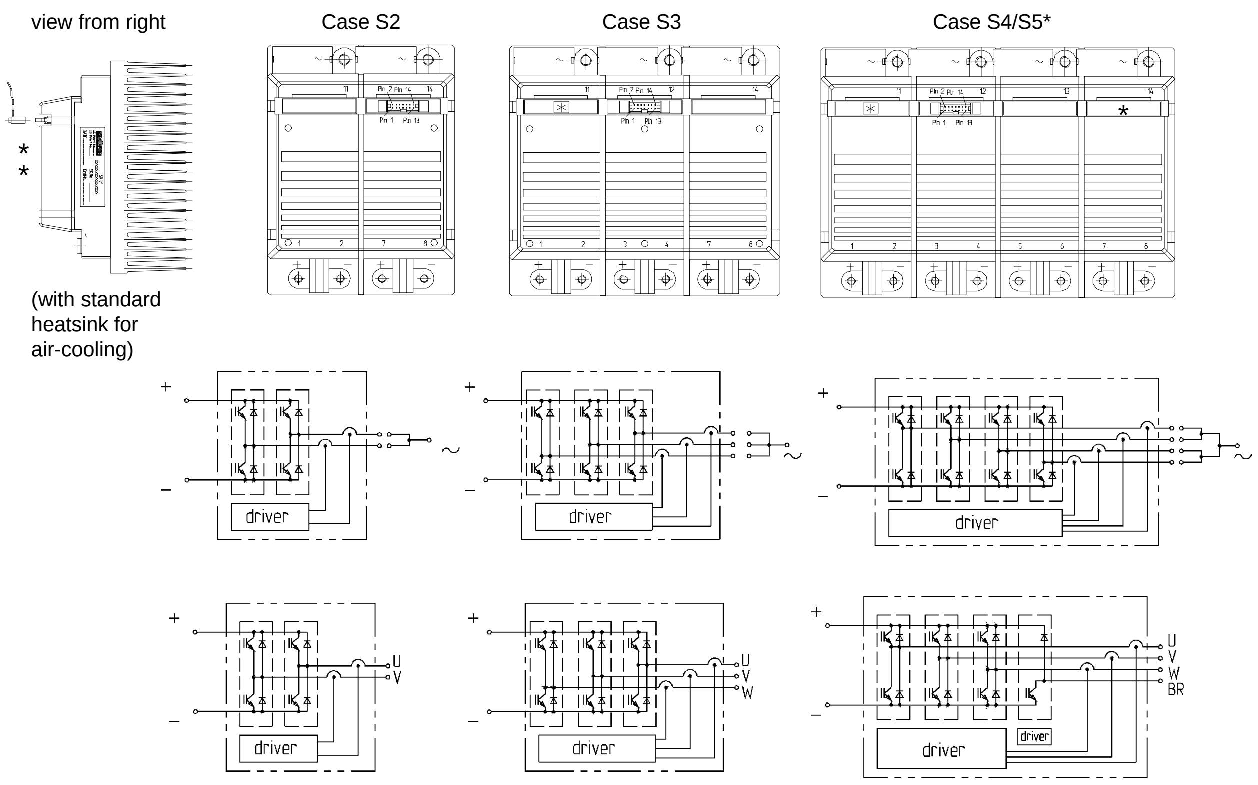
Figure 1.60 shows SKiiPPACK cases and some of standard internal circuits. Further circuits are available and may be integrated if required by the customer, respectively (e.g. brake chopper, asymmetrical bridges).
Besides the heatsink shown below, other air or water-cooled heatsinks may also be used for mounting of the SKiiPPACKs.



* case S5 has an additional DIN-Connector on the right quarter of top (for brake-chopper-input)

** F-Option: fibre optic connectors for driver input and fault detector output

Figure 1.60 SKiiPPACK cases and standard internal circuits

1.5.2 MiniSKiiP

Another new development for the low-power range, which is outstanding for its special flexibility and easy mounting is SEMIKRON's MiniSKiiP with pressure contacts, the basic structure of which is shown in Figure 1.61.

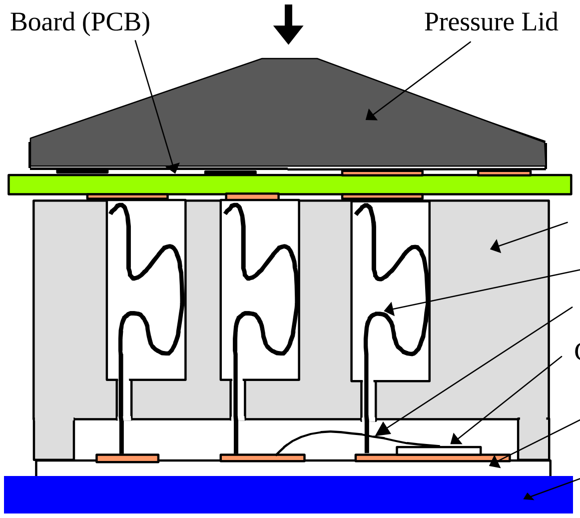


Figure 1.61 Basic structure of a MiniSKiiP

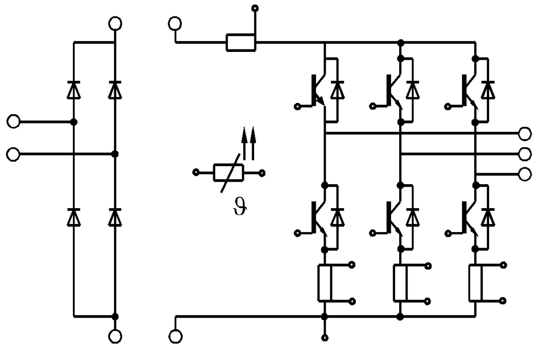
Basic elements of a MiniSKiiP are:
- DCB isolation substrate with soldered, wire-bonded semiconductor chips (e.g. IGBTs, MOSFETs, diodes, thyristors) as well as other components, such as current and temperature sensors, resistors and capacitors,
- silicone filled case with integrated contact springs and glued in DCB and
- hard plastic cover.

One or two screws take care of all electrical and thermal connections (to the heatsink) making a detachable connection between SKiiP cover, PCB, MiniSKiiP and heatsink. The contact springs have several functions: they serve as the electrical connection between the power semiconductors on the DCB and the other circuits on the PCB, and also as pressure spring pad between DCB and heatsink in the mounted state.
The high number of springs spread over the total MiniSKiiP area provides for even pressure between components and heatsink, which guarantees a low thermal resistance.

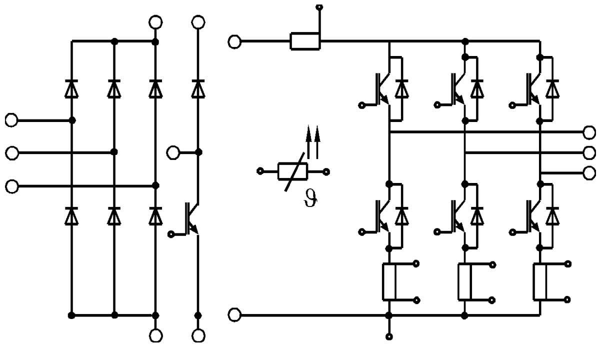
For the current range above 10 A, the contacts are connected in parallel. The multitude of spring shafts results in a high degree of flexibility concerning the production of many different circuits for drives and power supplies as well as other applications.

Several types of cases designed for different power ranges are available from MiniSKiiP 1 (line voltage up to 230 V, rated current up to 12 A) to MiniSKiiP 8 (line voltage up to 400 V, rated current up to 125 A) (Figure 1.62).

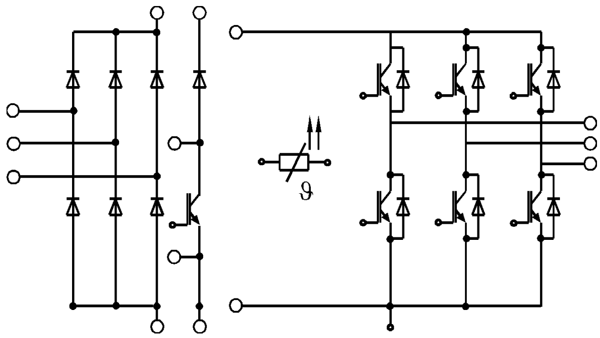
MiniSKiiP
Case M 1



MiniSKiiP
Case M 2

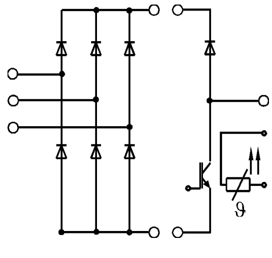


MiniSKiiP
Case M 3



MiniSKiiP
Case M 8a; Case M 8

M 8a



M 8

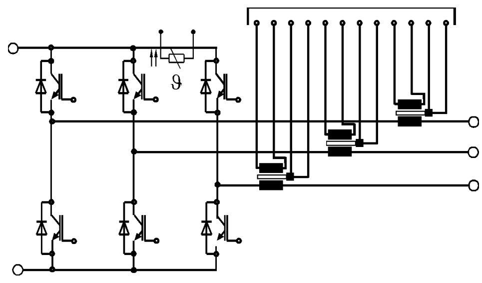


Figure 1.62 Standard MiniSKiiP types and circuits

In the biggest MiniSKiiP (MiniSKiiP 8) curved, pressure contact springs are used because of the high currents applied; these can be supported by compensating current sensors on the AC-side. (Figure 1.63).

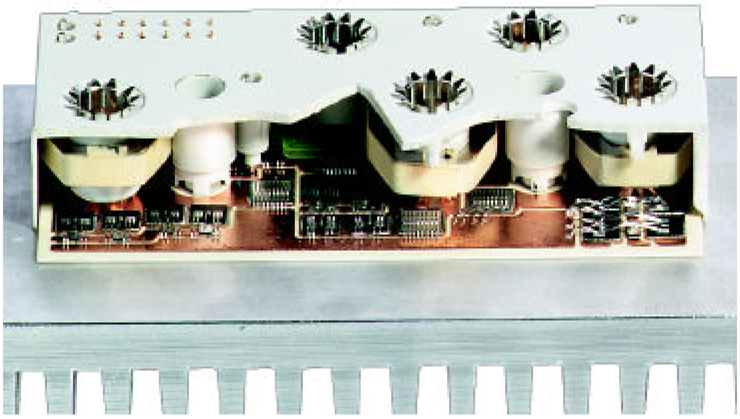


Figure 1.63 MiniSKiiP 8 curved springs with current sensors

In order to avoid too high a concentration of heat sources, the standard circuit is divided up over two cases, one of them containing the uncontrolled or half-controlled bridge rectifier and the brake chopper, the other containing the three-phase-converter.

1.5.3 SEMITOP

The product range of SEMITOP, which has already been mentioned, comprises 3 types of cases (see Figure 1.57).
Just like SKiiPPACK and MiniSKiiP, SEMITOP is also assigned to those constructions without base plate that generate widespread pressure of the DCB to the heatsink by a special construction of the plastic housing.
One or two screws make a closed linkage between module and heatsink. In contrast to MiniSKiiP the contacts to the PCB are made by two lines of solder pins.
Due to the ability of such a small module to integrate up to 12 power components, SEMITOP is used preferably in low-size applications. The unrestricted useability of the space between the solder pins for other printed circuit board components is advantageous in comparison to MiniSKiiP, which is very similar in its technology.

1.5.4 New low-inductive IGBT module constructions for high currents and voltages

A very interesting and promising development in high-power electronics (e.g. 1.2 kA and 2.5/3.3 kV) is the low-inductive FLIP-module (ABB Semiconductors, [6]) and the SKiM20-module (without base plate) by SEMIKRON (Figure 1.64).
These modules had been designed especially for high-power range. Therefore, the development goals had been mainly high reliability (high power and temperature cycling capability), good heat dissipation behaviour (decentralized heat sources / low thermal resistances), minimized inductances in the module and module busbarring as well as safe failure behaviour (explosion protection by means of defined areas for pressure balancing).
Figure 1.64 shows the basic assembly of a SKiM20-module as the most modern version of such module constructions.

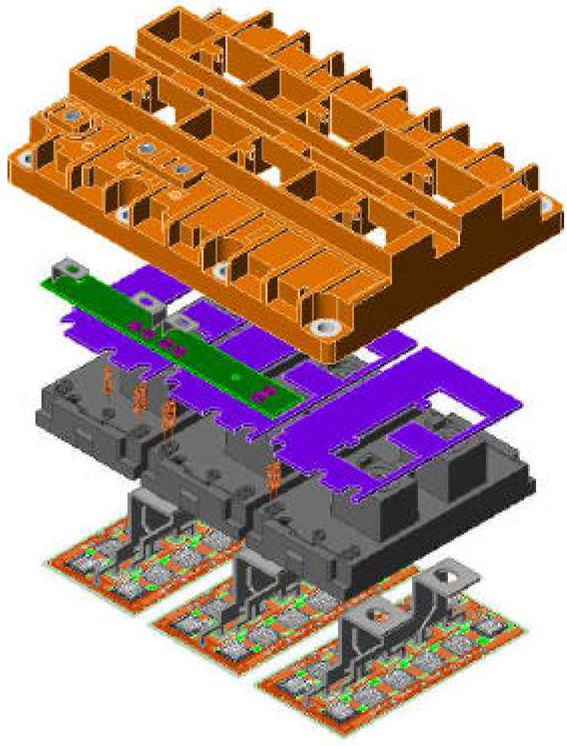


Figure 1.64 Construction of an IGBT-module SKiM20

As the other SKiM-models shown in Figure 1.57 the SKiM20 has no base plate. From this the advantageous basic features discussed in chapter 1.4.2.4 (Figure 1.54) result. The semiconductor chips are arranged on three small areas of AlN ceramic substrates.
One ceramic substrate combined with a case element and a pressure spread element made from plastic as well as a pressure plate forms a sub-module. The pressure spread element presses the substrate almost over its full area to the heatsink. The main terminals of each sub-module are soldered to the substrate. The control and auxiliary terminals are made as pressure contacts.
The case cover also acts as pressure element.

1.6 Integration of sensors, protective functions, drivers and intelligence

In the following, some examples for the integration of peripheral functions in power modules are described, sorted by increasing degrees of integration.

Sense IGBT-Module

Sense IGBT-modules contain sense-IGBTs as described in chapter 1.2.4.

Compared to solutions with shunts in the emitter circuit, a much higher measuring resistance may be chosen. Other than with overcurrent protection by V_{CE}-monitoring, either shorter dead-times are required or none at all.

Modules with integrated temperature sensor

As an alternative to the *TEMPFET* (see chapter 1.2.4) as a solution for discrete power semiconductors, simple PTC-temperature sensors in SMD-design are being used in modules more and more, with a higher degree of integration; they are soldered on to the DCB-substrate near the chips.
The heatsink temperature is indicated at a defined point by the sensors. Ideally, the transversal heat flow between this point and the heatsink areas under the hottest chips may be neglected. A suitable evaluation board takes care of overtemperature protection by active control on the driver or processing the analogous signal.

Rugged Modules [281]

Besides the IGBT hybrid protective circuit are integrated into the case for protection of the IGBT in case of failure. The terminal behaviour are determined by the driver just as with conventional IGBTs; the protective circuits are activated only in case of failure and will limit the short-circuit current.

*IPM (**I**ntelligent **P**ower **M**odules) [280]*

IPM modules are able to integrate, in addition to the IGBTs and free-wheeling diodes, drivers and protective units (IPM minimal configuration) as well as complete inverter control units. The user, himself, can no longer control switching and on-state characteristics, therefore IPMs are often designed specifically for the application (ASIPM = **A**ppl. **S**pecif. **IPM**).

*SKiiPPACKs (**S**emi**k**ron **i**ntegrated **i**ntelligent **P**ower **Packs**)*

As already described in chapter 1.5.1, SKiiPPACKs contain a driver unit, laid out as an SMD-PCB, which integrates all the necessary protective and monitoring functions and which is positioned over the pressure plate. (see Figure 1.58).

SKiiPPACKs may be driven and supplied on potential of the superordinated control system (CMOS or TTL level). The SKiiPPACK driver integrates all necessary potential separation, a SMPS and the power drivers.

SKiiPPACKs are equipped with current sensors in the AC-outputs and temperature sensors as well as an optional DC-link voltage sensor. The driver valuates the signals transmitted by the sensors in order to care for overcurrent/ short-circuit, overtemperature and overvoltage protection as well as supply-undervoltage protection. An error signal and standardized analogous voltage signals of the actual AC-output current value, the actual heatsink temperature and, optionally, the DC-link voltage are available on separate potentials at the driver connector for evaluation in the superordinate control circuit.

Figure 1.65 describes the OCP (**O**ver **C**urrent **P**rotection) driver principle, which will be detailed in chapter 3.5.8.

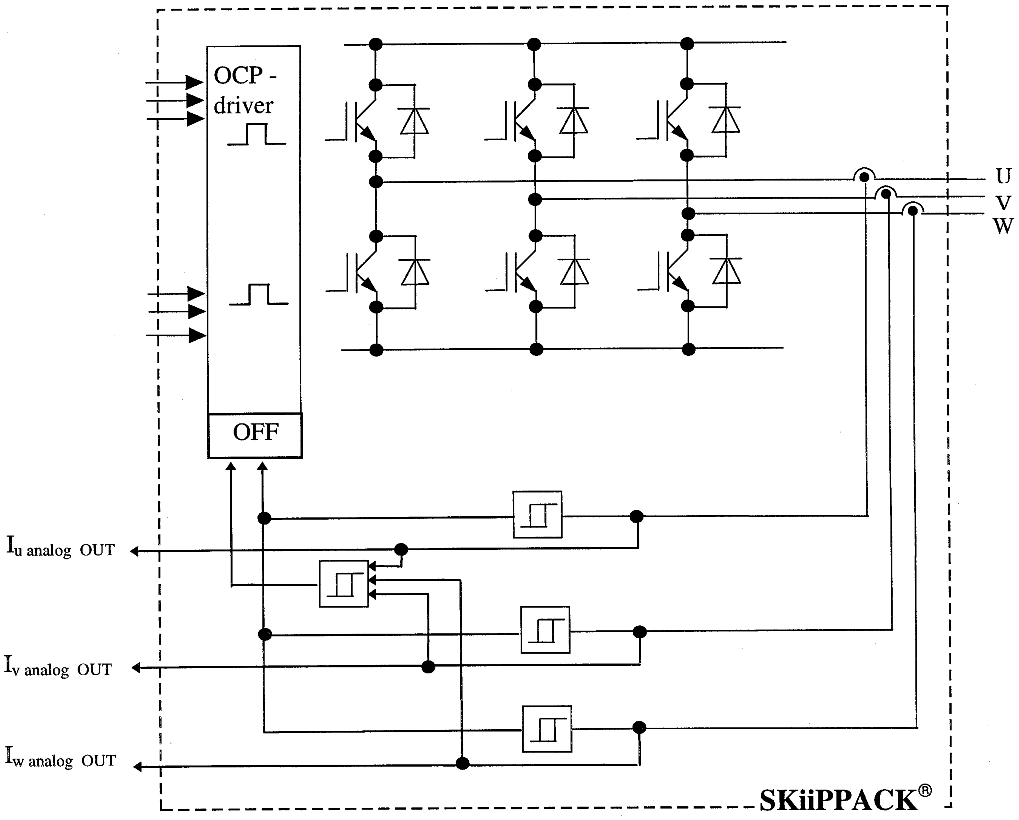


Figure 1.65 OCP-driver principle [264], [265]