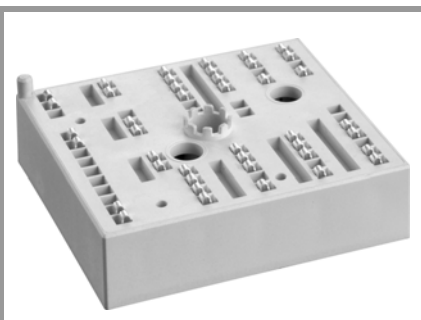


SKiIP 28TMLI12F4V1



MiniSKiIP® 2

3-Level TNPC Inverter (*)

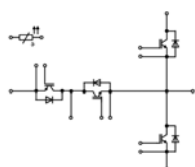
SKiIP 28TMLI12F4V1

Features

- Fast Trench 4 IGBTs
- Trench IGBTs
- Robust and soft diodes in CAL technology
- Highly reliable spring contacts for electrical connections
- UL recognised: File no. E63532

Remarks

- Case temperature limited to $T_C=125^\circ\text{C}$ max.; $T_C = T_S$ (for baseplateless modules)
- Product reliability results valid for $T_j \leq 150^\circ\text{C}$ (recommended $T_{jop} = -40 \dots +150^\circ\text{C}$)
- IGBT 1: outer IGBTs T1&T4
- IGBT 2: inner IGBTs T2&T3
- Diode 1: outer diodes D1&D4
- Diode 2: inner diodes D2&D3



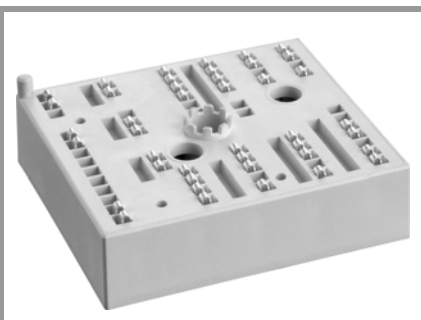
TMLI

Absolute Maximum Ratings				
Symbol	Conditions	Values	Unit	
IGBT 1				
V_{CES}	$T_j = 25^\circ\text{C}$	1200	V	
I_C	$T_j = 150^\circ\text{C}$	$T_s = 25^\circ\text{C}$	84	A
		$T_s = 70^\circ\text{C}$	65	A
I_C	$T_j = 175^\circ\text{C}$	$T_s = 25^\circ\text{C}$	93	A
		$T_s = 70^\circ\text{C}$	76	A
I_{Cnom}		80	A	
I_{CRM}	$I_{CRM} = 3 \times I_{Cnom}$	240	A	
V_{GES}		-20 ... 20	V	
t_{psc}	$V_{CC} = 800\text{ V}$ $V_{GE} \leq 15\text{ V}$ $V_{CES} \leq 1200\text{ V}$	$T_j = 150^\circ\text{C}$	10	μs
T_j		-40 ... 175	$^\circ\text{C}$	

Absolute Maximum Ratings				
Symbol	Conditions	Values	Unit	
IGBT 2				
V_{CES}	$T_j = 25^\circ\text{C}$	650	V	
I_C	$T_j = 150^\circ\text{C}$	$T_s = 25^\circ\text{C}$	68	A
		$T_s = 70^\circ\text{C}$	51	A
I_C	$T_j = 175^\circ\text{C}$	$T_s = 25^\circ\text{C}$	77	A
		$T_s = 70^\circ\text{C}$	61	A
I_{Cnom}		75	A	
I_{CRM}	$I_{CRM} = 3 \times I_{Cnom}$	225	A	
V_{GES}		-20 ... 20	V	
t_{psc}	$V_{CC} = 360\text{ V}$ $V_{GE} \leq 15\text{ V}$ $V_{CES} \leq 650\text{ V}$	$T_j = 150^\circ\text{C}$	6	μs
T_j		-40 ... 175	$^\circ\text{C}$	

Absolute Maximum Ratings				
Symbol	Conditions	Values	Unit	
Diode 1				
V_{RRM}	$T_j = 25^\circ\text{C}$	1200	V	
I_F	$T_j = 150^\circ\text{C}$	$T_s = 25^\circ\text{C}$	68	A
		$T_s = 70^\circ\text{C}$	51	A
I_F	$T_j = 175^\circ\text{C}$	$T_s = 25^\circ\text{C}$	76	A
		$T_s = 70^\circ\text{C}$	61	A
I_{Fnom}		75	A	
I_{FRM}	$I_{FRM} = 3 \times I_{Fnom}$	225	A	
I_{FSM}	10 ms, sin 180°, $T_j = 150^\circ\text{C}$	430	A	
T_j		-40 ... 175	$^\circ\text{C}$	

SKiIP 28TMLI12F4V1



MiniSKiIP® 2

3-Level TNPC Inverter (*)

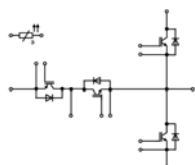
SKiIP 28TMLI12F4V1

Features

- Fast Trench 4 IGBTs
- Trench IGBTs
- Robust and soft diodes in CAL technology
- Highly reliable spring contacts for electrical connections
- UL recognised: File no. E63532

Remarks

- Case temperature limited to $T_C=125^{\circ}\text{C}$ max.; $T_C = T_S$ (for baseplateless modules)
- Product reliability results valid for $T_j \leq 150^{\circ}\text{C}$ (recommended $T_{jop} = -40 \dots +150^{\circ}\text{C}$)
- IGBT 1: outer IGBTs T1&T4
- IGBT 2: inner IGBTs T2&T3
- Diode 1: outer diodes D1&D4
- Diode 2: inner diodes D2&D3



TMLI

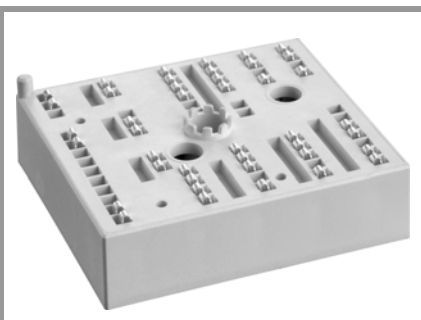
Absolute Maximum Ratings				
Symbol	Conditions	Values	Unit	
Diode 2				
V_{RRM}	$T_j = 25^{\circ}\text{C}$	650	V	
I_F	$T_j = 175^{\circ}\text{C}$	$T_s = 25^{\circ}\text{C}$	65	A
		$T_s = 70^{\circ}\text{C}$	51	A
I_{Fnom}		50	A	
I_{FRM}	$I_{FRM} = 2 \times I_{Fnom}$	100	A	
I_{FSM}	10 ms sin 180°	$T_j = 25^{\circ}\text{C}$	550	A
		$T_j = 150^{\circ}\text{C}$	460	A
T_j		-40 ... 175	°C	

Absolute Maximum Ratings			
Symbol	Conditions	Values	Unit
Module			
$I_{t(RMS)}$	$T_{terminal} = 80^{\circ}\text{C}$, 20 A per spring	80	A
T_{stg}		-40 ... 125	°C
V_{isol}	AC sinus 50 Hz, t = 1 min	2500	V

Characteristics					
Symbol	Conditions	min.	typ.	max.	Unit
IGBT 1					
$V_{CE(sat)}$	$I_C = 80\text{ A}$ $V_{GE} = 15\text{ V}$ chipelevel	$T_j = 25^{\circ}\text{C}$	2.05	2.40	V
		$T_j = 150^{\circ}\text{C}$	2.50	2.85	V
V_{CE0}	chipelevel	$T_j = 25^{\circ}\text{C}$	0.8	0.9	V
		$T_j = 150^{\circ}\text{C}$	0.7	0.8	V
r_{CE}	$V_{GE} = 15\text{ V}$ chipelevel	$T_j = 25^{\circ}\text{C}$	16	19	mΩ
		$T_j = 150^{\circ}\text{C}$	23	26	mΩ
$V_{GE(th)}$	$V_{GE} = V_{CE}\text{ V}$, $I_C = 1\text{ mA}$	5.2	5.8	6.4	V
I_{CES}	$V_{GE} = 0\text{ V}$ $V_{CE} = 1200\text{ V}$	$T_j = 25^{\circ}\text{C}$	0.1	0.3	mA
					mA
C_{ies}	$V_{CE} = 25\text{ V}$ $V_{GE} = 0\text{ V}$	f = 1 MHz	4.60		nF
C_{oes}		f = 1 MHz	0.37		nF
C_{res}		f = 1 MHz	0.27		nF
Q_G	- 8 V...+ 15 V		370		nC
R_{Gint}	$T_j = 25^{\circ}\text{C}$		4		Ω
$t_{d(on)}$	$V_{CE} = 300\text{ V}$	$T_j = 150^{\circ}\text{C}$	168		ns
t_r	$I_C = 80\text{ A}$ $R_{G on} = 1.6\ \Omega$	$T_j = 150^{\circ}\text{C}$	54		ns
		$T_j = 150^{\circ}\text{C}$	3.4		mJ
E_{on}	$R_{G off} = 1.6\ \Omega$	$T_j = 150^{\circ}\text{C}$	3.4		mJ
$t_{d(off)}$	$di/dt_{on} = 1330\text{ A}/\mu\text{s}$	$T_j = 150^{\circ}\text{C}$	285		ns
t_f	$di/dt_{off} = 1220\text{ A}/\mu\text{s}$	$T_j = 150^{\circ}\text{C}$	58		ns
E_{off}	$V_{GE neg} = -15\text{ V}$ $V_{GE pos} = 15\text{ V}$	$T_j = 150^{\circ}\text{C}$	2.2		mJ
$R_{th(j-s)}$	per IGBT, $\lambda_{paste} = 0.8\text{ W}/\text{K}^*\text{m}$		0.49		K/W

Characteristics					
Symbol	Conditions	min.	typ.	max.	Unit
Module					
M_s	to heat sink	2		2.5	Nm
w	weight		55		g

SKiIP 28TMLI12F4V1



MiniSKiIP® 2

3-Level TNPC Inverter (*)

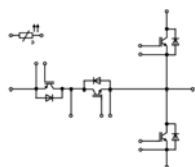
SKiIP 28TMLI12F4V1

Features

- Fast Trench 4 IGBTs
- Trench IGBTs
- Robust and soft diodes in CAL technology
- Highly reliable spring contacts for electrical connections
- UL recognised: File no. E63532

Remarks

- Case temperature limited to $T_C=125^\circ\text{C}$ max.; $T_C = T_S$ (for baseplateless modules)
- Product reliability results valid for $T_j \leq 150^\circ\text{C}$ (recommended $T_{jop} = -40 \dots +150^\circ\text{C}$)
- IGBT 1: outer IGBTs T1&T4
- IGBT 2: inner IGBTs T2&T3
- Diode 1: outer diodes D1&D4
- Diode 2: inner diodes D2&D3



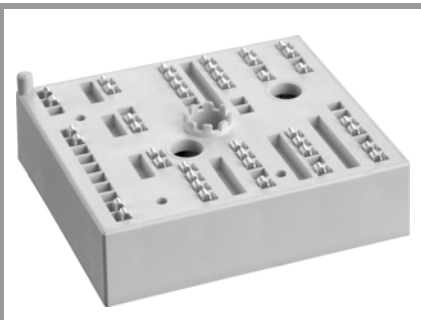
TMLI

Characteristics						
Symbol	Conditions		min.	typ.	max.	Unit
IGBT 2						
$V_{CE(sat)}$	$I_C = 75 \text{ A}$ $V_{GE} = 15 \text{ V}$ chipllevel	$T_j = 25^\circ\text{C}$	1.45	1.77		V
		$T_j = 150^\circ\text{C}$	1.70	2.10		V
V_{CE0}	chipllevel	$T_j = 25^\circ\text{C}$	0.9	1		V
		$T_j = 150^\circ\text{C}$	0.82	0.9		V
r_{CE}	$V_{GE} = 15 \text{ V}$ chipllevel	$T_j = 25^\circ\text{C}$	7.3	10		m Ω
		$T_j = 150^\circ\text{C}$	12	16		m Ω
$V_{GE(th)}$	$V_{GE} = V_{CE} \text{ V}, I_C = 1.5 \text{ mA}$		5.1	5.8	6.4	V
I_{CES}	$V_{GE} = 0 \text{ V}$ $V_{CE} = 650 \text{ V}$	$T_j = 25^\circ\text{C}$		0.1	0.3	mA
		$T_j = 150^\circ\text{C}$				mA
C_{ies}	$V_{CE} = 25 \text{ V}$ $V_{GE} = 0 \text{ V}$	$f = 1 \text{ MHz}$		4.62		nF
C_{oes}		$f = 1 \text{ MHz}$		0.30		nF
C_{res}		$f = 1 \text{ MHz}$		0.14		nF
Q_G	- 8 V...+ 15 V			680		nC
R_{Gint}	$T_j = 25^\circ\text{C}$			4		Ω
$t_{d(on)}$	$V_{CE} = 300 \text{ V}$	$T_j = 150^\circ\text{C}$		84		ns
t_r	$I_C = 75 \text{ A}$	$T_j = 150^\circ\text{C}$		33		ns
E_{on}	$R_{G on} = 1.6 \Omega$ $R_{G off} = 1.6 \Omega$	$T_j = 150^\circ\text{C}$		1.6		mJ
$t_{d(off)}$	$di/dt_{on} = 2600 \text{ A}/\mu\text{s}$	$T_j = 150^\circ\text{C}$		212		ns
t_f	$di/dt_{off} = 1000 \text{ A}/\mu\text{s}$	$T_j = 150^\circ\text{C}$		65		ns
E_{off}	$V_{GE neg} = -15 \text{ V}$ $V_{GE pos} = 15 \text{ V}$	$T_j = 150^\circ\text{C}$		1.9		mJ
$R_{th(j-s)}$	per IGBT, $\lambda_{paste}=0.8 \text{ W/K}^*\text{m}$			0.89		K/W

Characteristics						
Symbol	Conditions		min.	typ.	max.	Unit
Diode 1						
$V_F = V_{EC}$	$I_F = 75 \text{ A}$ $V_{GE} = 0 \text{ V}$ chipllevel	$T_j = 25^\circ\text{C}$	2.2	2.5		V
		$T_j = 150^\circ\text{C}$	2.1	2.4		V
V_{F0}	chipllevel	$T_j = 25^\circ\text{C}$	1.3	1.5		V
		$T_j = 150^\circ\text{C}$	0.9	1.1		V
r_F	chipllevel	$T_j = 25^\circ\text{C}$	12	13		m Ω
		$T_j = 150^\circ\text{C}$	16	18		m Ω
I_{RRM}	$I_F = 75 \text{ A}$	$T_j = 150^\circ\text{C}$		115		A
Q_{rr}	$di/dt_{off} = 2360 \text{ A}/\mu\text{s}$ $V_{GE} = -15 \text{ V}$	$T_j = 150^\circ\text{C}$		8.9		μC
E_{rr}	$V_R = 300 \text{ V}$	$T_j = 150^\circ\text{C}$		1.7		mJ
$R_{th(j-s)}$	per Diode, $\lambda_{paste}=0.8 \text{ W/K}^*\text{m}$			0.86		K/W

Characteristics						
Symbol	Conditions		min.	typ.	max.	Unit
Diode 2						
$V_F = V_{EC}$	$I_F = 50 \text{ A}$ $V_{GE} = 0 \text{ V}$ chipllevel	$T_j = 25^\circ\text{C}$	1.4	1.7		V
		$T_j = 150^\circ\text{C}$	1.4	1.7		V
V_{F0}	chipllevel	$T_j = 25^\circ\text{C}$	1	1.2		V
		$T_j = 150^\circ\text{C}$	0.9	1		V
r_F	chipllevel	$T_j = 25^\circ\text{C}$	6.7	9.8		m Ω
		$T_j = 150^\circ\text{C}$	10	15		m Ω
I_{RRM}	$I_F = 50 \text{ A}$	$T_j = 125^\circ\text{C}$		48.7		A
Q_{rr}	$di/dt_{off} = 1250 \text{ A}/\mu\text{s}$ $V_{GE} = -15 \text{ V}$	$T_j = 125^\circ\text{C}$		5		μC
E_{rr}	$V_R = 300 \text{ V}$	$T_j = 125^\circ\text{C}$		0.7		mJ
$R_{th(j-s)}$	per Diode, $\lambda_{paste}=0.8 \text{ W/K}^*\text{m}$			1.25		K/W

SKiiP 28TMLI12F4V1



MiniSKiiP® 2

Characteristics					
Symbol	Conditions	min.	typ.	max.	Unit
Temperature Sensor					
R ₁₀₀	T _r = 100 °C, tolerance = 3 %		1670 ± 3%		Ω
B _{100/125}	R(T)=1000Ω[1+A(T-25°C)+B(T-25°C) ²], A = 7.635*10 ⁻³ °C ⁻¹ , B = 1.731*10 ⁻⁵ °C ⁻²		3550 ± 2%		K

3-Level TNPC Inverter (*)

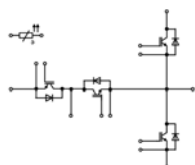
SKiiP 28TMLI12F4V1

Features

- Fast Trench 4 IGBTs
- Trench IGBTs
- Robust and soft diodes in CAL technology
- Highly reliable spring contacts for electrical connections
- UL recognised: File no. E63532

Remarks

- Case temperature limited to T_C=125°C max.; T_C = T_S (for baseplateless modules)
- Product reliability results valid for T_j≤150°C (recommended T_{jop}=-40...+150°C)
- IGBT 1: outer IGBTs T1&T4
- IGBT 2: inner IGBTs T2&T3
- Diode 1: outer diodes D1&D4
- Diode 2: inner diodes D2&D3



TMLI

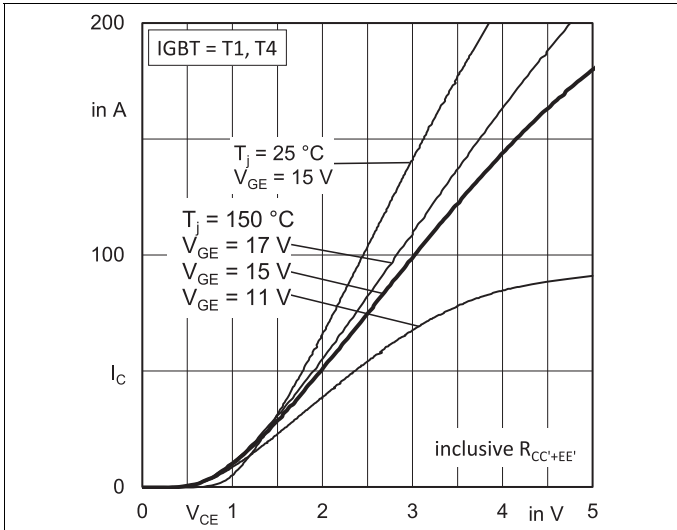


Fig. 1: Typ. output characteristic, inclusive $R_{CC+EE'}$

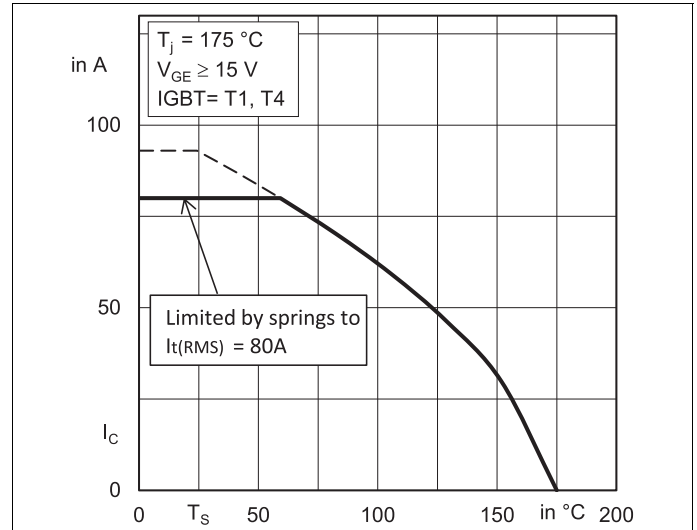


Fig. 2: Rated current vs. temperature $I_C = f(T_S)$

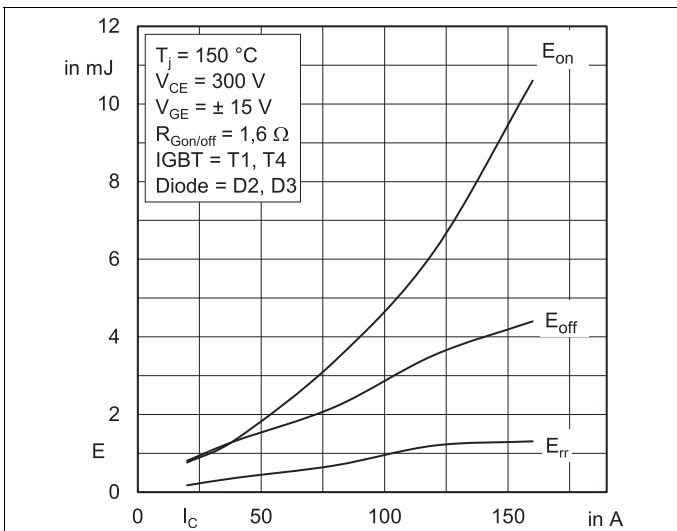


Fig. 3: Typ. turn-on /-off energy = $f(I_C)$

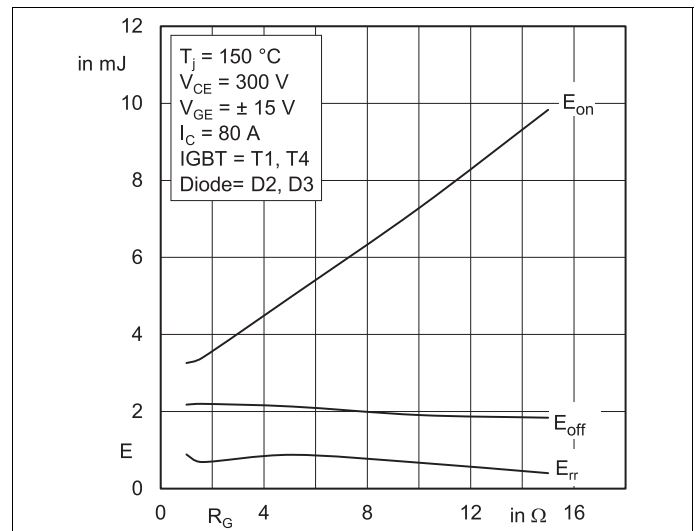


Fig. 4: Typ. turn-on /-off energy = $f(R_G)$

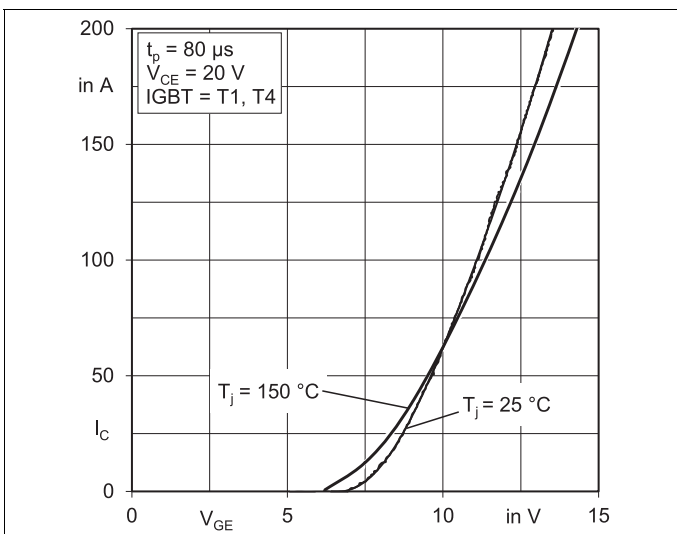


Fig. 5: Typ. transfer characteristic

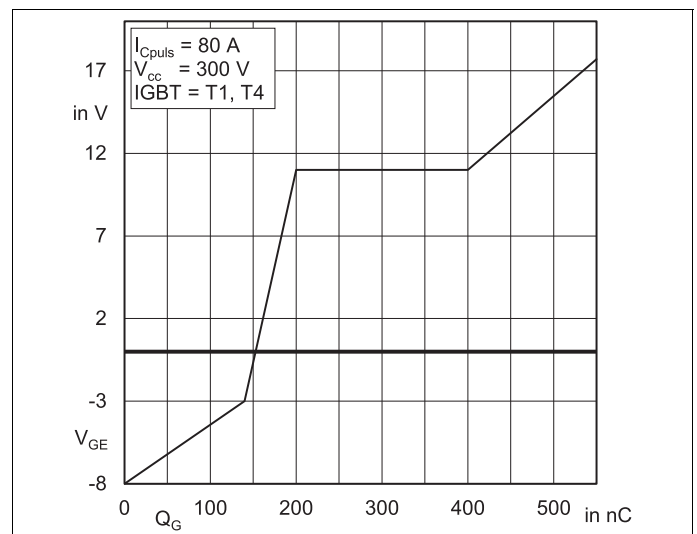


Fig. 6: Typ. gate charge characteristic

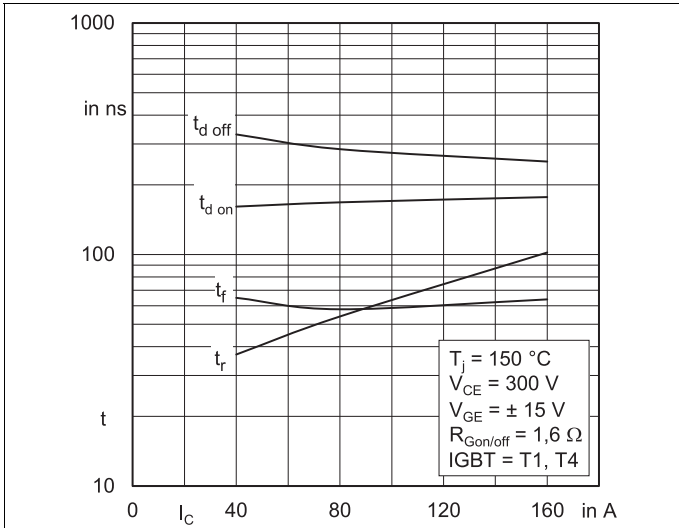


Fig. 7: Typ. switching times vs. I_C

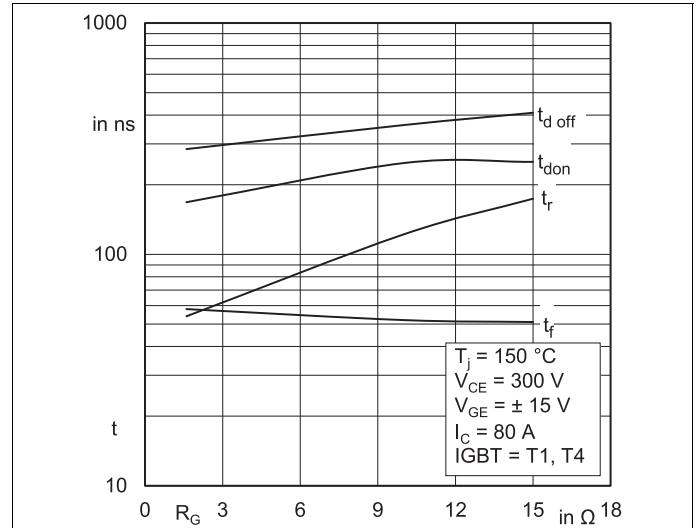


Fig. 8: Typ. switching times vs. gate resistor R_G

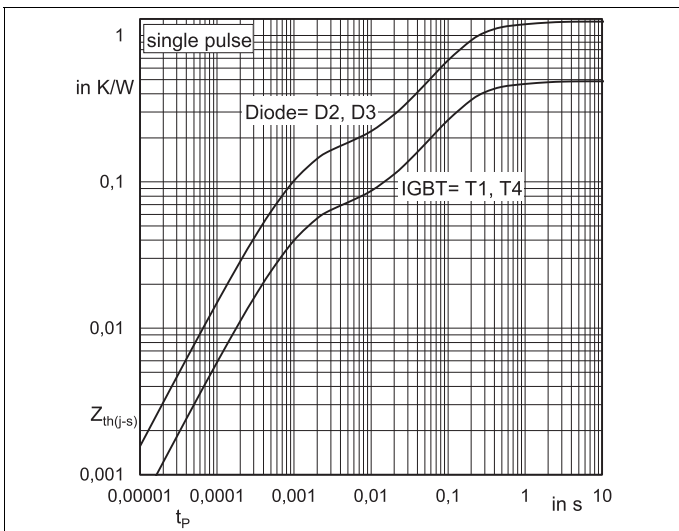


Fig. 9: Transient thermal impedance of IGBT and Diode

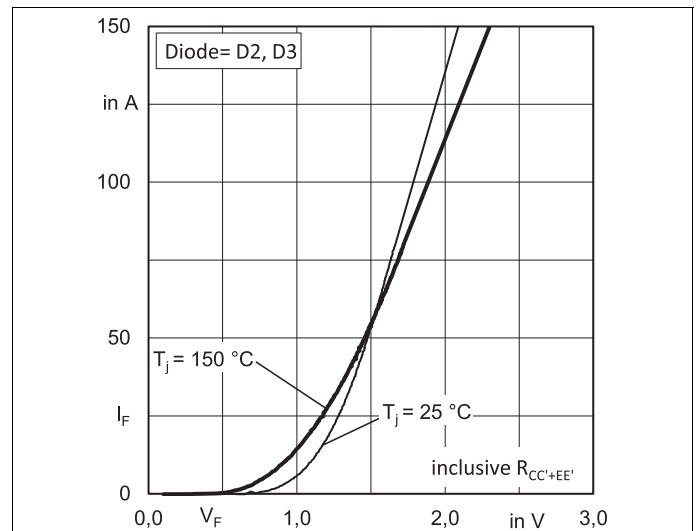


Fig. 10: CAL diode forward characteristic

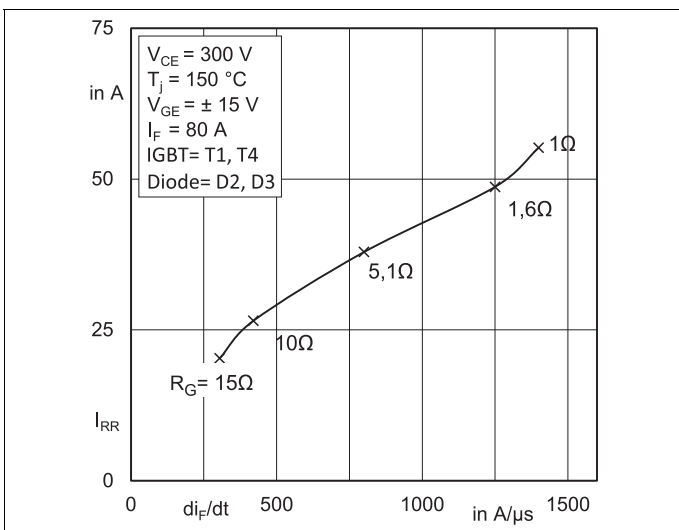


Fig. 11: Typ. CAL diode peak reverse recovery current

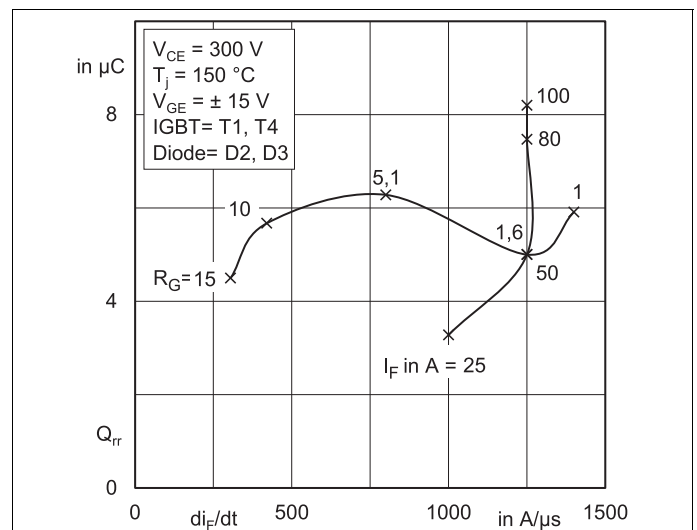


Fig. 12: Typ. CAL diode recovery charge

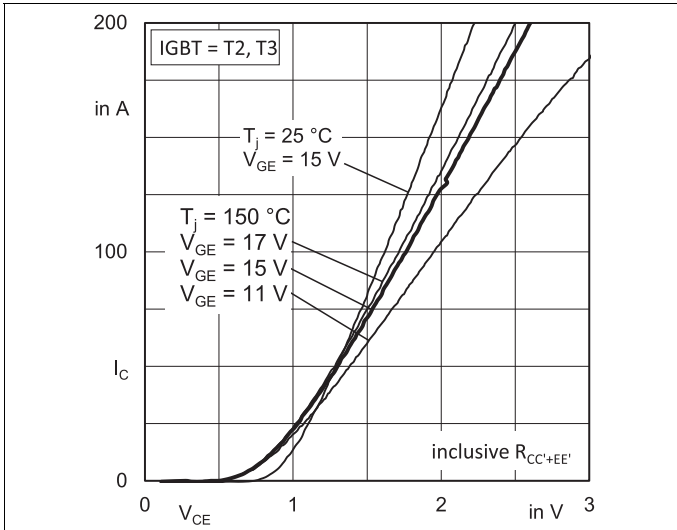


Fig. 13: Typ. output characteristic, inclusive $R_{CC'+EE'}$

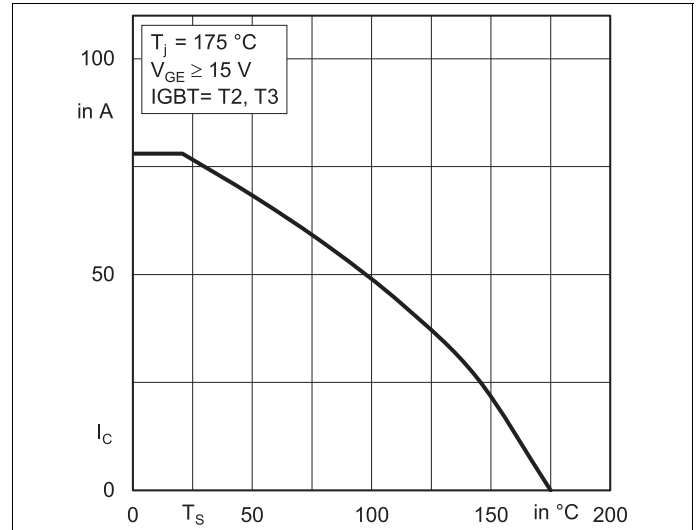


Fig. 14: Rated current vs. temperature $I_C = f(T_S)$

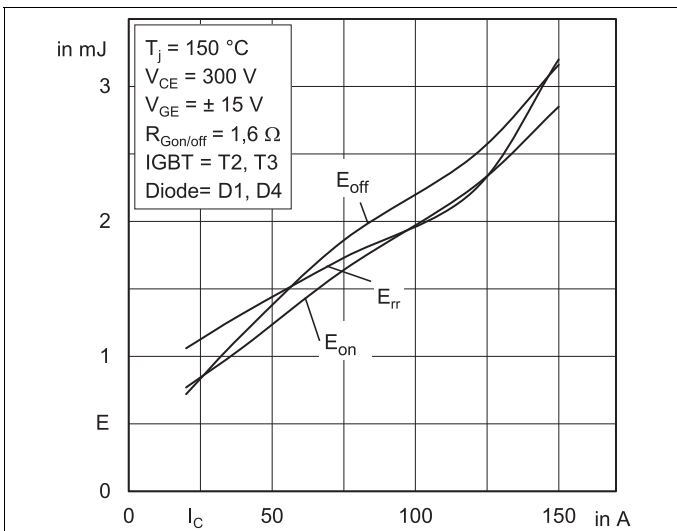


Fig. 15: Typ. turn-on /-off energy = $f(I_C)$

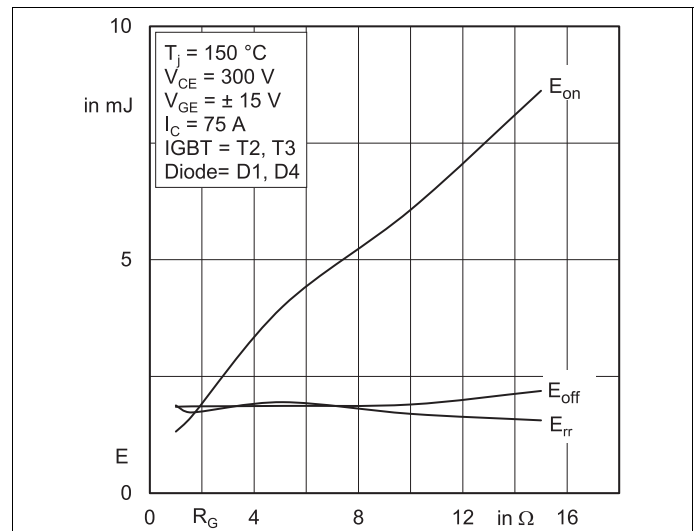


Fig. 16: Typ. turn-on /-off energy = $f(R_G)$

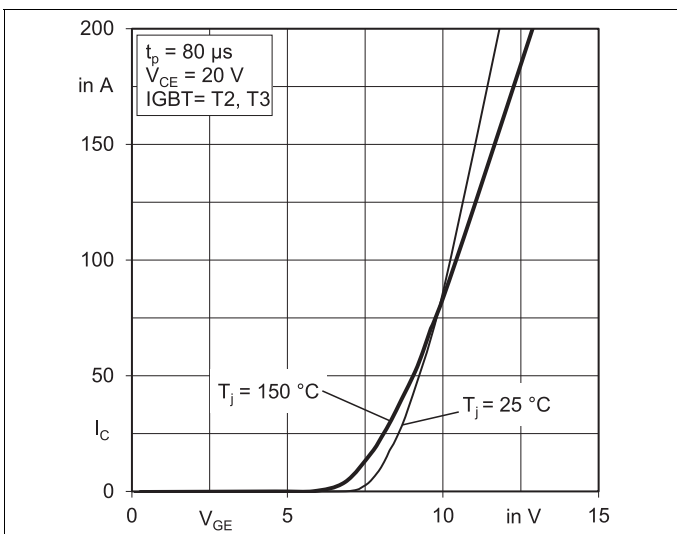


Fig. 17: Typ. transfer characteristic

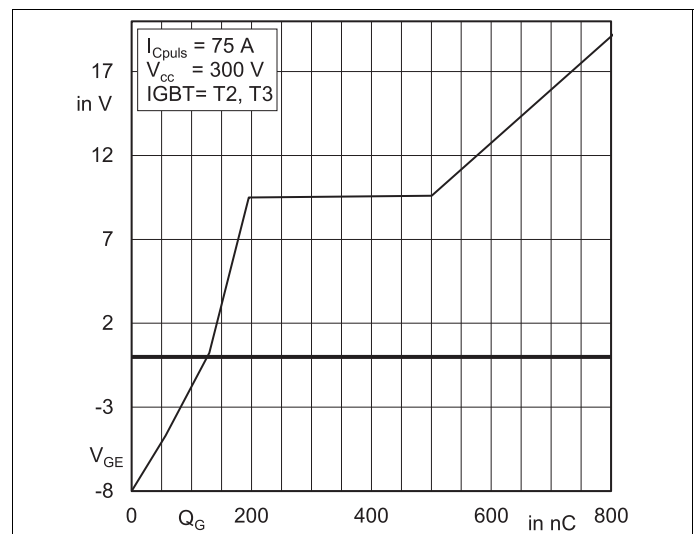


Fig. 18: Typ. gate charge characteristic

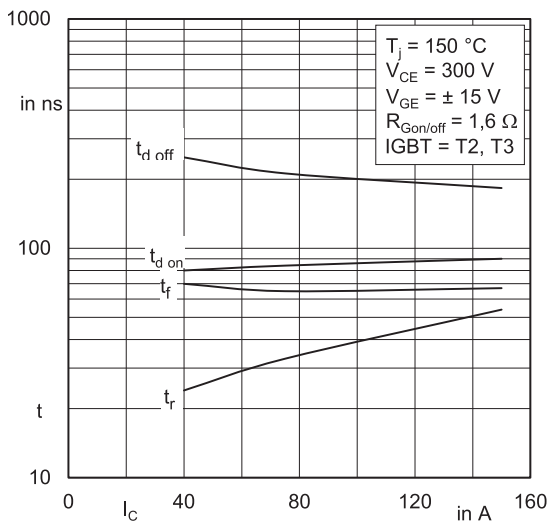


Fig. 19: Typ. switching times vs. I_C

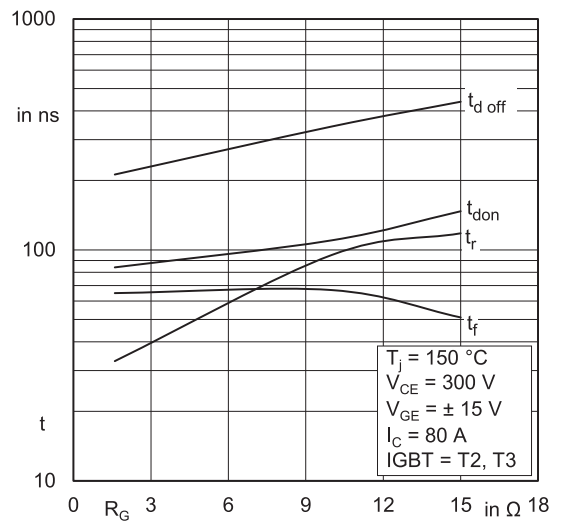


Fig. 20: Typ. switching times vs. gate resistor R_G

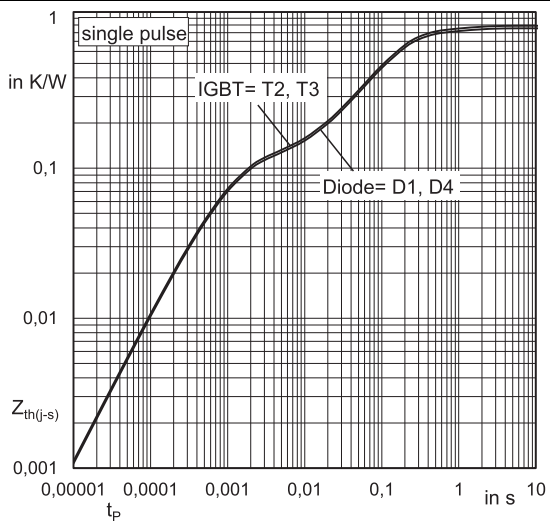


Fig. 21: Transient thermal impedance of IGBT and Diode

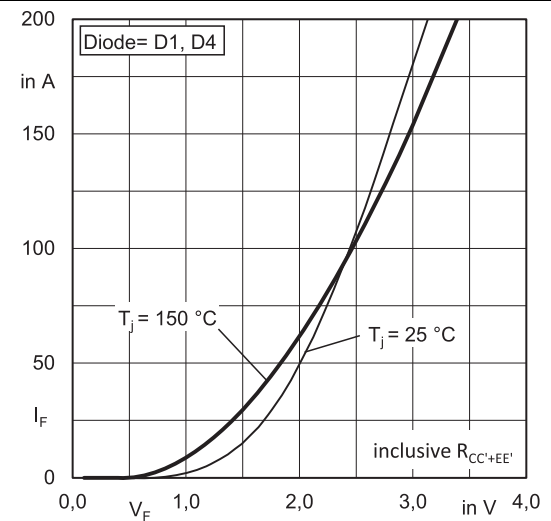


Fig. 22: CAL diode forward characteristic

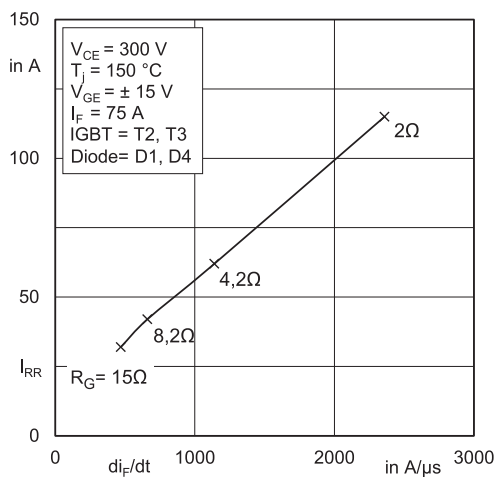


Fig. 23: Typ. CAL diode peak reverse recovery current

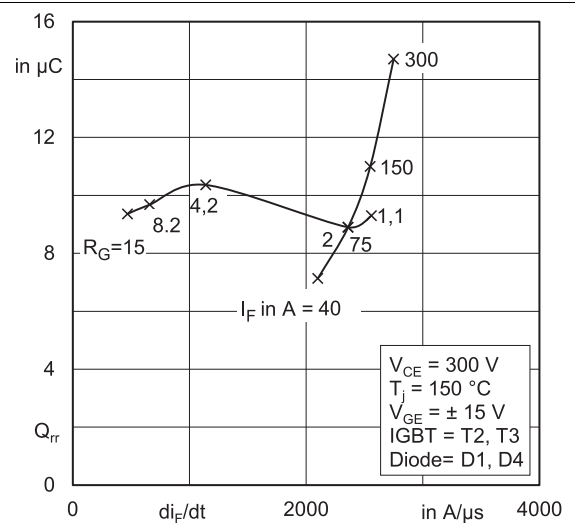


Fig. 24: Typ. CAL diode recovery charge

