

Highly insulated module with Trench/Fieldstop IGBT3 and emitter controlled 3 diode

Features

- Electrical features
 - $V_{CES} = 4500\text{ V}$
 - $I_{C\text{ nom}} = 1000\text{ A} / I_{CRM} = 2000\text{ A}$
 - High DC stability
 - High dynamic robustness
 - High short-circuit capability
 - Low $V_{CE,sat}$
 - Trench IGBT 3
 - $V_{CE,sat}$ with positive temperature coefficient
- Mechanical features
 - ALSiC base plate for increased thermal cycling capability
 - High creepage and clearance distances
 - Isolated base plate
 - Package with CTI > 600
 - Package with enhanced insulation of 10.4 kV AC 60 s



Potential applications

- Motor drives
- Traction drives
- Multi-level inverter
- High-power converters
- Medium-voltage converters

Product validation

- Qualified for industrial applications according to the relevant tests of IEC 60747, 60749 and 60068

Description

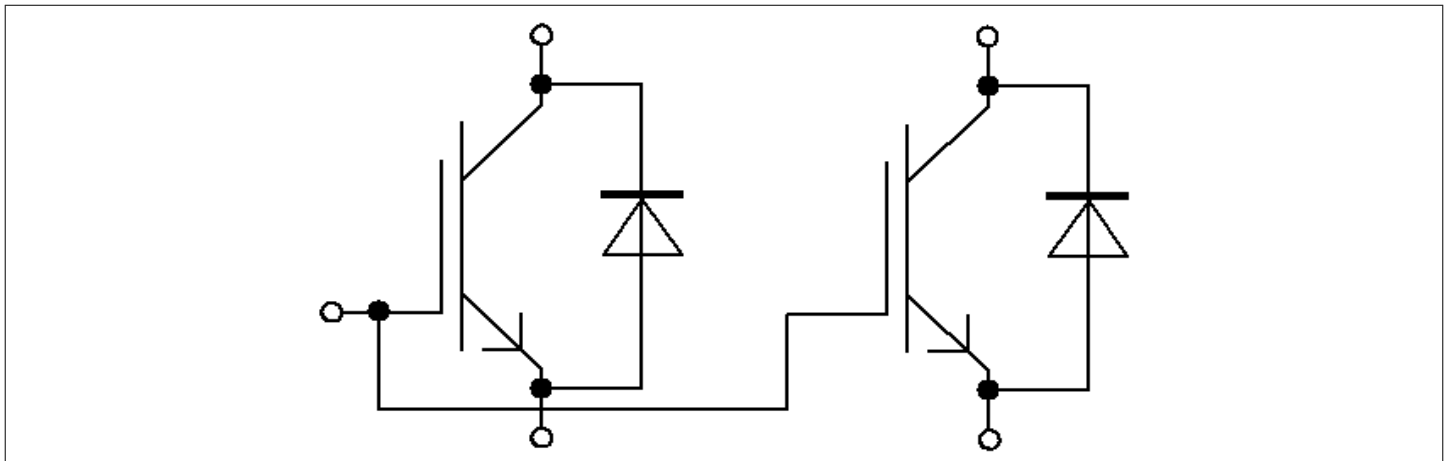


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1 Package

Table 1 Insulation coordination

| Parameter | Symbol | Note or test condition | Values | Unit |
|--------------------------------------|-------------|--|--------|------|
| Isolation test voltage | V_{ISOL} | RMS, $f = 50 \text{ Hz}$, $t = 60 \text{ s}$ | 10.4 | kV |
| Partial discharge extinction voltage | V_{isol} | RMS, $f = 50 \text{ Hz}$, $Q_{PD} \leq 10 \text{ pC}$ | 3.5 | kV |
| DC stability | $V_{CE(D)}$ | $T_{vj}=25^{\circ}\text{C}$, 100 Fit | 3000 | V |
| Material of module baseplate | | | AlSiC | |
| Internal isolation | | basic insulation (class 1, IEC 61140) | AlN | |
| Creepage distance | d_{Creep} | terminal to heatsink | 64.0 | mm |
| Creepage distance | d_{Creep} | terminal to terminal | 56.0 | mm |
| Clearance | d_{Clear} | terminal to heatsink | 40.0 | mm |
| Clearance | d_{Clear} | terminal to terminal | 26.0 | mm |
| Comparative tracking index | CTI | | > 600 | |

Table 2 Characteristic values

| Parameter | Symbol | Note or test condition | Values | | | Unit | |
|--|---------------|--|-----------|------|------|------|----|
| | | | Min. | Typ. | Max. | | |
| Stray inductance module | L_{sCE} | | | 20 | | nH | |
| Module lead resistance, terminals - chip | $R_{CC'+EE'}$ | $T_C=25^{\circ}\text{C}$, per switch | | 0.18 | | mΩ | |
| Storage temperature | T_{stg} | | -55 | | 125 | °C | |
| Mounting torque for module mounting | M | - Mounting according to valid application note | M6, Screw | 4.25 | | 5.75 | Nm |
| Terminal connection torque | M | - Mounting according to valid application note | M4, Screw | 1.8 | | 2.1 | Nm |
| | | | M8, Screw | 8 | | 10 | |
| Weight | G | | | 1000 | | g | |

Note: The maximum allowed dv/dt measured between 0,6 and $1 \times V_{ce}$ is $1400\text{V}/\mu\text{s}$.

2 IGBT, Inverter

Table 3 Maximum rated values

| Parameter | Symbol | Note or test condition | Values | Unit |
|---------------------------|-----------|--------------------------------|--------|------|
| Collector-emitter voltage | V_{CES} | $T_{vj} = -40^{\circ}\text{C}$ | 4500 | V |
| | | $T_{vj} = 25^{\circ}\text{C}$ | 4500 | |
| | | $T_{vj} = 125^{\circ}\text{C}$ | 4500 | |

(table continues...)
 Datasheet

Table 3 (continued) Maximum rated values

| Parameter | Symbol | Note or test condition | Values | Unit |
|-----------------------------------|-----------|---|----------|------|
| Continuous DC collector current | I_{CDC} | $T_{vj\ max} = 150\ ^\circ\text{C}$ $T_C = 80\ ^\circ\text{C}$ | 1000 | A |
| Repetitive peak collector current | I_{CRM} | t_p limited by $T_{vj\ op}$ | 2000 | A |
| Gate-emitter peak voltage | V_{GES} | | ± 20 | V |

Table 4 Characteristic values

| Parameter | Symbol | Note or test condition | Values | | | Unit |
|--------------------------------------|---------------|--|--------------------------------|-------|------|---------------|
| | | | Min. | Typ. | Max. | |
| Collector-emitter saturation voltage | $V_{CE\ sat}$ | $I_C = 1000\ \text{A}, V_{GE} = 15\ \text{V}$ | $T_{vj} = 25\ ^\circ\text{C}$ | 2.70 | 3.05 | V |
| | | | $T_{vj} = 125\ ^\circ\text{C}$ | 3.25 | 3.85 | |
| Gate threshold voltage | V_{GETh} | $I_C = 70.5\ \text{mA}, V_{CE} = V_{GE}, T_{vj} = 25\ ^\circ\text{C}$ | 5.40 | 6 | 6.60 | V |
| Gate charge | Q_G | $V_{GE} = \pm 15\ \text{V}, V_{CC} = 2800\ \text{V}$ | | 26.5 | | μC |
| Internal gate resistor | R_{Gint} | $T_{vj} = 25\ ^\circ\text{C}$ | | 1.1 | | Ω |
| Input capacitance | C_{ies} | $f = 1000\ \text{kHz}, T_{vj} = 25\ ^\circ\text{C}, V_{CE} = 25\ \text{V}, V_{GE} = 0\ \text{V}$ | | 185 | | nF |
| Reverse transfer capacitance | C_{res} | $f = 1000\ \text{kHz}, T_{vj} = 25\ ^\circ\text{C}, V_{CE} = 25\ \text{V}, V_{GE} = 0\ \text{V}$ | | 3.1 | | nF |
| Collector-emitter cut-off current | I_{CES} | $V_{CE} = 4500\ \text{V}, V_{GE} = 0\ \text{V}$ $T_{vj} = 25\ ^\circ\text{C}$ | | | 5 | mA |
| Gate-emitter leakage current | I_{GES} | $V_{CE} = 0\ \text{V}, V_{GE} = 20\ \text{V}, T_{vj} = 25\ ^\circ\text{C}$ | | | 400 | nA |
| Turn-on delay time (inductive load) | t_{don} | $I_C = 1000\ \text{A}, V_{CC} = 2800\ \text{V}, V_{GE} = \pm 15\ \text{V}, R_{Gon} = 1\ \Omega$ | $T_{vj} = 25\ ^\circ\text{C}$ | 0.910 | | μs |
| | | | $T_{vj} = 125\ ^\circ\text{C}$ | 0.960 | | |
| Rise time (inductive load) | t_r | $I_C = 1000\ \text{A}, V_{CC} = 2800\ \text{V}, V_{GE} = \pm 15\ \text{V}, R_{Gon} = 1\ \Omega$ | $T_{vj} = 25\ ^\circ\text{C}$ | 0.210 | | μs |
| | | | $T_{vj} = 125\ ^\circ\text{C}$ | 0.230 | | |
| Turn-off delay time (inductive load) | t_{doff} | $I_C = 1000\ \text{A}, V_{CC} = 2800\ \text{V}, V_{GE} = \pm 15\ \text{V}, R_{Goff} = 9.1\ \Omega$ | $T_{vj} = 25\ ^\circ\text{C}$ | 7.150 | | μs |
| | | | $T_{vj} = 125\ ^\circ\text{C}$ | 7.530 | | |
| Fall time (inductive load) | t_f | $I_C = 1000\ \text{A}, V_{CC} = 2800\ \text{V}, V_{GE} = \pm 15\ \text{V}, R_{Goff} = 9.1\ \Omega$ | $T_{vj} = 25\ ^\circ\text{C}$ | 1.100 | | μs |
| | | | $T_{vj} = 125\ ^\circ\text{C}$ | 2.120 | | |
| Turn-on time (resistive load) | t_{on_R} | $I_C = 500\ \text{A}, V_{CC} = 2000\ \text{V}, V_{GE} = \pm 15\ \text{V}, R_{Gon} = 1\ \Omega$ | 1.80 | | | μs |
| Turn-on energy loss per pulse | E_{on} | $I_C = 1000\ \text{A}, V_{CC} = 2800\ \text{V}, L_\sigma = 95\ \text{nH}, V_{GE} = \pm 15\ \text{V}, R_{Gon} = 1\ \Omega, di/dt = 3500\ \text{A}/\mu\text{s} (T_{vj} = 125\ ^\circ\text{C})$ | $T_{vj} = 25\ ^\circ\text{C}$ | 3700 | | mJ |
| | | | $T_{vj} = 125\ ^\circ\text{C}$ | 5400 | | |

(table continues...)

Table 4 (continued) Characteristic values

| Parameter | Symbol | Note or test condition | Values | | | Unit |
|--|------------|---|---|------|------|------------------|
| | | | Min. | Typ. | Max. | |
| Turn-off energy loss per pulse | E_{off} | $I_C = 1000\text{ A}$, $V_{CC} = 2800\text{ V}$, $L_\sigma = 95\text{ nH}$, $V_{GE} = \pm 15\text{ V}$, $R_{Goff} = 9.1\ \Omega$, $dv/dt = 1300\text{ V}/\mu\text{s}$ ($T_{vj} = 125\text{ }^\circ\text{C}$) | $T_{vj} = 25\text{ }^\circ\text{C}$ | 3800 | | mJ |
| | | | $T_{vj} = 125\text{ }^\circ\text{C}$ | 5000 | | |
| SC data | I_{SC} | $V_{GE} \leq 15\text{ V}$, $V_{CC} = 2800\text{ V}$, $V_{CEmax} = V_{CES} - L_{sCE} \cdot di/dt$ | $t_p \leq 10\ \mu\text{s}$, $T_{vj} \leq 125\text{ }^\circ\text{C}$ | 4600 | | A |
| Thermal resistance, junction to case | R_{thJC} | per IGBT | | | 11.1 | K/kW |
| Thermal resistance, case to heat sink | R_{thCH} | per IGBT, $\lambda_{grease} = 1\text{ W}/(\text{m}\cdot\text{K})$ | | 13.5 | | K/kW |
| Temperature under switching conditions | T_{vjop} | | -50 | | 125 | $^\circ\text{C}$ |

3 Diode, Inverter

Table 5 Maximum rated values

| Parameter | Symbol | Note or test condition | Values | Unit | |
|---------------------------------|-------------|---|--------------------------------------|---------------|-----------------------|
| Repetitive peak reverse voltage | V_{RRM} | | $T_{vj} = -40\text{ }^\circ\text{C}$ | 4500 | V |
| | | | $T_{vj} = 25\text{ }^\circ\text{C}$ | 4500 | |
| | | | $T_{vj} = 125\text{ }^\circ\text{C}$ | 4500 | |
| Continuous DC forward current | I_F | | 1000 | A | |
| Repetitive peak forward current | I_{FRM} | $t_p = 1\text{ ms}$ | 2000 | A | |
| I^2t - value | I^2t | $t_p = 10\text{ ms}$, $V_R = 0\text{ V}$ | $T_{vj} = 125\text{ }^\circ\text{C}$ | 255 | kA^2s |
| Maximum power dissipation | P_{RQM} | | $T_{vj} = 125\text{ }^\circ\text{C}$ | 1600 | kW |
| Minimum turn-on time | t_{onmin} | | 10 | μs | |

Table 6 Characteristic values

| Parameter | Symbol | Note or test condition | Values | | | Unit |
|-------------------------------|----------|---|--------------------------------------|------|------|------|
| | | | Min. | Typ. | Max. | |
| Forward voltage | V_F | $I_F = 1000\text{ A}$, $V_{GE} = 0\text{ V}$ | $T_{vj} = 25\text{ }^\circ\text{C}$ | 2.80 | 3.40 | V |
| | | | $T_{vj} = 125\text{ }^\circ\text{C}$ | 2.70 | 3.20 | |
| Peak reverse recovery current | I_{RM} | $V_{CC} = 2800\text{ V}$, $I_F = 1000\text{ A}$, $V_{GE} = -15\text{ V}$, $-di_F/dt = 3500\text{ A}/\mu\text{s}$ ($T_{vj} = 125\text{ }^\circ\text{C}$) | $T_{vj} = 25\text{ }^\circ\text{C}$ | 1030 | | A |
| | | | $T_{vj} = 125\text{ }^\circ\text{C}$ | 1100 | | |

(table continues...)

Table 6 (continued) **Characteristic values**

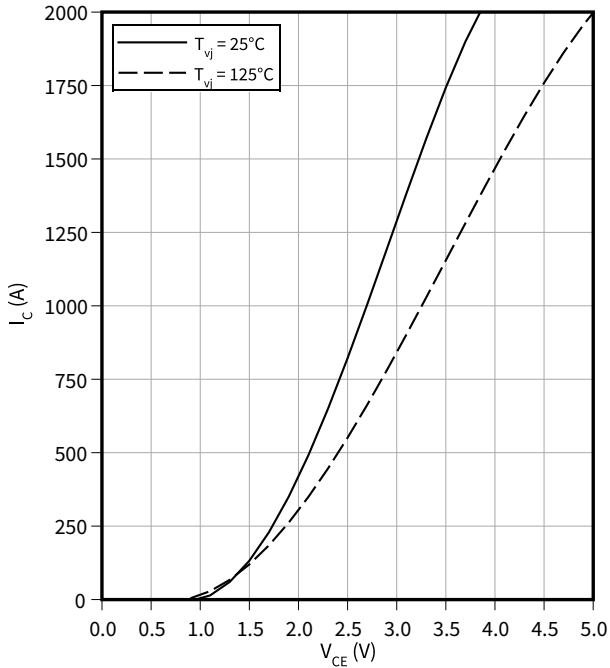
| Parameter | Symbol | Note or test condition | Values | | | Unit | |
|--|------------|---|---------------------------------------|------|------|------------------|---------------|
| | | | Min. | Typ. | Max. | | |
| Recovered charge | Q_r | $V_{CC} = 2800 \text{ V}$, $I_F = 1000 \text{ A}$, $V_{GE} = -15 \text{ V}$, $-di_F/dt =$ $3500 \text{ A}/\mu\text{s}$ ($T_{vj} = 125 \text{ }^\circ\text{C}$) | $T_{vj} = 25 \text{ }^\circ\text{C}$ | | 860 | | μC |
| | | | $T_{vj} = 125 \text{ }^\circ\text{C}$ | | 1700 | | |
| Reverse recovery energy | E_{rec} | $V_{CC} = 2800 \text{ V}$, $I_F = 1000 \text{ A}$, $V_{GE} = -15 \text{ V}$, $-di_F/dt =$ $3500 \text{ A}/\mu\text{s}$ ($T_{vj} = 125 \text{ }^\circ\text{C}$) | $T_{vj} = 25 \text{ }^\circ\text{C}$ | | 1300 | | mJ |
| | | | $T_{vj} = 125 \text{ }^\circ\text{C}$ | | 2800 | | |
| Thermal resistance, junction to case | R_{thJC} | per diode | | | 25.5 | K/kW | |
| Thermal resistance, case to heat sink | R_{thCH} | per diode, $\lambda_{grease} = 1 \text{ W}/(\text{m}\cdot\text{K})$ | | 21.0 | | K/kW | |
| Temperature under switching conditions | T_{vjop} | | -50 | | 125 | $^\circ\text{C}$ | |

4 Characteristics diagrams

Output characteristic (typical), IGBT, Inverter

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

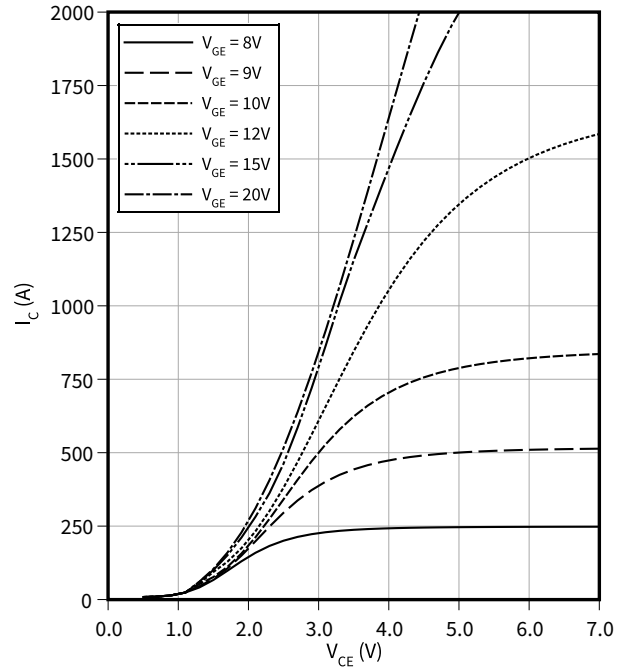
$$V_{GE} = 15 \text{ V}$$



Output characteristic field (typical), IGBT, Inverter

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

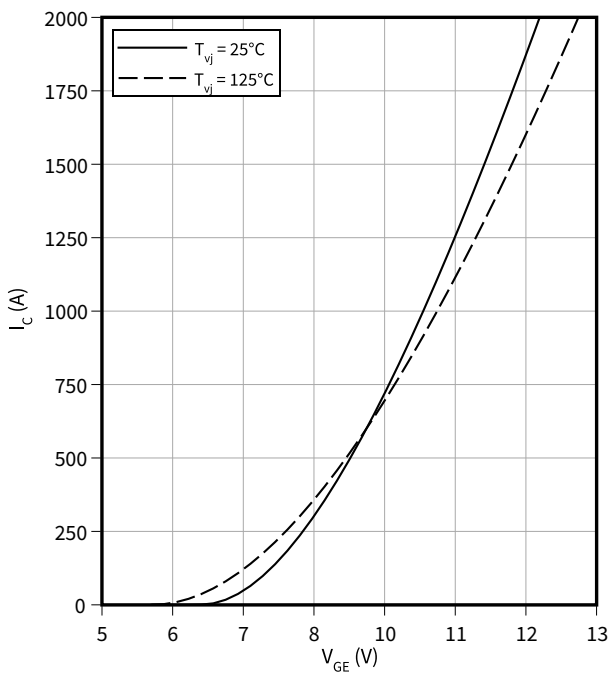
$$T_{vj} = 125 \text{ °C}$$



Transfer characteristic (typical), IGBT, Inverter

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

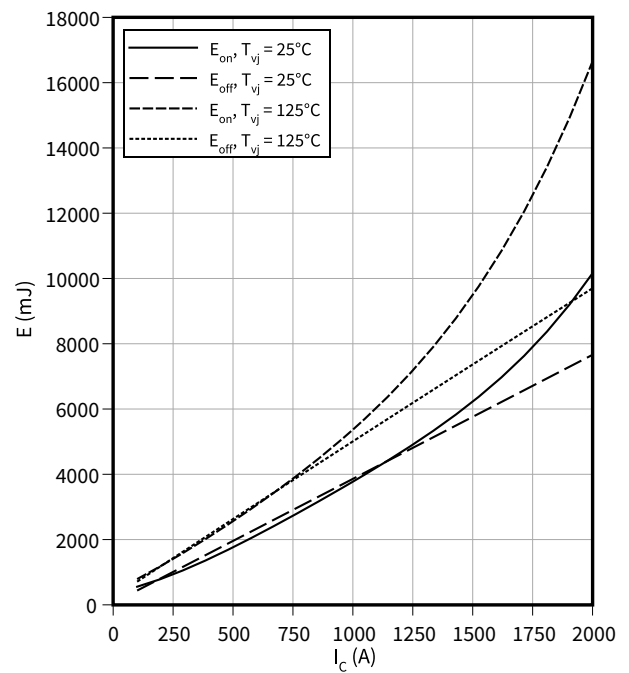
$$V_{CE} = 20 \text{ V}$$



Switching losses (typical), IGBT, Inverter

$$E = f(I_C)$$

$$R_{Goff} = 9,1 \text{ } \Omega, R_{Gon} = 1 \text{ } \Omega, V_{CC} = 2800 \text{ V}, V_{GE} = \pm 15 \text{ V}$$

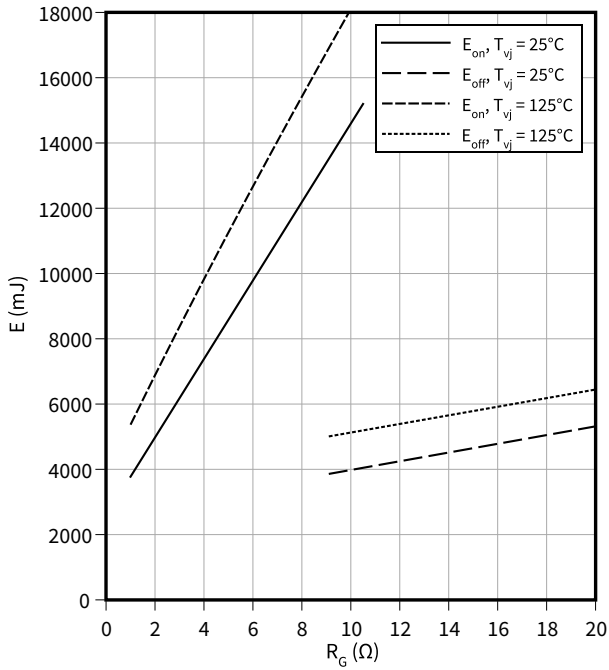


4 Characteristics diagrams

Switching losses (typical), IGBT, Inverter

$E = f(R_G)$

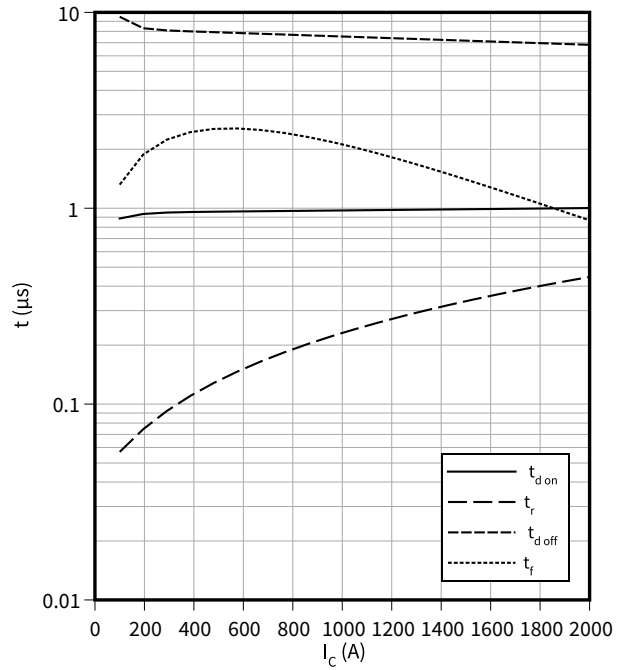
$I_C = 1000 \text{ A}$, $V_{CC} = 2800 \text{ V}$, $V_{GE} = \pm 15 \text{ V}$



Switching times (typical), IGBT, Inverter

$t = f(I_C)$

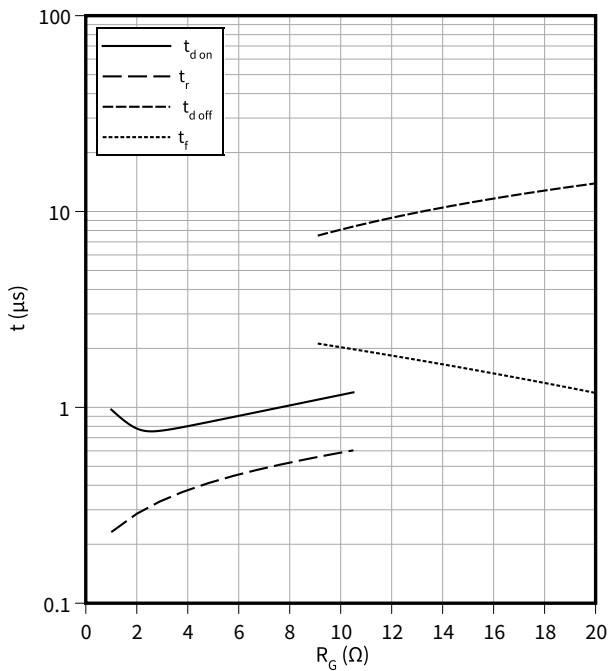
$R_{Goff} = 9.1 \Omega$, $R_{Gon} = 1 \Omega$, $V_{GE} = \pm 15 \text{ V}$, $V_{CC} = 2800 \text{ V}$, $T_{vj} = 125 \text{ °C}$



Switching times (typical), IGBT, Inverter

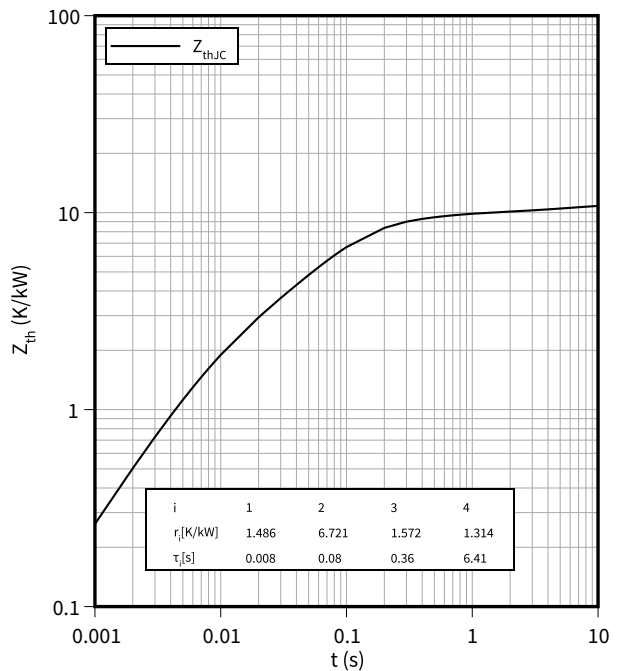
$t = f(R_G)$

$V_{GE} = \pm 15 \text{ V}$, $I_C = 1000 \text{ A}$, $V_{CC} = 2800 \text{ V}$, $T_{vj} = 125 \text{ °C}$



Transient thermal impedance , IGBT, Inverter

$Z_{th} = f(t)$

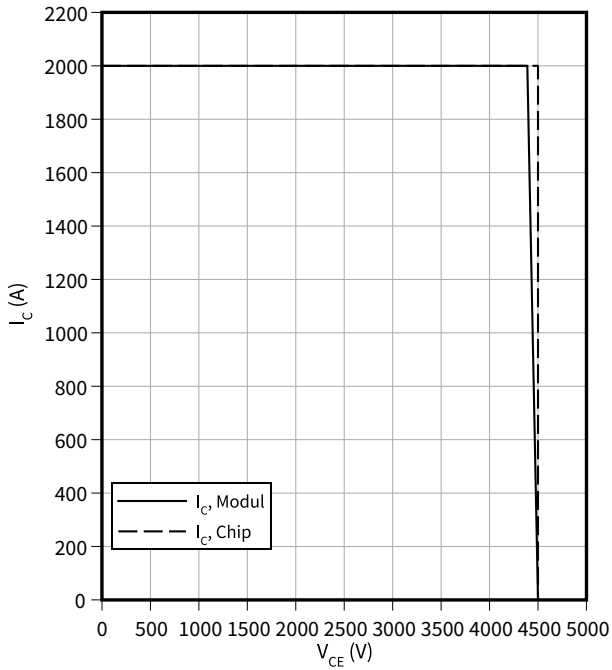


4 Characteristics diagrams

Reverse bias safe operating area (RBSOA), IGBT, Inverter

$I_C = f(V_{CE})$

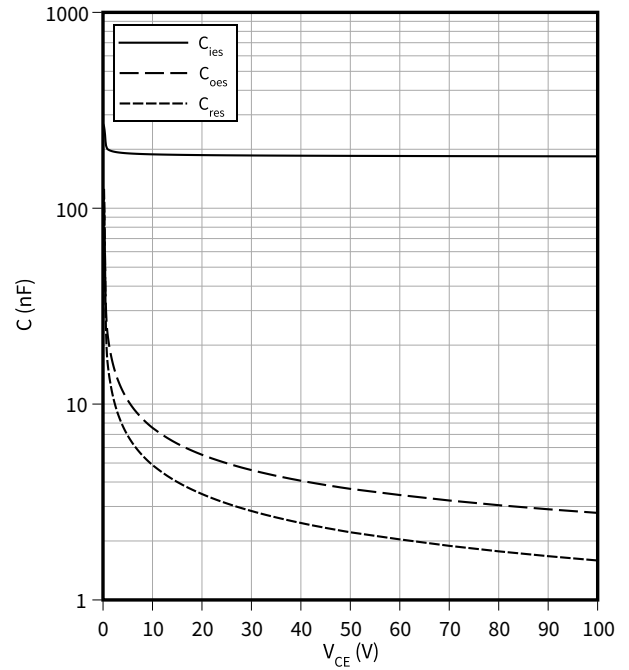
$R_{Goff} = 9.1 \Omega, V_{GE} = \pm 15 V, T_{vj} = 125 \text{ }^\circ\text{C}$



Capacity characteristic (typical), IGBT, Inverter

$C = f(V_{CE})$

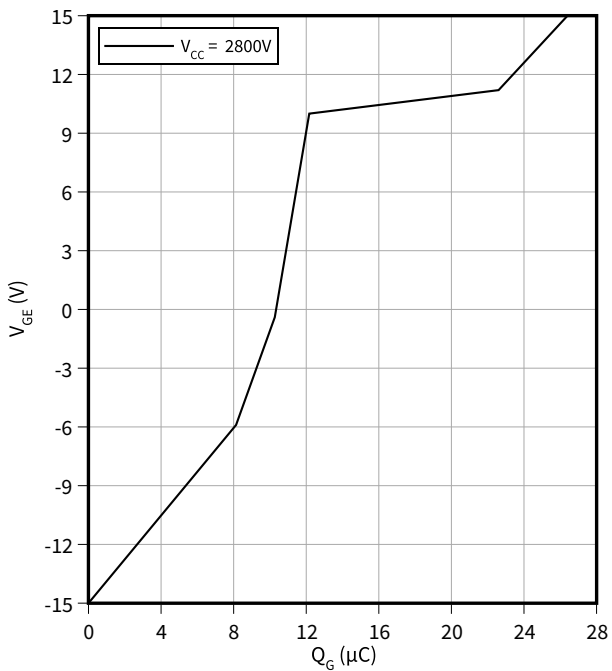
$f = 1000 \text{ kHz}, V_{GE} = 0 V, T_{vj} = 25 \text{ }^\circ\text{C}$



Gate charge characteristic (typical), IGBT, Inverter

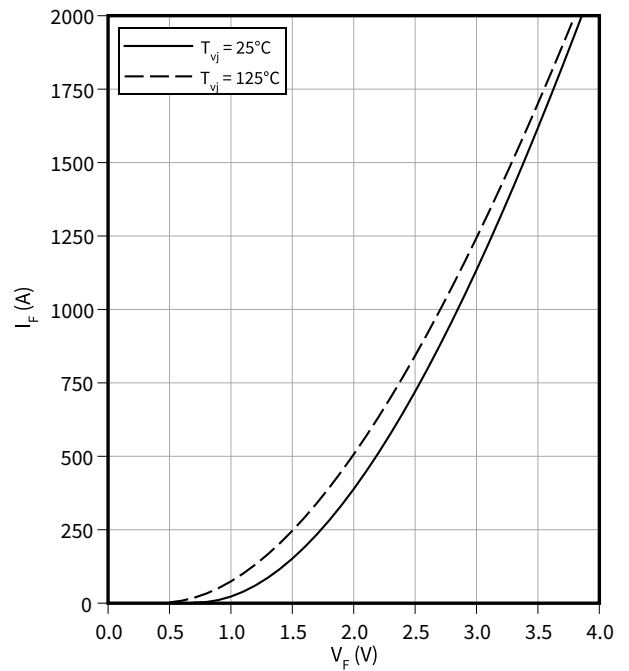
$V_{GE} = f(Q_G)$

$I_C = 1000 \text{ A}, T_{vj} = 25 \text{ }^\circ\text{C}$



Forward characteristic (typical), Diode, Inverter

$I_F = f(V_F)$

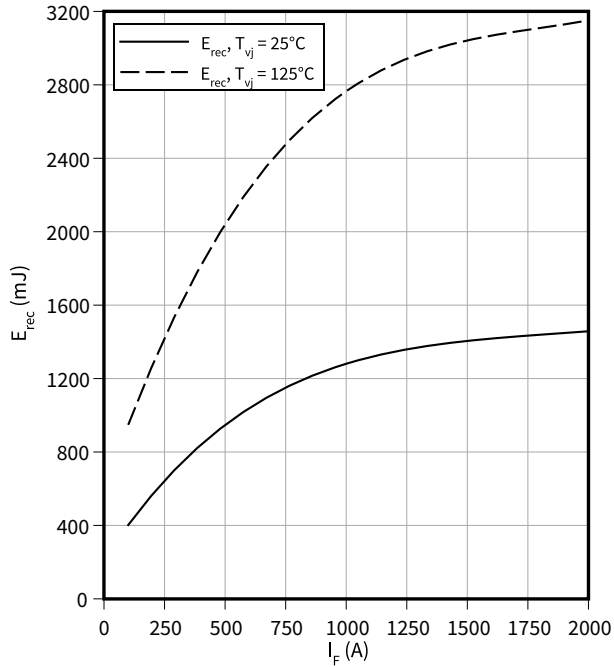


4 Characteristics diagrams

Switching losses (typical), Diode, Inverter

$E_{rec} = f(I_F)$

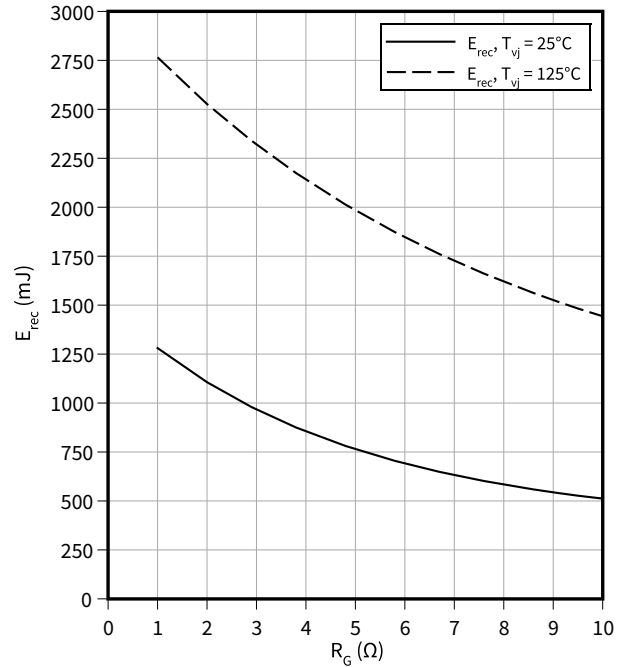
$R_{Gon} = R_{Gon}(IGBT), V_{CC} = 2800 V$



Switching losses (typical), Diode, Inverter

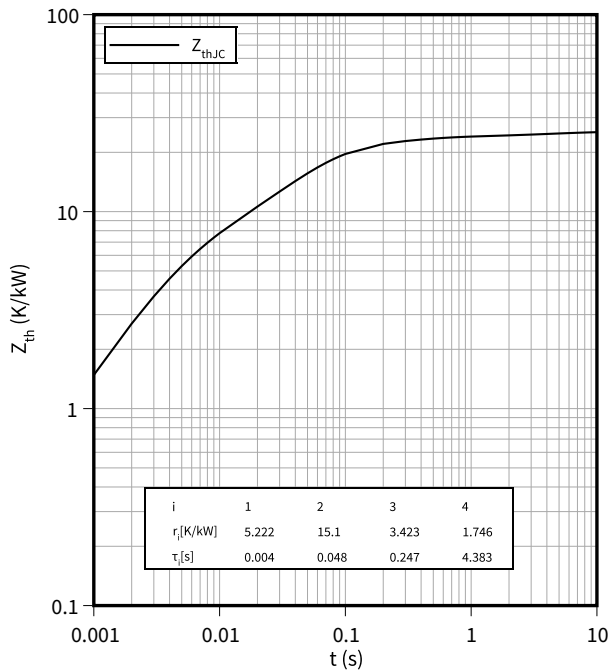
$E_{rec} = f(R_G)$

$I_F = 1000 A, V_{CC} = 2800 V$



Transient thermal impedance, Diode, Inverter

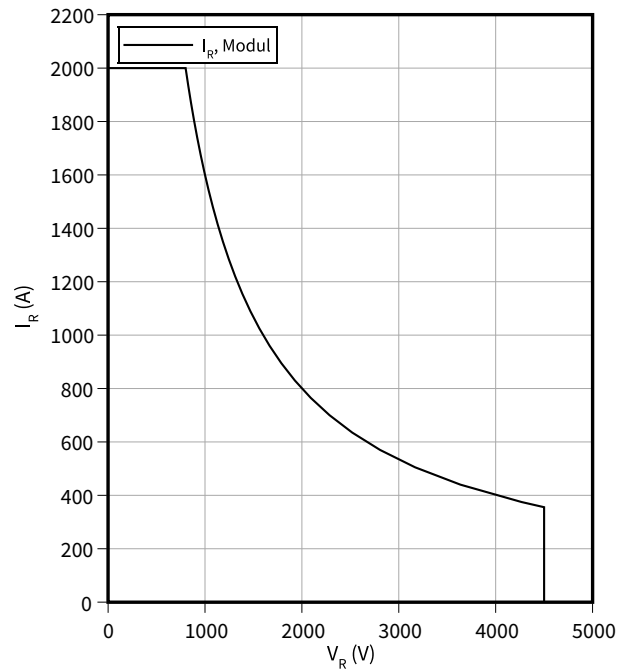
$Z_{th} = f(t)$



Safe operating area (SOA), Diode, Inverter

$I_R = f(V_R)$

$T_{vj} = 125 \text{ °C}$



5 Circuit diagram

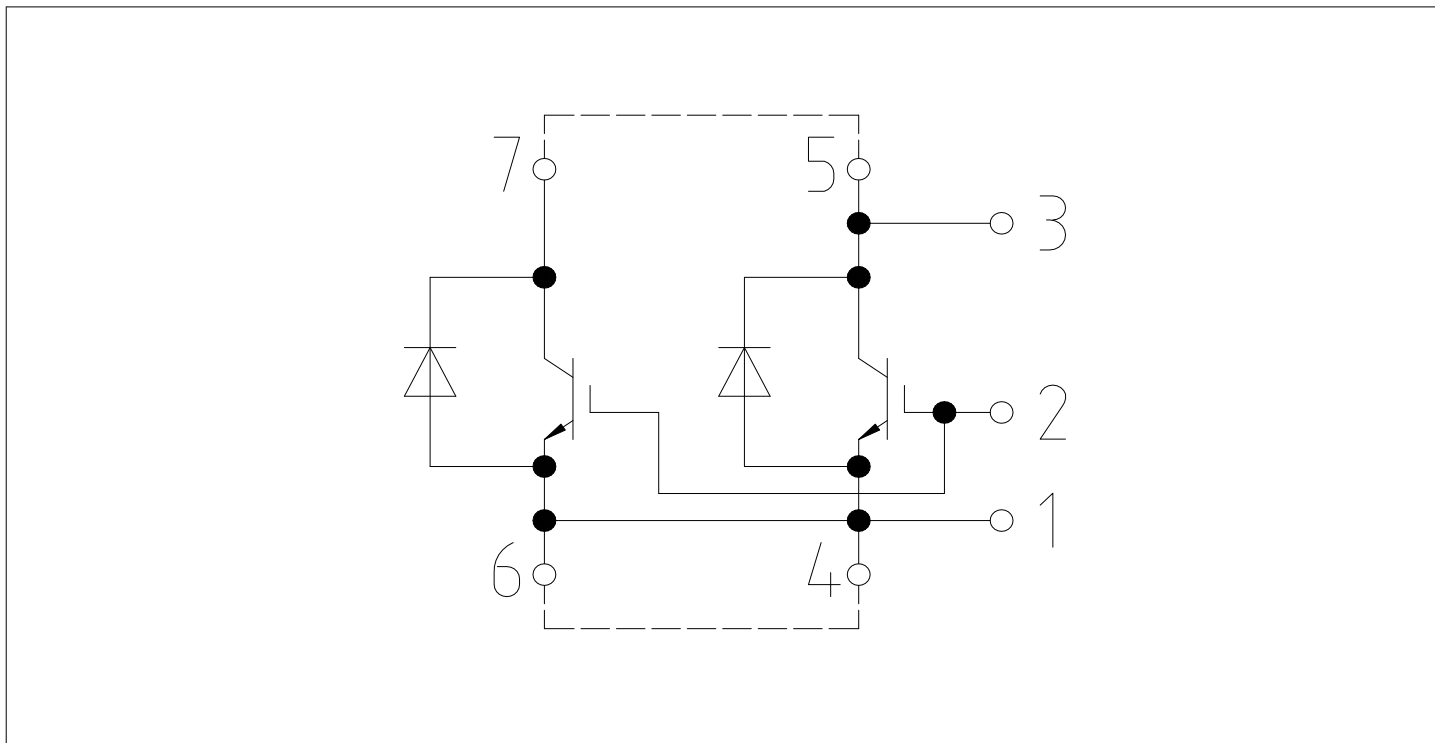


Figure 1

7 Module label code


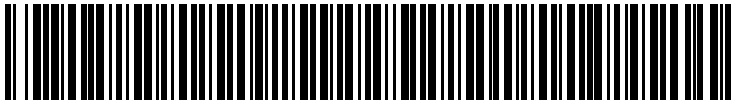
| Module label code | | | |
|--------------------------|--|-----------------|-------------------------|
| Code format | Data Matrix | Barcode Code128 | |
| Encoding | ASCII text | Code Set A | |
| Symbol size | 16x16 | 23 digits | |
| Standard | IEC24720 and IEC16022 | IEC8859-1 | |
| Code content | <i>Content</i> | <i>Digit</i> | <i>Example</i> |
| | Module serial number | 1 - 5 | 71549 |
| | Module material number | 6 - 11 | 142846 |
| | Production order number | 12 - 19 | 55054991 |
| | Date code (production year) | 20 - 21 | 15 |
| | Date code (production week) | 22 - 23 | 30 |
| Example |   | | |
| | 71549142846550549911530 | | 71549142846550549911530 |

Figure 3

Revision history

| Document revision | Date of release | Description of changes |
|-------------------|-----------------|------------------------|
| 0.10 | 2021-09-15 | Initial version |
| 0.20 | 2022-02-24 | Target datasheet |
| 0.30 | 2022-05-16 | Preliminary datasheet |
| 1.00 | 2022-08-15 | Final datasheet |

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