SEMiX® IGBT Modules

Features

- New module platform for optimum connection between driver and intermediate circuit
- Based on well-tried SEMIKRON module technologies
- IGBT modules in half-bridge, sixpack or chopper topology
- 3-mm Cu baseplate and soldered main terminals
- 17-mm-high, flat modules
- Optimum power scaling in phase leg modules thanks to 4 module sizes

  SEMiX® 13:
  Rated current 100....250 A, 69 x 136 mm

  SEMiX® 2:
  Rated current 190....470 A, 62 x 117 mm

  SEMiX® 3:
  Rated current 250....700 A, 62 x 150 mm

  SEMiX® 4:
  Rated current 600....900 A, 69 x 183 mm
- Easy parallel connection
- Driver interface on top of module
- 2 alternative driver interfaces for solder-pin- or spring-contact-version
- Also available in competitor compatible sixpack topology

  SEMiX® 33c:
  Rated current 250 ...700 A, 162 x 150 mm
- Low-inductive module case
- High insulation voltage, long creepage distances, 100 % production test at AC 4.8 kV, 1 s in accordance with EN 50178
- State-of-the-art, optimum-loss IGBT chips in 3 voltage classes (600 V, 1200 V and 1700 V) and 2 different technologies, optimised for different applications:
  Trench technology (600 V, 1200 V, 1700 V) ...066, ...126, ...176: Field-Stop Trench IGBT chips with very low forward losses and optimised use of module area
  SPT technology (1200 V) ...128: planar Soft-Punch-Through chips with very good trade-off between forward and switching losses
- Optimally adapted inverse diodes:
  CAL (**C**ontrolled **A**xial **L**ifetime) and HD-CAL (**H**igh **D**ensity-**C**ontrolled **A**xial **L**ifetime) diode technology
  Soft recovery behaviour even in extreme conditions
  High dynamic robustness for high di/dt up to 15 kA/ µs * cm^2
  Newly developed HD-CAL diodes show very low forward losses
  Forward characteristic with minimised temperature coefficient
- Integrated NTC temperature sensor for measuring the heat sink temperature in the vicinity of the chips

SEMiX® offers users a high degree of flexibility in system configuration. Inverters, for instance, can be constructed either with compact sixpacks (SEMiX® 13/33c) or with thermally decoupled half bridges in the same family of housings. This can result in a better thermal spreading effect that can reduce the external thermal resistance by up to 20 %, thus making it possible to increase the current by up to 15 % or reduce the chip temperature by 15...20 K. If these advantages are not made use of, less complex heat sink designs than those in sixpacks are possible. This is illustrated by the temperature profiles shown in Fig. 1.

Fig. 1 Typical temperature profiles for 3 SEMiX® modules

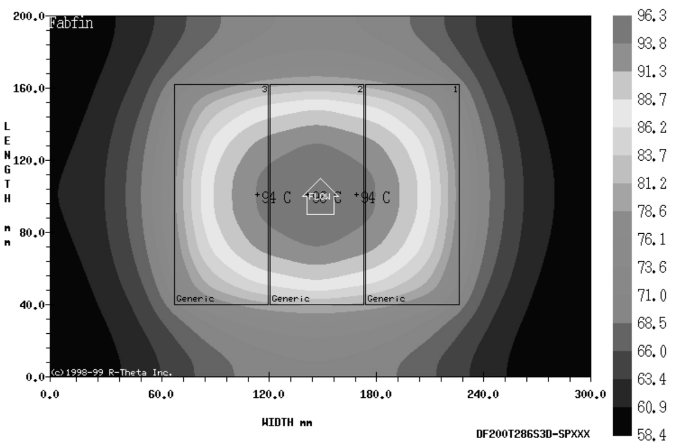

Fig. 1 a) Sixpack topology

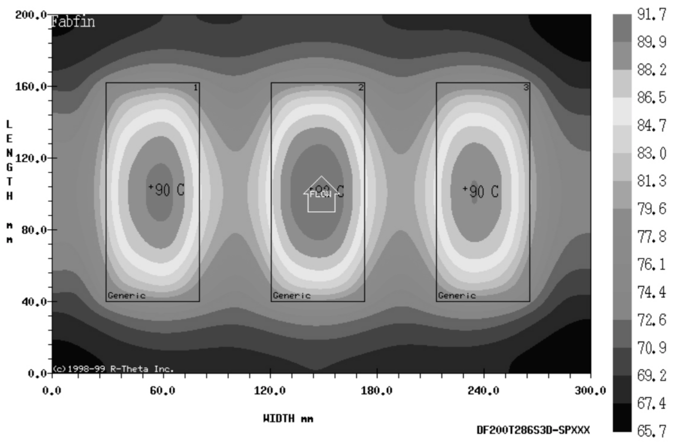

Fig. 1 b) Configuration with 3 half-bridges for optimum thermal spreading

Type Designation System

SEMiX IGBT module series

❶ ❷ ❸ ❹ ❺ ❻ ❼ ❽

SEMiX 70 3 GB 12 6 HD c

❶ SEMiX IGBT module series

❷ Rated current I_C @ T_C = 25 °C (80 °C @ 600 V) in [A] / 10

❸ Module dimensions

1: SEMiX® 13

2: SEMiX® 2

3: SEMiX® 3

4: SEMiX® 4

❹ Topology

GAL: Low side chopper

GAR: High side chopper

GB: Half-bridge

GD: Sixpack

❺ Collector-emitter voltage class in [V] / 100

❻ IGBT chip technology

6: Trench IGBT

8: Soft Punch Through IGBT

❼ Integrated inverse diode technology

D: CAL diode

HD: High Density CAL diode

❽ Contact version:

c: compatible solder pin version

s: spring contact version

SEMiX Bridge Rectifier

❶ ❷ ❸ ❹ ❺

SEMiX 30 1 KD 16

❶ SEMiX Bridge Rectifier

❷ Rated current I_C @ T_C = 25 °C (80 °C @ 600 V) in [A] / 10

❸ Module dimensions

1: SEMiX® 1 or SEMiX® 13

2: SEMiX® 2

❹ Topologie

KD: uncontrolled diode halfbridge

KH: halfcontrolled diode-/thyristor halfbridge

D: uncontrolled diode bridge

DH: halfcontrolled diode-/thyristor bridge

❺ Voltage classes (V_{DRM}, V_{RRM}) in [V] / 100

Captions of the Figures

Fig. 1 Collector current I_C as a function of the collector-emitter voltage V_{CE} (typical output characteristics) for T_j = 25 °C and T_j = 125 °C, Parameter: Gate-emitter voltage V_{GE}; Values at terminal level, inclusive $R_{CC' + EE'}$

Fig. 2 Maximum rated continuous DC collector current I_C as a function of the case temperature T_{case}, terminal current I_{cmax} = 600 A @ $T_{Terminal}$ = 100 °C

Fig. 3 Typical turn-on and turn-off energy dissipation E_{on} and E_{off} of an IGBT element and turn-off energy dissipation E_{rr} of a freewheeling diode as a function of the continuous collector current I_C for inductive load

Fig. 4 Typical turn-on and turn-off energy dissipation E_{on} and E_{off} of an IGBT element and turn-off energy dissipation E_{rr} of a freewheeling diode as a function of the gate series resistance R_G for inductive load

Fig. 5 Typical transfer characteristic: continuous collector current I_C as a function of the gate-emitter voltage $V_{GE;}$ Values at terminal level, inclusive $R_{CC' + EE'}$

Fig. 6 Typical gate charge characteristic: gate-emitter voltage V_{GE} as a function of the gate charge Q_G

Fig. 7 Typical IGBT switching times t_{don}, t_r , t_{doff} and t_f as a function of the continuous collector current I_C for inductive load and fixed gate series resistance R_G for T_j = 125 °C

Fig. 8 Typical IGBT switching times t_{don}, t_r , t_{doff} and t_f as a function of the gate series resistance R_G for inductive load and fixed collector current I_C for T_j = 125 °C

Fig. 9 Transient thermal impedance Z_{thjc} of the IGBT element as a function of the time t (single pulse) expired following an abrupt change in power dissipation and the pulse duration t_p (Parameter: duty factor D) for f < 3 kHz

Fig. 10 Transient thermal impedance Z_{thjcD} of the inverse diode as a function of the time t (single pulse) expired following an abrupt change in power dissipation and the pulse duration t_p (Parameter: duty factor D) for f < 3 kHz

Fig. 11 Typical forward characteristics of the inverse diode (typical and maximum values) for T_j = 25 °C and T_j = 125 °C

Fig. 12 Typical peak reverse recovery current I_{RRM} of the inverse diode as a function of the fall rate di_F/dt of the forward current with corresponding gate series resistance R_G of the IGBT during turn-on

Fig. 13 Typical recovery charge Q_{rr} of the inverse diode as a function of the fall rate di_F/dt of the forward current (Parameters: forward current I_F and gate series resistance R_G of the IGBT during turn-on)

The data given in Figures 1 - 13 refer to the values measurable at the terminals.

Application Notes

ESD Protection

SEMiX® IGBT modules are electrostatic sensitive devices. All of these modules are supplied with ESD protection via a conductive connection between the gate and emitter terminals. This connection should be kept intact until the driver has been connected. Module assembly should be carried out by qualified staff wearing conductive grounded bracelets at ESD protected, grounded workplaces.

Mounting instructions

In order to ensure good thermal contact and achieve the thermal contact resistance values specified in the data sheets, the contact surface of the heat sink must be clean and free from dust particles, as well as fulfilling the following mechanical specifications:

- Unevenness: < 20 µm over a distance of 100 mm
- Roughness R_Z: < 10 µm

Before assembly onto the heat sink, the baseplate or the contact surface of the heat sink should be evenly coated with a thin layer (approx. 50 µm) of a heat sink compound such as Wacker-Chemie P 12 (silicon-based, 30 g tube: SEMIKRON ID No. 30106620). To ensure even distribution, we recommend using a hard rubber roller or silk screen process. To secure the SEMiX® IGBT modules, we recommend the use of either M5 steel screws (DIN, property class 4.8) in combination with a washer or combination screws. When doing so, the torque value specified must be observed. The screws must be tightened in diagonal order with equal torque in several steps until the specified mounting torque M_s is reached. We further recommend that the screws are retightened according to the given torque value following a period of a few hours, as part of the heat sink compound may spread under the mounting pressure.

For the electrical terminals, suitable M6 screws (DIN), washers and spring lock washers or combination screws are to be used. Here, the maximum and minimum thread reaches, which can be taken from the module drawings (see datasheets), and the permissible tightening torque M_t must be observed. For details on the contents of the SEMIKRON mounting accessories kit for all SEMiX® modules, see the section on "Mounting Accessories".

Power terminals

For the power rail connections on the DC side of the circuit, laminar intermediate circuits (busbars) should be used to produce minimum stray inductance, thus guaranteeing a low load with switching surges. In most applications, the use of low-inductance pulse capacitors (MKP, MKT, 0.1 ... 1.0 µF) at the DC terminals (collector TOP-IGBT/emitter BOT-IGBT) is recommended to prevent parasitic oscillations.

Drive connections

All of the electrical connections between the driver and the SEMiX® module must be as short as possible to minimise stray inductance and avoid electromagnetic interference and oscillation. For gate connections via cables, twisted-conductor cables must be used. For soldered gate terminals (using a grounded solder tool) a soldering temperature of T_{solder} = 245 ± 5 °C / < 5 sec. must be observed.

Customer-specific and integrated drivers/driver interfaces: The different SEMiX® topologies offer different possibilities for driver adaption.

- Standard driver connection via solderable/plug pin connectors or as spring contact interface
- adaptable SEMIKRON Driver (e.g. SKYPER™)
- Sixpack SEMiX® 33c with competitor compatible interface

Integrated temperature sensor

All SEMiX® modules contain an integrated KG3B-35-5 temperature sensor with an NTC (Negative Temperature Coefficient) characteristic for measuring the heat sink temperature. This sensor is located on the DCB ceramic substrate, as are the IGBT element and the diode chips. The insulation voltage to the IGBT/diode chips, as specified in the relevant SEMiX® datasheets, is achieved by way of soft encapsulation using silicon gel.
According to EN 50178 (VDE 0160), this type of insulation is regarded as basic insulation, since, in the worst-case scenario of electrical overload in the SEMiX® module, for example, the bond wires could melt, in doing so producing an arc with high energy plasma which may touch the temperature sensor and consequently create a short-circuit across the insulation. As this can cause the temperature sensor to come into contact with the potential of the IGBT/diode chips, further steps must be taken by the user to guarantee the safety grade "Safe electrical isolation" in accordance with the specifications of EN 50178.

The temperature-dependent resistance of the NTC sensor is described by the following equation (also refer to Table 1):

$R(T) = 5000\ \Omega * \exp[B * (1/T - 1/298\ K)]$

where T: Temperature in K and
B = 3420 K ± 2 % (25 °C / 85 °C)

At 25 °C the max. measurement tolerance is ± 5 %.

T [°C]	R [kΩ]
25	5.000
30	4.156
35	3.471
40	2.914
45	2.458
50	2.083
55	1.772
60	1.515

65	1.300
70	1.120
75	0.9683
80	0.8404
85	0.7319
90	0.6396
95	0.5608
100	0.4933
105	0.4352
110	0.3851
115	0.3418
120	0.3042
125	0.2714
130	0.2428
135	0.2178
140	0.1959
145	0.1765
150	0.1595

Table 1: KG3B-35-5 temperature sensor with NTC: typical temperature-dependent resistances

The latest version of our mounting instructions and application notes can be found on the SEMiX® product overview page at: www.semikron.com

