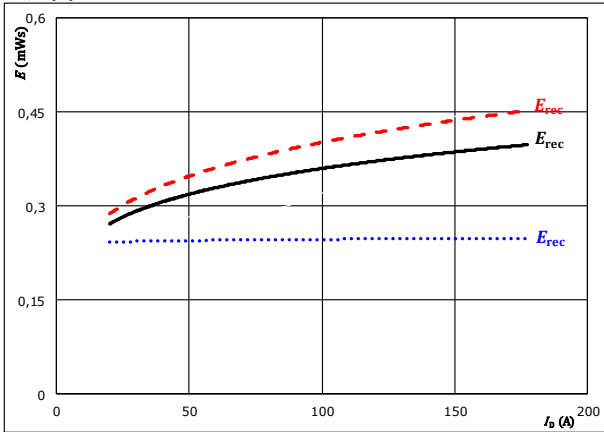
With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $I_D = 100$ A

T_j : 25 °C (dotted blue), 125 °C (solid black), 150 °C (dashed red)

figure 3. FWD

Typical reverse recovered energy loss as a function of drain current

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



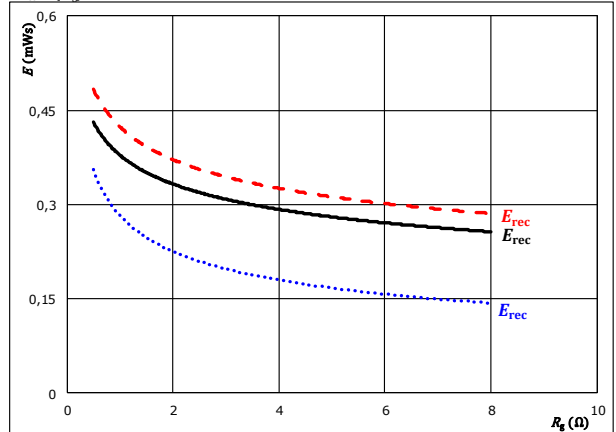
With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $R_{gon} = 2$ Ω

T_j : 25 °C (dotted blue), 125 °C (solid black), 150 °C (dashed red)

figure 4. FWD

Typical reverse recovered energy loss as a function of gate resistor

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



With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $I_D = 100$ A

T_j : 25 °C (dotted blue), 125 °C (solid black), 150 °C (dashed red)

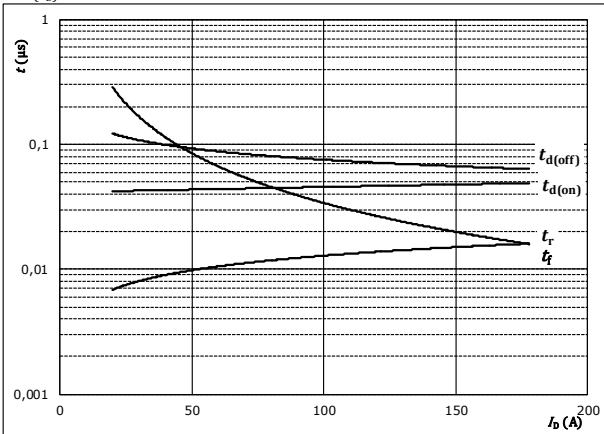


AC Real Open Switching Characteristics

figure 5. MOSFET

Typical switching times as a function of drain current

$$t = f(I_D)$$



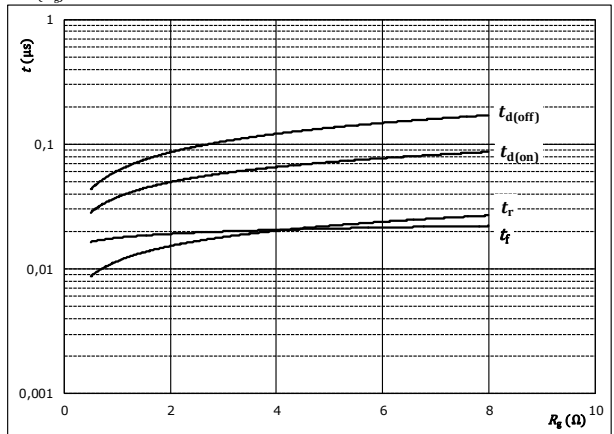
With an inductive load at

$T_J = 150 \text{ }^\circ\text{C}$
 $V_{DS} = 600 \text{ V}$
 $V_{GS} = -5 / 16 \text{ V}$
 $R_{g(on)} = 2 \text{ } \Omega$
 $R_{g(off)} = 2 \text{ } \Omega$

figure 6. MOSFET

Typical switching times as a function of gate resistor

$$t = f(R_g)$$



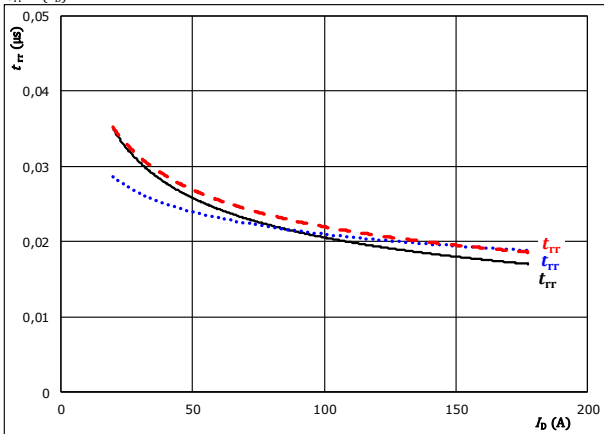
With an inductive load at

$T_J = 150 \text{ }^\circ\text{C}$
 $V_{DS} = 600 \text{ V}$
 $V_{GS} = -5 / 16 \text{ V}$
 $I_D = 100 \text{ A}$

figure 7. FWD

Typical reverse recovery time as a function of drain current

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



With an inductive load at

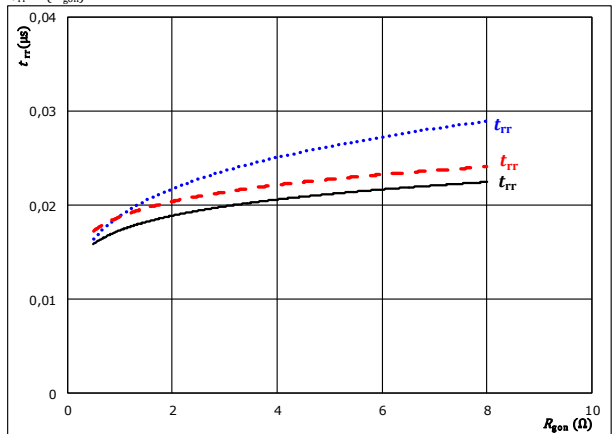
$V_{DS} = 600 \text{ V}$
 $V_{GS} = -5 / 16 \text{ V}$
 $R_{g(on)} = 2 \text{ } \Omega$

T_J : 25 °C (dotted blue line)
 125 °C (solid black line)
 150 °C (dashed red line)

figure 8. FWD

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

$$t_{rr} = f(R_{g(on)})$$



With an inductive load at

$V_{DS} = 600 \text{ V}$
 $V_{GS} = -5 / 16 \text{ V}$
 $I_D = 100 \text{ A}$

T_J : 25 °C (dotted blue line)
 125 °C (solid black line)
 150 °C (dashed red line)

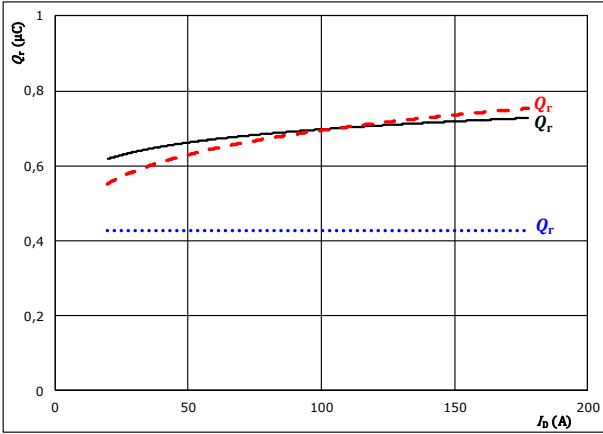


AC Real Open Switching Characteristics

figure 9. FWD

Typical recovered charge as a function of drain current

$$Q_r = f(I_D)$$

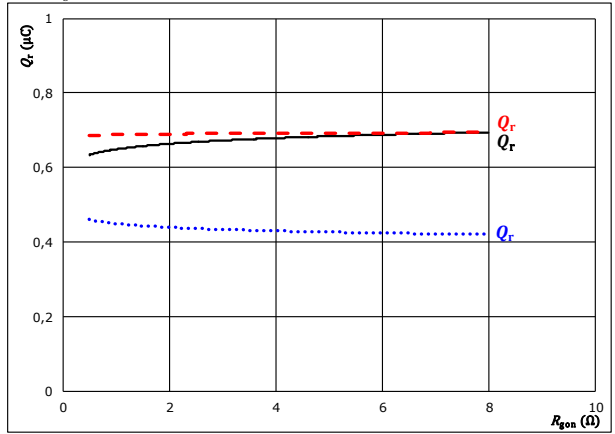


With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $R_{gon} = 2$ Ω
 T_j : 25 °C (dotted blue line)
 125 °C (dashed red line)
 150 °C (solid black line)

figure 10. FWD

Typical recovered charge as a function of MOSFET turn on gate resistor

$$Q_r = f(R_{gon})$$

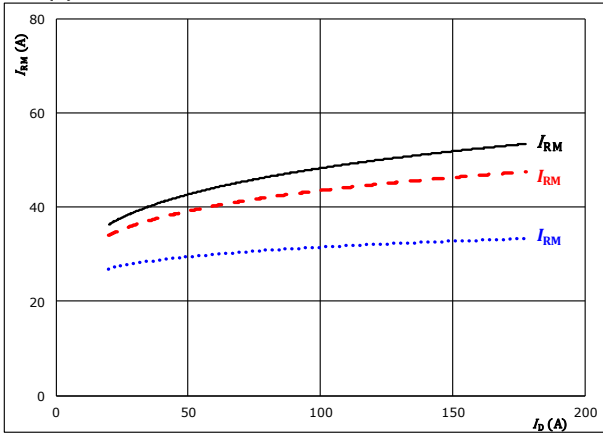


With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $I_D = 100$ A
 T_j : 25 °C (dotted blue line)
 125 °C (dashed red line)
 150 °C (solid black line)

figure 11. FWD

Typical peak reverse recovery current as a function of drain current

$$I_{RM} = f(I_D)$$

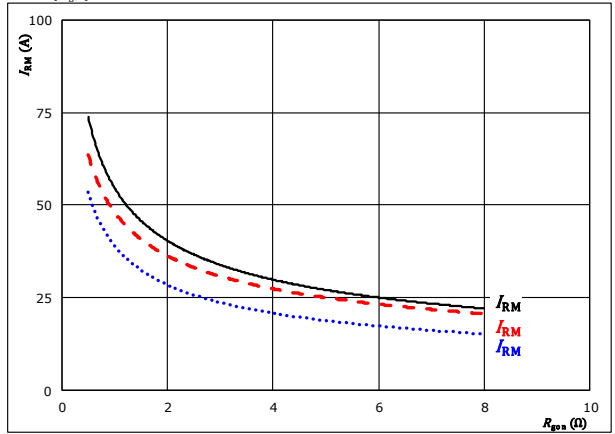


With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $R_{gon} = 2$ Ω
 T_j : 25 °C (dotted blue line)
 125 °C (dashed red line)
 150 °C (solid black line)

figure 12. FWD

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

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



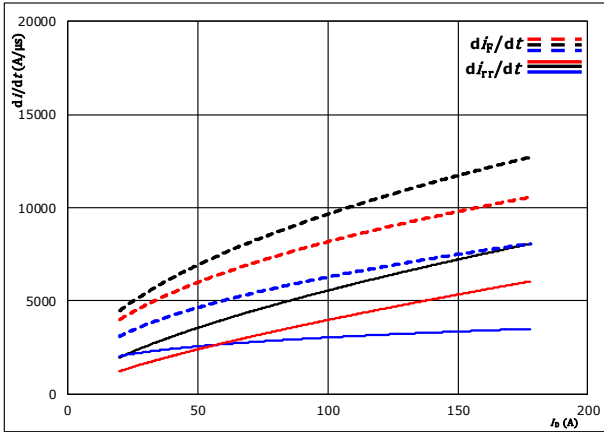
With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $I_D = 100$ A
 T_j : 25 °C (dotted blue line)
 125 °C (dashed red line)
 150 °C (solid black line)



AC Real Open Switching Characteristics

figure 13. FWD

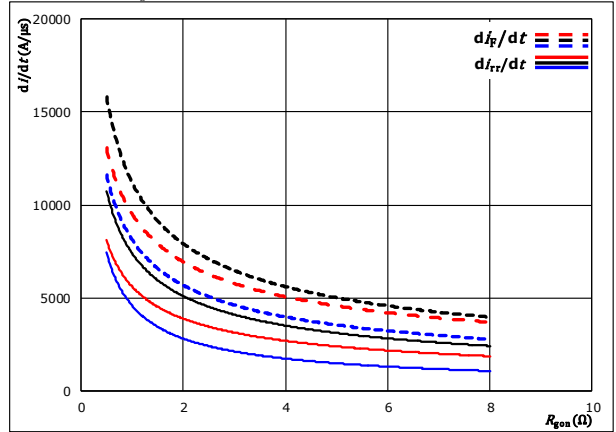
Typical rate of fall of forward and reverse recovery current as a function of drain current
 $di_f/dt, di_{rr}/dt = f(I_D)$



With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $R_{gpn} = 2$ Ω
 $T_j: 125$ °C
 150 °C

figure 14. FWD

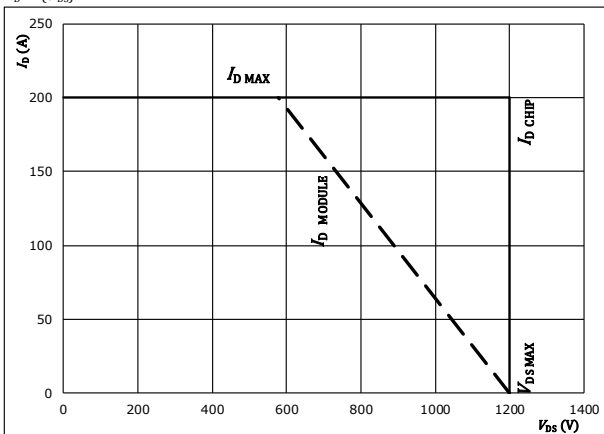
Typical rate of fall of forward and reverse recovery current as a function of MOSFET turn on gate resistor
 $di_f/dt, di_{rr}/dt = f(R_{gpn})$



With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $I_D = 100$ A
 $T_j: 125$ °C
 150 °C

figure 15. MOSFET

Reverse bias safe operating area
 $I_D = f(V_{DS})$

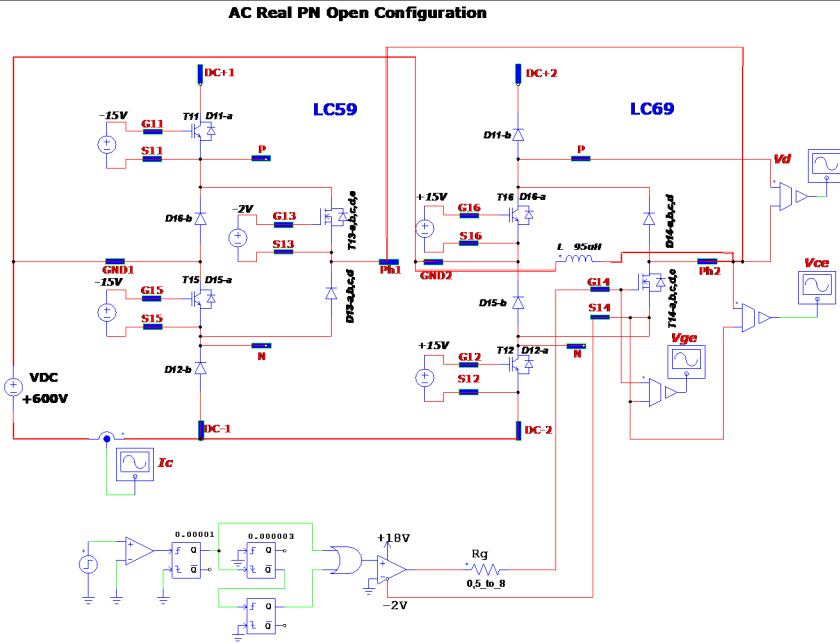


At
 $T_j = 125$ °C
 $R_{gpn} = 2$ Ω
 $R_{goff} = 2$ Ω



AC Real Open measurement circuit

figure 1.



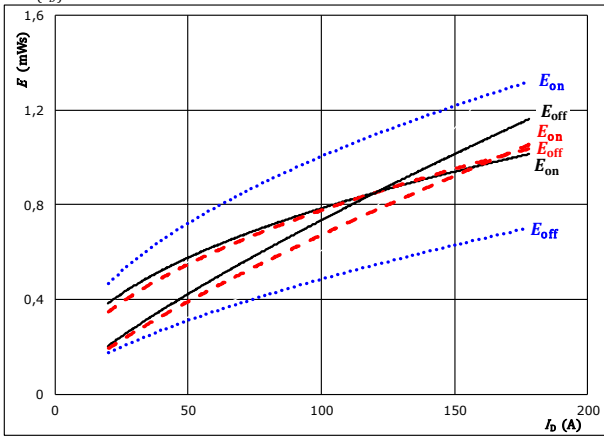


AC Reactive Open Switching Characteristics

figure 1. MOSFET

Typical switching energy losses as a function of drain current

$$E = f(I_D)$$



With an inductive load at

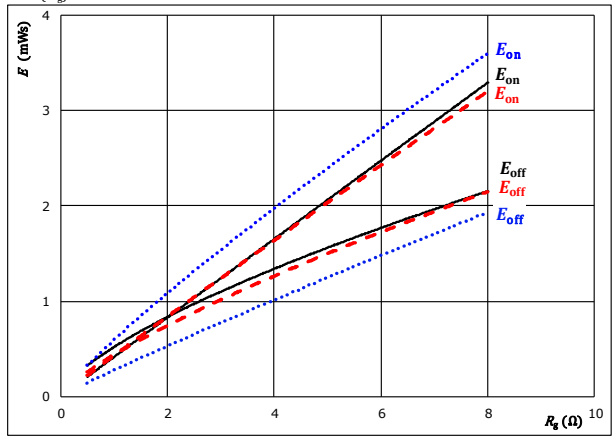
$V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $R_{g\text{on}} = 2$ Ω
 $R_{g\text{off}} = 2$ Ω

T_j : 25 °C (dotted blue)
 125 °C (solid black)
 150 °C (dashed red)

figure 2. MOSFET

Typical switching energy losses as a function of gate resistor

$$E = f(R_g)$$



With an inductive load at

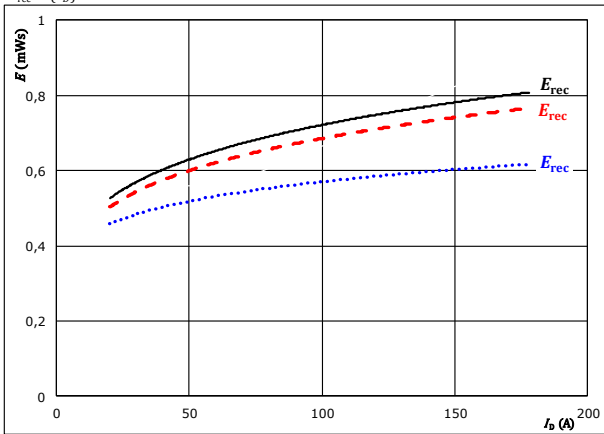
$V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $I_D = 100$ A

T_j : 25 °C (dotted blue)
 125 °C (solid black)
 150 °C (dashed red)

figure 3. FWD

Typical reverse recovered energy loss as a function of drain current

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



With an inductive load at

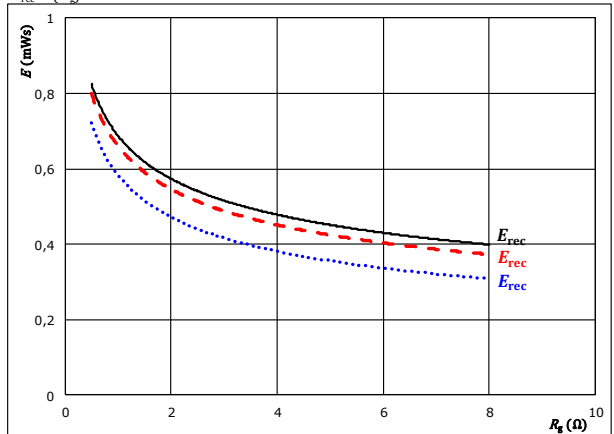
$V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $R_{g\text{on}} = 2$ Ω

T_j : 25 °C (dotted blue)
 125 °C (solid black)
 150 °C (dashed red)

figure 4. FWD

Typical reverse recovered energy loss as a function of gate resistor

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



With an inductive load at

$V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $I_D = 100$ A

T_j : 25 °C (dotted blue)
 125 °C (solid black)
 150 °C (dashed red)

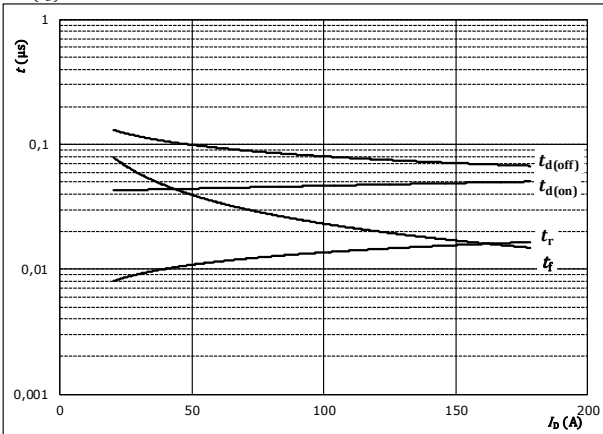


AC Reactive Open Switching Characteristics

figure 5. MOSFET

Typical switching times as a function of drain current

$$t = f(I_D)$$



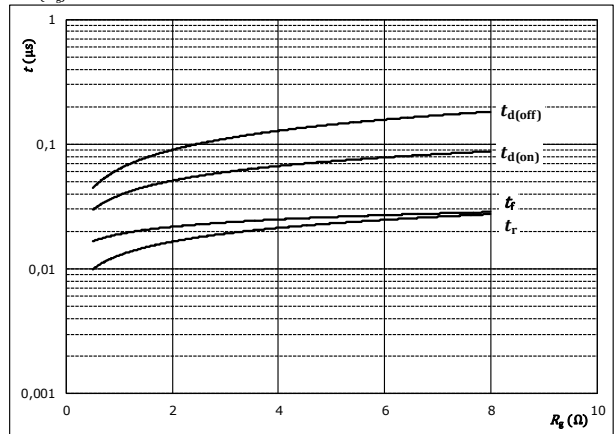
With an inductive load at

- $T_j = 150 \text{ } ^\circ\text{C}$
- $V_{DS} = 600 \text{ V}$
- $V_{GS} = -5 / 16 \text{ V}$
- $R_{gpn} = 2 \text{ } \Omega$
- $R_{goff} = 2 \text{ } \Omega$

figure 6. MOSFET

Typical switching times as a function of gate resistor

$$t = f(R_g)$$



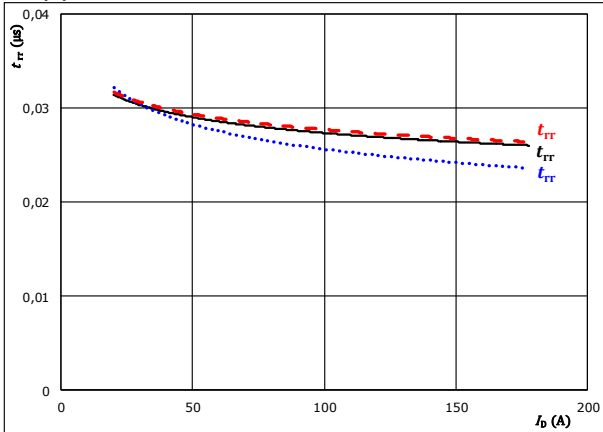
With an inductive load at

- $T_j = 150 \text{ } ^\circ\text{C}$
- $V_{DS} = 600 \text{ V}$
- $V_{GS} = -5 / 16 \text{ V}$
- $I_D = 100 \text{ A}$

figure 7. FWD

Typical reverse recovery time as a function of drain current

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



With an inductive load at

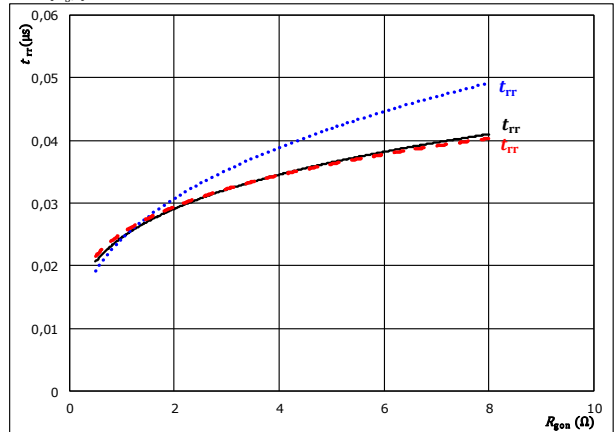
- $V_{DS} = 600 \text{ V}$
- $V_{GS} = -5 / 16 \text{ V}$
- $R_{gpn} = 2 \text{ } \Omega$

- $T_j: 25 \text{ } ^\circ\text{C}$ (dotted blue line)
- $125 \text{ } ^\circ\text{C}$ (solid black line)
- $150 \text{ } ^\circ\text{C}$ (dashed red line)

figure 8. FWD

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

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



With an inductive load at

- $V_{DS} = 600 \text{ V}$
- $V_{GS} = -5 / 16 \text{ V}$
- $I_D = 100 \text{ A}$

- $T_j: 25 \text{ } ^\circ\text{C}$ (dotted blue line)
- $125 \text{ } ^\circ\text{C}$ (solid black line)
- $150 \text{ } ^\circ\text{C}$ (dashed red line)

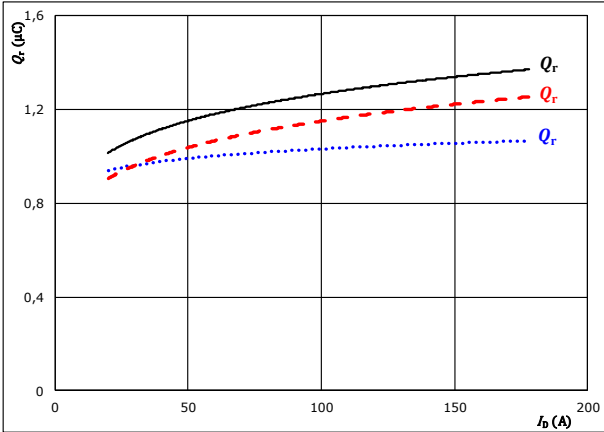


AC Reactive Open Switching Characteristics

figure 9. FWD

Typical recovered charge as a function of drain current

$$Q_r = f(I_D)$$



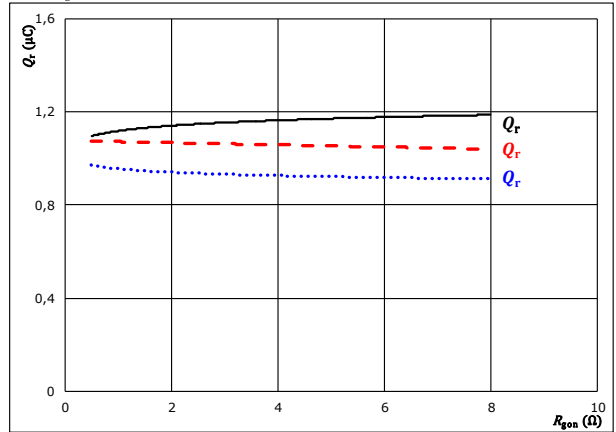
With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $R_{gon} = 2$ Ω

T_j : 25 °C (dotted blue line)
 125 °C (solid black line)
 150 °C (dashed red line)

figure 10. FWD

Typical recovered charge as a function of MOSFET turn on gate resistor

$$Q_r = f(R_{gon})$$



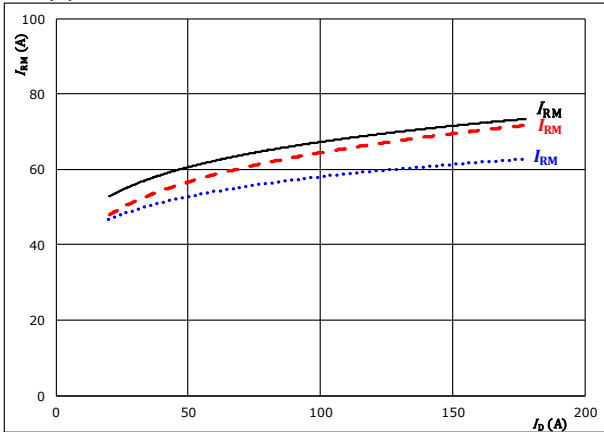
With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $I_D = 100$ A

T_j : 25 °C (dotted blue line)
 125 °C (solid black line)
 150 °C (dashed red line)

figure 11. FWD

Typical peak reverse recovery current current as a function of drain current

$$I_{RM} = f(I_D)$$



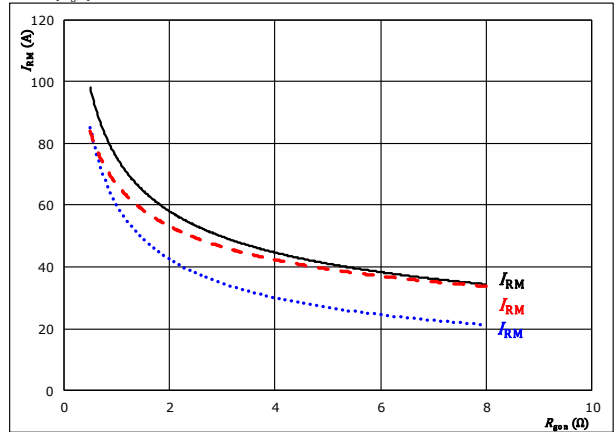
With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $R_{gon} = 2$ Ω

T_j : 25 °C (dotted blue line)
 125 °C (solid black line)
 150 °C (dashed red line)

figure 12. FWD

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

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



With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $I_D = 100$ A

T_j : 25 °C (dotted blue line)
 125 °C (solid black line)
 150 °C (dashed red line)

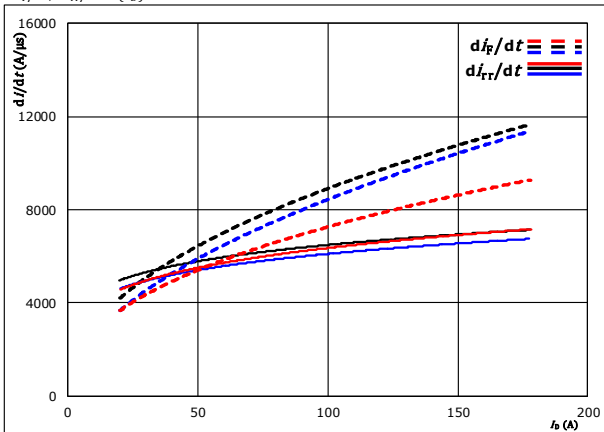


Vincotech

AC Reactive Open Switching Characteristics

figure 13. FWD

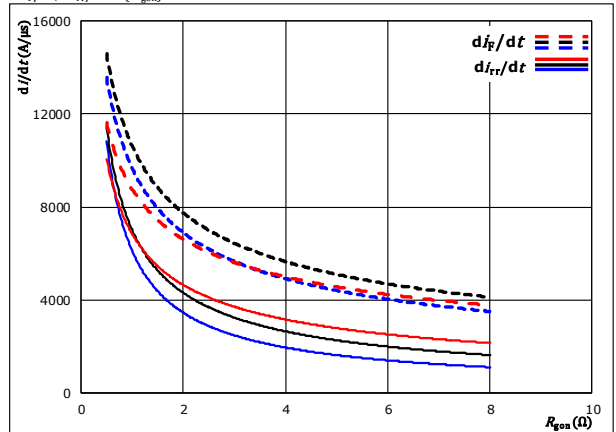
Typical rate of fall of forward and reverse recovery current as a function of drain current
 $di_f/dt, di_{rr}/dt = f(I_D)$



With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $R_{gon} = 2$ Ω
 $T_j = 25$ °C
 125 °C
 150 °C

figure 14. FWD

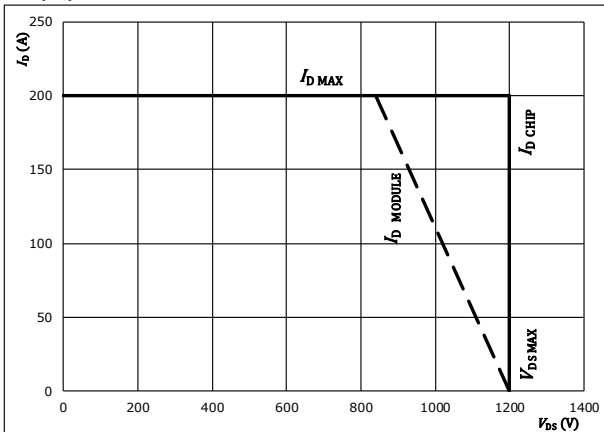
Typical rate of fall of forward and reverse recovery current as a function of MOSFET turn on gate resistor
 $di_f/dt, di_{rr}/dt = f(R_{gon})$



With an inductive load at
 $V_{DS} = 600$ V
 $V_{GS} = -5 / 16$ V
 $I_D = 100$ A
 $T_j = 25$ °C
 125 °C
 150 °C

figure 15. MOSFET

Reverse bias safe operating area
 $I_D = f(V_{DS})$



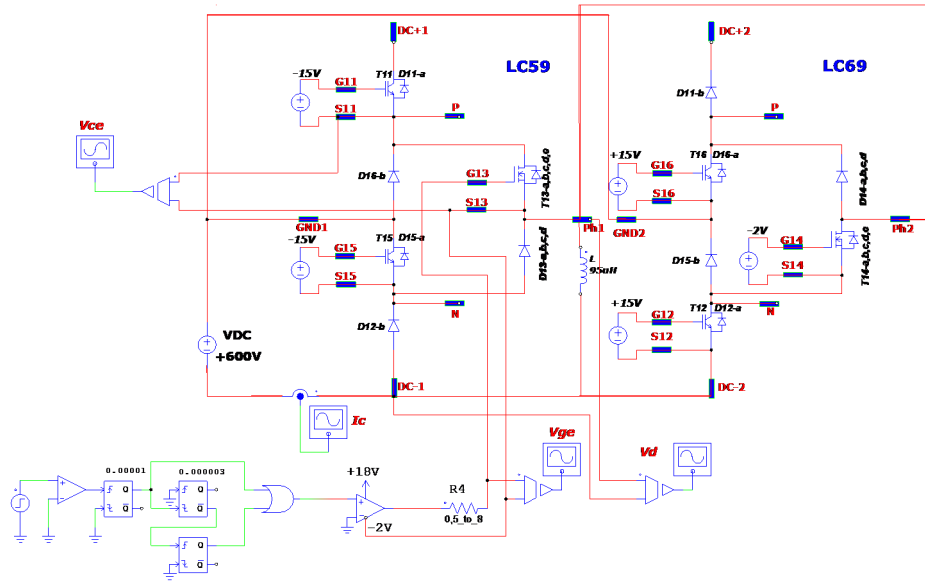
At
 $T_j = 125$ °C
 $R_{gon} = 2$ Ω
 $R_{goff} = 2$ Ω



AC Reactive Open measurement circuit

figure 1.

AC Reactive PN Open Configuration





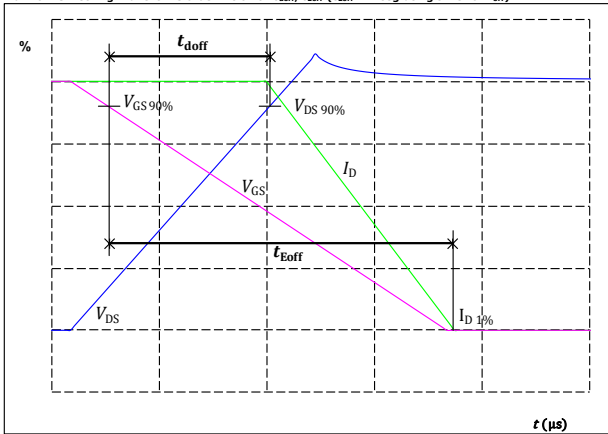
AC Switching Definitions

General conditions

T_j	=	125 °C
R_{gon}	=	2 Ω
R_{goff}	=	2 Ω

figure 1. MOSFET

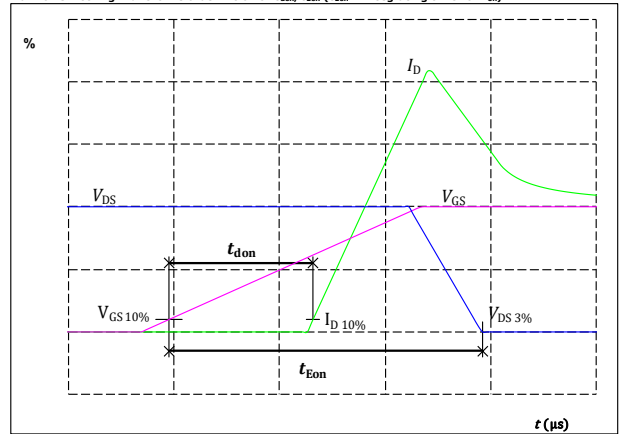
Turn-off Switching Waveforms & definition of t_{doff} , t_{Eoff} (t_{Eoff} = integrating time for E_{off})



$V_{GS}(0\%) =$	-5	V
$V_{GS}(100\%) =$	16	V
$V_{DS}(100\%) =$	600	V
$I_D(100\%) =$	100	A
$t_{doff} =$	77	ns

figure 2. MOSFET

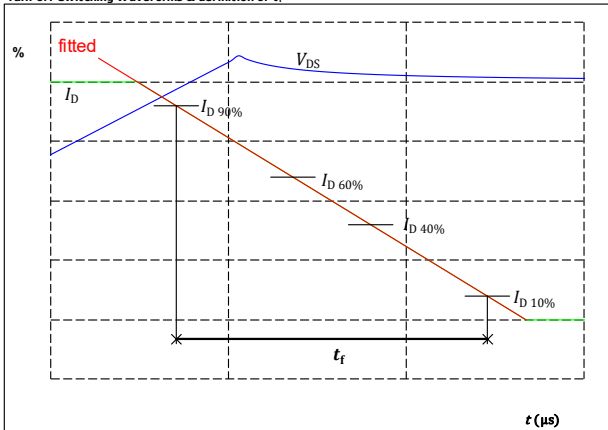
Turn-on Switching Waveforms & definition of t_{don} , t_{Eon} (t_{Eon} = integrating time for E_{on})



$V_{GS}(0\%) =$	-5	V
$V_{GS}(100\%) =$	16	V
$V_{DS}(100\%) =$	600	V
$I_D(100\%) =$	100	A
$t_{don} =$	46	ns

figure 3. MOSFET

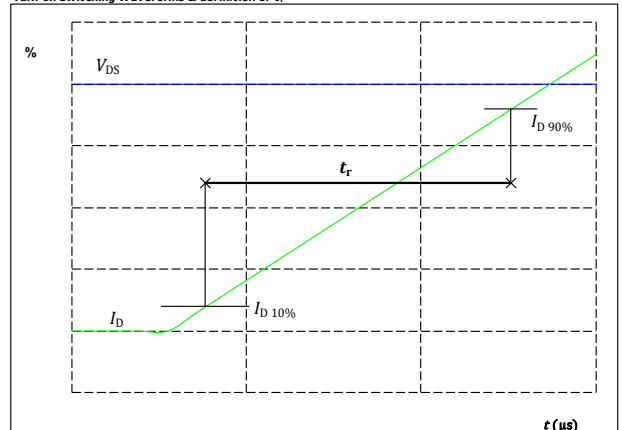
Turn-off Switching Waveforms & definition of t_f



$V_{DS}(100\%) =$	600	V
$I_D(100\%) =$	100	A
$t_f =$	19	ns

figure 4. MOSFET

Turn-on Switching Waveforms & definition of t_r

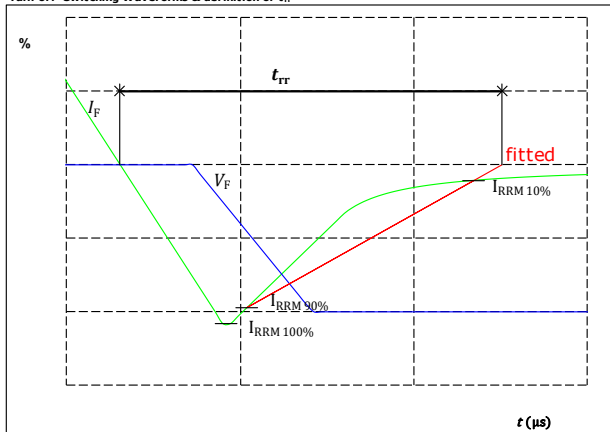


$V_{DS}(100\%) =$	600	V
$I_D(100\%) =$	100	A
$t_r =$	13	ns



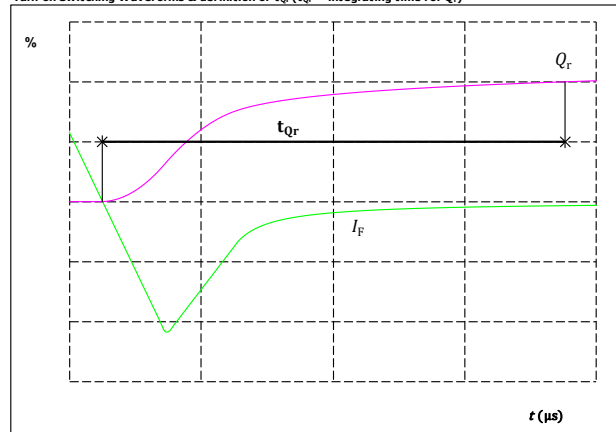
AC Switching Definitions

figure 5. Turn-off Switching Waveforms & definition of t_{rr} FWD



$V_F(100\%) =$	600	V
$I_F(100\%) =$	100	A
$I_{RRM}(100\%) =$	68	A
$t_{rr} =$	27	ns

figure 6. Turn-on Switching Waveforms & definition of t_{Qr} ($t_{Qr} =$ integrating time for Q_r) FWD



$I_F(100\%) =$	100	A
$Q_r(100\%) =$	1,185	μC

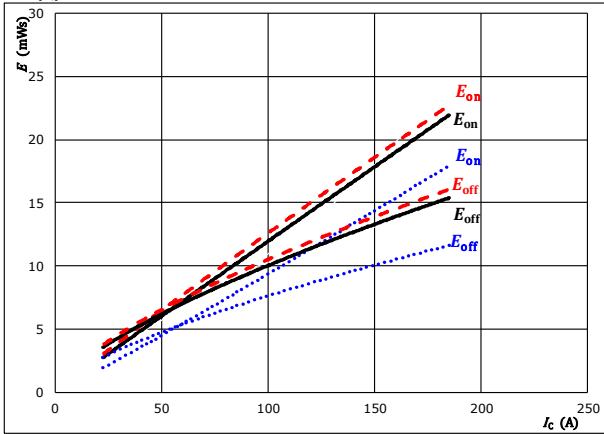


Neutral Switching Characteristics

figure 1. IGBT

Typical switching energy losses as a function of collector current

$$E = f(I_c)$$

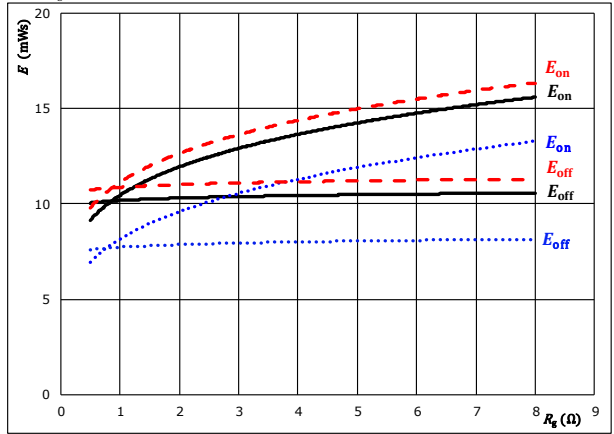


With an inductive load at
 $V_{CE} = 600$ V
 $V_{GE} = \pm 15$ V
 $R_{g\text{on}} = 2$ Ω
 $R_{g\text{off}} = 2$ Ω
 $T_j: 25$ °C (dotted), 125 °C (solid), 150 °C (dashed)

figure 2. IGBT

Typical switching energy losses as a function of gate resistor

$$E = f(R_g)$$

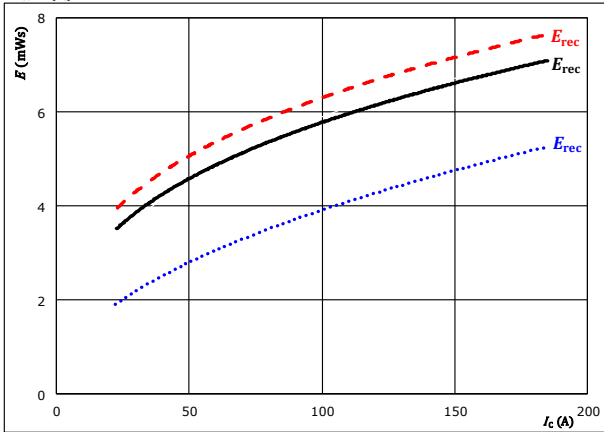


With an inductive load at
 $V_{CE} = 600$ V
 $V_{GE} = \pm 15$ V
 $I_c = 100$ A
 $T_j: 25$ °C (dotted), 125 °C (solid), 150 °C (dashed)

figure 3. FWD

Typical reverse recovered energy loss as a function of collector current

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

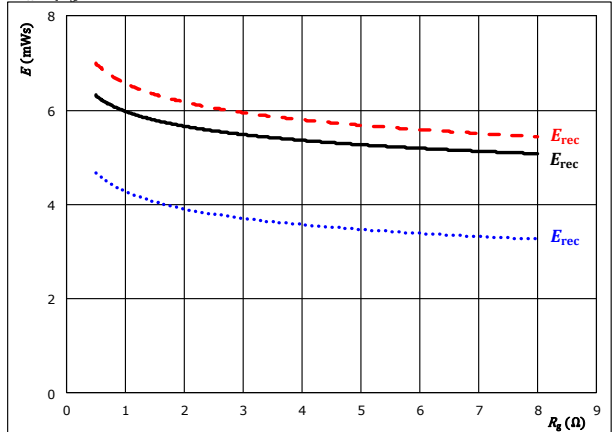


With an inductive load at
 $V_{CE} = 600$ V
 $V_{GE} = \pm 15$ V
 $R_{g\text{on}} = 2$ Ω
 $T_j: 25$ °C (dotted), 125 °C (solid), 150 °C (dashed)

figure 4. FWD

Typical reverse recovered energy loss as a function of gate resistor

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



With an inductive load at
 $V_{CE} = 600$ V
 $V_{GE} = \pm 15$ V
 $I_c = 100$ A
 $T_j: 25$ °C (dotted), 125 °C (solid), 150 °C (dashed)

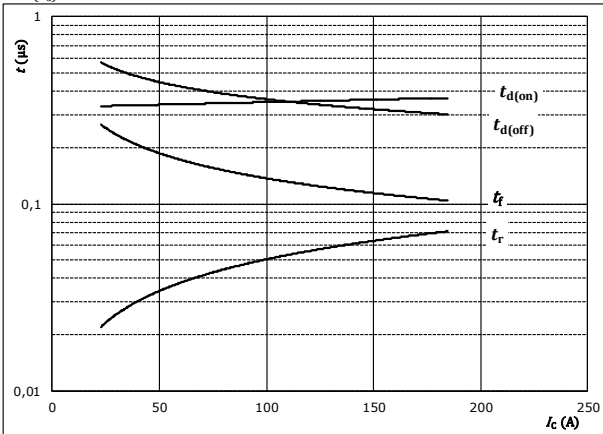


Neutral Switching Characteristics

figure 5. IGBT

Typical switching times as a function of collector current

$$t = f(I_C)$$



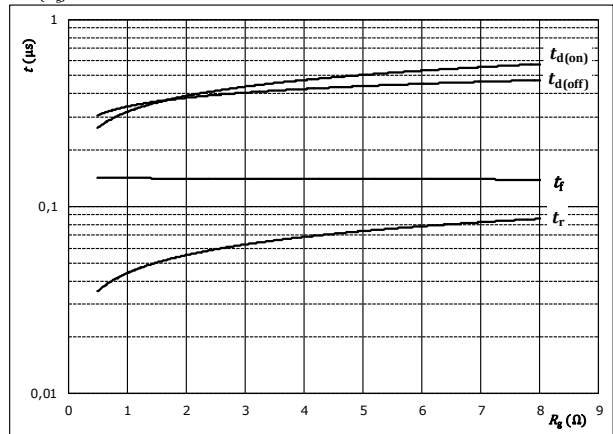
With an inductive load at

$T_j =$	150	°C
$V_{CE} =$	600	V
$V_{GE} =$	±15	V
$R_{g(on)} =$	2	Ω
$R_{g(off)} =$	2	Ω

figure 6. IGBT

Typical switching times as a function of gate resistor

$$t = f(R_g)$$



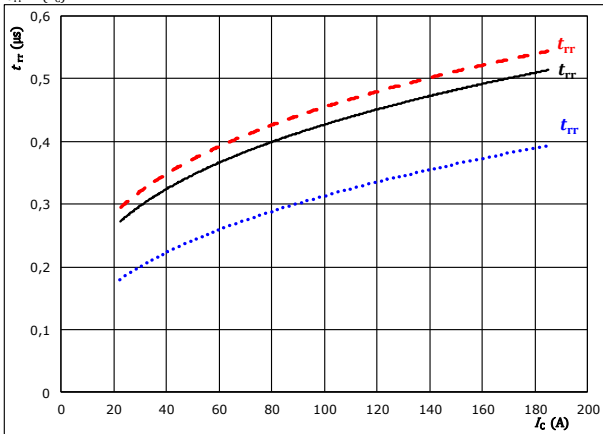
With an inductive load at

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

figure 7. FWD

Typical reverse recovery time as a function of collector current

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

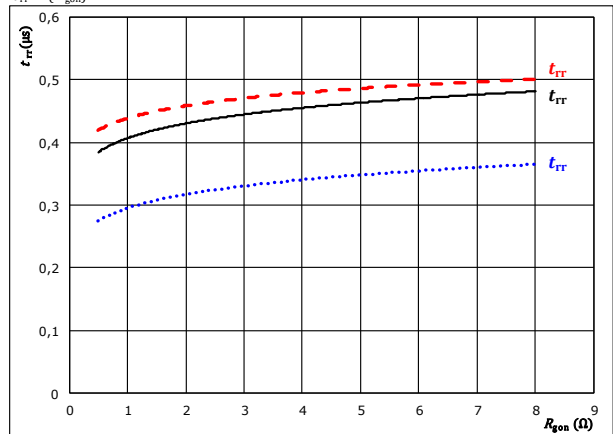


At	$V_{CE} =$	600	V	$T_j:$	25 °C
	$V_{GE} =$	±15	V		125 °C	————
	$R_{g(on)} =$	2	Ω		150 °C	-----

figure 8. FWD

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

$$t_{rr} = f(R_{g(on)})$$



At	$V_{CE} =$	600	V	$T_j:$	25 °C
	$V_{GE} =$	±15	V		125 °C	————
	$I_C =$	100	A		150 °C	-----

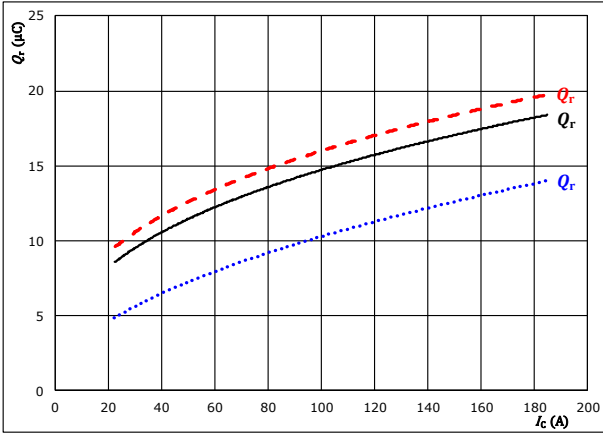


Neutral Switching Characteristics

figure 9. FWD

Typical recovered charge as a function of collector current

$$Q_r = f(I_c)$$

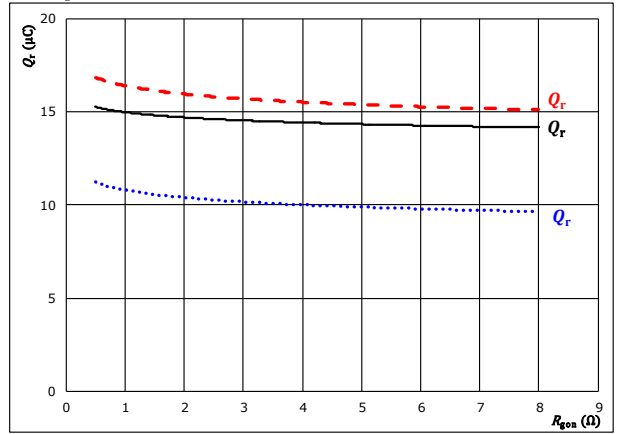


At $V_{CE} = 600$ V $T_j = 25$ °C $\dots\dots\dots$
 $V_{GE} = \pm 15$ V $T_j = 125$ °C ---
 $R_{gdn} = 2$ Ω $T_j = 150$ °C --- --

figure 10. FWD

Typical recovered charge as a function of IGBT turn on gate resistor

$$Q_r = f(R_{gdn})$$

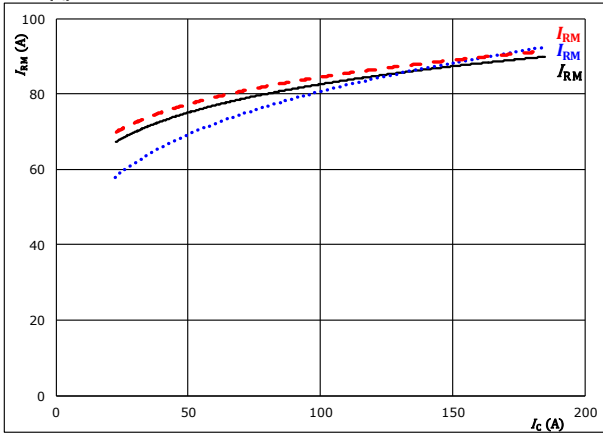


At $V_{CE} = 600$ V $T_j = 25$ °C $\dots\dots\dots$
 $V_{GE} = \pm 15$ V $T_j = 125$ °C ---
 $I_c = 100$ A $T_j = 150$ °C --- --

figure 11. FWD

Typical peak reverse recovery current current as a function of collector current

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

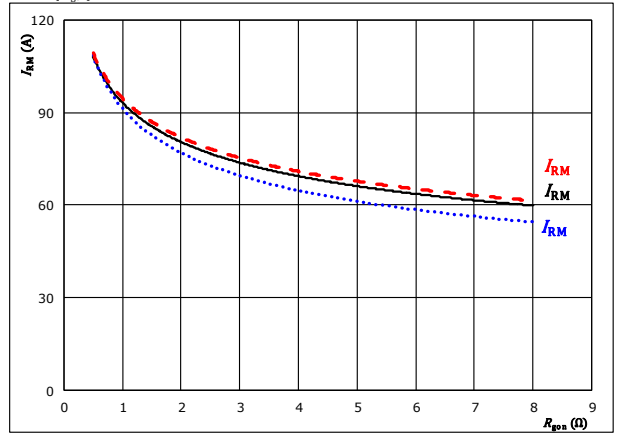


At $V_{CE} = 600$ V $T_j = 25$ °C $\dots\dots\dots$
 $V_{GE} = \pm 15$ V $T_j = 125$ °C ---
 $R_{gdn} = 2$ Ω $T_j = 150$ °C --- --

figure 12. FWD

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

$$I_{RM} = f(R_{gdn})$$



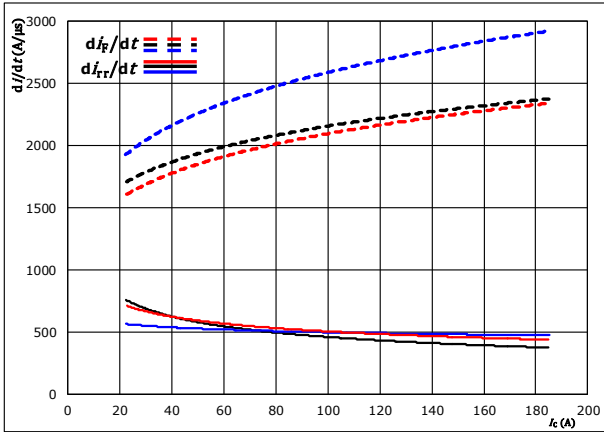
At $V_{CE} = 600$ V $T_j = 25$ °C $\dots\dots\dots$
 $V_{GE} = \pm 15$ V $T_j = 125$ °C ---
 $I_c = 100$ A $T_j = 150$ °C --- --



Neutral Switching Characteristics

figure 13. FWD

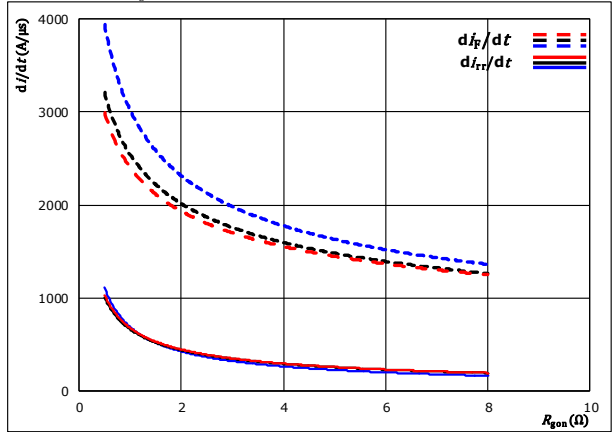
Typical rate of fall of forward and reverse recovery current as a function of collector current
 $di_f/dt, di_{rr}/dt = f(I_c)$



At $V_{CE} = 600$ V $T_j = 25$ °C
 $V_{GE} = \pm 15$ V $T_j = 125$ °C
 $R_{g\text{on}} = 2$ Ω $T_j = 150$ °C

figure 14. FWD

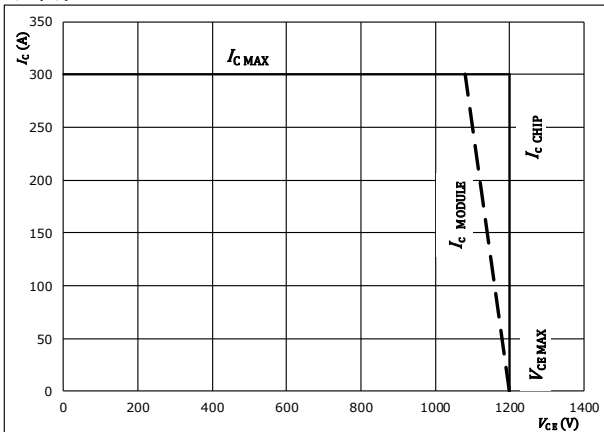
Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor
 $di_f/dt, di_{rr}/dt = f(R_{g\text{on}})$



At $V_{CE} = 600$ V $T_j = 25$ °C
 $V_{GE} = \pm 15$ V $T_j = 125$ °C
 $I_c = 100$ A $T_j = 150$ °C

figure 15. IGBT

Reverse bias safe operating area
 $I_c = f(V_{CB})$

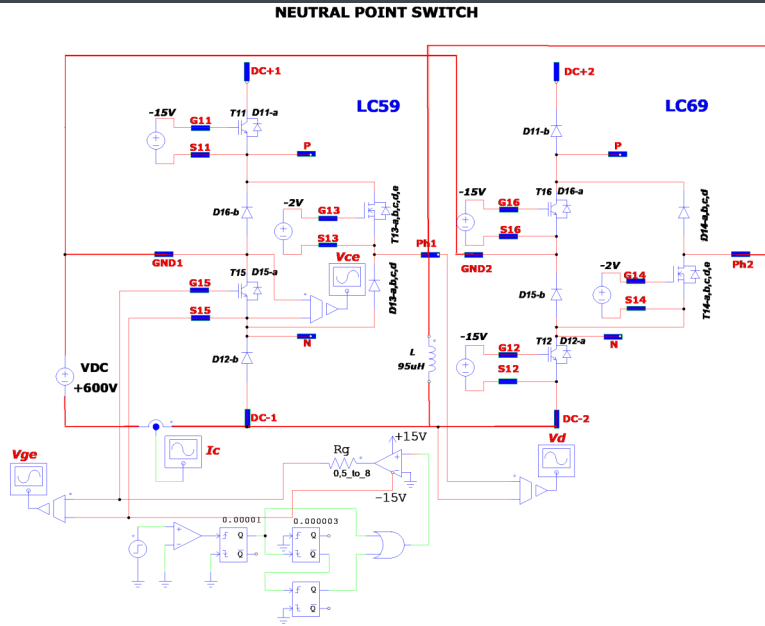


At $T_j = 125$ °C
 $R_{g\text{on}} = 2$ Ω
 $R_{g\text{off}} = 2$ Ω



Neutral Switching measurement circuit

figure 1.





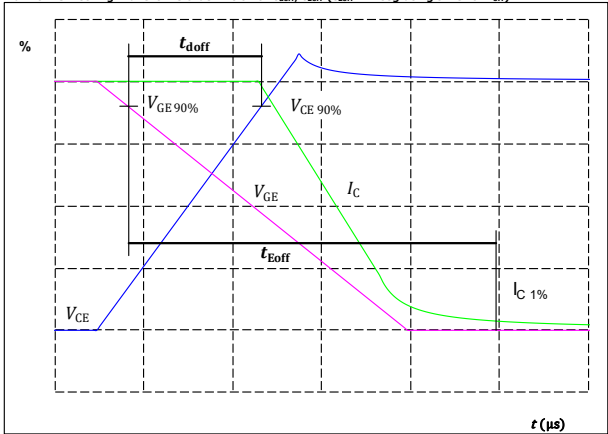
Neutral Switching Definitions

General conditions

T_j	=	125 °C
R_{gon}	=	2 Ω
R_{goff}	=	2 Ω

figure 1. IGBT

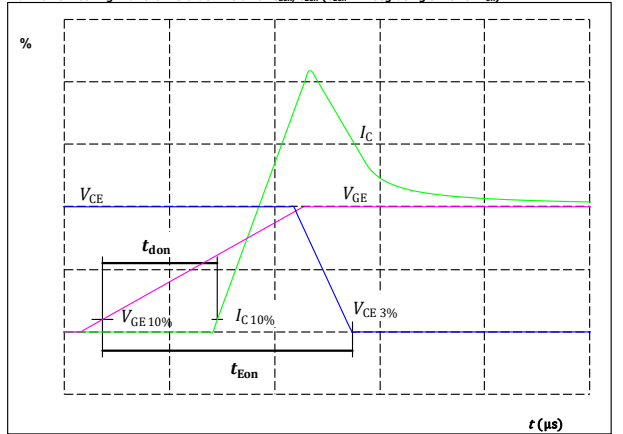
Turn-off Switching Waveforms & definition of t_{doff} , t_{Eoff} (t_{Eoff} = integrating time for E_{off})



$V_{CE}(0\%) =$	-15	V
$V_{GE}(100\%) =$	15	V
$V_C(100\%) =$	600	V
$I_C(100\%) =$	100	A
$t_{doff} =$	351	ns

figure 2. IGBT

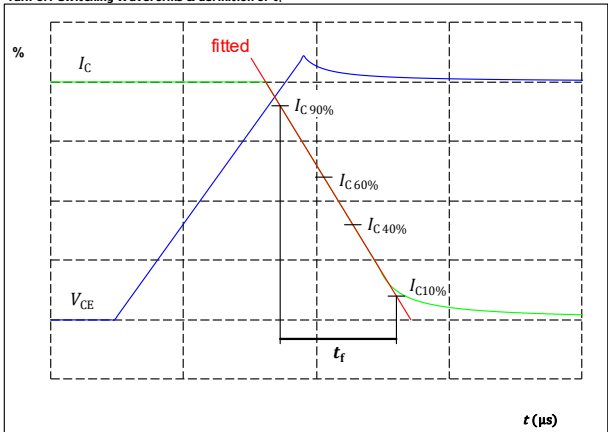
Turn-on Switching Waveforms & definition of t_{don} , t_{Eon} (t_{Eon} = integrating time for E_{on})



$V_{CE}(0\%) =$	-15	V
$V_{GE}(100\%) =$	15	V
$V_C(100\%) =$	600	V
$I_C(100\%) =$	100	A
$t_{don} =$	349	ns

figure 3. IGBT

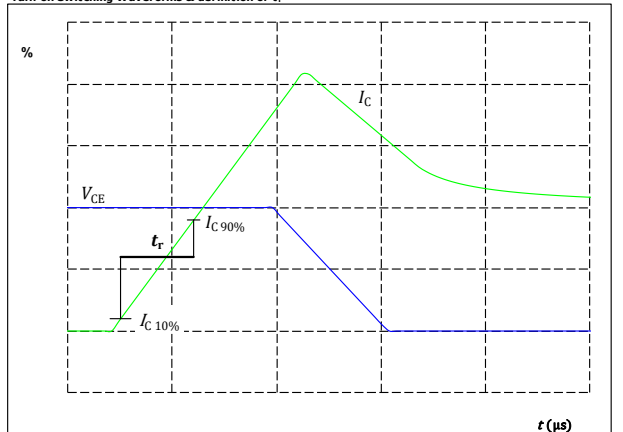
Turn-off Switching Waveforms & definition of t_f



$V_C(100\%) =$	600	V
$I_C(100\%) =$	100	A
$t_f =$	139	ns

figure 4. IGBT

Turn-on Switching Waveforms & definition of t_r

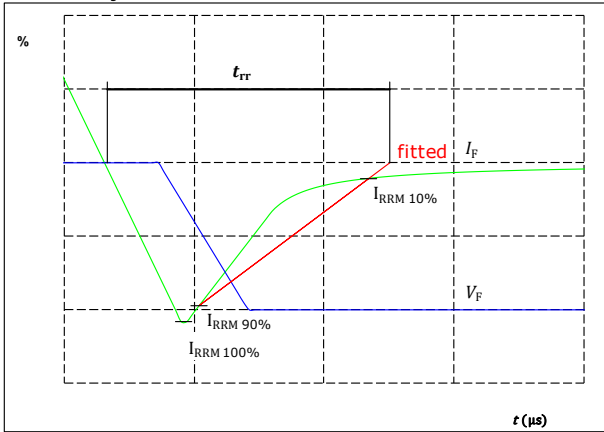


$V_C(100\%) =$	600	V
$I_C(100\%) =$	100	A
$t_r =$	47	ns



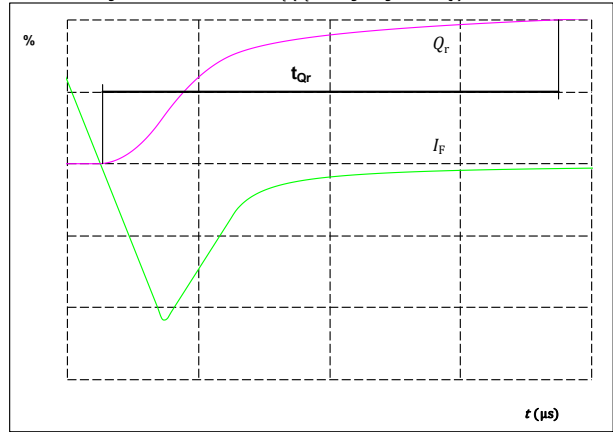
Neutral Switching Definitions

figure 5. FWD
 Turn-off Switching Waveforms & definition of t_{rr}



$V_F(100\%) =$	600	V
$I_F(100\%) =$	100	A
$I_{RRM}(100\%) =$	86	A
$t_{rr} =$	419	ns

figure 6. FWD
 Turn-on Switching Waveforms & definition of t_{qr} (t_{qr} = integrating time for Q_r)



$I_F(100\%) =$	100	A
$Q_r(100\%) =$	15,02	μC

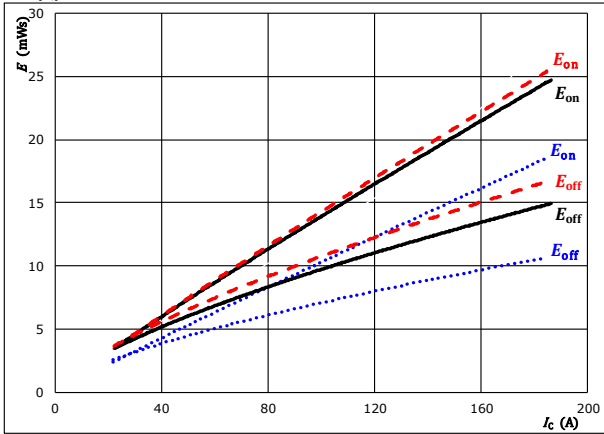


DC-Link Switching Characteristics

figure 1. IGBT

Typical switching energy losses as a function of collector current

$$E = f(I_C)$$



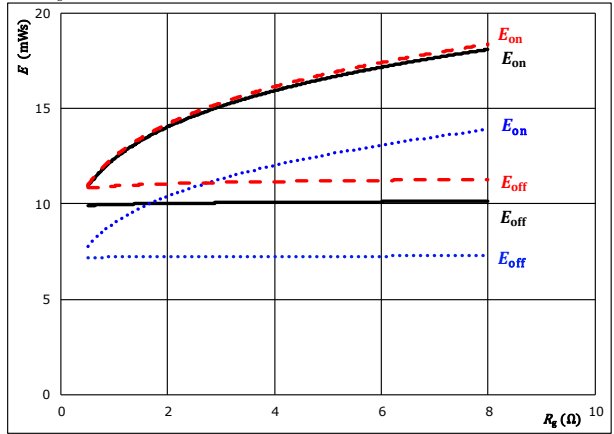
With an inductive load at

$V_{CE} = 600$ V	$T_j: 25$ °C
$V_{GE} = \pm 15$ V	$T_j: 125$ °C	————
$R_{g\text{on}} = 2$ Ω	$T_j: 150$ °C	-----
$R_{g\text{off}} = 2$ Ω		

figure 2. IGBT

Typical switching energy losses as a function of gate resistor

$$E = f(R_g)$$



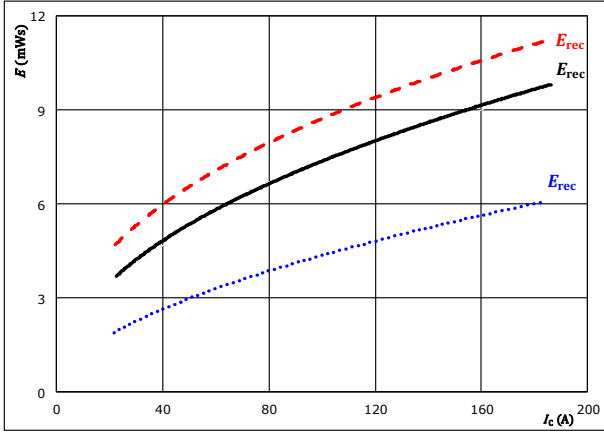
With an inductive load at

$V_{CE} = 600$ V	$T_j: 25$ °C
$V_{GE} = \pm 15$ V	$T_j: 125$ °C	————
$I_C = 100$ A	$T_j: 150$ °C	-----

figure 3. FWD

Typical reverse recovered energy loss as a function of collector current

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



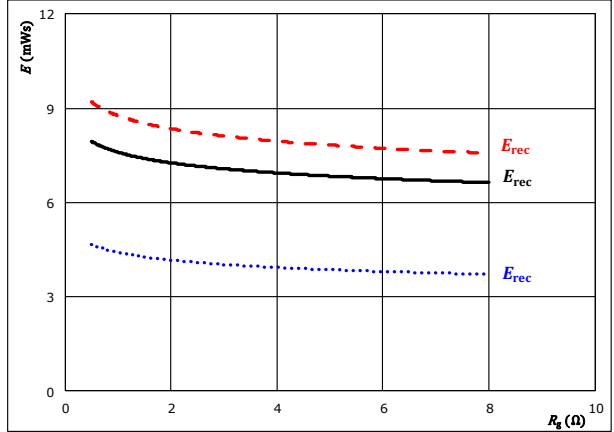
With an inductive load at

$V_{CE} = 600$ V	$T_j: 25$ °C
$V_{GE} = \pm 15$ V	$T_j: 125$ °C	————
$R_{g\text{on}} = 2$ Ω	$T_j: 150$ °C	-----

figure 4. FWD

Typical reverse recovered energy loss as a function of gate resistor

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



With an inductive load at

$V_{CE} = 600$ V	$T_j: 25$ °C
$V_{GE} = \pm 15$ V	$T_j: 125$ °C	————
$I_C = 100$ A	$T_j: 150$ °C	-----

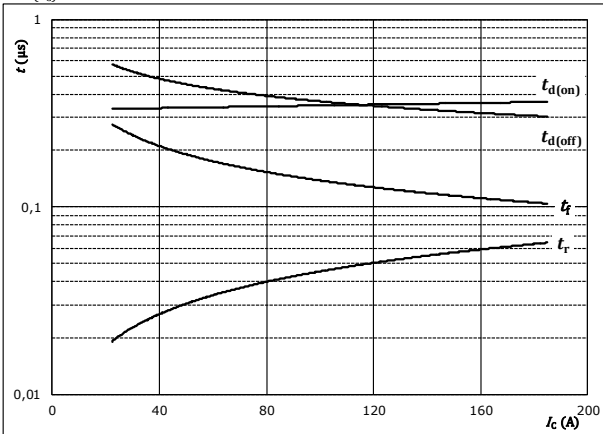


DC-Link Switching Characteristics

figure 5. IGBT

Typical switching times as a function of collector current

$$t = f(I_C)$$



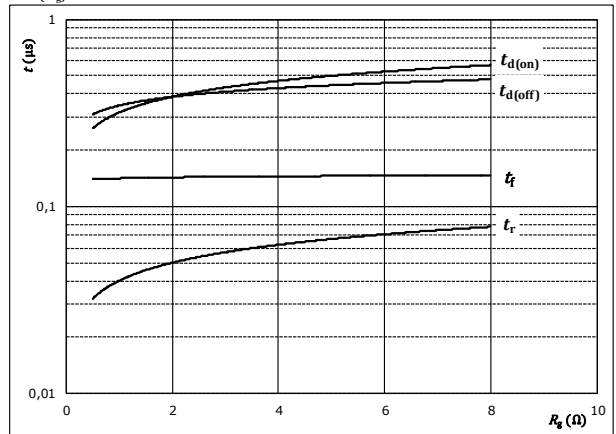
With an inductive load at

$T_j =$	150	°C
$V_{CE} =$	600	V
$V_{GE} =$	±15	V
$R_{g(on)} =$	2	Ω
$R_{g(off)} =$	2	Ω

figure 6. IGBT

Typical switching times as a function of gate resistor

$$t = f(R_g)$$



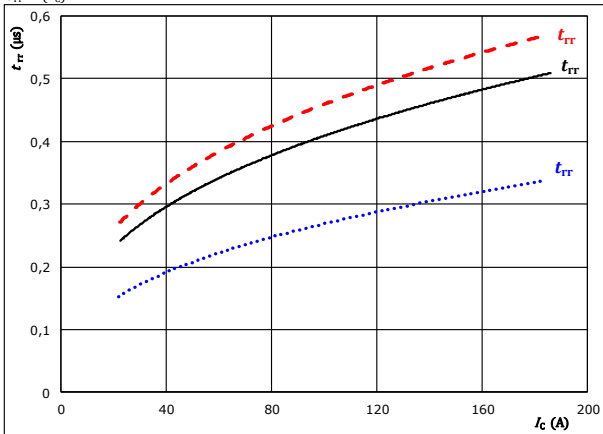
With an inductive load at

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

figure 7. FWD

Typical reverse recovery time as a function of collector current

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

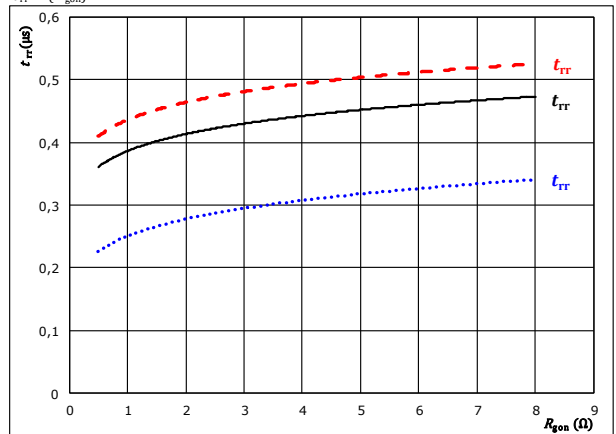


At	$V_{CE} =$	600	V	$T_j:$	25 °C
	$V_{GE} =$	±15	V		125 °C	————
	$R_{g(on)} =$	2	Ω		150 °C	- - - -

figure 8. FWD

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

$$t_{rr} = f(R_{g(on)})$$



At	$V_{CE} =$	600	V	$T_j:$	25 °C
	$V_{GE} =$	±15	V		125 °C	————
	$I_C =$	100	A		150 °C	- - - -

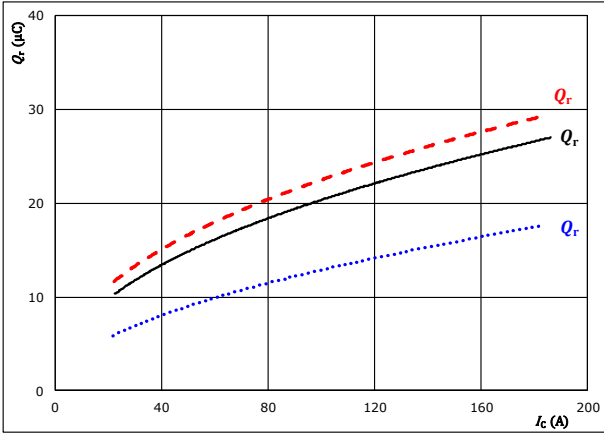


DC-Link Switching Characteristics

figure 9. FWD

Typical recovered charge as a function of collector current

$$Q_r = f(I_c)$$

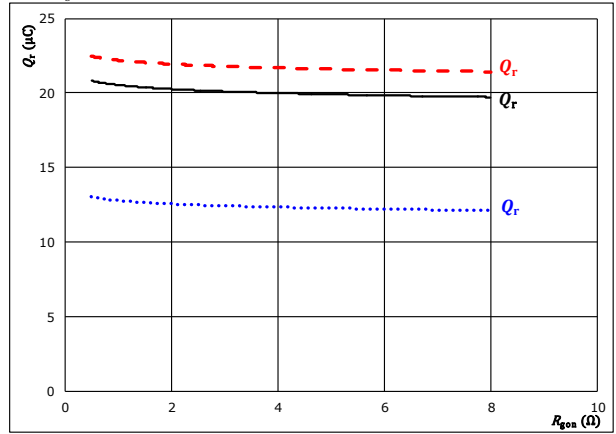


At $V_{CE} = 600$ V $T_j = 25$ °C $I_c = 100$ A
 $V_{GE} = \pm 15$ V $T_j = 125$ °C
 $R_{gon} = 2$ Ω $T_j = 150$ °C

figure 10. FWD

Typical recovered charge as a function of IGBT turn on gate resistor

$$Q_r = f(R_{gon})$$

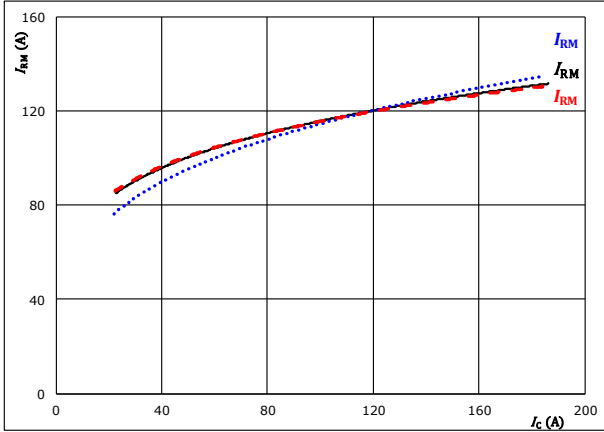


At $V_{CE} = 600$ V $T_j = 25$ °C $I_c = 100$ A
 $V_{GE} = \pm 15$ V $T_j = 125$ °C
 $I_c = 100$ A $T_j = 150$ °C

figure 11. FWD

Typical peak reverse recovery current current as a function of collector current

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

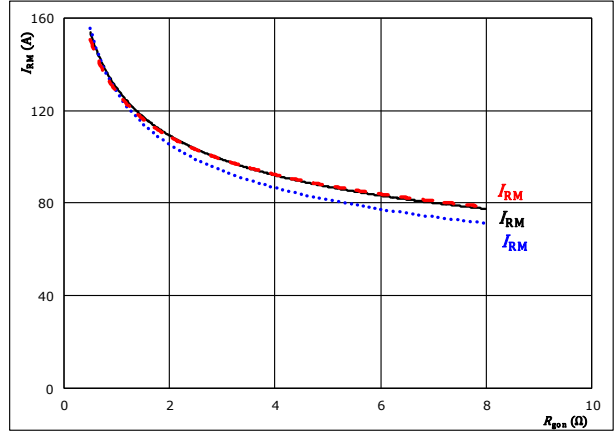


At $V_{CE} = 600$ V $T_j = 25$ °C
 $V_{GE} = \pm 15$ V $T_j = 125$ °C
 $R_{gon} = 2$ Ω $T_j = 150$ °C

figure 12. FWD

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

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



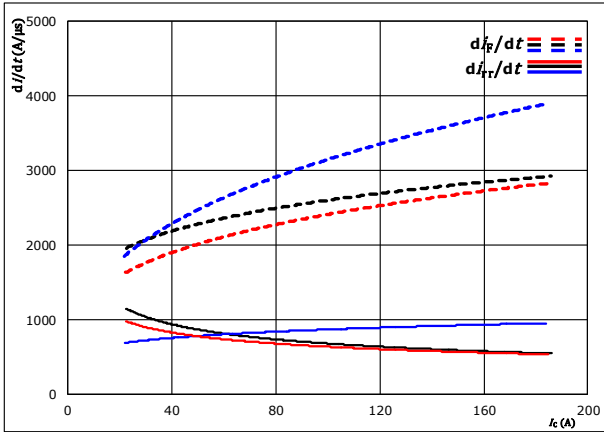
At $V_{CE} = 600$ V $T_j = 25$ °C
 $V_{GE} = \pm 15$ V $T_j = 125$ °C
 $I_c = 100$ A $T_j = 150$ °C



DC-Link Switching Characteristics

figure 13. FWD

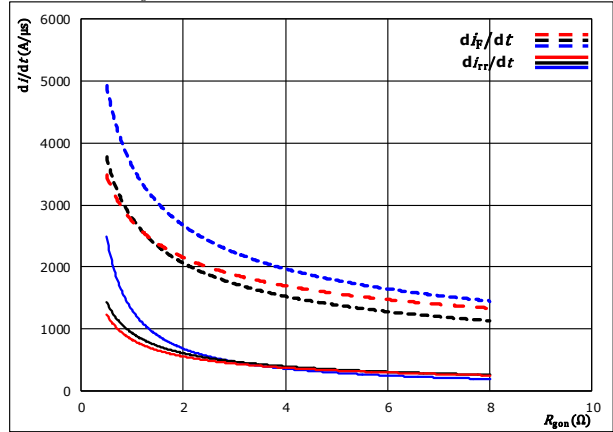
Typical rate of fall of forward and reverse recovery current as a function of collector current
 $di_f/dt, di_{rr}/dt = f(I_c)$



At $V_{CE} = 600$ V $T_j = 25$ °C
 $V_{GE} = \pm 15$ V $T_j = 125$ °C
 $R_{gpn} = 2$ Ω $T_j = 150$ °C

figure 14. FWD

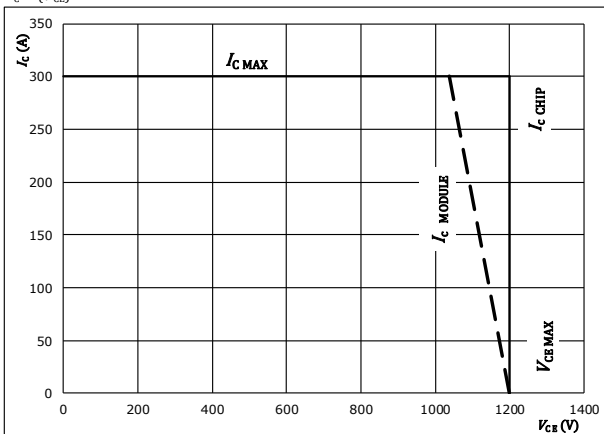
Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor
 $di_f/dt, di_{rr}/dt = f(R_{gpn})$



At $V_{CE} = 600$ V $T_j = 25$ °C
 $V_{GE} = \pm 15$ V $T_j = 125$ °C
 $I_c = 100$ A $T_j = 150$ °C

figure 15. IGBT

Reverse bias safe operating area
 $I_c = f(V_{CB})$

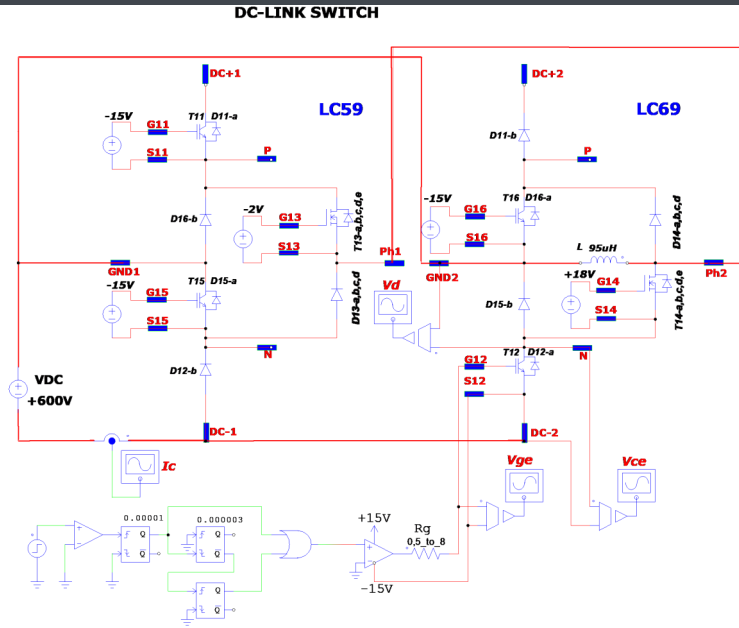


At $T_j = 125$ °C
 $R_{gpn} = 2$ Ω
 $R_{goff} = 2$ Ω



DC Open Switching Characteristics

figure 1.





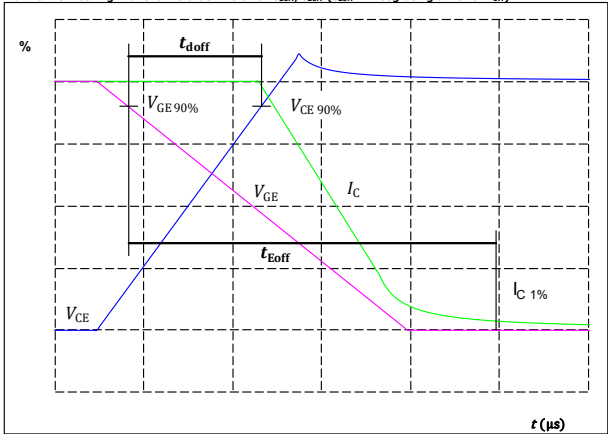
DC-Link Switching Definitions

General conditions

T_j	=	125 °C
R_{gon}	=	2 Ω
R_{goff}	=	2 Ω

figure 1. IGBT

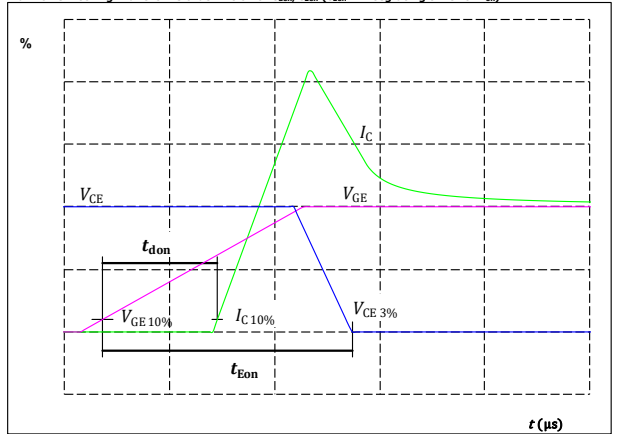
Turn-off Switching Waveforms & definition of t_{doff} , t_{Eoff} (t_{Eoff} = integrating time for E_{off})



$V_{CE}(0\%) =$	-15	V
$V_{GE}(100\%) =$	15	V
$V_C(100\%) =$	600	V
$I_C(100\%) =$	100	A
$t_{doff} =$	351	ns

figure 2. IGBT

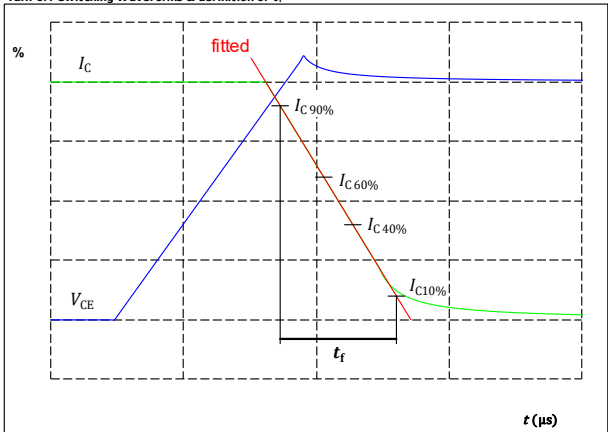
Turn-on Switching Waveforms & definition of t_{don} , t_{Eon} (t_{Eon} = integrating time for E_{on})



$V_{CE}(0\%) =$	-15	V
$V_{GE}(100\%) =$	15	V
$V_C(100\%) =$	600	V
$I_C(100\%) =$	100	A
$t_{don} =$	335	ns

figure 3. IGBT

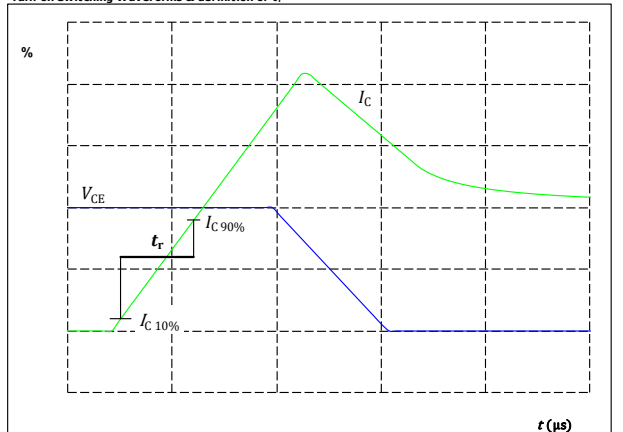
Turn-off Switching Waveforms & definition of t_f



$V_C(100\%) =$	600	V
$I_C(100\%) =$	100	A
$t_f =$	136	ns

figure 4. IGBT

Turn-on Switching Waveforms & definition of t_r



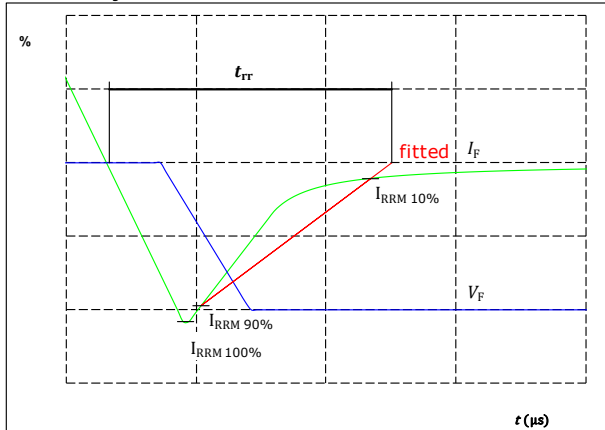
$V_C(100\%) =$	600	V
$I_C(100\%) =$	100	A
$t_r =$	41	ns



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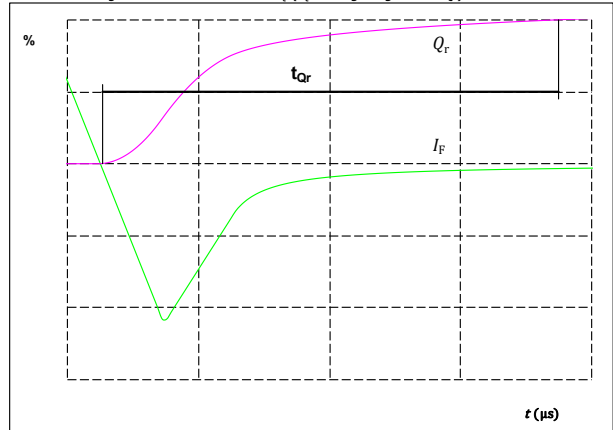
DC-Link Switching Definitions

figure 5. FWD
 Turn-off Switching Waveforms & definition of t_{rr}



$V_F(100\%) =$	600	V
$I_F(100\%) =$	100	A
$I_{RRM}(100\%) =$	120	A
$t_{rr} =$	406	ns

figure 6. FWD
 Turn-on Switching Waveforms & definition of t_{Qr} ($t_{Qr} =$ integrating time for Q_r)



$I_F(100\%) =$	100	A
$Q_r(100\%) =$	20,79	μC



10-PG12NAB009CS04-LC59F88T 10-PG12NAC009CS04-LC69F88T

datasheet

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Ordering Code & Marking						
Version			Ordering Code			
without thermal paste 12 mm housing with Press-fit pins			10-PG12NAB009CS04-LC59F88T			
with thermal paste 12 mm housing with Press-fit pins			10-PG12NAB009CS04-LC59F88T-/3/			
NN-NNNNNNNNNNNN TTTTTTWWYY UL VIN LLLL SSSS						
Text	Name		Date code	UL & VIN	Lot	Serial
	NN-NNNNNNNNNNNN-TTTTTWW		WWYY	UL VIN	LLLLL	SSSS
Datamatrix	Type&Ver	Lot number	Serial	Date code		
	TTTTTTTWW	LLLLL	SSSS	WWYY		

High Side Module 10-PG12NAB009CS04-LC59F88T

Pin table				Outline	
Pin	X	Y	Function	<p>center of press-fit pinhead for connection parameter see the handling instruction</p> <p>0.2mm ±0.1 mm</p> <p>Tolerance of pinpositions ±0.4mm at the end of pins Dimension of coordinate axis is only offset without tolerance</p>	
1			Not assembled		
2	52,9	3	DC-1		
3	49,9	3	DC-1		
4	52,9	0	DC-1		
5	49,9	0	DC-1		
6			Not assembled		
7	40	0	GND1		
8	37	0	GND1		
9			Not assembled		
10			Not assembled		
11	21,8	0	GND1		
12	18,9	0	GND1		
13			Not assembled		
14	9	0	DC+1		
15	6	0	DC+1		
16	3	0	DC+1		
17	0	0	DC+1		
18	0	9,5	G11		
19	0	12,5	S11		
20	12,45	17,45	G13		
21	15,45	18,45	S13		
22	0	28,9	Therm11		
23	3	28,9	Therm12		
24			Not assembled		
25			Not assembled		
26			Not assembled		
27			Not assembled		
28			Not assembled		
29			Not assembled		
30			Not assembled		
31			Not assembled		
32	40,9	28,9	Ph1		
33	43,9	28,9	Ph1		
34	46,9	28,9	Ph1		
35	49,9	28,9	Ph1		
36	52,9	28,9	Ph1		
37	44,3	17,9	N1		
38	41,2	14,7	S15		
39	38,2	14,7	G15		
40	37,95	17,9	N1		
41			Not assembled		
42			Not assembled		
43	29,35	18,5	P1		
44	26,9	15,6	P1		
45			Not assembled		
46			Not assembled		
47			Not assembled		
48			Not assembled		

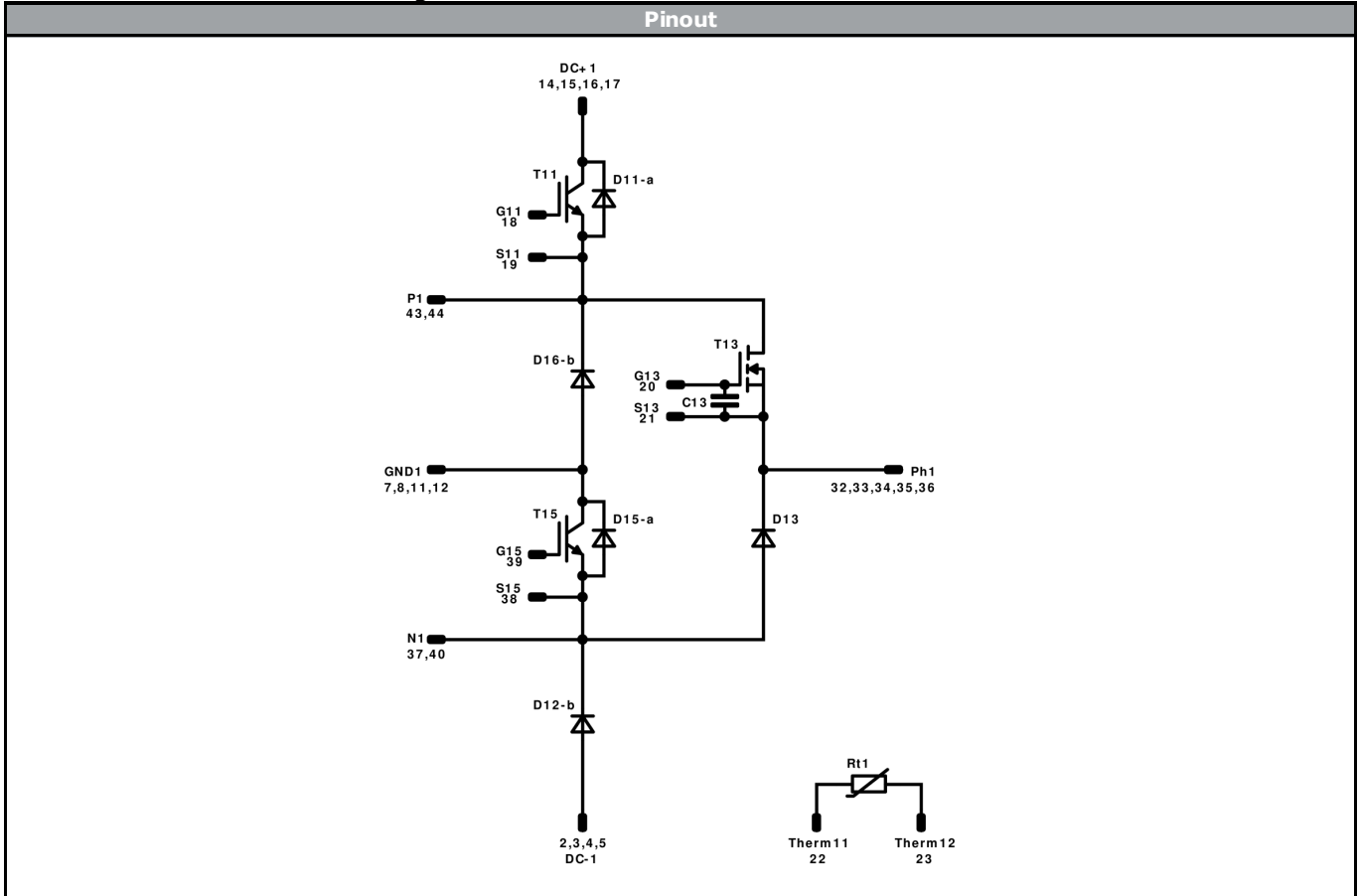


Vincotech

10-PG12NAB009CS04-LC59F88T
10-PG12NAC009CS04-LC69F88T
 datasheet

High Side Module 10-PG12NAB009CS04-LC59F88T

Pinout



Identification

ID	Component	Voltage	Current	Function	Comment
T13	MOSFET	1200 V	9 mΩ	AC Switch	
D13	FWD	1200 V	60 A	AC Diode	
T15	IGBT	1200 V	150 A	Neutral Point Switch	
D12-b	FWD	1200 V	100 A	DC-Link Diode	
D15-a	FWD	1200 V	15 A	Neutral Point Switch Prot. Diode	
T11	IGBT	1200 V	150 A	DC-Link Switch	
D16-b	FWD	1200 V	150 A	Neutral Point Diode	
D11-a	FWD	1200 V	100 A	DC-Link Switch Prot. Diode	
C13	Capacitor	25 V		Capacitor (GS)	
Rt1	NTC			Thermistor	



10-PG12NAB009CS04-LC59F88T
10-PG12NAC009CS04-LC69F88T
 datasheet

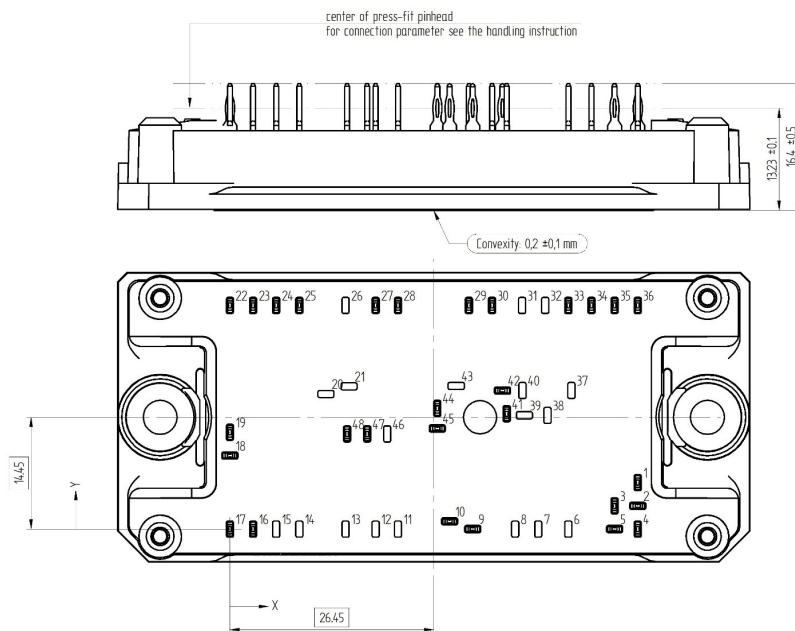
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Ordering Code & Marking																																
Version			Ordering Code																													
without thermal paste 12 mm housing with Press-fit pins			10-PG12NAC009CS04-LC69F88T																													
with thermal paste 12 mm housing with Press-fit pins			10-PG12NAC009CS04-LC69F88T-/3/																													
<table border="1"> <thead> <tr> <th rowspan="3">Text</th> <th colspan="2">Name</th> <th>Date code</th> <th>UL & VIN</th> <th>Lot</th> <th>Serial</th> </tr> <tr> <td colspan="2">NN-NNNNNNNNNNNNNN-TTTTTIV</td> <td>WWYY</td> <td>UL VIN</td> <td>LLLLL</td> <td>SSSS</td> </tr> <tr> <th>Type&Ver</th> <th>Lot number</th> <th>Serial</th> <th>Date code</th> <td></td> <td></td> </tr> </thead> <tbody> <tr> <td>Datamatrix</td> <td>TTTTTIV</td> <td>LLLLL</td> <td>SSSS</td> <td>WWYY</td> <td></td> <td></td> </tr> </tbody> </table>							Text	Name		Date code	UL & VIN	Lot	Serial	NN-NNNNNNNNNNNNNN-TTTTTIV		WWYY	UL VIN	LLLLL	SSSS	Type&Ver	Lot number	Serial	Date code			Datamatrix	TTTTTIV	LLLLL	SSSS	WWYY		
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	NN-NNNNNNNNNNNNNN-TTTTTIV		WWYY	UL VIN	LLLLL	SSSS																										
	Type&Ver	Lot number	Serial	Date code																												
Datamatrix	TTTTTIV	LLLLL	SSSS	WWYY																												

Low Side Module 10-PG12NAC009CS04-LC69F88T

Outline

Pin table			
Pin	X	Y	Function
1	52,9	6	Ph2
2	52,9	3	Ph2
3	49,9	3	Ph2
4	52,9	0	Ph2
5	49,9	0	Ph2
6	Not assembled		
7	Not assembled		
8	Not assembled		
9	31,5	0	S14
10	28,5	1	G14
11	Not assembled		
12	Not assembled		
13	Not assembled		
14	Not assembled		
15	Not assembled		
16	3	0	Therm21
17	0	0	Therm22
18	0	9,5	S16
19	0	12,5	G16
20	Not assembled		
21	Not assembled		
22	0	28,9	DC+2
23	3	28,9	DC+2
24	6	28,9	DC+2
25	9	28,9	DC+2
26	Not assembled		
27	18,9	28,9	GND2
28	21,8	28,9	GND2
29	31	28,9	GND2
30	34	28,9	GND2
31	Not assembled		
32	Not assembled		
33	43,9	28,9	DC-2
34	46,9	28,9	DC-2
35	49,9	28,9	DC-2
36	52,9	28,9	DC-2
37	Not assembled		
38	Not assembled		
39	Not assembled		
40	Not assembled		
41	35,9	14,9	G12
42	35,35	17,9	S12
43	Not assembled		
44	26,9	15,6	N2
45	26,9	13	N2
46	Not assembled		
47	17,8	12,3	P2
48	15,2	12,3	P2

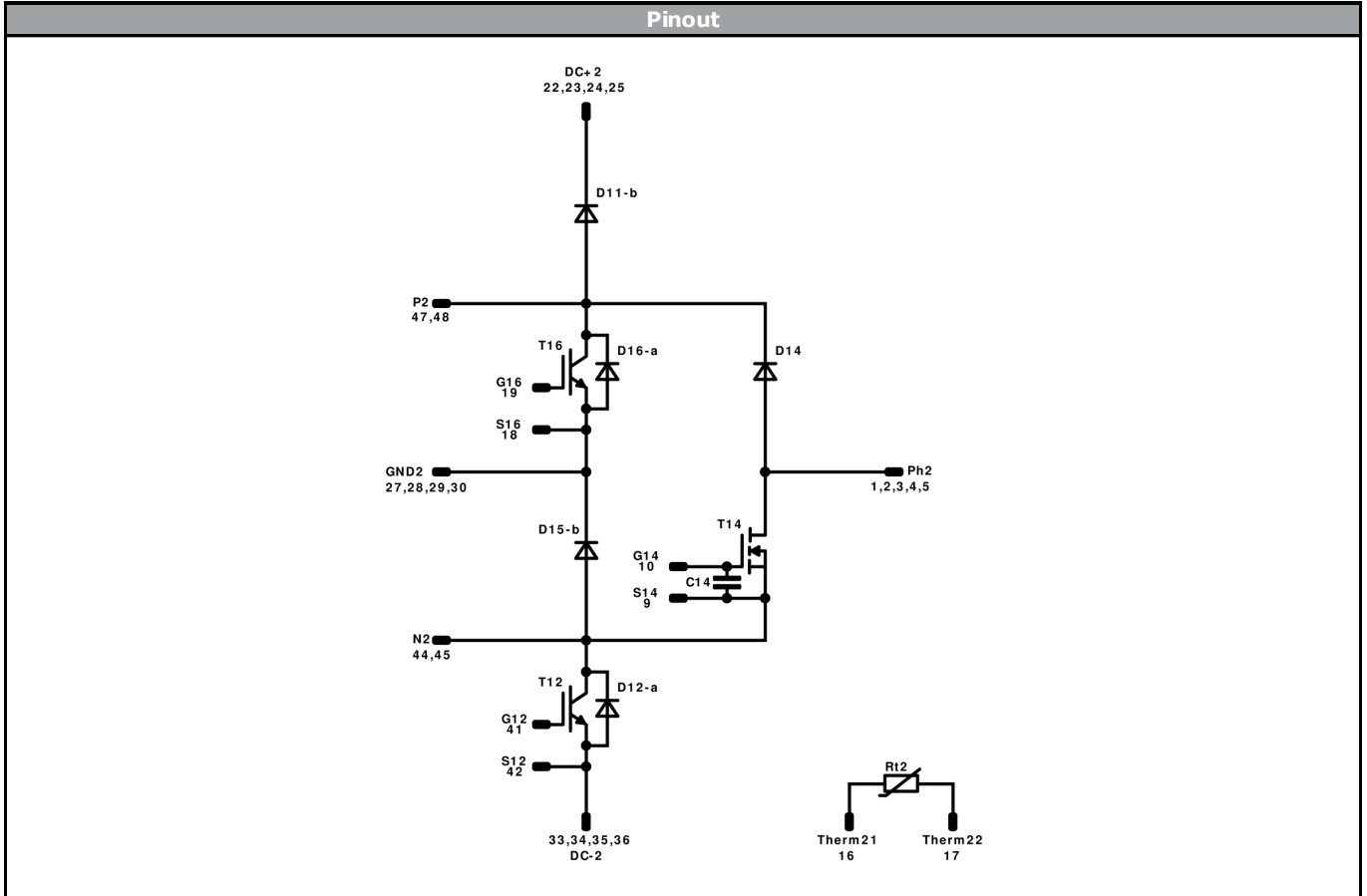


Tolerance of pinpositions ±0,4mm at the end of pins
 Dimension of coordinate axis is only offset without tolerance.



Low Side Module 10-PG12NAC009CS04-LC69F88T

Pinout



Identification

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T12	IGBT	1200 V	150 A	DC-Link Switch	
D11-b	FWD	1200 V	150 A	Neutral Point Diode	
D16-a	FWD	1200 V	100 A	DC-Link Switch Prot. Diode	
C14	Capacitor	25 V		Capacitor (GS)	
Rt2	NTC			Thermistor	




Vincotech

Packaging instruction			
Standard packaging quantity (SPQ) 100	>SPQ	Standard	<SPQ Sample

Handling instruction
Handling instructions for <i>flow 1</i> packages see vincotech.com website.

Package data
Package data for <i>flow 1</i> packages see vincotech.com website.

UL recognition and file number
This device is certified according to UL 1557 standard, UL file number E192116. For more information see vincotech.com website. 

Document No.:	Date:	Modification:	Pages
10-PG12NAX009CS04-LCx9F88T-D2-14	09 Jul. 2019	Marketing application voltage modified	1

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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.