SKiiP® power modules

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- SKiiP Technology
- SKiiP – Technical Details
- SKiiP – Logistical Details

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SKiiP

Introduction

Power semiconductors

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Discrete | Modules | Systems

IGBT

MOSFET

Thyristor

Diode

CIB

SEMITOP

MiniSKiiP

SEMI-TRANS

SEMiX

SKiM

SKiiP 2, 3

SEMI-STACK

SEMIPONT

SEMIX

SEMIPACK

Low power rectifier

Chips | Driver | Heat sink

Competence

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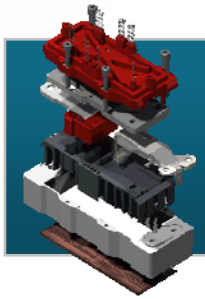
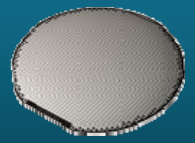
Technologies

Electronics



Packaging



Chip

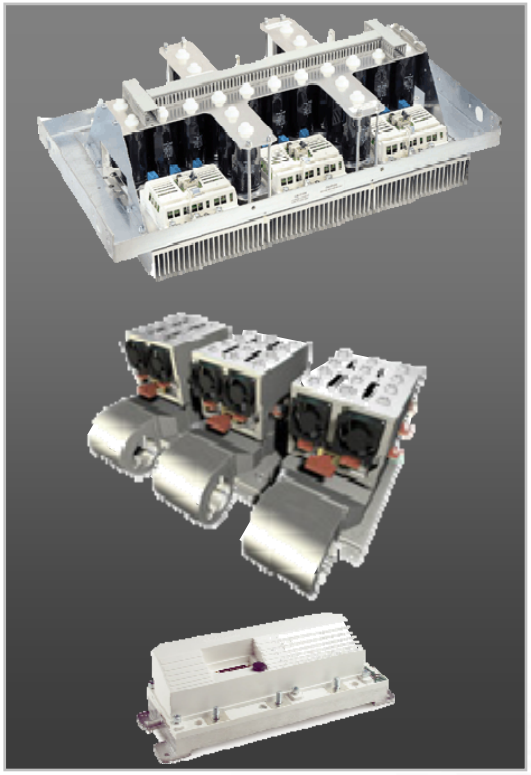
Components

IPM

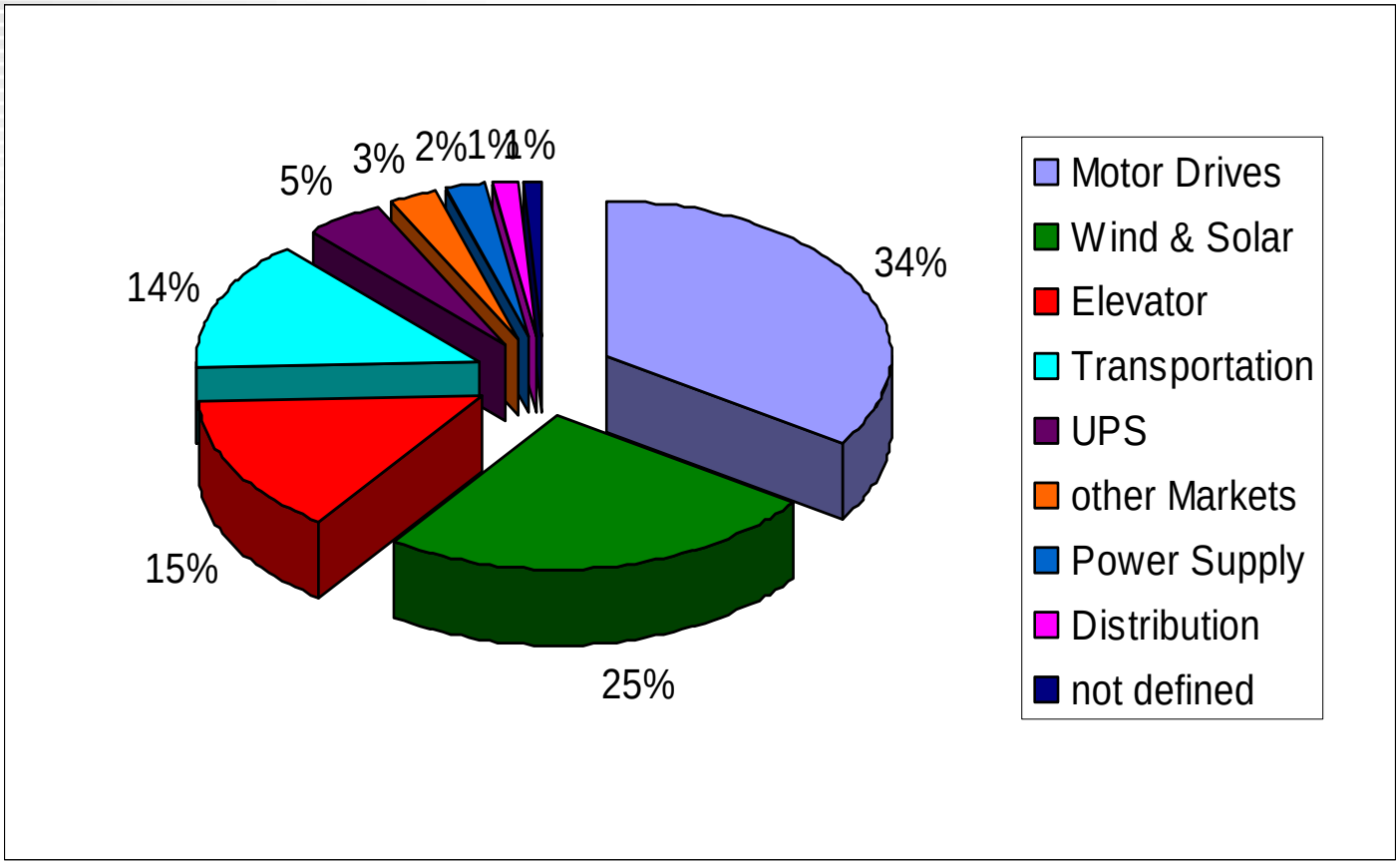
Module

Discrete

Systems



SKiiP markets



SKiiP: 20% of Semikron Germany turn over

SKiiP® family

Features

- **pure pressure contacted system**
- **integrated driver circuit and sensors**
- **cooling system**

Power Range

- **SKiiP® 2**
  - 150A -1200A / 1200V, 1700V
  - Motor power range from 37kW to 500kW
  - Circuits: half bridge, 1-phase bridge, 3-phase-bridge, chopper
- **SKiiP® 3**
  - 300A - 2400A / 1200V, 1700V
  - Motor power range from 55kW to 750 kW
  - Circuits: half bridge (GB), 3-phase-bridge (GD)

SKiiP® Systems Introduction

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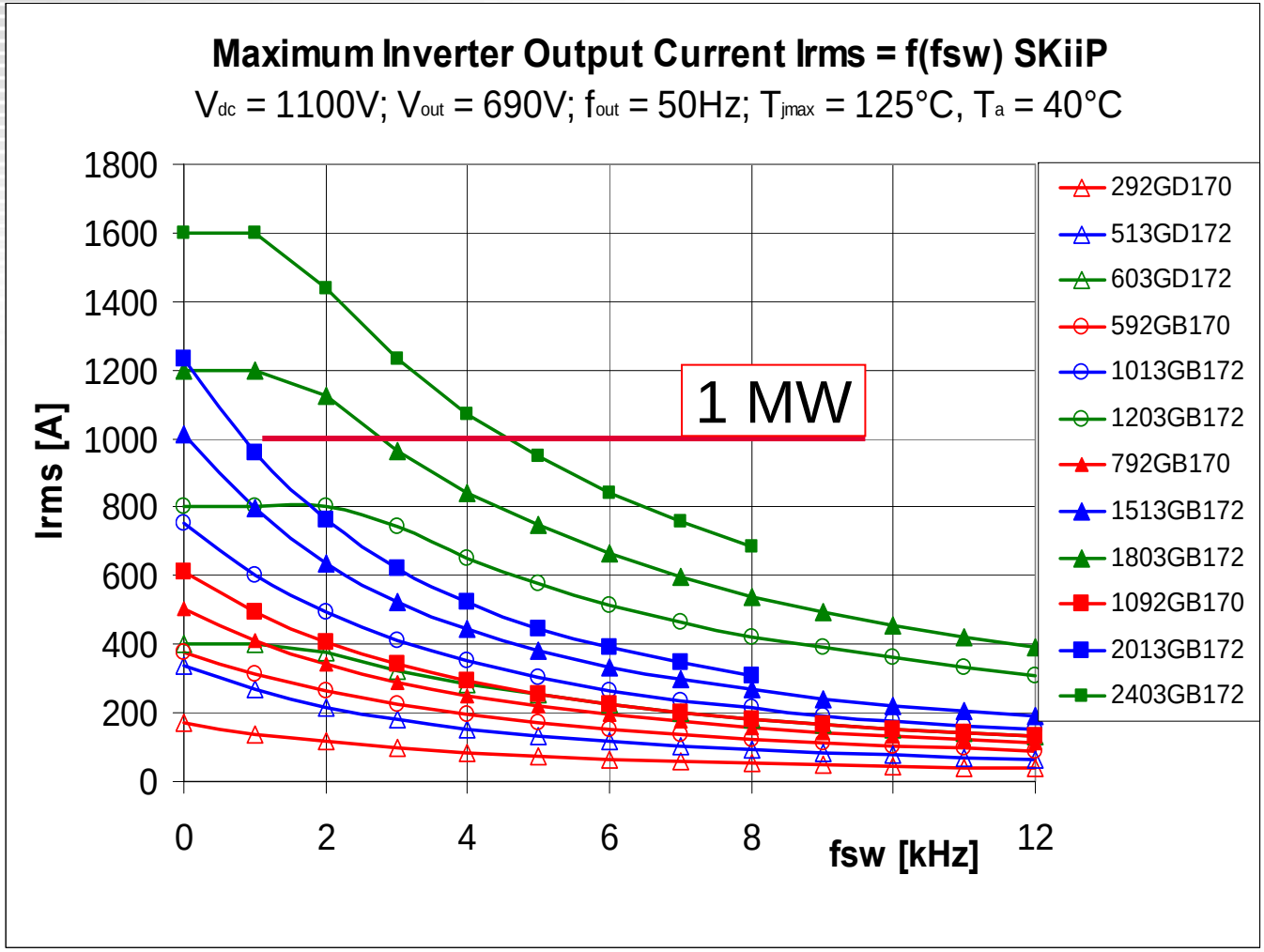
SKiiP® Systems feature

- **IGBT and CAL® diode power semiconductors assembled with SKiiP® technology**
- **Integrated gate driver**
- **Integrated sensors**
- **Integrated heat sink**

Max. Power range overview (example 1700V SKiiP)

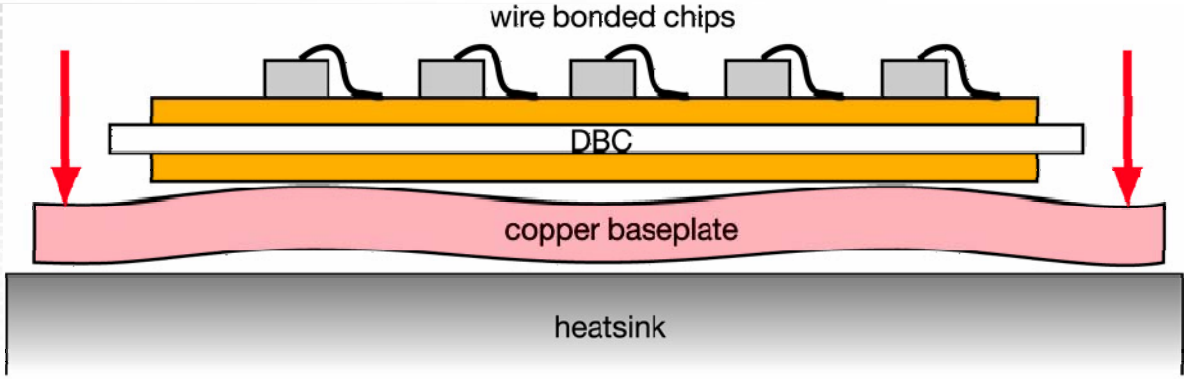


Green
water-cooled SKiiP3
Blue
air-cooled SKiiP3
Red
air-cooled SKiiP2

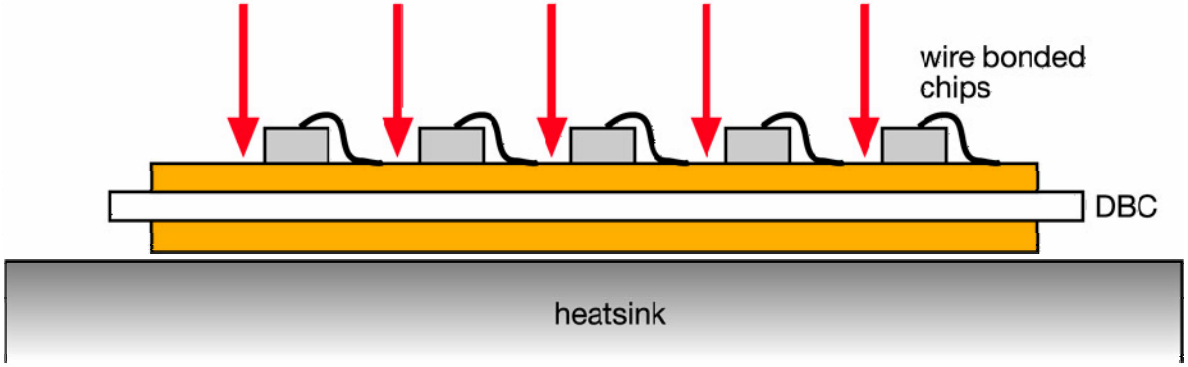
SKiiP

Technology

Comparison module with and without copper baseplate



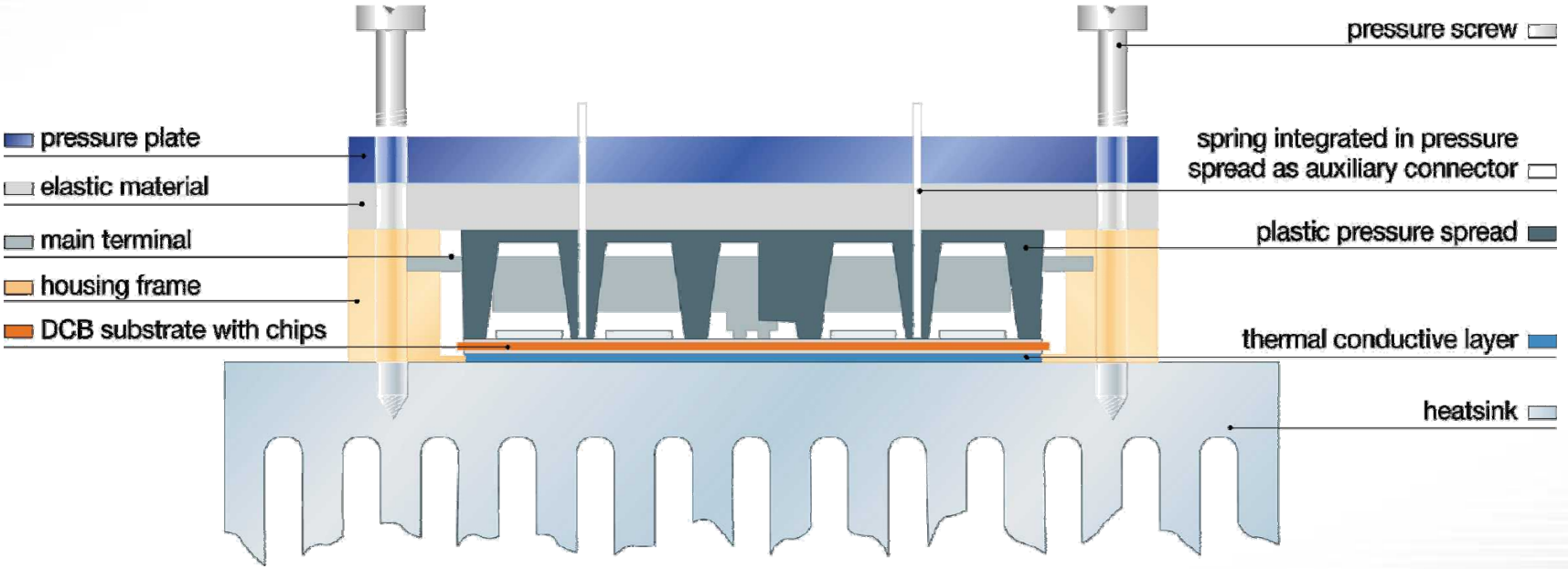
Baseplate mounted module expansion behavior at high temperatures



Distributed vertical pressure

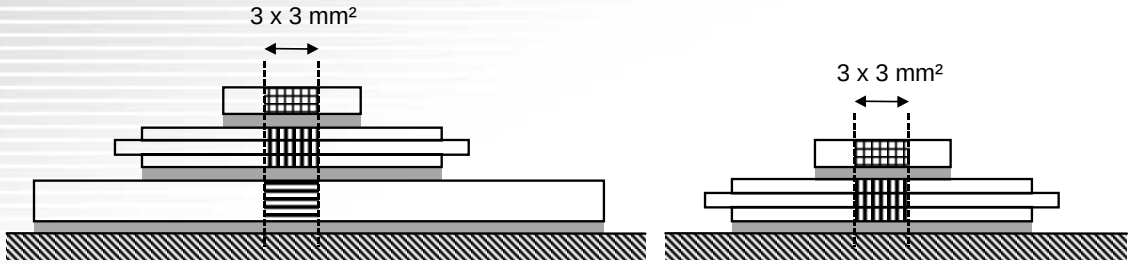
SKiiP® technology

- base plate free power section
- inherent pressure contact technology for thermal and electrical contacts
- low stray inductance, homogenous current distribution

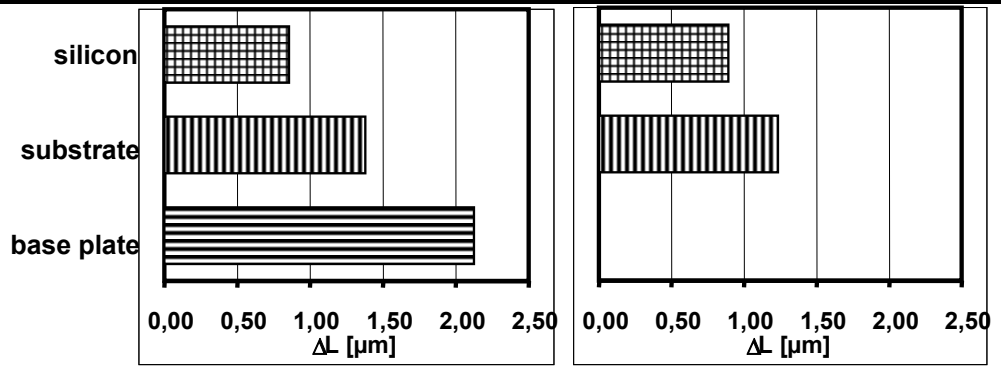


SKiiP® technology

Comparison: Match of thermal expansion Module - SKiiP® (AL_2O_3 - substrate)



System:	standard 34mm module 0,38mm-Al2O3 / Cu base plate			SKiiP pressure system 0,38mm-Al2O3		
Results:	T-Tkk [K]	ΔL/L [1E-6/K]	ΔL [µm]	T-Tkk [K]	ΔL/L [1E-6/K]	ΔL [µm]
silicon	69,7	4,1	0,86	62,6	4,1	0,77
substrate	55,4	8,3	1,38	48,3	7,8	1,13
base plate	40,5	17,5	2,13	—	—	—



thermal fatigue in power modules

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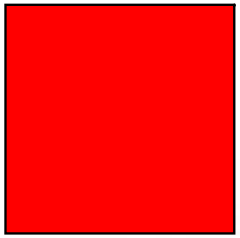
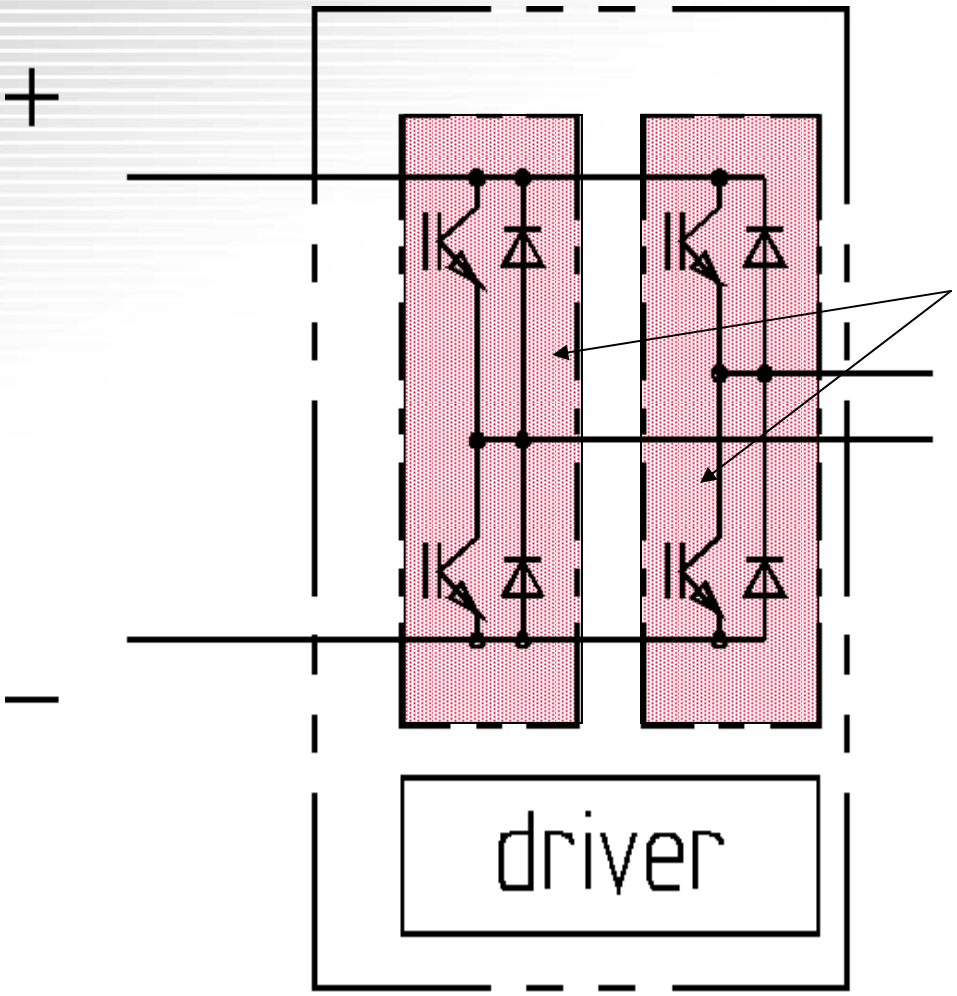
R = characteristic figure for reliability risc considerations when two different materials are joined by soldering, brazing or welding

R = difference in CTE (Coefficient of Thermal Expansion) X length of mechanical contact

typical example	difference in CTE		length of contact		reliability risc R
wire bonding		X		=	
soldering of chip to substrate		X		=	
soldering of substrate to baseplate		X		=	

guarantees low inductance in commutation circuit



SKiiP® technology

Semiconductors of commutation circuit, i.e.
TOP switch - BOTTOM diode
BOTTOM switch - TOP diode,
are integrated on one ceramic substrate:
=> low inductance
=> low voltage overshoot
=> high utilisation of Vces

guarantees homogenous current distribution

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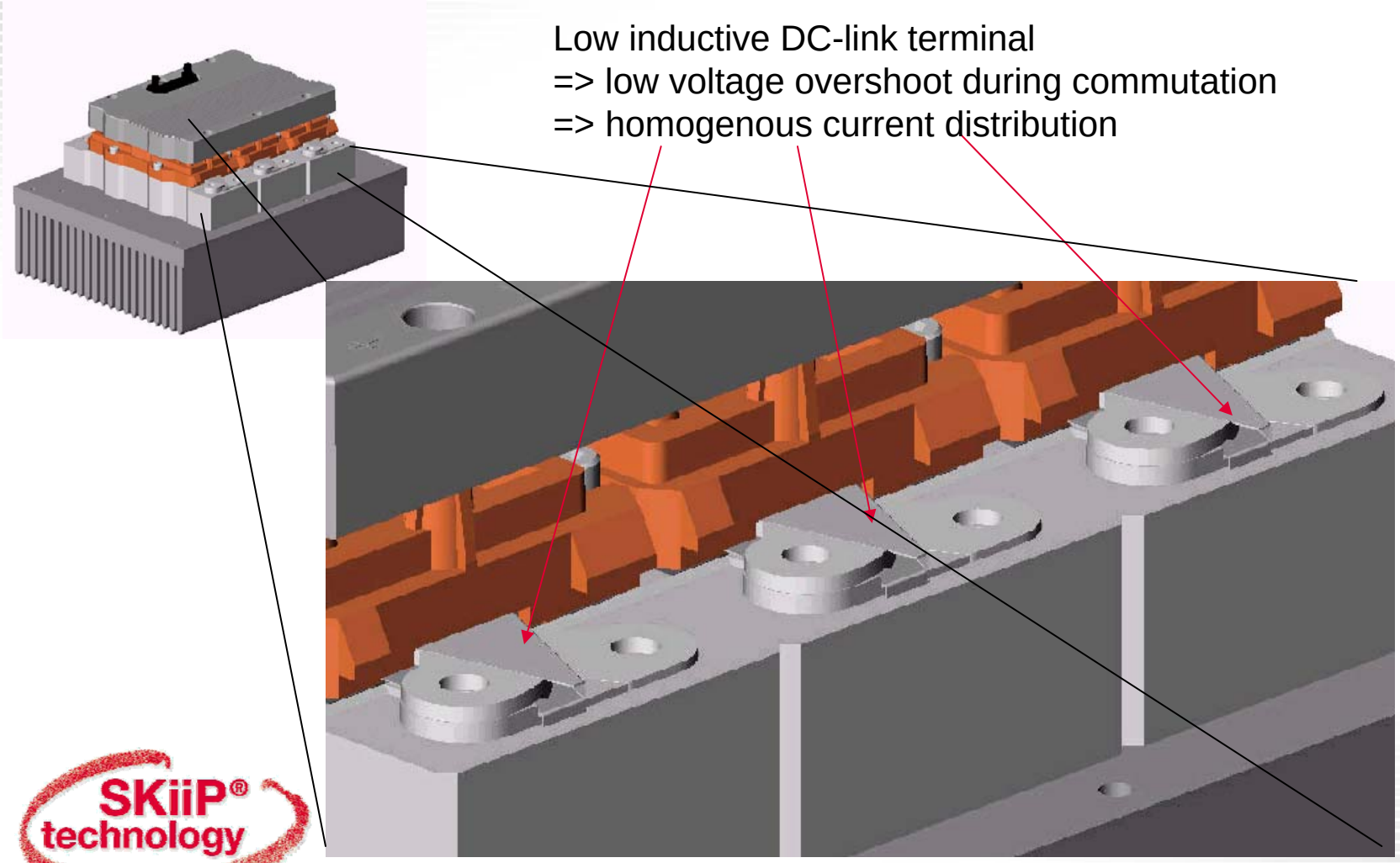

SKiiP® technology

Summary: Benefits of SKiiP® technology

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- no solder ceramic to baseplate => no thermal fatigue => outstanding thermal cycling capability
- more homogenous contact module-heat sink => lower Rthjh => longer lifetime
- full utilization of high performance AlN ceramic => best cost/performance ratio
- multiple paralleled terminals => homogenous current distribution
- DC-terminals prepared for low inductive connection to DC-link => low voltage overshoot during commutation => high DC link voltage feasible, e.g. 900V for 1200V SKiiP

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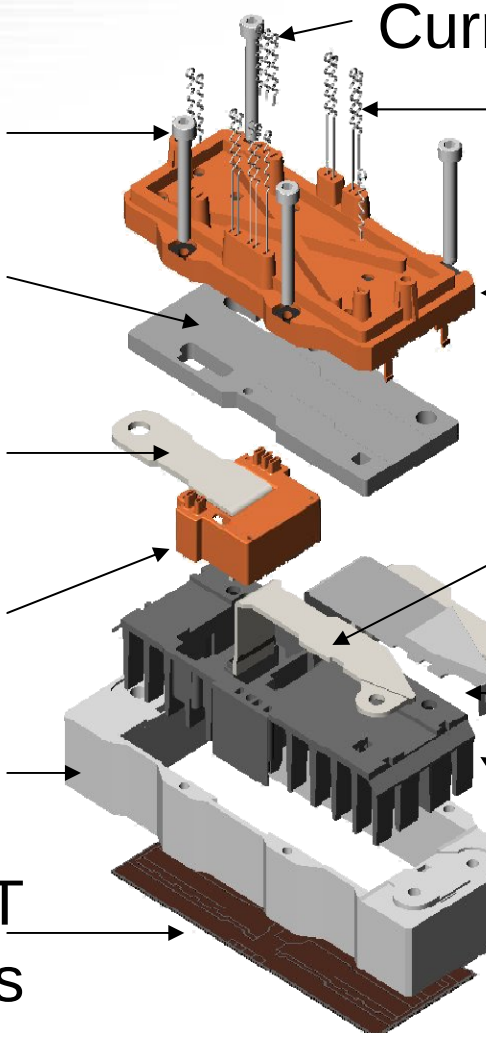
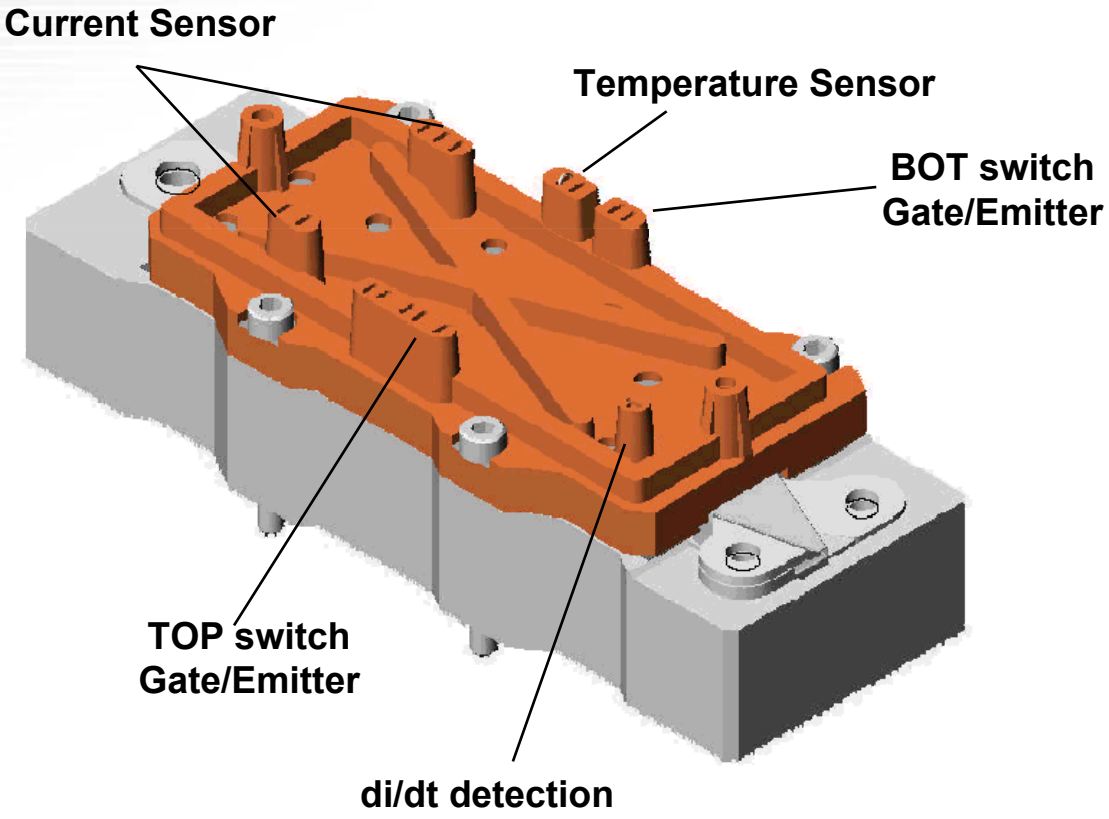
SKiiP - Technical Details

Example: SKiiP® 3 power section assembly with



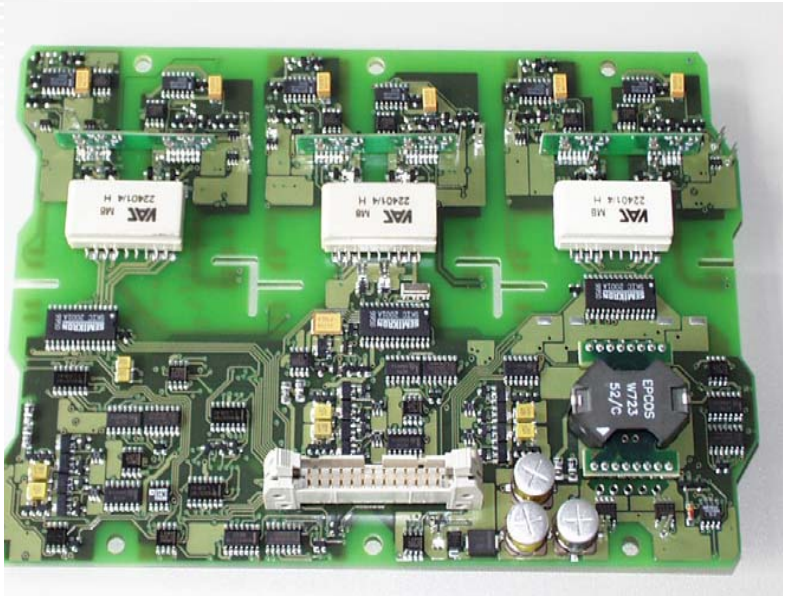
Current sensor springs
Gate/Emitter
mounting screws
Pressure part with steel inlay
spring pad
AC- Terminal
DC- Terminals
Current sensor
Isolation foil
Case
Bridge element
DCB including IGBT and CAL diodes

Connection to driver

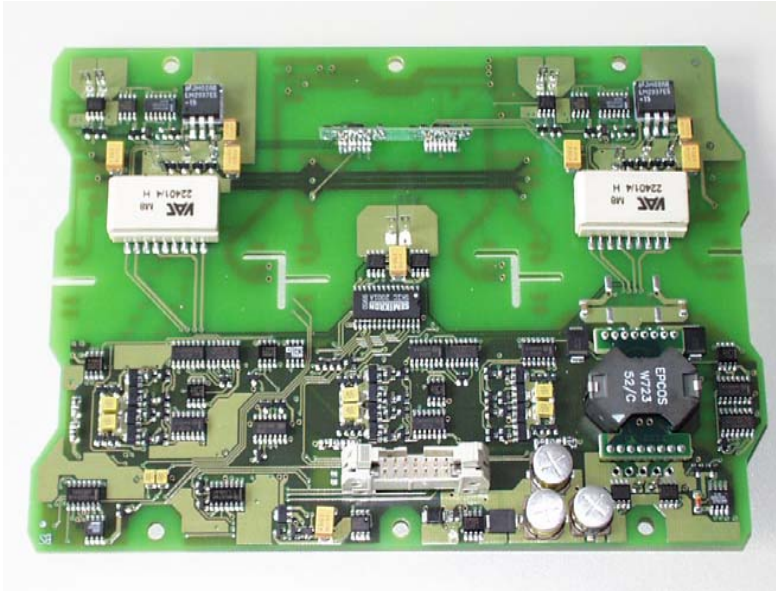


SKiiP® 3 gate driver

(without cover and moulding)

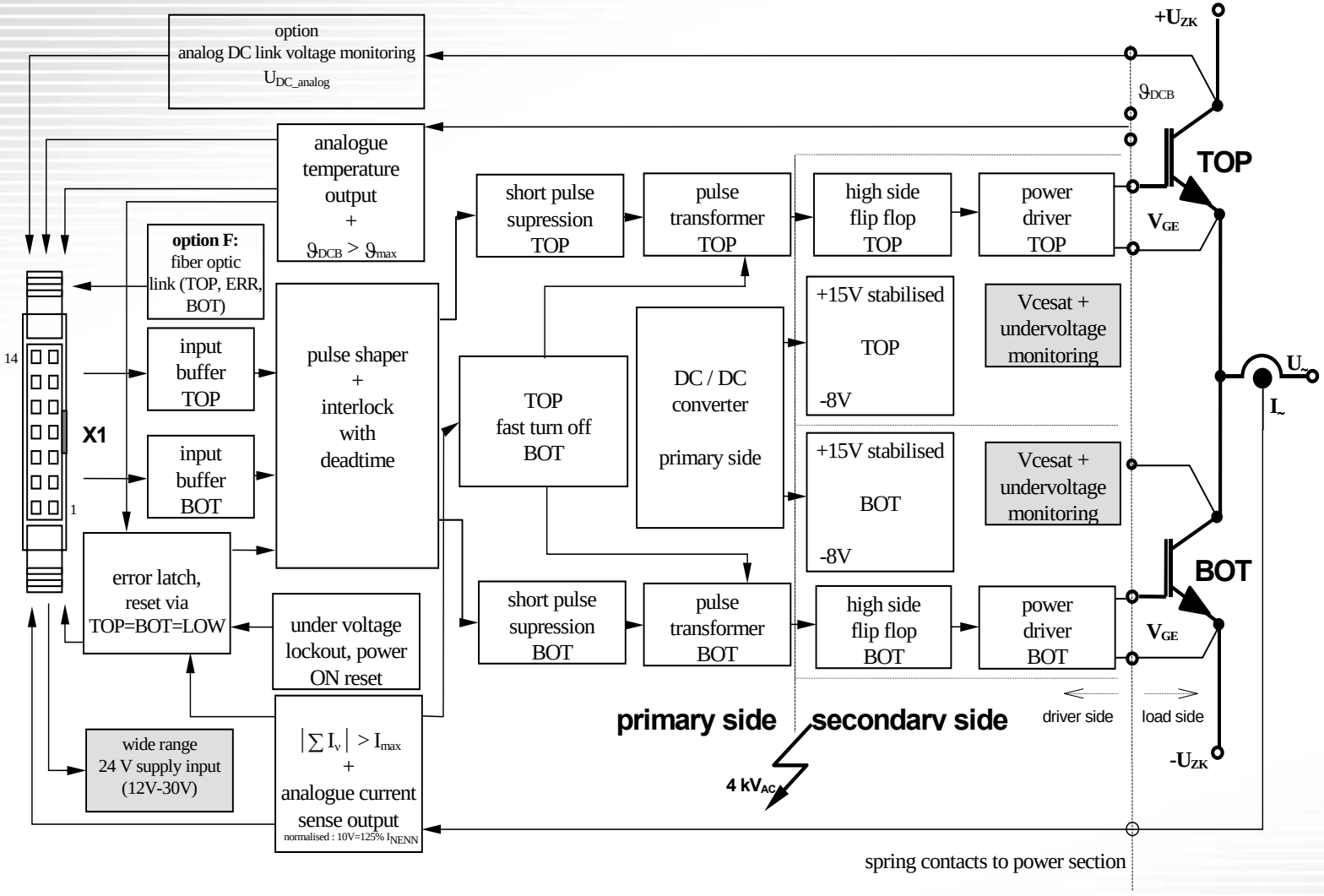


GD- Driver

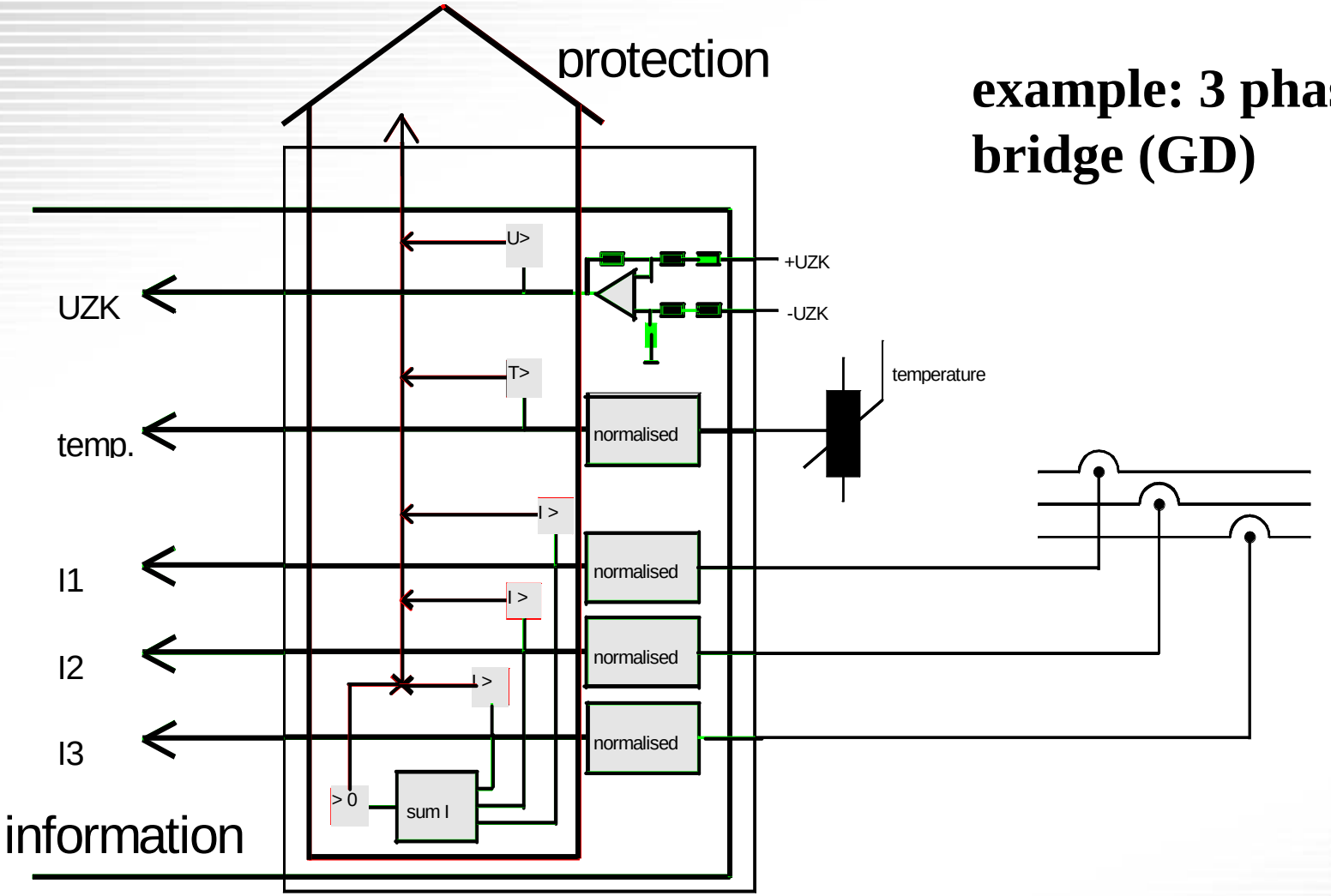


GB 3-fold Driver

SKiiP® System: Integrated gate driver example: block diagram dual gate drive

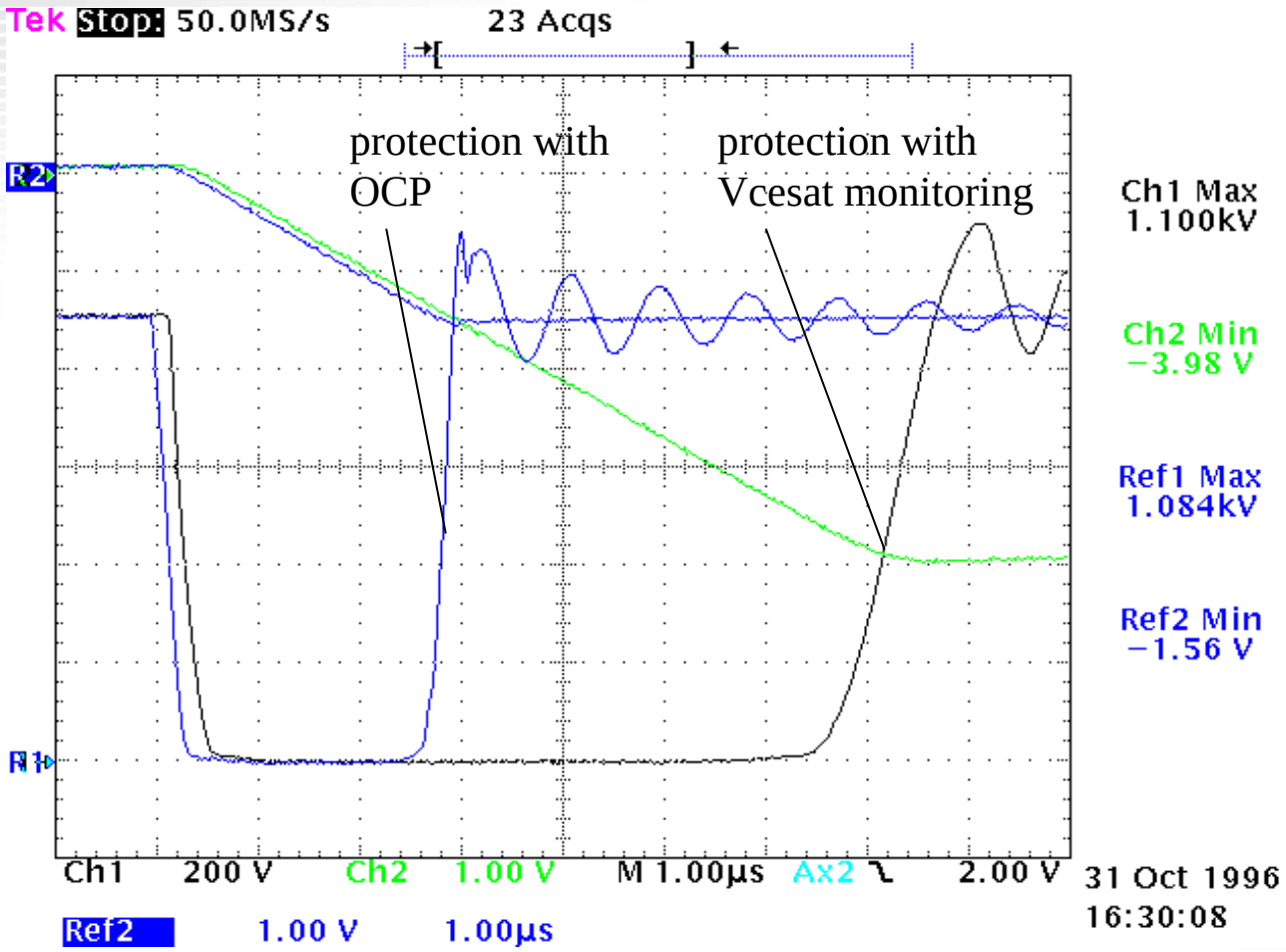


Integrated functions for *protection and information*



example: 3 phase bridge (GD)

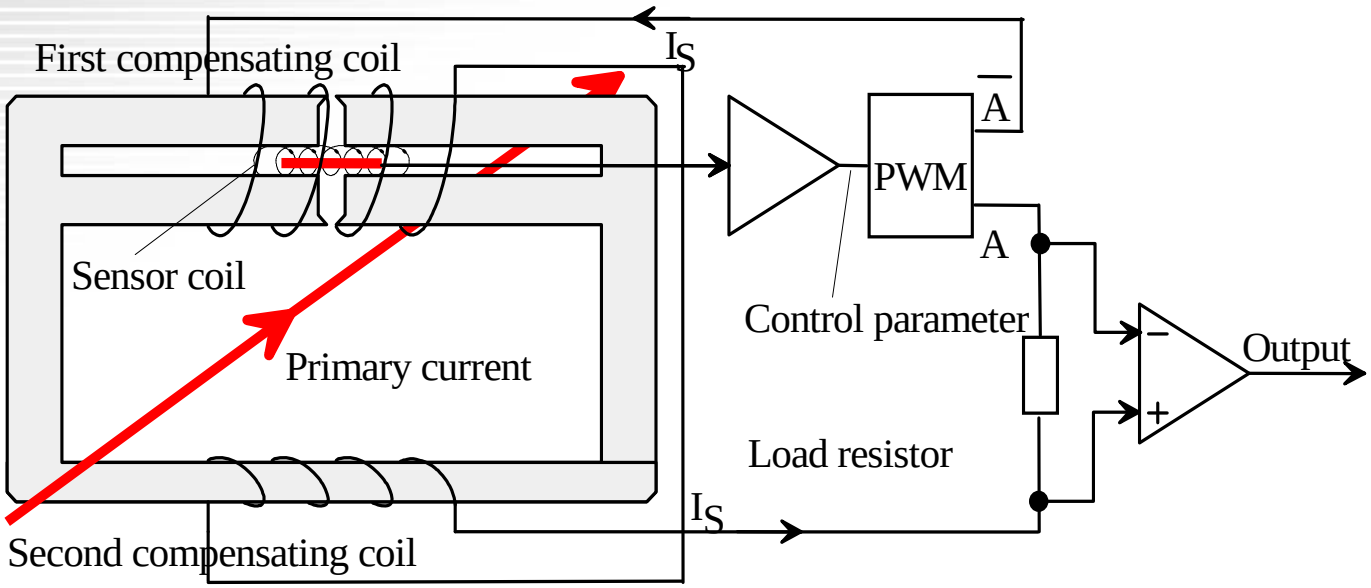
Protection comparison: V_{CEsat} monitoring versus OCP



Protection and supervisory functions

- interlock and dead time generation for TOP and BOTTOM IGBT
- short pulse suppression
- input pulse shaping
- input signal clamping
- under voltage monitoring of the (internal) supply voltage on primary side (SKiiP2/3) and secondary side (SKiiP3)
- transient over voltage and inverted polarity protection by suppressor diode
- ceramic substrate over temperature protection (if forced air cooling is used)
- short circuit and over current protection
- Vcesat protection (SKiiP3)
- line to ground fault protection (only for type SKiiP2 GD, GH)
- over voltage protection of the DC link voltage (optional; SKiiP3 GD: standard

Compensated current sensor: working principle



Compared with Hall effect sensor

- No temperature dependence of the off-set
- Negligible offset failure

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SKiiP – Logistical Details

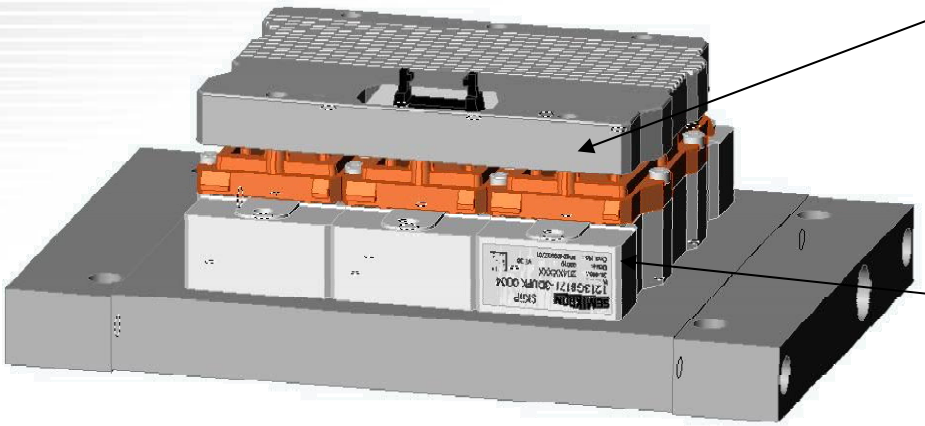
SKiiP® 3 type designation system

SKiiP ❶❷❸ ❹ ❺❺❻❻ ❼ - ❽ ❾❾ ❿

SKiiP3 example: SKiiP 5 1 3 G D 1 2 2 - 3 DU L

❶ nominal current I_C (@ $T_{heatsink}$=25°C) divided by 100 as e.g. 500A →5, can contain 2 letters eg. 15,
❷ SKiiP3: insulation DBC (direct bonded copper) ceramic substrate type
0 →standard aluminum nitride (AlN) DBC ceramic
1 →standard aluminum oxide (Al_2O_3) DBC ceramic
❸ SKiiP generation , e.g. 3 for 3rd generation
❹ chip type as e.g. G = IGBT
❺ circuit B →2 - pack (half bridge, dual) H →4 - pack (single phase bridge)
D →6 - pack (3 phase bridge) DL →6 - pack + brake chopper
❻ voltage class 12 →V_{CES} = 1200 V 17 →V_{CES} = 1700 V
❼ chip generation
❽ number of used modular half bridges (2-packs)
❾ SKiiP3: gate drive designator
DU →gate driver with DC-link voltage measurement and over voltage protection
D →gate driver without DC-link voltage measurement
DUF →gate driver with DC-link voltage measurement, over voltage protection and F-Option (optional for GB type only)
DF →gate driver without DC-link voltage measurement and F-Option (optional for GB type only)
❿ SKiiP3: heat sink designator L →standard profile for forced air cooling
W →standard profile for liquid cooling, K →Customer specific heat sink

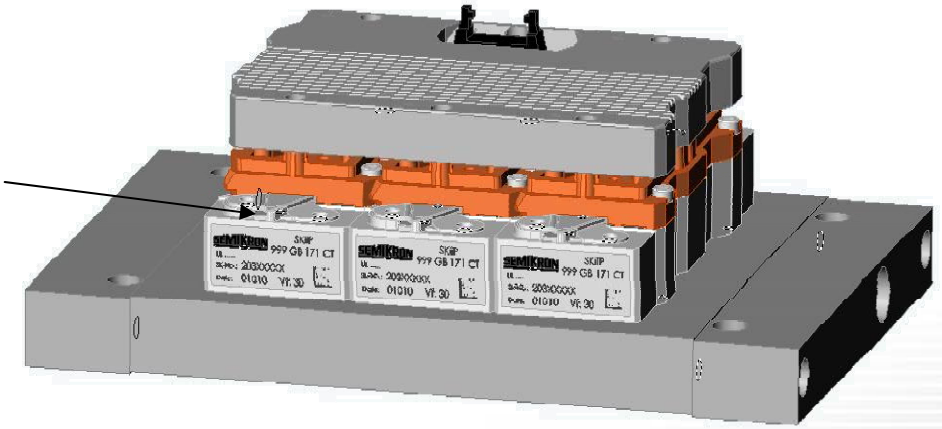
position of SKiiP® 3 System and half bridge labels



AC terminal side:
SKiiP® 3 Driver Label

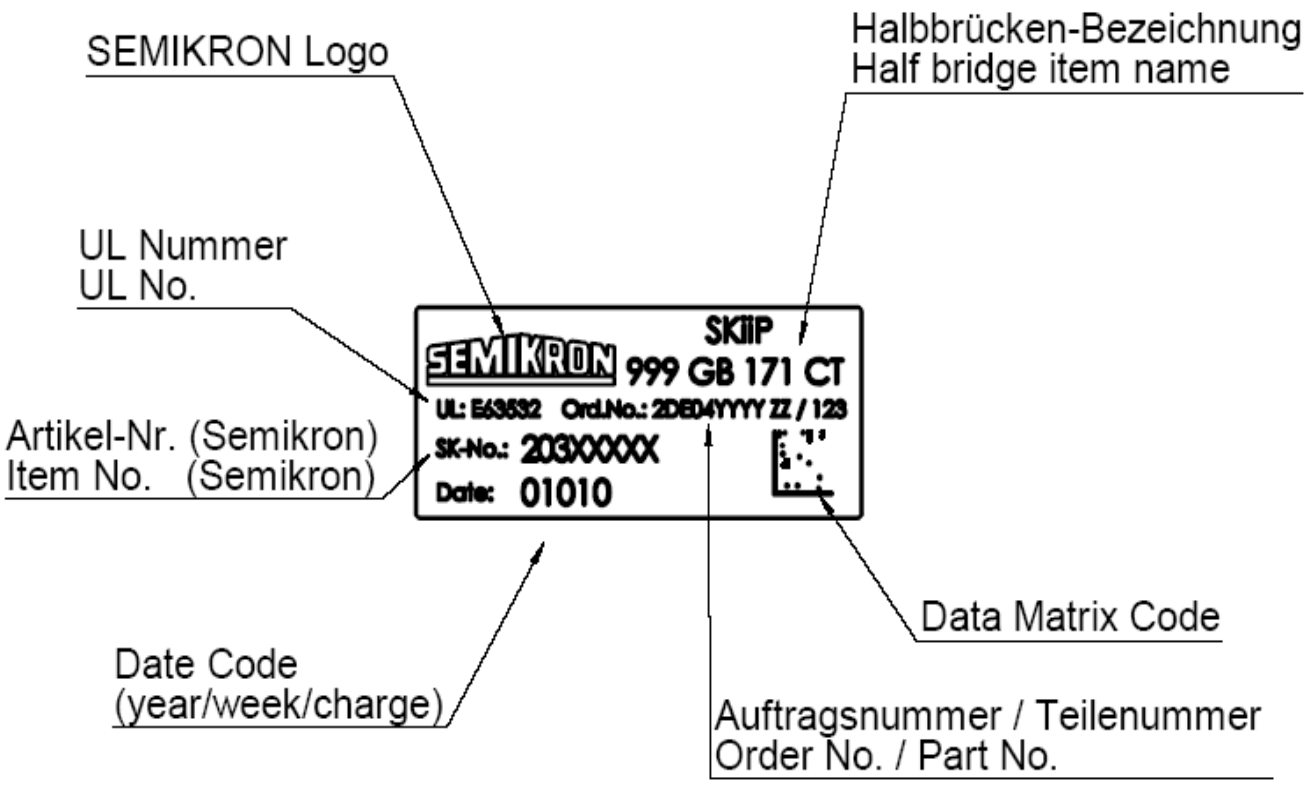
AC terminal side:
SKiiP® 3 System Label
(upside down)

DC terminal side:
SKiiP® 3 Halfbridge Label



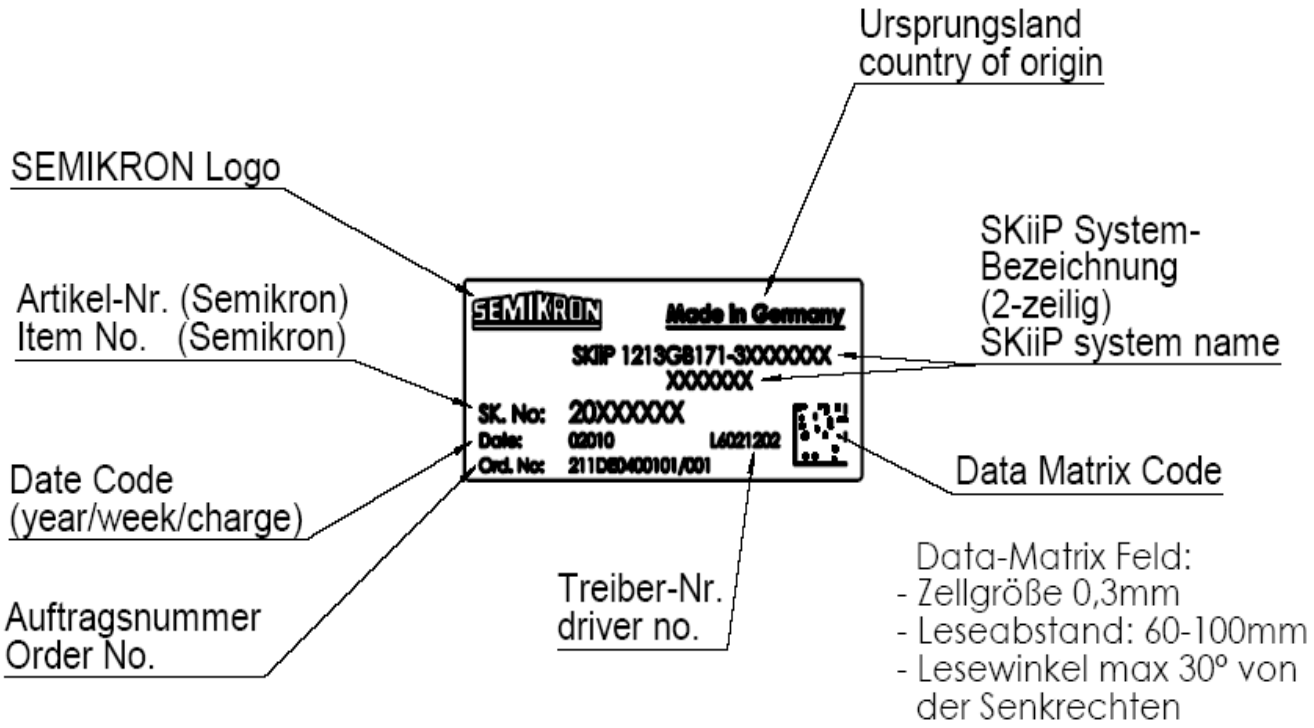
Identification (4): label SKiiP® 3

Identification (1): label SKiiP® 3 Half Bridge

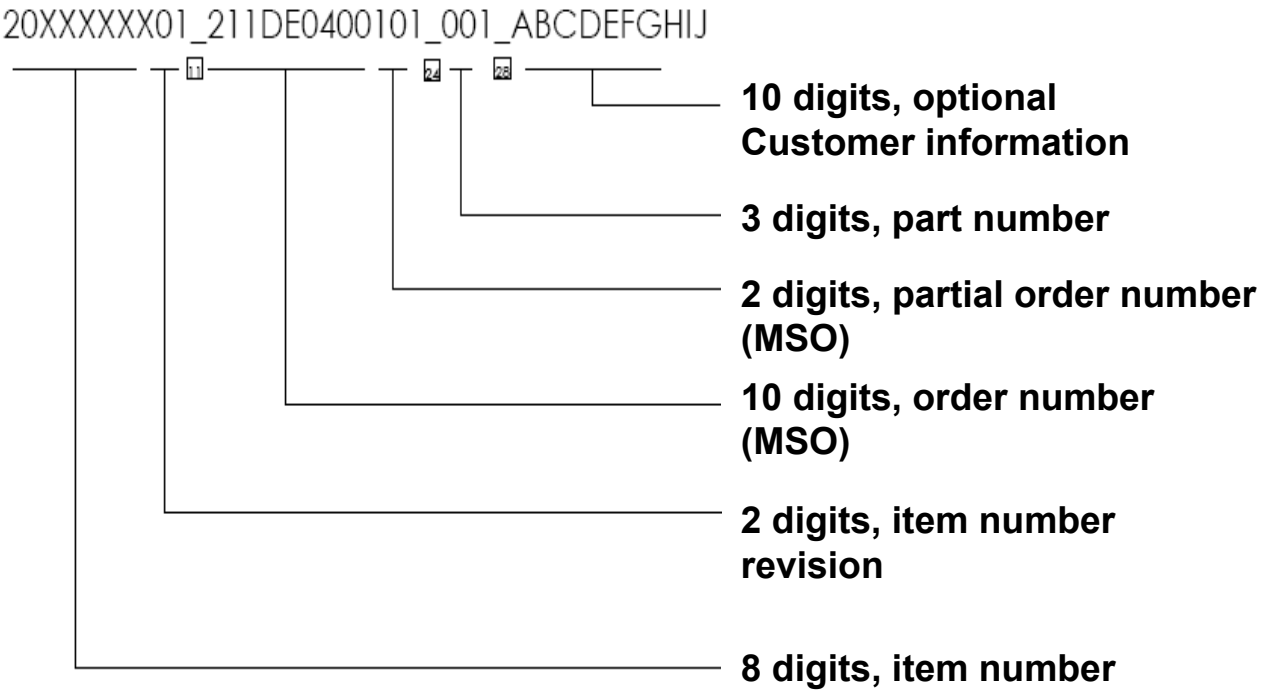


Identification (4): label SKiiP® 3

Identification (1): label SKiiP® 3 System

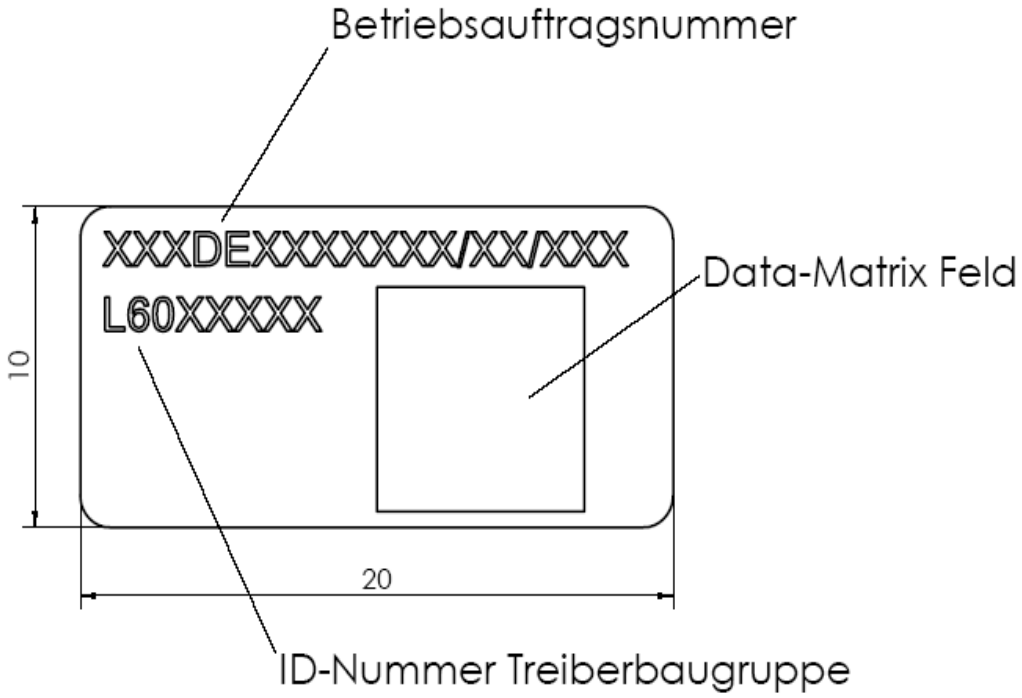


Identification (2): label SKiiP® 3 Data Matrix Code



Blanks on position 11; 24; 28

Label SKiiP® 3 Driver



SKiiP® 3 Driver Label

SKiiP® 3 Warranty Label

Please note:
warranty is lost
when cover
is removed