Vincotech

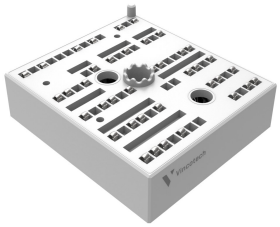
V23990-K220-A40
datasheet

MiniSKiiP®PIM 2 **1200 V / 35 A**

Features

- Solderless interconnection
- Trench Fieldstop IGBT4 technology

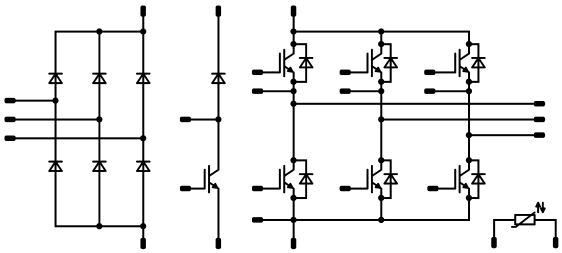
MiniSkiip®2 housing



Target applications

- Industrial Drives

Schematic



Types

- V23990-K220-A40

Maximum Ratings

T_j = 25 °C, unless otherwise specified

Parameter	Symbol	Condition	Value	Unit
Inverter Switch				
Collector-emitter voltage	V_{CES}		1200	V
Collector current	I_C	T_j = T_{jmax} T_s = 80 °C	46	A
Repetitive peak collector current	I_{CRM}	t_p limited by T_{jmax}	105	A
Total power dissipation	P_{tot}	T_j = T_{jmax} T_s = 80 °C	134	W
Gate-emitter voltage	V_{GES}		±20	V
Short circuit ratings	t_{SC}	T_j ≤ 150 °C V_{GE} = 15 V V_{CC} = 800 V	10	µs
Maximum junction temperature	T_{jmax}		175	°C

Maximum Ratings

T_j = 25 °C, unless otherwise specified

Parameter	Symbol	Condition	Value	Unit
Inverter Diode				
Peak repetitive reverse voltage	V_{RRM}		1200	V
Continuous (direct) forward current	I_F	$T_j = T_{jmax}$ T_s = 80 °C	40	A
Surge (non-repetitive) forward current	I_{FSM}	50 Hz Single Half Sine Wave t_p = 10 ms T_j = 150 °C	170	A
Surge current capability	I^2t		145	A^2s
Total power dissipation	P_{tot}	$T_j = T_{jmax}$ T_s = 80 °C	99	W
Maximum junction temperature	T_{jmax}		175	°C
Brake Switch				
Collector-emitter voltage	V_{CES}		1200	V
Collector current	I_C	$T_j = T_{jmax}$ T_s = 80 °C	46	A
Repetitive peak collector current	I_{CRM}	t_p limited by T_{jmax}	105	A
Total power dissipation	P_{tot}	$T_j = T_{jmax}$ T_s = 80 °C	134	W
Gate-emitter voltage	V_{GES}		±20	V
Short circuit ratings	t_{SC}	$T_j \leq$ 150 °C V_{GE} = 15 V V_{CC} = 800 V	10	µs
Maximum junction temperature	T_{jmax}		175	°C
Brake Diode				
Peak repetitive reverse voltage	V_{RRM}		1200	V
Continuous (direct) forward current	I_F	$T_j = T_{jmax}$ T_s = 80 °C	40	A
Surge (non-repetitive) forward current	I_{FSM}	50 Hz Single Half Sine Wave t_p = 10 ms T_j = 150 °C	170	A
Surge current capability	I^2t		145	A^2s
Total power dissipation	P_{tot}	$T_j = T_{jmax}$ T_s = 80 °C	99	W
Maximum junction temperature	T_{jmax}		175	°C

Maximum Ratings

T_j = 25 °C, unless otherwise specified

Parameter	Symbol	Condition	Value	Unit
Rectifier Diode				
Peak repetitive reverse voltage	V_{RRM}		1600	V
Continuous (direct) forward current	I_F	$T_j = T_{jmax}$ T_s = 80 °C	50	A
Surge (non-repetitive) forward current	I_{FSM}	50 Hz Single Half Sine Wave t_p = 10 ms T_j = 150 °C	270	A
Surge current capability	I^2t		370	A^2s
Total power dissipation	P_{tot}	$T_j = T_{jmax}$ T_s = 80 °C	64	W
Maximum junction temperature	T_{jmax}		150	°C
Module Properties				
Thermal Properties				
Storage temperature	T_{stg}		-40…+125	°C
Operation temperature under switching condition	T_{jop}		-40…(T_{jmax} - 25)	°C
Isolation Properties				
Isolation voltage	V_{isol}	DC Test Voltage* t_p = 2 s	5500	V
		AC Voltage t_p = 1 min	2500	V
Creepage distance		With std lid For more informations see handling instructions	6,3	mm
Clearance		With std lid For more informations see handling instructions	6,3	mm
Comparative Tracking Index	CTI		> 200	

*100 % tested in production

Characteristic Values

Parameter	Symbol	Conditions					Value			Unit
			V_{GE} [V] V_{GS} [V]	V_{CE} [V] V_{DS} [V] V_F [V]	I_C [A] I_D [A] I_F [A]	T_j [°C]	Min	Typ	Max	
Inverter Switch										
Static										
Gate-emitter threshold voltage	$V_{GE(th)}$	$V_{GE} = V_{CE}$			0,0012	25	5,3	5,8	6,3	V
Collector-emitter saturation voltage	V_{CEsat}		15		35	25 150	1,58	1,87 2,30	2,07	V
Collector-emitter cut-off current	I_{CES}		0	1200		25			5	µA
Gate-emitter leakage current	I_{GES}		20	0		25			120	nA
Internal gate resistance	r_g							none		Ω
Input capacitance	C_{ies}	f= 1 Mhz	0	25		25		2000		pF
Reverse transfer capacitance	C_{res}							70		
Gate charge	Q_g		15			25		270		
Thermal										
Thermal resistance junction to sink	$R_{th(j-s)}$	λ_{paste} = 2,5 W/mK (HPTP)						0,71		K/W
Dynamic										
Turn-on delay time	$t_{d(on)}$	R_{gon} = 16 Ω R_{goff} = 16 Ω	±15	600	35	25 125 150		311 298 294		ns
Rise time	t_r					25 125 150		131 140 140		
Turn-off delay time	$t_{d(off)}$					25 125 150		208 269 286		
Fall time	t_f					25 125 150		73 136 150		
Turn-on energy (per pulse)	E_{on}	Q_{rFWD} = 2 µC Q_{rFWD} = 4,2 µC Q_{rFWD} = 5,2 µC				25 125 150		3,87 5,27 5,86		mWs
Turn-off energy (per pulse)	E_{off}					25 125 150		1,94 3,20 3,52		

Characteristic Values

Parameter	Symbol	Conditions					Value			Unit
			V_{GE} [V] V_{GS} [V]	V_{CE} [V] V_{DS} [V] V_F [V]	I_C [A] I_D [A] I_F [A]	T_j [°C]	Min	Typ	Max	
Inverter Diode										
Static										
Forward voltage	V_F				35	25 150		2,37 2,35	2,62	V
Reverse leakage current	I_R			1200		25 150			60 5500	µA
Thermal										
Thermal resistance junction to sink	$R_{th(j-s)}$	λ_{paste} = 2,5 W/mK (HPTP)						0,96		K/W
Dynamic										
Peak recovery current	I_{RRM}	di/dt = 213 A/µs di/dt = 196 A/µs di/dt = 223 A/µs	±15	600	35	25 125 150		12 16 17		A
Reverse recovery time	t_{rr}					25 125 150		344 514 625		ns
Recovered charge	Q_r					25 125 150		2,01 4,21 5,25		µC
Reverse recovered energy	E_{rec}					25 125 150		0,76 1,66 2,07		mWs
Peak rate of fall of recovery current	$(di_{rf}/dt)_{max}$					25 125 150		126 64 65		A/µs

Characteristic Values

Parameter	Symbol	Conditions					Value			Unit
			V_{GE} [V] V_{GS} [V]	V_{CE} [V] V_{DS} [V] V_F [V]	I_C [A] I_D [A] I_F [A]	T_j [°C]	Min	Typ	Max	
Brake Switch										
Static										
Gate-emitter threshold voltage	$V_{GE(th)}$	$V_{GE} = V_{CE}$			0,0012	25	5,3	5,8	6,3	V
Collector-emitter saturation voltage	V_{CEsat}		15		35	25 150	1,58	1,87 2,30	2,07	V
Collector-emitter cut-off current	I_{CES}		0	1200		25			5	µA
Gate-emitter leakage current	I_{GES}		20	0		25			120	nA
Internal gate resistance	r_g							none		Ω
Input capacitance	C_{ies}	f= 1 Mhz	0	25		25		2000		pF
Reverse transfer capacitance	C_{res}							70		
Gate charge	Q_g		15			25		270		
Thermal										
Thermal resistance junction to sink	$R_{th(j-s)}$	λ_{paste} = 2,5 W/mK (HPTP)						0,71		K/W
Dynamic										
Turn-on delay time	$t_{d(on)}$	R_{gon} = 16 Ω R_{goff} = 16 Ω	-5 / 15	600	35	25 125 150		134 179 117		ns
Rise time	t_r					25 125 150		128 139 136		
Turn-off delay time	$t_{d(off)}$					25 125 150		368 330 444		
Fall time	t_f					25 125 150		51 138 151		
Turn-on energy (per pulse)	E_{on}	Q_{rFWD} = 1,9 µC Q_{rFWD} = 4 µC Q_{rFWD} = 5,2 µC				25 125 150		3,69 5,17 5,64		mWs
Turn-off energy (per pulse)	E_{off}					25 125 150		2,20 3,22 3,68		

Characteristic Values

Parameter	Symbol	Conditions					Value			Unit
			V_{GE} [V] V_{GS} [V]	V_{CE} [V] V_{DS} [V] V_F [V]	I_C [A] I_D [A] I_F [A]	T_j [°C]	Min	Typ	Max	
Brake Diode										
Static										
Forward voltage	V_F				35	25 150		2,37 2,35	2,62	V
Reverse leakage current	I_R			1200		25 150			60 5500	µA
Thermal										
Thermal resistance junction to sink	$R_{th(j-s)}$	λ_{paste} = 2,5 W/mK (HPTP)						0,96		K/W
Dynamic										
Peak recovery current	I_{RRM}	di/dt = 245 A/µs di/dt = 221 A/µs di/dt = 206 A/µs	-5 / 15	600	35	25 125 150		12 16 18		A
Reverse recovery time	t_{rr}					25 125 150		343 515 609		ns
Recovered charge	Q_r					25 125 150		1,89 4,03 5,23		µC
Reverse recovered energy	E_{rec}					25 125 150		0,72 1,59 2,09		mWs
Peak rate of fall of recovery current	$(di_{rf}/dt)_{max}$					25 125 150		134 65 66		A/µs
Rectifier Diode										
Static										
Forward voltage	V_F				35	25 125		1,17 1,13		V
Reverse leakage current	I_R			1600		25			50	µA
Thermal										
Thermal resistance junction to sink	$R_{th(j-s)}$	λ_{paste} = 2,5 W/mK (HPTP)						1,10		K/W

Characteristic Values

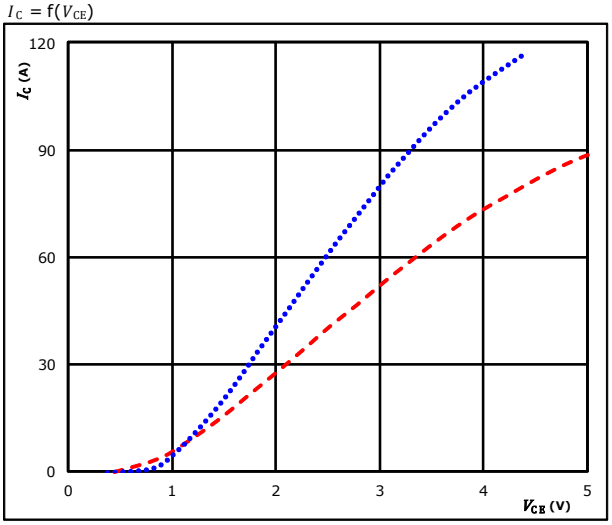
Parameter	Symbol	Conditions					Value			Unit
			V_{GE} [V] V_{GS} [V]	V_{CE} [V] V_{DS} [V] V_F [V]	I_C [A] I_D [A] I_F [A]	T_j [°C]	Min	Typ	Max	
Thermistor										
Rated resistance	R					25		1		kΩ
Deviation of R_{100}	$\Delta_{R/R}$	R_{100} = 1670 Ω				100	-2		+2	%
R_{100}	R					100		1670		Ω
Power dissipation constant						25		0,76		mW/K
A-value	$A_{(25/50)}$					25		$7{,}635*10^{-3}$		1/K
B-value	$B_{(25/100)}$					25		$1{,}731*10^{-5}$		1/K²
Vincotech PTC Reference									E	

Inverter Switch Characteristics

figure 1. **IGBT**

Typical output characteristics

$I_C = f(V_{CE})$

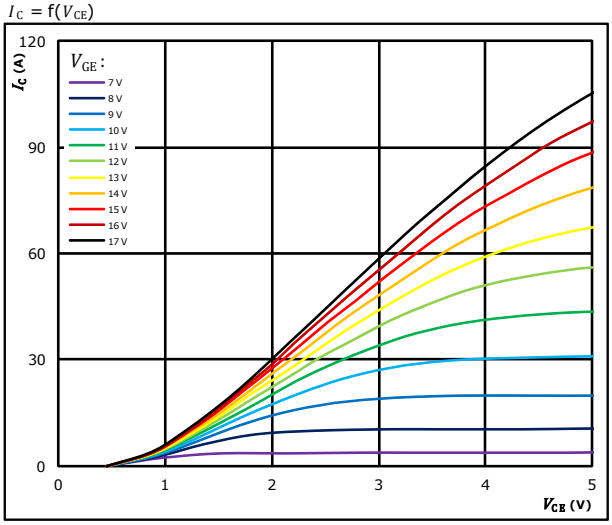


t_p =	250	µs	T_j:	25 °C	·····
V_{GE} =	15	V		150 °C	— — —

figure 2. **IGBT**

Typical output characteristics

$I_C = f(V_{CE})$

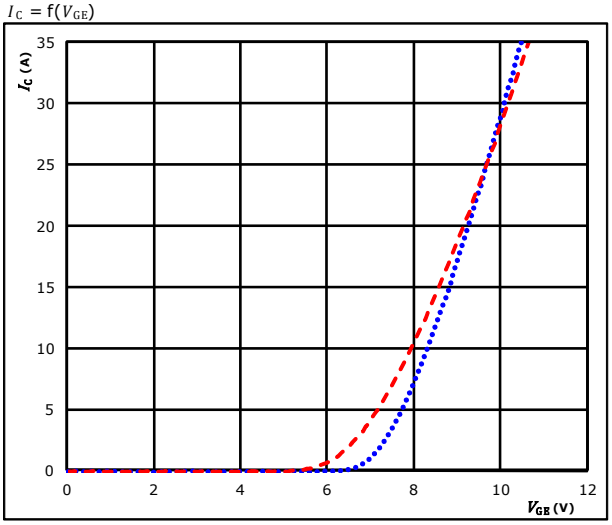


t_p =	250	µs
T_j =	150	°C
V_{GE} from	7 V to 17 V in steps of 1 V	

figure 3. **IGBT**

Typical transfer characteristics

$I_C = f(V_{GE})$

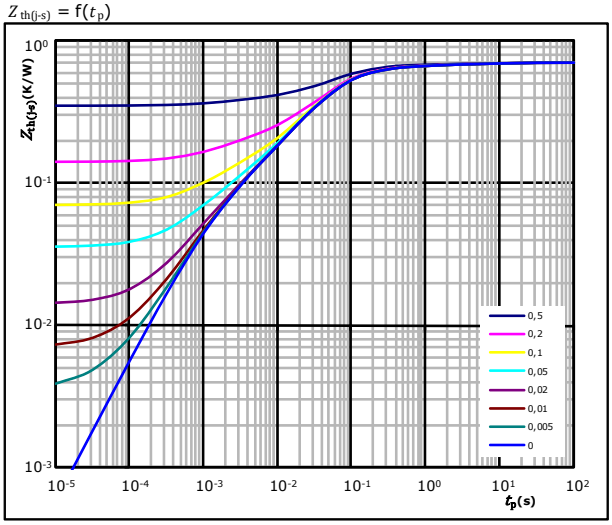


t_p =	100	µs	T_j:	25 °C	·····
V_{CE} =	10	V		150 °C	— — —

figure 4. **IGBT**

Transient thermal impedance as function of pulse duration

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



D =	t_p / T	
$R_{th(j-s)}$ =	0,71	K/W

IGBT thermal model values

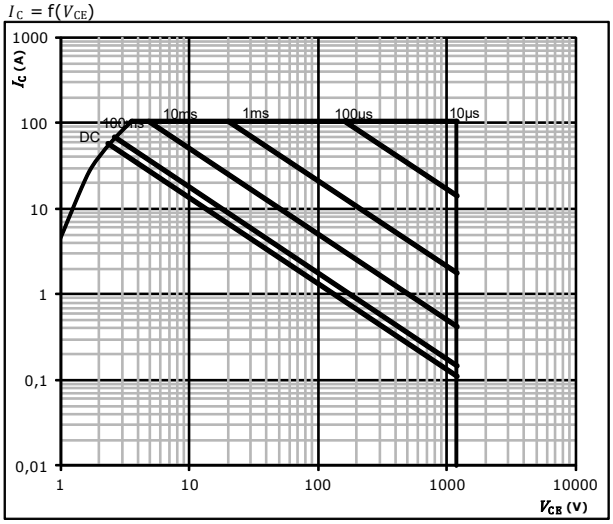
R (K/W)	τ (s)
2,63E-02	5,27E+00
4,93E-02	4,49E-01
1,31E-01	8,01E-02
3,79E-01	2,68E-02
7,06E-02	5,21E-03
4,74E-02	8,00E-04
3,27E-03	3,86E-04

Inverter Switch Characteristics

figure 5. **IGBT**

Safe operating area

$I_C = f(V_{CE})$



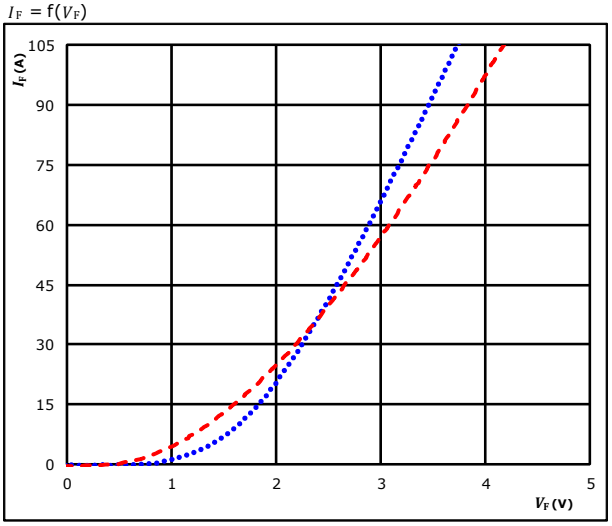
D =	single pulse	
T_s =	80	ºC
V_{GE} =	±15	V
T_j =	T_{jmax}	

Inverter Diode Characteristics

figure 1. **FWD**

Typical forward characteristics

$I_F = f(V_F)$



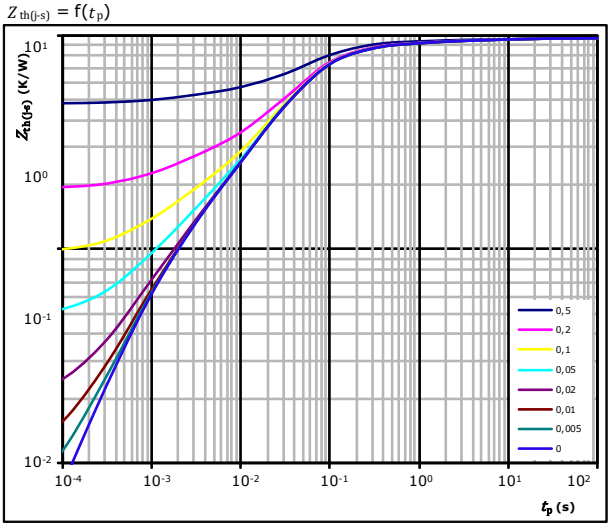
t_p = 250 µs

T_j: 25 °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

$R_{th(j-s)}$ = 0,96 K/W

FWD thermal model values

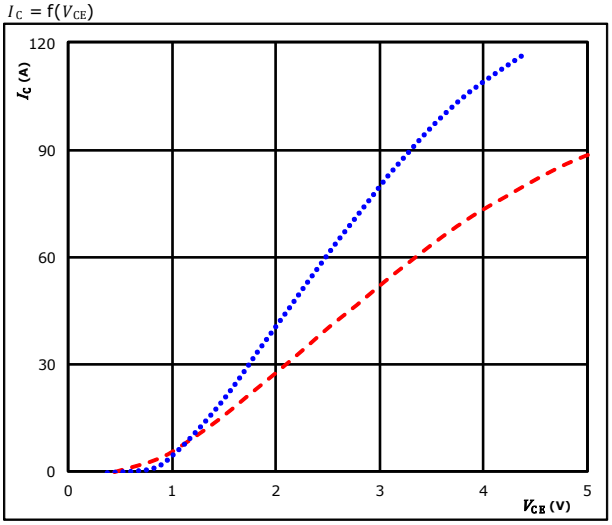
R (K/W)	τ (s)
3,58E-02	7,17E+00
6,71E-02	6,11E-01
1,78E-01	1,09E-01
5,16E-01	3,64E-02
9,61E-02	7,09E-03
6,45E-02	1,09E-03
4,45E-03	5,25E-04

Brake Switch Characteristics

figure 1. **IGBT**

Typical output characteristics

$I_C = f(V_{CE})$

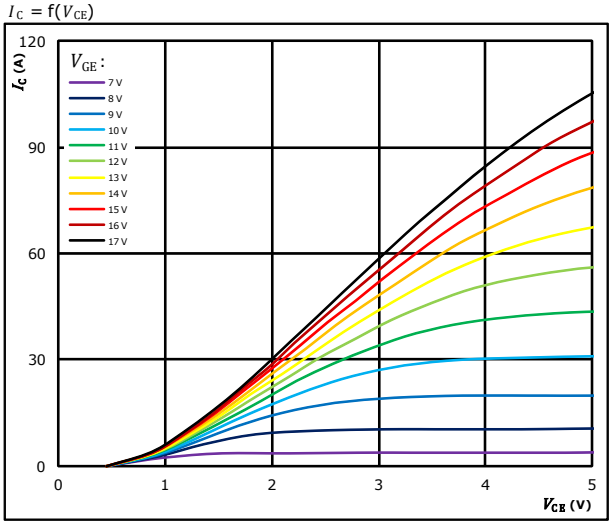


t_p =	250	µs	T_j:	25 °C	·····
V_{GE} =	15	V		150 °C	— — —

figure 2. **IGBT**

Typical output characteristics

$I_C = f(V_{CE})$

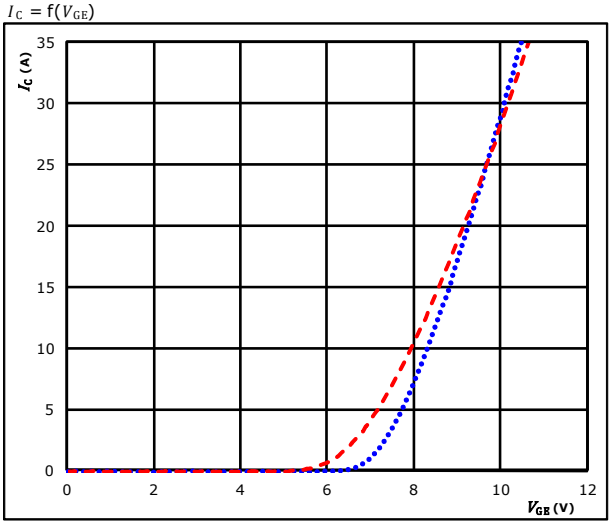


t_p =	250	µs
T_j =	150	°C
V_{GE} from	7 V to 17 V in steps of 1 V	

figure 3. **IGBT**

Typical transfer characteristics

$I_C = f(V_{GE})$

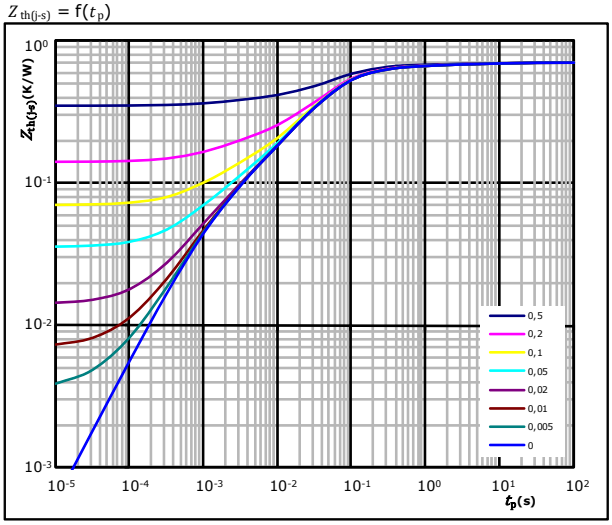


t_p =	100	µs	T_j:	25 °C	·····
V_{CE} =	10	V		150 °C	— — —

figure 4. **IGBT**

Transient thermal impedance as function of pulse duration

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



D =	t_p / T	
$R_{th(j-s)}$ =	0,71	K/W

IGBT thermal model values

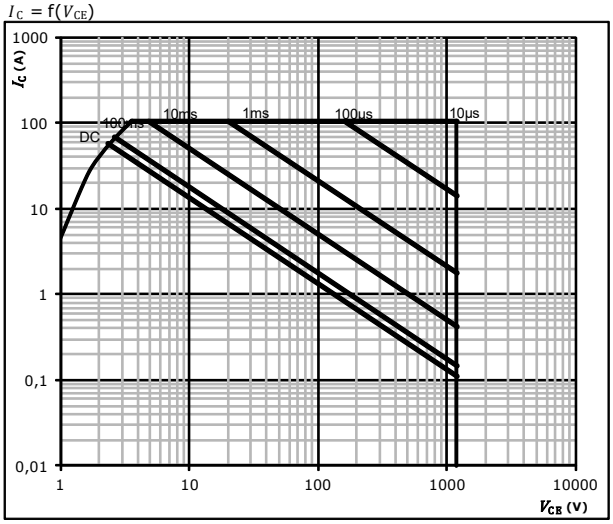
R (K/W)	τ (s)
2,63E-02	5,27E+00
4,93E-02	4,49E-01
1,31E-01	8,01E-02
3,79E-01	2,68E-02
7,06E-02	5,21E-03
4,74E-02	8,00E-04
3,27E-03	3,86E-04

Brake Switch Characteristics

figure 5. **IGBT**

Safe operating area

$I_C = f(V_{CE})$



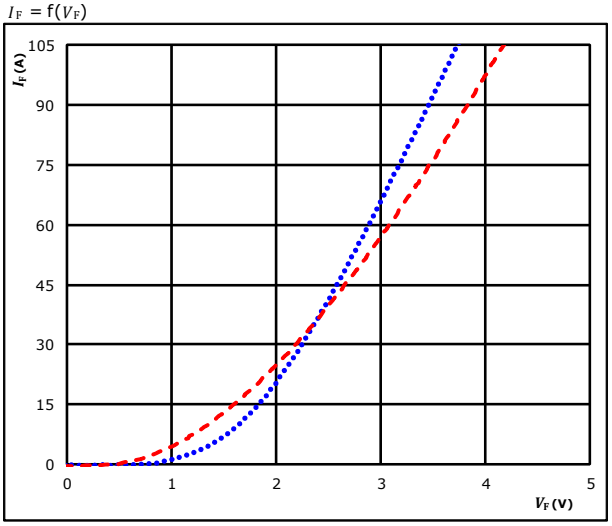
D =	single pulse	
T_s =	80	ºC
V_{GE} =	±15	V
T_j =	T_{jmax}	

Brake Diode Characteristics

figure 1. **FWD**

Typical forward characteristics

$I_F = f(V_F)$



t_p = 250 µs

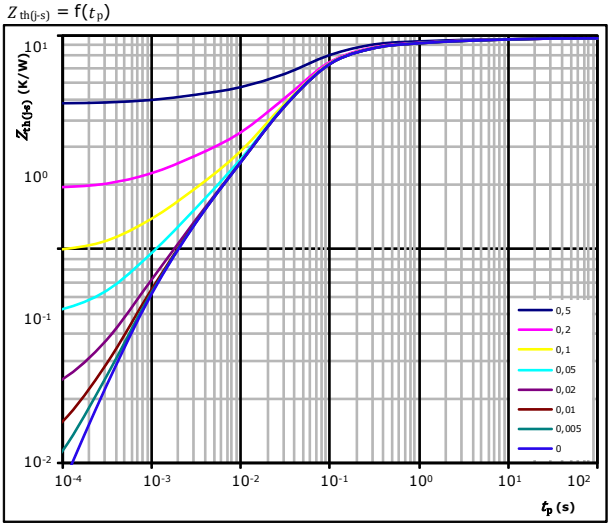
T_j: 25 °C

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

$R_{th(j-s)}$ = 0,96 K/W

FWD thermal model values

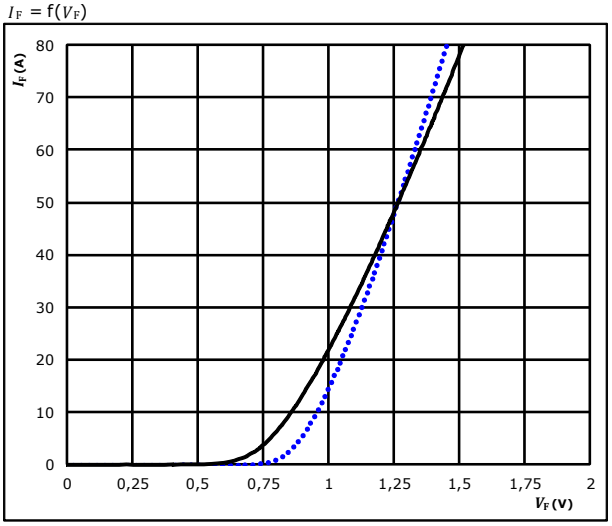
R (K/W)	τ (s)
3,58E-02	7,17E+00
6,71E-02	6,11E-01
1,78E-01	1,09E-01
5,16E-01	3,64E-02
9,61E-02	7,09E-03
6,45E-02	1,09E-03
4,45E-03	5,25E-04

Rectifier Diode Characteristics

figure 1. **Rectifier Diode**

Typical forward characteristics

$I_F = f(V_F)$



t_p = 250 µs

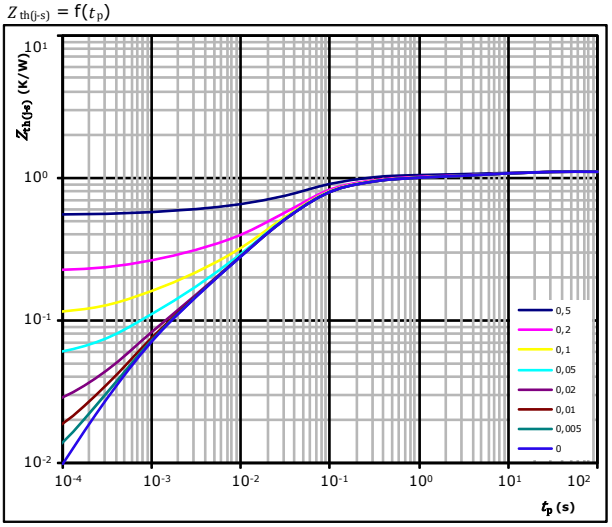
T_j: 25 °C

125 °C

figure 2. **Rectifier Diode**

Transient thermal impedance as a function of pulse width

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



D = t_p / T

$R_{th(j-s)}$ = 1,10 K/W

Diode thermal model values

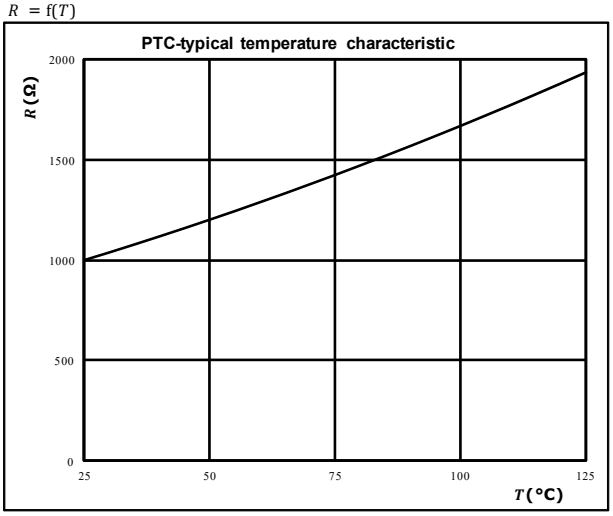
R (K/W)	τ (s)
1,03E-01	7,04E+00
1,17E-01	3,94E-01
5,19E-01	5,87E-02
2,38E-01	2,15E-02
7,64E-02	3,49E-03
4,71E-02	6,93E-04

Thermistor Characteristics

figure 1. **Thermistor**

Typical PTC characteristic
as a function of temperature

$R = f(T)$

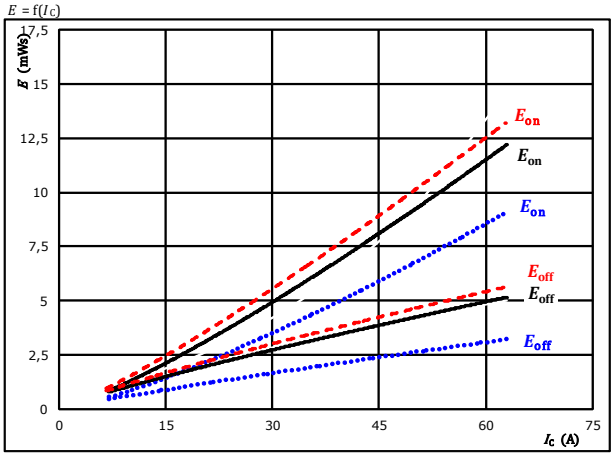


Inverter Switching Characteristics

figure 1. IGBT

Typical switching energy losses as a function of collector current

$E = f(I_C)$



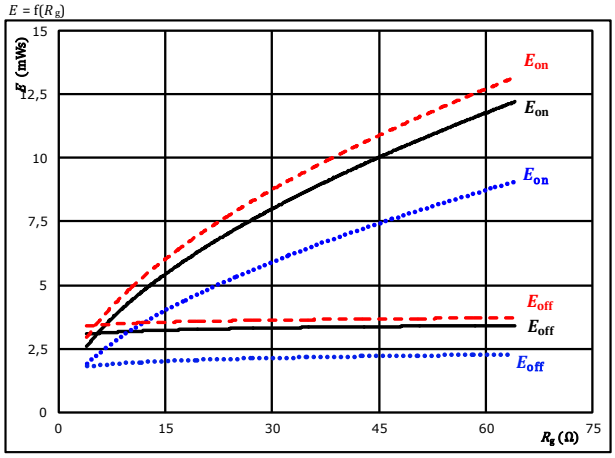
With an inductive load at

V_{CE} =	600	V	T_j:	25 °C
V_{GE} =	±15	V		125 °C
R_{gon} =	16	Ω		150 °C
R_{goff} =	16	Ω		

figure 2. IGBT

Typical switching energy losses as a function of gate resistor

$E = f(R_g)$



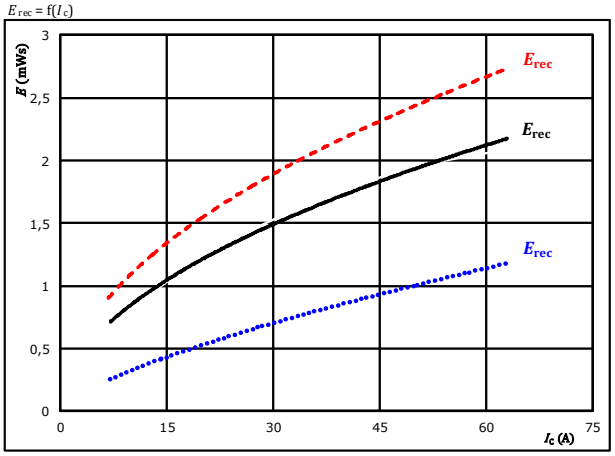
With an inductive load at

V_{CE} =	600	V	T_j:	25 °C
V_{GE} =	±15	V		125 °C
I_C =	35	A		150 °C

figure 3. FWD

Typical reverse recovered energy loss as a function of collector current

$E_{rec} = f(I_C)$



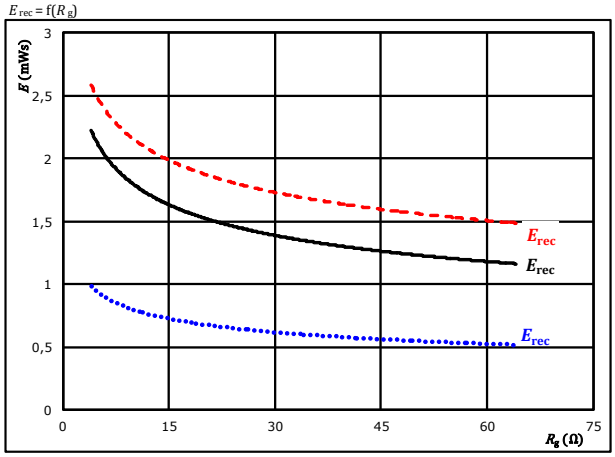
With an inductive load at

V_{CE} =	600	V	T_j:	25 °C
V_{GE} =	±15	V		125 °C
R_{gon} =	16	Ω		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

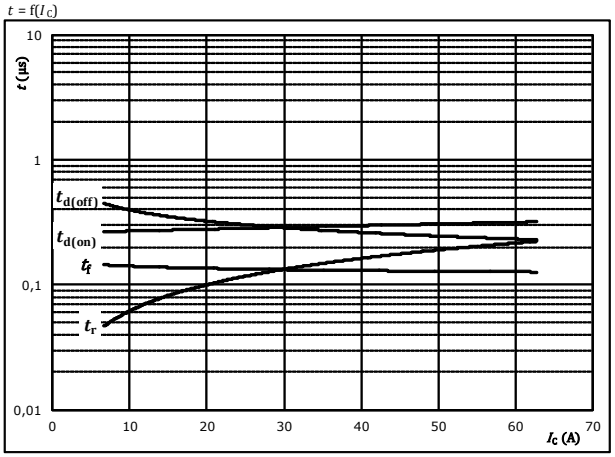
V_{CE} =	600	V	T_j:	25 °C
V_{GE} =	±15	V		125 °C
I_C =	35	A		150 °C

Inverter Switching Characteristics

figure 5. **IGBT**

Typical switching times as a function of collector current

$t = f(I_C)$



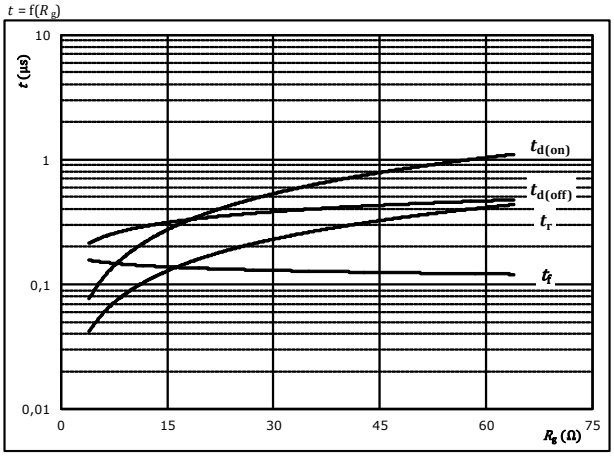
With an inductive load at

T_j =	150	°C
V_{CE} =	600	V
V_{GE} =	±15	V
R_{gon} =	16	Ω
R_{goff} =	16	Ω

figure 6. **IGBT**

Typical switching times as a function of gate resistor

$t = f(R_g)$



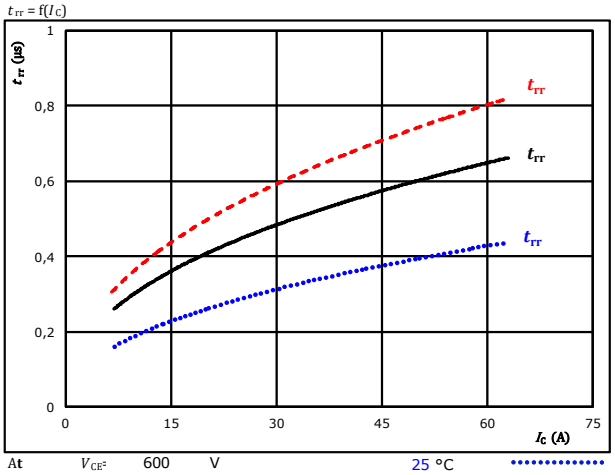
With an inductive load at

T_j =	150	°C
V_{CE} =	600	V
V_{GE} =	±15	V
I_C =	35	A

figure 7. **FWD**

Typical reverse recovery time as a function of collector current

$t_{rr} = f(I_C)$

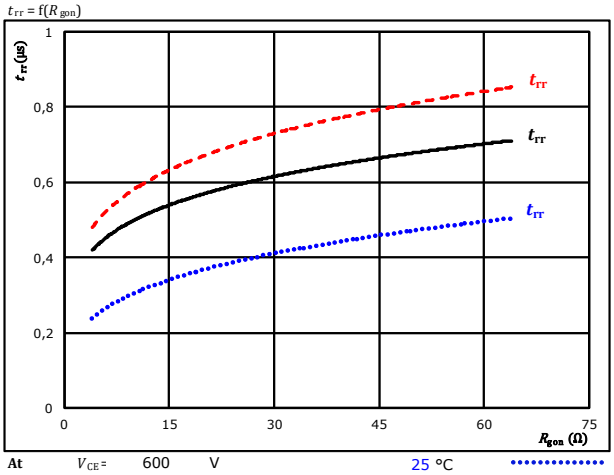


At	V_{CE} =	600	V	T_j:	25 °C
	V_{GE} =	±15	V		125 °C
	R_{gon} =	16	Ω		150 °C

figure 8. **FWD**

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

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



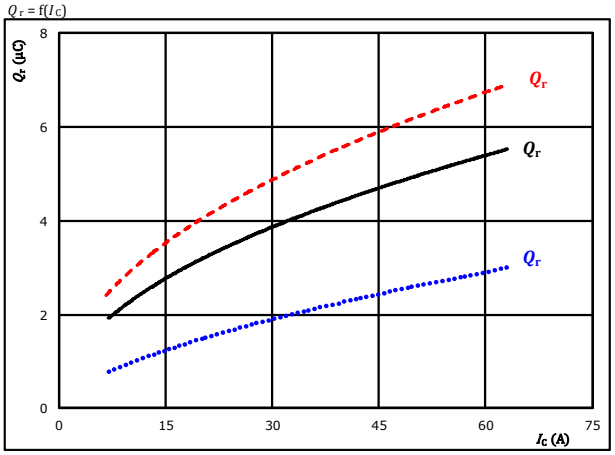
At	V_{CE} =	600	V	T_j:	25 °C
	V_{GE} =	±15	V		125 °C
	I_C =	35	A		150 °C

Inverter Switching Characteristics

figure 9. **FWD**

Typical recovered charge as a function of collector current

$Q_r = f(I_C)$

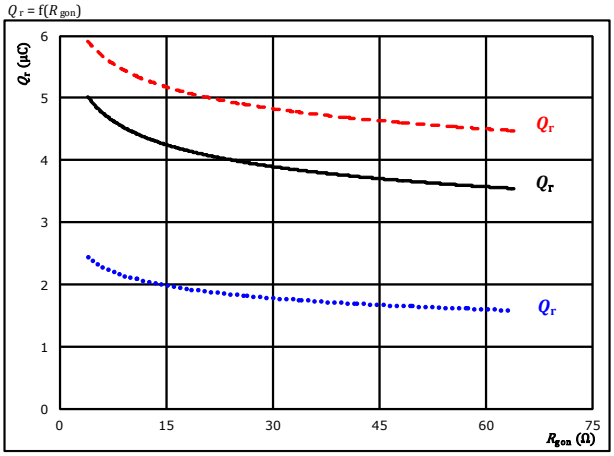


At					
V_{CE} =	600	V		25 °C	
V_{GE} =	±15	V	T_j:	125 °C	
R_{gon} =	16	Ω		150 °C	

figure 10. **FWD**

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

$Q_r = f(R_{gon})$

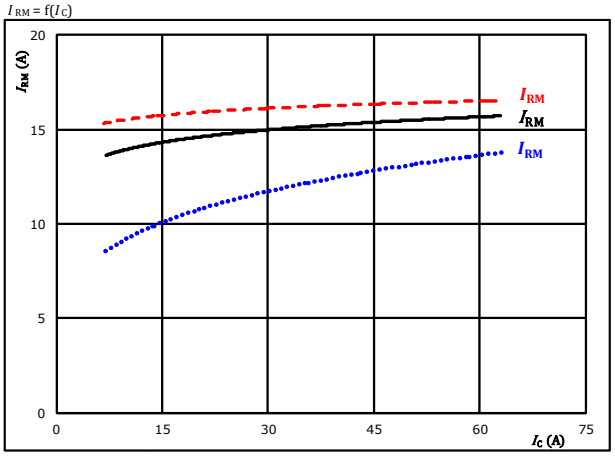


At					
V_{CE}=	600	V		25 °C	
V_{GE} =	±15	V	T_j:	125 °C	
I_C=	35	A		150 °C	

figure 11. **FWD**

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

$I_{RM} = f(I_C)$

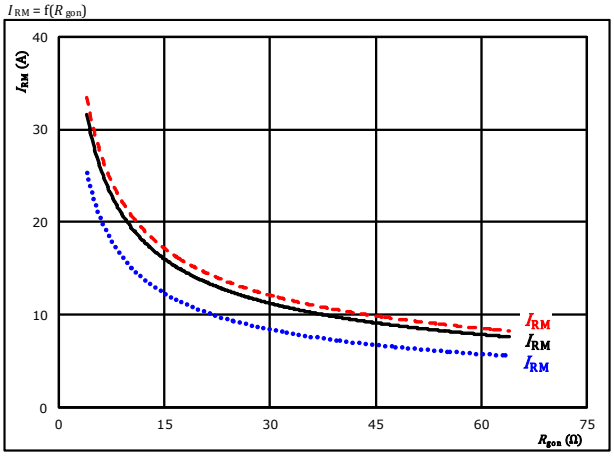


At					
V_{CE}:	600	V		25 °C	
V_{GE} =	±15	V	T_j:	125 °C	
R_{gon} =	16	Ω		150 °C	

figure 12. **FWD**

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

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



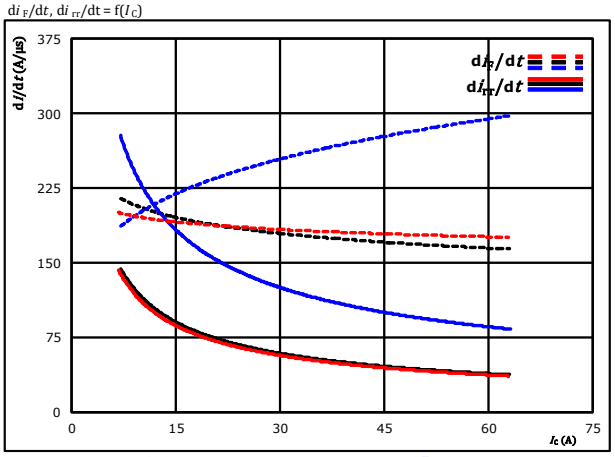
At					
V_{CE} =	600	V		25 °C	
V_{GE} =	±15	V	T_j:	125 °C	
I_C =	35	A		150 °C	

Inverter Switching Characteristics

figure 13. **FWD**

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

di_F/dt, $di_{rr}/dt = f(I_C)$

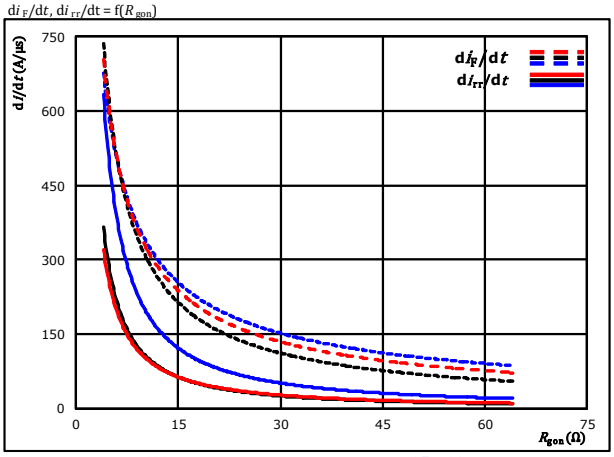


At						
	V_{CE}:	600	V		25	°C
	V_{GE} =	±15	V	T_j:	125	°C
	R_{gon} =	16	Ω		150	°C

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, $di_{rr}/dt = f(R_{gon})$

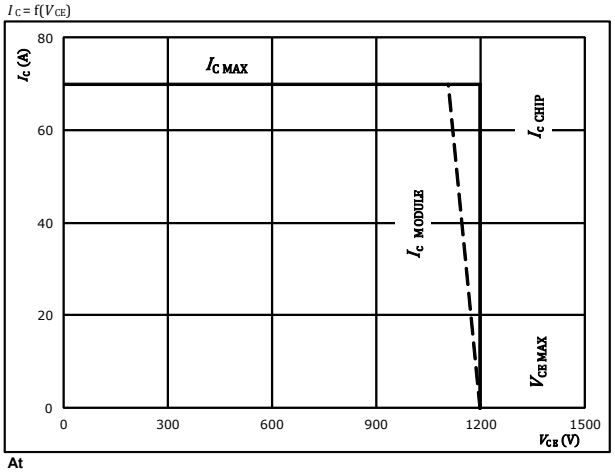


At						
	V_{CE} =	600	V		25	°C
	V_{GE} =	±15	V	T_j:	125	°C
	I_C=	35	A		150	°C

figure 15. **IGBT**

Reverse bias safe operating area

$I_C = f(V_{CE})$



At			
	T_j =	175	°C
	R_{gon} =	16	Ω
	R_{goff} =	16	Ω

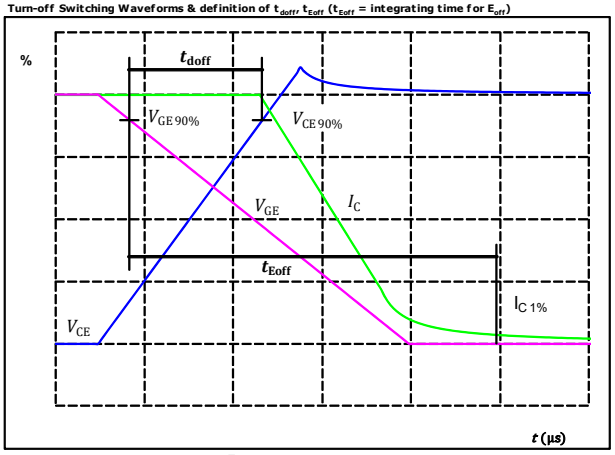
Inverter Switching Definitions

General conditions

T_j	=	125 °C
R_{gon}	=	16 Ω
R_{goff}	=	16 Ω

figure 1. IGBT

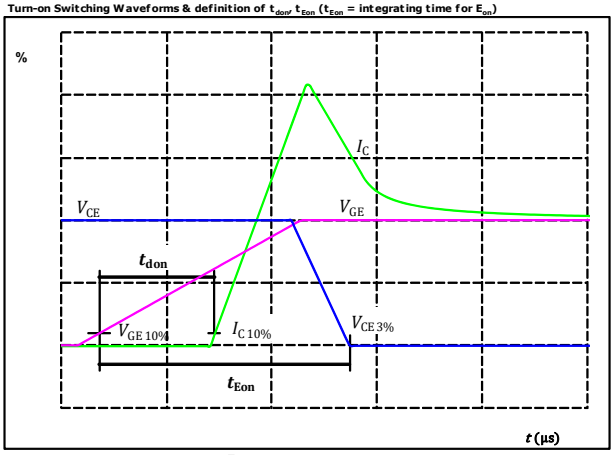
Turn-off Switching Waveforms & definition of t_{doff}, t_{Eoff} (t_{Eoff} = integrating time for E_{off})



$V_{GE}(0\%)$ =	-15	V
$V_{GE}(100\%)$ =	15	V
$V_C(100\%)$ =	600	V
$I_C(100\%)$ =	35	A
t_{doff} =	269	ns

figure 2. IGBT

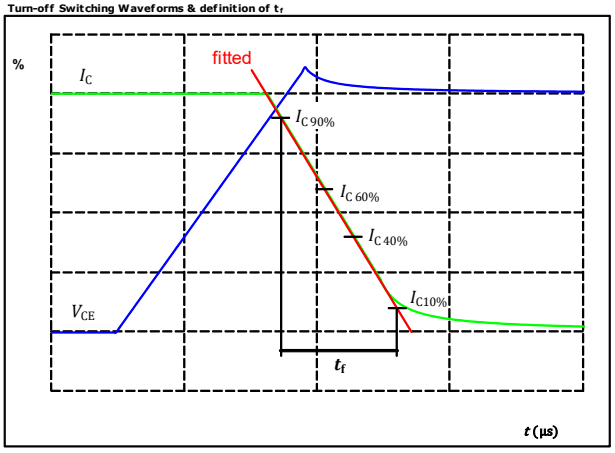
Turn-on Switching Waveforms & definition of t_{don}, t_{Eon} (t_{Eon} = integrating time for E_{on})



$V_{GE}(0\%)$ =	-15	V
$V_{GE}(100\%)$ =	15	V
$V_C(100\%)$ =	600	V
$I_C(100\%)$ =	35	A
t_{don} =	298	ns

figure 3. IGBT

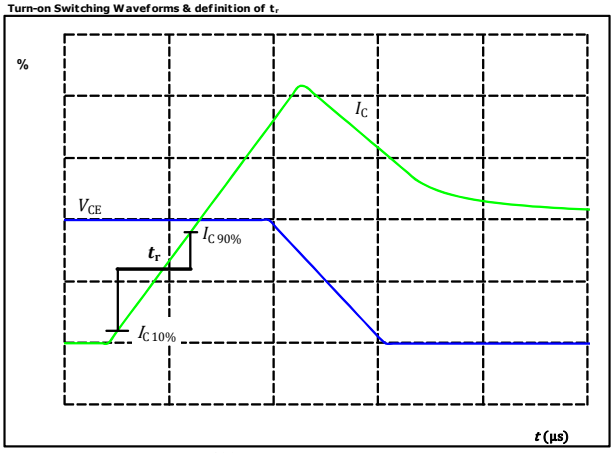
Turn-off Switching Waveforms & definition of t_f



$V_C(100\%)$ =	600	V
$I_C(100\%)$ =	35	A
t_f =	136	ns

figure 4. IGBT

Turn-on Switching Waveforms & definition of t_r

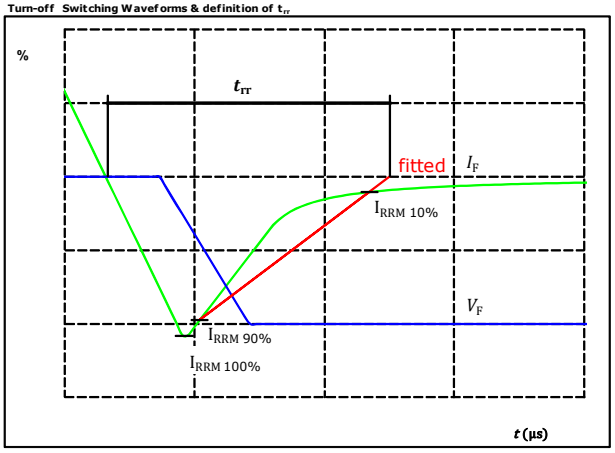


$V_C(100\%)$ =	600	V
$I_C(100\%)$ =	35	A
t_r =	140	ns

Inverter Switching Characteristics

figure 5. **FWD**

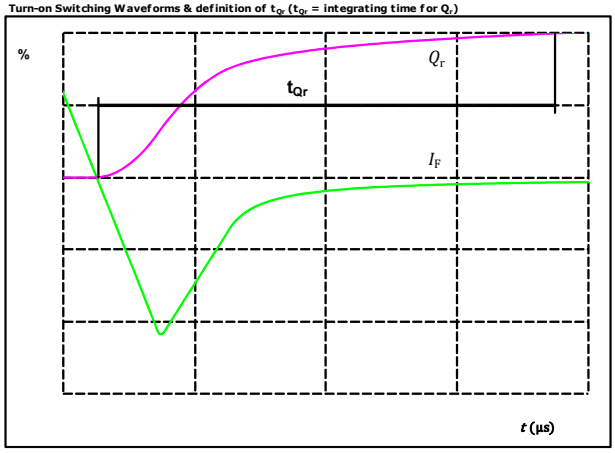
Turn-off Switching Waveforms & definition of t_{rr}



$V_F(100\%)$ =	600	V
$I_F(100\%)$ =	35	A
$I_{RRM}(100\%)$ =	16	A
t_{rr} =	514	ns

figure 6. **FWD**

Turn-on Switching Waveforms & definition of t_{Qr} (t_{Qr} = integrating time for Q_r)



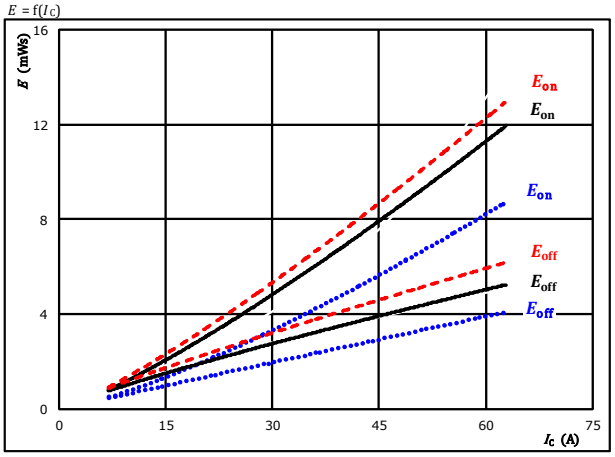
$I_F(100\%)$ =	35	A
$Q_r(100\%)$ =	4,21	µC

Brake Switching Characteristics

figure 1. **IGBT**

Typical switching energy losses as a function of collector current

$E = f(I_C)$



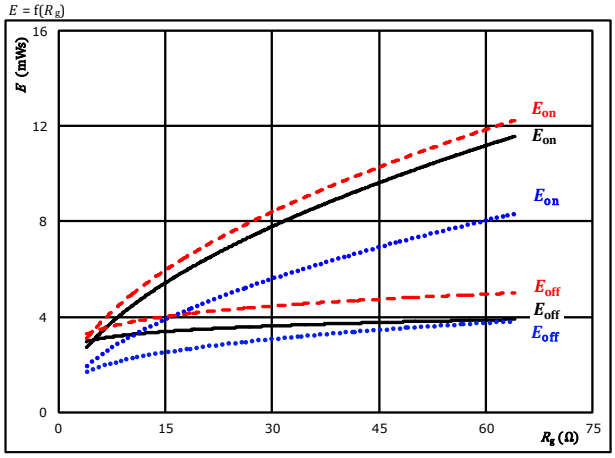
With an inductive load at

V_{CE} =	600	V	T_j:	25 °C
V_{GE} =	-5 / 15	V		125 °C
R_{gon} =	16	Ω		150 °C
R_{goff} =	16	Ω		

figure 2. **IGBT**

Typical switching energy losses as a function of gate resistor

$E = f(R_g)$



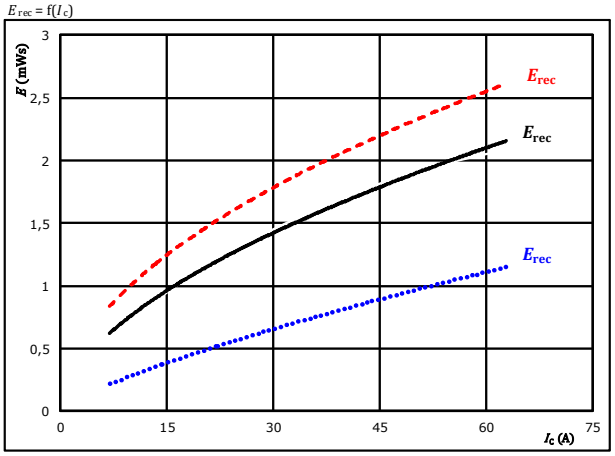
With an inductive load at

V_{CE} =	600	V	T_j:	25 °C
V_{GE} =	-5 / 15	V		125 °C
I_C =	35	A		150 °C

figure 3. **FWD**

Typical reverse recovered energy loss as a function of collector current

$E_{rec} = f(I_C)$



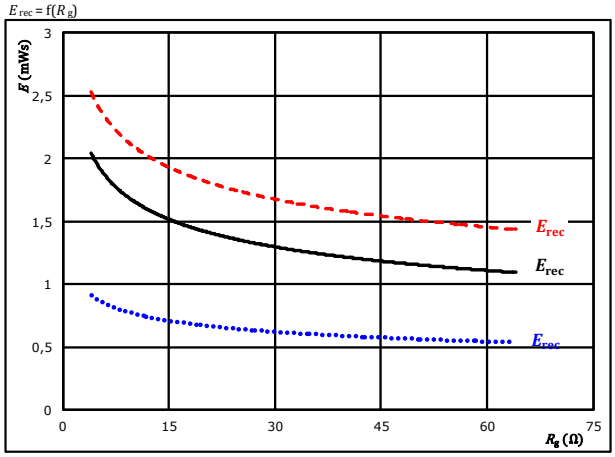
With an inductive load at

V_{CE} =	600	V	T_j:	25 °C
V_{GE} =	-5 / 15	V		125 °C
R_{gon} =	16	Ω		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

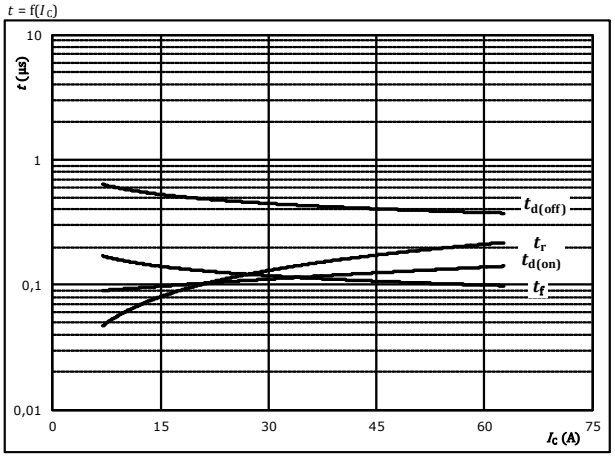
V_{CE} =	600	V	T_j:	25 °C
V_{GE} =	-5 / 15	V		125 °C
I_C =	35	A		150 °C

Brake Switching Characteristics

figure 5. **IGBT**

Typical switching times as a function of collector current

$t = f(I_C)$



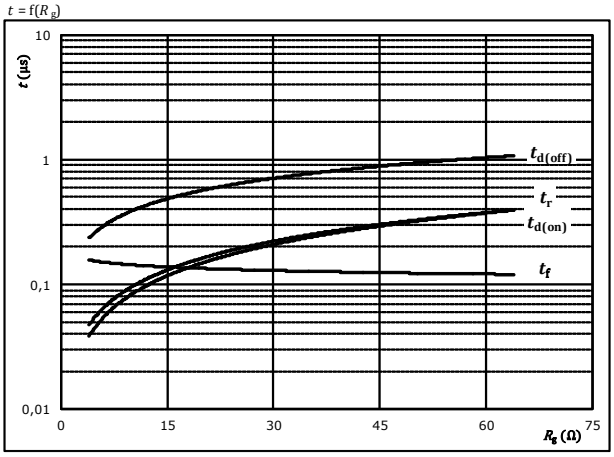
With an inductive load at

T_j =	150	°C
V_{CE} =	600	V
V_{GE} =	-5 / 15	V
R_{gon} =	16	Ω
R_{goff} =	16	Ω

figure 6. **IGBT**

Typical switching times as a function of gate resistor

$t = f(R_g)$



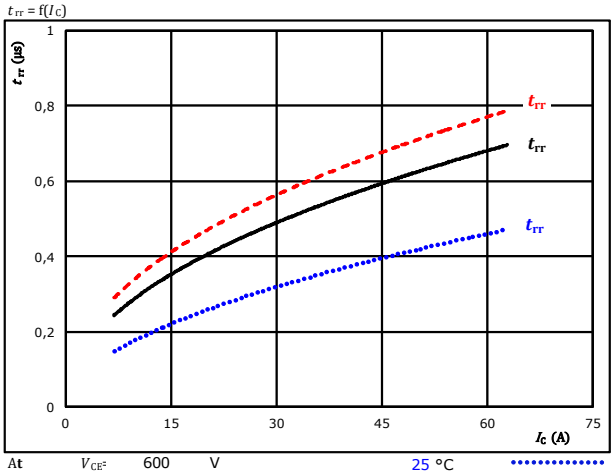
With an inductive load at

T_j =	150	°C
V_{CE} =	600	V
V_{GE} =	-5 / 15	V
I_C =	35	A

figure 7. **FWD**

Typical reverse recovery time as a function of collector current

$t_{rr} = f(I_C)$

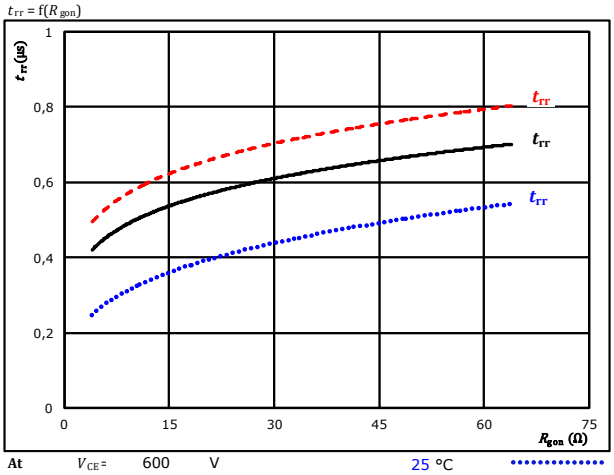


At					
	V_{CE} =	600	V		25 °C
	V_{GE} =	-5 / 15	V	T_j:	125 °C
	R_{gon} =	16	Ω		150 °C

figure 8. **FWD**

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

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



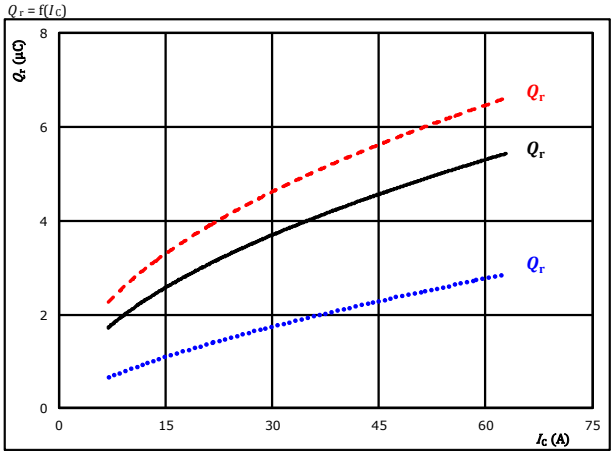
At					
	V_{CE} =	600	V		25 °C
	V_{GE} =	-5 / 15	V	T_j:	125 °C
	I_C =	35	A		150 °C

Brake Switching Characteristics

figure 9. **FWD**

Typical recovered charge as a function of collector current

$Q_r = f(I_C)$

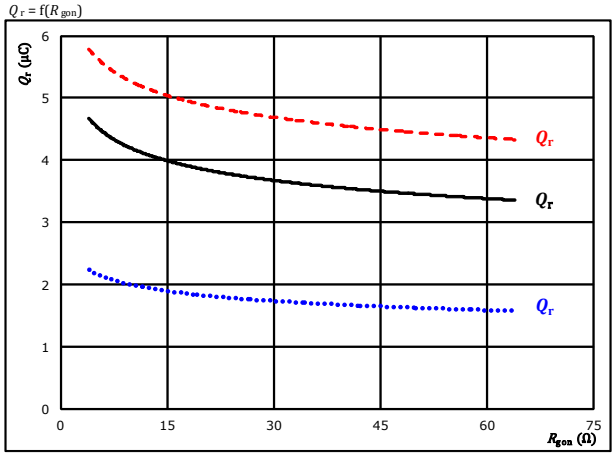


At					
	V_{CE} =	600	V		25 °C
	V_{GE} =	-5 / 15	V	T_j:	125 °C
	R_{gon} =	16	Ω		150 °C

figure 10. **FWD**

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

$Q_r = f(R_{gon})$

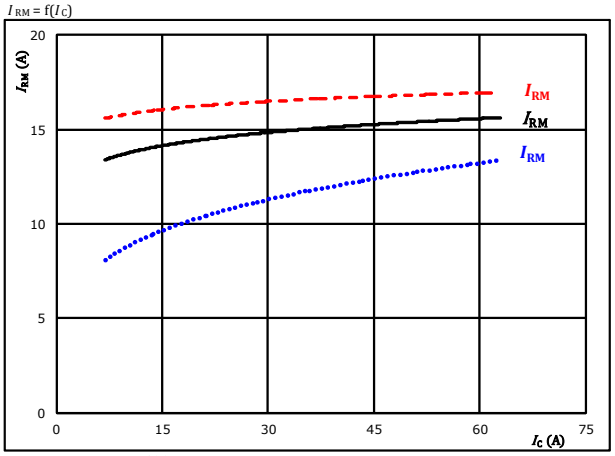


At					
	V_{CE}=	600	V		25 °C
	V_{GE} =	-5 / 15	V	T_j:	125 °C
	I_C=	35	A		150 °C

figure 11. **FWD**

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

$I_{RM} = f(I_C)$

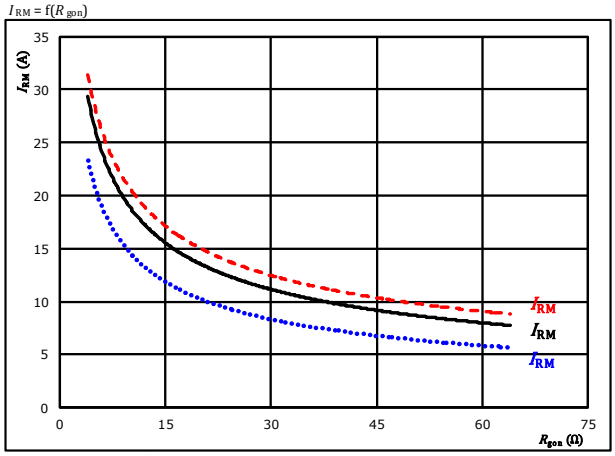


At					
	V_{CE}:	600	V		25 °C
	V_{GE} =	-5 / 15	V	T_j:	125 °C
	R_{gon} =	16	Ω		150 °C

figure 12. **FWD**

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

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



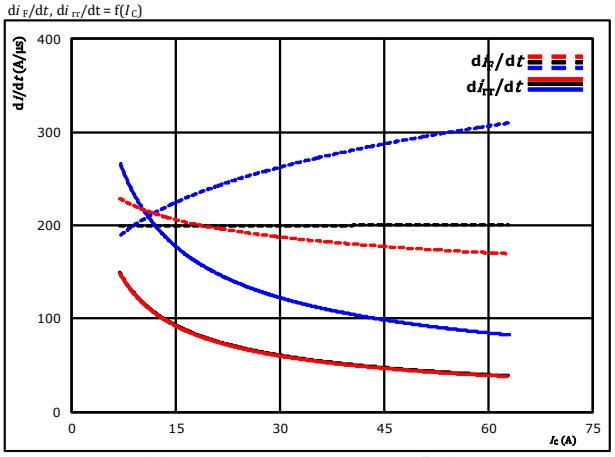
At					
	V_{CE} =	600	V		25 °C
	V_{GE} =	-5 / 15	V	T_j:	125 °C
	I_C =	35	A		150 °C

Brake Switching Characteristics

figure 13. **FWD**

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

di_F/dt, $di_{rr}/dt = f(I_C)$

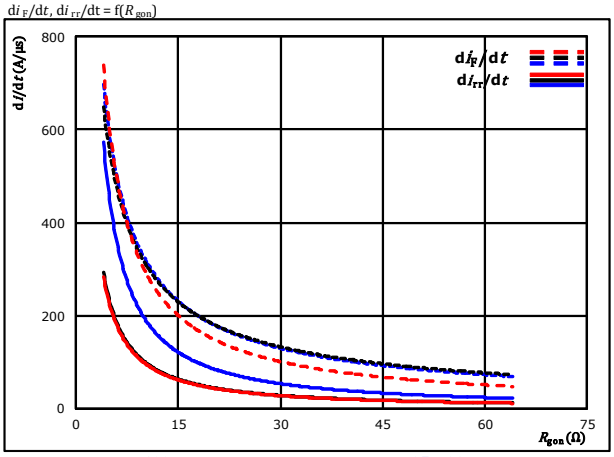


At	V_{CE}:	600	V		25 °C
	V_{GE} =	-5 / 15	V	T_j:	125 °C
	R_{gon} =	16	Ω		150 °C

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, $di_{rr}/dt = f(R_{gon})$

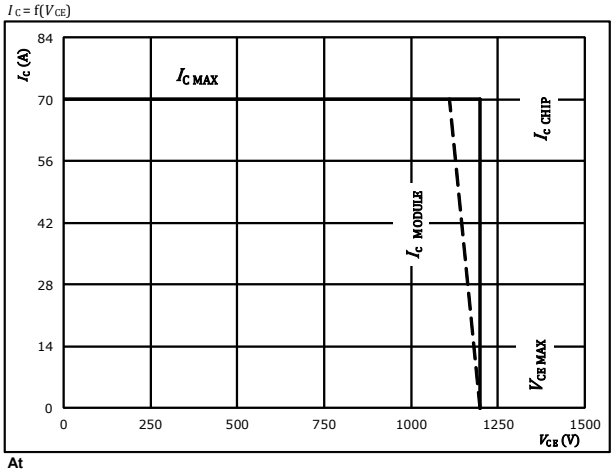


At	V_{CE} =	600	V		25 °C
	V_{GE} =	-5 / 15	V	T_j:	125 °C
	I_C=	35	A		150 °C

figure 15. **IGBT**

Reverse bias safe operating area

$I_C = f(V_{CE})$



At

T_j =	175	°C	
R_{gon} =	16	Ω	
R_{goff} =	16	Ω	

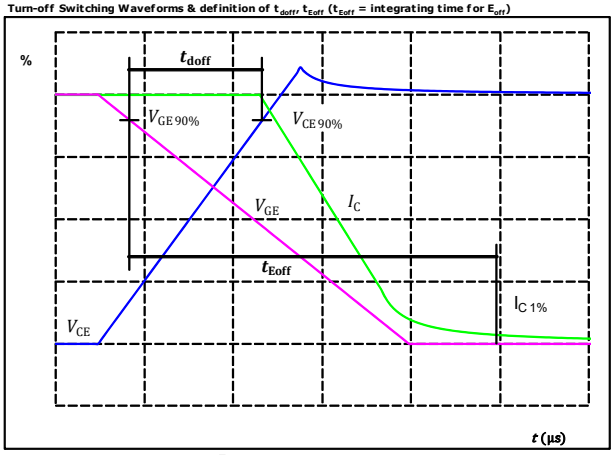
Brake Switching Definitions

General conditions

T_j	=	125 °C
R_{gon}	=	16 Ω
R_{goff}	=	16 Ω

figure 1. IGBT

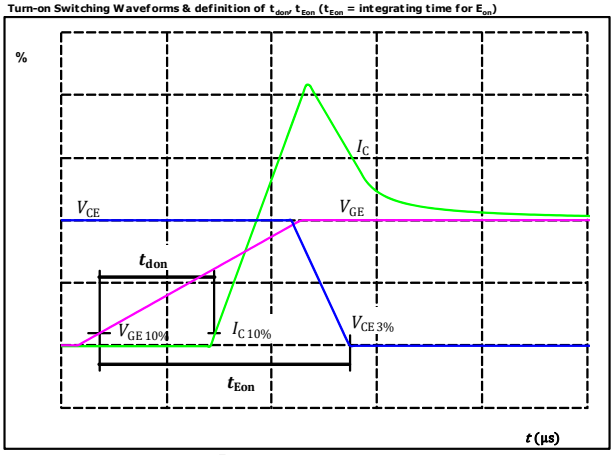
Turn-off Switching Waveforms & definition of t_{doff}, t_{Eoff} (t_{Eoff} = integrating time for E_{off})



$V_{GE}(0\%)$ =	-5	V
$V_{GE}(100\%)$ =	15	V
$V_C(100\%)$ =	600	V
$I_C(100\%)$ =	35	A
t_{doff} =	330	ns

figure 2. IGBT

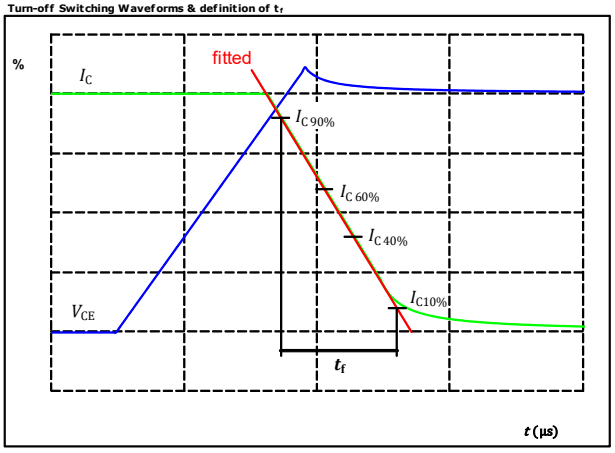
Turn-on Switching Waveforms & definition of t_{don}, t_{Eon} (t_{Eon} = integrating time for E_{on})



$V_{GE}(0\%)$ =	-5	V
$V_{GE}(100\%)$ =	15	V
$V_C(100\%)$ =	600	V
$I_C(100\%)$ =	35	A
t_{don} =	179	ns

figure 3. IGBT

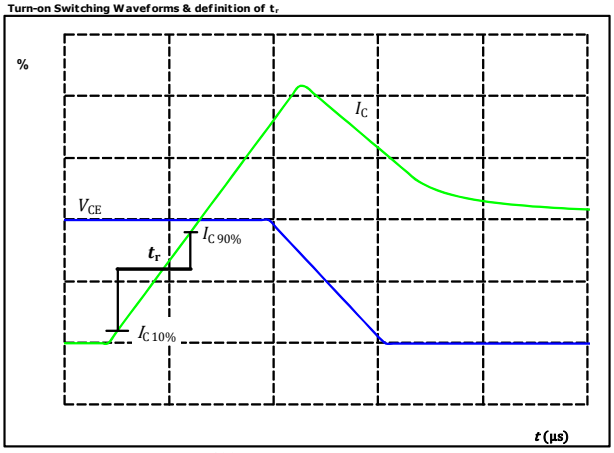
Turn-off Switching Waveforms & definition of t_f



$V_C(100\%)$ =	600	V
$I_C(100\%)$ =	35	A
t_f =	138	ns

figure 4. IGBT

Turn-on Switching Waveforms & definition of t_r

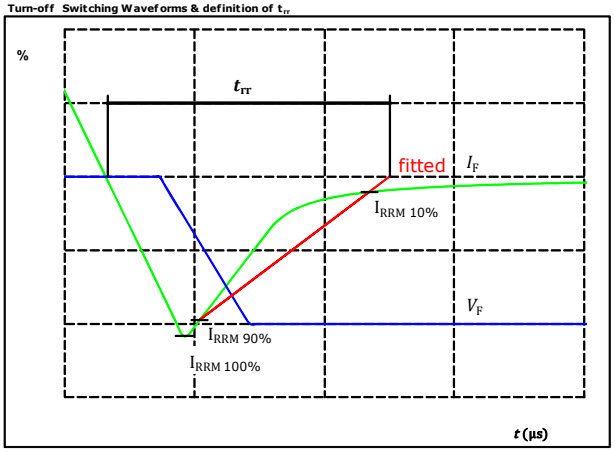


$V_C(100\%)$ =	600	V
$I_C(100\%)$ =	35	A
t_r =	139	ns

Brake Switching Characteristics

figure 5. **FWD**

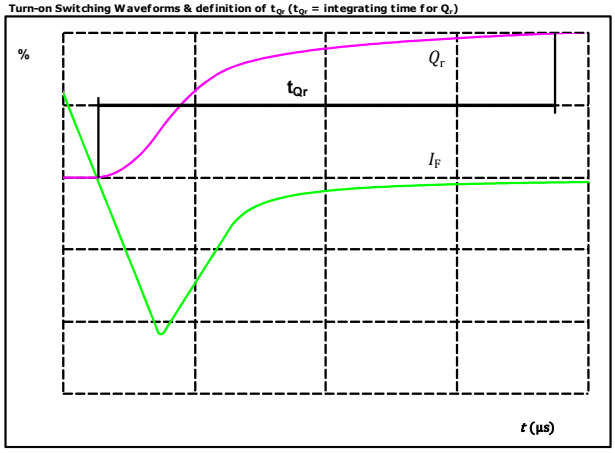
Turn-off Switching Waveforms & definition of t_{rr}



$V_F(100\%)$ =	600	V
$I_F(100\%)$ =	35	A
$I_{RRM}(100\%)$ =	16	A
t_{rr} =	515	ns

figure 6. **FWD**

Turn-on Switching Waveforms & definition of t_{Qr} (t_{Qr} = integrating time for Q_r)



$I_F(100\%)$ =	35	A
$Q_r(100\%)$ =	4,03	µC

Ordering Code & Marking

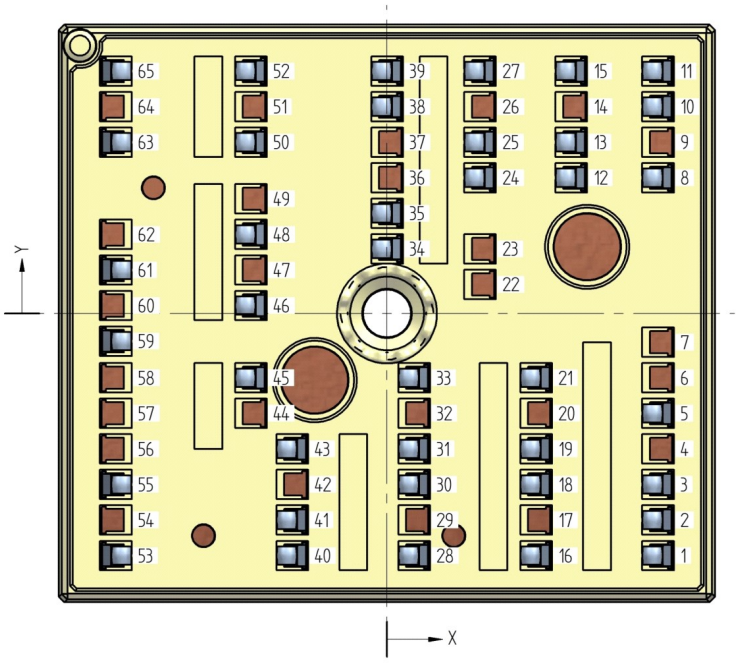
Version	Ordering Code
With std lid (6.5mm height) + no thermal grease	V23990-K220-A40-/0A/
With thin lid (2.8mm height) + no thermal grease	V23990-K220-A40-/0B/
With std lid (6.5mm height) + thermal grease (0,8 W/mK, P12, silicone-based)	V23990-K220-A40-/1A/
With thin lid (2.8mm height) + thermal grease (0,8 W/mK, P12, silicone-based)	V23990-K220-A40-/1B/
With std lid (6.5mm height) + thermal grease (2,5 W/mK, TG20032, silicone-free)	V23990-K220-A40-/4A/
With thin lid (2.8mm height) + thermal grease (2,5 W/mK, TG20032, silicone-free)	V23990-K220-A40-/4B/
With std lid (6.5mm height) + thermal grease (2,5 W/mK, HPTP, silicone-based)	V23990-K220-A40-/5A/
With thin lid (2.8mm height) + thermal grease (2,5 W/mK, HPTP, silicone-based)	V23990-K220-A40-/5B/

Text	**VIN**	**Date code**	**Name&Ver**	**UL**	**Lot**	**Serial**
	VIN	WWYY	NNNNNNNVV	UL	LLLLL	SSSS
Datamatrix	**Type&Ver**	**Lot number**	**Serial**	**Date code**		
	TTTTTTVV	LLLLL	SSSS	WWYY		

Outline

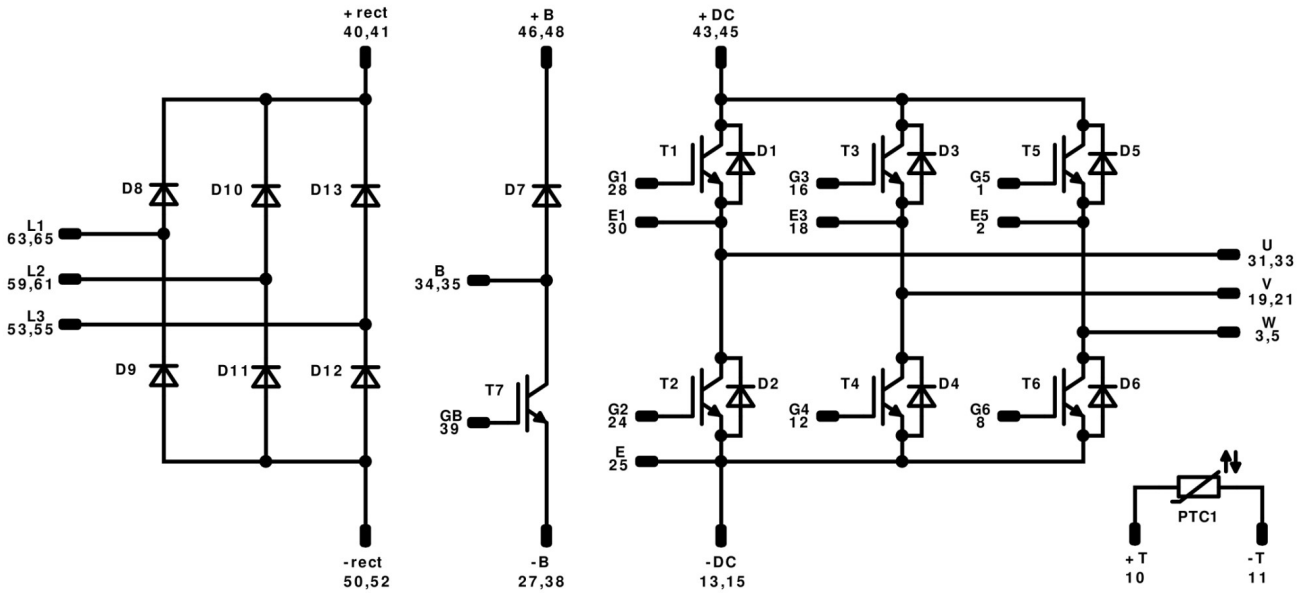
PCB pad table			
Pin	X	Y	Function
1	24,38	-21,8	G5
2	24,38	-18,6	E5
3	24,38	-15,4	W
4	Not assembled		
5	24,38	-9	W
6	Not assembled		
7	Not assembled		
8	24,38	12,2	G6
9	Not assembled		
10	24,38	18,6	+T
11	24,38	21,8	-T
12	16,58	12,2	G4
13	16,58	15,4	-DC
14	Not assembled		
15	16,58	21,8	-DC
16	13,42	-21,8	G3
17	Not assembled		
18	13,42	-15,4	E3
19	13,42	-12,2	V
20	Not assembled		
21	13,42	-5,8	V
22	Not assembled		
23	Not assembled		
24	8,38	12,2	G2
25	8,38	15,4	E
26	Not assembled		
27	8,38	21,8	-B
28	2,46	-21,8	G1
29	Not assembled		
30	2,46	-15,4	E1
31	2,46	-12,2	U
32	Not assembled		
33	2,46	-5,8	U
34	0,03	5,8	B
35	0,03	9	B
36	Not assembled		
37	Not assembled		
38	0,03	18,6	-B
39	0,03	21,8	GB
40	-8,5	-21,8	+rect
41	-8,5	-18,6	+rect
42	Not assembled		
43	-8,5	-12,2	+DC

PCB pad table			
Pin	X	Y	Function
44	Not assembled		
45	-12,22	-5,8	+DC
46	-12,22	0,7	+B
47	Not assembled		
48	-12,22	7,1	+B
49	Not assembled		
50	-12,22	15,4	-rect
51	Not assembled		
52	-12,22	21,8	-rect
53	-24,38	-21,8	L3
54	Not assembled		
55	-24,38	-15,4	L3
56	Not assembled		
57	Not assembled		
58	Not assembled		
59	-24,38	-2,5	L2
60	Not assembled		
61	-24,38	3,9	L2
62	Not assembled		
63	-24,38	15,4	L1
64	Not assembled		
65	-24,38	21,8	L1



Pad positions refers to center point. For more informations on pad design please see package data

Pinout



Identification

ID	Component	Voltage	Current	Function	Comment
T1, T2, T3, T4, T5, T6	IGBT	1200 V	35 A	Inverter Switch	
D1, D2, D3, D4, D5, D6	FWD	1200 V	35 A	Inverter Diode	
T7	IGBT	1200 V	35 A	Brake Switch	
D7	FWD	1200 V	35 A	Brake Diode	
D8, D9, D10, D11, D12, D13	Rectifier	1600 V	35 A	Rectifier Diode	
PTC1	PTC			Thermistor	

Packaging instruction				
Standard packaging quantity (SPQ) 72	>SPQ	Standard	<SPQ	Sample

Handling instruction
Handling instructions for MiniSkiiP® 2 packages see vincotech.com website.

Package data
Package data for MiniSkiiP® 2 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
V23990-K220-A40-D5-14	01 Mar. 2019	Correction of I_c/I_f values	1,2,3