

## 2 Datasheet parameters for MOSFET, IGBT, MiniSKiiP- and SKiiPPACK modules

### 2.1 General

#### 2.1.1 Letter symbols, terms, standards

*Letter symbols and terms [264], [265]*

**Voltages:** firstly, two index letters are used to indicate the terminals between which the applied voltage is taken. If the potential of the terminal designated with the first index letter is positive versus the terminal designated with the second index letter (reference potential), the applied voltage is positive, e.g.  $V_{CE}$ .

As for diodes, “F” is used for the forward on-state voltage (positive anode potential versus cathode potential) and “R” for the reverse blocking voltage (positive cathode potential versus anode potential).

As for transistors, an additional third index letter may indicate the type of circuit between terminal 2 and a non-designated third terminal, e.g.  $V_{CGR}$ , where the third letter symbol is defined as follows:

- S: short-circuit between terminal 2 and 3,
- R: resistor to be specified between terminal 2 and 3,
- V: external voltage between terminal 2 and 3, to be specified,
- X: resistor and external voltage between terminal 2 and 3, to be specified.

Index letters can be followed or preceded by other index abbreviations for further specification of parameters, either with or without brackets and either as capital or small letters (e.g.  $V_{(BR)DS}$  or  $V_{GE(th)}$  or  $V_{CEsat}$ ), for example:

- (BR): breakdown voltage,
- sat: saturation voltage,
- (th): threshold voltage,
- clamp: clamping voltage limited by external circuits.

Supply voltages are often marked by doubleindex letters, e.g.  $V_{GG}$  (supply voltage of gate-emitter circuit),  $V_{CC}$ ,  $V_{DD}$ .

**Currents:** at least one index letter is used to specify a current. Positive values specify positive currents, which enter the component at the terminal and are named first in the index, e.g.  $I_{GE}$ . If there is no danger of mix-up, only the first index letter is usually used, e.g.  $I_C$  (collector current),  $I_D$ ,  $I_G$ . The same applies when indicating negative currents.

As for diodes, “F” is used for indicating forward on-state currents (anode-cathode) and “R” for reverse currents (cathode-anode).

As for transistors, an additional third index letter may indicate the type of circuit between terminal 2 and a non-designated third terminal, e.g.  $I_{GES}$ , where the third letter symbol is defined as follows:

- S: short-circuit between terminal 2 and 3,
- R: resistor to be specified between terminal 2 and 3,
- V: external voltage between terminal 2 and 3, to be specified,
- X: resistor and external voltage between terminal 2 and 3, to be specified.

Index letters can be followed or preceded by other index abbreviations, either with or without brackets and either as capital or small letters, for example:

AV : average value,  
RMS: effective value, (root mean square)  
M: peak value (maximum),  
R: periodic (repetitive),  
S: non-periodic (spike),  
puls: pulsed (direct current).

**Other symbols:** the terminology used for other symbol indications for electrical, thermal and mechanical parameters mainly follows the terminology for voltages and currents; for further explanation please see the following table. Index letters may also specify turn-on (on) and turn-off (off) switching states (mostly in brackets).

### *Standards for terms and definitions*

Details with regard to definitions, determination of terms, datasheet parameters and measurement procedures may be taken, for example, from the following standards:

#### **Standards, terms and definitions**

|                               |    |                                                     |
|-------------------------------|----|-----------------------------------------------------|
| DIN 40 900                    | T5 | Semiconductors, switching symbols                   |
| DIN 41 781                    |    | Diodes: terms and definitions                       |
| DIN 41 785                    | T3 | Power semiconductors: symbols                       |
| DIN 41 858                    |    | Field effect transistors: terms and definitions     |
| IEC 191-1...4                 |    | Mechanical standards (cases)                        |
| IEC 50 (521) 1984, (551) 1982 |    | International dictionary for electrical engineering |
| IEC 617-5                     |    | Graphic symbols, switching symbols for diagrams     |
| IEC 971 (1989-07)             |    | Semiconductor converters: designation system        |

#### **Datasheet parameters and measurement procedures**

|                                     |    |                                                                                                                          |
|-------------------------------------|----|--------------------------------------------------------------------------------------------------------------------------|
| DIN 41 791                          | T1 | Principle designations for datasheets                                                                                    |
| DIN 41 792                          | T2 | Test procedures: diodes                                                                                                  |
|                                     | T3 | Test procedures: heat resistance                                                                                         |
| IEC 747-1: 1983                     |    | Semiconductor components/ Volume 1: General hints with reference to maximum ratings and characteristics, test procedures |
| IEC 747-2: 1983, A1(1992), A2(1993) |    | Rectifier diodes                                                                                                         |
| IEC 747-8: 1984, A1(1991), A2(1993) |    | Field effect transistors                                                                                                 |
| IEC 60747-9: 1998 FDIS              |    | IGBTs (in preparation)                                                                                                   |

#### **R & D standards and reliability**

|                                     |  |                                                                                                             |
|-------------------------------------|--|-------------------------------------------------------------------------------------------------------------|
| IEC 664-1: 1992                     |  | Co-ordination for the isolation of electrical appliances < 1 kVeff<br>Volume 1: principles, test procedures |
| IEC 146-1-1: 1991/EN60146-1-1: 1993 |  | Semiconductor converters: basic requirements                                                                |
| DIN EN50178 (VDE0160): 4/1998       |  | Electronic devices for power systems:<br>general isolation test procedures                                  |
| IEC 947-4-2/EN60947-4-2:1997        |  | Designation system for low-voltage appliances,<br>volume 4.                                                 |
| UL 1557: 5/1993                     |  | Inflammability, isolation safety                                                                            |

|                         |                                                     |
|-------------------------|-----------------------------------------------------|
| UL 94-V0: 9/1981        | Inflammability of plastic materials                 |
| IEC 747-1, IX: 1983     | Components at risk of ESD (Electrostatic Discharge) |
| DIN IEC 68-2-...        | Reliability tests                                   |
| ISO 9001/EN29001: 1995  | Quality system certification                        |
| DIN EN ISO 9001: 8/1994 | Re-qualification of quality system                  |

## 2.1.2 Maximum ratings and characteristics

### *Maximum ratings*

Maximum ratings for modules indicated in the datasheets are extreme values of electrical, thermal and mechanical load permissible without risk of destruction or damage. Every limit value has been specified according to exactly defined conditions, which have inevitably to be indicated in the datasheets, since some of these conditions have not (yet) been standardized.

Exceeding one of the maximum ratings may lead to destruction of the component, even if other maximum ratings have not been strained to their utmost limit.

In addition to the “static“ maximum ratings listed in the following there are so-called “dynamic“ maximum ratings, which designate the permissible course of the characteristics (current/ voltage) during switching.

If not otherwise shown, the maximum ratings in the datasheets are valid at a chip or case temperature of 25°C, for higher temperatures deratings usually have to be considered.

### *Characteristics*

Characteristics describe the features of components determined under certain specified measuring conditions (mostly application-specific).

Just as with maximum ratings, all characteristics are subject to exactly specified ambient conditions which have to be indicated in the datasheets, since some of those conditions are also not standardized.

Characteristics are often indicated as typical values within a range.

The reference temperatures for chip or case are normally indicated with e.g. 25°C or 125°C so temperature dependency has to be considered in the case of differing temperatures.

Limits and characteristics are published in the form of tables and diagrams.

## 2.2 Power MOSFET modules [264], [265]

### 2.2.1 Maximum ratings

#### *MOSFETs/module structure*

#### **Drain-source voltage $V_{DS}$**

Maximum voltage between drain and source contacts of MOSFET chips for open or closed gate-source circuit.

Parameter: case temperature  $T_{case} = 25^{\circ}C$

**Drain-gate voltage  $V_{DGR}$**

Maximum voltage between drain and gate,

Parameters: external resistance  $R_{GS}$  between gate and source, case temperature  $T_{case} = 25^{\circ}C$

**Continuous direct drain current  $I_D$**

Maximum direct current at drain output

Parameters: case temperature, e.g.  $T_{case} = 25^{\circ}C, 80^{\circ}C$ :  $I_D@25^{\circ}C, I_D@80^{\circ}C$

**Peak value of a periodic drain current  $I_{DM}$  or pulsed drain current  $I_{Dpuls}$**

Peak value of current at drain output during pulse operation,

Parameters: pulse duration  $t_p$ , case temperature, e.g.  $T_{case} = 25^{\circ}C, 80^{\circ}C$  and pulse/break ratio (diagram "maximum safe operating area")

**Single pulse avalanche energy dissipation  $E_{AS}$**

Maximum avalanche energy dissipation from drain to source of a single chip during turn-off of an unclamped inductive load (single pulse load),

Parameters: instantaneous drain current  $i_D$ , drain-source supply voltage  $V_{DD}$ , external gate-source resistance  $R_{GS}$ , external drain inductance  $L$ , chip temperature, e.g.  $T_j = 25^{\circ}C$

**Gate-source voltage  $V_{GSS}$  or  $V_{GS}$**

Maximum voltage between gate and source

Parameter: case temperature  $T_{case} = 25^{\circ}C$

**Total power dissipation  $P_{tot}$  or  $P_D$**

Maximum power dissipation per transistor/diode or within the whole power module

$P_{tot} = (T_{jmax} - T_{case}) / R_{thjc}$ ,

Parameter: case temperature  $T_{case} = 25^{\circ}C$

**Operating temperature range  $T_{vj}$  or  $T_j$ ;  $T_{j(min)} \dots T_{j(max)}$**

Permissible chip temperature range within which the module may be permanently operated

**Storage temperature range  $T_{stg}$ ;  $T_{stg(min)} \dots T_{stg(max)}$**

Temperature range within which the module may be stored or transported without being subject to electrical load.

**Isolation test voltage  $V_{isol}$  or  $V_{is}$**

Effective value of the permissible test voltage between input terminals/ control terminals (short-circuited, all terminals connected to each other) and module base plate.

Parameters: test duration (1 min, 1 s), rate of rise of test voltage, if required;

according to IEC 146-1-1 (1991), EN 60146-1-1 (1993), section 4.2.1 (corresponds to VDE 0558, volume 1-1: 1993-04) and DIN VDE 0160 (1988-05), section 7.6 (corresponds to EN 50178 (1994)/ E VDE 0160 (1994-11) the test voltage shall only rise gradually up to its maximum rating.

**Grade of humidity**

describes the permissible ambient conditions (atmospheric humidity) according to DIN 40 040

**Grade of climate**

describes the permissible ambient test conditions (climate) according to DIN IEC 68-1