The module has to be split up as simply as possible in metal and non-metal components during recycling. Therefore, the currently available modules are cast solely with elastomeric materials (soft moulding).

1.4.3 Assembly and connection technology: types of cases

Cases of current power modules containing 1...7 MOSFET or IGBT-switches are mostly equipped with screw, plug-in or solder-terminals.
For the majority of transistor modules, different manufacturers are striving for a large degree of compatibility with partly historically developed structures (Figure 1.57).

First of all, the inevitably deviating high-integration modules (e.g. SKiiPPACK, MiniSKiiP) are not to be considered in the following.

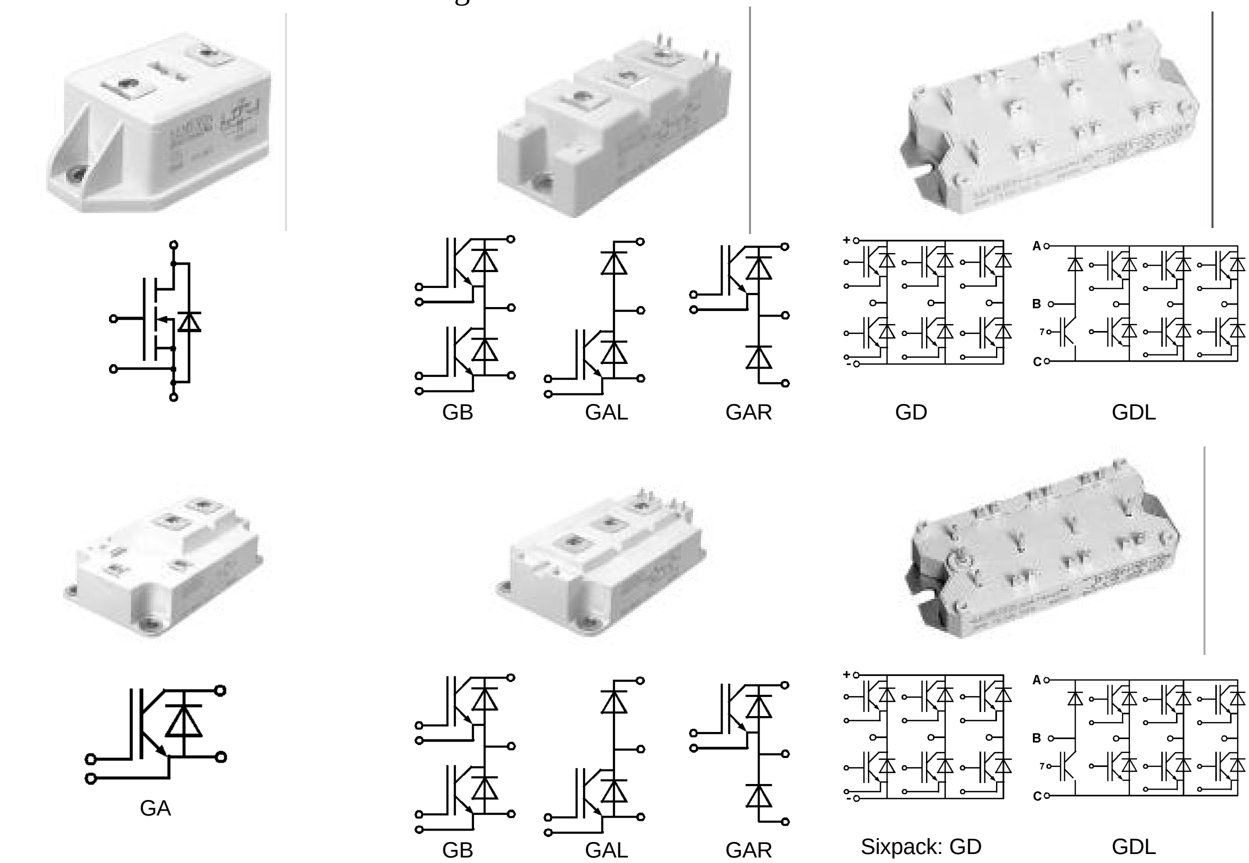

Figure 1.57a Transistor modules with base plate

SEMITOP

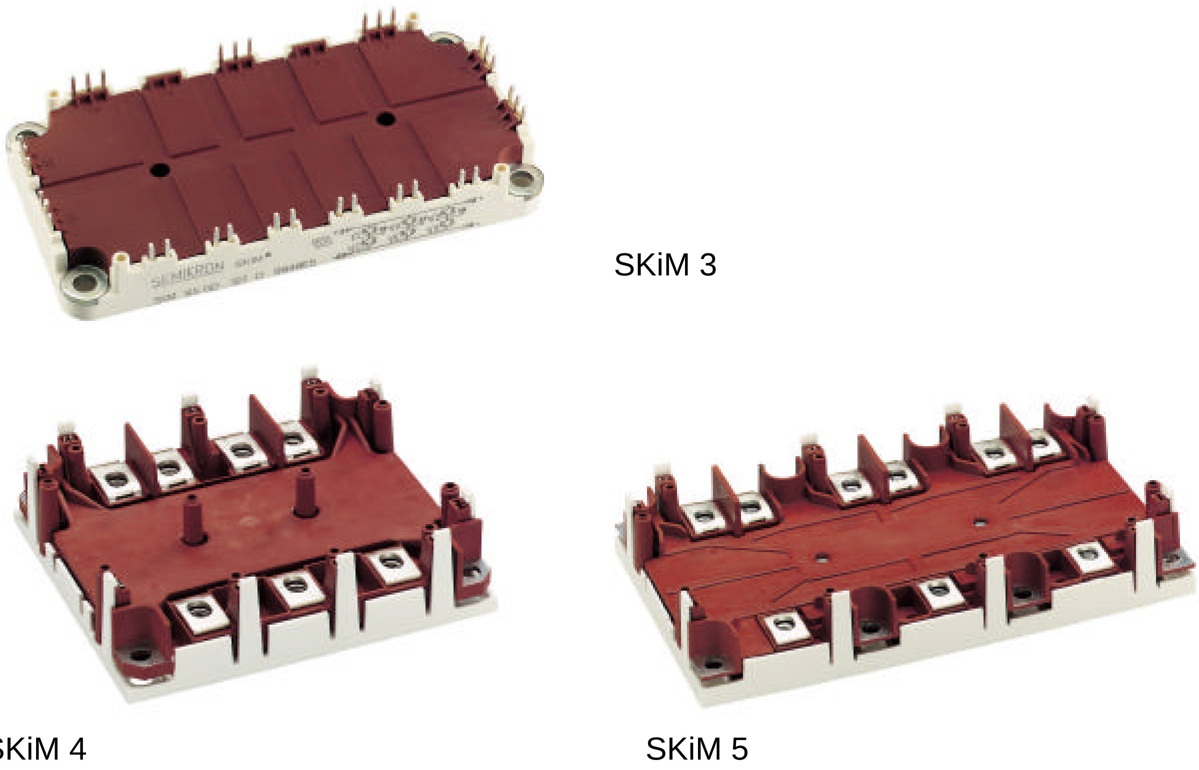

Figure 1.57b Transistor modules without base plate

The highest degree of standardization is assigned to module types with screw connectors. The main supplies may be contacted by busbars or sandwich assemblies. Often, additional outputs are provided for control and sense-units (e.g. control-emitter, sense-collector) in order to minimize the influence of inductive voltage drop in the main circuit generated during switching, especially at the bonded connecting wires. Auxiliary supplies are mostly designed as 2.8 mm flat strip plug connectors, sometimes also as screw connectors.
For low-current modules the use of 6.3 mm or 2.8 mm flat strip plug connectors for power and control circuit, respectively, has also been very common up to now.
Solderable modules for PCB-assembly (e.g. SEMITOP, ECONOPACK) are gaining importance, because they offer cost advantages during automatic production and tooling procedures. Optimized layout of connectors will take care of low-inductance assemblies, and currents up to 100 A may be realized by paralleling several solder connectors. In this respect, the necessary track sections (for high currents) and the realization of long creepage paths on the PCB might be problematic.

1.4.4 SEMIKRON code designation system for SEMITRANS- and SEMITOP-power modules

Different functions, internal circuits, current and voltage range and other informations are coded by the manufacturers in their type designations.
The following tables indicate the code designation system for SEMIKRON MOSFET and IGBT-modules.

SEMITRANS power-MOSFET-modules

There is an “old“ and a “new“ designation code for SEMITRANS-MOSFET-modules. The “old“ designation code had been introduced with the first MOSFET-modules, some of which are still being produced, at the end of the eighties following the PRO-ELECTRON-recommendations by SEMIKRON. All newly developed modules are designated according to the “new“ code, which gives more information and corresponds basically to the designation code for SEMITRANS-IGBT-modules.

“old” designation code, e.g.
SK M 1 5 1 A F R C

SEMIKRON component

MOS technology

Circuit configuration
1: Single switch
2: Dual mode (halfbridge)
3: Special type
4: 4-pack (H-bridge)
6: 6-pack (three-phase-bridge)

Voltage grade
0: V_{DS} = 50 V 5: V_{DS} = 500 V
1: V_{DS} = 100 V 8: V_{DS} = 800 V
2: V_{DS} = 200 V 9: V_{DS} = 1000 V
4: V_{DS} = 400 V

Internal arrangement
0: 4...5 chips in parallel 3: Special type
1: 6 chips in parallel 4: 4+4 chips
2: 2 chips in parallel

A: avalanche-proof single chips
F: built-in fast inverse diode
R: built-in gate series resistors
C: built-in gate driver circuit (manufactured until 1996)

“new” designation code, e.g.
SK M 120 B 020

SEMIKRON component

MOS technology

Drain current grade
(I_D/A at T_{case} = 25°C)

Circuit configuration
A: Single switch
B: Dual mode (halfbridge)
D: 6-pack (three-phase-bridge)
M: 2 MOSFETs in center tap connection

Drain-source voltage grade
(V_{DS}/V/10)

SEMITRANS IGBT-modules

z.B. **SK M 100 G B 12 3 D L**

SEMIKRON component

M: MOS technology
D: 7D-pack (B6-diode input bridge with IGBT chopper)

Collector current grade (I_C/A at T_{case} = 25°C)

G: IGBT switch

Circuit configuration
A: Single switch
AL: Chopper module (IGBT and free-wheeling diode on collector side)
AR: Chopper module (IGBT and free-wheeling diode on emitter side))
AH: Asymmetric H-bridge
AX: Single IGBT + series diode on collector side (reverse blocking)
AY: Single IGBT + series diode on emitter side (reverse blocking)
B: Dual module (halfbridge)
BD: Dual module (halfbridge) + 2 diodes in series (reverse blocking)
D: 6-pack (three-phase-bridge)
DL: 7-pack (three-phase-bridge + AL-chopper)
H: Full single phase H-bridge
M: 2 IGBTs in collector connection

Collector-emitter voltage grade (V_{CE}/V/100)

IGBT-series no.
0: first generation 1988-1991 (collector current grade specified at T_{case} = 80°C)
1, 2: first generation 1992-1996 (collector current grade specified at T_{case} = 25°C)
(600V-types: PT-IGBTs, collector current grade specified at T_{case} = 80°C)
3: second generation (high density-NPT-IGBTs for 600 V and 1200 V),
first generation NPT-IGBT-chips for 1700 V, CAL-diodes;
600 V-types: collector current grade specified at T_{case} = 80°C,
1200 V-/1700 V-types: collector current grade specified at T_{case} = 25°C;
low inductance case
4: high density, lowV_{CEsat}-NPT-IGBT-chips (1200 V, 1700 V)
5: high density, high speed-NPT-IGBT-chips (600 V, 1200 V)
6: Trench-NPT-IGBT-Chips

Features
D: fast inverse diode
K: SEMITRANS 5-case with screw connectors
L: 6-pack-case with solder pins
S: Collector-Sense-Terminal
I: enlarged inverse diode (higher power capability)

SKiiP converter in an automobile with hybrid drive ▷

SEMITOP power modules

The SEMIKRON SEMITOP module range comprises solderable power modules with thyristors, diodes, power MOSFETs and IGBTs; in the following only SEMITOPs with MOSFETs and IGBTs are considered,

e.g. **SK 100 G B 12 3 x**

SEMIKRON component

Current rating in A at $T_h = 25°C$

G: IGBT-switch
M: MOSFET-switch

Circuit
A: Single switch
AL: Chopper module (IGBT/MOSFET + free-wheeling diode at collector side)
AR: Chopper module (IGBT/MOSFET + free-wheeling diode at emitter side)
AH: Asymmetric H-bridge
B: Dual module (halfbridge)
D: 6-pack (three-phase-bridge)
H: Full single phase H-bridge

Voltage grade (V_{CE}/V/100 or V_{DS}/V/100)

IGBT-series
2: PT-IGBT-chips (only for 600 V)
3: high density-NPT-IGBT-chips
4: high density, low V_{CEsat}-NPT-IGBT-chips
5: high density, high speed-NPT-IGBT-chips

Features (not yet defined for SEMITOPs with IGBT and MOSFET-chips)

The fast inverse diode(s) integrated in every IGBT-SEMITOP are not indicated in the designation code.

1.5 Examples for new packaging technologies

New packaging technologies are being developed mainly with regard to:
- improvement of heat dissipation and temperature cycling capability,
- minimized inductances in the module and in the supply leads by means of suitable module construction,
- highly flexible assembly and connection technology, easy mounting at the user's facilities,
- higher complexity of integration (converter circuits),
- integration of monitoring, protection and driver functions,
- delivery of tested electric or thermal-electrical systems.

The following four ranges of power modules, which have been developed with consideration to the requirements mentioned above, are therefore regarded as exemplary.

1.5.1 SKiiPPACK

Figure 1.58 shows the scheme of a SKiiPPACK (**S**emi**k**ron **i**ntegrated **i**ntelligent **P**ower **Pack**).

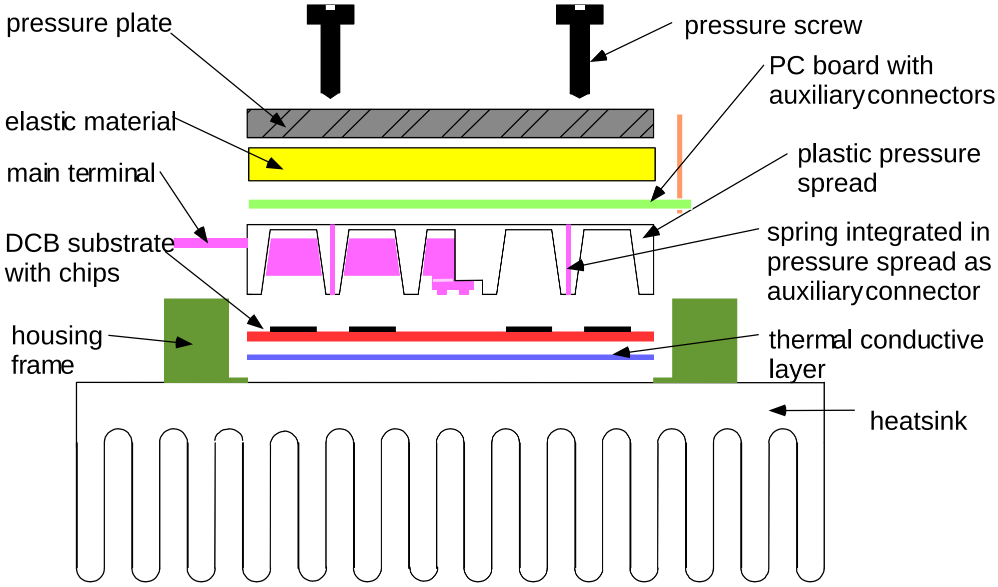

Figure 1.58 Basic SKiiPPACK structure

In contrast to conventional transistor modules, the DCB-substrates carrying the IGBT and diode chips are not soldered on to a copper base plate, but are pressed almost with the complete surface directly to the heatsink by means of a plastic pressure spread. The electrical connection of the DCB to the SKiiPPACK terminals, designed for connection of laminated, low-inductance busbars, is made by pressure contacts and low-inductive track layout. A metal plate serves as pressure element and as thermal and EMI-shield for the driver circuit, which is also integrated into the SKiiP case.
By paralleling many, relatively small IGBT-chips and with their optimal contact to the heatsink, the thermal resistance may be reduced considerably compared to standard modules, since the heat is spread evenly over the heatsink.

Three sizes of cases (2, 3 and 4 arms in GB, GAL or GAR-configuration) and different chip arrangements as well as adapted driver components connected by simple external constructions guarantee the realization of dual modules, H-bridges, SIXPACKS and SEVENPACKs in 600 V-, 1200 V- and 1700 V-technology. 3300 V-SKiiPPACKs are under development.

In Figure 1.59 the special flexibility of the SKiiPPACK principle is explained with an example.

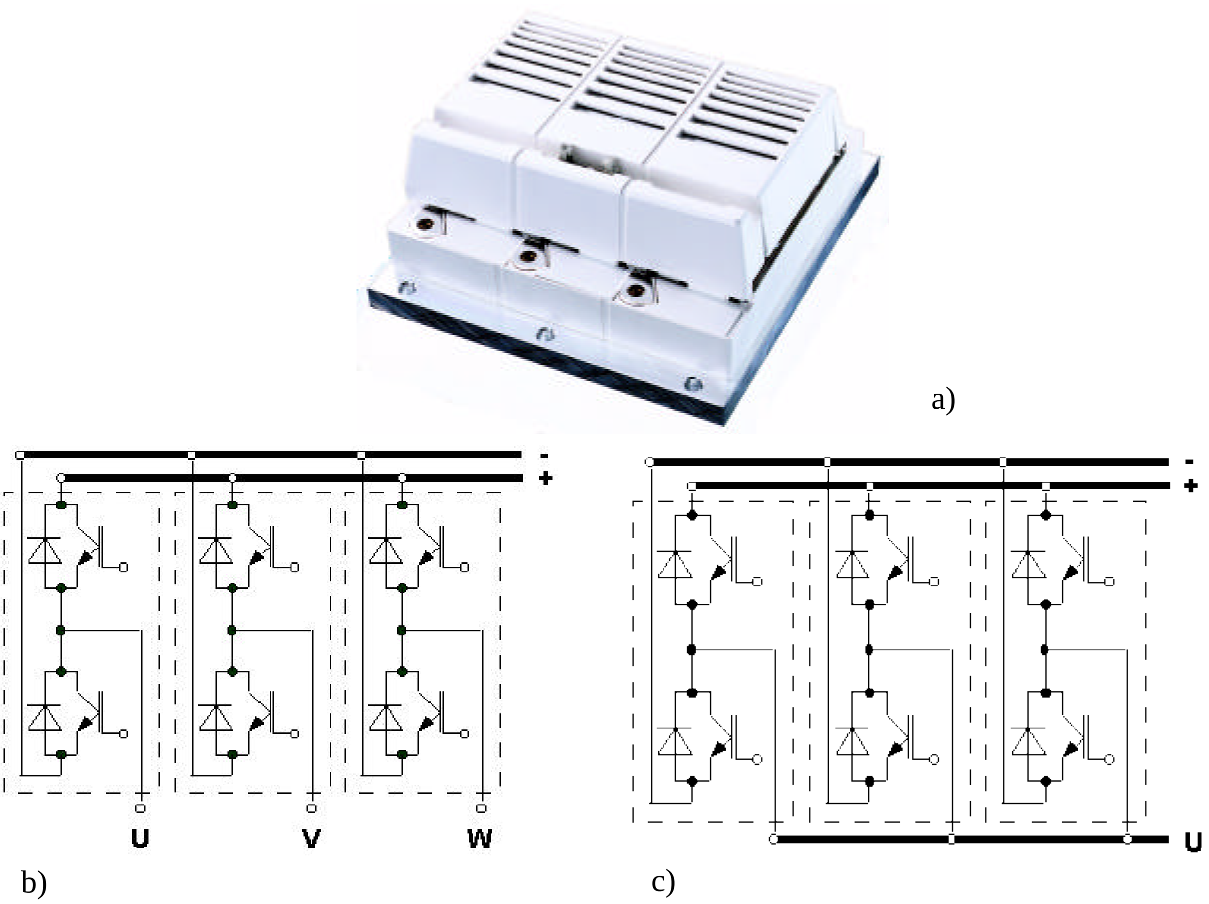

Figure 1.59 Possible applications of a SKiiPPACK with 3 identical DCBs (example)
a) View of a SKiiPPACK on an aluminium heatsink
b) SIXPACK
c) Dual module (halfbridge)

Besides transistor and diode chips, PTC-temperature sensors are integrated into the DCB; their output signal directly affects driver operation (temperature limit) and - due to analogous amplification in the driver - it can also be used for evaluation of the heatsink temperature.
The AC-connectors of the SKiiPPACK accommodate current sensors for overcurrent and short-circuit protection of the IGBTs. Signal processing and linkage is done by the internal driver, which is positioned on the pressure plate; this will be described in detail in chapters 1.6 and 3.5.8. The potential-free current signals may also be used as actual values for external sensors and control circuits.

Advantages offered by SKiiPPACKs in comparison to conventional modules are:
- improved temperature cycling capability,
- reduced thermal resistance by direct heat transfer chip-DCB-heatsink,
- possibility of producing very compact constructions with high power density,
- low switching overvoltages due to thorough low-inductive structure, i.e. high permissible DC-link voltage and reduction of interference generation,
- repairable and recyclable by excluding hard moulding and internal soldering,
- optimal adjustment of internal, intelligent driver,
- load test of complete systems carried out at manufacturer.