

# KEB 00.F4.010-1009

## Operator Interface



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# COMBIVERT



## F4

0,75...160 kW

**D**

BETRIEBSANLEITUNG

Leistungsteil

**GB**

INSTRUCTION MANUAL

Power Circuit

**E**

MANUAL DE INSTRUCCIONES

Circuito de Potencia

**I**

MANUALE D'ISTRUZIONE

Circuito di potenza

**RU**

Руководство по эксплуатации

Силовая часть

**F**

MANUEL D'INSTRUCTIONS

Circuit de Puissance



Erst Betriebsanleitung Teil 1 lesen !  
Read Instruction manual part 1 first !  
Leer manual de instrucciones parte 1 antes !  
Prima leggere le manuale di istruzione 1 parte !  
Сначала прочти инструкцию 1 часть !  
Lisez d'abord le manuel d'instructions partie 1 !



09/2002



Seite D - 3 ..... D - 40

Diese Betriebsanleitung muß jedem Anwender zugänglich gemacht werden. Vor jeglichen Arbeiten muß sich der Anwender mit dem Gerät vertraut machen. Darunter fällt insbesondere die Kenntnis und Beachtung der Sicherheits- und Warnhinweise. Die in dieser Betriebsanleitung verwendeten Pictogramme entsprechen folgender Bedeutung:



**Gefahr  
Warnung  
Vorsicht**



**Achtung,  
unbedingt  
beachten**



**Information  
Hilfe  
Tip**



Page GB - 3 ..... GB - 40

This instruction manual must be made available to any user. Before working with this unit the user must be familiarized with it. This is especially true for the attention, safety and warning guides. The meaning of the pictograms used in this manual are:



**Danger  
Warning  
Caution**



**Attention,  
observe at  
all costs**



**Information  
Help  
Tip**



Páginas E - 3 .... E - 40

Este manual de instrucciones debe estar a disposición de cualquier usuario. Antes de manipular el convertidor el usuario debe familiarizarse con él. Esto debe aplicarse especialmente al conocimiento de las indicaciones de advertencia y seguridad. El significado de los pictogramas usados en este manual son:



**Peligro  
Advertencia  
Precaución**



**Atención,  
Cuidado**



**Consejo  
Comentario  
Información**



Page I - 3 ..... I - 40

Prima di eseguire qualsiasi lavoro sull'unità l'utente deve familiarizzare con l'apparecchiatura. Questo comprende, specialmente, la conoscenza e le osservanze delle direttive di sicurezza e di avvertimento sottoindicate. I simboli usati in questo Manuale di Istruzione hanno il seguente significato:



**Avvertimento  
Pericolo  
Cautela**



**Attenzione,  
osservare  
assolutamente**



**Informazione  
Aiuto  
Suggerimento**



Страницы RU-3...RU-40

Эта инструкция должна быть доступна для каждого пользователя. Прежде чем приступить к работе каждый пользователь должен тщательно ознакомиться с прибором. Особенно это касается знаний по технике безопасности. Ниже приведённые пиктограммы означают следующее:



**Опасность  
Предупреждение  
Осторожно**



**Внимание  
обязательно  
соблюдать**



**Совет  
Указание  
Информация**



Page F - 3 ..... F - 40

Ce manuel d'instructions doit être rendu accessible à tout utilisateur. Avant tous travaux, l'utilisateur doit se familiariser d'abord avec le variateur, notamment tenir compte des mesures de sécurité et des avertissements. Les pictogrammes utilisés dans ce manuel ont les significations suivantes:



**Danger  
Avertissement  
Précaution**



**Attention,  
à respecter  
obligatoirement**



**Information  
Aide  
Astuces**

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# 1. General

## 1.1 Product Description



It is exclusively for a stepless speed regulation of a three-phase motor.



The operation of other electrical loads is forbidden and can lead to disturbances of the unit.

This manual describes the power circuit for **KEB COMBIVERT F4-S, F4-C and F4-F** frequency inverters in the range of

- **0.75 kW...30 kW / 230V class**
- **0.75 kW...160 kW / 400V class**



The power circuits of the frequency inverters in the W-housing (**200 kW...315 kW**) are described in an additional instruction manual (part no. 00.F4.01Z-KWxx).

Not only is this unit small in size and in price, it also has the following features:

- with IGBT power circuits there are only slight switching losses
- slight noise on high switching frequency
- extensive safety device for current, voltage and temperature
- voltage and current monitoring in static and dynamic operation
- conditionally short circuit proof and earth-fault proof
- noise immunity in accordance with IEC1000
- hardware current regulation
- integrated cooling fan
- uniform mounting grid
- can be aligned next to each other using the rack

## 1.2 Rating Plate

### Part number

**15.F4.C1G-3440**

|  |                      |                                                                                                                                                                                |
|--|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | Optionen             | 0 = Standard<br>1 = InterBus                                                                                                                                                   |
|  | Switching frequency  | 1 = 2 kHz<br>2 = 4 kHz<br>4 = 8 kHz<br>6 = 12 kHz<br>8 = 16 kHz                                                                                                                |
|  | Supply voltage       | 2 = 230 V- Class<br>4 = 400 V- Class                                                                                                                                           |
|  | Input identification | 1 = 1-phase<br>2 = DC<br>3 = 3-phase<br>4 = Special- / Customer version *<br>5 = Special- / Customer version *                                                                 |
|  | Housing type         | D, E, G, H, R, U, W                                                                                                                                                            |
|  | Accessory            | 0 = without<br>1 = Braking transistor<br>2 = Filter<br>3 = Filter and braking transistor<br>4 = Braking transistor and resistor<br>5 = Braking transistor, resistor and filter |
|  | Control inserted     | C = Compact<br>S = Standard<br>F = Field orientated Control                                                                                                                    |
|  | Unit marking         | F4                                                                                                                                                                             |
|  | Unit size            | 07...30                                                                                                                                                                        |

\*) On special- or customer versions the last 4 places differs from the rating plate above.

### 1.3 Installation Instructions

- Install KEB COMBIVERT stationary and ground.
- Take into consideration the minimum distance surrounding elements when positioning the inverter (see enclosed cabinet).
- Rack units are designed for vertical installation and can be aligned next to each other. Maintain a distance of at least 50mm to the elements stored in front. Make sure cooling is sufficient.
- No mist or water may get into the KEB COMBIVERT.
- Prevent dust from getting into the KEB COMBIVERT.  
When installing a dust-proof housing make sure it has enough heat dissipation.
- Do not operate KEB COMBIVERT in an explosion-protected room! In explosion-protected rooms the KEB COMBIVERT must be installed in an explosion protected housing, in observance of the local regulations.
- Protect KEB COMBIVERT against conductive and aggressive gases and liquids.
- Consumers, which produce electrical or magnetic fields or have an influence on the voltage supply, must be placed as far away as possible and measures must be taken to suppress the influences.
- when installing COMBIVERT in the proximity of trafo or transformer stations we urgently recommend to connect in series a line reactor. Through high Rsc-values ( $R_{sc}$ =short-circuit power/apparent power) the intermediate circuit capacitors can age above average and lead to a defect. Guide values according to IEC 1000-2-6:  

|                            |                                                               |
|----------------------------|---------------------------------------------------------------|
| $R_{sc} < 100$ :           | no reactor necessary                                          |
| $R_{sc} = 100 \dots 200$ : | a reactor is recommended if the load exceeds 75 % permanently |
| $R_{sc} > 200$ :           | reactor is necessary                                          |
- Regarding applications, that require cyclic switching off and on of the static frequency inverter, a minimum time-out of at least 5 minutes must be kept after power-off. If shorter cycle times are needed, please contact KEB.

### 1.3.1 RCD (FI-Protective Switch)

If personnel protection is required during installation of the system the frequency inverters must be protected according to EN 50178 (VDE 0160):

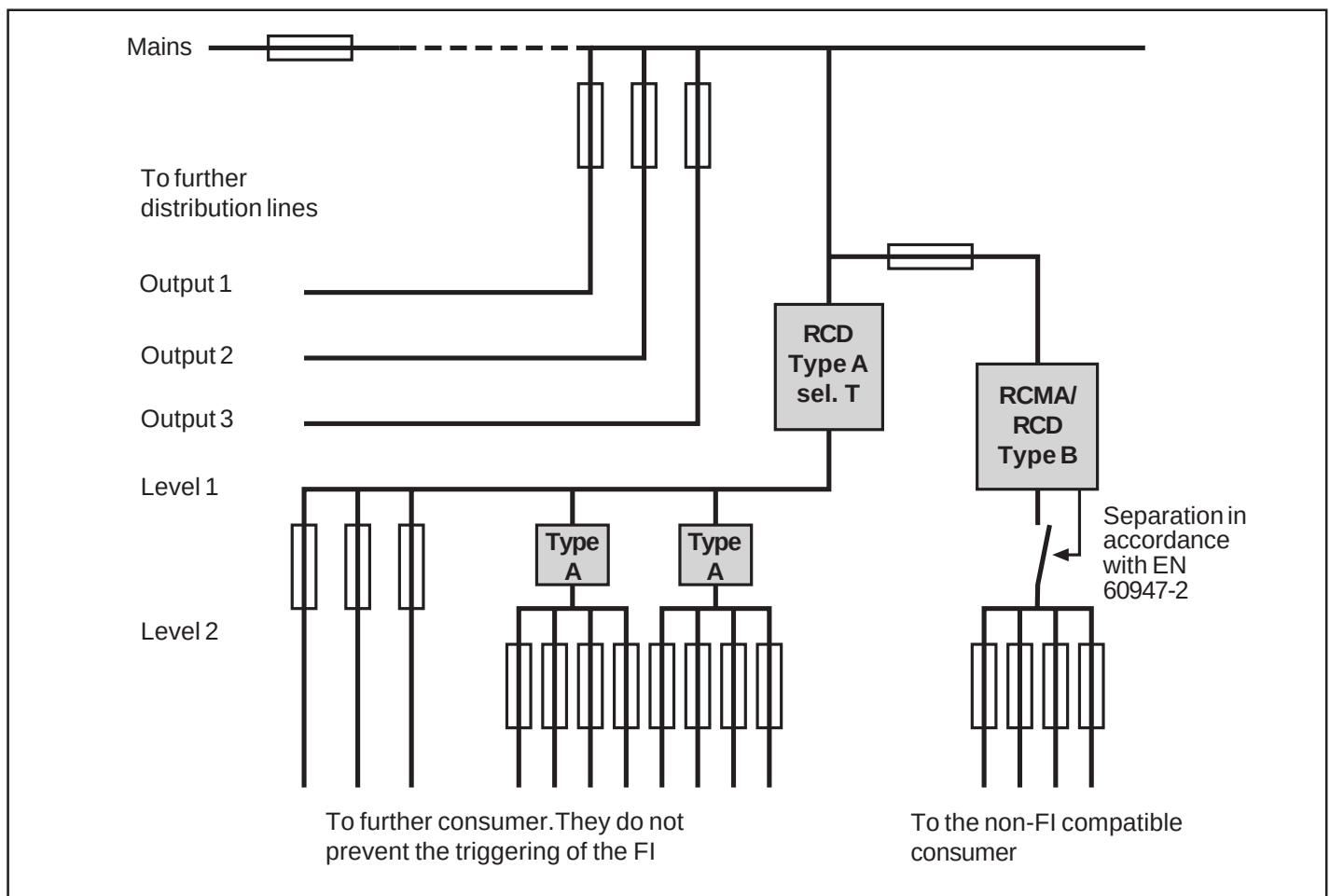
- 1-phase inverters by RCD type A (pulse-current sensitive FI's) or type B (all-current sensitive FI's)
- 3-phase inverters (with B6 bridge-connected rectifier) by RCMA's with separation (used privileged) or RCD's type B (all-current sensitive FI's)

The tripping current should be 300mA or more, in order to avoid a premature triggering of the inverter by discharge currents (about 200mA).

Dependent on the load, the length of the motor cable and the use of a radio interference filter, substantially higher leakage current can occur.

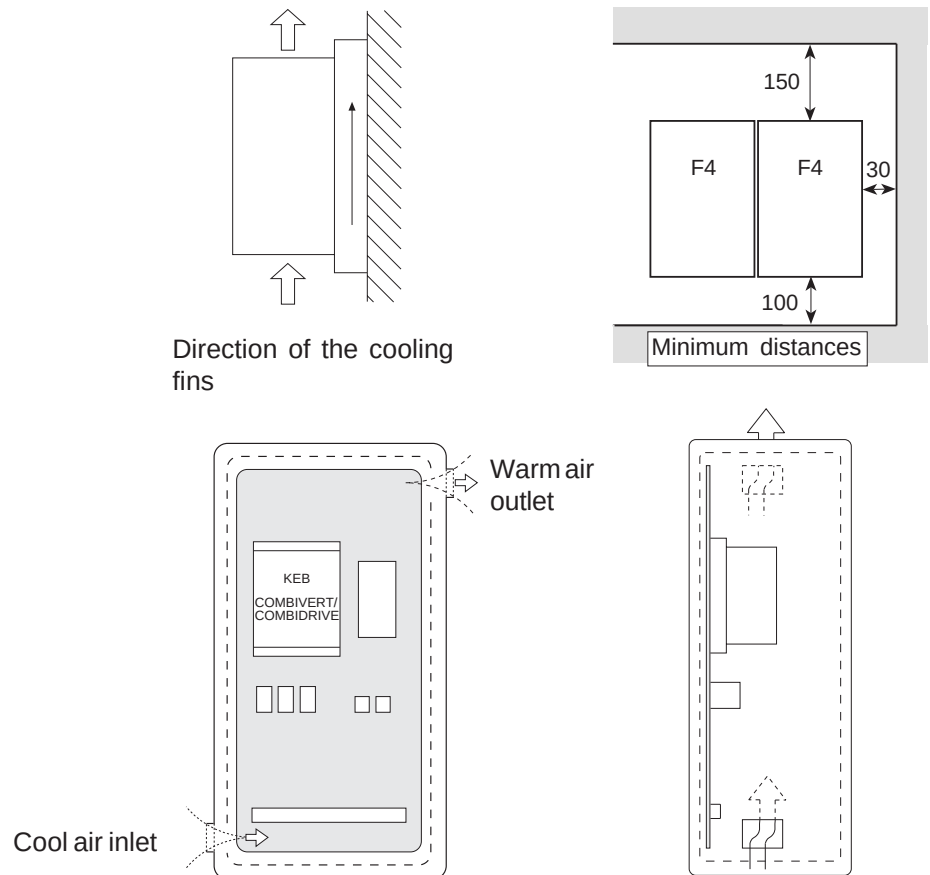
The connection instructions from the manufacturer and the valid local requirements must be observed. Dependent on the available mains form (TN, IT, TT) further protective measures are necessary in accordance with VDE Part 410 (Part 4; Chapter 41). For example, with TN-mains this protection is made with overcurrent protective devices. With IT-mains it is insulation monitoring with a pulse-code measuring method. A protective separation can be used with all mains forms as long as the required power and cable lengths permit this.

Diagram of a distribution board (principle of protective elements)



## 1.4 Control Cabinet Installation

GB



## 1.5 DC-supply

The **DC input current** of the inverter is basically determined by the used motor. The data can be taken from the motor name plate.

### 230V Class:

$$\frac{\sqrt{3} \times \text{rated motor voltage} \times \text{rated motor current} \times \text{motor cos } \varphi}{310V}$$

### 400V Class:

$$\frac{\sqrt{3} \times \text{rated motor voltage} \times \text{rated motor current} \times \text{motor cos } \varphi}{540V}$$

The **DC input peak current** is determined by the operating range.

- if you accelerate on the hardware current limit, the short-time limit current of the inverter must be set in the formula above (instead rated motor current).
- if the motor in normal operation is never stressed with rated torque, it can be calculated with the real motor current.
- a good value agrees with approx. 1,5 times of the rated motor current (from 90kW 1,25-times)

## 2. Technical Data

### 2.1 Summary Technical Data 230V Class

| Inverter Size                                  |       | 07                                   | 09   | 10  | 13   | 14   | 15  | 16   | 17   | 18  | 19   | 20   | 21   |      |     |     |    |
|------------------------------------------------|-------|--------------------------------------|------|-----|------|------|-----|------|------|-----|------|------|------|------|-----|-----|----|
| Output nominal power                           | [kVA] | 1,6                                  | 2,8  | 4   | 9,5  | 13   | 19  | 26   | 33   | 40  | 46   | 59   | 71   |      |     |     |    |
| Max. rated motor power                         | [kW]  | 0,75                                 | 1,5  | 2,2 | 5,5  | 7,5  | 11  | 15   | 18,5 | 22  | 30   | 37   | 45   |      |     |     |    |
| Output nominal current                         | [A]   | 4                                    | 7    | 10  | 24   | 33   | 48  | 66   | 84   | 100 | 115  | 145  | 180  |      |     |     |    |
| Max. short-time current <sup>1)</sup>          | [A]   | 7,2                                  | 12,6 | 18  | 36,5 | 49,5 | 72  | 99   | 126  | 150 | 172  | 217  | 270  |      |     |     |    |
| OC-tripping current                            | [A]   | 8,8                                  | 15   | 22  | 43   | 59   | 88  | 119  | 151  | 180 | 206  | 261  | 324  |      |     |     |    |
| Nominal input current                          | [A]   | 8                                    | 4    | 14  | 7,7  | 20   | 11  | 26,5 | 36   | 53  | 73   | 92   | 116  | 126  | 165 | 198 |    |
| Housing size                                   |       | D                                    | D    | D   | E    | G    | G   | H    | H    | R   | R    | R    | R    | R    |     |     |    |
| Rated operating frequency <sup>2)</sup>        | [kHz] | 16                                   | 8    | 16  | 4    | 16   | 16  | 16   | 16   | 8   | 8    | 8    | 8    | 8    |     |     |    |
| Max.operating frequency                        | [kHz] | 16                                   | 8    | 16  | 4    | 16   | 16  | 16   | 16   | 8   | 8    | 8    | 8    | 8    |     |     |    |
| Power loss at nominal operating                | [W]   | 65                                   | 70   | 135 | 165  | 220  | 280 | 430  | 550  | 850 | 1020 | 1200 | 1350 | 1620 |     |     |    |
| Stall current at 8kHz                          | [A]   | -                                    | -    | -   | -    | -    | 24  | 33   | 48   | 66  | 84   | 100  | 115  | 145  | 180 |     |    |
| Stall current at 16kHz                         | [A]   | -                                    | -    | -   | -    | -    | 24  | 33   | 48   | 66  | -    | -    | -    | -    | -   |     |    |
| Max. heat sink temperatureT <sub>OH</sub>      | [°C]  | 85                                   | 85   | 85  | 73   | 90   | 90  |      |      |     |      |      |      |      |     |     |    |
| Max. permissible mains fuse (inert)            | [A]   | 20                                   | 10   | 20  | 10   | 25   | 20  | 35   | 50   | 80  | 80   | 100  | 160  | 160  | 200 | 315 |    |
| Line cross section                             | [mm²] | 2,5                                  | 1,5  | 2,5 | 1,5  | 4,0  | 2,5 | 6    | 10   | 25  | 25   | 35   | 50   | 50   | 95  | 95  |    |
| Min. braking resistor <sup>3)</sup>            | [Ω]   | 56                                   | 56   | 28  | 18   | 16   | 13  | 5,6  | 5,6  | 4,7 | 4,7  | 3,9  | 2,0  | 2,0  |     |     |    |
| Typ. braking resistor <sup>3)</sup>            | [Ω]   | 180                                  | 100  | 68  | 27   |      | 20  | 13   | 10   | 7   | 5,6  | 4,7  | 3,9  | 3,0  |     |     |    |
| Max. braking current                           | [A]   | 7                                    | 7    | 14  | 21   | 29   | 29  | 70   | 70   | 85  | 85   | 102  | 160  | 160  |     |     |    |
| Overload curve (Page 40)                       |       | 1                                    |      |     |      |      |     |      |      |     |      |      |      |      |     |     |    |
| Tightening torque for terminals                | [Nm]  | 0,5                                  |      |     |      | 1,2  |     |      | 2,5  |     | 6    |      |      | 15   |     |     |    |
| Wiring diagram (Page 18/19)                    |       | 1                                    | 2    | 1   | 2    | 1    | 2   | 3    | 4    | 4   | 4    | 4    | 3    | 3    | 3   | 3   |    |
| Mains voltage (Rated voltage)                  | [V]   | 180...260 +/-0 (230V)                |      |     |      |      |     |      |      |     |      |      |      |      |     |     |    |
| Phases                                         |       | 1                                    | 3    | 1   | 3    | 1    | 3   | 3    | 3    | 3   | 3    | 3    | 3    | 3    | 3   | 3   |    |
| Mains frequency                                | [Hz]  | 50 / 60 +/- 2                        |      |     |      |      |     |      |      |     |      |      |      |      |     |     |    |
| Output voltage (U <sub>N</sub> =Mains voltage) | [V]   | 3 x 0...U <sub>N</sub>               |      |     |      |      |     |      |      |     |      |      |      |      |     |     |    |
| Output frequency                               | [Hz]  | 0...409,58 (0...819,16; 0...1638,32) |      |     |      |      |     |      |      |     |      |      |      |      |     |     |    |
| Shielded motor line length                     | [m]   | 30                                   | 30   | 50  | 50   | 100  |     |      |      |     | 50   |      |      |      |     |     |    |
| Storage temperature                            | [°C]  | -25...70                             |      |     |      |      |     |      |      |     |      |      |      |      |     |     |    |
| Operating temperature                          | [°C]  | -10...45                             |      |     |      |      |     |      |      |     |      |      |      |      |     |     |    |
| Model / protective system                      |       | IP20                                 |      |     |      |      |     |      |      |     |      |      |      |      |     |     |    |
| Relative humidity (without condensation)       | [%]   | max. 95                              |      |     |      |      |     |      |      |     |      |      |      |      |     |     |    |
| EMC tested in accordance with...               |       | EN 61800-3                           |      |     |      |      |     |      |      |     |      |      |      |      |     |     |    |
| Climatic category (EN 50178)                   |       | 3K3                                  |      |     |      |      |     |      |      |     |      |      |      |      |     |     |    |
| Mains choke (s.page 29)                        |       | 3                                    | 4    | 5   | 6    | 7    | 8   | 11   | 12   | 13  | 15   | 16   | 17   | 17   | 19  | 19  |    |
| Motor choke (s.page 35)                        |       | 4                                    | 6    |     | 8    |      | 11  | 12   | 13   | 14  | 15   | 16   | 17   | 18   | 19  |     |    |
| HF-Filter assembly kit (s. page 31)            |       | 1                                    | 4    | 2   | 4    | 3    | 5   | 6    | 7    | 7   | 8    | 9    | 10   | 11   | 11  | 12  | 13 |
| Sine filter (s. page 37)                       |       | 1                                    | 2    |     | 3    |      | 5   | 6    | 9    | -   | -    | -    | -    | -    | -   | -   |    |

1) For F4F-Types 5% must be subtracted as control reserve

2) For F4F-Types generally a operating frequency of min. 8 kHz is valid (for 16 kHz version ask KEB).

3) The statement counts only for frequency inverters with internal braking transistor (see "Rating Plate").

The technical data is for 2/4 pole standard motors. With other pole numbers the inverter must be dimensioned onto the motor rated current. Contact KEB for special or medium frequency motors.



Site altitude max. 2000 m. With site altitudes over 1000 m a power reduction of 1% per 100m must be taken into consideration.

## 2.2 Summary of Technical Data 400V Class (<= Size 17)

| Inverter Size                                  |       | 07                                   | 09                                   | 10                                   | 12                                   | 13                                   |
|------------------------------------------------|-------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|
| Output nominal power                           | [kVA] | 1,8                                  | 2,8                                  | 4                                    | 6,6                                  | 8,3                                  |
| Max. rated motor power                         | [kW]  | 0,75                                 | 1,5                                  | 2,2                                  | 4                                    | 5,5                                  |
| Output nominal current                         | [A]   | 2,6                                  | 4,1                                  | 5,8                                  | 9,5                                  | 12                                   |
| Max. short-time current <sup>1)</sup>          | [A]   | 4,6                                  | 7,4                                  | 10,4                                 | 17,1                                 | 21,6                                 |
| OC-tripping current                            | [A]   | 5,7                                  | 9                                    | 12,7                                 | 20,9                                 | 26,4                                 |
| Nominal input current                          | [A]   | 2,8                                  | 4,5                                  | 6,4                                  | 10,5                                 | 13,2                                 |
| Housing size                                   |       | D                                    | D                                    | D                                    | D                                    | E                                    |
| Rated operating frequency <sup>2)</sup>        | [kHz] | 4                                    | 4                                    | 4                                    | 12                                   | 4                                    |
| Max. operating frequency                       | [kHz] | 4                                    | 4                                    | 4                                    | 12                                   | 4                                    |
| Power loss at nominal operating                | [W]   | 45                                   | 60                                   | 80                                   | 130                                  | 115                                  |
| Stall current at 8kHz                          | [A]   | -                                    | -                                    | -                                    | 6,4                                  | -                                    |
| Stall current at 16kHz                         | [A]   | -                                    | -                                    | -                                    | -                                    | 9,5                                  |
| Max. heat sink temperature T <sub>OH</sub>     | [°C]  | 85                                   | 85                                   | 79                                   | 85                                   | 73                                   |
| Max. permissible mains fuse (inert)            | [A]   | 10                                   | 10                                   | 20                                   | 20                                   | 20                                   |
| Line cross section                             | [mm²] | 1,5                                  | 1,5                                  | 2,5                                  | 2,5                                  | 2,5                                  |
| Min. braking resistor <sup>3)</sup>            | [Ω]   | 160                                  | 160                                  | 82                                   | 50                                   | 82                                   |
| Typ. braking resistor <sup>3)</sup>            | [Ω]   | 680                                  | 390                                  | 270                                  | 150                                  | 110                                  |
| Max. braking current                           | [A]   | 5                                    | 10                                   | 15                                   | 10                                   | 15                                   |
| Overload curve (Page 40)                       |       | 1                                    | 1                                    | 1                                    | 1                                    | 1                                    |
| Tightening torque for terminals                | [Nm]  | 0,5                                  | 0,5                                  | 0,5                                  | 0,5                                  | 1,2                                  |
| Wiring diagram (Page 18/19)                    |       | 2                                    | 3                                    | 2                                    | 3                                    | 4                                    |
| Mains voltage (Rated voltage) <sup>4)</sup>    | [V]   | 305...500 +/-0 (400V)                | 305...500 +/-0 (400V)                | 305...500 +/-0 (400V)                | 305...500 +/-0 (400V)                | 305...500 +/-0 (400V)                |
| Phases                                         |       | 3                                    | 3                                    | 3                                    | 3                                    | 3                                    |
| Mains frequency                                | [Hz]  | 50 / 60 +/- 2                        | 50 / 60 +/- 2                        | 50 / 60 +/- 2                        | 50 / 60 +/- 2                        | 50 / 60 +/- 2                        |
| Output voltage (U <sub>N</sub> =Mains voltage) | [V]   | 3 x 0...U <sub>N</sub>               | 3 x 0...U <sub>N</sub>               | 3 x 0...U <sub>N</sub>               | 3 x 0...U <sub>N</sub>               | 3 x 0...U <sub>N</sub>               |
| Output frequency                               | [Hz]  | 0...409,58 (0...819,16; 0...1638,32) | 0...409,58 (0...819,16; 0...1638,32) | 0...409,58 (0...819,16; 0...1638,32) | 0...409,58 (0...819,16; 0...1638,32) | 0...409,58 (0...819,16; 0...1638,32) |
| Shielded motor line length                     | [m]   | 50                                   | 50                                   | 100                                  | 100                                  | 100                                  |
| Storage temperature                            | [°C]  | -25...70 °C                          | -25...70 °C                          | -25...70 °C                          | -25...70 °C                          | -25...70 °C                          |
| Operating temperature                          | [°C]  | -10...45 °C                          | -10...45 °C                          | -10...45 °C                          | -10...45 °C                          | -10...45 °C                          |
| Model / protective system                      |       | IP20                                 | IP20                                 | IP20                                 | IP20                                 | IP20                                 |
| Relative humidity (without condensation)       | [%]   | max. 95                              | max. 95                              | max. 95                              | max. 95                              | max. 95                              |
| EMC tested in accordance with...               |       | EN 61800-3                           | EN 61800-3                           | EN 61800-3                           | EN 61800-3                           | EN 61800-3                           |
| Climatic category (EN 50178)                   |       | 3K3                                  | 3K3                                  | 3K3                                  | 3K3                                  | 3K3                                  |
| Mains choke (s.page 29)                        |       | 19                                   | 20                                   | 21                                   | 23                                   | 23                                   |
| Motor choke (s.page 35)                        |       | 19                                   | 20                                   | 20                                   | 22                                   | 23                                   |
| HF-Filter assembly kit (s. page 31)            |       | 10                                   | 10                                   | 10                                   | 11                                   | 12                                   |
| Sine filter (s. page 37)                       |       | 1                                    | 1                                    | 2                                    | 2                                    | 3                                    |
| Sine filter plus (s. page 39)                  |       | -                                    | -                                    | -                                    | 2                                    | 3                                    |

- 1) For F4F-Types 5% must be substrated as control reserve
- 2) F4-F units need a power circuit with rated operating frequency of min. 8kHz.
- 3) This data is only valid for units with internal brake transistor (see "unit identification").
- 4) At mains voltage ≥460V multiply the nominal current with factor 0,86.



| Inverter Size                                  |       | 14                                   |      | 15   |     |     | 16   |     | 17   |      |     |
|------------------------------------------------|-------|--------------------------------------|------|------|-----|-----|------|-----|------|------|-----|
| Output nominal power                           | [kVA] | 11                                   |      | 17   |     |     | 23   |     | 29   |      |     |
| Max. rated motor power                         | [kW]  | 7,5                                  |      | 11   |     |     | 15   |     | 18,5 |      |     |
| Output nominal current                         | [A]   | 16,5                                 |      | 24   |     |     | 33   |     | 42   |      |     |
| Max. short-time current <sup>1)</sup>          | [A]   | 29,7                                 | 24,8 | 36   |     |     | 49,5 |     | 63   |      |     |
| OC-tripping current                            | [A]   | 36,3                                 | 29,7 | 43,2 |     |     | 59,4 |     | 75,6 |      |     |
| Nominal input current                          | [A]   | 18,1                                 |      | 26,5 |     |     | 36,5 |     | 46   |      |     |
| Housing size                                   |       | E                                    | G    | E    | G   | H   | G    | H   | G    | H    | R   |
| Rated operating frequency <sup>2)</sup>        | [kHz] | 8                                    | 16   | 4    | 8   | 16  | 8    | 16  | 4    | 8    | 16  |
| Max.operating frequency                        | [kHz] | 16                                   | 16   | 12   | 16  | 16  | 16   | 16  | 16   | 16   | 16  |
| Power loss at nominal operating                | [W]   | 240                                  | 260  | 260  | 290 | 360 | 310  | 490 | 360  | 470  | 700 |
| Stall current at 8kHz                          | [A]   | 16,5                                 | 19   | -    | 19  | 25  | 21,5 | 33  | -    | 30   | 42  |
| Stall current at 16kHz                         | [A]   | -                                    | 12   | -    | 8,5 | 15  | 9,7  | 20  | -    | 13,5 | 30  |
| Max. heat sink temperatureT <sub>OH</sub>      | [°C]  | 73                                   | 90   | 73   | 90  |     |      |     |      |      |     |
| Max. permissible mains fuse (inert)            | [A]   | 25                                   |      | 35   |     |     | 50   |     | 63   |      |     |
| Line cross section                             | [mm²] | 4                                    |      | 6    |     |     | 10   |     | 16   |      |     |
| Min. braking resistor <sup>3)</sup>            | [Ω]   | 50                                   | 39   | 39   |     | 22  | 25   | 22  | 25   | 22   | 9   |
| Typ. braking resistor <sup>3)</sup>            | [Ω]   | 85                                   |      | 56   |     |     | 42   |     | 30   |      |     |
| Max. braking current                           | [A]   | 15                                   | 21   | 21   |     | 37  | 30   | 37  | 30   | 37   | 88  |
| Overload curve (Page 40)                       |       | 1                                    |      |      |     |     |      |     |      |      |     |
| Tightening torque for terminals                | [Nm]  | 0,5                                  | 1,2  | 1,2  | 1,2 | 2,5 | 1,2  | 2,5 | 1,2  | 2,5  | 6   |
| Wiring diagram (Page 18/19)                    |       | 3                                    | 4    | 3    | 4   |     | 4    |     | 4    |      | 3   |
| Mains voltage (Rated voltage) <sup>4)</sup>    | [V]   | 305...500 +/-0 (400V)                |      |      |     |     |      |     |      |      |     |
| Phases                                         |       | 3                                    |      |      |     |     |      |     |      |      |     |
| Mains frequency                                | [Hz]  | 50 / 60 +/- 2                        |      |      |     |     |      |     |      |      |     |
| Output voltage (U <sub>N</sub> =Mains voltage) | [V]   | 3 x 0...U <sub>N</sub>               |      |      |     |     |      |     |      |      |     |
| Output frequency                               | [Hz]  | 0...409,58 (0...819,16; 0...1638,32) |      |      |     |     |      |     |      |      |     |
| Shielded motor line length                     | [m]   | 100                                  |      |      |     |     |      |     |      |      |     |
| Storage temperature                            | [°C]  | -25...70 °C                          |      |      |     |     |      |     |      |      |     |
| Operating temperature                          | [°C]  | -10...45 °C                          |      |      |     |     |      |     |      |      |     |
| Model / protective system                      |       | IP20                                 |      |      |     |     |      |     |      |      |     |
| Relative humidity (without condensation)       | [%]   | max. 95                              |      |      |     |     |      |     |      |      |     |
| EMC tested in accordance with...               |       | EN 61800-3                           |      |      |     |     |      |     |      |      |     |
| Climatic category (EN 50178)                   |       | 3K3                                  |      |      |     |     |      |     |      |      |     |
| Mains choke (s.page 29)                        |       | 24                                   |      | 25   |     |     | 26   |     | 27   |      |     |
| Motor choke (s.page 35)                        |       | 24                                   |      | 25   |     |     | 26   |     | 27   |      |     |
| HF-Filter assembly kit (s. page 31)            |       | 12                                   | 14   | 13   | 15  | 17  | 16   | 17  | 15   | 17   | 20  |
| Sine filter (s. page 37)                       |       | 4                                    |      | 5    |     |     | 6    |     | 7    |      |     |
| Sine filter plus (s. page 39)                  |       | 4                                    |      | -    | 5   |     | -    | -   | -    | -    | -   |

The technical data is for 2/4 pole standard motors. With other pole numbers the inverter must be dimensioned onto the motor rated current. Contact KEB for special or medium frequency motors.



Site altitude max. 2000 m. With site altitudes over 1000 m a power reduction of 1% per 100m must be taken into consideration.

## Summary of Technical Data 400V Class (>= Size 18)

| Inverter Size                                  |       | 18                                   |     | 19  |     | 20    | 21   | 22    |      |
|------------------------------------------------|-------|--------------------------------------|-----|-----|-----|-------|------|-------|------|
| Output nominal power                           | [kVA] | 35                                   |     | 42  |     | 52    | 62   | 80    |      |
| Max. rated motor power                         | [kW]  | 22                                   |     | 30  |     | 37    | 45   | 55    |      |
| Output nominal current                         | [A]   | 50                                   |     | 60  |     | 75    | 90   | 115   |      |
| Max. short-time current <sup>1)</sup>          | [A]   | 75                                   |     | 90  |     | 112,5 | 135  | 172,5 |      |
| OC-tripping current                            | [A]   | 90                                   |     | 108 |     | 135   | 162  | 207   |      |
| Nominal input current                          | [A]   | 55                                   |     | 66  |     | 83    | 100  | 127   |      |
| Housing size                                   |       | H                                    | R   | H   | R   | R     | R    | R     | R    |
| Rated operating frequency <sup>2)</sup>        | [kHz] | 8                                    | 16  | 4   | 8   | 8     | 4/8  | 4     | 8    |
| Max. operating frequency                       | [kHz] | 16                                   | 16  | 16  | 16  | 16    | 16   | 4     | 8    |
| Power loss at nominal operating                | [W]   | 610                                  | 850 | 540 | 750 | 900   | 1100 | 1200  | 1500 |
| Stall current at 8kHz                          | [A]   | 45                                   | 50  | -   | 60  | 75    | 90   | -     | 115  |
| Stall current at 16kHz                         | [A]   | 20,3                                 | 40  | -   | 27  | 33,7  | 40,5 | -     | -    |
| Max. heat sink temperature T <sub>OH</sub>     | [°C]  | 90                                   |     |     |     |       |      |       |      |
| Max. permissible mains fuse (inert)            | [A]   | 80                                   |     | 80  |     | 100   | 160  | 160   |      |
| Line cross section                             | [mm²] | 25                                   |     | 25  |     | 35    | 50   | 50    |      |
| Min. braking resistor <sup>3)</sup>            | [Ω]   | 13                                   | 9   | 13  | 9   | 9     | 9    | 8     |      |
| Typ. braking resistor <sup>3)</sup>            | [Ω]   | 20                                   |     | 15  |     | 12    | 10   | 8,6   |      |
| Max. braking current                           | [A]   | 63                                   | 88  | 63  | 88  | 88    | 88   | 88    |      |
| Overload curve (Page 40)                       |       | 1                                    |     |     |     |       |      |       |      |
| Tightening torque for terminals                | [Nm]  | 2,5                                  | 6   | 2,5 | 6   |       |      |       |      |
| Wiring diagram (Page 18/19)                    |       | 4                                    | 3   | 4   | 3   | 3     | 3    | 3     |      |
| Mains voltage (Rated voltage) <sup>4)</sup>    | [V]   | 305...500 +/-0 (400V)                |     |     |     |       |      |       |      |
| Phases                                         |       | 3                                    |     |     |     |       |      |       |      |
| Mains frequency                                | [Hz]  | 50 / 60 +/- 2                        |     |     |     |       |      |       |      |
| Output voltage (U <sub>N</sub> =Mains voltage) | [V]   | 3 x 0...U <sub>N</sub>               |     |     |     |       |      |       |      |
| Output frequency                               | [Hz]  | 0...409,58 (0...819,16; 0...1638,32) |     |     |     |       |      |       |      |
| Shielded motor line length                     | [m]   | 100                                  |     | 100 |     | 50    | 50   | 50    |      |
| Storage temperature                            | [°C]  | -25...70 °C                          |     |     |     |       |      |       |      |
| Operating temperature                          | [°C]  | -10...45 °C                          |     |     |     |       |      |       |      |
| Model / protective system                      |       | IP20                                 |     |     |     |       |      |       |      |
| Relative humidity (without condensation)       | [%]   | max. 95                              |     |     |     |       |      |       |      |
| EMC tested in accordance with...               |       | EN 61800-3                           |     |     |     |       |      |       |      |
| Climatic category (EN 50178)                   |       | 3K3                                  |     |     |     |       |      |       |      |
| Mains choke (s.page 29)                        |       | 28                                   |     | 29  |     | 30    | 31   | 32    |      |
| Motor choke (s.page 35)                        |       | 28                                   |     | 29  |     | 30    | 31   | 32    |      |
| HF-Filter assembly kit (s. page 31)            |       | 17                                   | 20  | 17  | 20  | 20    | 22   | 22    |      |
| Sine filter (s. page 37)                       |       | 8                                    |     | 9   |     | 10    | 11   | 12    |      |
| Sine filter plus (s. page 39)                  |       | -                                    | -   | -   | -   | -     | -    | -     | -    |

- 1) For F4F-Types 5% must be substrated as control reserve
- 2) F4-F units need a power circuit with rated operating frequency of min. 8kHz.
- 3) This data is only valid for units with internal brake transistor (see "unit identification").
- 4) At mains voltage ≥460V multiply the nominal current with factor 0,86.

| Inverter Size                                  |                    | 23                                   |      | 24   |      | 25    | 26    | 27   |
|------------------------------------------------|--------------------|--------------------------------------|------|------|------|-------|-------|------|
| Output nominal power                           | [kVA]              | 104                                  |      | 125  |      | 145   | 173   | 208  |
| Max. rated motor power                         | [kW]               | 75                                   |      | 90   |      | 110   | 132   | 160  |
| Output nominal current                         | [A]                | 150                                  |      | 180  |      | 210   | 250   | 300  |
| Max. short-time current <sup>1)</sup>          | [A]                | 225                                  |      | 270  |      | 262,5 | 312,5 | 375  |
| OC-tripping current                            | [A]                | 270                                  |      | 324  |      | 315   | 375   | 450  |
| Nominal input current                          | [A]                | 165                                  |      | 198  |      | 231   | 275   | 330  |
| Housing size                                   |                    | R                                    | U    | U    |      | U     | U     | U    |
| Rated operating frequency <sup>2)</sup>        | [kHz]              | 2                                    | 8    | 4    | 8    | 4     | 4     | 2    |
| Max.operating frequency                        | [kHz]              | 2                                    | 16   | 4    | 8    | 4     | 4     | 2    |
| Power loss at nominal operating                | [W]                | 1300                                 | 1900 | 2000 | 2400 | 2300  | 2800  | 3100 |
| Stall current at 8kHz                          | [A]                | -                                    | 150  | -    | 180  | -     | -     | -    |
| Stall current at 16kHz                         | [A]                | -                                    | -    | -    | -    | -     | -     | -    |
| Max. heat sink temperatureT <sub>OH</sub>      | [°C]               | 90                                   |      |      |      |       |       |      |
| Max. permissible mains fuse (inert)            | [A]                | 200                                  |      | 315  |      | 315   | 400   | 450  |
| Line cross section                             | [mm <sup>2</sup> ] | 95                                   |      | 95   |      | 95    | 120   | 150  |
| Min. braking resistor <sup>3)</sup>            | [Ω]                | 6                                    | 5    | 4    |      | 2,7   | 2,7   | 2,7  |
| Typ. braking resistor <sup>3)</sup>            | [Ω]                | 6,7                                  |      | 5    |      | 4,3   | 3,8   | 3,3  |
| Max. braking current                           | [A]                | 133                                  | 160  | 200  |      | 200   | 200   | 200  |
| Overload curve (Page 40)                       |                    | 1                                    |      |      |      | 2     |       |      |
| Tightening torque for terminals                | [Nm]               | 15                                   |      |      |      | 25    |       |      |
| Wiring diagram (Page 18/19)                    |                    | 3                                    | 3    | 3    |      | 3     | 3     | 3    |
| Mains voltage (Rated voltage) <sup>4)</sup>    | [V]                | 305...500 +/-0 (400V)                |      |      |      |       |       |      |
| Phases                                         |                    | 3                                    |      |      |      |       |       |      |
| Mains frequency                                | [Hz]               | 50 / 60 +/- 2                        |      |      |      |       |       |      |
| Output voltage (U <sub>N</sub> =Mains voltage) | [V]                | 3 x 0...U <sub>N</sub>               |      |      |      |       |       |      |
| Output frequency                               | [Hz]               | 0...409,58 (0...819,16; 0...1638,32) |      |      |      |       |       |      |
| Shielded motor line length                     | [m]                | 50                                   |      |      |      |       |       |      |
| Storage temperature                            | [°C]               | -25...70 °C                          |      |      |      |       |       |      |
| Operating temperature                          | [°C]               | -10...45 °C                          |      |      |      |       |       |      |
| Model / protective system                      |                    | IP20                                 |      |      |      |       |       |      |
| Relative humidity (without condensation)       | [%]                | max. 95                              |      |      |      |       |       |      |
| EMC tested in accordance with...               |                    | EN 61800-3                           |      |      |      |       |       |      |
| Climatic category (EN 50178)                   |                    | 3K3                                  |      |      |      |       |       |      |
| Mains choke (s.page 29)                        |                    | 33                                   |      | 34   |      | 35    | 36    | 37   |
| Motor choke (s.page 35)                        |                    | 33                                   |      | 34   |      | 35    | 36    | 37   |
| HF-Filter assembly kit (s. page 31)            |                    | 23                                   |      | 24   |      | 24    | 26    | 26   |
| Sine filter (s. page 37)                       |                    | -                                    | 33   | 34   |      | 35    | 36    | 37   |
| Sine filter plus (s. page 39)                  |                    | -                                    | -    | -    | -    | -     | -     | -    |

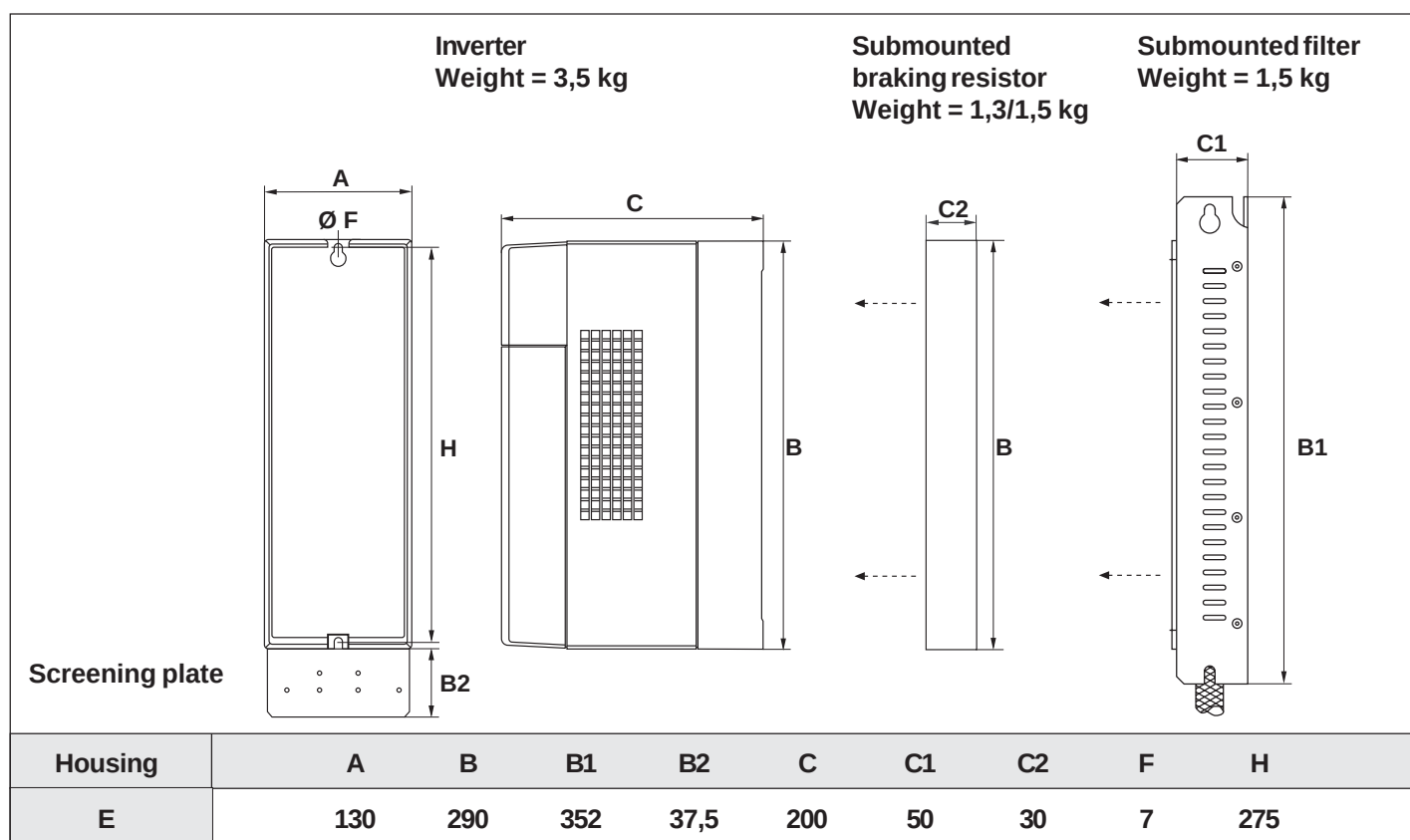
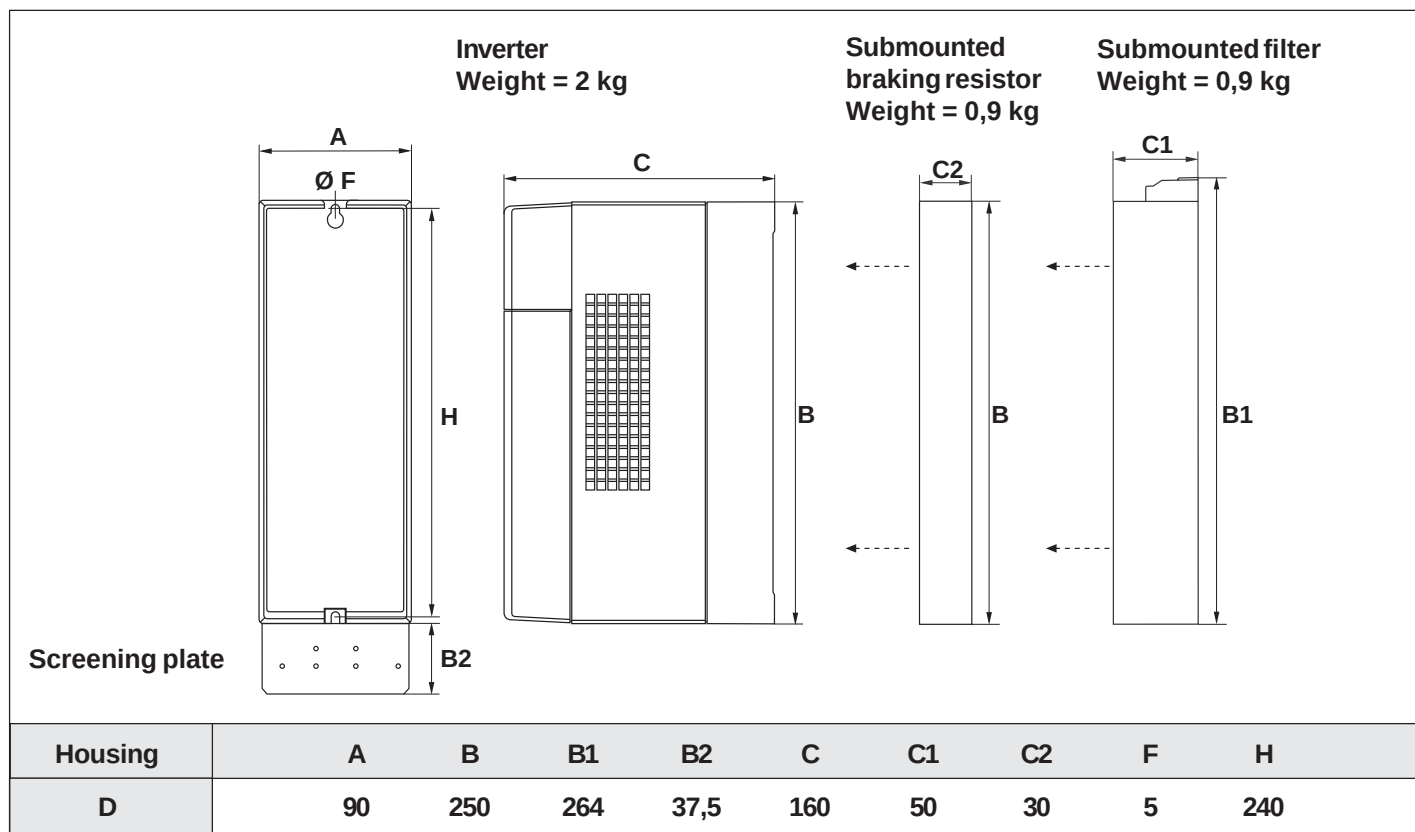


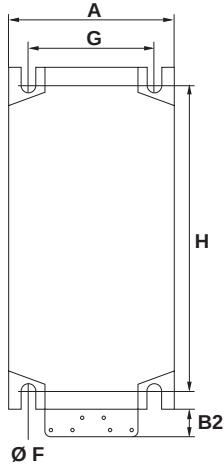
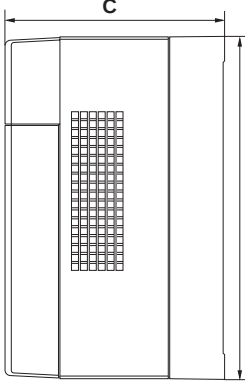
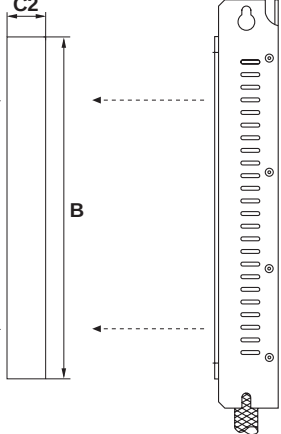
An input choke is necessary from size 23!

The technical data is for 2/4 pole standard motors. With other pole numbers the inverter must be dimensioned onto the motor rated current. Contact KEB for special or medium frequency motors.

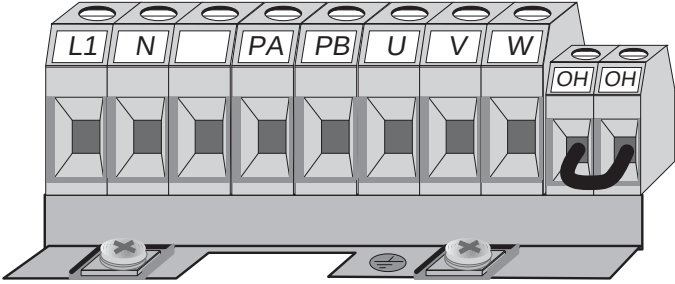
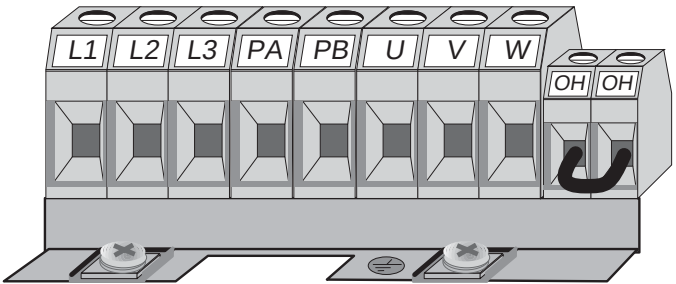
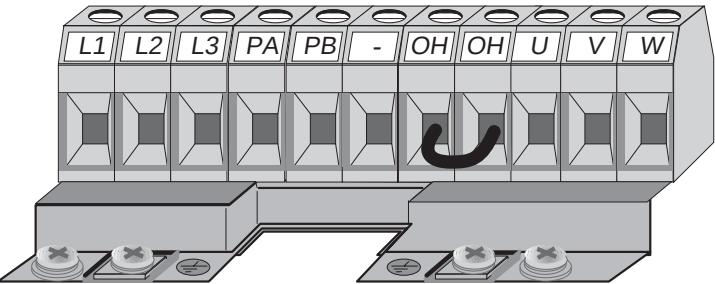
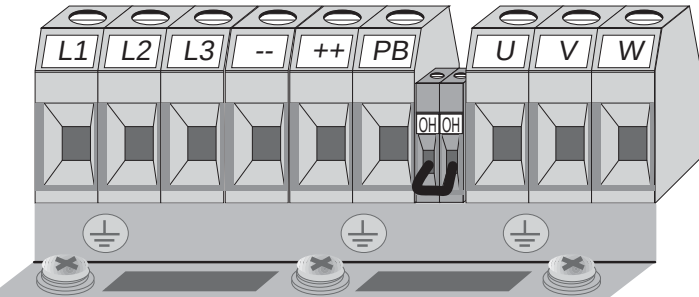


Site altitude max. 2000 m. With site altitudes over 1000 m a power reduction of 1% per 100m must be taken into consideration.



| <div><div><div>Inverter</div><div><div>Screening plate</div></div></div><div><div>Submounted braking resistor</div><div>Weight = 1,5/1,9 kg</div><div></div></div><div><div>Submounted filter</div><div></div></div></div> |     |     |    |     |    |    |     |     |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|-----|----|-----|----|----|-----|-----|------------|
| Housing                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | A   | B   | B2 | C   | C2 | F  | G   | H   | Weight[kg] |
| G                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 170 | 340 | 32 | 255 | 30 | 7  | 150 | 330 | 10         |
| H                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 297 | 340 | 51 | 255 | -  | 7  | 250 | 330 | 14         |
| R *                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 340 | 520 | 68 | 355 | -  | 11 | 300 | 495 | 25-29      |
| U                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 340 | 800 | -  | 355 | -  | 11 | 300 | 775 | 75         |
| Dimensions and wights of the HF-filter: see page 31 / pic. 2                                                                                                                                                                                                                                                                                                                                                                                                                    |     |     |    |     |    |    |     |     |            |
| *) The R-Housing installation filter have no influence to the dimensions of the housing. ( Weight = 7 kg )                                                                                                                                                                                                                                                                                                                                                                      |     |     |    |     |    |    |     |     |            |

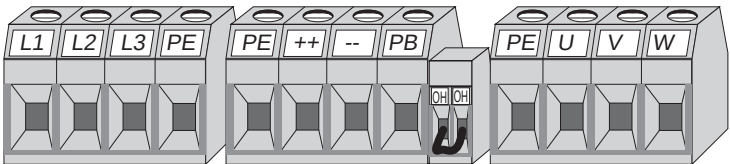
2.4 Summary of the Power Circuit Terminals

|                                                                                         |  |                                                                                                                                                                                                                                                                                           |  |
|-----------------------------------------------------------------------------------------|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Housing size D                                                                          |  | ⚠ Note input voltage, since 230V and 400V class (3 phase) is possible.                                                                                                                                                                                                                    |  |
| 1 phase                                                                                 |  | 3 phase                                                                                                                                                                                                                                                                                   |  |
|         |  |                                                                                                                                                                                                         |  |
| L1, N<br>L1, L2, L3<br>PA, PB                                                           |  | U, V, W<br>OH, OH                                                                                                                                                                                                                                                                         |  |
| 1 phase mains connection<br>3 phase mains connection<br>Connection for braking resistor |  | Motor connection<br>Connection for temperature sensor<br>Connection for screening/earthing                                                                                                                                                                                                |  |
| Housing size E                                                                          |  | ⚠ Note input voltage, since 230V and 400V class (3 phase) is possible.                                                                                                                                                                                                                    |  |
|       |  | L1, L2, L3<br>PA, PB<br>PA, -<br><br>OH, OH<br>U, V, W                                                                                                                                                                                                                                    |  |
|                                                                                         |  | 3 phase mains connection<br>Connection for braking resistor<br>Connection for braking module and feedback unit<br><br>Connection for temperature sensor<br>Motor connection<br>Connection for screening/earthing                                                                          |  |
| Housing size G                                                                          |  | ⚠ Note input voltage, since 230V and 400V class (3 phase) is possible.                                                                                                                                                                                                                    |  |
|       |  | L1, L2, L3<br>++, PB<br>++, --<br><br>OH, OH<br>U, V, W                                                                                                                                                                                                                                   |  |
|                                                                                         |  | 3 phase mains connection<br>Connection for braking resistor<br>Connection for braking module, feedback and supply unit DC input 250...370 VDC (230 V-class) 420...720 VDC (400 V-class)<br><br>Connection for temperature sensor<br>Motor connection<br>Connection for screening/earthing |  |

Housing size H



Note input voltage, since 230V and 400V class (3 phase) is possible.

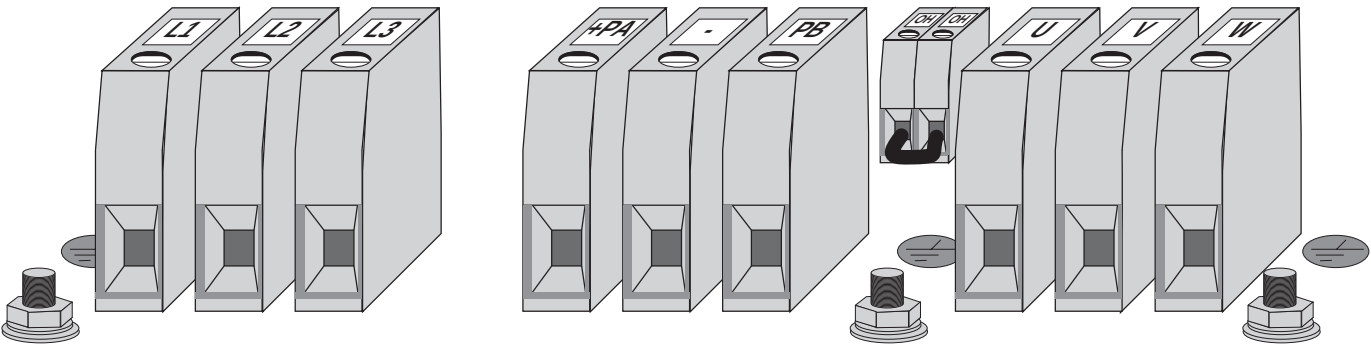


- L1, L2, L3 3 phase mains connection
- ++, PB Connection for braking resistor
- ++, -- **Connection for braking module, feedback and supply unit DC input**  
250...370 VDC (230 V-class)  
420...720 VDC (400 V-class)
- OH, OH Connection for temperature sensor
- U, V, W Motor connection
- PE Connection for screening/earthing

Housing size R and U



Note input voltage, since 230V and 400V class (3 phase) is possible.



- L1, L2, L3 3 phase mains connection
- +PA, PB Connection for braking resistor
- +PA, - Connection for braking module and feedback unit
- OH, OH Connection for temperature sensor
- U, V, W Motor connection
- PE Connection for screening/earthing

# Connection of the Power Circuit

## 2.6 Connection of the Power Circuit

Assignment see technical data "Wiring diagram" Page 9-13

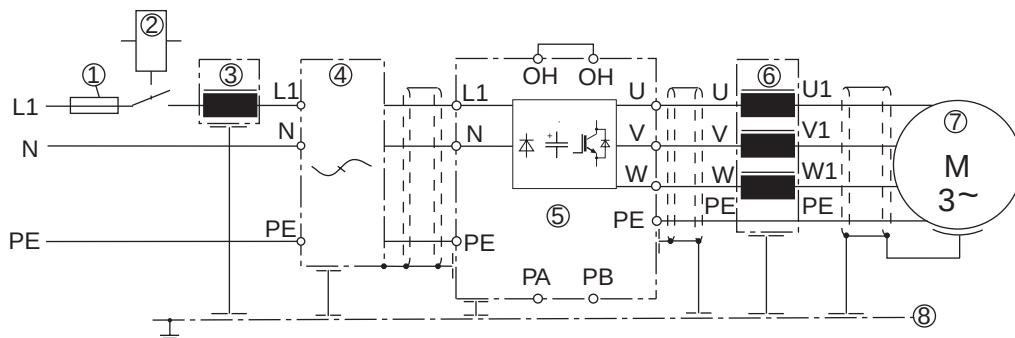


If the mains and motor connection are exchanged, this leads to immediate destruction of the unit.

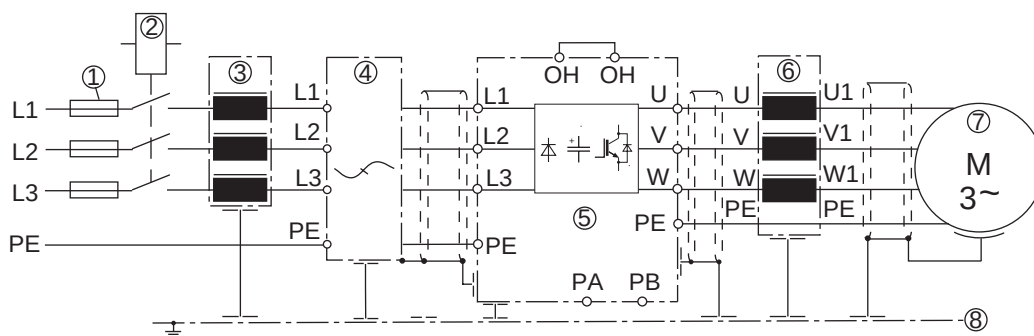


Pay attention to the supply voltage and the correct polarity of the motor!

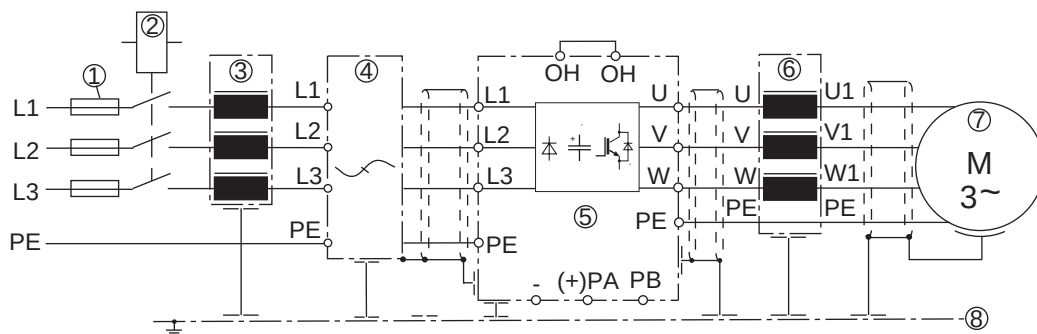
Wiring diagram 1



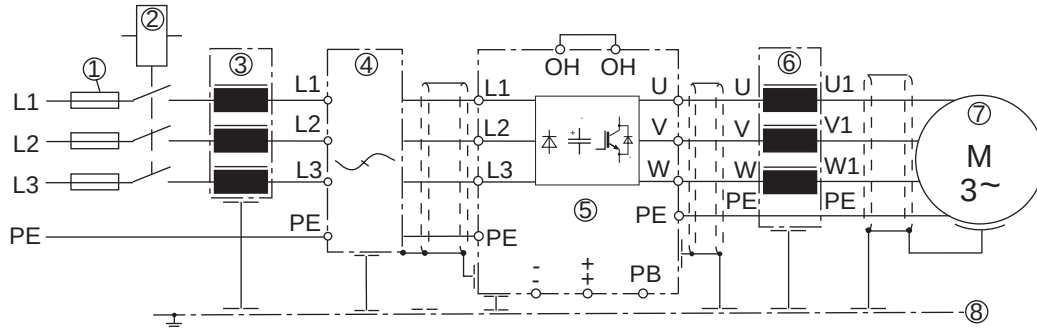
Wiring diagram 2



Wiring diagram 3



Wiring diagram 4



① Mains fuse

② Main contactor

③ Input choke

④ Interference suppression filter

⑤ KEB COMBIVERT

⑥ Motor choke or output filter (not for F4-F)

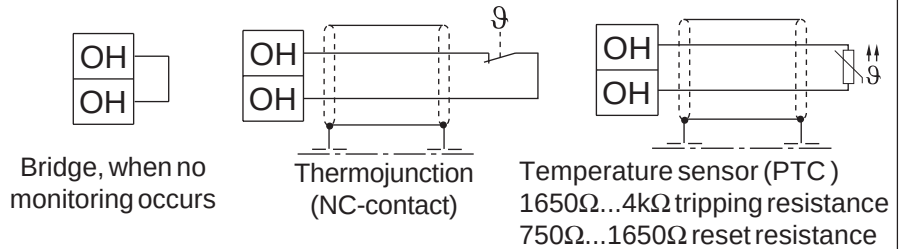
⑦ Motor

⑧ Mounting plate

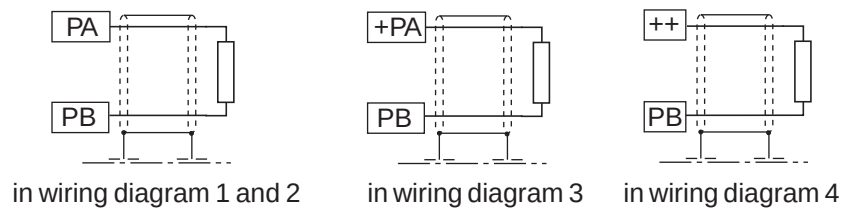


## External temperature monitoring (for all units)

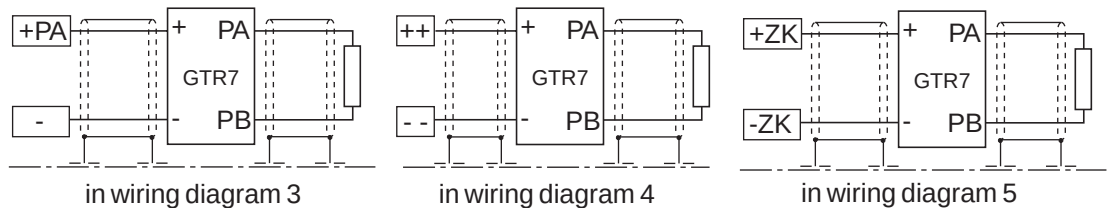
Don't install OH-wiring (also shielding)  
with control cable!  
Only permissible with double-  
shielding into the motor cable!



## Connection of braking resistor (only with internal brake transistor see page 5)

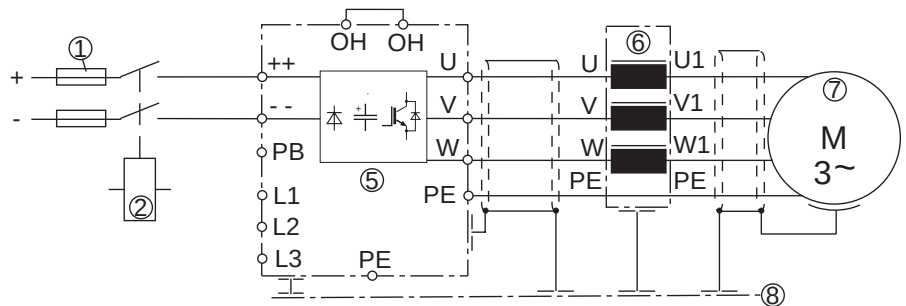


## Connection of a braking module



## DC mains power input (only when terminals are ++ and - -)

250...370 VDC (230 V-class)  
420...720V DC (400 V-class)



- |                                   |                                               |
|-----------------------------------|-----------------------------------------------|
| ① Mains fuse                      | ⑤ KEB COMBIVERT                               |
| ② Main contactor                  | ⑥ Motor choke or output filter (not for F4-F) |
| ③ Input choke                     | ⑦ Motor                                       |
| ④ Interference suppression filter | ⑧ Mounting plate                              |

### 3. Accessories

#### 3.1 Braking resistor

Installation Tip



KEB COMBIVERT is equipped with an external braking resistor or an external braking option and is suited for restricted 4 quadrant operation. The braking energy that is refed into the intermediate circuit during regenerative operation is dissipated by means of the braking transistor, the control and the braking resistor.

The braking resistor heats up during braking. If it is installed inside a control cabinet sufficient cooling of the control cabinet interior must be provided and sufficient distance to the KEB COMBIVERT must be kept.

Different braking resistors are available for KEB COMBIVERT. They are selected according to their application requirements. The respective formulas and restrictions (validity range) are listed on the next page.

Selection of the braking resistor

1. Preset desired braking time.
2. Calculate braking time without braking resistor ( $t_{Bmin}$ ).
3. If the desired braking time is smaller than the calculated braking time, it will be necessary to use a braking resistor. ( $t_B < t_{Bmin}$ )
4. Calculate braking torque ( $M_B$ ) and take the load torque into account.
5. Calculate peak braking power ( $P_B$ ). This must always be calculated for the "worst case" ( $n_{max}$  at standstill).
6. Selection of the braking resistors:
  - a)  $P_R \geq P_B$
  - b)  $P_N$  is to be selected in accordance with the cyclic duration factor.  
The braking resistors may only be used for the units listed. The max. ON period of the braking resistor may not be exceeded.  
Longer ON periods require special-designed braking resistors. Take into account the continuous output of the braking transistor.
7. Check whether the desired braking time is attained with the braking resistor ( $t_{Bmin}$ ).

**Restriction:** Considering the capacity of the braking resistor and the braking capacity of the motor, the braking torque may not exceed the rated torque of the motor by more than 1.5 times (see formula).

To utilize the maximum possible braking torque the frequency inverter must be layed out for the increased current.

## Braking time

The braking time is adjusted on the frequency inverter. If the selected time is too short the KEB COMBIVERT/COMBIDRIVE automatically switches off and displays the error message **OP** or **OC**. The following formulas allow an approximate determination of the braking time.

## Formulas

### 1. Braking time without braking resistor

$$t_{Bmin} = \frac{(J_M + J_L) \cdot (n_1 - n_2)}{9,55 \cdot (K \cdot M_N + M_L)}$$

Validity range:  $n_1 > n_N$

(field weakening range)

### 2. Braking torque (required)

$$M_B = \frac{(J_M + J_L) \cdot (n_1 - n_2)}{9,55 \cdot t_B} M_L$$

Condition:  $M_B \leq 1,5 \cdot M_N$

$f \leq 70 \text{ Hz}$

### 3. Peak braking power

$$P_B = \frac{M_B \cdot n_1}{9,55}$$

Condition:  $P_B \leq P_R$

### 4. Braking time with braking resistor

$$t_{Bmin}^* = \frac{(J_M + J_L) \cdot (n_1 - n_2)}{9,55 \cdot (K \cdot M_N + M_L + \frac{P_R \cdot 9,55}{(n_1 - n_2)})}$$

Validity range:  $n_1 > n_N$

Condition:  $\frac{P_R \cdot 9,55}{(n_1 - n_2)} \leq M_N \cdot (1,5 - K)$

$f \leq 70 \text{ Hz}$

$P_B \leq P_R$

|                     |              |
|---------------------|--------------|
| K = 0,25 for motors | to 1,5 kW    |
| 0,20 for motors     | 2,2 to 4 kW  |
| 0,15 for motors     | 5,5 to 11 kW |
| 0,08 for motors     | 15 to 45 kW  |
| 0,05 for motors     | > 45 kW      |

|            |   |                                    |                      |
|------------|---|------------------------------------|----------------------|
| $J_M$      | = | Moment of inertia of the motor     | [kgm <sup>2</sup> ]  |
| $J_L$      | = | Moment of inertia of the load      | [kgm <sup>2</sup> ]  |
| $n_1$      | = | Motor speed before deceleration    | [min <sup>-1</sup> ] |
| $n_2$      | = | Motor speed after deceleration     | [min <sup>-1</sup> ] |
|            |   | (Stand still = 0 rpm)              |                      |
| $n_N$      | = | Motor rated speed                  | [min <sup>-1</sup> ] |
| $M_N$      | = | Motor rated torque                 | [Nm]                 |
| $M_B$      | = | Braking torque (required)          | [Nm]                 |
| $M_L$      | = | Load torque                        | [Nm]                 |
| $t_B$      | = | Braking time (required)            | [s]                  |
| $t_{Bmin}$ | = | Minimum braking time               | [s]                  |
| $t_z$      | = | Cycle time                         | [s]                  |
| $P_B$      | = | Peak braking power                 | [W]                  |
| $P_R$      | = | Peak power of the braking resistor | [W]                  |

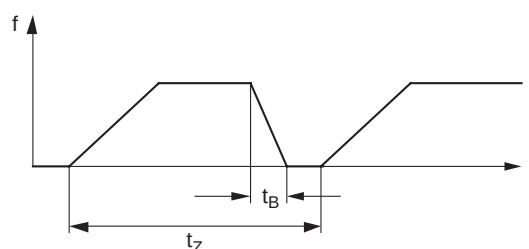
## On period c.d.f.

ON period c.d.f for cycle time  $t_z \leq 120 \text{ s}$

$$\text{c.d.f} = \frac{t_B}{t_z} \cdot 100 \%$$

ON period c.d.f for cycle time  $t_z > 120 \text{ s}$

$$\text{c.d.f} = \frac{t_B}{120 \text{ s}} \cdot 100 \%$$

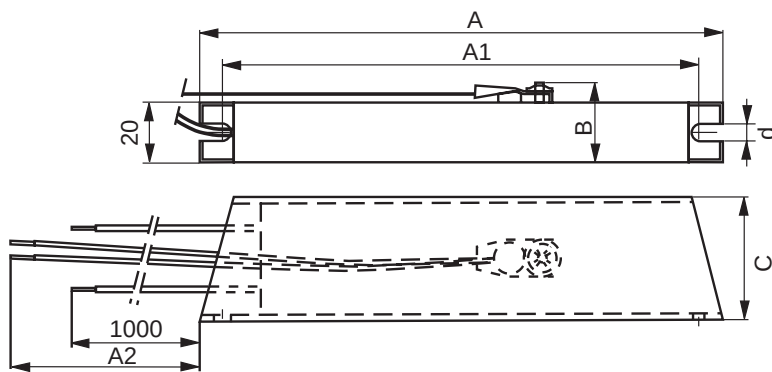


## 3.1.1 Side mounting braking resistor

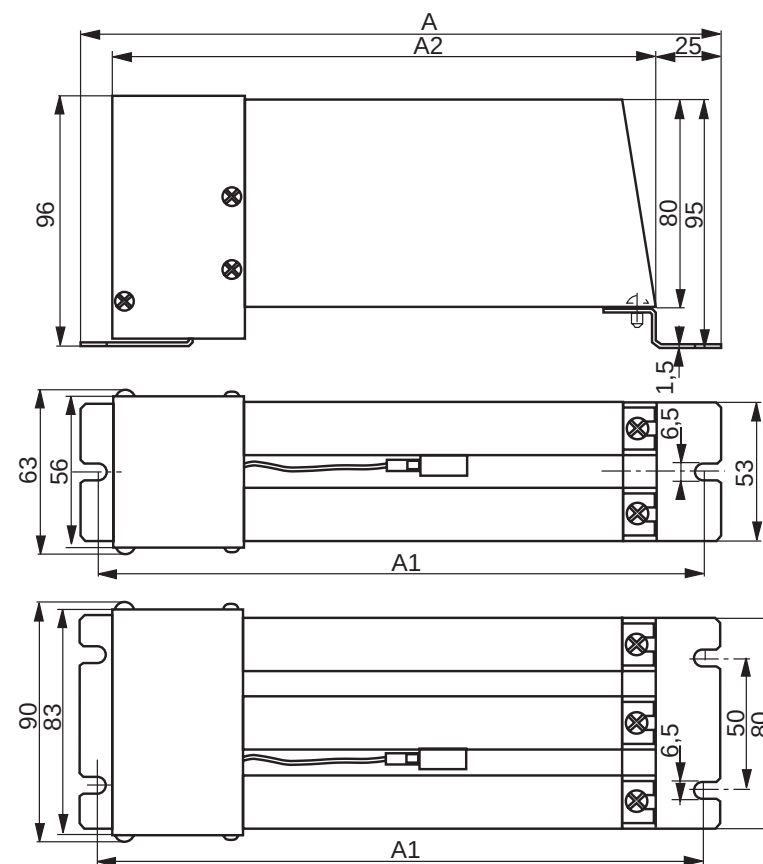
### Technical data braking resistor

| Part number    | R <sub>B</sub> | P <sub>Rated</sub> | COMBIVERT                  | Nominal power <sup>1)</sup> [W] |        |       |
|----------------|----------------|--------------------|----------------------------|---------------------------------|--------|-------|
|                | [OHM]          | [kW]               |                            | 6 %                             | 25 %   | 40 %  |
| 230 V - Class  |                |                    |                            |                                 |        |       |
| 07.BR.100-1180 | 180            | 44                 | 05, 07                     | 800                             | 300    | 180   |
| 09.BR.100-1100 | 100            | 82                 | 07, 09                     | 1500                            | 500    | 300   |
| 10.BR.100-1683 | 68             | 120                | 07, 09, 10, 13(E)          | 2200                            | 800    | 500   |
| 12.BR.100-1333 | 33             | 250                | 10, 13(G)                  | 4400                            | 1300   | 750   |
| 13.BR.100-1273 | 27             | 300                | 13(G), 14                  | 5400                            | 1500   | 900   |
| 14.BR.100-1203 | 20             | 450                | 13(G), 14                  | 7300                            | 1800   | 1100  |
| 15.BR.110-1133 | 13             | 630                | 14, 15                     | 10000                           | 3200   | 1800  |
| 16.BR.110-1103 | 10             | 850                | 15, 16                     | 14000                           | 3600   | 2200  |
| 17.BR.110-1073 | 7              | 1100               | 15, 16                     | 21000                           | 5400   | 3100  |
| 18.BR.xxx-xxxx | on request     |                    |                            |                                 |        |       |
| 19.BR.xxx-xxxx | on request     |                    |                            |                                 |        |       |
| 20.BR.xxx-xxxx | on request     |                    |                            |                                 |        |       |
| 21.BR.xxx-xxxx | on request     |                    |                            |                                 |        |       |
| 400 V - Class  |                |                    |                            |                                 |        |       |
| 07.BR.100-6620 | 620            | 56                 | 05, 07                     | 900                             | 300    | 180   |
| 09.BR.100-6390 | 390            | 90                 | 07, 09                     | 1500                            | 500    | 300   |
| 10.BR.100-6270 | 270            | 130                | 07, 09, 10                 | 2100                            | 800    | 500   |
| 12.BR.100-6150 | 150            | 230                | 12                         | 3700                            | 1300   | 750   |
| 13.BR.100-6110 | 110            | 350                | 12, 13                     | 5000                            | 1500   | 900   |
| 14.BR.100-6853 | 85             | 410                | 12, 13, 14                 | 6500                            | 1800   | 1100  |
| 15.BR.110-6563 | 56             | 620                | 12(E), 13(E,G), 14, 15     | 10000                           | 3200   | 1800  |
| 16.BR.110-6423 | 42             | 820                | 13(G), 14(G), 15, 16       | 13500                           | 3600   | 2200  |
| 17.BR.110-6303 | 30             | 1200               | 15(H), 16, 17              | 18500                           | 5400   | 3100  |
| 18.BR.226-6203 | 20             | 1700               | 17(R), 18, 19              | 27500                           | 7500   | 4500  |
| 19.BR.226-6153 | 15             | 2300               | 17(R), 18, 19, 20          | 37000                           | 10000  | 6000  |
| 20.BR.226-6123 | 12             | 2900               | 18(R), 19(R), 20, 21       | 46000                           | 12500  | 7500  |
| 21.BR.226-6103 | 10             | 3000               | 18(R), 19(R), 20, 21, 22   | 55000                           | 15000  | 9000  |
| 22.BR.226-6866 | 8,6            | 4000               | 21(L), 22(L), 23           | 64000                           | 17500  | 10000 |
| 23.BR.226-6676 | 6,7            | 5200               | 22(L), 23, 24(U)           | 82000                           | 22000  | 12500 |
| 24.BR.226-6506 | 5              | 6900               | 23(U), 24(U), 25(U)        | 110000                          | 30000  | 18000 |
| 25.BR.226-6436 | 4,3            | 8100               | 24(U), 25(U), 26(U), 27(U) | 130000                          | 35000  | 20000 |
| 26.BR.226-6386 | 3,8            | 9200               | 25, 26, 27(U)              | 145000                          | 40000  | 22500 |
| 27.BR.226-6336 | 3,3            | 10000              | 25, 26, 27(U)              | 170000                          | 45000  | 25000 |
| 28.BR.226-6226 | 2,2            | 15000              | 28(W), 29(W), 30(W)        | 250000                          | 67000  | 37000 |
| 29.BR.226-6176 | 1,7            | 20000              | 28(W), 29(W), 30(W)        | 325000                          | 90000  | 50000 |
| 30.BR.226-6136 | 1,3            | 26000              | 28(W), 29(W), 30(W)        | 425000                          | 112000 | 62000 |

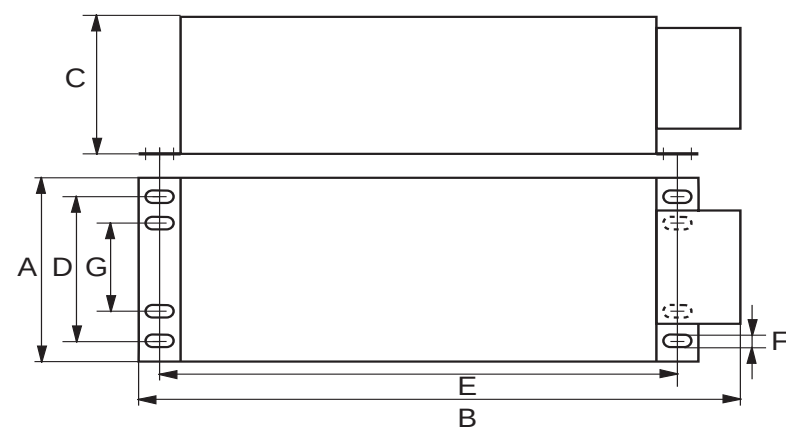
1) Permissible load of the resistor in dependence on the cyclic duration factor related to 120 s cycle time. The calculated peak braking time must be ≤ the load of the resistor. If the value is not achieved, please contact KEB.



| Part number    | A   | A1  | A2   | B  | C  | d   |
|----------------|-----|-----|------|----|----|-----|
| 07.BR.100-xxxx | 160 | 145 | 1120 | 26 | 40 | 6   |
| 09.BR.100-xxxx | 240 | 222 | 1060 | 26 | 40 | 6   |
| 10.BR.100-xxxx | 300 | 285 | 1030 | 26 | 40 | 6   |
| 11.BR.100-xxxx | 240 | 225 | 1085 | 28 | 80 | 5,5 |
| 12.BR.100-xxxx | 300 | 285 | 1055 | 28 | 80 | 5,5 |
| 13.BR.100-xxxx | 400 | 400 | 1005 | 28 | 80 | 5,5 |
| 14.BR.100-xxxx | 400 | 400 | 1005 | 28 | 80 | 5,5 |



| Part number    | A   | A1  | A2  |
|----------------|-----|-----|-----|
| 15.BR.110-xxxx | 370 | 355 | 300 |
| 16.BR.110-xxxx | 470 | 455 | 400 |
| 17.BR.110-xxxx | 470 | 455 | 400 |

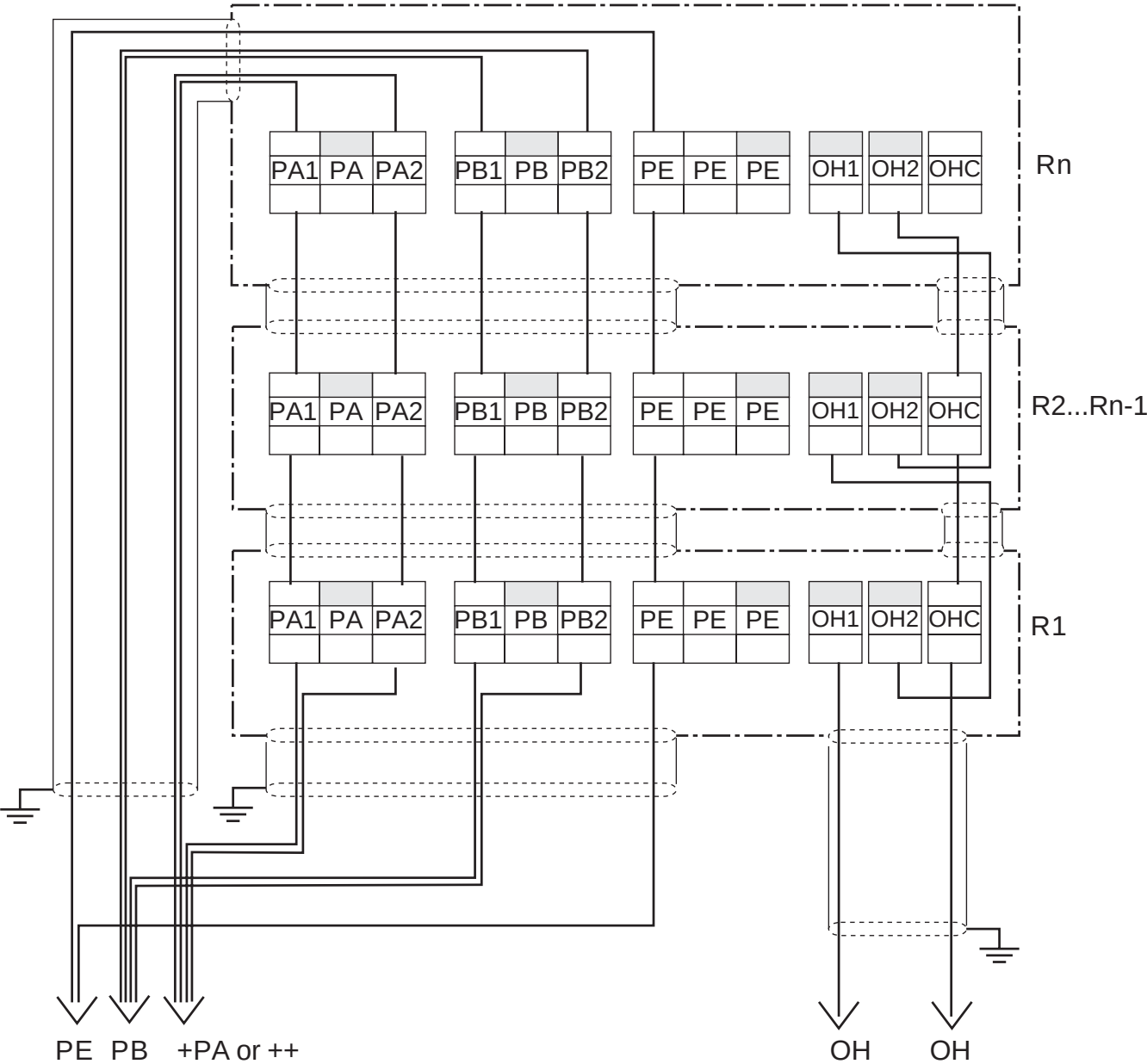
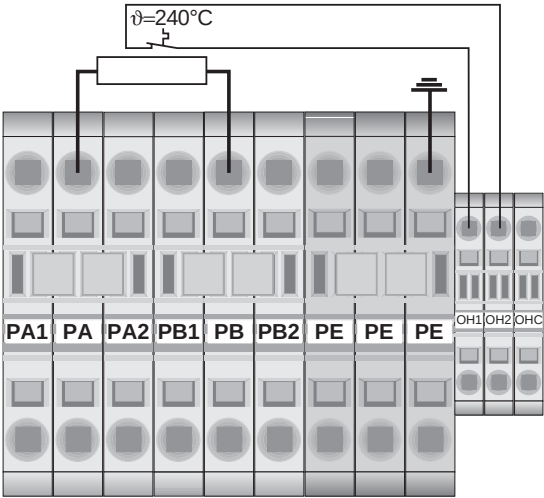


| Part number    | A                                            | B   |
|----------------|----------------------------------------------|-----|
| 18.BR.226-6203 | 611                                          | 116 |
| 19.BR.226-6153 | 611                                          | 116 |
| 20.BR.226-6123 | 631                                          | 221 |
| 21.BR.226-6103 | 631                                          | 221 |
| 22.BR.226-6866 | 631                                          | 271 |
| 23.BR.226-6676 | 631                                          | 271 |
| 24.BR.226-6506 | = 2 x 21.BR.226-6103                         |     |
| 25.BR.226-6436 | = 2 x 22.BR.226-6866                         |     |
| 26.BR.226-6386 | = 1 x 22.BR.226-6866<br>+ 1 x 23.BR.226-6676 |     |
| 27.BR.226-6336 | = 2 x 23.BR.226-6676                         |     |
| 28.BR.226-6226 | = 3 x 23.BR.226-6676                         |     |
| 29.BR.226-6176 | = 4 x 23.BR.226-6676                         |     |
| 30.BR.226-6136 | = 5 x 23.BR.226-6676                         |     |

3.1.2 Parallel connection of braking resistors

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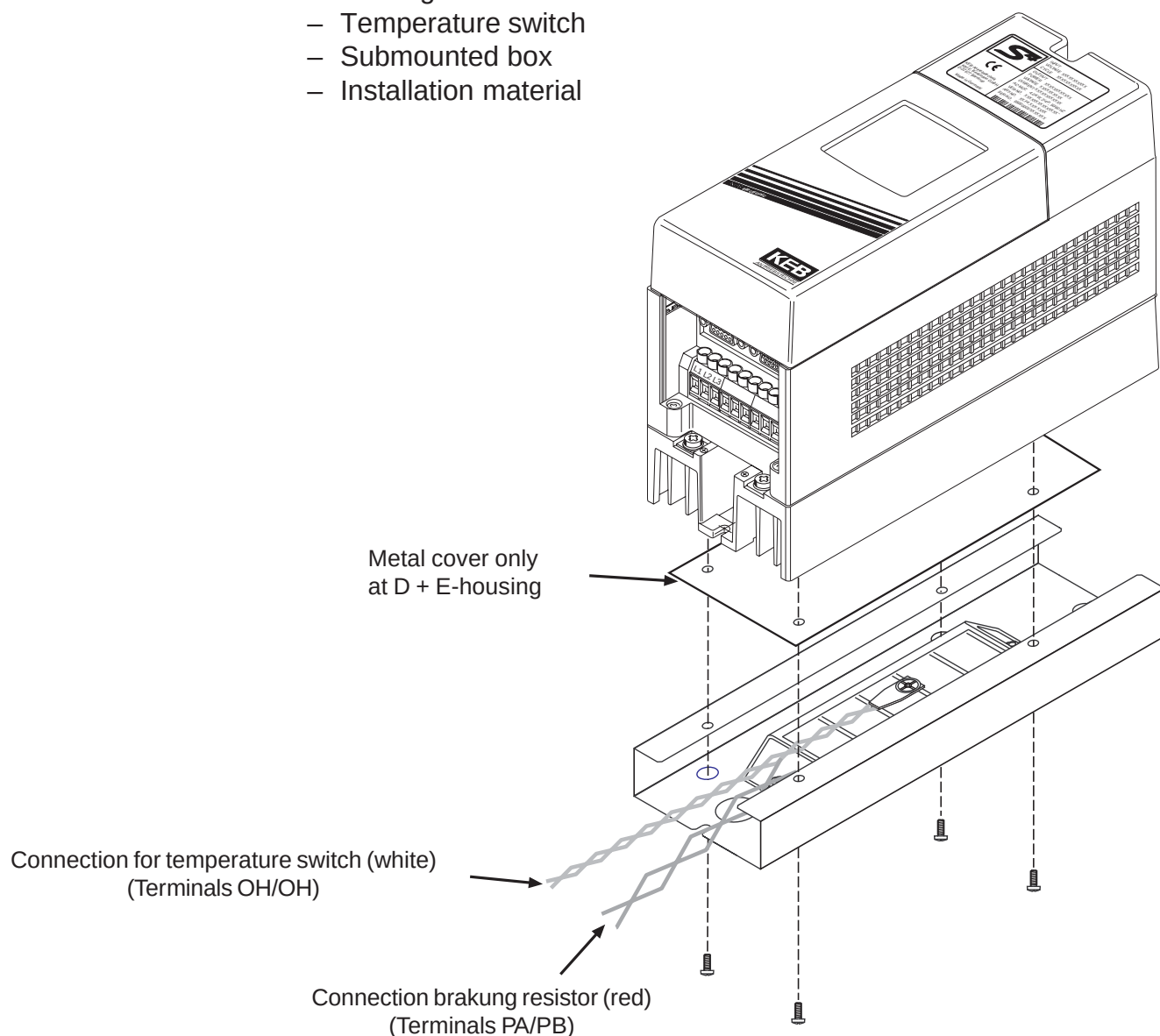
Terminal strip braking resistor



### 3.1.3 Submounting braking resistor

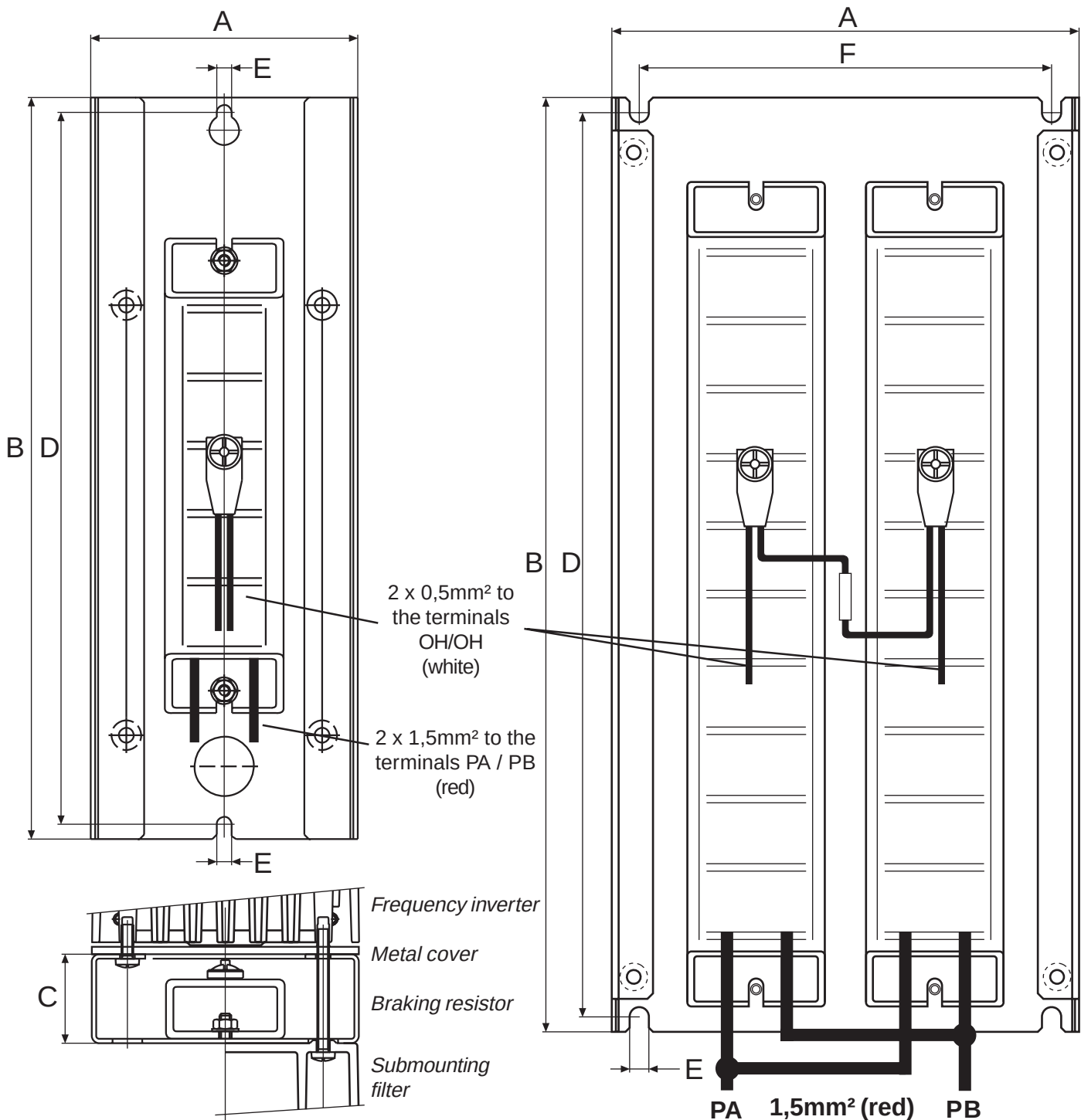
The submounting braking resistors are planned for a small volume installation directly under the frequency inverter. Mostly they are suitable for short braking cycles and clock system. The assemblies are made of:

- Braking resistor
- Temperature switch
- Submounted box
- Installation material



| Size                           |      | 10             | 12             | 12/13/14       | 15             | 13/14/15       | 16             |
|--------------------------------|------|----------------|----------------|----------------|----------------|----------------|----------------|
| Housing                        |      | D              | D              | E              | E              | G              | G              |
| Braking resistor               | [Ω]  | 160            | 82             | 60             | 30             | 50             | 25             |
| Permanent load                 | [W]  | 35             | 35             | 60             | 2 x 60         | 80             | 2 x 80         |
| Non-recurring load (max. 3s)   | [W]  | 3600           | 7800           | 9600           | 19000          | 11500          | 23000          |
| Permissible load at 5% c.d.f.  | [W]  | 700            | 700            | 1200           | 2400           | 1600           | 3200           |
| Permissible load at 10% c.d.f. | [W]  | 350            | 350            | 600            | 1200           | 800            | 1600           |
| Permissible load at 20% c.d.f. | [W]  | 175            | 175            | 300            | 600            | 400            | 800            |
| Permissible load at 40% c.d.f. | [W]  | 90             | 90             | 150            | 300            | 200            | 400            |
| Weight                         | [kg] | 0,89           | 0,9            | 1,3            | 1,5            | 1,5            | 1,9            |
| Partnumber of the kit          |      | 10.F4.D50-4200 | 12.F4.D50-4200 | 14.F4.E50-4200 | 15.F4.E50-4200 | 15.F4.G50-4200 | 16.F4.G50-4200 |

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Dimensions  
Submounting braking  
resistors

| Housing | D   | E   | G   |
|---------|-----|-----|-----|
| A [mm]  | 90  | 130 | 170 |
| B [mm]  | 250 | 290 | 340 |
| C [mm]  | 30  | 30  | 25  |
| D [mm]  | 240 | 275 | 329 |
| E [mm]  | 5   | 7   | 7   |
| F [mm]  | -   | -   | 150 |



## Attention Fire Risk!



In order to detect the overheating of a braking resistor it is absolutely necessary to monitor the temperatur switch. The overheating can have following causes:

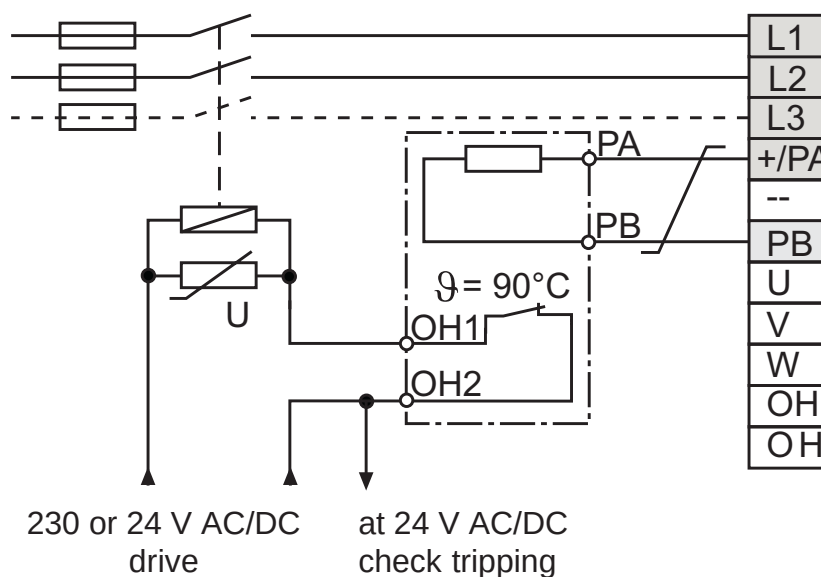
- ramps too short or the operation-time too long
- incorrect dimensioning of the braking resistor
- input voltage too high
- defect of braking transistor in the inverter or the braking module

The disconnection of the mains voltage offers the only protection in the case of a defective braking transistor (see diagram).

Braking resistors can develop a very high surface temperature, therefore install as safe-to-touch as possible!

### Connection of the braking resistor

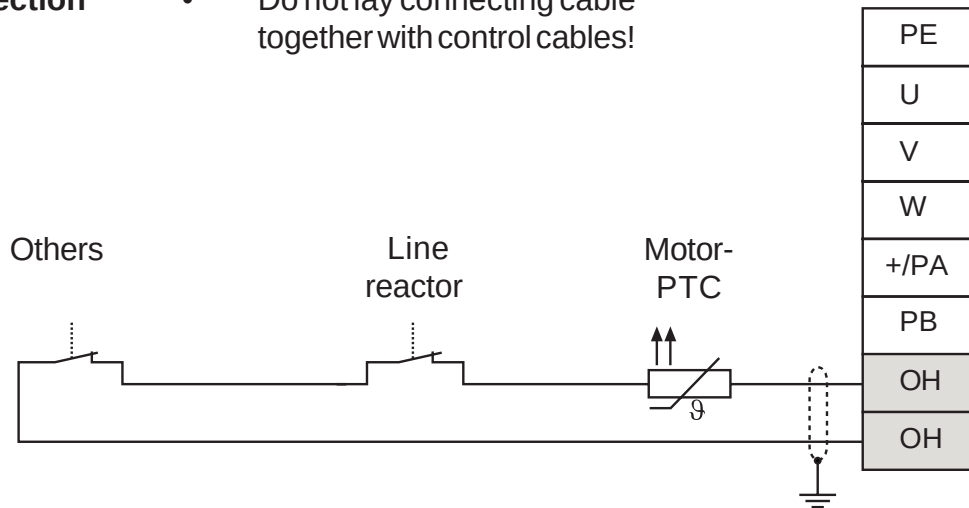
- +/PA, PB Terminals for the braking resistor
- during release of the temperature monitoring the input voltage is switched off



A simplified protection is achieved, if the links of the temperature sensor are integrated into the temperature detection in accordance with following drawing. This measure does not protect with a defect of the braking transistor however against the developing extreme overload with acute danger of fire.

## Connection of the temperature detection

- Terminals OH
- Do not lay connecting cable together with control cables!



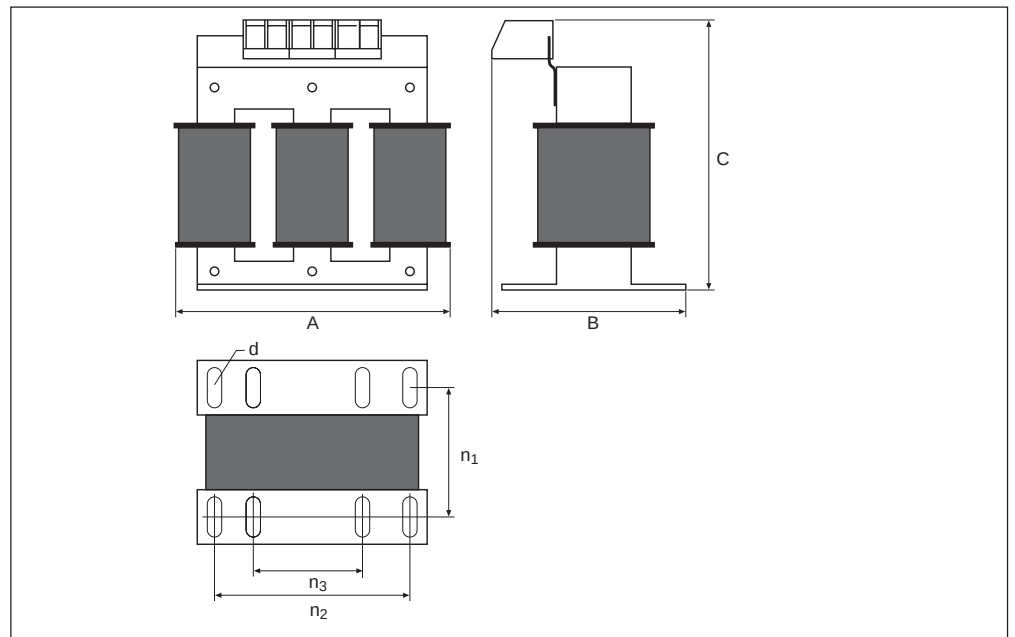
## 3.2 Input filter

### 3.2.1 Input choke

The KEB input choke is dimensioned according to the regulations VDE 0160 with short circuit voltage of  $U_K = 4\%$ . By reducing the harmonics the power factor of the inverter improves from 0.5...0.6 to approximately 0.8...0.9.

With a frequency range from 10 kHz to approximately 300 kHz the values of the conducted HF-interferences are reduced up to 30 db.

Additionally the noise immunity of the system is improved and the DC-link capacitors lifetime increases.



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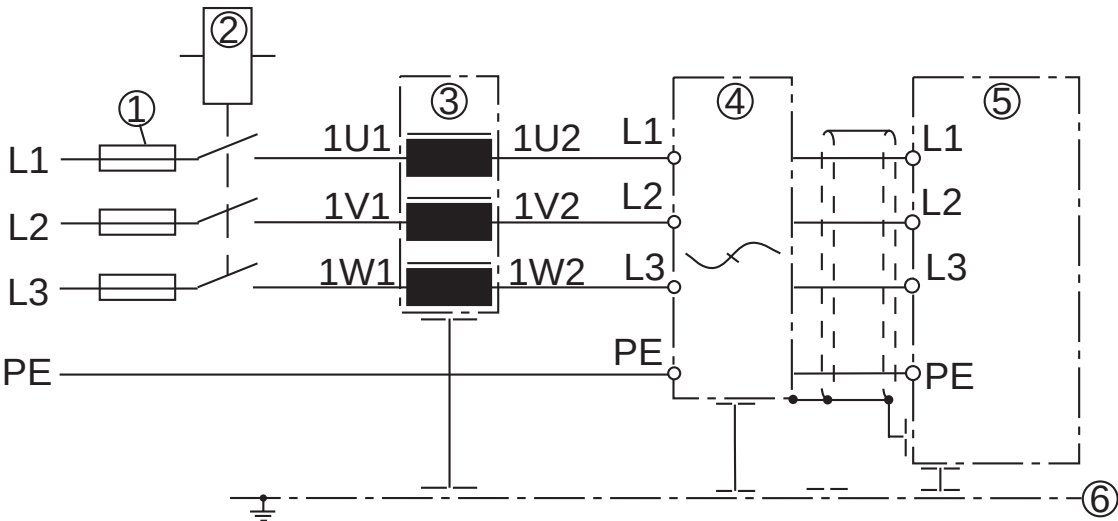
**230V-Class 4% terminal short circuit voltage**

| Number | For<br>COMBIVERT | Phases | $I_{rated}$<br>[A] | $P_{loss}$<br>[W] | Part number    | Dimensions |     |     |       |       |       |         | Terminal<br>[mm <sup>2</sup> ] | Weight<br>[kg] |
|--------|------------------|--------|--------------------|-------------------|----------------|------------|-----|-----|-------|-------|-------|---------|--------------------------------|----------------|
|        |                  |        |                    |                   |                | A          | B   | C   | $n_1$ | $n_2$ | $n_3$ | d       |                                |                |
| 1      | 05               | 1      | 6                  | 9                 | 05.DR.F08-4951 | 60         | 60  | 80  | 37    | 45    | -     | 3,6 x 7 | 4                              | 0,5            |
| 2      | 05               | 3      | 4                  | 14                | 05.DR.A08-4251 | 129        | 62  | 115 | 41    | 112   | -     | 4,8 x 9 | 4                              | 0,8            |
| 3      | 07               | 1      | 10                 | 9                 | 07.DR.F08-2951 | 84         | 86  | 100 | 48    | 64    | -     | 4,8 x 9 | 4                              | 1,4            |
| 4      | 07               | 3      | 6                  | 21                | 07.DR.A08-2851 | 129        | 62  | 115 | 41    | 112   | -     | 4,8 x 9 | 4                              | 1,2            |
| 5      | 09               | 1      | 16                 | 15                | 09.DR.F08-1851 | 84         | 86  | 100 | 48    | 64    | -     | 4,8 x 9 | 4                              | 1,5            |
| 6      | 09               | 3      | 8                  | 21                | 09.DR.A08-2151 | 129        | 62  | 115 | 41    | 112   | -     | 4,8 x 9 | 4                              | 1,2            |
| 7      | 10               | 1      | 20                 | 15                | 10.DR.F08-1551 | 84         | 86  | 100 | 48    | 64    | -     | 4,8 x 9 | 4                              | 1,5            |
| 8      | 10               | 3      | 12                 | 30                | 10.DR.A08-1551 | 129        | 72  | 115 | 50    | 112   | -     | 4,8 x 9 | 4                              | 1,8            |
| 9      | 12               | 1      | 25                 | 18                | 12.DR.F08-1151 | 96         | 100 | 115 | 62    | 84    | -     | 5 x 11  | 4                              | 2,5            |
| 10     | 12               | 3      | 20                 | 30                | 12.DR.A08-8541 | 148        | 100 | 160 | 60    | 136   | 60    | 4,8 x 8 | 10                             | 3              |
| 11     | 13               | 3      | 30                 | 45                | 13.DR.A08-5641 | 148        | 100 | 160 | 60    | 136   | 60    | 4,8 x 8 | 10                             | 3,7            |
| 12     | 14               | 3      | 40                 | 50                | 14.DR.A08-4241 | 178        | 130 | 195 | 55    | 166   | 113   | 4,8 x 8 | 16                             | 5              |
| 13     | 15               | 3      | 60                 | 63                | 15.DR.A08-2841 | 178        | 145 | 235 | 70    | 166   | 113   | 4,8 x 8 | 16                             | 6,4            |
| 14     | 16               | 3      | 70                 | 74                | 16.DR.A08-2241 | 219        | 148 | 240 | 71    | 201   | 136   | 7 x 12  | 35                             | 7,6            |
| 15     | 17               | 3      | 85                 | 92                | 17.DR.A08-1841 | 219        | 170 | 255 | 81    | 201   | 136   | 7 x 12  | 95                             | 10,5           |
| 16     | 18               | 3      | 100                | 90                | 18.DR.A08-1541 | 219        | 190 | 255 | 91    | 201   | 136   | 7 x 12  | 95                             | 12             |
| 17     | 19               | 3      | 130                | 115               | 19.DR.A08-1241 | 267        | 195 | 300 | 81    | 249   | 176   | 7 x 12  | 95                             | 15,3           |
| 18     | 20               | 3      | 160                | 155               | 20.DR.A08-1041 | 267        | 220 | 300 | 105   | 249   | 176   | 7 x 12  | 95                             | 18             |
| 19     | 21               | 3      | 200                | 158               | 21.DR.A08-8031 | 267        | 215 | 310 | 102   | 249   | 176   | 7 x 12  | 95                             | 29             |
| 20     | 22               | 3      | 230                | 170               | 22.DR.A08-6031 | 267        | 235 | 335 | 116   | 249   | 176   | 7 x 12  | 150                            | 31             |

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| 400V-Class 4% terminal short circuit voltage |               |        |                        |                       |                |            |     |     |                |                |                |         |                |             |
|----------------------------------------------|---------------|--------|------------------------|-----------------------|----------------|------------|-----|-----|----------------|----------------|----------------|---------|----------------|-------------|
| Number                                       | For COMBIVERT | Phases | I <sub>rated</sub> [A] | P <sub>loss</sub> [W] | Part number    | Dimensions |     |     |                |                |                |         | Terminal [mm²] | Weight [kg] |
|                                              |               |        |                        |                       |                | A          | B   | C   | n <sub>1</sub> | n <sub>2</sub> | n <sub>3</sub> | d       |                |             |
| 19                                           | 05            | 3      | 4                      | 22                    | 05.DR.B08-7351 | 129        | 72  | 115 | 50             | 112            | -              | 4,8 x 9 | 2,5            | 1,35        |
| 20                                           | 07, 09        |        | 6                      | 22                    | 07.DR.B08-4951 | 129        | 72  | 115 | 50             | 112            | -              | 4,8 x 9 | 2,5            | 1,6         |
| 21                                           | 10            |        | 8                      | 33                    | 10.DR.B08-3751 | 148        | 80  | 140 | 60             | 136            | 90             | 4,8 x 8 | 2,5            | 2,5         |
| 22                                           | 12            |        | 10                     | 33                    | 12.DR.B08-2851 | 148        | 80  | 140 | 60             | 136            | 60             | 4,8 x 8 | 2,5            | 2,5         |
| 23                                           | 13            |        | 16                     | 53                    | 13.DR.B08-1851 | 178        | 95  | 165 | 55             | 166            | 113            | 4,8 x 8 | 2,5            | 5,2         |
| 24                                           | 14            |        | 20                     | 54                    | 14.DR.B08-1451 | 178        | 95  | 165 | 55             | 166            | 113            | 4,8 x 8 | 4              | 5,4         |
| 25                                           | 15            |        | 30                     | 76                    | 15.DR.B08-9841 | 178        | 110 | 175 | 70             | 166            | 113            | 4,8 x 8 | 10             | 5,8         |
| 26                                           | 16            |        | 40                     | 76                    | 16.DR.B08-7341 | 178        | 110 | 175 | 70             | 166            | 113            | 7 x 12  | 10             | 6,8         |
| 27                                           | 17            |        | 50                     | 97                    | 17.DR.B08-5941 | 219        | 100 | 200 | 71             | 201            | 136            | 7 x 12  | 10             | 8           |
| 28                                           | 18            |        | 60                     | 100                   | 18.DR.B18-4941 | 219        | 110 | 200 | 81             | 201            | 136            | 7 x 12  | 10             | 9,8         |
| 29                                           | 19            |        | 75                     | 110                   | 19.DR.B18-3941 | 219        | 160 | 235 | 91             | 201            | 136            | 7 x 12  | 35             | 13,1        |
| 30                                           | 20            |        | 90                     | 151                   | 20.DR.B18-3341 | 267        | 186 | 285 | 81             | 249            | 176            | 7 x 12  | 35             | 15,6        |
| 31                                           | 21            |        | 115                    | 181                   | 21.DR.B18-2841 | 267        | 210 | 275 | 105            | 249            | 176            | 7 x 12  | 35             | 21,9        |
| 32                                           | 22            |        | 150                    | 205                   | 22.DR.B18-2241 | 316        | 200 | 330 | 99             | 292            | 200            | 9 x 13  | 95             | 24,7        |
| 33                                           | 23            |        | 180                    | 145                   | 23.DR.B18-1741 | 267        | 207 | 310 | 94             | 249            | 176            | 7 x 12  | 95             | 24,1        |
| 34                                           | 24            |        | 200                    | 168                   | 24.DR.B18-1541 | 267        | 215 | 310 | 102            | 249            | 176            | 7 x 12  | 95             | 28,3        |
| 35                                           | 25            |        | 230                    | 230                   | 25.DR.B18-1341 | 267        | 230 | 335 | 111            | 249            | 176            | 9 x 13  | 150            | 30          |
| 36                                           | 26            |        | 270                    | 290                   | 26.DR.B28-1141 | 352        | 230 | 400 | 105            | 328            | 224            | 10 x 16 | 240            | 37,3        |
| 37                                           | 27            |        | 300                    | 308                   | 27.DR.B28-1041 | 352        | 210 | 270 | 121            | 328            | 224            | 10 x 16 | M12            | 48,2        |
| 38                                           | 28            |        | 400                    | 420                   | 28.DR.B28-8031 | 480        | 200 | 390 | 120            | 450            | 316            | 12 x 20 | 40 x 5         | 61          |
| 39                                           | 29            |        | 580                    | 470                   | 29.DR.B28-5331 | 480        | 210 | 390 | 130            | 450            | 316            | 12 x 20 | 40 x 5         | 73,5        |
| 40                                           | 30            |        | 660                    | 530                   | 30.DR.B22-4430 | 480        | 210 | 390 | 130            | 450            | 316            | 12 x 20 | 50 x 5         | 77          |

Connection of the input choke



- ①

Mains fuse
- ②

Main protection
- ③

Input choke
- ④

Interference suppression filter
- ⑤

KEB COMBIVERT
- ⑥

Mounting plate

### 3.2.2 HF-Filter

The KEB COMBIVERT frequency inverters are optionally available with radio interference filters. Dependent on the housing size they are available as factory installed complete units (D-R Housing) or as filter assembly kits for local installation. The filter assembly kits contain the complete installation material incl. earth connection. They are ready for installation for max. 30 kW with connected lead wires at the filter output. Dependent on the available space and filter type the filter can either be installed under the frequency inverter (submounted), or beside the frequency inverter (side mounted).

All filters are dimensioned for the inverter and relate to the conducted emission in accordance with the limit curves EN 55011/B. When adhering to the specifications standard filters can be operated with a shielded motor cable up to 30 m.

For further filters e.g. for IT or delta networks, I/O filters or customized solutions please contact KEB.

| Number                                       | I [A] | Pv [W] | Kit incl. Filter | Filter         | Submounting at housing type |
|----------------------------------------------|-------|--------|------------------|----------------|-----------------------------|
| <b>HF-Filter, Phases 1, max. 240V (+10%)</b> |       |        |                  |                |                             |
| 1                                            | 12    | 5      | 07.U4.00D-B606   | 07.E4.T60-0061 | D                           |
| 2                                            | 20    | 12     | 09.U4.00D-B601   | 09.E4.T60-0001 | D                           |
| 3                                            | 30    | 17,6   | 10.U4.00D-B601   | 10.E4.T60-0001 | D                           |
| <b>HF-Filter, Phases 3, max. 240V (+10%)</b> |       |        |                  |                |                             |
| 4                                            | 8     | 7      | 10.U4.00D-BA01   | 10.E4.T60-1001 | D                           |
| 5                                            | 16    | 11,5   | 13.U4.00D-BA01   | 13.E4.T60-1001 | D                           |
| 6                                            | 30    | 21     | 13.U4.00E-BA01   | 15.E4.T60-1001 | E                           |
| 7                                            | 50    | 14     | 14.U4.00G-BA01   | 16.E4.T60-1001 | G                           |
| 8                                            | 70    | 15     | 15.U4.00H-BA01   | 18.E4.T60-1001 | H                           |
| 9                                            | 90    | 20     | 16.U4.00H-BA01   | 19.E4.T60-1001 | H                           |
| 10                                           | 110   | 60     | 17.U4.00R-BA01   | 20.E4.T60-1001 | R                           |
| 11                                           | 150   | 60     | 19.U4.00R-BA01   | 22.E4.T60-1001 | R                           |
| 12                                           | 180   | 40     | 23.U4.0RU-BM01   | 23.E4.T60-1001 | -                           |
| 13                                           | 250   | 50     | 25.U4.00U-BM01   | 25.E4.T60-1001 | -                           |
| <b>HF-Filter, Phases 3, max. 480V (+5%)</b>  |       |        |                  |                |                             |
| 14                                           | 8     | 7      | 10.U4.00D-BM01   | 10.E4.T60-1001 | D                           |
| 15                                           | 16    | 11,5   | 13.U4.00D-BM01   | 13.E4.T60-1001 | D                           |
| 16                                           | 20    | 14     | 14.U4.00E-BM01   | 14.E4.T60-1001 | E                           |
| 17                                           | 30    | 21     | 15.U4.00E-BM01   | 15.E4.T60-1001 | E                           |
| 18                                           | 20    | 14     | 14.U4.00G-BM01   | 14.E4.T60-1001 | -                           |
| 19                                           | 50    | 14     | 16.U4.00G-BM01   | 16.E4.T60-1001 | G                           |
| 20                                           | 50    | 14     | 16.U4.00H-BM01   | 16.E4.T60-1001 | -                           |
| 21                                           | 70    | 15     | 18.U4.00H-BM01   | 18.E4.T60-1001 | H                           |
| 22                                           | 90    | 20     | 19.U4.00H-BM01   | 19.E4.T60-1001 | H                           |
| 23                                           | 110   | 60     | 20.U4.00R-BM01   | 20.E4.T60-1001 | R                           |
| 24                                           | 150   | 60     | 22.U4.00R-BM01   | 22.E4.T60-1001 | R*                          |
| 25                                           | 180   | 40     | 23.U4.0RU-BM01   | 23.E4.T60-1001 | -                           |
| 26                                           | 250   | 50     | 25.U4.00U-BM01   | 25.E4.T60-1001 | -                           |
| 27                                           | 300   | 50     | 26.U5.A0U-3000   | 26.E4.T60-1001 | -                           |
| 28                                           | 330   | 75     | 27.U4.00U-BM01   | 27.E4.T60-1001 | -                           |
| 29                                           | 410   | 50     | 28.U4.00W-BM0S   | 28.E4.T60-1001 | -                           |
| 30                                           | 660   | 60     | 30.U5.A0W-3000   | 30.E4.T60-1001 | -                           |
| 31                                           | 1000  | 90     | -                | 32.E4.T60-1001 | -                           |

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Fig. 1

Supply

Inverter

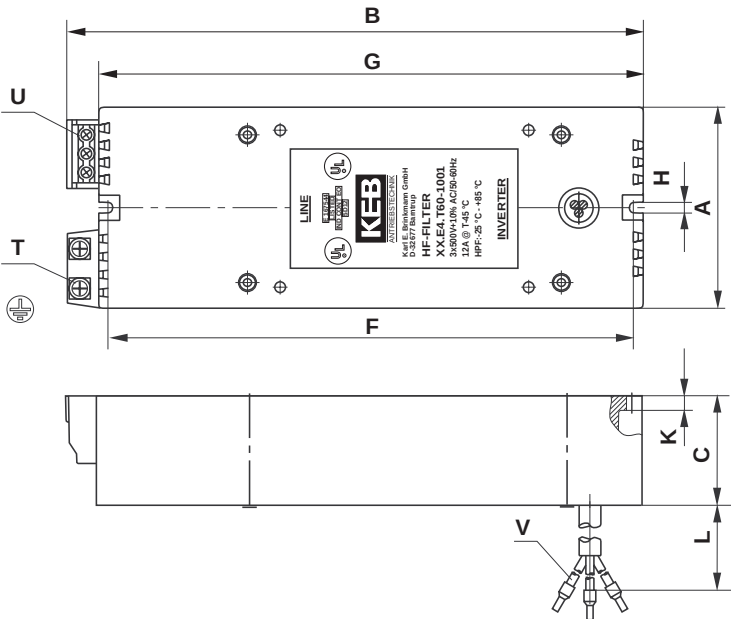
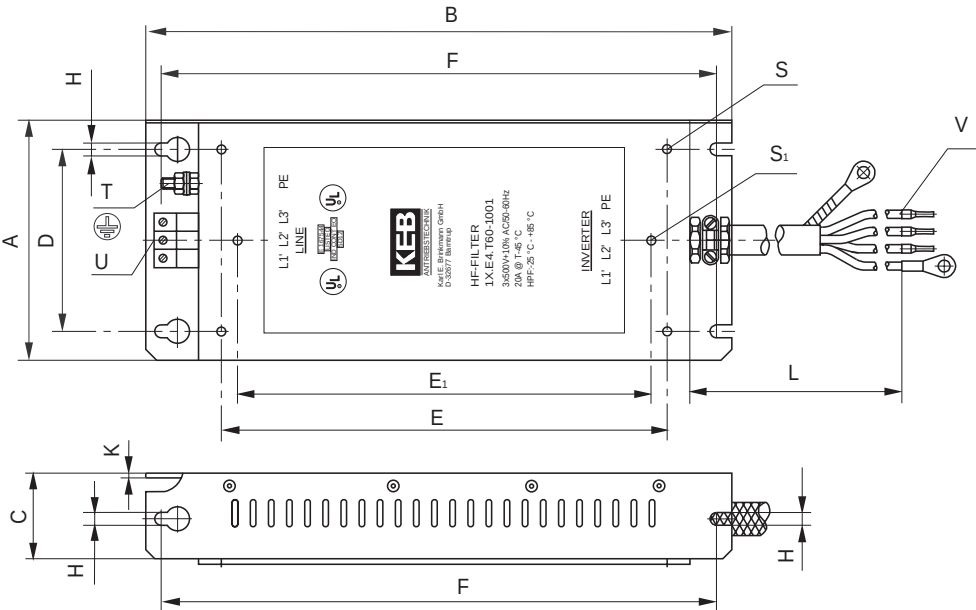


Fig. 2

Supply

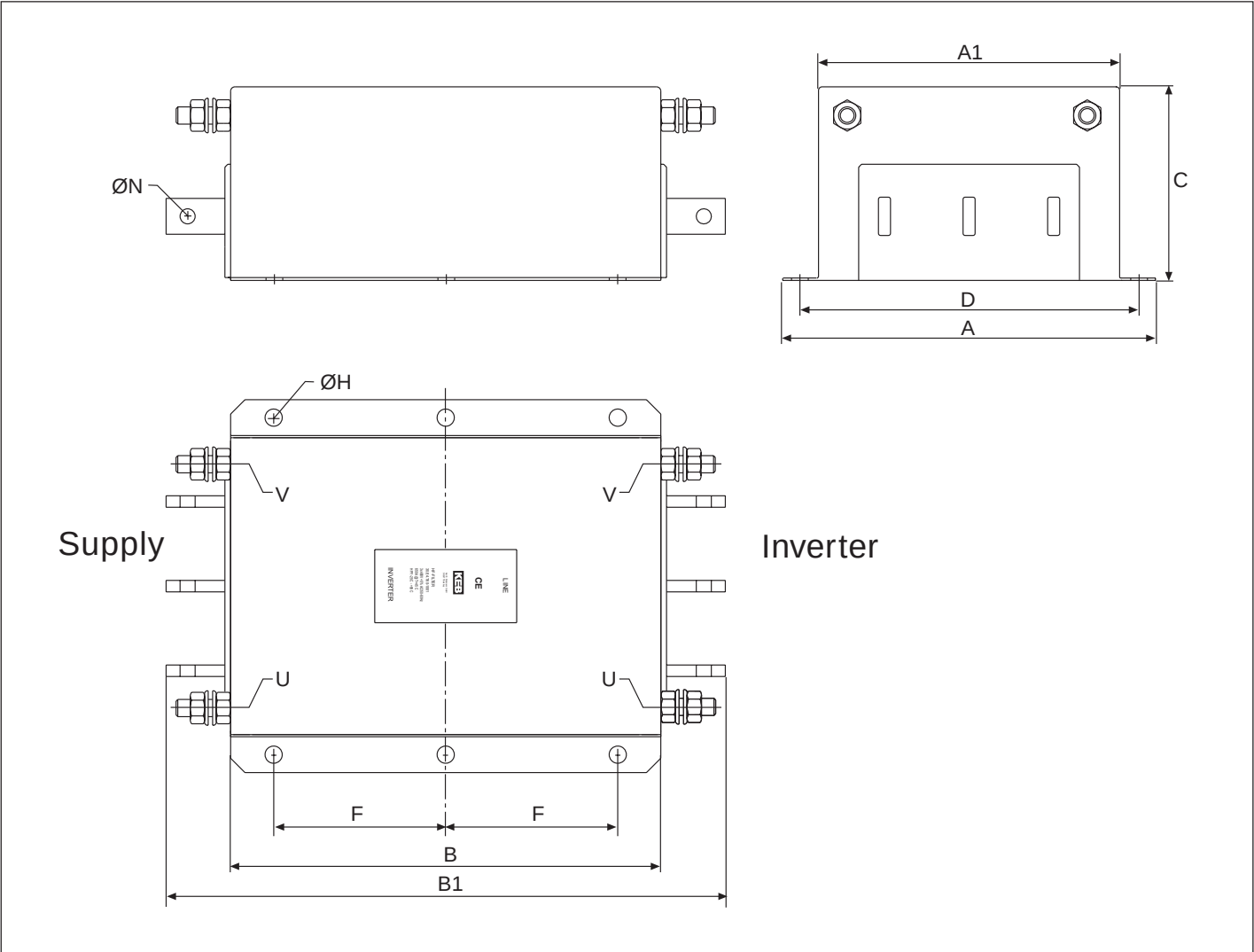
Inverter



| Rated current  |                 |          | Fig. | A   | B   | C  | D   | E   | E1 | F   | G   | H | K | S  | S1 | T  | LINE      | INVERTER  | L         | Weight<br>[kg] |    |     |   |     |     |   |   |   |   |    |    |           |           |     |     |
|----------------|-----------------|----------|------|-----|-----|----|-----|-----|----|-----|-----|---|---|----|----|----|-----------|-----------|-----------|----------------|----|-----|---|-----|-----|---|---|---|---|----|----|-----------|-----------|-----|-----|
| Voltage        | U max.          | Terminal |      |     |     |    |     |     |    |     |     |   |   |    |    |    | V         |           |           |                |    |     |   |     |     |   |   |   |   |    |    |           |           |     |     |
| KEB Art.No.:   | [M]             |          |      |     |     |    |     |     |    |     |     |   |   |    |    |    |           | [A]       |           |                |    |     |   |     |     |   |   |   |   |    |    |           |           |     |     |
| 07.E4.T60-0061 | 1x240<br>(+10%) | 12       | 1    | 90  | 264 | 50 | -   | -   | -  | 240 | 250 | 5 | 4 | -  | -  | M4 | 2x 4mm²   | 2x AWG 14 | 110       | 0,9            |    |     |   |     |     |   |   |   |   |    |    |           |           |     |     |
| 09.E4.T60-0001 |                 | 20       |      |     |     |    |     |     |    |     |     |   |   |    |    |    | 2x AWG 10 |           |           |                |    |     |   |     |     |   |   |   |   |    |    |           |           |     |     |
| 10.E4.T60-0001 |                 | 30       |      |     |     |    |     |     |    |     |     |   |   |    |    |    | 2x AWG 10 |           |           |                |    |     |   |     |     |   |   |   |   |    |    |           |           |     |     |
| 09.E4.T60-1001 | 3x480<br>(+5%)  | 8        |      |     |     |    |     |     |    |     |     |   |   |    |    |    | 2         | 132       |           | 352            | 50 | 100 | - | 275 | 335 | - | 7 | 3 | - | M6 | M6 | 3x 4mm²   | 3x AWG 14 | 400 | 1,3 |
| 10.E4.T60-1001 |                 | 8        |      |     |     |    |     |     |    |     |     |   |   |    |    |    |           |           |           |                |    |     |   |     |     |   |   |   |   |    |    | 3x AWG 10 | 3x AWG 14 |     |     |
| 13.E4.T60-1001 |                 | 16       |      |     |     |    |     |     |    |     |     |   |   |    |    |    |           |           |           |                |    |     |   |     |     |   |   |   |   |    |    |           |           |     |     |
| 14.E4.T60-1001 | 3x480<br>(+5%)  | 20       | 2    | 181 | 415 | 56 | 150 | 330 | -  | 400 | -   | 7 | 3 | M6 | -  | M6 |           |           | 4x AWG 12 |                |    |     |   |     |     |   |   |   |   |    |    | 4x AWG 10 | 350       |     | 1,5 |
| 15.E4.T60-1001 |                 | 30       |      |     |     |    |     |     |    |     |     |   |   |    |    |    |           |           | 4x AWG 8  |                |    |     |   |     |     |   |   |   |   |    |    | 4x AWG 6  |           |     |     |
| 16.E4.T60-1001 |                 | 50       |      |     |     |    |     |     |    |     |     |   |   |    |    |    |           |           | 4x AWG 6  |                |    |     |   |     |     |   |   |   |   |    |    | 4x AWG 4  |           |     |     |
| 18.E4.T60-1001 |                 | 70       |      |     |     |    |     |     |    |     |     |   |   |    |    |    | 3x 25mm²  | 3x AWG 2  |           |                |    |     |   |     |     |   |   |   |   |    |    |           |           |     |     |
| 19.E4.T60-1001 |                 | 90       |      |     |     |    |     |     |    |     |     |   |   |    |    |    | 3x AWG 2  | 4x AWG 4  |           |                |    |     |   |     |     |   |   |   |   |    |    |           |           |     |     |



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| Rated current  |                 | Pv   |     | A   | A1  | B   | B1  | C   | D   | F   | H  | N    | U   | V   | Weight |
|----------------|-----------------|------|-----|-----|-----|-----|-----|-----|-----|-----|----|------|-----|-----|--------|
| Voltage        | U max.          | [A]  | [W] |     |     |     |     |     |     |     |    |      |     |     | [kg]   |
| KEB Art.No.:   | [V]             |      |     |     |     |     |     |     |     |     |    |      |     |     |        |
| 26.E4.T60-1001 | 3x 480<br>(+5%) | 300  | 50  | 260 | 210 | 300 | 390 | 115 | 235 | 120 | 12 | 10,5 | M12 | -   | 14,0   |
| 28.E4.T60-1001 |                 | 410  | 50  |     |     |     |     |     |     |     |    |      |     |     | 14,0   |
| 30.E4.T60-1001 |                 | 650  | 60  | 280 | 230 | 350 | 440 | 135 |     |     |    |      | -   | M12 | 14,0   |
| 32.E4.T60-1001 |                 | 1000 | 90  |     |     |     |     | 185 | 255 | 145 |    | 14   |     |     | 17,0   |

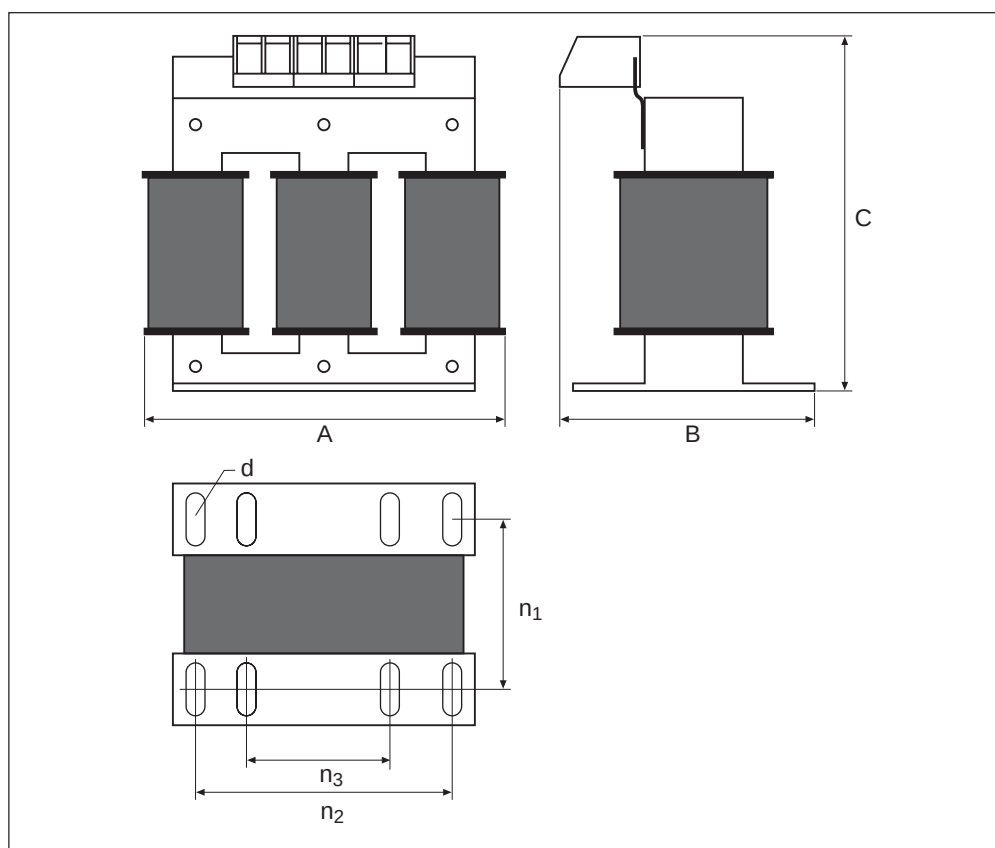


### 3.3 Output filter

#### 3.3.1 Motor choke

The KEB output choke is a cost-effective possibility to reduce the voltage rise  $dv/dt$ , to avoid a premature age of the winding insulation of three-phase current motors. The KEB output choke can also be used for applications with long supply motor cables (>15m).

The following motor chokes are qualified for a max. motor frequency of 52 Hz. With a frequency range from 53 Hz... 60 the next size choke must be used. For motor frequencies > 60 Hz special chokes are available upon request.



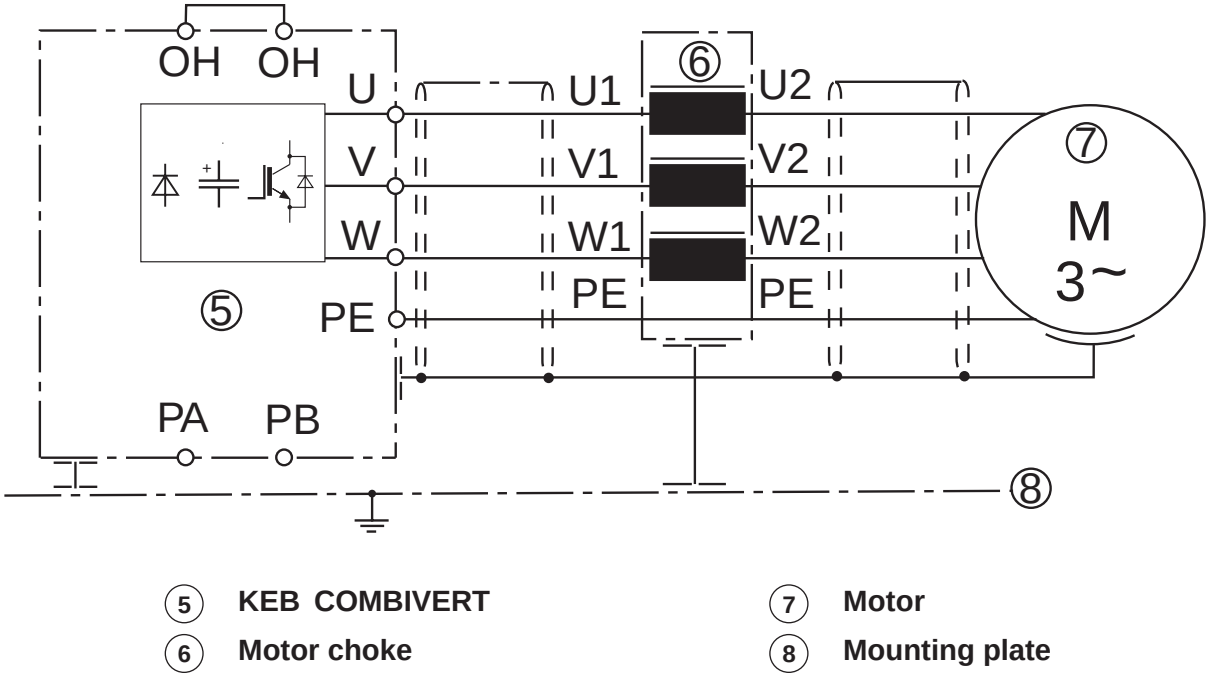
**230V-Class 4% terminal short circuit voltage**

| Number | For<br>COMBIVERT | Phases | I <sub>rated</sub><br>[A] | P <sub>loss</sub><br>[W] | Part number    | Dimensions |     |     |                |                |                |         | Terminal<br>[mm <sup>2</sup> ] | Weight<br>[kg] |
|--------|------------------|--------|---------------------------|--------------------------|----------------|------------|-----|-----|----------------|----------------|----------------|---------|--------------------------------|----------------|
|        |                  |        |                           |                          |                | A          | B   | C   | n <sub>1</sub> | n <sub>2</sub> | n <sub>3</sub> | d       |                                |                |
| 2      | <b>05</b>        | 3      | 4                         | 14                       | 05.DR.A08-4251 | 129        | 62  | 115 | 41             | 112            | -              | 4,8 x 9 | 4                              | 0,8            |
| 4      | <b>07</b>        | 3      | 6                         | 21                       | 07.DR.A08-2851 | 129        | 62  | 115 | 41             | 112            | -              | 4,8 x 9 | 4                              | 1,2            |
| 6      | <b>09</b>        | 3      | 8                         | 21                       | 09.DR.A08-2151 | 129        | 62  | 115 | 41             | 112            | -              | 4,8 x 9 | 4                              | 1,2            |
| 8      | <b>10</b>        | 3      | 12                        | 30                       | 10.DR.A08-1551 | 129        | 72  | 115 | 50             | 112            | -              | 4,8 x 9 | 4                              | 1,8            |
| 10     | <b>12</b>        | 3      | 20                        | 30                       | 12.DR.A08-8541 | 148        | 100 | 160 | 60             | 136            | 60             | 4,8 x 8 | 10                             | 3              |
| 11     | <b>13</b>        | 3      | 30                        | 45                       | 13.DR.A08-5641 | 148        | 100 | 160 | 60             | 136            | 60             | 4,8 x 8 | 10                             | 3,7            |
| 12     | <b>14</b>        | 3      | 40                        | 50                       | 14.DR.A08-4241 | 178        | 130 | 195 | 55             | 166            | 113            | 4,8 x 8 | 16                             | 5              |
| 13     | <b>15</b>        | 3      | 60                        | 63                       | 15.DR.A08-2841 | 178        | 145 | 235 | 70             | 166            | 113            | 4,8 x 8 | 16                             | 6,4            |
| 14     | <b>16</b>        | 3      | 70                        | 74                       | 16.DR.A08-2241 | 219        | 148 | 240 | 71             | 201            | 136            | 7 x 12  | 35                             | 7,6            |
| 15     | <b>17</b>        | 3      | 85                        | 92                       | 17.DR.A08-1841 | 219        | 170 | 255 | 81             | 201            | 136            | 7 x 12  | 95                             | 10,5           |
| 16     | <b>18</b>        | 3      | 100                       | 90                       | 18.DR.A08-1541 | 219        | 190 | 255 | 91             | 201            | 136            | 7 x 12  | 95                             | 12             |
| 17     | <b>19</b>        | 3      | 130                       | 115                      | 19.DR.A08-1241 | 267        | 195 | 300 | 81             | 249            | 176            | 7 x 12  | 95                             | 15,3           |
| 18     | <b>20</b>        | 3      | 160                       | 155                      | 20.DR.A08-1041 | 267        | 220 | 300 | 105            | 249            | 176            | 7 x 12  | 95                             | 18             |
| 19     | <b>21</b>        | 3      | 200                       | 158                      | 21.DR.A08-8031 | 267        | 215 | 310 | 102            | 249            | 176            | 7 x 12  | 95                             | 29             |
| 20     | <b>22</b>        | 3      | 230                       | 170                      | 22.DR.A08-6031 | 267        | 235 | 335 | 116            | 249            | 176            | 7 x 12  | 150                            | 31             |

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| 400V-Class 4% terminal short circuit voltage |               |        |                        |                       |                |            |     |     |                |                |                |         |                |             |
|----------------------------------------------|---------------|--------|------------------------|-----------------------|----------------|------------|-----|-----|----------------|----------------|----------------|---------|----------------|-------------|
| Number                                       | For COMBIVERT | Phases | I <sub>rated</sub> [A] | P <sub>loss</sub> [W] | Part number    | Dimensions |     |     |                |                |                |         | Terminal [mm²] | Weight [kg] |
|                                              |               |        |                        |                       |                | A          | B   | C   | n <sub>1</sub> | n <sub>2</sub> | n <sub>3</sub> | d       |                |             |
| 19                                           | 05            | 3      | 4                      | 22                    | 05.DR.B08-7351 | 129        | 72  | 115 | 50             | 112            | -              | 4,8 x 9 | 2,5            | 1,35        |
| 20                                           | 07, 09        |        | 6                      | 22                    | 07.DR.B08-4951 | 129        | 72  | 115 | 50             | 112            | -              | 4,8 x 9 | 2,5            | 1,6         |
| 21                                           | 10            |        | 8                      | 33                    | 10.DR.B08-3751 | 148        | 80  | 140 | 60             | 136            | 90             | 4,8 x 8 | 2,5            | 2,5         |
| 22                                           | 12            |        | 10                     | 33                    | 12.DR.B08-2851 | 148        | 80  | 140 | 60             | 136            | 60             | 4,8 x 8 | 2,5            | 2,5         |
| 23                                           | 13            |        | 16                     | 53                    | 13.DR.B08-1851 | 178        | 95  | 165 | 55             | 166            | 113            | 4,8 x 8 | 2,5            | 5,2         |
| 24                                           | 14            |        | 20                     | 54                    | 14.DR.B08-1451 | 178        | 95  | 165 | 55             | 166            | 113            | 4,8 x 8 | 4              | 5,4         |
| 25                                           | 15            |        | 30                     | 76                    | 15.DR.B08-9841 | 178        | 110 | 175 | 70             | 166            | 113            | 4,8 x 8 | 10             | 5,8         |
| 26                                           | 16            |        | 40                     | 76                    | 16.DR.B08-7341 | 178        | 110 | 175 | 70             | 166            | 113            | 7 x 12  | 10             | 6,8         |
| 27                                           | 17            |        | 50                     | 97                    | 17.DR.B08-5941 | 219        | 100 | 200 | 71             | 201            | 136            | 7 x 12  | 10             | 8           |
| 28                                           | 18            |        | 60                     | 100                   | 18.DR.B18-4941 | 219        | 110 | 200 | 81             | 201            | 136            | 7 x 12  | 10             | 9,8         |
| 29                                           | 19            |        | 75                     | 110                   | 19.DR.B18-3941 | 219        | 160 | 235 | 91             | 201            | 136            | 7 x 12  | 35             | 13,1        |
| 30                                           | 20            |        | 90                     | 151                   | 20.DR.B18-3341 | 267        | 186 | 285 | 81             | 249            | 176            | 7 x 12  | 35             | 15,6        |
| 31                                           | 21            |        | 115                    | 181                   | 21.DR.B18-2841 | 267        | 210 | 275 | 105            | 249            | 176            | 7 x 12  | 35             | 21,9        |
| 32                                           | 22            |        | 150                    | 205                   | 22.DR.B18-2241 | 316        | 200 | 330 | 99             | 292            | 200            | 9 x 13  | 95             | 24,7        |
| 33                                           | 23            |        | 180                    | 145                   | 23.DR.B18-1741 | 267        | 207 | 310 | 94             | 249            | 176            | 7 x 12  | 95             | 24,1        |
| 34                                           | 24            |        | 200                    | 168                   | 24.DR.B18-1541 | 267        | 215 | 310 | 102            | 249            | 176            | 7 x 12  | 95             | 28,3        |
| 35                                           | 25            |        | 230                    | 230                   | 25.DR.B18-1341 | 267        | 230 | 335 | 111            | 249            | 176            | 9 x 13  | 150            | 30          |
| 36                                           | 26            |        | 270                    | 290                   | 26.DR.B28-1141 | 352        | 230 | 400 | 105            | 328            | 224            | 10 x 16 | 240            | 37,3        |
| 37                                           | 27            |        | 300                    | 308                   | 27.DR.B28-1041 | 352        | 210 | 270 | 121            | 328            | 224            | 10 x 16 | M12            | 48,2        |
| 38                                           | 28            |        | 400                    | 420                   | 28.DR.B28-8031 | 480        | 200 | 390 | 120            | 450            | 316            | 12 x 20 | 40 x 5         | 61          |
| 39                                           | 29            |        | 580                    | 470                   | 29.DR.B28-5331 | 480        | 210 | 390 | 130            | 450            | 316            | 12 x 20 | 40 x 5         | 73,5        |
| 40                                           | 30            |        | 660                    | 530                   | 30.DR.B22-4430 | 480        | 210 | 390 | 130            | 450            | 316            | 12 x 20 | 50 x 5         | 77          |

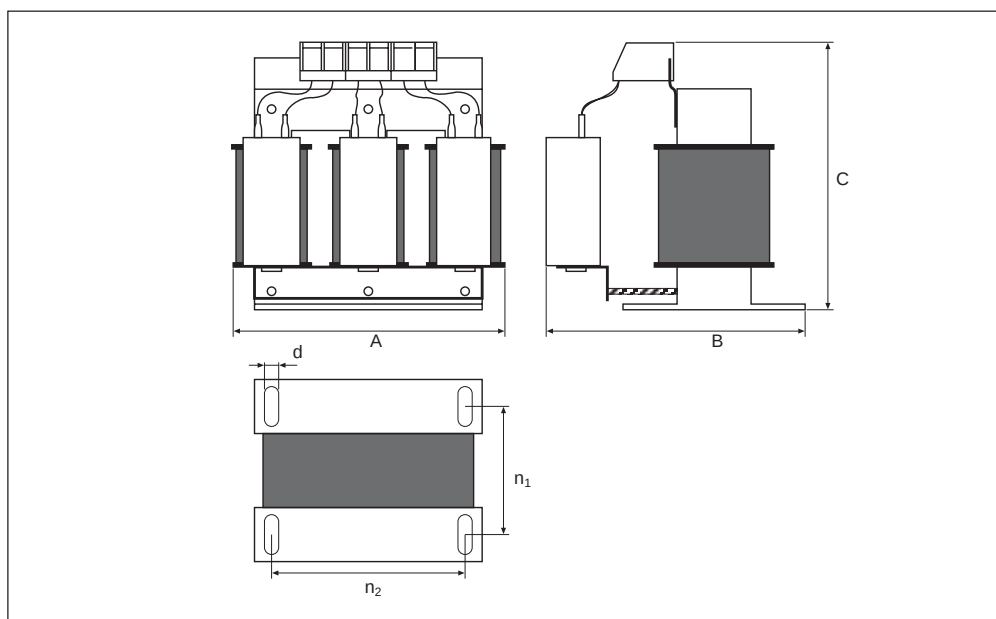
Connection of the motor choke



### 3.3.2 Sinus filter

Via the pulse duration modulation output voltage of the frequency inverters a voltage rise of  $du/dt$  of 5...10 kV/ $\mu$ s can occur dependent on the used power modules, control process, motor line length and type of the motor. Installation of KEB sinus filters reduce the speed of the voltage rise between the phases of mains conditions, that no negative influences to the long-time behaviour of the winding insulation of three-phase current motors have to be expected. The standard-sinus filters are made for an output frequency of max. 120 Hz.

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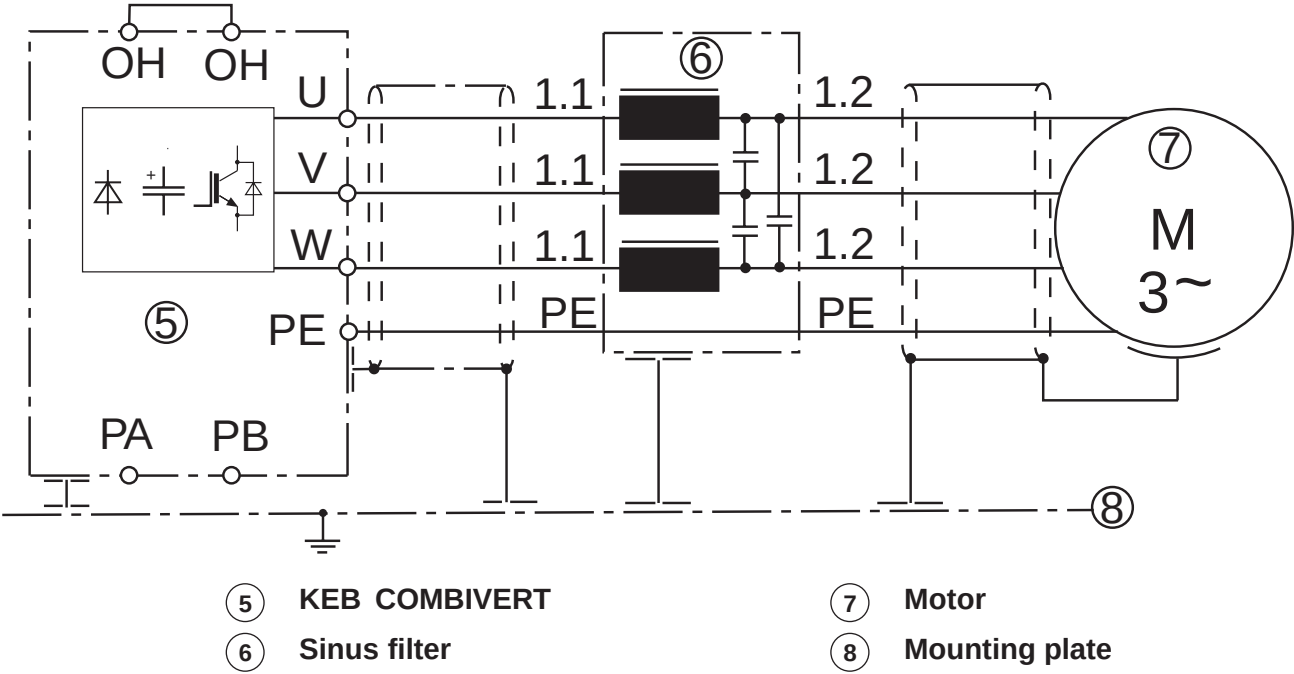
**230V-Class, up to  $f_{out}$  max. 120Hz, for 4kHz switching frequency, IP00, VBG4, T 40/F**

| Number | For<br>COMBIVERT | Part number    | $I_N$<br>[A] | Dimensions |     |     | Mounting |     |    | Terminals<br>[mm <sup>2</sup> ] | Weight<br>[kg] |
|--------|------------------|----------------|--------------|------------|-----|-----|----------|-----|----|---------------------------------|----------------|
|        |                  |                |              | A          | B   | C   | n1       | n2  | d  |                                 |                |
| 1      | 07               | 00.90.428-5099 | 4,1          | 125        | 110 | 180 | 55       | 100 | 8  | 4                               | 3,2            |
| 2      | 09               | 00.90.428-5129 | 9,5          | 155        | 130 | 210 | 72       | 130 | 8  | 4                               | 6,8            |
| 3      | 10               | 00.90.428-5139 | 12           | 190        | 140 | 220 | 58       | 170 | 8  | 10                              | 8              |
| 4      | 12               | 00.90.428-5149 | 16,5         | 190        | 150 | 220 | 68       | 170 | 8  | 10                              | 12             |
| 5      | 13               | 00.90.428-5159 | 24           | 210        | 165 | 240 | 82       | 180 | 8  | 10                              | 12             |
| 6      | 14               | 00.90.428-5169 | 33           | 240        | 195 | 280 | 106      | 190 | 11 | 16                              | 20             |
| 8      | 15               | 00.90.428-5189 | 50           | 240        | 220 | 295 | 126      | 190 | 11 | 35                              | 30             |
| 9      | 16               | 00.90.428-5199 | 60           | 300        | 355 | 355 | 121      | 240 | 11 | 35                              | 38             |

GB

| 400V-Class, f <sub>out</sub> max. 120Hz, IP00, VBG4, T 40/F |           |                 |                |                |            |     |     |          |     |    |                    |        |
|-------------------------------------------------------------|-----------|-----------------|----------------|----------------|------------|-----|-----|----------|-----|----|--------------------|--------|
| Number                                                      | For       | min.            | Part number    | I <sub>N</sub> | Dimensions |     |     | Mounting |     |    | Terminals          | Weight |
|                                                             | COMBIVERT | Switching freq. |                | [A]            | A          | B   | C   | n1       | n2  | d  | [mm <sup>2</sup> ] | [kg]   |
| 1                                                           | 07 /09    | 4 kHz           | 00.90.428-5099 | 4,1            | 125        | 110 | 180 | 55       | 100 | 8  | 4                  | 3,2    |
| 2                                                           | 10/12     | 4 kHz           | 00.90.428-5129 | 9,5            | 155        | 130 | 210 | 72       | 130 | 8  | 4                  | 6,8    |
| 3                                                           | 13        | 4 kHz           | 00.90.428-5139 | 12             | 190        | 140 | 220 | 58       | 170 | 8  | 10                 | 8      |
| 4                                                           | 14        | 4 kHz           | 00.90.428-5149 | 16,5           | 190        | 150 | 220 | 68       | 170 | 8  | 10                 | 12     |
| 5                                                           | 15        | 4 kHz           | 00.90.428-5159 | 24             | 210        | 165 | 240 | 82       | 180 | 8  | 10                 | 12     |
| 6                                                           | 16        | 4 kHz           | 00.90.428-5169 | 33             | 240        | 195 | 280 | 106      | 190 | 11 | 16                 | 20     |
| 7                                                           | 17        | 4 kHz           | 00.90.428-5179 | 42             | 240        | 220 | 295 | 126      | 190 | 8  | 35                 | 30     |
| 8                                                           | 18        | 4 kHz           | 00.90.428-5189 | 50             | 240        | 220 | 295 | 126      | 190 | 11 | 35                 | 30     |
| 9                                                           | 19        | 4 kHz           | 00.90.428-5199 | 60             | 300        | 355 | 355 | 121      | 240 | 11 | 35                 | 38     |
| 10                                                          | 20        | 4 kHz           | 00-90.428-5209 | 75             | 300        | 240 | 355 | 134      | 240 | 11 | 35                 | 42     |
| 11                                                          | 21        | 4 kHz           | 00-90.428-5219 | 90             | 300        | 255 | 360 | 146      | 240 | 11 | 50                 | 50     |
| 12                                                          | 22        | 4 kHz           | 00-90.428-5229 | 115            | 360        | 260 | 405 | 126      | 310 | 11 | 70                 | 60     |
| 13                                                          | 23        | 4 kHz           | 00-90.428-5239 | 152            | 360        | 280 | 420 | 141      | 310 | 11 | 95                 | 70     |
| 14                                                          | 24        | 4 kHz           | 00-90.428-5249 | 180            | 360        | 305 | 440 | 156      | 310 | 11 | 150                | 85     |
| 15                                                          | 25        | 4 kHz           | 00-90.428-5259 | 210            | 420        | 290 | 495 | 152      | 370 | 11 | 150                | 110    |
| 16                                                          | 26        | 4 kHz           | 00-90.428-5269 | 250            | 420        | 320 | 495 | 182      | 370 | 11 | 150                | 130    |
| 17                                                          | 27        | 2 kHz           | 00-90.428-5279 | 300            | 420        | 420 | 495 | 212      | 370 | 11 | 150                | 160    |
| 18                                                          | 28        | 2 kHz           | 00-90.428-5289 | 370            | 480        | 450 | 560 | 240      | 430 | 11 | 240                | 250    |
| 19                                                          | 29        | 2 kHz           | 00-90.428-5299 | 450            | 480        | 450 | 560 | 240      | 430 | 11 | 240                | 250    |

Connection of the sinus filter

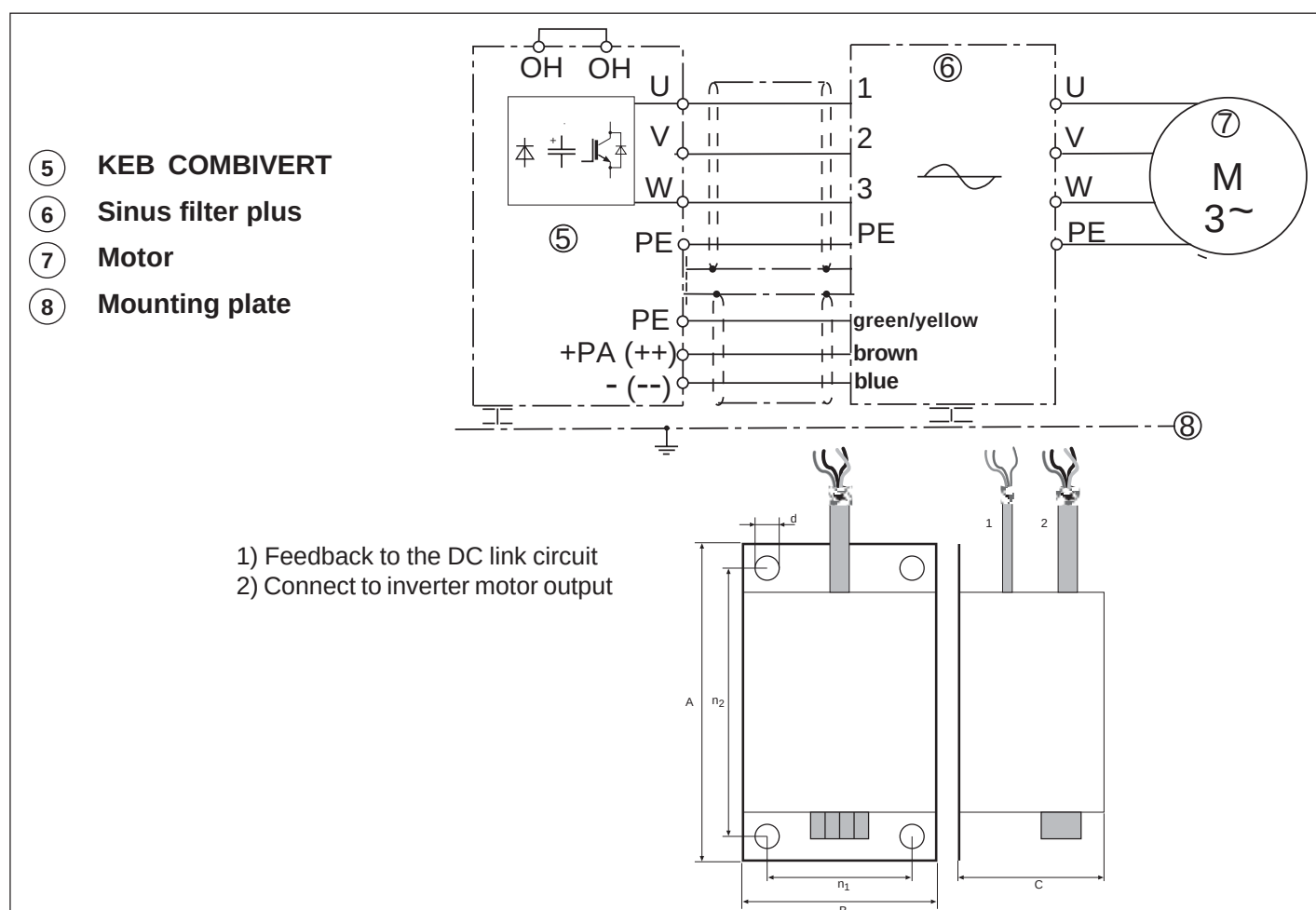


### 3.3.3 Sinus filter plus

The KEB sinus filter enables a sinusoidal voltage characteristic of the motor terminal voltage between the phases and against earth. Extremely long motor lines can be realized without shielding or later installation of FU's can be done without any problems in already existing units. The legal limits of interference are observed.

Information about dimension: With loads >150% inverter-rated current ( $I_N$ ) the next higher filter must be used. Min. 8 kHz (better 16 kHz) carrier frequency are required. The filter is dimensioned to max. output frequency of 100 Hz.

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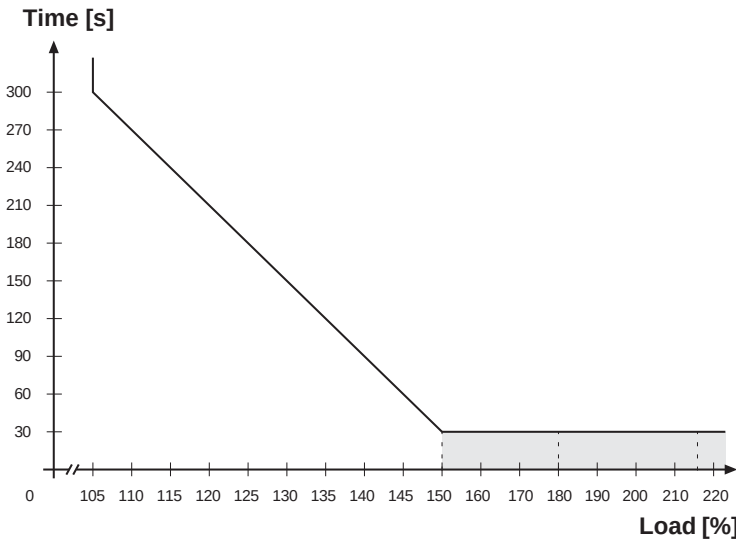
**400V-Class,  $f_{out}$  max. 100Hz, for min. 8kHz switching frequency, IP20, VBG4, T 40/F**

| Number | For<br>COMBIVERT | Part Number    | $I_N$<br>[A] | Dimensions |     |     | Mounting |     |     | Terminals<br>[mm <sup>2</sup> ] | Weight<br>[kg] |
|--------|------------------|----------------|--------------|------------|-----|-----|----------|-----|-----|---------------------------------|----------------|
|        |                  |                |              | A          | B   | C   | n1       | n2  | d   |                                 |                |
| 1      | 07/09            | 00.90.426-5099 | 4            | 390        | 90  | 150 | 44       | 373 | 6,5 | 4                               | 11,5           |
| 2      | 10               | 00.90.426-5119 | 8            | 390        | 90  | 180 | 44       | 370 | 8,7 | 4                               | 15             |
| 3      | 12/13            | 00.90.426-5139 | 12           | 390        | 90  | 215 | 44       | 370 | 8,7 | 10                              | 18,5           |
| 4      | 14               | 00.90.426-5149 | 16           | 350        | 140 | 230 | 95       | 330 | 8,7 | 10                              | 23             |
| 5      | 15               | 00.90.426-5159 | 25           | 390        | 165 | 230 | 135      | 370 | 8,7 | 10                              | 25             |

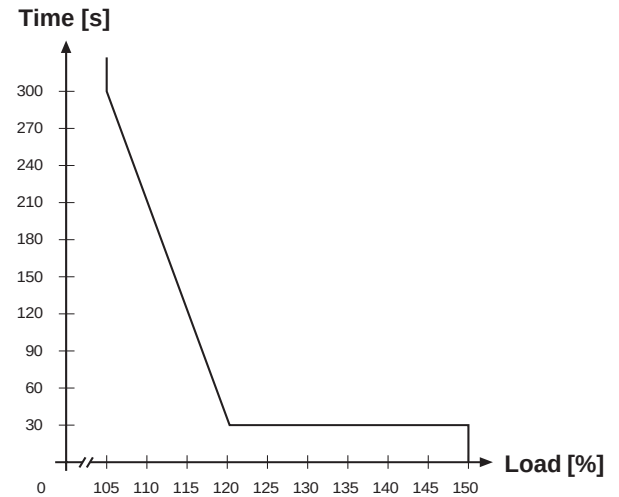
## 4. Annex

### 4.1 Overload curve

#### ① Inverter size $\leq 24$

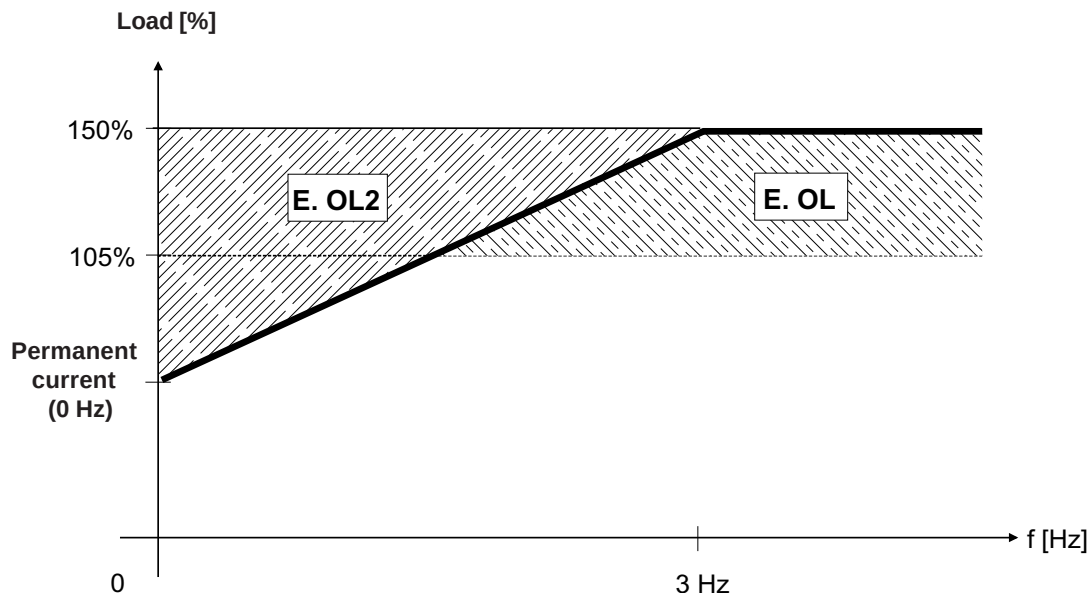


#### ② Inverter size $\geq 25$



The characteristic declines device-dependently in this range (see technical data)

### 4.2 Overload protection in the lower speed range (only valid for F4-F, stall current see Page 9-13)



$$I_{T_K} = \text{stall current} \times \frac{180^\circ\text{C} - T_K}{180^\circ\text{C} - T_{OH}}$$

$T_{OH}$  = Max.Heat sink temperature before error OH

$T_K$  = Heat sink temperature

**D**

Vor Auslieferung durchlaufen alle Produkte mehrfach eine Qualitäts- und Funktionskontrolle, so daß Fehler auszuschließen sind. Bei Beachtung unserer Betriebsanleitung sind keine Störungen zu erwarten. Sollte sich trotzdem ein Grund zur Reklamation ergeben, so ist das Gerät mit Angabe der Rechnungsnummer, des Lieferdatums, der Fehlerursache und den Einsatzbedingungen an uns zurückzusenden. Für Fehler, die aufgrund falscher Behandlung, falscher Lagerung oder sonstigen allgemeinen Irrtümern auftreten, übernehmen wir keine Verantwortung. Prospekte, Kataloge und Angebote enthalten nur Richtwerte. Technische Änderungen jeder Art behalten wir uns vor. Alle Rechte vorbehalten. Nachdruck, Vervielfältigung und fotomechanische Wiedergabe sind ohne schriftliche Genehmigung durch KEB auch auszugsweise verboten.

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