

SKiM<sup>®</sup> 4

## Trench IGBT Modules

### SKiM201MLI12E4

#### Features

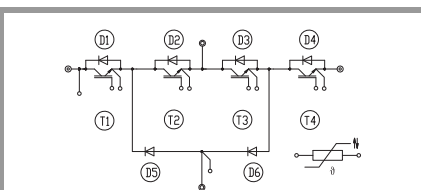
- IGBT 4 Trench Gate Technology
- Solder technology
- $V_{CE(sat)}$  with positive temperature coefficient
- Low inductance case
- Insulated by  $Al_2O_3$  DCB (Direct Copper Bonded) ceramic substrate
- Pressure contact technology for thermal contacts
- Spring contact system to attach driver PCB to the control terminals
- High short circuit capability, self limiting to  $6 \times I_C$
- Integrated temperature sensor

#### Typical Applications

- Automotive inverter
- High reliability AC inverter wind
- High reliability AC inverter drives

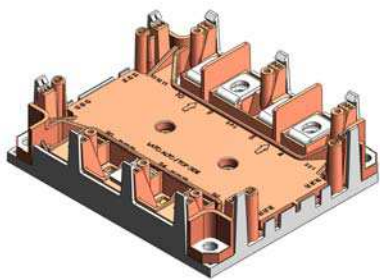
#### Remarks\*

- Case temperature limited to  $T_s = 125^\circ C$  max;  $T_C = T_s$  (for baseplateless modules)
- Recommended  $T_{jop} = -40 \dots +150^\circ C$
- IGBT1 : outer IGBTs T1 & T4
- IGBT2 : inner IGBTs T2 & T3
- Diode1 : outer diodes D1 & D4
- Diode2 : inner diodes D2 & D3
- Diode5 : clamping diodes D5 & D6



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Absolute Maximum Ratings			
Symbol	Conditions	Values	Unit
<b>IGBT1</b>			
$V_{CES}$	$T_j = 25^\circ C$	1200	V
$I_C$	$T_j = 175^\circ C$	$T_s = 25^\circ C$	206
		$T_s = 70^\circ C$	166
$I_{Cnom}$		200	A
$I_{CRM}$	$I_{CRM} = 3 \times I_{Cnom}$	600	A
$V_{GES}$		-20 ... 20	V
$t_{psc}$	$V_{CC} = 800 V, V_{GE} \leq 15 V, T_j = 150^\circ C, V_{CES} \leq 1200 V$	10	$\mu s$
$T_j$		-40 ... 175	$^\circ C$
<b>IGBT2</b>			
$V_{CES}$	$T_j = 25^\circ C$	1200	V
$I_C$	$T_j = 175^\circ C$	$T_s = 25^\circ C$	206
		$T_s = 70^\circ C$	166
$I_{Cnom}$		200	A
$I_{CRM}$	$I_{CRM} = 3 \times I_{Cnom}$	600	A
$V_{GES}$		-20 ... 20	V
$t_{psc}$	$V_{CC} = 800 V, V_{GE} \leq 15 V, T_j = 150^\circ C, V_{CES} \leq 1200 V$	10	$\mu s$
$T_j$		-40 ... 175	$^\circ C$
<b>Diode1</b>			
$V_{RRM}$	$T_j = 25^\circ C$	1200	V
$I_F$	$T_j = 175^\circ C$	$T_s = 25^\circ C$	187
		$T_s = 70^\circ C$	148
$I_{Fnom}$		200	A
$I_{FRM}$	$I_{FRM} = 2 \times I_{Fnom}$	400	A
$I_{FSM}$	10 ms, sin 180°, $T_j = 25^\circ C$	990	A
$T_j$		-40 ... 175	$^\circ C$
<b>Diode2</b>			
$V_{RRM}$	$T_j = 25^\circ C$	1200	V
$I_F$	$T_j = 175^\circ C$	$T_s = 25^\circ C$	187
		$T_s = 70^\circ C$	148
$I_{Fnom}$		200	A
$I_{FRM}$	$I_{FRM} = 2 \times I_{Fnom}$	400	A
$I_{FSM}$	10 ms, sin 180°, $T_j = 25^\circ C$	990	A
$T_j$		-40 ... 175	$^\circ C$
<b>Diode5</b>			
$V_{RRM}$	$T_j = 25^\circ C$	1200	V
$I_F$	$T_j = 175^\circ C$	$T_s = 25^\circ C$	141
		$T_s = 70^\circ C$	111
$I_{Fnom}$		200	A
$I_{FRM}$	$I_{FRM} = 2 \times I_{Fnom}$	400	A
$I_{FSM}$	10 ms, sin 180°, $T_j = 25^\circ C$	990	A
$T_j$		-40 ... 175	$^\circ C$
<b>Module</b>			
$I_{t(RMS)}$		400	A
$T_{stg}$		-40 ... 125	$^\circ C$
$V_{isol}$	AC sinus 50 Hz, t = 1 min	2500	V



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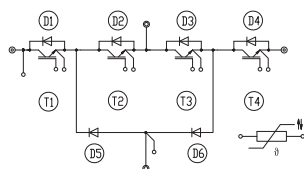
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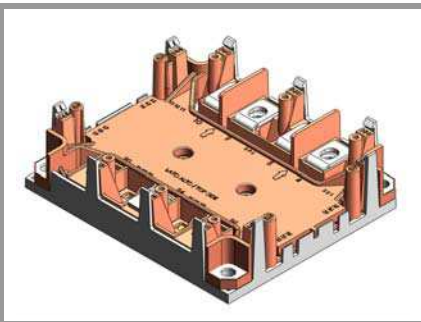
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- IGBT1 : outer IGBTs T1 & T4
- IGBT2 : inner IGBTs T2 & T3
- Diode1 : outer diodes D1 & D4
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- Diode5 : clamping diodes D5 & D6



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## Characteristics

Symbol	Conditions	min.	typ.	max.	Unit
<b>IGBT1</b>					
$V_{CE(sat)}$	$I_C = 200 \text{ A}$ $V_{GE} = 15 \text{ V}$ chipelevel	$T_j = 25^\circ C$	1.80	2.05	V
		$T_j = 150^\circ C$	2.20	2.40	V
$V_{CE0}$	chipelevel	$T_j = 25^\circ C$	0.80	0.90	V
		$T_j = 150^\circ C$	0.70	0.80	V
$r_{CE}$	$V_{GE} = 15 \text{ V}$ chipelevel	$T_j = 25^\circ C$	5.0	5.8	m $\Omega$
		$T_j = 150^\circ C$	7.5	8.0	m $\Omega$
$V_{GE(th)}$	$V_{GE} = V_{CE}, I_C = 7.6 \text{ mA}$	5	5.8	6.5	V
$I_{CES}$	$V_{GE} = 0 \text{ V}, V_{CE} = 1200 \text{ V}, T_j = 25^\circ C$			2.7	mA
$C_{ies}$	$V_{CE} = 25 \text{ V}$ $V_{GE} = 0 \text{ V}$	$f = 1 \text{ MHz}$	12.3		nF
$C_{oes}$		$f = 1 \text{ MHz}$	0.81		nF
$C_{res}$		$f = 1 \text{ MHz}$	0.69		nF
$Q_G$	$V_{GE} = -15 \text{ V} \dots +15 \text{ V}$		1600		nC
$R_{Gint}$	$T_j = 25^\circ C$		3.8		$\Omega$
$t_{d(on)}$	$V_{CE} = 600 \text{ V}$ $I_C = 200 \text{ A}$	$T_j = 150^\circ C$	182		ns
$t_r$	$V_{GE} = +15/-15 \text{ V}$	$T_j = 150^\circ C$	52		ns
$E_{on}$	$R_{G on} = 1.5 \Omega$	$T_j = 150^\circ C$	14.81		mJ
$t_{d(off)}$	$R_{G off} = 1.5 \Omega$	$T_j = 150^\circ C$	446		ns
$t_f$	$di/dt_{on} = 5700 \text{ A}/\mu\text{s}$ $di/dt_{off} = 2600 \text{ A}/\mu\text{s}$	$T_j = 150^\circ C$	98		ns
$E_{off}$		$T_j = 150^\circ C$	22.6		mJ
$R_{th(j-s)}$	per IGBT		0.29		K/W
<b>IGBT2</b>					
$V_{CE(sat)}$	$I_C = 200 \text{ A}$ $V_{GE} = 15 \text{ V}$ chipelevel	$T_j = 25^\circ C$	1.80	2.05	V
		$T_j = 150^\circ C$	2.20	2.40	V
$V_{CE0}$	chipelevel	$T_j = 25^\circ C$	0.80	0.90	V
		$T_j = 150^\circ C$	0.70	0.80	V
$r_{CE}$	$V_{GE} = 15 \text{ V}$ chipelevel	$T_j = 25^\circ C$	5.0	5.8	m $\Omega$
		$T_j = 150^\circ C$	7.5	8.0	m $\Omega$
$V_{GE(th)}$	$V_{GE} = V_{CE}, I_C = 7.6 \text{ mA}$	5	5.8	6.5	V
$I_{CES}$	$V_{GE} = 0 \text{ V}, V_{CE} = 1200 \text{ V}, T_j = 25^\circ C$			2.7	mA
$C_{ies}$	$V_{CE} = 25 \text{ V}$ $V_{GE} = 0 \text{ V}$	$f = 1 \text{ MHz}$	12.3		nF
$C_{oes}$		$f = 1 \text{ MHz}$	0.81		nF
$C_{res}$		$f = 1 \text{ MHz}$	0.69		nF
$Q_G$	$V_{GE} = -15 \text{ V} \dots +15 \text{ V}$		1600		nC
$R_{Gint}$	$T_j = 25^\circ C$		3.8		$\Omega$
$t_{d(on)}$	$V_{CE} = 600 \text{ V}$ $I_C = 200 \text{ A}$	$T_j = 150^\circ C$	184		ns
$t_r$	$V_{GE} = +15/-15 \text{ V}$	$T_j = 150^\circ C$	59		ns
$E_{on}$	$R_{G on} = 1.5 \Omega$	$T_j = 150^\circ C$	7.33		mJ
$t_{d(off)}$	$R_{G off} = 1.5 \Omega$	$T_j = 150^\circ C$	457		ns
$t_f$	$di/dt_{on} = 4960 \text{ A}/\mu\text{s}$ $di/dt_{off} = 1840 \text{ A}/\mu\text{s}$	$T_j = 150^\circ C$	73		ns
$E_{off}$		$T_j = 150^\circ C$	23.87		mJ
$R_{th(j-s)}$	per IGBT		0.29		K/W



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### SKiM201MLI12E4

#### Features

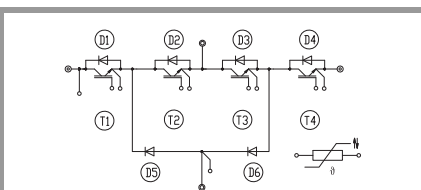
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- Solder technology
- $V_{CE(sat)}$  with positive temperature coefficient
- Low inductance case
- Insulated by Al<sub>2</sub>O<sub>3</sub> DCB (Direct Copper Bonded) ceramic substrate
- Pressure contact technology for thermal contacts
- Spring contact system to attach driver PCB to the control terminals
- High short circuit capability, self limiting to 6 x I<sub>C</sub>
- Integrated temperature sensor

#### Typical Applications

- Automotive inverter
- High reliability AC inverter wind
- High reliability AC inverter drives

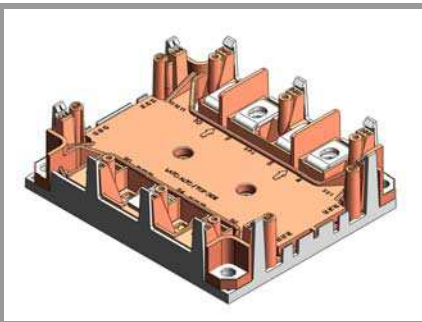
#### Remarks\*

- Case temperature limited to T<sub>s</sub> = 125°C max; T<sub>C</sub> = T<sub>s</sub> (for baseplateless modules)
- Recommended T<sub>jop</sub> = -40 ... +150°C
- IGBT1 : outer IGBTs T1 & T4
- IGBT2 : inner IGBTs T2 & T3
- Diode1 : outer diodes D1 & D4
- Diode2 : inner diodes D2 & D3
- Diode5 : clamping diodes D5 & D6



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Characteristics						
Symbol	Conditions		min.	typ.	max.	Unit
<b>Diode1</b>						
V <sub>F</sub> = V <sub>EC</sub>	I <sub>F</sub> = 200 A	T <sub>j</sub> = 25 °C		2.20	2.52	V
		chipelevel	T <sub>j</sub> = 150 °C	2.15	2.47	V
V <sub>F0</sub>	chipelevel	T <sub>j</sub> = 25 °C		1.30	1.50	V
		T <sub>j</sub> = 150 °C		0.90	1.10	V
r <sub>F</sub>	chipelevel	T <sub>j</sub> = 25 °C		4.5	5.1	mΩ
		T <sub>j</sub> = 150 °C		6.3	6.9	mΩ
I <sub>RRM</sub>	I <sub>F</sub> = 200 A	T <sub>j</sub> = 150 °C		211		A
Q <sub>rr</sub>	di/dt <sub>off</sub> = 5000 A/μs V <sub>R</sub> = 600 V	T <sub>j</sub> = 150 °C		36.47		μC
E <sub>rr</sub>	V <sub>GE</sub> = +15/-15 V	T <sub>j</sub> = 150 °C		14.53		mJ
R <sub>th(j-s)</sub>				0.36		K/W
<b>Diode2</b>						
V <sub>F</sub> = V <sub>EC</sub>	I <sub>F</sub> = 200 A	T <sub>j</sub> = 25 °C		2.20	2.52	V
		chipelevel	T <sub>j</sub> = 150 °C	2.15	2.47	V
V <sub>F0</sub>	chipelevel	T <sub>j</sub> = 25 °C		1.30	1.50	V
		T <sub>j</sub> = 150 °C		0.90	1.10	V
r <sub>F</sub>	chipelevel	T <sub>j</sub> = 25 °C		4.5	5.1	mΩ
		T <sub>j</sub> = 150 °C		6.3	6.9	mΩ
I <sub>RRM</sub>	I <sub>F</sub> = 200 A	T <sub>j</sub> = 150 °C		212		A
Q <sub>rr</sub>	di/dt <sub>off</sub> = 5000 A/μs V <sub>R</sub> = 600 V	T <sub>j</sub> = 150 °C		36.47		μC
E <sub>rr</sub>	V <sub>GE</sub> = +15/-15 V	T <sub>j</sub> = 150 °C		-		mJ
R <sub>th(j-s)</sub>				0.36		K/W
<b>Diode5</b>						
V <sub>F</sub> = V <sub>EC</sub>	I <sub>F</sub> = 200 A	T <sub>j</sub> = 25 °C		2.20	2.52	V
		chipelevel	T <sub>j</sub> = 150 °C	2.15	2.47	V
V <sub>F0</sub>	chipelevel	T <sub>j</sub> = 25 °C		1.30	1.50	V
		T <sub>j</sub> = 150 °C		0.90	1.10	V
r <sub>F</sub>	chipelevel	T <sub>j</sub> = 25 °C		4.5	5.1	mΩ
		T <sub>j</sub> = 150 °C		6.3	6.9	mΩ
I <sub>RRM</sub>	I <sub>F</sub> = 200 A	T <sub>j</sub> = 150 °C		212		A
Q <sub>rr</sub>	di/dt <sub>off</sub> = 5700 A/μs V <sub>R</sub> = 600 V	T <sub>j</sub> = 150 °C		34.87		μC
E <sub>rr</sub>	V <sub>GE</sub> = +15/-15 V	T <sub>j</sub> = 150 °C		15.79		mJ
R <sub>th(j-s)</sub>				0.55		K/W



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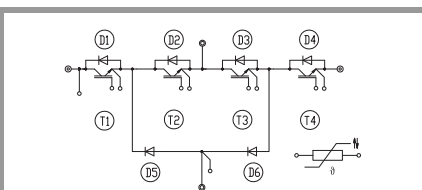
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Characteristics						
Symbol	Conditions		min.	typ.	max.	Unit
<b>Module</b>						
$L_{sCE1}$				25		nH
$L_{sCE2}$				32		nH
$R_{CC'+EE'}$	measured between terminal 4 and 24	$T_s = 25^\circ\text{C}$		0.4		m $\Omega$
		$T_s = 125^\circ\text{C}$		0.6		m $\Omega$
$M_s$	to heat sink M5		2		3	Nm
$M_t$	to terminals M6		4		5	Nm
$w$				317		g
<b>Temperature Sensor</b>						
$R_{100}$	$T_c=100^\circ\text{C}$ ( $R_{25}=5\text{ k}\Omega$ )			$493 \pm 5\%$		$\Omega$
$B_{100/125}$	$R(T)=R_{100}\exp[B_{100/125}(1/T-1/T_{100})]$ ; T[K];			$3550 \pm 2\%$		K

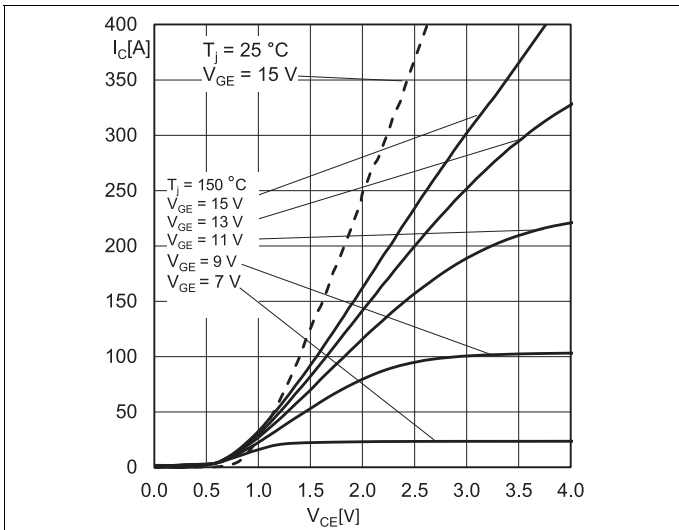


Fig. 1: Typ. IGBT1 output characteristic, incl.  $R_{CC'+EE'}$

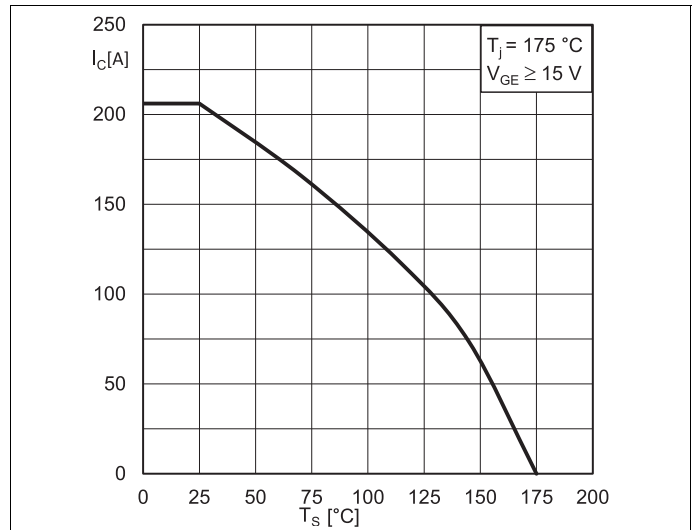


Fig. 2: IGBT1 rated current vs. Temperature  $I_C=f(T_s)$

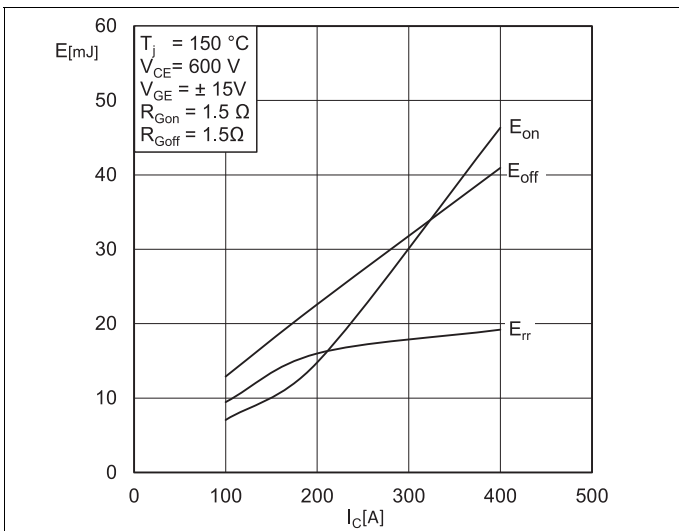


Fig. 3: Typ. IGBT1 & Diode5 turn-on /-off energy =  $f(I_C)$

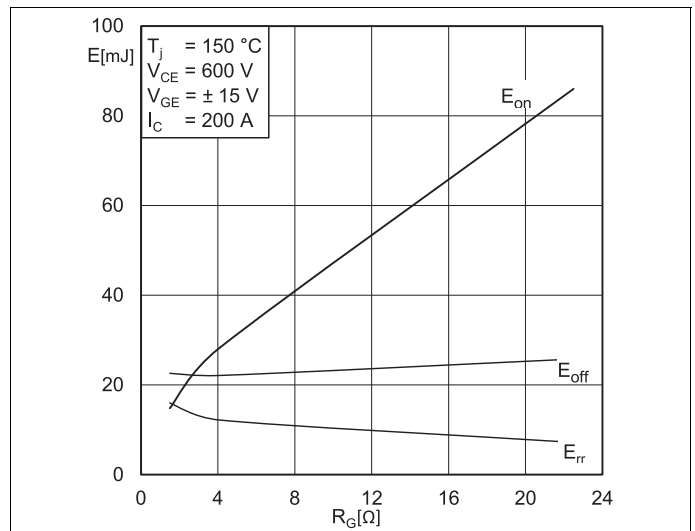


Fig. 4: Typ. IGBT1 & Diode5 turn-on /-off energy =  $f(R_G)$

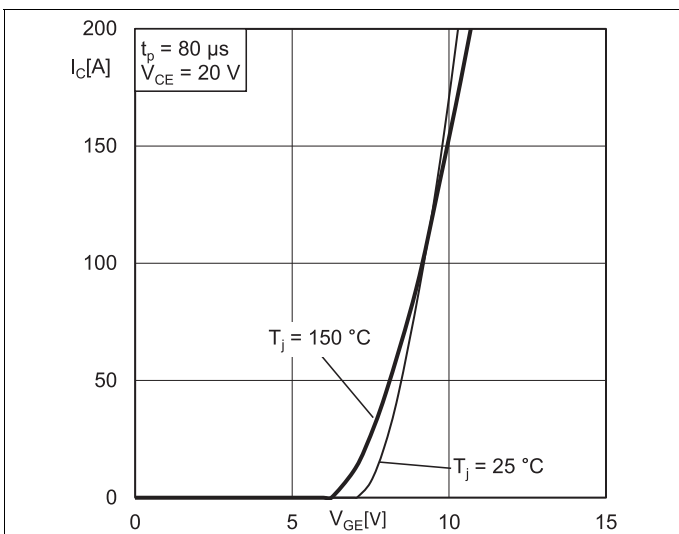


Fig. 5: Typ. IGBT1 transfer characteristic

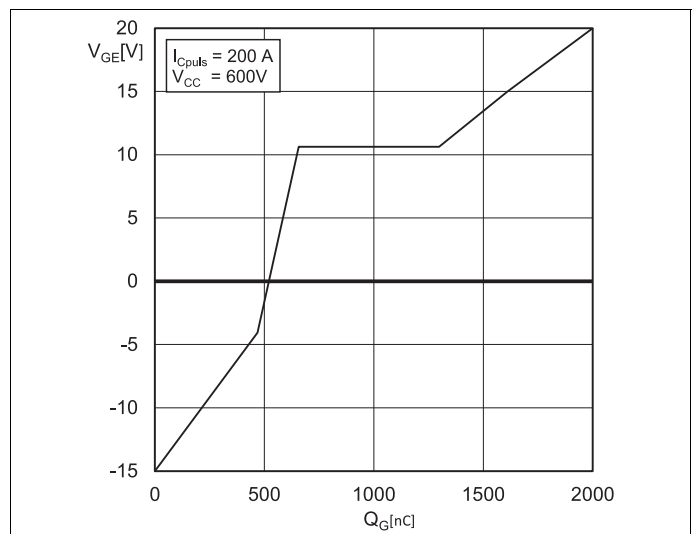


Fig. 6: Typ. IGBT1 gate charge characteristic

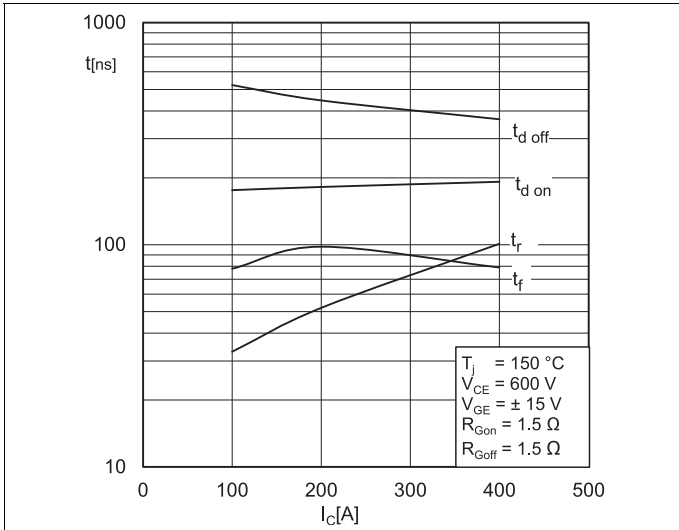


Fig. 7: Typ. IGBT1 switching times vs.  $I_c$

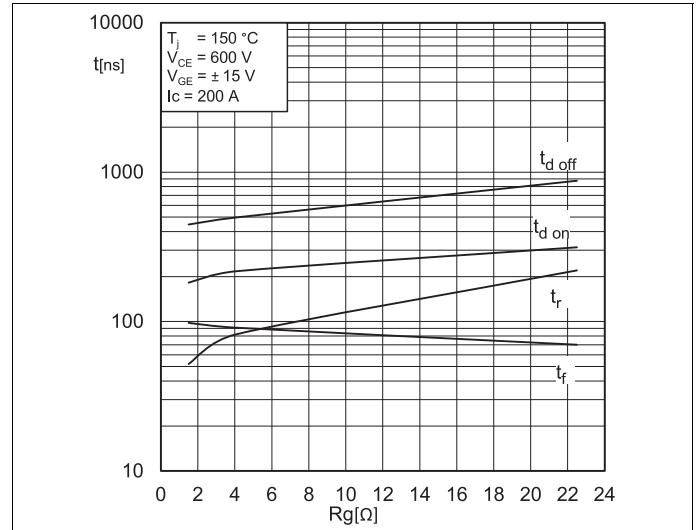


Fig. 8: Typ. IGBT1 switching times vs. gate resistor  $R_G$

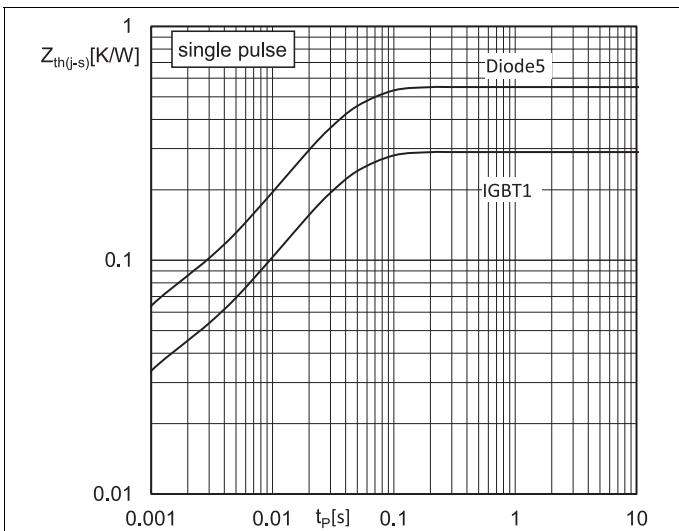


Fig. 9: Transient thermal impedance of IGBT1 & Diode5

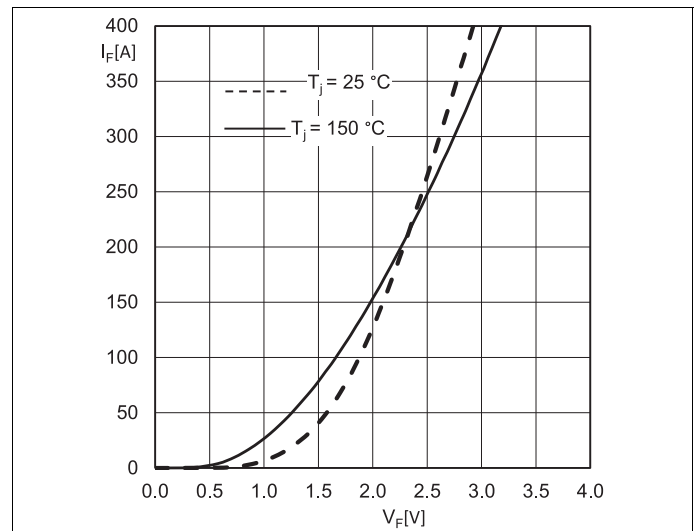


Fig. 10: Typ. Diode5 forward characteristic, incl.  $R_{CC+EE'}$

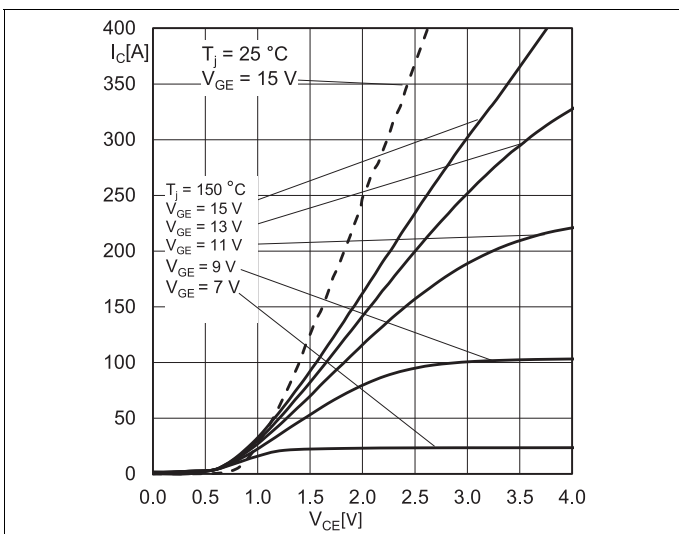


Fig. 13: Typ. IGBT2 output characteristic, incl.  $R_{CC+EE'}$

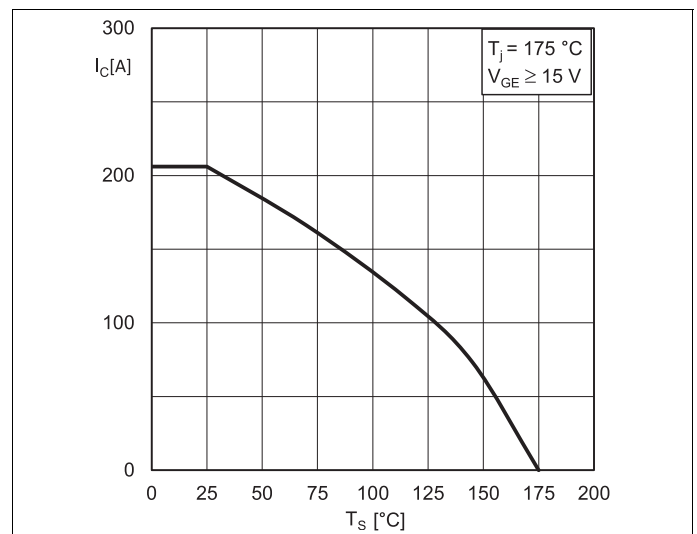


Fig. 14: IGBT2 Rated current vs. Temperature  $I_c = f(T_s)$

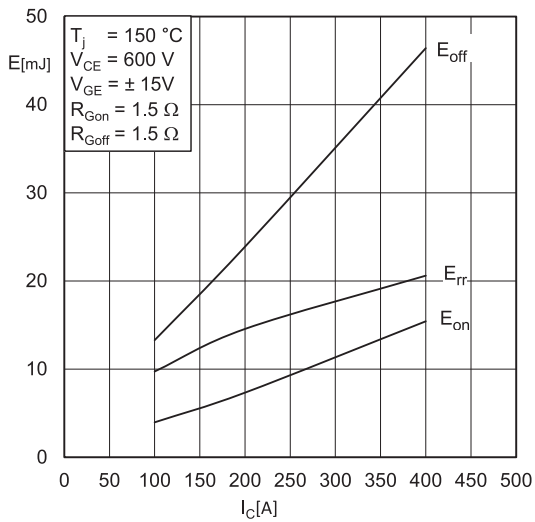


Fig. 15: Typ. IGBT2 & Diode1 turn-on /-off energy =  $f(I_c)$

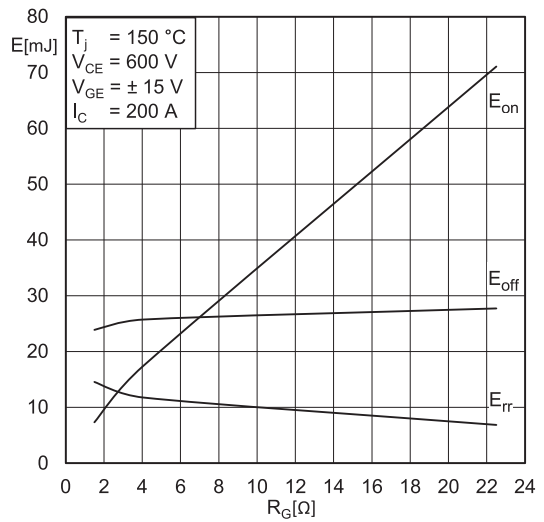


Fig. 16: Typ. IGBT2 & Diode1 turn-on / -off energy =  $f(R_G)$

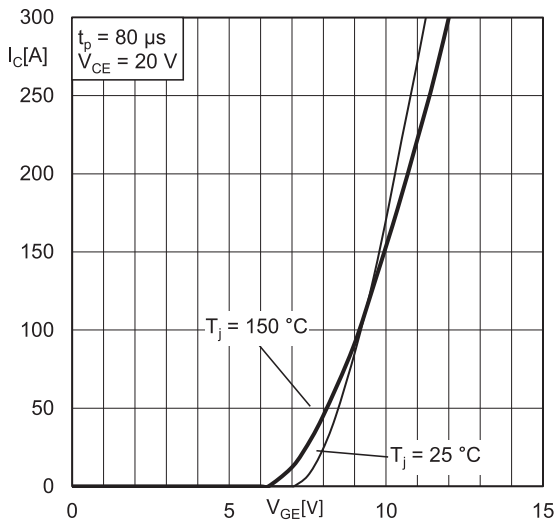


Fig. 17: Typ. IGBT2 transfer characteristic

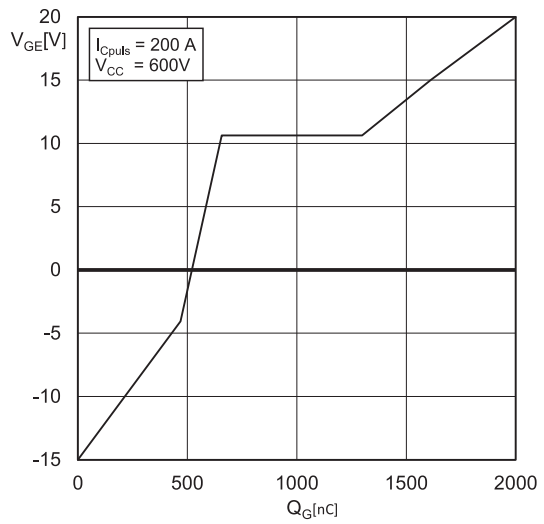


Fig. 18: Typ. IGBT2 gate charge characteristic

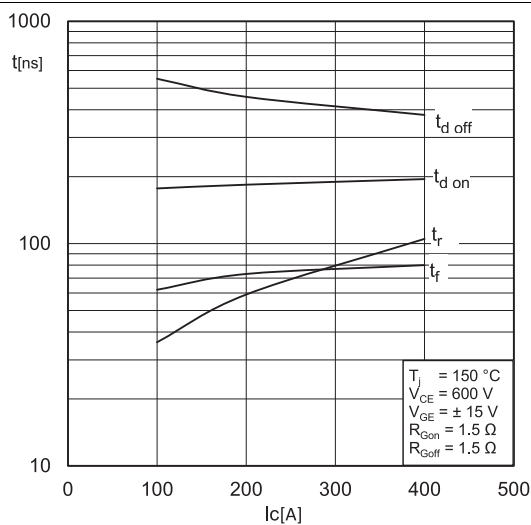


Fig. 19: Typ. IGBT2 switching times vs.  $I_c$

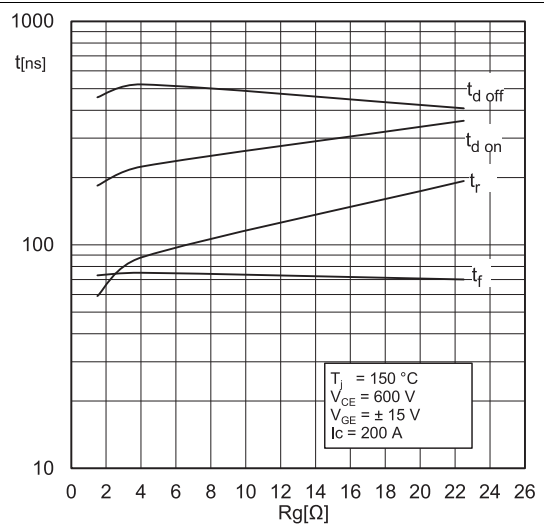


Fig. 20: Typ. IGBT2 switching times vs. gate resistor  $R_G$

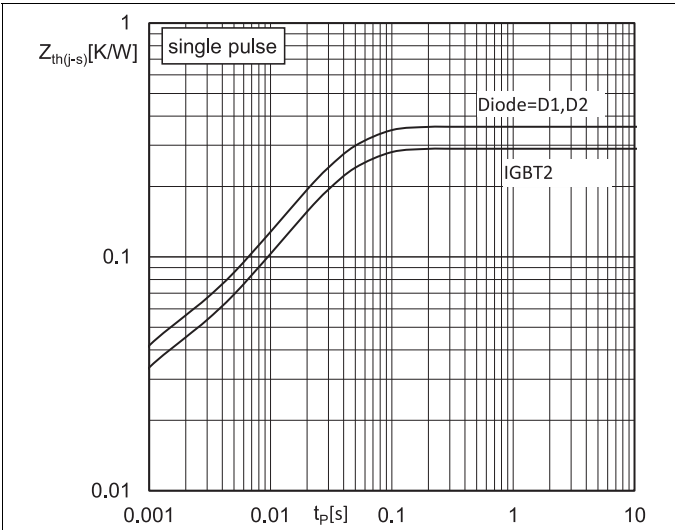


Fig. 21: Transient thermal impedance of IGBT2, Diode1 & Diode2

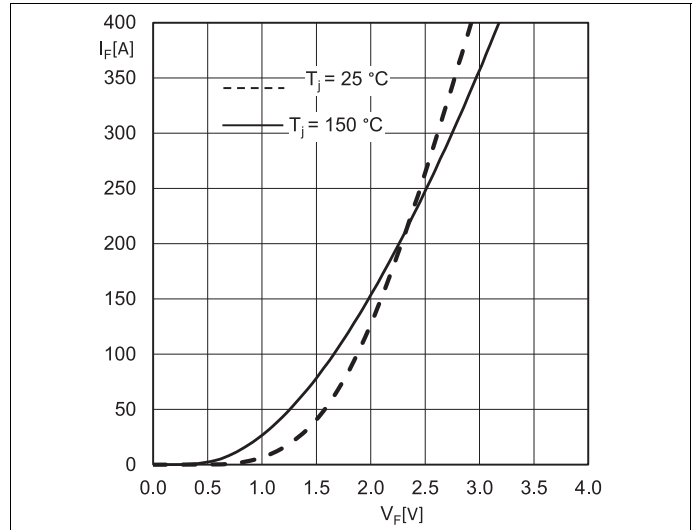
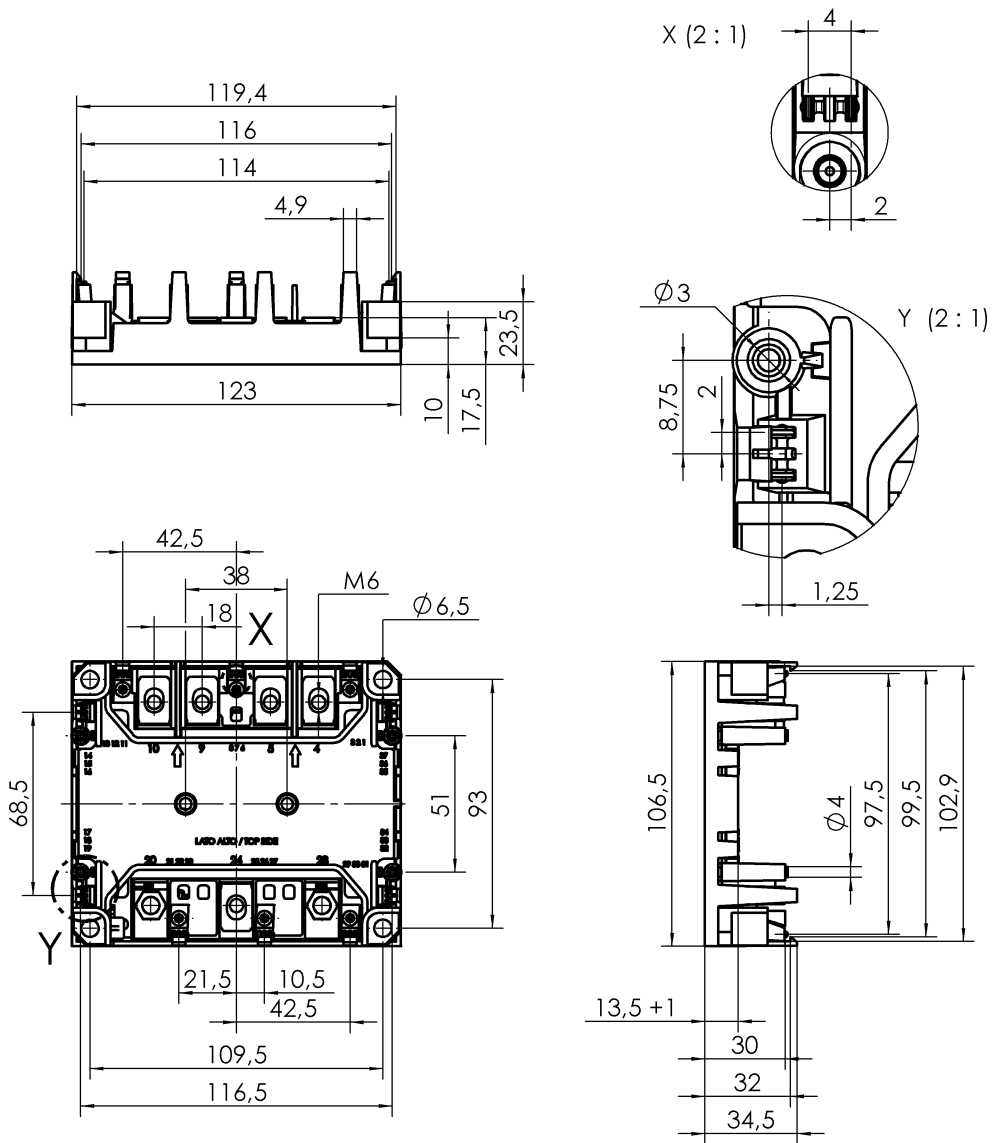
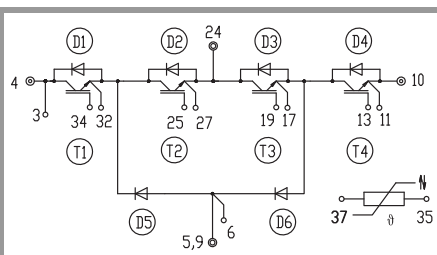


Fig. 22: Typ. Diode1 & Diode2 forward characteristic, incl.  $R_{CC'+EE'}$

# SKiM201MLI12E4



SKiM 4



MLI

This is an electrostatic discharge sensitive device (ESDS), international standard IEC 60747-1, chapter IX.

## **\*IMPORTANT INFORMATION AND WARNINGS**

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