



flowFC S3

950 V / 200 A

Features

- High efficient flying capacitor topology
- Optimized for 1500 Vdc applications
- Low inductive package
- Enhanced thermal performance

Target applications

- Solar Inverters

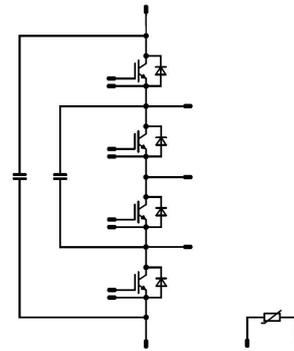
Types

- B0-SP10FCA200S702-LM87F93T

flow S3 12 mm housing



Schematic





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Maximum Ratings

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

Parameter	Symbol	Conditions	Value	Unit
AC 1 Switch L				
Collector-emitter voltage	V_{CES}		950	V
Collector current (DC current)	I_C	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	148	A
Repetitive peak collector current	I_{CRM}	t_p limited by T_{jmax}	400	A
Total power dissipation	P_{tot}	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	283	W
Gate-emitter voltage	V_{GES}		± 20	V
Maximum junction temperature	T_{jmax}		175	°C
AC 1 Diode L				
Peak repetitive reverse voltage	V_{RRM}		1200	V
Forward current (DC current)	I_F	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	79	A
Repetitive peak forward current	I_{FRM}	t_p limited by T_{jmax}	273	A
Surge (non-repetitive) forward current	I_{FSM}	Single Half Sine Wave, $t_p = 10\text{ ms}$	390	A
Total power dissipation	P_{tot}	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	197	W
Maximum junction temperature	T_{jmax}		175	°C
AC 1 Switch H				
Collector-emitter voltage	V_{CES}		950	V
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AC 2 Switch H

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AC 2 Diode H

Peak repetitive reverse voltage	V_{RRM}		1200	V
Forward current (DC current)	I_F	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	79	A
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Total power dissipation	P_{tot}	$T_j = T_{jmax}$ $T_s = 80\text{ °C}$	197	W
Maximum junction temperature	T_{jmax}		175	°C

Flying Capacitor

Maximum DC voltage	V_{MAX}		1000	V
Operation Temperature	T_{op}		-55 ... 125	°C

Capacitor (DC)

Maximum DC voltage	V_{MAX}		1500	V
Operation Temperature	T_{op}		-55 ... 125	°C



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datasheet

Maximum Ratings

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

Parameter	Symbol	Conditions	Value	Unit
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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* $t_p = 2\text{ s}$	6000	V
Creepage distance			>12,7	mm
Clearance			>12,7	mm
Comparative Tracking Index	CTI		≥ 600	

*100 % tested in production



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Characteristic Values

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

AC 1 Switch L

Static

Gate-emitter threshold voltage	$V_{GE(th)}$	$V_{CE} = V_{GE}$			0,00334	25	4,35	5,1	5,85	V
Collector-emitter saturation voltage	$V_{CE(sat)}$		15		200	25 125 150		1,83 2,06 2,11	2,35 ⁽¹⁾	V
Collector-emitter cut-off current	I_{CES}		0	950		25			4	μA
Gate-emitter leakage current	I_{GES}		20	0		25			200	nA
Internal gate resistance	r_g							0,75		Ω
Input capacitance	C_{ies}							13000		pF
Output capacitance	C_{oes}	$f = 100$ kHz	0	25		25		278		pF
Reverse transfer capacitance	C_{res}							40		pF
Gate charge	Q_g		15		0	25		460		nC

Thermal

Thermal resistance junction to sink ⁽²⁾	$R_{th(j-s)}$	$\lambda_{paste} = 4,4$ W/mK (PTM)						0,34		K/W
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Dynamic

Turn-on delay time	$t_{d(on)}$					25 125 150		72 66,24 64,64		ns
Rise time	t_r					25 125 150		18,88 21,44 22,4		ns
Turn-off delay time	$t_{d(off)}$					25 125 150		443,52 494,08 509,44		ns
Fall time	t_f					25 125 150		20,58 66,19 80,08		ns
Turn-on energy (per pulse)	E_{on}	$Q_{tFWD} = 0,343$ μC $Q_{tFWD} = 0,349$ μC $Q_{tFWD} = 0,347$ μC				25 125 150		5,04 5,16 5,17		mWs
Turn-off energy (per pulse)	E_{off}					25 125 150		4,12 6,68 7,48		mWs



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Characteristic Values

Parameter	Symbol	Conditions					Values			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		
AC 1 Diode L										
Static										
Forward voltage	V_F			60	25 125 150		1,5 1,86 2,01	1,8 ⁽¹⁾		V
Reverse leakage current	I_R	$V_r = 1200$ V			25		105	600		μA
Thermal										
Thermal resistance junction to sink ⁽²⁾	$R_{th(j-s)}$	$\lambda_{paste} = 4,4$ W/mK (PTM)					0,48			K/W
Dynamic										
Peak recovery current	I_{RRM}				25 125 150		48,52 46,87 46,53			A
Reverse recovery time	t_{rr}				25 125 150		14,75 15,49 15,58			ns
Recovered charge	Q_r	$di/dt=8183$ A/μs $di/dt=7191$ A/μs $di/dt=7139$ A/μs	0/15	600	135	25 125 150	0,343 0,349 0,347			μC
Reverse recovered energy	E_{rec}				25 125 150		0,033 0,036 0,035			mWs
Peak rate of fall of recovery current	$(di_r/dt)_{max}$				25 125 150		8531 8226 7968			A/μs



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Characteristic Values

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

AC 1 Switch H

Static

Gate-emitter threshold voltage	$V_{GE(th)}$	$V_{CE} = V_{GE}$			0,00334	25	4,35	5,1	5,85	V
Collector-emitter saturation voltage	$V_{CE(sat)}$		15		200	25 125 150		1,83 2,06 2,11	2,35 ⁽¹⁾	V
Collector-emitter cut-off current	I_{CES}		0	950		25			4	μA
Gate-emitter leakage current	I_{GES}		20	0		25			200	nA
Internal gate resistance	r_g							0,75		Ω
Input capacitance	C_{ies}							13000		pF
Output capacitance	C_{oes}	$f = 100$ kHz	0	25		25		278		pF
Reverse transfer capacitance	C_{res}							40		pF
Gate charge	Q_g		15		0	25		460		nC

Thermal

Thermal resistance junction to sink ⁽²⁾	$R_{th(j-s)}$	$\lambda_{paste} = 4,4$ W/mK (PTM)						0,34		K/W
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Dynamic

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Turn-off energy (per pulse)	E_{off}					25 125 150		4,12 6,68 7,48		mWs



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Characteristic Values

Parameter	Symbol	Conditions					Values			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		
AC 1 Diode H										
Static										
Forward voltage	V_F			60	25 125 150		1,5 1,86 2,01	1,8 ⁽¹⁾		V
Reverse leakage current	I_R	$V_r = 1200$ V			25		105	600		μA
Thermal										
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Dynamic										
Peak recovery current	I_{RRM}				25 125 150		48,52 46,87 46,53			A
Reverse recovery time	t_{rr}				25 125 150		14,75 15,49 15,58			ns
Recovered charge	Q_r	$di/dt=8183$ A/μs $di/dt=7191$ A/μs $di/dt=7139$ A/μs	0/15	600	135	25 125 150	0,343 0,349 0,347			μC
Reverse recovered energy	E_{rec}				25 125 150		0,033 0,036 0,035			mWs
Peak rate of fall of recovery current	$(di_r/dt)_{max}$				25 125 150		8531 8226 7968			A/μs



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Characteristic Values

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

AC 2 Switch L

Static

Gate-emitter threshold voltage	$V_{GE(th)}$	$V_{CE} = V_{GE}$			0,00334	25	4,35	5,1	5,85	V
Collector-emitter saturation voltage	$V_{CE(sat)}$		15		200	25 125 150		1,83 2,06 2,11	2,35 ⁽¹⁾	V
Collector-emitter cut-off current	I_{CES}		0	950		25			4	μA
Gate-emitter leakage current	I_{GES}		20	0		25			200	nA
Internal gate resistance	r_g							0,75		Ω
Input capacitance	C_{ies}							13000		pF
Output capacitance	C_{oes}	$f = 100$ kHz	0	25		25		278		pF
Reverse transfer capacitance	C_{res}							40		pF
Gate charge	Q_g		15		0	25		460		nC

Thermal

Thermal resistance junction to sink ⁽²⁾	$R_{th(j-s)}$	$\lambda_{paste} = 4,4$ W/mK (PTM)						0,34		K/W
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Turn-off energy (per pulse)	E_{off}					25 125 150		4,12 6,68 7,48		mWs



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Characteristic Values

Parameter	Symbol	Conditions					Values			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		
AC 2 Diode L										
Static										
Forward voltage	V_F			60	25 125 150		1,5 1,86 2,01	1,8 ⁽¹⁾		V
Reverse leakage current	I_R	$V_r = 1200$ V			25		105	600		μA
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Reverse recovered energy	E_{rec}				25 125 150		0,033 0,036 0,035			mWs
Peak rate of fall of recovery current	$(di_r/dt)_{max}$				25 125 150		8531 8226 7968			A/μs



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		V_{GS} [V]	V_{GE} [V]	V_{DS} [V]	I_D [A]	T_j [°C]	Min	Typ	Max	

AC 2 Switch H

Static

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Internal gate resistance	r_g								0,75		Ω
Input capacitance	C_{ies}								13000		pF
Output capacitance	C_{oes}	$f = 100$ kHz	0	25			25		278		pF
Reverse transfer capacitance	C_{res}								40		pF
Gate charge	Q_g		15			0	25		460		nC

Thermal

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Reverse recovered energy	E_{rec}				25 125 150		0,033 0,036 0,035			mWs
Peak rate of fall of recovery current	$(di_r/dt)_{max}$				25 125 150		8531 8226 7968			A/μs



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Characteristic Values

Parameter	Symbol	Conditions					Values			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		

Flying Capacitor

Static

Capacitance	C	DC bias voltage = 0 V				25		200		nF
Tolerance							-10		10	%
Dissipation factor		$f = 1$ kHz				25		2,5		%

Capacitor (DC)

Static

Capacitance	C	DC bias voltage = 0 V				25		56		nF
Tolerance							-10		10	%
Dissipation factor		$f = 1$ kHz				25		2,5		%

Thermistor

Static

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

(1) Value at chip level

(2) Only valid with pre-applied Vincotech thermal interface material.

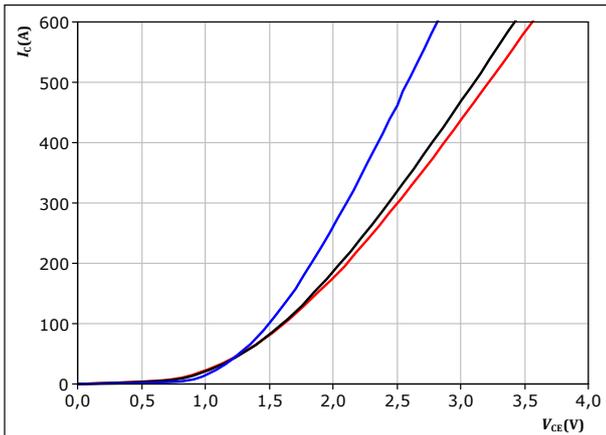


AC 1 Switch L Characteristics

figure 1. IGBT

Typical output characteristics

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



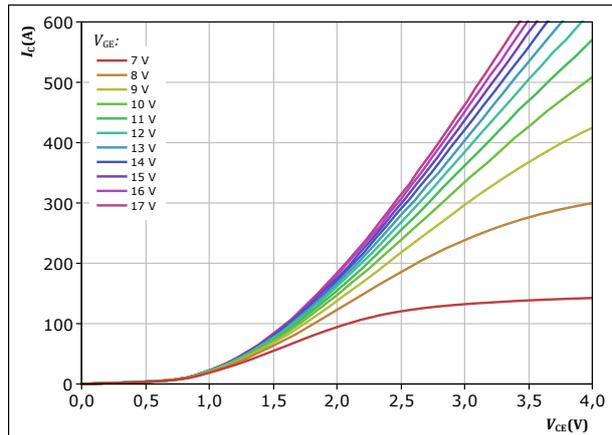
$t_p = 250 \mu s$
 $V_{GE} = 15 V$

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

figure 2. IGBT

Typical output characteristics

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

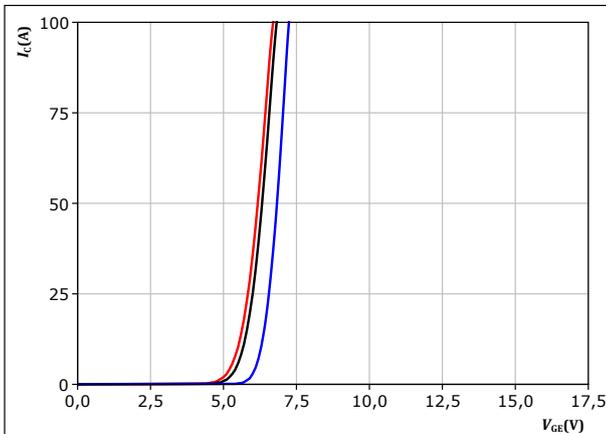


$t_p = 250 \mu s$
 $T_j = 150 \text{ }^\circ\text{C}$
 V_{GE} from 7 V to 17 V in steps of 1 V

figure 3. IGBT

Typical transfer characteristics

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



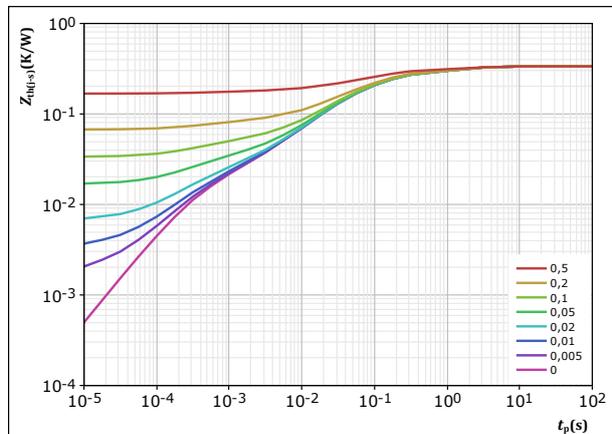
$t_p = 250 \mu s$
 $V_{CE} = 8 V$

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

figure 4. IGBT

Transient thermal impedance as a function of pulse width

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



$D = t_p / T$
 $R_{th(j-s)} = 0,336 \text{ K/W}$

IGBT thermal model values

R (K/W)	τ (s)
6,56E-02	1,61E+00
1,54E-01	1,15E-01
9,21E-02	2,31E-02
1,13E-02	2,30E-03
1,31E-02	3,26E-04

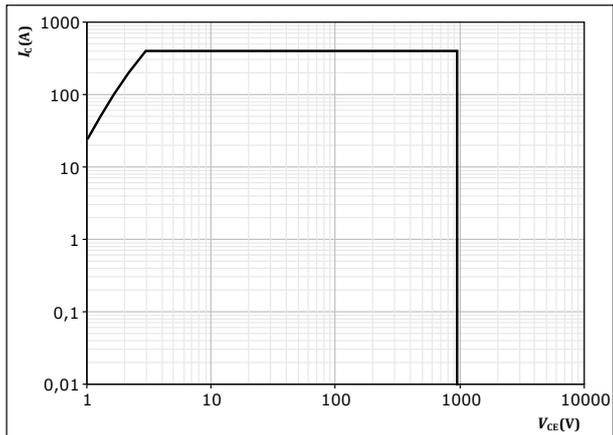


AC 1 Switch L Characteristics

figure 5. IGBT

Safe operating area

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



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



AC 1 Diode L Characteristics

figure 6. FWD

Typical forward characteristics

$$I_F = f(V_F)$$

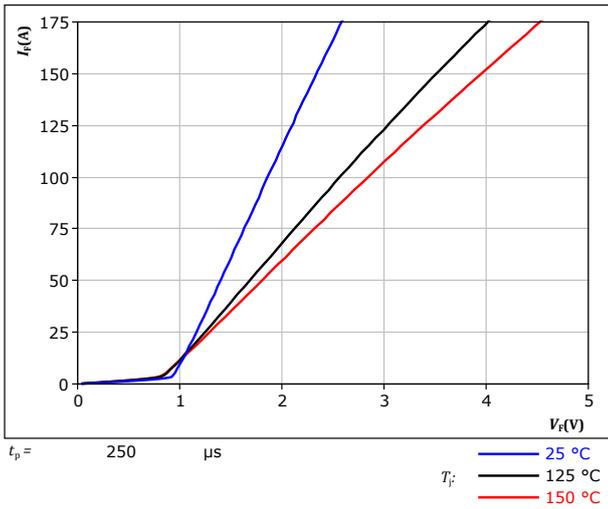
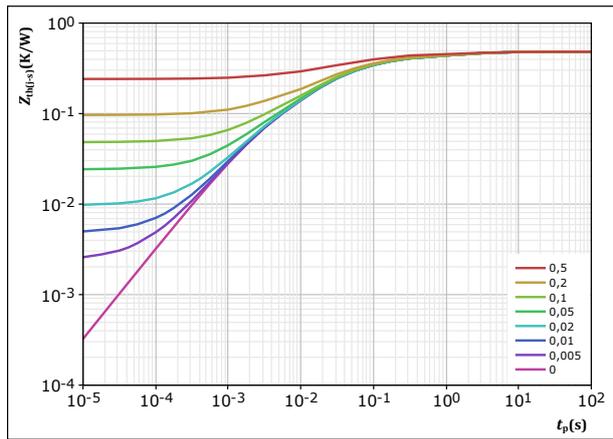


figure 7. FWD

Transient thermal impedance as a function of pulse width

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



$D = t_p / T$

$R_{th(j-s)} = 0,482 \text{ K/W}$

FWD thermal model values

R (K/W)	τ (s)
3,66E-02	3,84E+00
5,22E-02	8,76E-01
1,74E-01	8,75E-02
1,75E-01	1,75E-02
4,55E-02	2,23E-03

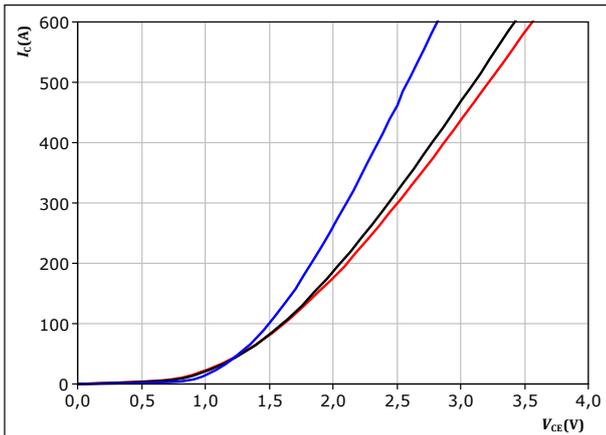


AC 1 Switch H Characteristics

figure 8. IGBT

Typical output characteristics

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



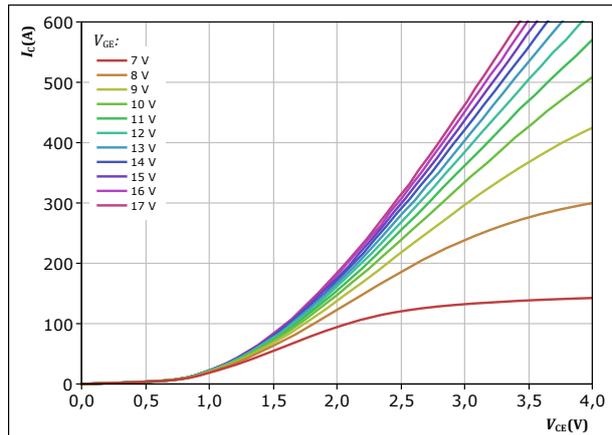
$t_p = 250 \mu s$
 $V_{GE} = 15 V$

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

figure 9. IGBT

Typical output characteristics

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

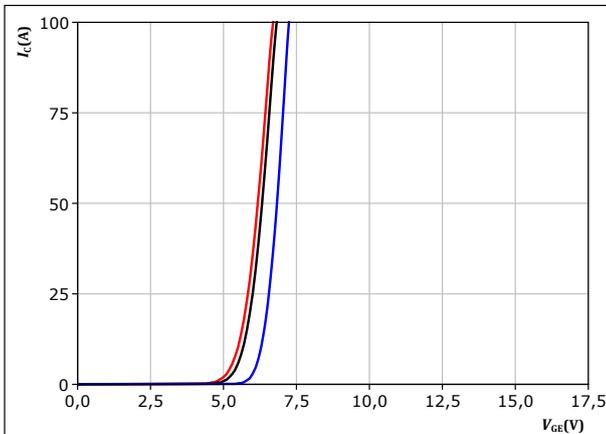


$t_p = 250 \mu s$
 $T_j = 150 \text{ °C}$
 V_{GE} from 7 V to 17 V in steps of 1 V

figure 10. IGBT

Typical transfer characteristics

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



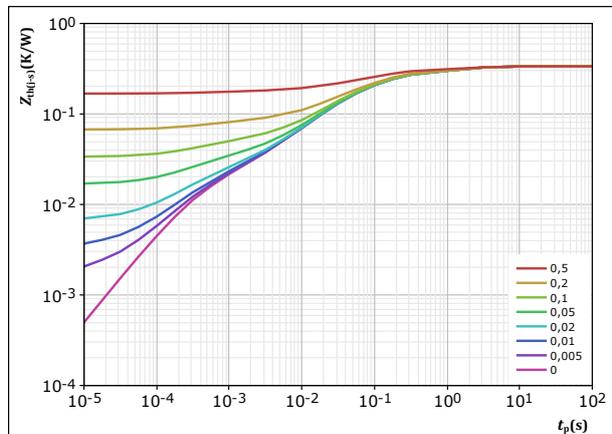
$t_p = 250 \mu s$
 $V_{CE} = 8 V$

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

figure 11. IGBT

Transient thermal impedance as a function of pulse width

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



$D = t_p / T$
 $R_{th(j-s)} = 0,336 \text{ K/W}$

IGBT thermal model values

R (K/W)	τ (s)
6,56E-02	1,61E+00
1,54E-01	1,15E-01
9,21E-02	2,31E-02
1,13E-02	2,30E-03
1,31E-02	3,26E-04

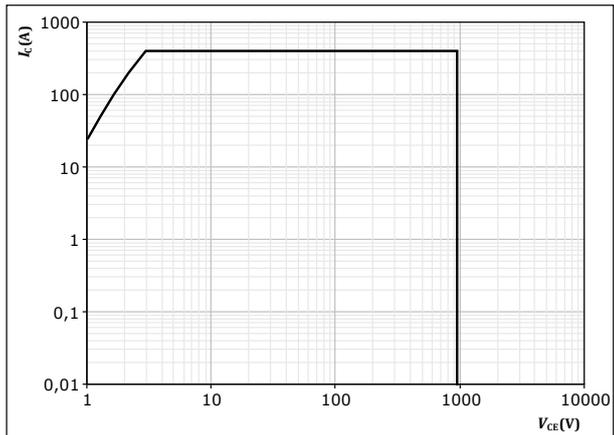


AC 1 Switch H Characteristics

figure 12. IGBT

Safe operating area

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



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



AC 1 Diode H Characteristics

figure 13. FWD

Typical forward characteristics

$$I_F = f(V_F)$$

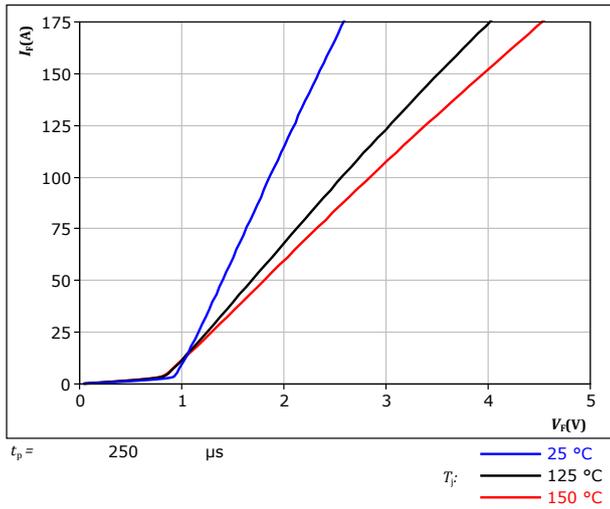
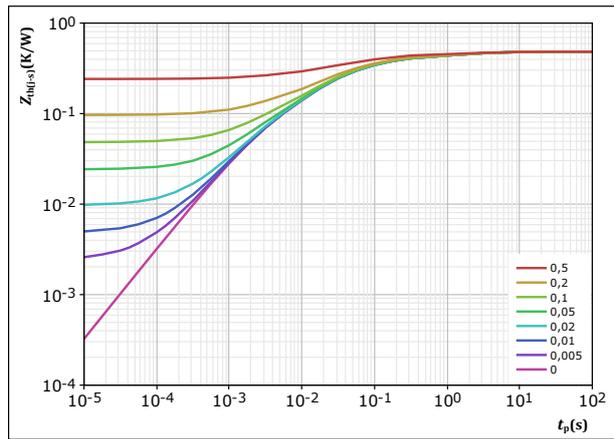


figure 14. FWD

Transient thermal impedance as a function of pulse width

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



$D = \frac{t_p}{T}$
 $R_{th(j-s)} = 0,482 \text{ K/W}$
 FWD thermal model values

R (K/W)	τ (s)
3,66E-02	3,84E+00
5,22E-02	8,76E-01
1,74E-01	8,75E-02
1,75E-01	1,75E-02
4,55E-02	2,23E-03

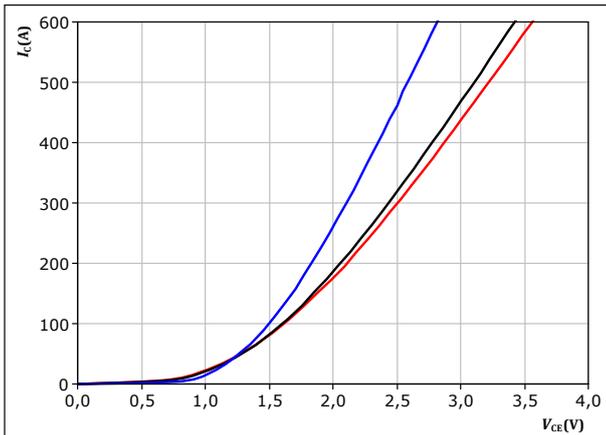


AC 2 Switch L Characteristics

figure 15. IGBT

Typical output characteristics

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



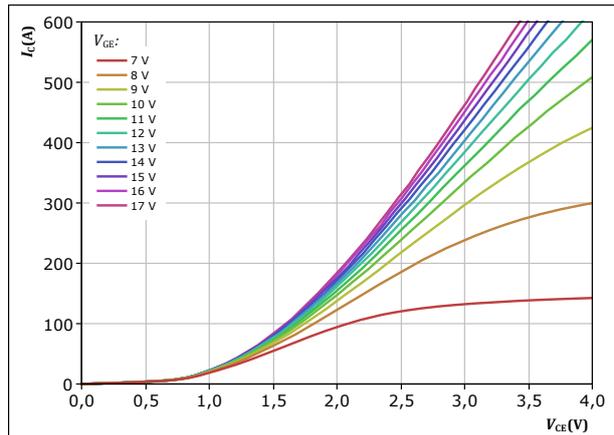
$t_p = 250 \mu s$
 $V_{GE} = 15 V$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 16. IGBT

Typical output characteristics

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

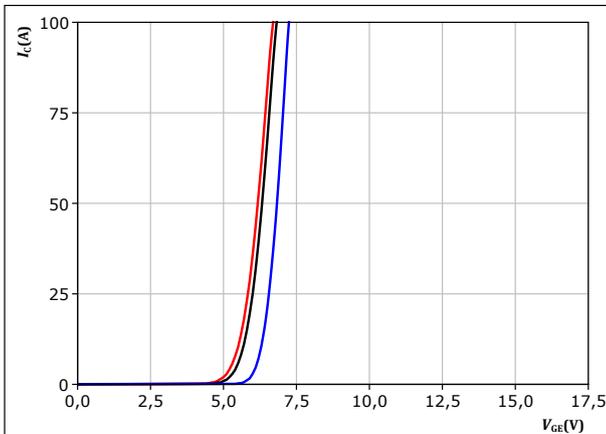


$t_p = 250 \mu s$
 $T_j = 150 \text{ °C}$
 V_{GE} from 7 V to 17 V in steps of 1 V

figure 17. IGBT

Typical transfer characteristics

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



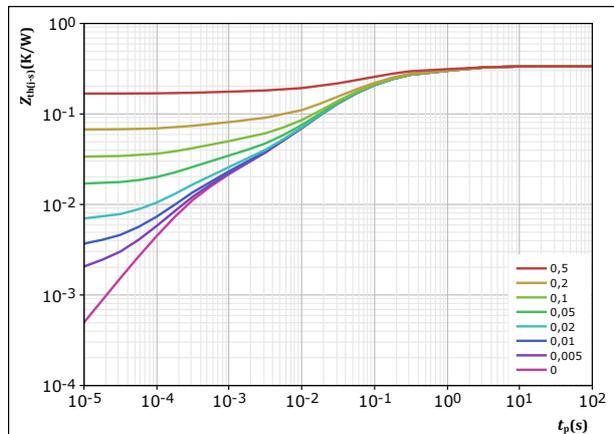
$t_p = 250 \mu s$
 $V_{CE} = 8 V$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 18. IGBT

Transient thermal impedance as a function of pulse width

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



$D = t_p / T$
 $R_{th(j-s)} = 0,336 \text{ K/W}$

IGBT thermal model values

R (K/W)	τ (s)
6,56E-02	1,61E+00
1,54E-01	1,15E-01
9,21E-02	2,31E-02
1,13E-02	2,30E-03
1,31E-02	3,26E-04

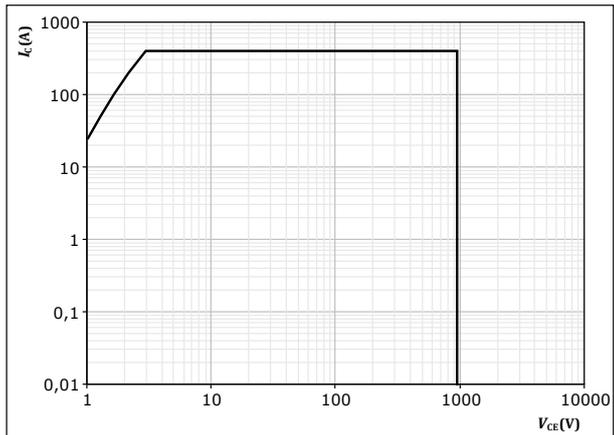


AC 2 Switch L Characteristics

figure 19. IGBT

Safe operating area

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



$D =$ single pulse

$T_s = 80$ °C

$V_{CE} = 15$ V

$T_j = T_{jmax}$



AC 2 Diode L Characteristics

figure 20. FWD

Typical forward characteristics

$$I_F = f(V_F)$$

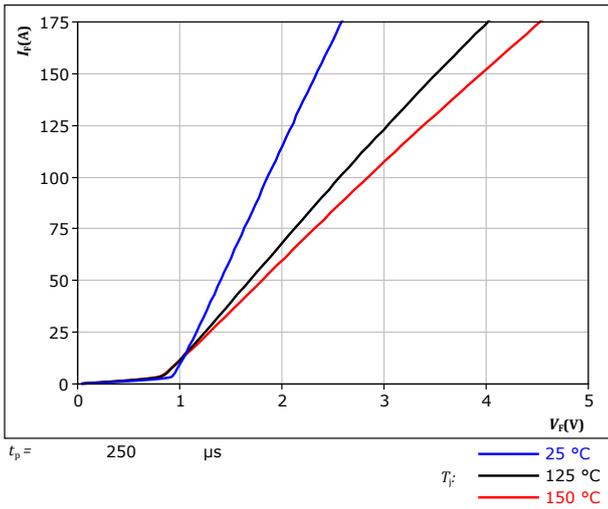
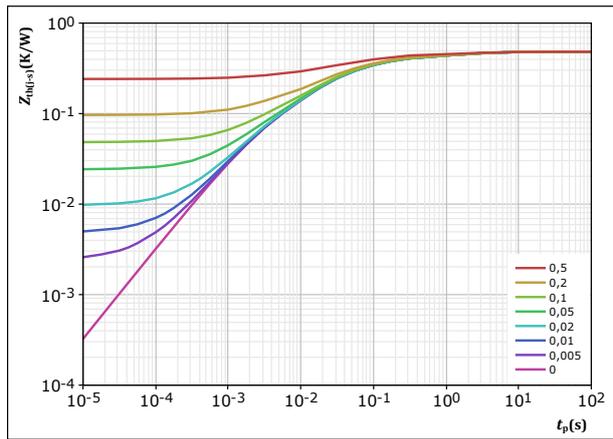


figure 21. FWD

Transient thermal impedance as a function of pulse width

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



$D = t_p / T$
 $R_{th(j-s)} = 0,482 \text{ K/W}$
 FWD thermal model values

R (K/W)	τ (s)
3,66E-02	3,84E+00
5,22E-02	8,76E-01
1,74E-01	8,75E-02
1,75E-01	1,75E-02
4,55E-02	2,23E-03

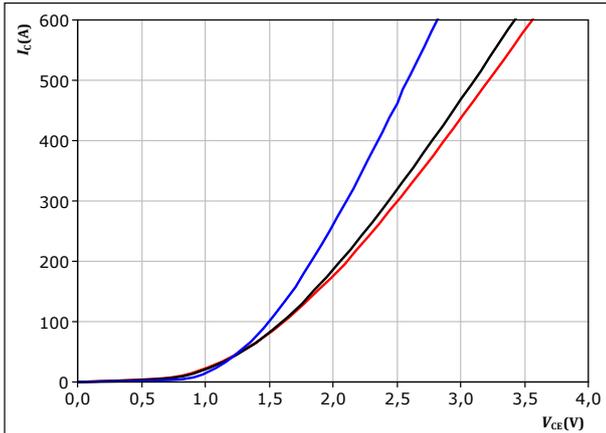


AC 2 Switch H Characteristics

figure 22. IGBT

Typical output characteristics

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



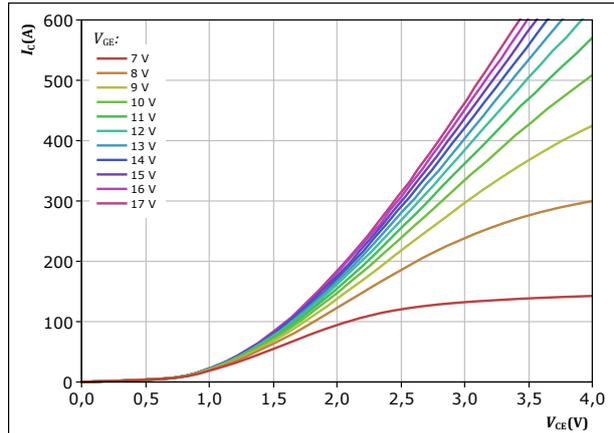
$t_p = 250 \mu\text{s}$
 $V_{GE} = 15 \text{ V}$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 23. IGBT

Typical output characteristics

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

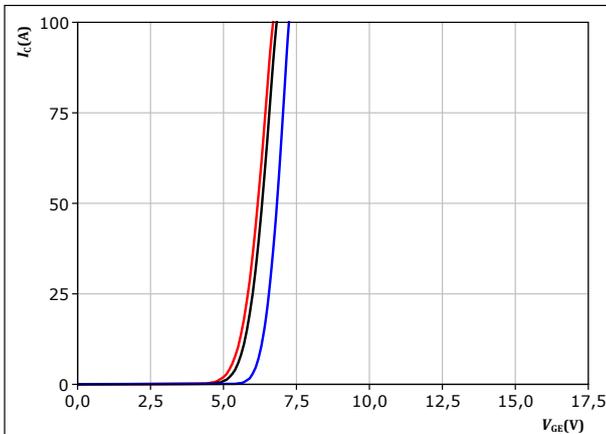


$t_p = 250 \mu\text{s}$
 $T_j = 150 \text{ °C}$
 V_{GE} from 7 V to 17 V in steps of 1 V

figure 24. IGBT

Typical transfer characteristics

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



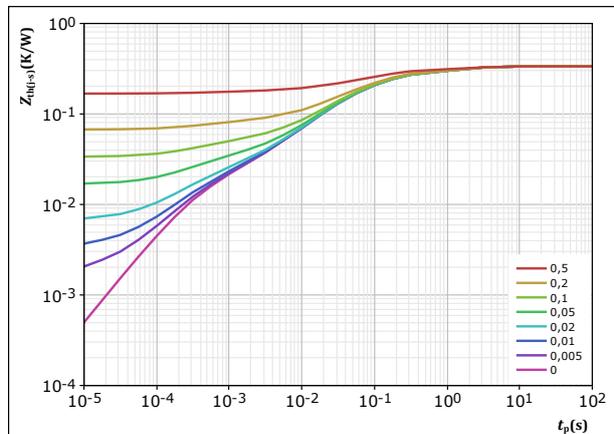
$t_p = 250 \mu\text{s}$
 $V_{CE} = 8 \text{ V}$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 25. IGBT

Transient thermal impedance as a function of pulse width

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



$D = t_p / T$
 $R_{th(j-s)} = 0,336 \text{ K/W}$

IGBT thermal model values

R (K/W)	τ (s)
6,56E-02	1,61E+00
1,54E-01	1,15E-01
9,21E-02	2,31E-02
1,13E-02	2,30E-03
1,31E-02	3,26E-04

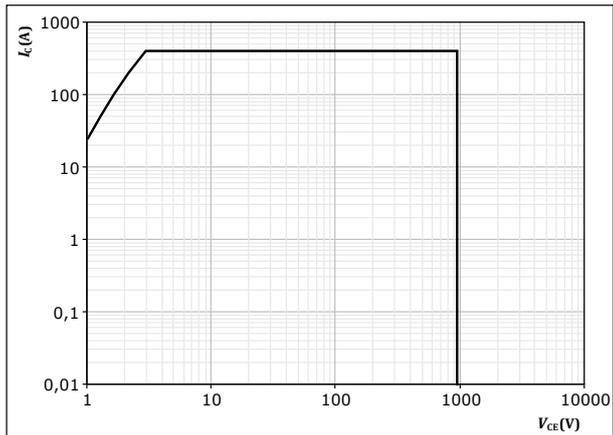


AC 2 Switch H Characteristics

figure 26. IGBT

Safe operating area

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



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



AC 2 Diode H Characteristics

figure 27. FWD

Typical forward characteristics

$$I_F = f(V_F)$$

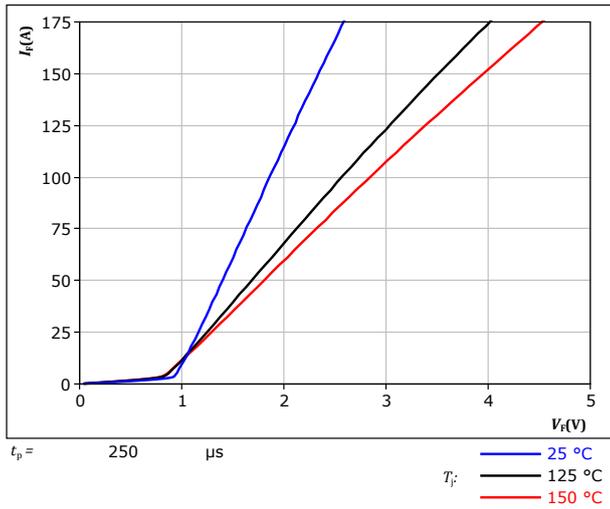
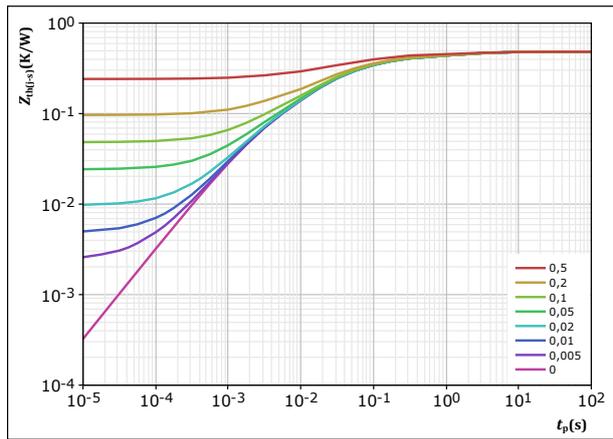


figure 28. FWD

Transient thermal impedance as a function of pulse width

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



$D = t_p / T$

$R_{th(j-s)} = 0,482 \text{ K/W}$

FWD thermal model values

$R \text{ (K/W)}$	$\tau \text{ (s)}$
3,66E-02	3,84E+00
5,22E-02	8,76E-01
1,74E-01	8,75E-02
1,75E-01	1,75E-02
4,55E-02	2,23E-03

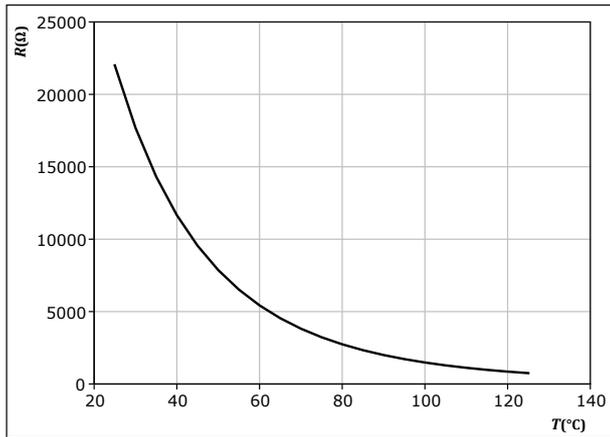


Thermistor Characteristics

figure 29. Thermistor

Typical NTC characteristic as function of temperature

$$R_T = f(T)$$



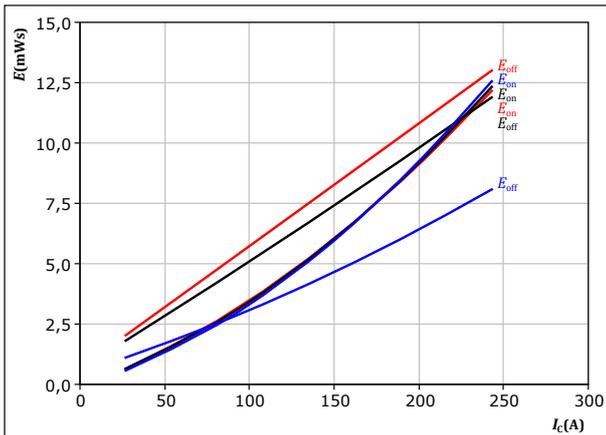


AC 1 Switching Characteristics L

figure 30. IGBT

Typical switching energy losses as a function of collector current

$$E = f(I_c)$$



With an inductive load at

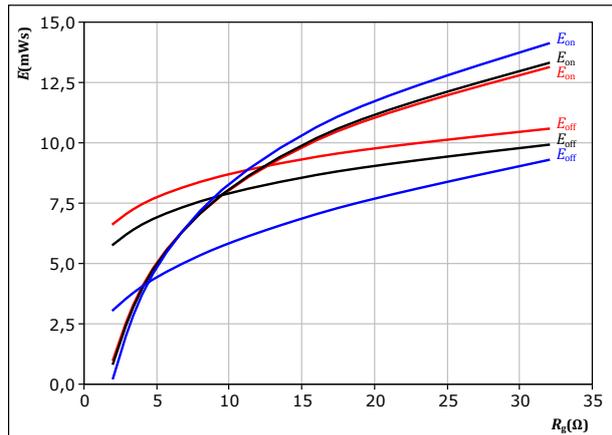
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{gon} = 8 \ \Omega$
 $R_{goff} = 8 \ \Omega$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 31. IGBT

Typical switching energy losses as a function of gate resistor

$$E = f(R_g)$$



With an inductive load at

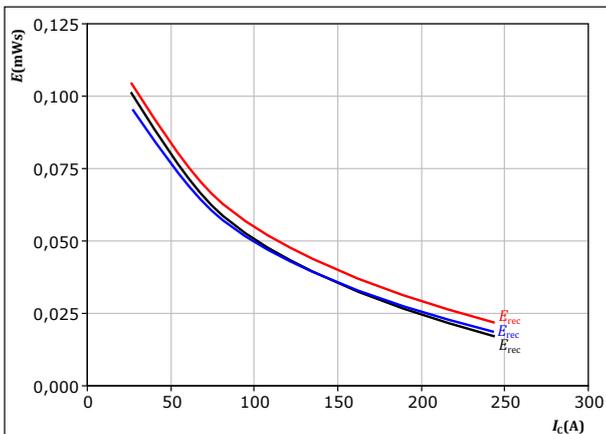
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 32. FWD

Typical reverse recovered energy loss as a function of collector current

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



With an inductive load at

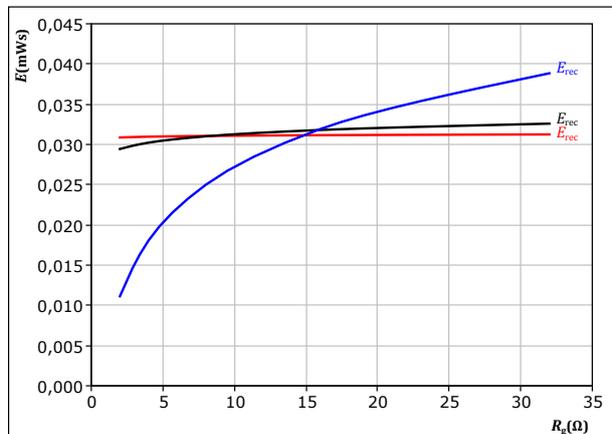
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{gon} = 8 \ \Omega$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 33. FWD

Typical reverse recovered energy loss as a function of gate resistor

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



With an inductive load at

$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

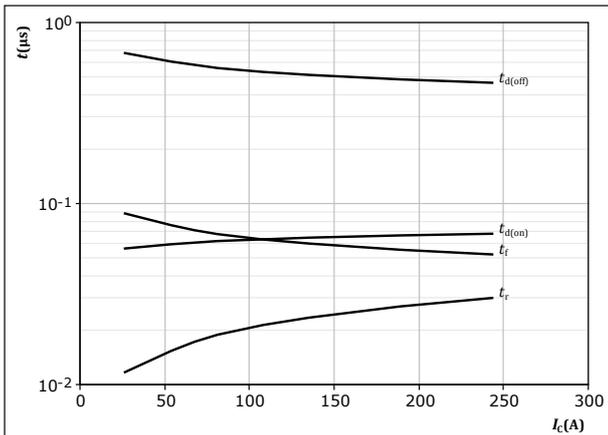
T_j : — 25 °C
— 125 °C
— 150 °C



AC 1 Switching Characteristics L

figure 34. IGBT

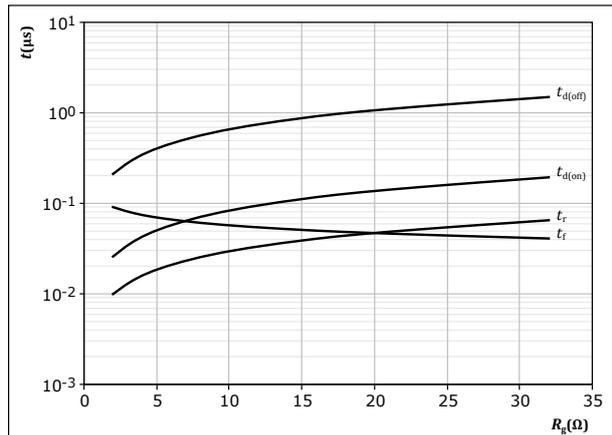
Typical switching times as a function of collector current
 $t = f(I_c)$



With an inductive load at
 $T_j = 150 \text{ }^\circ\text{C}$
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{gon} = 8 \text{ } \Omega$
 $R_{goff} = 8 \text{ } \Omega$

figure 35. IGBT

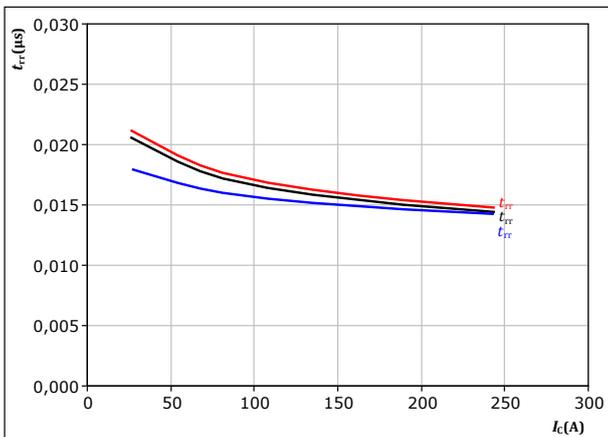
Typical switching times as a function of gate resistor
 $t = f(R_g)$



With an inductive load at
 $T_j = 150 \text{ }^\circ\text{C}$
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

figure 36. FWD

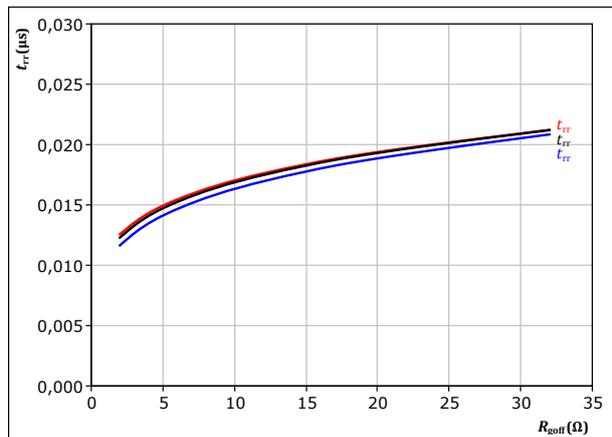
Typical reverse recovery time as a function of collector current
 $t_{rr} = f(I_c)$



With an inductive load at
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{gon} = 8 \text{ } \Omega$
 $T_j: \text{ — } 25 \text{ }^\circ\text{C}$
 $\text{ — } 125 \text{ }^\circ\text{C}$
 $\text{ — } 150 \text{ }^\circ\text{C}$

figure 37. FWD

Typical reverse recovery time as a function of IGBT turn off gate resistor
 $t_{rr} = f(R_{goff})$



With an inductive load at
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$
 $T_j: \text{ — } 25 \text{ }^\circ\text{C}$
 $\text{ — } 125 \text{ }^\circ\text{C}$
 $\text{ — } 150 \text{ }^\circ\text{C}$

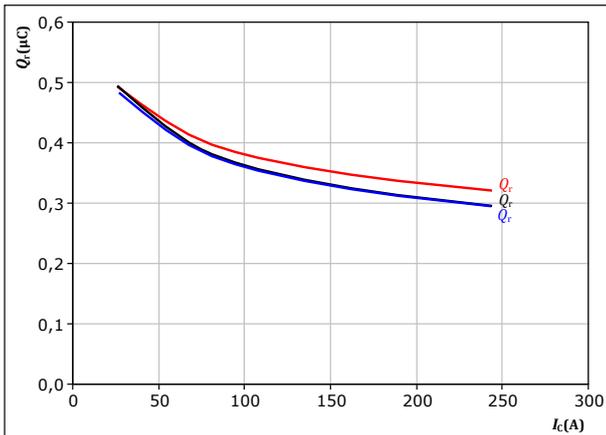


AC 1 Switching Characteristics L

figure 38. FWD

Typical recovered charge as a function of collector current

$$Q_r = f(I_c)$$



With an inductive load at

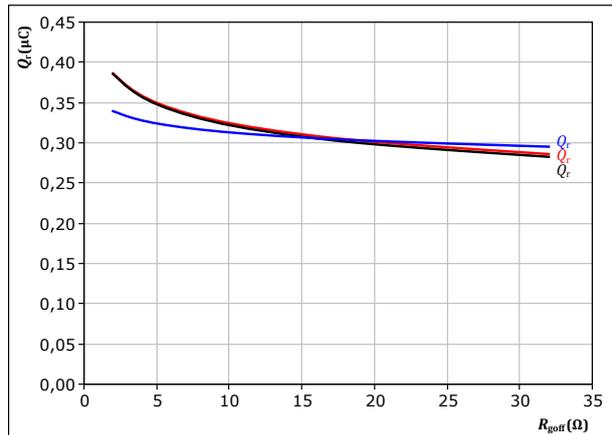
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{goff} = 8 \text{ } \Omega$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 39. FWD

Typical recovered charge as a function of turn off gate resistor

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



With an inductive load at

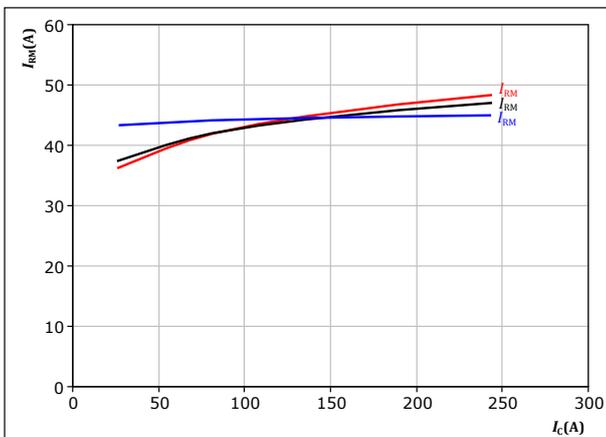
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 40. FWD

Typical peak reverse recovery current as a function of collector current

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



With an inductive load at

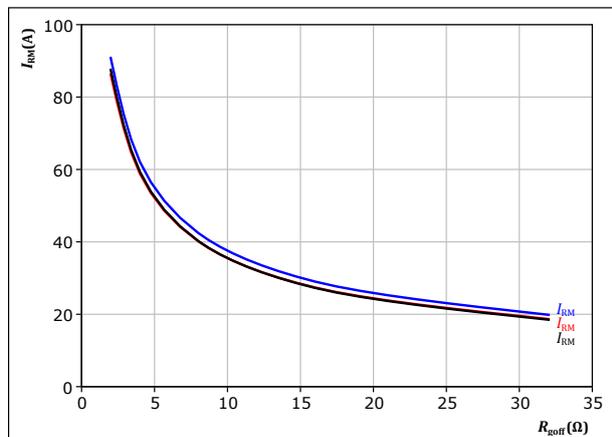
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{goff} = 8 \text{ } \Omega$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 41. FWD

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

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



With an inductive load at

$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

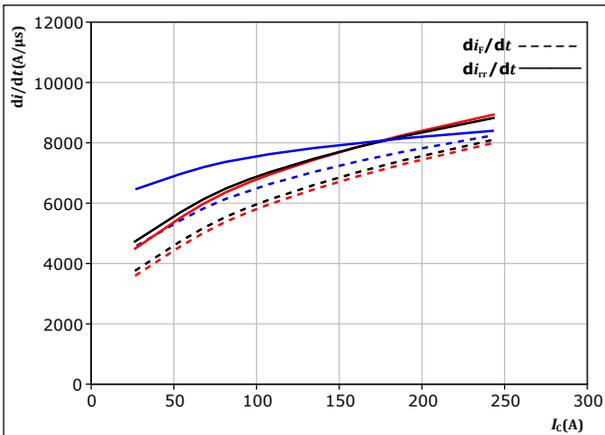
T_j : — 25 °C
— 125 °C
— 150 °C



AC 1 Switching Characteristics L

figure 42. FWD

Typical rate of fall of forward and reverse recovery current as a function of collector current
 $di_i/dt, di_r/dt = f(I_C)$



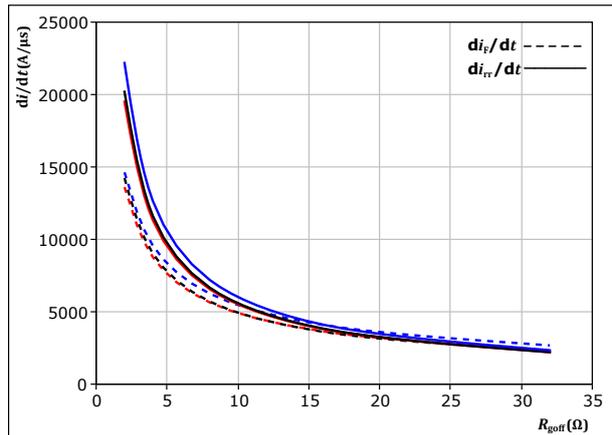
With an inductive load at

$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{goff} = 8 \text{ } \Omega$

$T_j =$ — 25 °C
 — 125 °C
 — 150 °C

figure 43. FWD

Typical rate of fall of forward and reverse recovery current as a function of turn off gate resistor
 $di_i/dt, di_r/dt = f(R_{goff})$



With an inductive load at

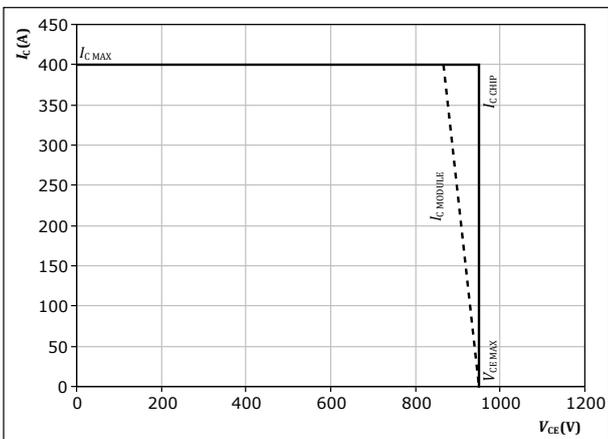
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_C = 135 \text{ A}$

$T_j =$ — 25 °C
 — 125 °C
 — 150 °C

figure 44. IGBT

Reverse bias safe operating area

$I_C = f(V_{CE})$



At $T_j = 150 \text{ } ^\circ\text{C}$
 $R_{goff} = 8 \text{ } \Omega$
 $R_{goff} = 8 \text{ } \Omega$

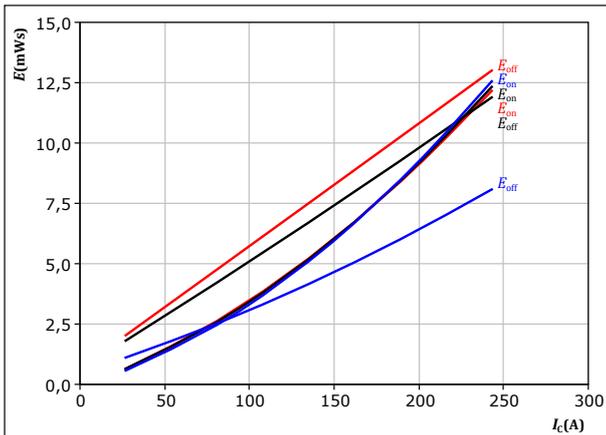


AC 1 Switching Characteristics H

figure 45. IGBT

Typical switching energy losses as a function of collector current

$$E = f(I_c)$$



With an inductive load at

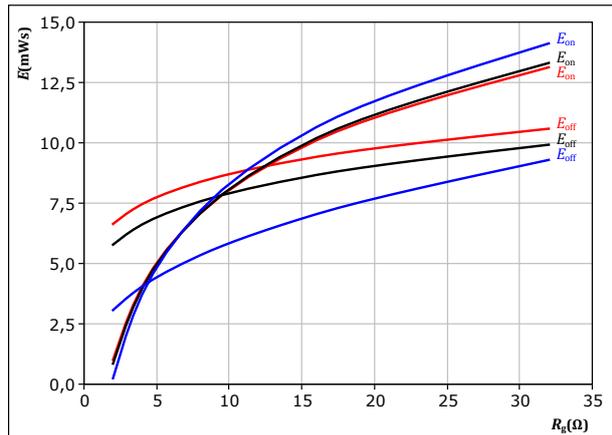
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{gon} = 8 \ \Omega$
 $R_{goff} = 8 \ \Omega$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 46. IGBT

Typical switching energy losses as a function of gate resistor

$$E = f(R_g)$$



With an inductive load at

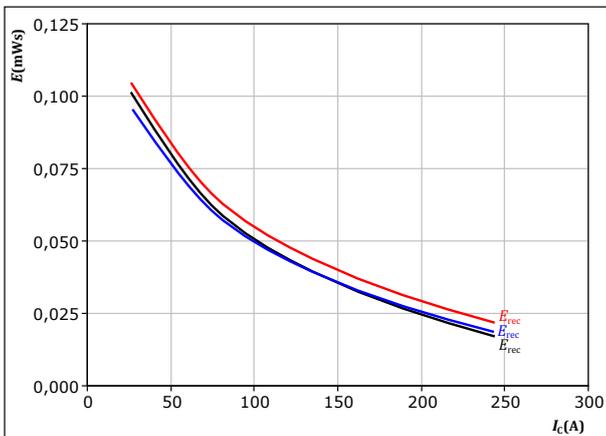
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 47. FWD

Typical reverse recovered energy loss as a function of collector current

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



With an inductive load at

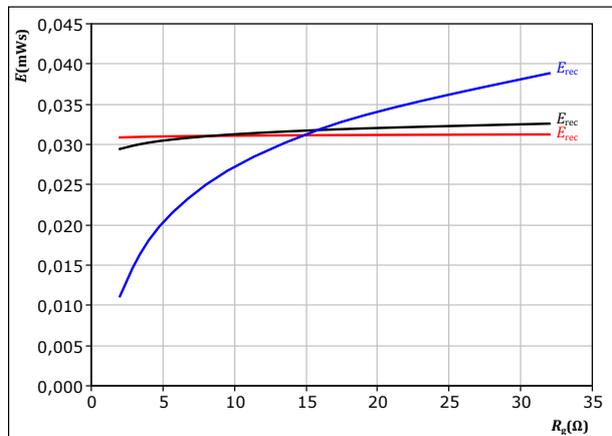
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{gon} = 8 \ \Omega$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 48. FWD

Typical reverse recovered energy loss as a function of gate resistor

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



With an inductive load at

$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

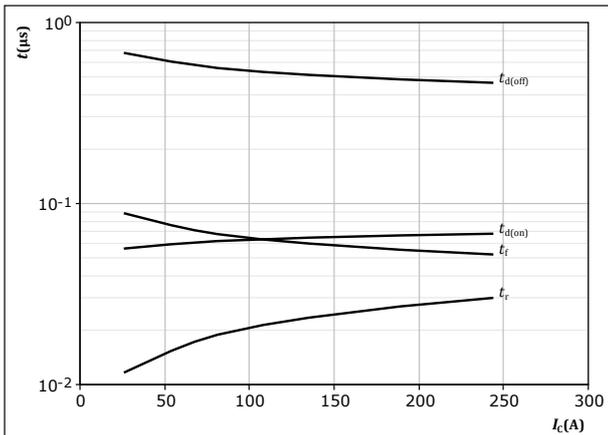
T_j : — 25 °C
— 125 °C
— 150 °C



AC 1 Switching Characteristics H

figure 49. IGBT

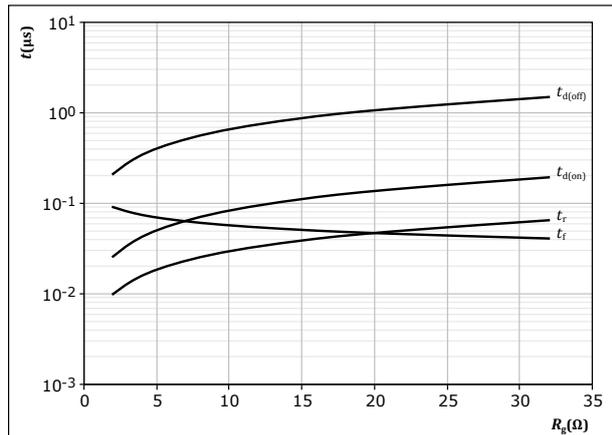
Typical switching times as a function of collector current
 $t = f(I_c)$



With an inductive load at
 $T_j = 150 \text{ } ^\circ\text{C}$
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{g(on)} = 8 \text{ } \Omega$
 $R_{g(off)} = 8 \text{ } \Omega$

figure 50. IGBT

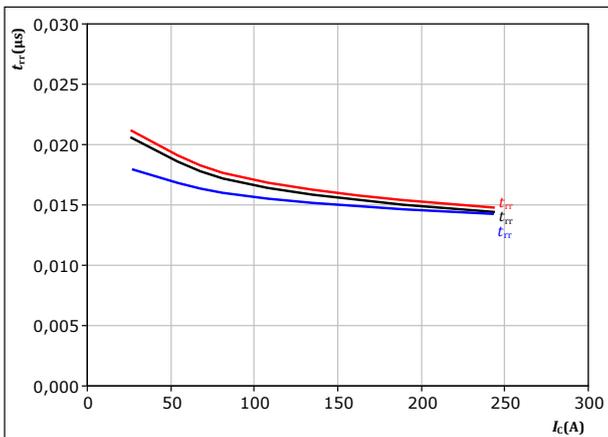
Typical switching times as a function of gate resistor
 $t = f(R_g)$



With an inductive load at
 $T_j = 150 \text{ } ^\circ\text{C}$
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

figure 51. FWD

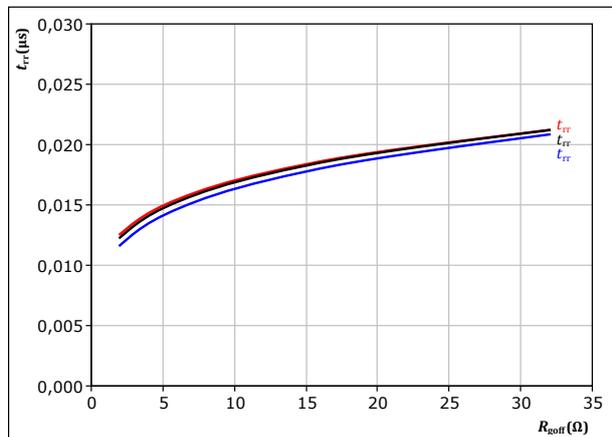
Typical reverse recovery time as a function of collector current
 $t_{rr} = f(I_c)$



With an inductive load at
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{g(on)} = 8 \text{ } \Omega$
 $T_j: \text{ — } 25 \text{ } ^\circ\text{C}$
 $\text{ — } 125 \text{ } ^\circ\text{C}$
 $\text{ — } 150 \text{ } ^\circ\text{C}$

figure 52. FWD

Typical reverse recovery time as a function of IGBT turn off gate resistor
 $t_{rr} = f(R_{g(off)})$



With an inductive load at
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$
 $T_j: \text{ — } 25 \text{ } ^\circ\text{C}$
 $\text{ — } 125 \text{ } ^\circ\text{C}$
 $\text{ — } 150 \text{ } ^\circ\text{C}$

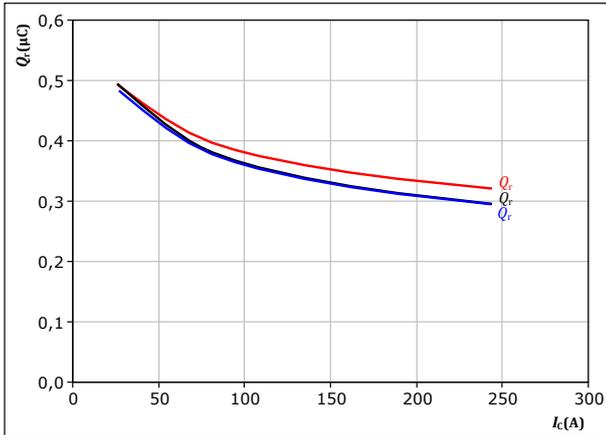


AC 1 Switching Characteristics H

figure 53. FWD

Typical recovered charge as a function of collector current

$$Q_r = f(I_c)$$



With an inductive load at

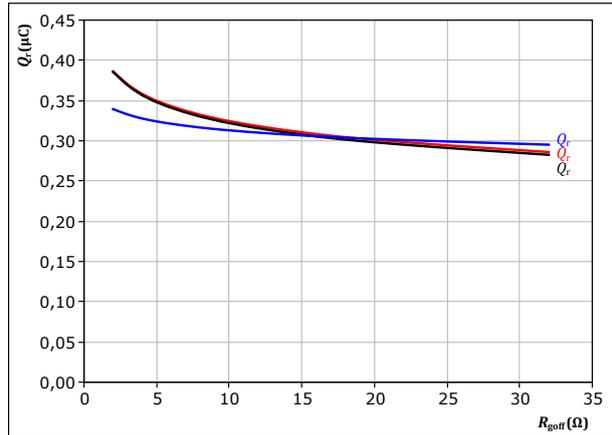
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{goff} = 8 \ \Omega$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 54. FWD

Typical recovered charge as a function of turn off gate resistor

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



With an inductive load at

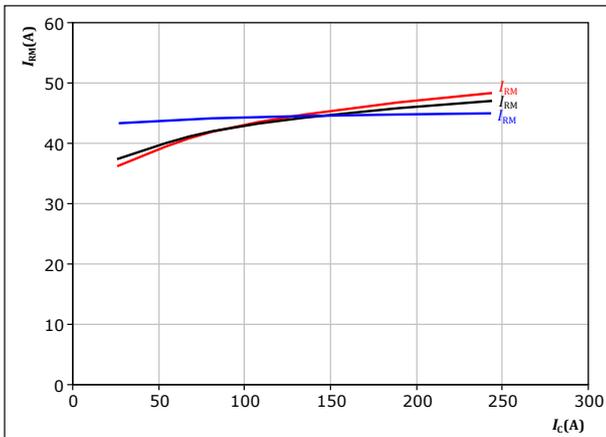
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 55. FWD

Typical peak reverse recovery current as a function of collector current

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



With an inductive load at

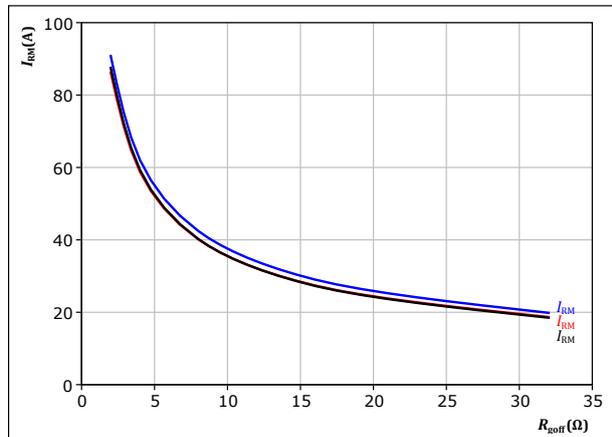
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{goff} = 8 \ \Omega$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 56. FWD

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

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



With an inductive load at

$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

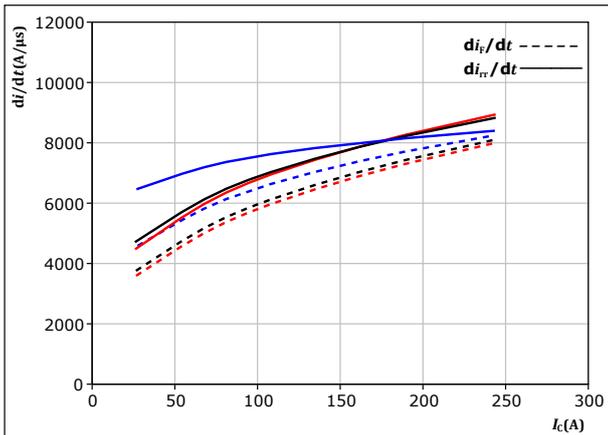
T_j : — 25 °C
— 125 °C
— 150 °C



AC 1 Switching Characteristics H

figure 57. FWD

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



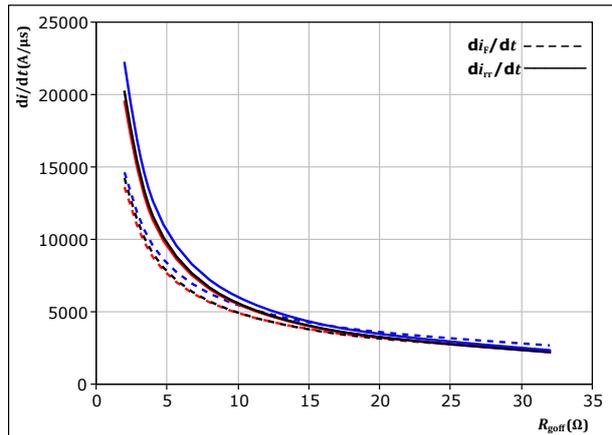
With an inductive load at

$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{goff} = 8 \text{ } \Omega$

T_j : — 25 °C
 — 125 °C
 — 150 °C

figure 58. FWD

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



With an inductive load at

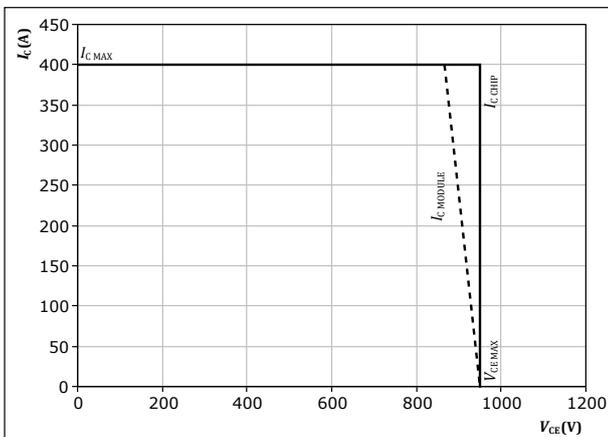
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_C = 135 \text{ A}$

T_j : — 25 °C
 — 125 °C
 — 150 °C

figure 59. IGBT

Reverse bias safe operating area

$I_C = f(V_{CE})$



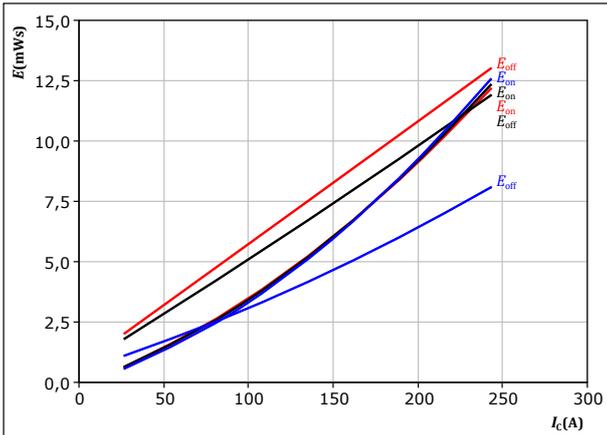
At $T_j = 150 \text{ } ^\circ\text{C}$
 $R_{goff} = 8 \text{ } \Omega$
 $R_{goff} = 8 \text{ } \Omega$



AC 2 Switching Characteristics L

figure 60. IGBT

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

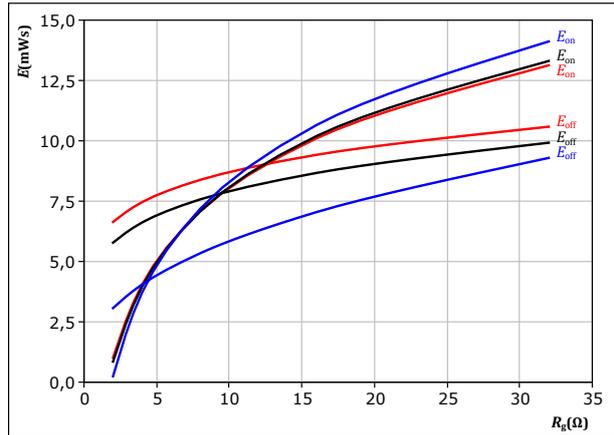


With an inductive load at
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{gon} = 8 \ \Omega$
 $R_{goff} = 8 \ \Omega$

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

figure 61. IGBT

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

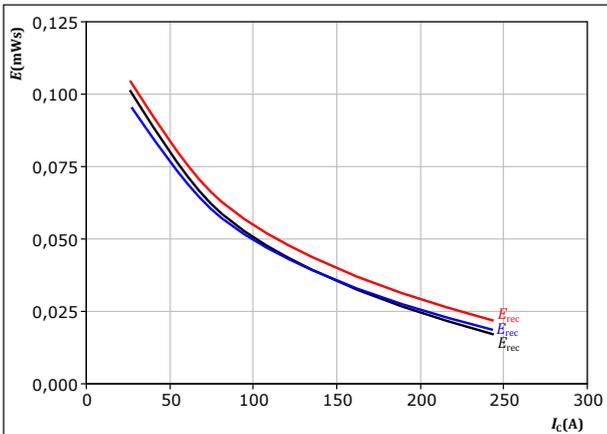


With an inductive load at
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

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

figure 62. FWD

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

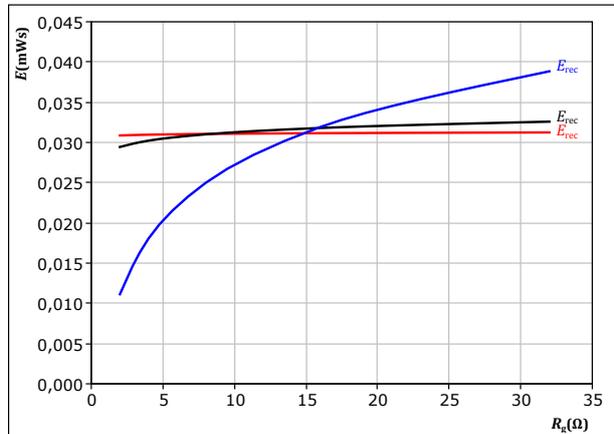


With an inductive load at
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{gon} = 8 \ \Omega$

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

figure 63. FWD

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



With an inductive load at
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

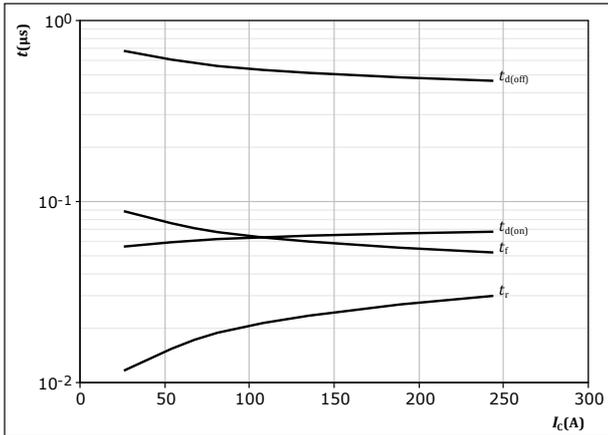
T_j : 25 °C (blue), 125 °C (black), 150 °C (red)



AC 2 Switching Characteristics L

figure 64. IGBT

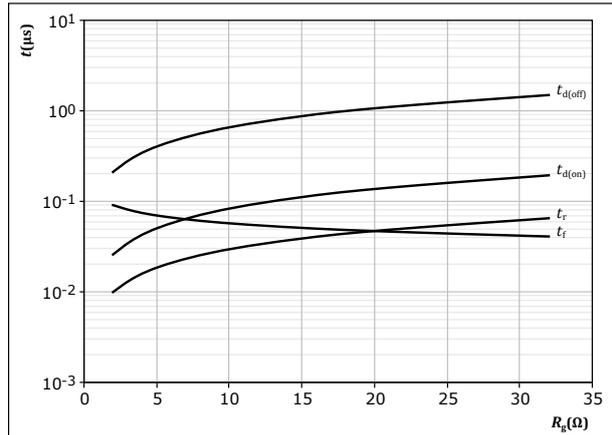
Typical switching times as a function of collector current
 $t = f(I_c)$



With an inductive load at
 $T_j = 150 \text{ }^\circ\text{C}$
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{gon} = 8 \text{ } \Omega$
 $R_{goff} = 8 \text{ } \Omega$

figure 65. IGBT

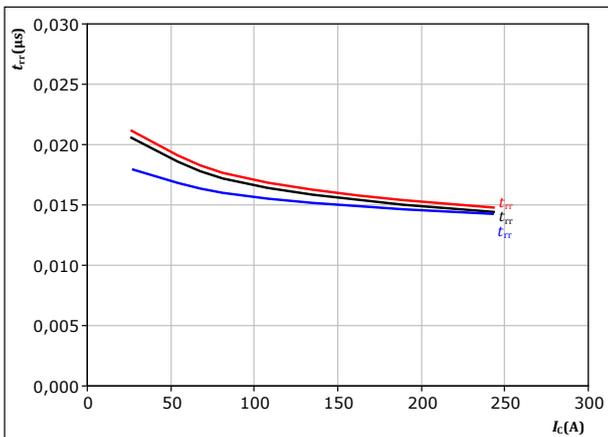
Typical switching times as a function of gate resistor
 $t = f(R_g)$



With an inductive load at
 $T_j = 150 \text{ }^\circ\text{C}$
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

figure 66. FWD

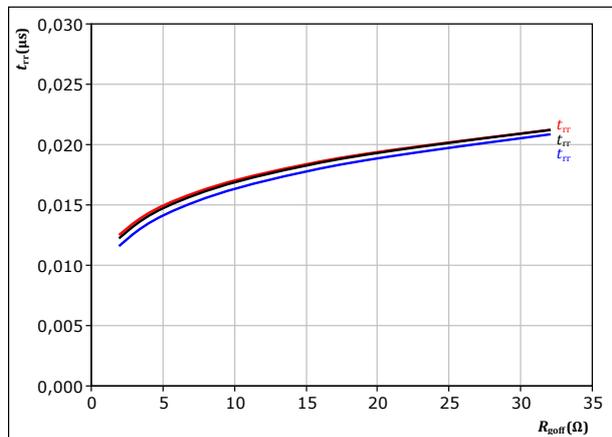
Typical reverse recovery time as a function of collector current
 $t_{rr} = f(I_c)$



With an inductive load at
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{gon} = 8 \text{ } \Omega$
 $T_j: \text{ — } 25 \text{ }^\circ\text{C}$
 $\text{ — } 125 \text{ }^\circ\text{C}$
 $\text{ — } 150 \text{ }^\circ\text{C}$

figure 67. FWD

Typical reverse recovery time as a function of IGBT turn off gate resistor
 $t_{rr} = f(R_{goff})$



With an inductive load at
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$
 $T_j: \text{ — } 25 \text{ }^\circ\text{C}$
 $\text{ — } 125 \text{ }^\circ\text{C}$
 $\text{ — } 150 \text{ }^\circ\text{C}$

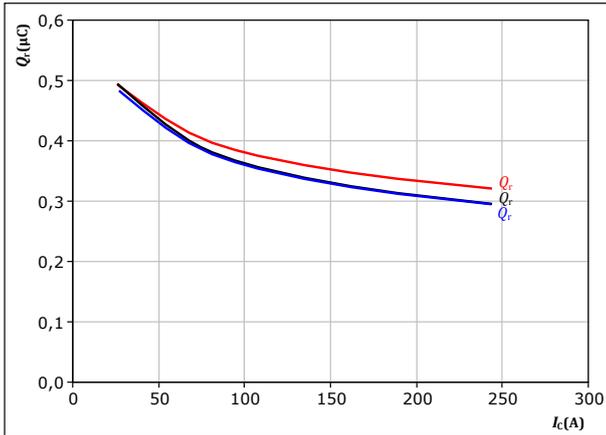


AC 2 Switching Characteristics L

figure 68. FWD

Typical recovered charge as a function of collector current

$$Q_r = f(I_c)$$



With an inductive load at

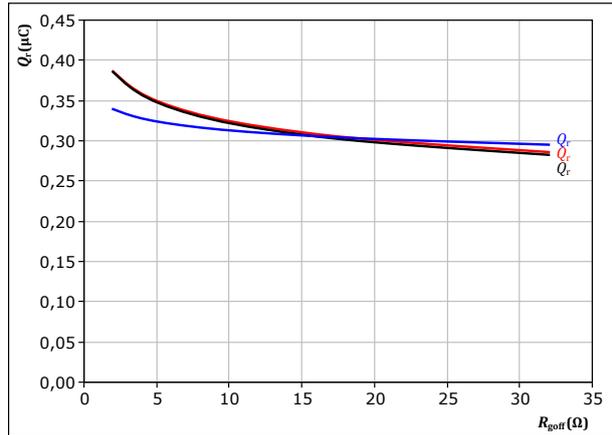
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{goff} = 8 \ \Omega$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 69. FWD

Typical recovered charge as a function of turn off gate resistor

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



With an inductive load at

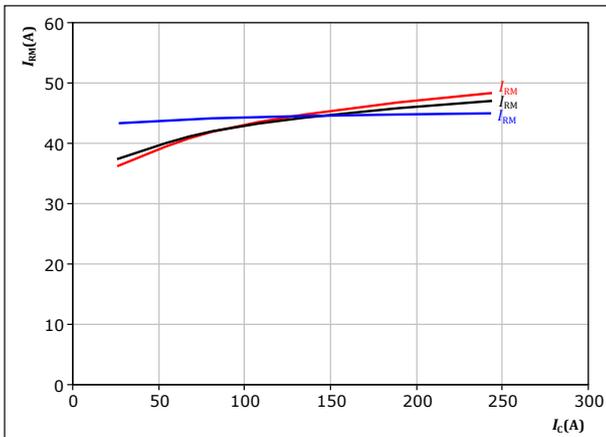
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 70. FWD

Typical peak reverse recovery current as a function of collector current

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



With an inductive load at

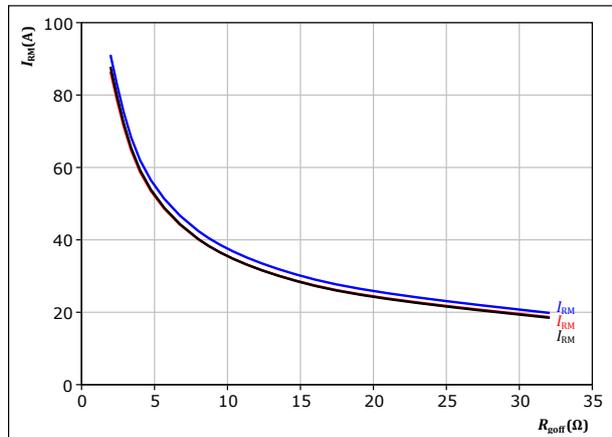
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{goff} = 8 \ \Omega$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 71. FWD

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

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



With an inductive load at

$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

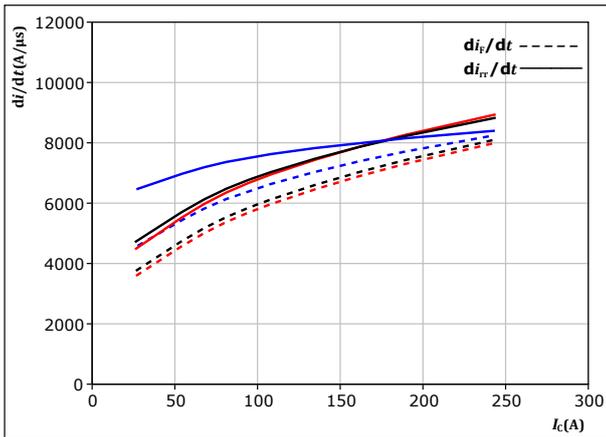
T_j : — 25 °C
— 125 °C
— 150 °C



AC 2 Switching Characteristics L

figure 72. FWD

Typical rate of fall of forward and reverse recovery current as a function of collector current
 $di_i/dt, di_r/dt = f(I_C)$



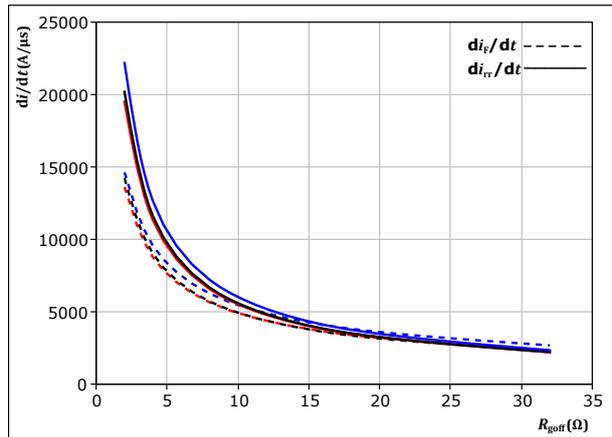
With an inductive load at

$V_{CE} = 600$ V
 $V_{GE} = 0/15$ V
 $R_{goff} = 8$ Ω

T_j : — 25 °C
 — 125 °C
 — 150 °C

figure 73. FWD

Typical rate of fall of forward and reverse recovery current as a function of turn off gate resistor
 $di_i/dt, di_r/dt = f(R_{goff})$



With an inductive load at

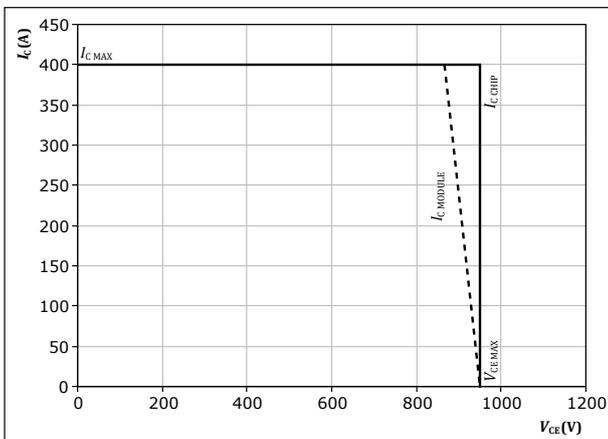
$V_{CE} = 600$ V
 $V_{GE} = 0/15$ V
 $I_C = 135$ A

T_j : — 25 °C
 — 125 °C
 — 150 °C

figure 74. IGBT

Reverse bias safe operating area

$I_C = f(V_{CE})$



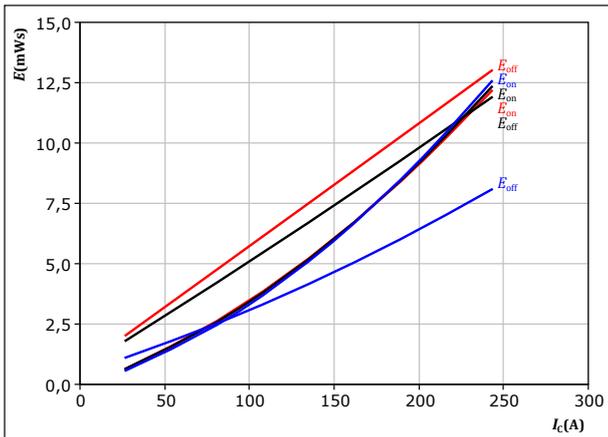
At $T_j = 150$ °C
 $R_{goff} = 8$ Ω
 $R_{goff} = 8$ Ω



AC 2 Switching Characteristics H

figure 75. IGBT

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

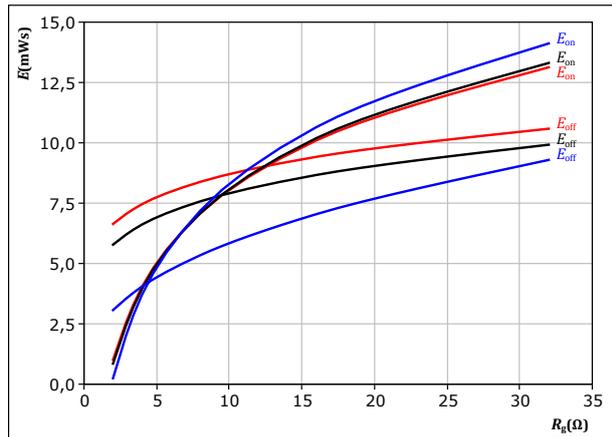


With an inductive load at

$V_{CE} =$	600	V	$T_j:$	— 25 °C
$V_{GE} =$	0/15	V		— 125 °C
$R_{gon} =$	8	Ω		— 150 °C
$R_{goff} =$	8	Ω		

figure 76. IGBT

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

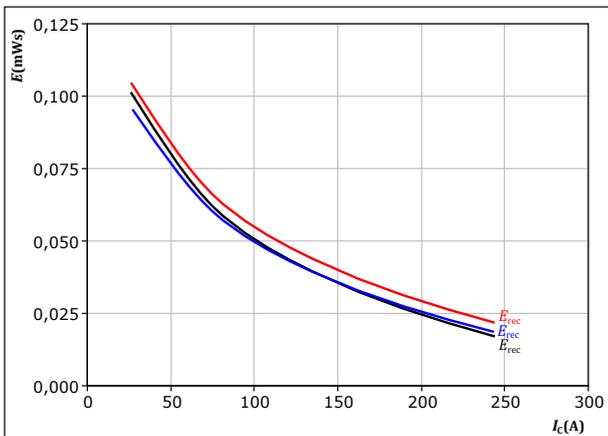


With an inductive load at

$V_{CE} =$	600	V	$T_j:$	— 25 °C
$V_{GE} =$	0/15	V		— 125 °C
$I_c =$	135	A		— 150 °C

figure 77. FWD

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

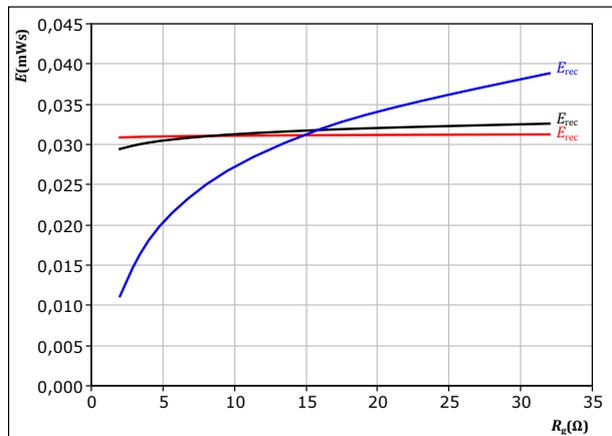


With an inductive load at

$V_{CE} =$	600	V	$T_j:$	— 25 °C
$V_{GE} =$	0/15	V		— 125 °C
$R_{gon} =$	8	Ω		— 150 °C

figure 78. FWD

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



With an inductive load at

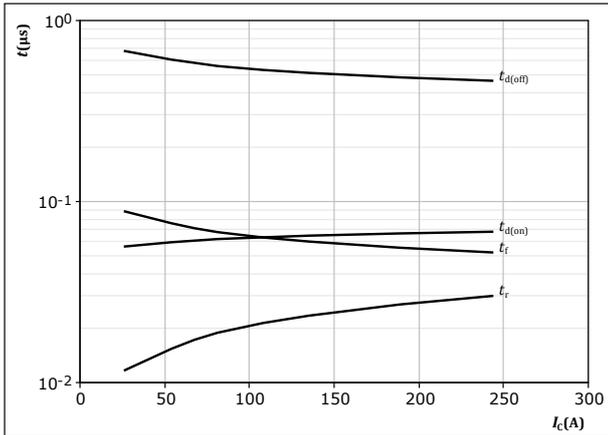
$V_{CE} =$	600	V	$T_j:$	— 25 °C
$V_{GE} =$	0/15	V		— 125 °C
$I_c =$	135	A		— 150 °C



AC 2 Switching Characteristics H

figure 79. IGBT

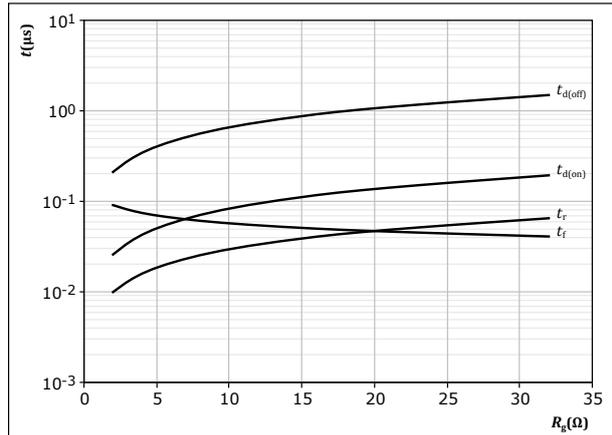
Typical switching times as a function of collector current
 $t = f(I_c)$



With an inductive load at
 $T_j = 150 \text{ }^\circ\text{C}$
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{gon} = 8 \text{ } \Omega$
 $R_{goff} = 8 \text{ } \Omega$

figure 80. IGBT

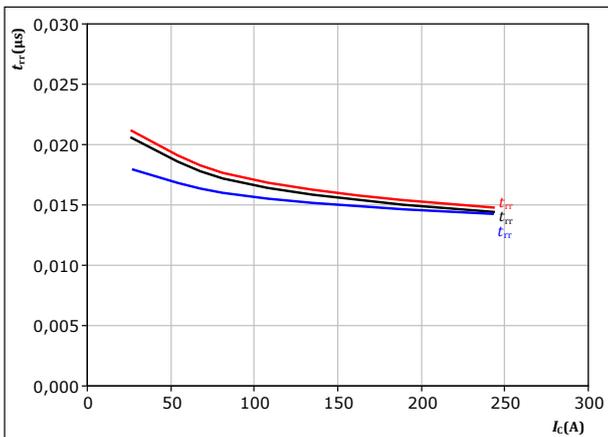
Typical switching times as a function of gate resistor
 $t = f(R_g)$



With an inductive load at
 $T_j = 150 \text{ }^\circ\text{C}$
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

figure 81. FWD

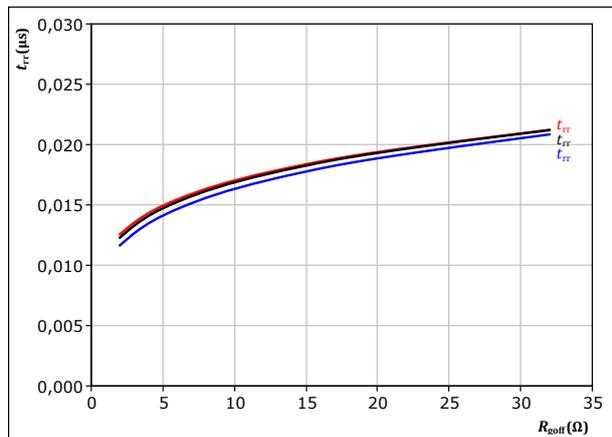
Typical reverse recovery time as a function of collector current
 $t_{rr} = f(I_c)$



With an inductive load at
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{gon} = 8 \text{ } \Omega$
 $T_j: \text{ — } 25 \text{ }^\circ\text{C}$
 $\text{ — } 125 \text{ }^\circ\text{C}$
 $\text{ — } 150 \text{ }^\circ\text{C}$

figure 82. FWD

Typical reverse recovery time as a function of IGBT turn off gate resistor
 $t_{rr} = f(R_{goff})$



With an inductive load at
 $V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$
 $T_j: \text{ — } 25 \text{ }^\circ\text{C}$
 $\text{ — } 125 \text{ }^\circ\text{C}$
 $\text{ — } 150 \text{ }^\circ\text{C}$

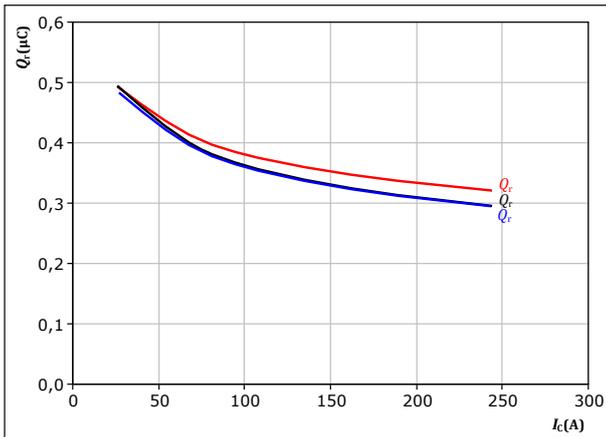


AC 2 Switching Characteristics H

figure 83. FWD

Typical recovered charge as a function of collector current

$$Q_r = f(I_c)$$



With an inductive load at

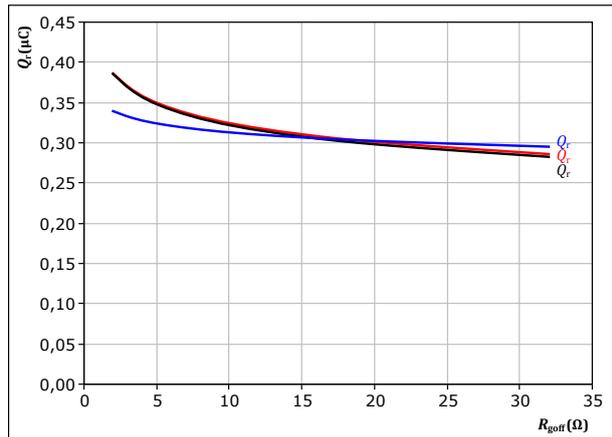
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{goff} = 8 \text{ } \Omega$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 84. FWD

Typical recovered charge as a function of turn off gate resistor

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



With an inductive load at

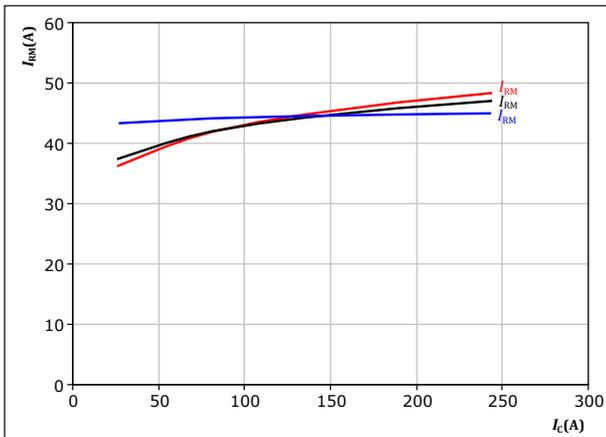
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 85. FWD

Typical peak reverse recovery current as a function of collector current

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



With an inductive load at

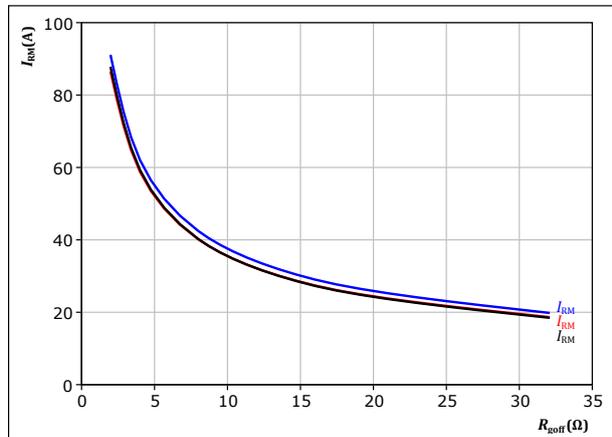
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{goff} = 8 \text{ } \Omega$

T_j : — 25 °C
— 125 °C
— 150 °C

figure 86. FWD

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

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



With an inductive load at

$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_c = 135 \text{ A}$

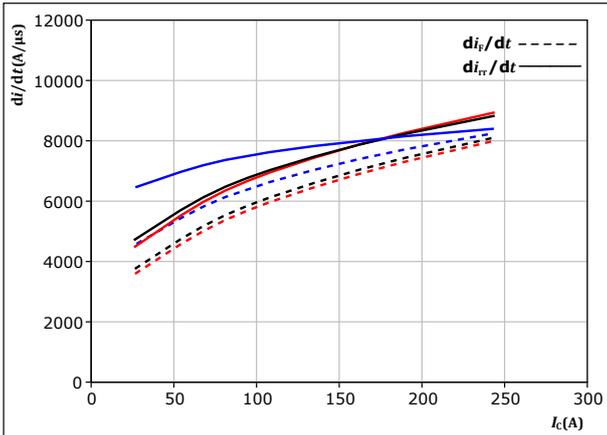
T_j : — 25 °C
— 125 °C
— 150 °C



AC 2 Switching Characteristics H

figure 87. FWD

Typical rate of fall of forward and reverse recovery current as a function of collector current
 $di_i/dt, di_r/dt = f(I_C)$



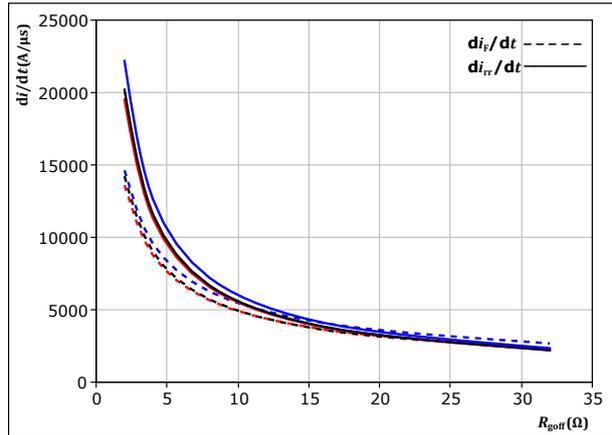
With an inductive load at

$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $R_{goff} = 8 \text{ } \Omega$

$T_j = 25 \text{ } ^\circ\text{C}$
 $125 \text{ } ^\circ\text{C}$
 $150 \text{ } ^\circ\text{C}$

figure 88. FWD

Typical rate of fall of forward and reverse recovery current as a function of turn off gate resistor
 $di_i/dt, di_r/dt = f(R_{goff})$



With an inductive load at

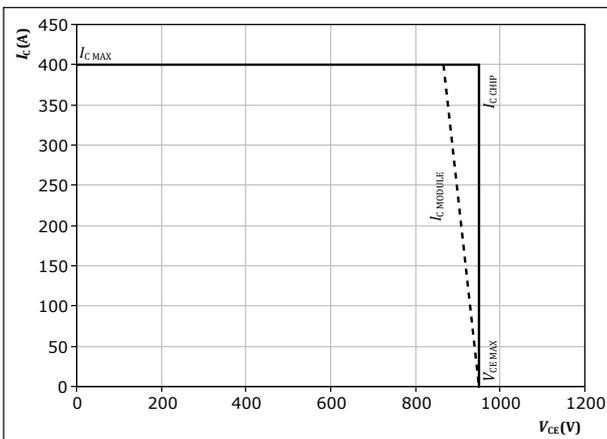
$V_{CE} = 600 \text{ V}$
 $V_{GE} = 0/15 \text{ V}$
 $I_C = 135 \text{ A}$

$T_j = 25 \text{ } ^\circ\text{C}$
 $125 \text{ } ^\circ\text{C}$
 $150 \text{ } ^\circ\text{C}$

figure 89. IGBT

Reverse bias safe operating area

$I_C = f(V_{CE})$



At $T_j = 150 \text{ } ^\circ\text{C}$
 $R_{goff} = 8 \text{ } \Omega$
 $R_{goff} = 8 \text{ } \Omega$



Switching Definitions

figure 90. IGBT
Turn-off Switching Waveforms & definition of t_{doff} , t_{Eoff} (t_{Eoff} = integrating time for E_{off})

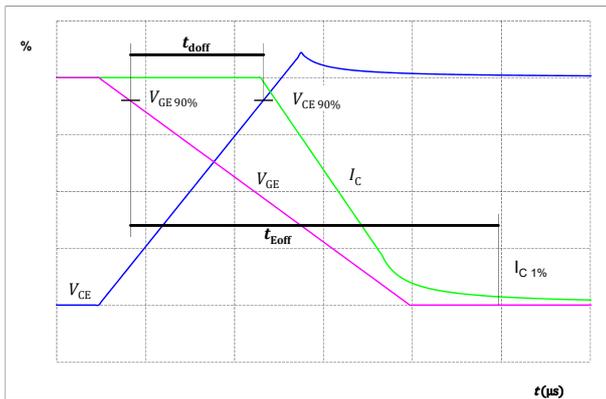


figure 91. IGBT
Turn-on Switching Waveforms & definition of t_{don} , t_{Eon} (t_{Eon} = integrating time for E_{on})

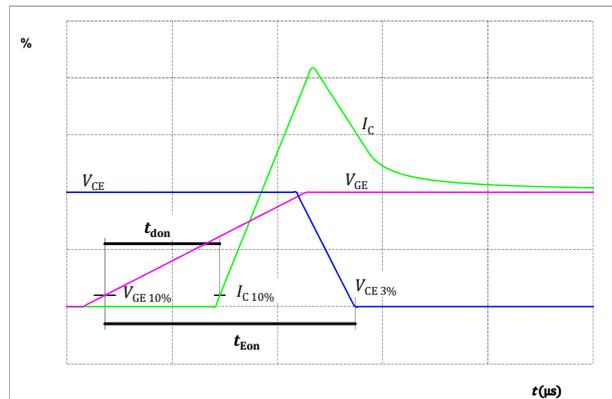


figure 92. IGBT
Turn-off Switching Waveforms & definition of t_f

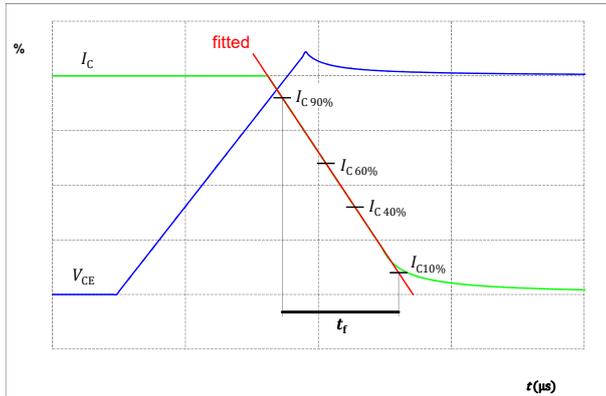
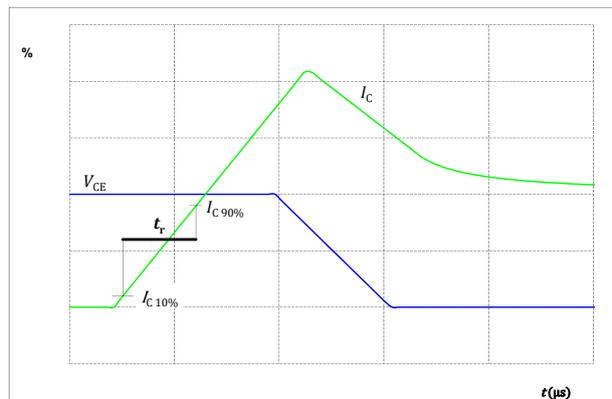


figure 93. IGBT
Turn-on Switching Waveforms & definition of t_r





Switching Definitions

figure 94. FWD

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

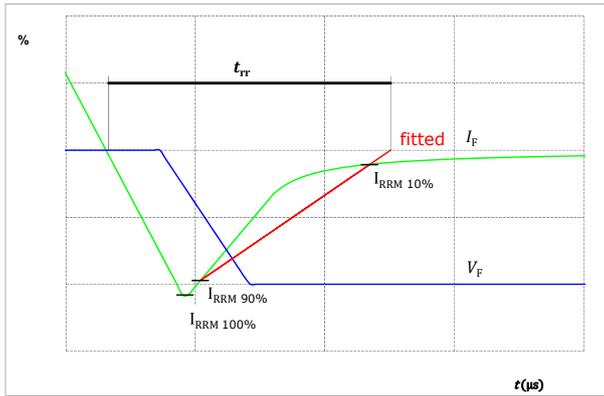
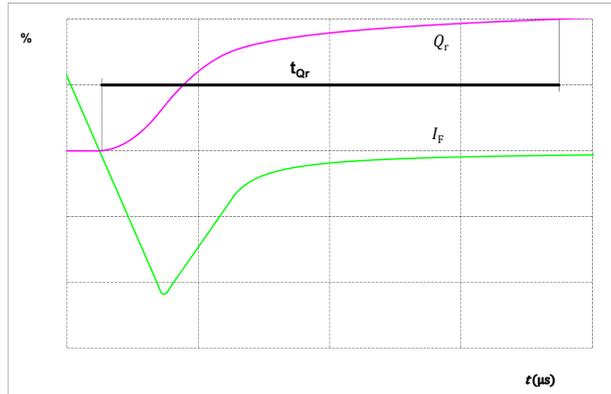
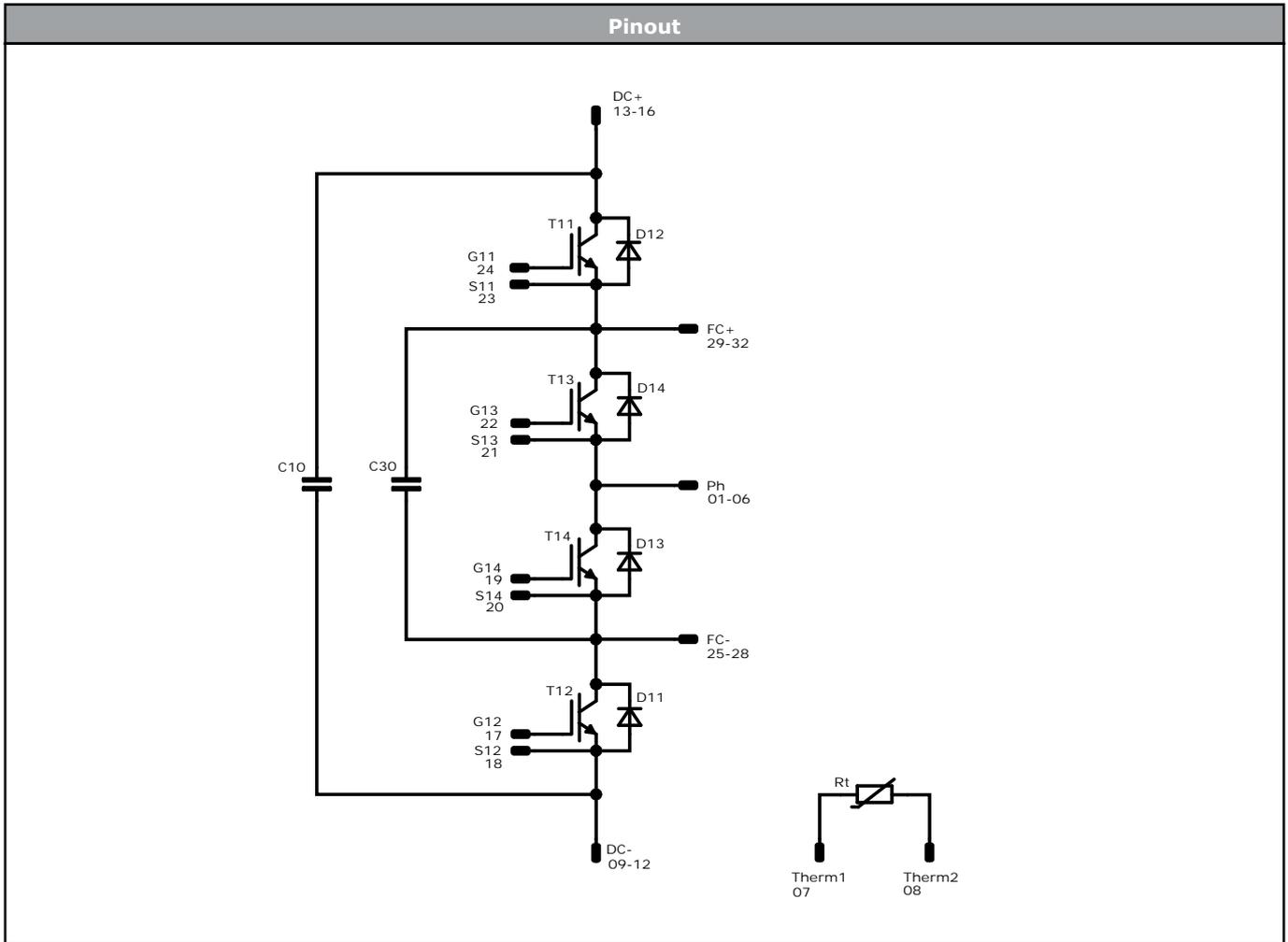


figure 95. FWD

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





Identification					
ID	Component	Voltage	Current	Function	Comment
T12	IGBT	950 V	200 A	AC 1 Switch L	
D11	FWD	1200 V	60 A	AC 1 Diode L	
T11	IGBT	950 V	200 A	AC 1 Switch H	
D12	FWD	1200 V	60 A	AC 1 Diode H	
T14	IGBT	950 V	200 A	AC 2 Switch L	
D13	FWD	1200 V	60 A	AC 2 Diode L	
T13	IGBT	950 V	200 A	AC 2 Switch H	
D14	FWD	1200 V	60 A	AC 2 Diode H	
C30	Capacitor	1000 V		Flying Capacitor	
C10	Capacitor	1500 V		Capacitor (DC)	
Rt	Thermistor			Thermistor	



Vincotech

Packaging instruction				
Standard packaging quantity (SPQ) 45	>SPQ	Standard	<SPQ	Sample

Handling instruction
Handling instructions for <i>flow</i> S3 packages see vincotech.com website.

Package data
Package data for <i>flow</i> S3 packages see vincotech.com website.

Vincotech thermistor reference
See Vincotech thermistor reference table at vincotech.com website.

UL recognition and file number
Certification pending. For more information see vincotech.com website.

Document No.:	Date:	Modification:	Pages
B0-SP10FCA200S702-LM87F93T-D1-14	10 May, 2021		

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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.