COMBIVERT

F5/F6

Instruction manual

Housing U

55…90 kW 230 V

75…200 kW 400 V

Original manual	
Mat.No.	Rev.
00F50EB-KU00	2N

KEB

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1. Preface

1.1 General

The described hard- and software are developments of the KEB Automation KG. The enclosed documents correspond to conditions valid at printing. Misprint, mistakes and technical changes reserved.
The instruction manual must be made available to the user. Before working with the unit the user must become familiar with it. This especially applies to the knowledge and observance of the following safety and warning indications. The pictographs used in this instruction manual have following meaning:

	Danger Warning Caution	Is used, if life or health of the user is in danger or if substantial damage to property can occur.

	Attention observe at all costs	Is used, if a measure is necessary for safe and trouble-free operation.

	Information Aid Tip	Is used, if a measure simplifies the handling or operation of the unit.

Non-observance of the safety instructions leads to the loss of any liability claims. This list is not exhaustive.

1.2 Validity and liability

The use of our units in the target products is outside of our control and therefore lies exclusively in the area of responsibility of the machine manufacturer.
The information contained in the technical documentation, as well as any user-specific advice in spoken and written and through tests, are made to best of our knowledge and information about the application. However, they are considered for information only without responsibility. This also applies to any violation of industrial property rights of a third-party.
Selection of our units in view of their suitability for the intended use must be done generally by the user.
Tests can only be done within the application by the machine manufacturer. They must be repeated, even if only parts of hardware, software or the unit adjustment are modified.
Unauthorised opening and tampering may lead to bodily injury and property damage and may entail the loss of warranty rights. Original spare parts and authorized accessories by the manufacturer serve as security. The use of other parts excludes liability for the consequences arising out of.
The suspension of liability is especially valid also for operation interruption loss, loss of profit, data loss or other damages. This is also valid, if we referred first to the possibility of such damages.
If single regulations should be or become void, invalid or impracticable, the effectivity of all other regulations or agreements is not affected.

1.3 Copyright

1.4 Specified application

The KEB COMBIVERT serves exclusively for stepless open loop / closed-loop speed control of three-phase a.c. motors.

The operation of other electric consumers is prohibited and can lead to the destruction of the unit.

The used semiconductors and components of KEB are developed and dimensioned for the use in industrial products. If the KEB COMBIVERT is used in machines, which work under exceptional conditions or if essential functions, life-supporting measures or an extraordinary safety step must be fulfilled, the necessary reliability and security must be ensured by the machine builder. The operation of the KEB COMBIVERT outside the indicated limit values of the technical data leads to the loss of any liability claims.
Units with safety function are limited to a service life of 20 years. After this time the units must be replaced.

1.5 Product description

This instruction manual describes the power circuits of the following units:

Unit type:	Frequency inverter
Series:	COMBIVERT F5/F6
Power range:	55…90 kW / 230 V class 75…200 kW / 400 V class
Housing size:	U

Features of the power circuits:

- only slight switching losses due to IGBT
- low noise development due to 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
- hardware current limit
- integrated cooling fan (air-cooled units)

1.6 Part code

27.F5.ABU-9 0 0 A

Cooling	
0, 5, A, F	Heat sink (standard)
1, B, G	Flat rear
2, C, H	Water-cooling system
3, D, I	Convection

Encoder interface
0: none

Switching frequency; short time current limit; overcurrent limit							
0	2 kHz; 125 %; 150 %	5	4 kHz; 150 %; 180 %	A	8 kHz; 180 %; 216 %	F	16 kHz; 200 %; 240 %
1	4 kHz; 125 %; 150 %	6	8 kHz; 150 %; 180 %	B	16 kHz; 180 %; 216 %	G	2 kHz; 400 %; 480 %
2	8 kHz; 125 %; 150 %	7	16 kHz; 150 %; 180 %	C	2 kHz; 200 %; 240 %	H	4 kHz; 400 %; 480 %
3	16 kHz; 125 %; 150 %	8	2 kHz; 180 %; 216 %	D	4 kHz; 200 %; 240 %	I	8 kHz; 400 %; 480 %
4	2 kHz; 150 %; 180 %	9	4 kHz; 180 %; 216 %	E	8 kHz; 200 %; 240 %	K	16 kHz; 400 %; 480 %

Input identification							
0	1ph 230 V AC/DC	5	400 V class DC	A	6ph 400 V AC		
1	3ph 230 V AC/DC	6	1ph 230 V AC	B	3ph 600 V AC		
2	1/3ph 230 V AC/DC	7	3ph 230 V AC	C	6ph 600 V AC		
3	3ph 400 V AC/DC	8	1/3ph 230 V AC	D	600 V DC		
4	230 V class DC	9	3ph 400 V AC				

Housing type A, B, D, E, G, H, R, U, W, P

Internal options (A...D with STO relay according to EN954-1 / 1997)	
0, A	none
B	Braking transistor without resistance monitoring
1, 5	Braking transistor with resistor monitoring
2, C	integrated EMC filter
3, D	Braking transistor without resistance monitoring and EMC filter
7	Braking transistor with resistor monitoring and EMC filter

Control type			
A	APPLICATION	K	like A with safety technology
C	COMPACT (controlled frequency inverter)		
E	SCL	P	like E with safety technology
G	GENERAL (controlled frequency inverter)		
H	ASCL	L	like H with safety technology
M	MULTI (regulated, field-oriented frequency inverter for three-phase asynchronous motors)		
S	SERVO (regulated frequency inverter for synchronous motors)		

Series F5/F6

Inverter size

1.7 Transport instructions

Transport of heat sinks with an edge length of ≥ 75 cm:
Transport by fork-lift truck can lead to a deflection of the heat sink.This can have the aging or destruction of internal components as a result.

Attention **Transport instructions must be observed.**	
	To avoid damage, the inverter may only be transported on suitable pallets.

1.8 Installation instructions

1.8.1 Cooling systems

The KEB COMBIVERT F5/F6 is available for different cooling systems:

Heat sink with cooling fan (mounted version)
The standard version is delivered with heat sink and cooling fan.

Special versions
The dissipation of power loss must be guaranteed by the machine builder.

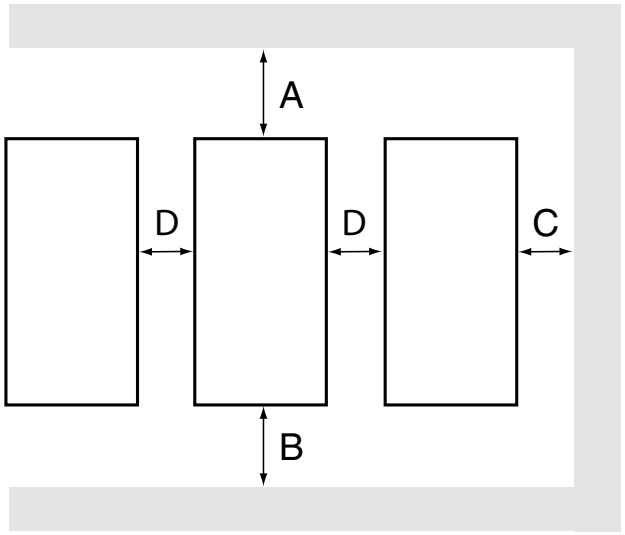
Flat rear
There is no heat sink at this version. The unit must be mounted on an appropriate ground for heat dissipation.

Water cooling
This version is dimensioned for the connection to an available cooling system. The dissipation of the power loss must be ensured by the machine builder. In order to avoid moisture condensation, the minimum inlet temperature may not decrease the ambient temperature. The max. inlet temperature may not exceed 40°C. No aggressive coolant shall be used. Measures against contamination and calcination must be done externally. We recommend a pressure of 4 bar on the cooling system.

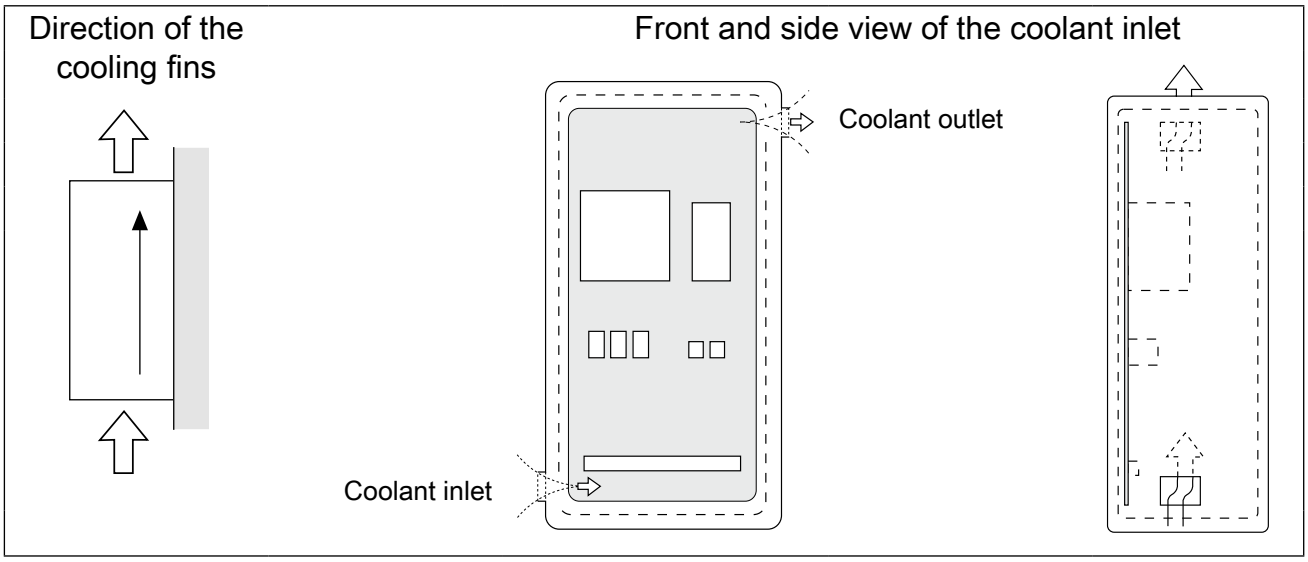
Convection (trough-mount version)
In this version the heat sink is placed externally with a cutout in the control cabinet.

Heat sinks can reach temperatures, which can cause burns when touching. If in case of structural measures a direct contact cannot be avoided, a warning notice "hot surface" must be mounted at the machine.

1.8.2 Control cabinet installation

Mounting distances	Dimen-sion	Distance in mm	Distance in inch
	A	150	6
	B	100	4
	C	30	1.2
	D	30	1.2
	X 1)	50	2

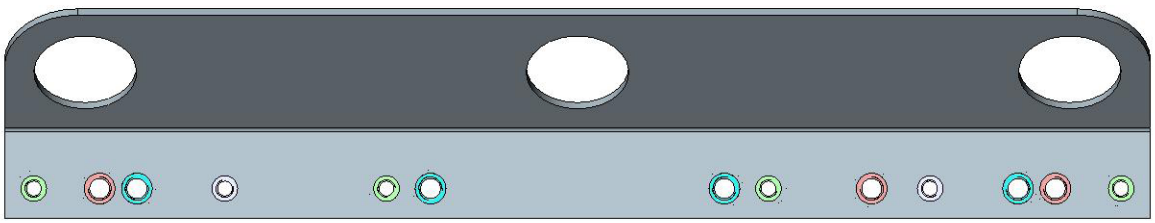
1) Distance to preceding elements in the cabinet door.



See annex C for instructions of water-cooled units.

1.8.3 Assembly aid

An assembly aid is available as accessories (part number 00F5ZTB-0001). It is screwed to the inverter and enables the carriage by lifting devices.



1.9 Safety and application notes

Safety and application notes for drive converter
(in accordance with: Low-Voltage Directive 2006/95/EC)

1. General
In operation, drive converter depending on their degree of protection, may have live, uninsulated and possibly also moving or rotating parts, as well as hot surfaces.
In case of inadmissible removal of the required covers, of improper use, wrong installation or maloperation, there is the danger of serious personal injury and damage to property.
For further information, see documentation.
All operations serving transport, installation and commissioning as well as maintenance are to be carried out by skilled technical personnel (observe IEC 364 or CENELEC HD 384 or DIN VDE 0100 and IEC 664 or DIN/VDE 0110 and national accident prevention rules).
For the purposes of these basic safety instructions, „skilled technical personnel“ means persons who are familiar with the installation, mounting, commissioning and operation of the product and have the qualifications needed for the performance of their functions.

2. Specified application
Drive converter are components which are intended for the installation in electric systems or machines.
In case of installation in machinery, commissioning of the drive converter (i.e. the starting of normal operation) is prohibited until the machinery has been proved to conform to the provisions of the directive 2006/42/EC (Machine Directive). Account is to be taken of EN 60204.
Start-up (i.e. the starting of normal operation) is only permitted in compliance with the EMC directive (2004/108/EC).
The drive converter meet the requirements of the Low-Voltage directive 2006/95/EC. The harmonized standards of the series EN 50178/DIN VDE 0160 in connection with EN 60439-1/DIN VDE 0660 part 500 and EN 60146/DIN VDE 0558 were used for drive converter.
The technical data as well as information concerning the supply conditions shall be taken from the rating plate and from the documentation and shall be strictly observed.

3. Transport, storage
The instructions for transport, storage and proper use shall be complied with.
The climatic conditions shall be in conformity with prEN 50178.

4. Installation
The installation and cooling of the appliances shall be in accordance with the specifications in the pertinent documentation.
The drive converter shall be protected against excessive strains. In particular, no components must be bent or isolating distances altered in the course of transportation or handling. No contact shall be made with electronic components and contacts.
Drive converter contain electrostatic sensitive components which are liable to damage through improper use. Electric components must not be mechanically damaged or destroyed (potential health risks).

5. Electrical connection
When working on live drive converter, the applicable national accident prevention rules (e.g. VBG 4) must be complied with.
The electrical installation shall be carried out in accordance with the relevant requirements (e.g. cross-sectional areas of conductors, fusing, PE connection). For further information, see documentation.
Instructions for the installation in accordance with EMC requirements, like screening, earthing, location of filters and wiring, are contained in the drive converter documentation. They must always be complied with, also for drive converter bearing a CE marking. Observance of the limit values required by EMC law is the responsibility of the manufacturer of the installation or machine.

6. Operation
Installations which include drive converter shall be equipped with additional control and protective devices in accordance with the relevant applicable safety requirements, e.g. act respecting technical equipment, accident prevention rules etc. Changes to the drive converter by means of the operating software are admissible.
After disconnection of the drive converter from the voltage supply, live appliance parts and power terminals must not be touched immediately because of possibly energized capacitors. In this respect, the corresponding signs and markings on the drive converter must be observed.
During operation, all covers and doors shall be kept closed.

7. Maintenance and servicing
The manufacturer’s documentation shall be followed.
Keep safety instructions in a safe place!

2. Technical Data

2.1 Operating conditions

		Standard	Standard/ class	Instructions
Definition acc.		EN 61800-2		Inverter product standard: **rated specifications**
		EN 61800-5-1		Inverter product standard: **general safety**
Site altitude				max. 2000 m above sea level With site altitudes over 1000 m a derating of 1 % per 100 m must be taken into consideration.
Ambient conditions during operation				
Climate	**Temperature**	EN 60721-3-3	3K3	extended to -10…45 °C (use frost protection for water cooling systems and temperatures below zero) With temperature over 45°C to max. 55°C a derating of 5 % per 1 K must be taken into consideration.
	Humidity		3K3	5…85 % (without condensation)
Mechanical	**Vibration**		3M1	
Contamination	**Gas**		3C2	
	Solids		3S2	
Ambient conditions during transport				
Climate	**Temperature**	EN 60721-3-2	2K3	Drain heat sink completely
	Humidity		2K3	(without condensation)
Mechanical	**Vibration**		2M1	
	Surge		2M1	max. 100 m/s²; 11 ms
Contamination	**Gas**		2C2	
	Solids		2S2	
Ambient conditions for the storage				
Climate	**Temperature**	EN 60721-3-1	1K4	Drain heat sink completely
	Humidity		1K3	(without condensation)
Mechanical	**Vibration**		1M1	
	Surge		1M1	max. 100 m/s²; 11 ms
Contamination	**Gas**		1C2	
	Solids		1S2	
Type of protection		EN 60529	IP20	
Environment		IEC 664-1		Pollution degree 2
Definition acc.		EN 61800-3		Inverter product standard: **EMC**
EMC emitted interference				
Cable-based interferences		–	C3[1)2)]	Earlier limit value A (B optional) according to EN55011
Radiated interferences		–	C3[2)]	Earlier limit value according to EN55011
Interference immunity				
Static discharges		EN 61000-4-2	8 kV	AD (air discharge) and CD (contact discharge)
Burst - Ports for process measurement control lines and signal interfaces		EN 61000-4-4	2 kV	
Burst - power interfaces		EN 61000-4-4	4 kV	
Surge - power interfaces		EN 61000-4-5	1 / 2 kV	Phase-phase / phase-ground
Electromagnetic fields		EN 61000-4-3	10 V/m	
Cable-fed disturbances, induced by high frequency fields		EN 61000-4-6	10 V	0.15-80 MHz
Voltage variation / voltage drop		EN 61000-2-1	3	+10 % -15 % 90 %
Voltage unsymmetries / Frequency changes		EN 61000-2-4	3	3 % 2 %

1) This product can cause high frequency disturbances in residential areas (category c1) which require noise suppression measures.

2) The specified value is only meet in connection with a corresponding filter.

2.2 Technical data of the 230 V class

Unit size			22	23	24
Housing size			U		
Phases			3		
Rated apparent output power		[kVA]	87	115	143
Max. rated motor power		[kW]	55	75	90
Rated output current		[A]	220	290	360
Max. short time current	1)	[A]	330	362	450
Overcurrent		[A]	396	435	540
Rated input current		[A]	242	319	396
Max. permissible mains fuse gG	7)	[A]	400	450	550
Rated switching frequency		[kHz]	4	4	4
Max. switching frequency		[kHz]	8	8	8
Power dissipation at nominal operating		[W]	2320	3000	3660
Power dissipation at DC operating		[W]	1940	2500	3060
Standstill current at 4 kHz	2)	[A]	220	290	360
Standstill current at 8 kHz	2)	[A]	198	203	252
Min. frequency at continuous full load		[Hz]	3		
Max. heat sink temperature		[°C]	90		
Cooling mode (L=air; W=water)			W / L	W / L	W / L
Motor cable cross-section	3)	[mm²]	120	150	240
Max. motor cable length shielded		[m]	50		
Min. braking resistor	4)	[Ω]	1.2		
Max. braking current	4)	[A]	340		
Rated input voltage		[V]	230 (UL: 240)		
Input voltage range		[V]	180…260 ±0		
Input voltage at DC operation		[V]	250…370 ±0		
Mains frequency		[Hz]	50 / 60 ±2		
permitted mains forms			TN, TT, IT[8], Δ mains[9]		
Output voltage	10)	[V]	3 x 0…Uin		
Output frequency	11)	[Hz]	0 - max. 599		
Overload characteristic (see annex A)			1	2	2
Cooling water content			600 ml		

1) With the regulated systems 5% are to be subtracted as overmodulation capacity
2) Max. current before the OL2 function triggers (not in operating mode F5 GENERAL)
3) Recommended minimum cross section of the motor line for rated power and a cable length of upto 100 m (CU)
4) This data is only valid for units with internal brake transistor GTR 7 (see "Unit identification")
7) Protection in accordance with UL see annex B
8) Restrictions when using HF filters
9) Phase conductor grounded mains are only permissible without HF filters
10) The voltage at the motor is dependent on the series-connected units and on the control method (see A.3)
11) The output frequency is to be limited in such way that 1/10 of the switching frequency is not exceeded. Units with higher max. output frequency are subject to export restrictions and are only available on request.

The technical data are 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.

2.3 Technical data of the 400 V class

Unit size			23	24		25	26	27	28
Housing size			U						
Phases			3						
Rated apparent output power		[kVA]	104	125		145	173	208	256
Max. rated motor power		[kW]	75	90		110	132	160	200
Rated output current		[A]	150	180		210	250	300	370
Max. short time current	1)	[A]	225	270		263	313	375	463
Overcurrent		[A]	270	324		315	375	450	555
Rated input current		[A]	165	198		231	275	330	400
Max. permissible mains fuse gG	7)	[A]	200	315		315	400	450	550
Rated switching frequency		[kHz]	8	4	8	4	4	2	2
Max. switching frequency		[kHz]	8	8	8	8	8	8	4
Power dissipation at nominal operating		[W]	1900	2000	2400	2300	2800	3100	3200
Power dissipation at DC operating		[W]	1760	1830	2230	2100	2550	2800	2850
Standstill current at 4 kHz	2)	[A]	150	180		210	250	240	370
Standstill current at 8 kHz	2)	[A]	150	180		168	162.5	180	–
Standstill current at 16 kHz	2)	[A]	–	–	–	–	–	–	–
Min. frequency at continuous full load		[Hz]	3						
Max. heat sink temperature			90°C						60/90°C
Cooling mode (L=air; W=water)			W	L	W	L	W	L	W	L	W	L	W	L	W	L
Motor cable cross-section	3)	[mm²]	95	95		95	120	150	240
Max. motor cable length shielded		[m]	50						
Min. braking resistor	4)	[Ω]	5	4		2.2			
Max. braking current	4)	[A]	160	200		380			
Rated input voltage	5)	[V]	400 (UL: 480)						
Input voltage range		[V]	305…528 ±0						
Input voltage at DC operation		[V]	420…746 ±0						
Mains frequency		[Hz]	50 / 60 ±2						
permitted mains forms			TN, TT, IT[8], Δ mains[9]						
Output voltage	10)	[V]	3 x 0…Uin						
Output frequency	11)	[Hz]	0 - max. 599						
Overload characteristic (see annex A)			1			2			
Cooling water content			600 ml						

1) With the regulated systems 5% are to be subtracted as overmodulation capacity
2) Max. current before the OL2 function triggers (not in operating mode F5 GENERAL)
3) Recommended minimum cross section of the motor line for rated power and a cable length of upto 100 m (CU)
4) This data is only valid for units with internal brake transistor GTR 7 (see "Unit identification")
5) At rated voltages ≥ 460 V multiply the rated input current with factor 0.86
7) Protection in accordance with UL see annex B
8) Restrictions when using HF filters
9) Phase conductor grounded mains are only permissible without HF filters
10) The voltage at the motor is dependent on the series-connected units and on the control method (see A.3)
11) The output frequency is to be limited in such way that 1/10 of the switching frequency is not exceeded. Units with higher max. output frequency are subject to export restrictions and are only available on request.

The technical data are 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.

	From size 23 the use of a input choke is absolutely necessary.
	The response threshold of the braking transistsor (Pn.69) for all controls without safety technology must be adjusted at least to 770 Vdc (see annex D).

2.3.1 DC supply

2.3.2 Calculation of the DC input current

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

230V class :

$$I_{DC} = \frac{\sqrt{3} \bullet \text{rated motor voltage} \bullet \text{rated motor current} \bullet \text{Motor cos}\varphi}{\text{DC voltage (310 V)}}$$

400V class :

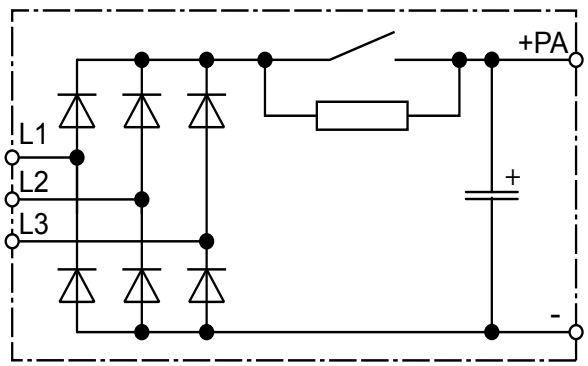
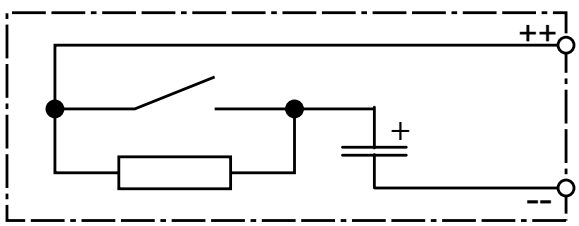
$$I_{DC} = \frac{\sqrt{3} \bullet \text{rated motor voltage} \bullet \text{rated motor current} \bullet \text{Motor cos}\varphi}{\text{DC voltage (540 V)}}$$

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

- If you accelerate on the hardware current limit, the short-time current limit of the inverter must be used in the formula above (instead of the rated motor current).
- If the motor in normal operation is never stressed with rated torque, it can be calculated with the real motor current.

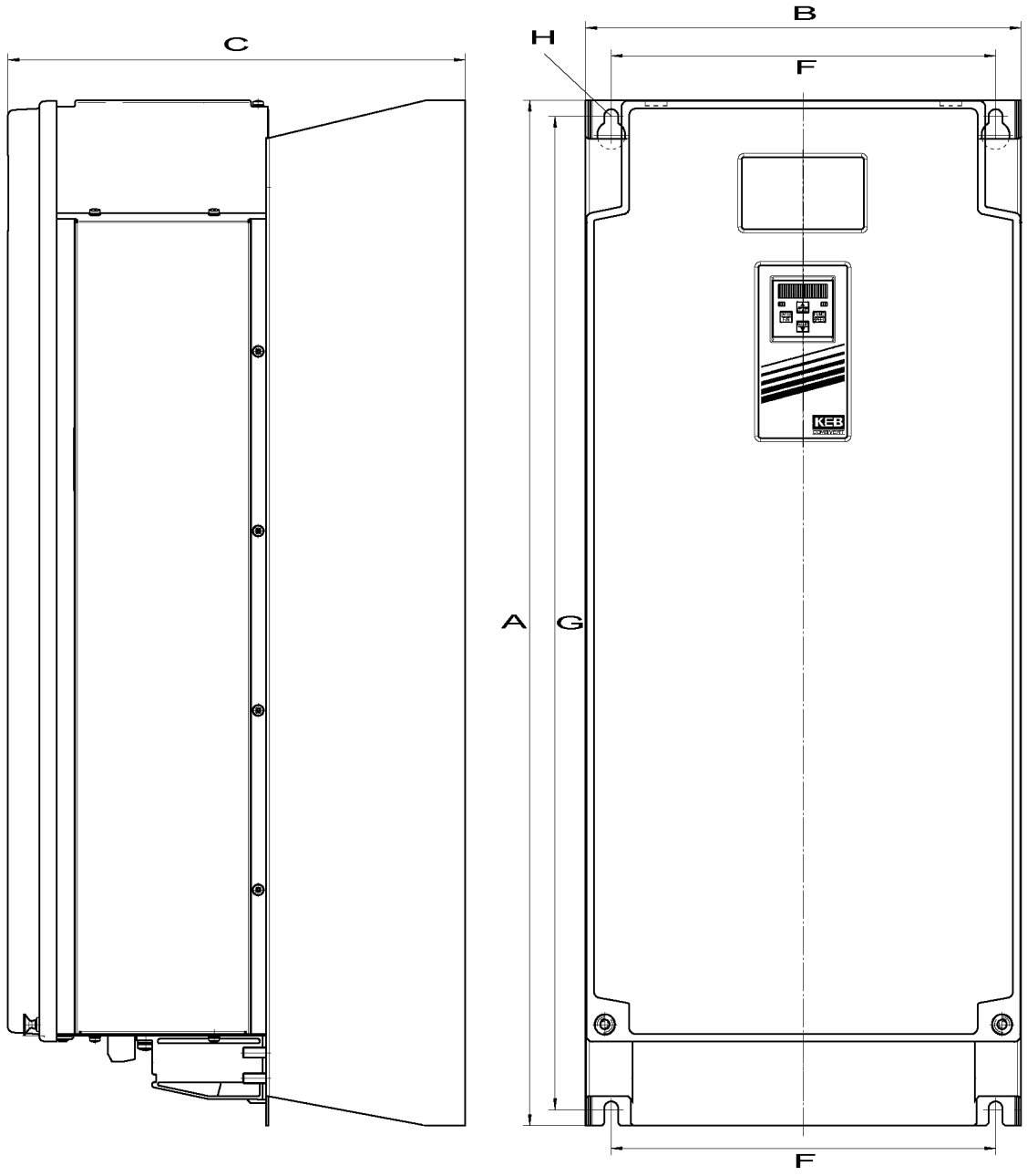
2.3.3 Internal input circuit

The COMBIVERT F5/F6 in U housing corresponds to the inverter type B1. Pay attention to the inverter type in DC interconnection and in operation at regenerative units.

Inverter type for COMBIVERT F5/F6 in U housing:	
Type B1	Type C1
	

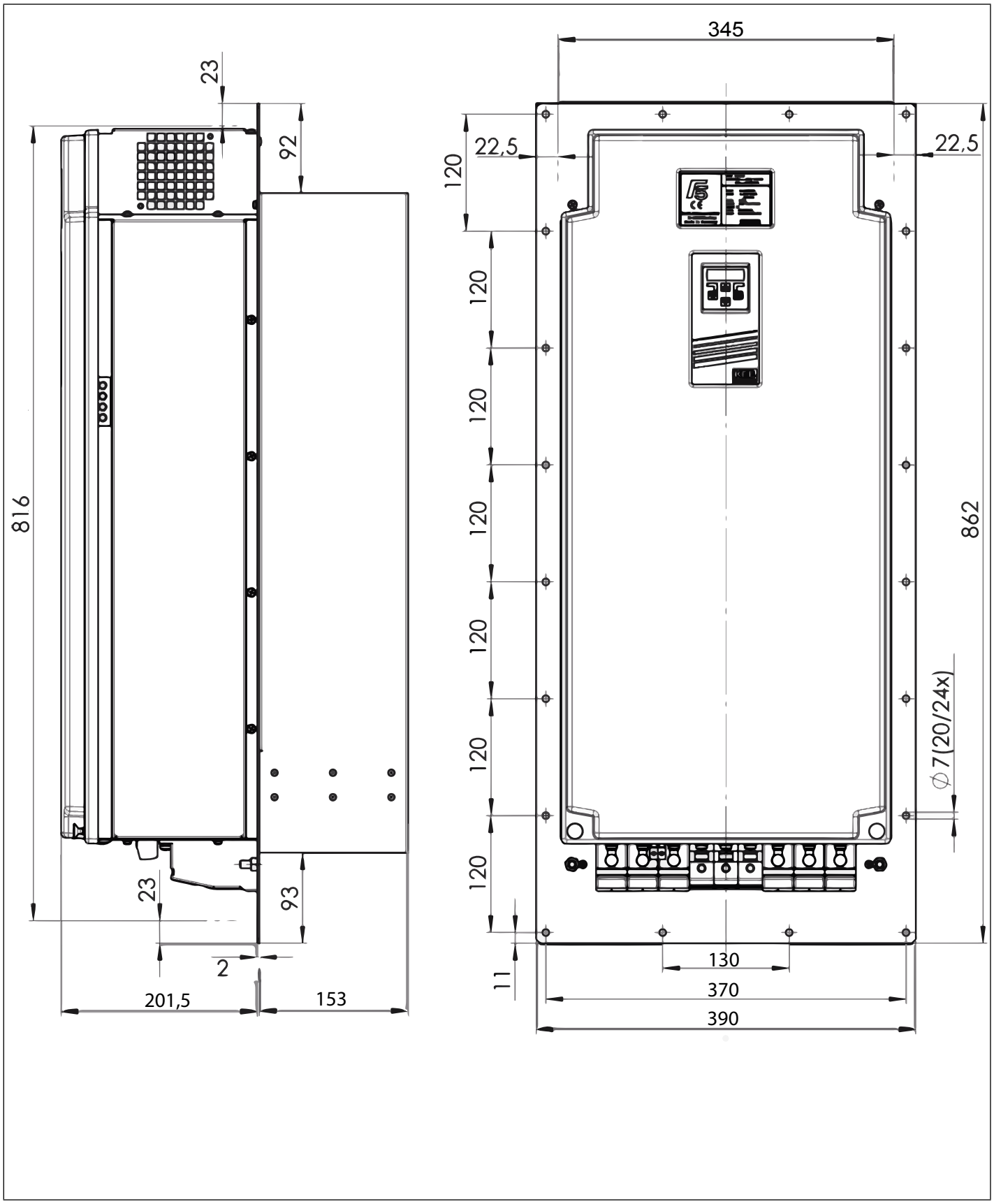
2.4 Dimensions and Weights

2.4.1 Mounted version with sub construction (default)

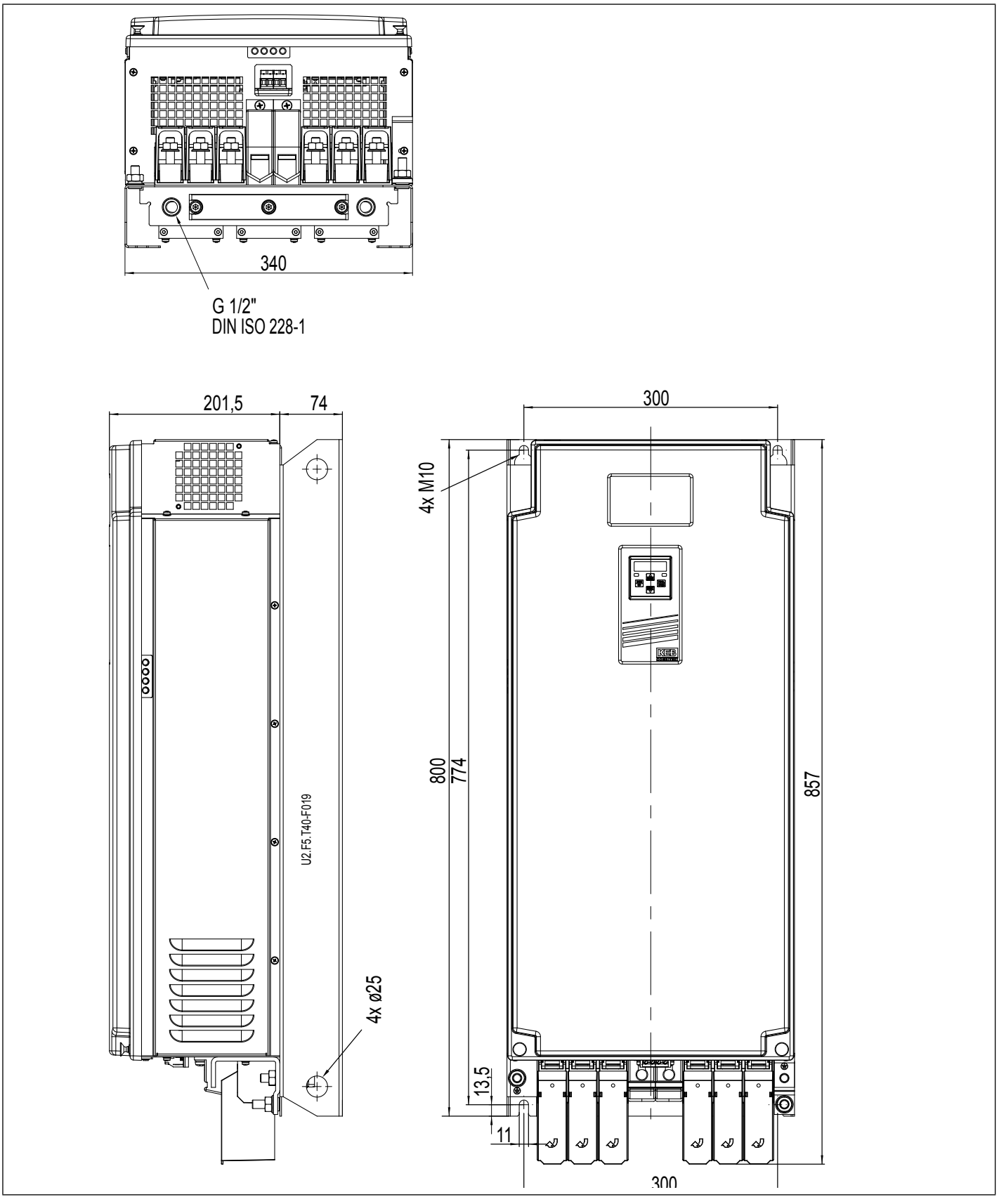


Housing type	A	B	C	F	G	H	Weight
Air-cooling	800	340	357	300	775	Ø11	75 kg
Water cooling 2-plate heat sink (special version)	800	340	275.5	300	775	Ø11	–
Water cooling extrusion casting heat sink	800	344	275.5	300	774	Ø11	–

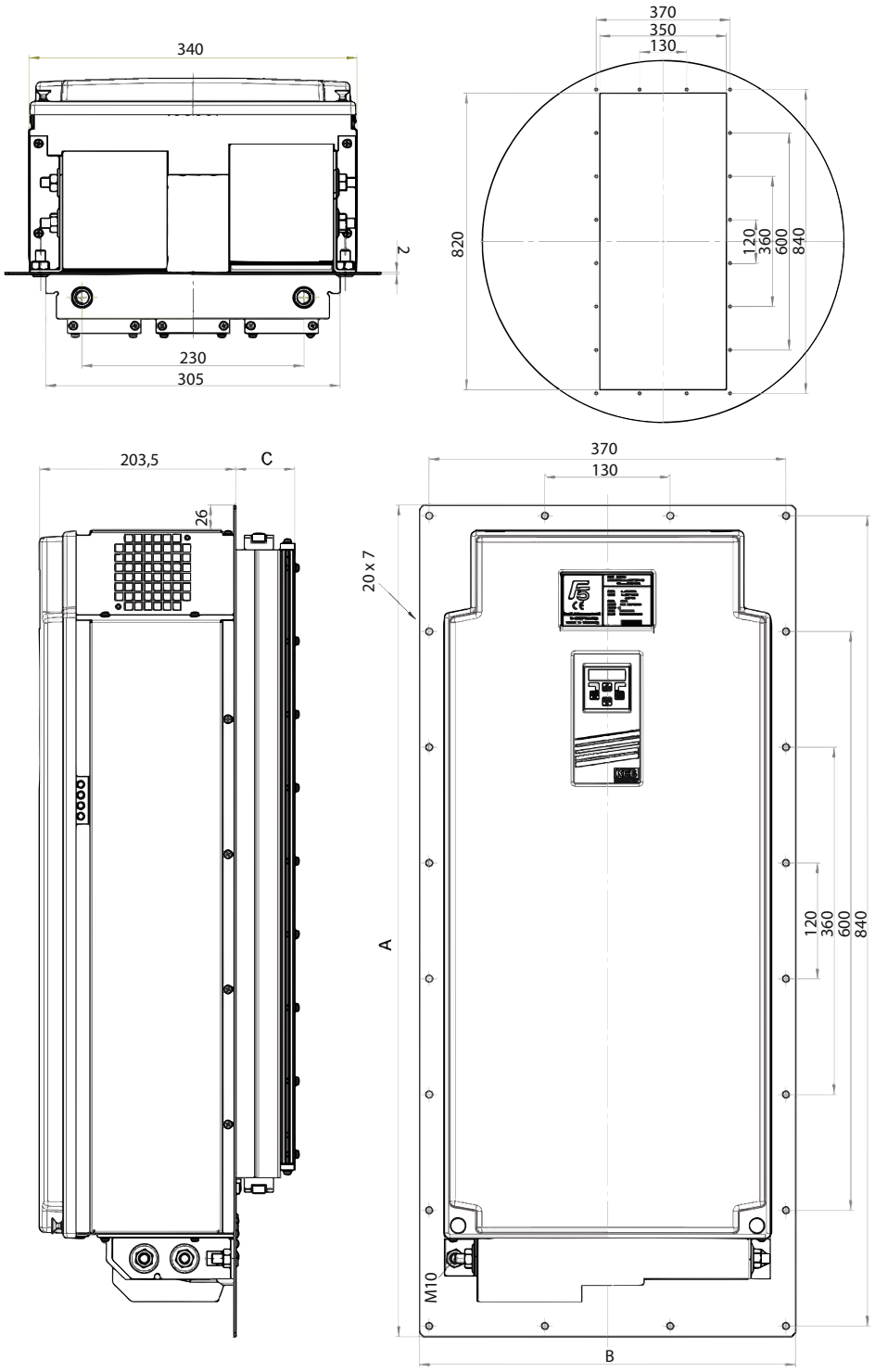
2.4.2 Through-mount version heat sink with fan (size 24…27)



2.4.3 Mounted version water-cooled heat sink

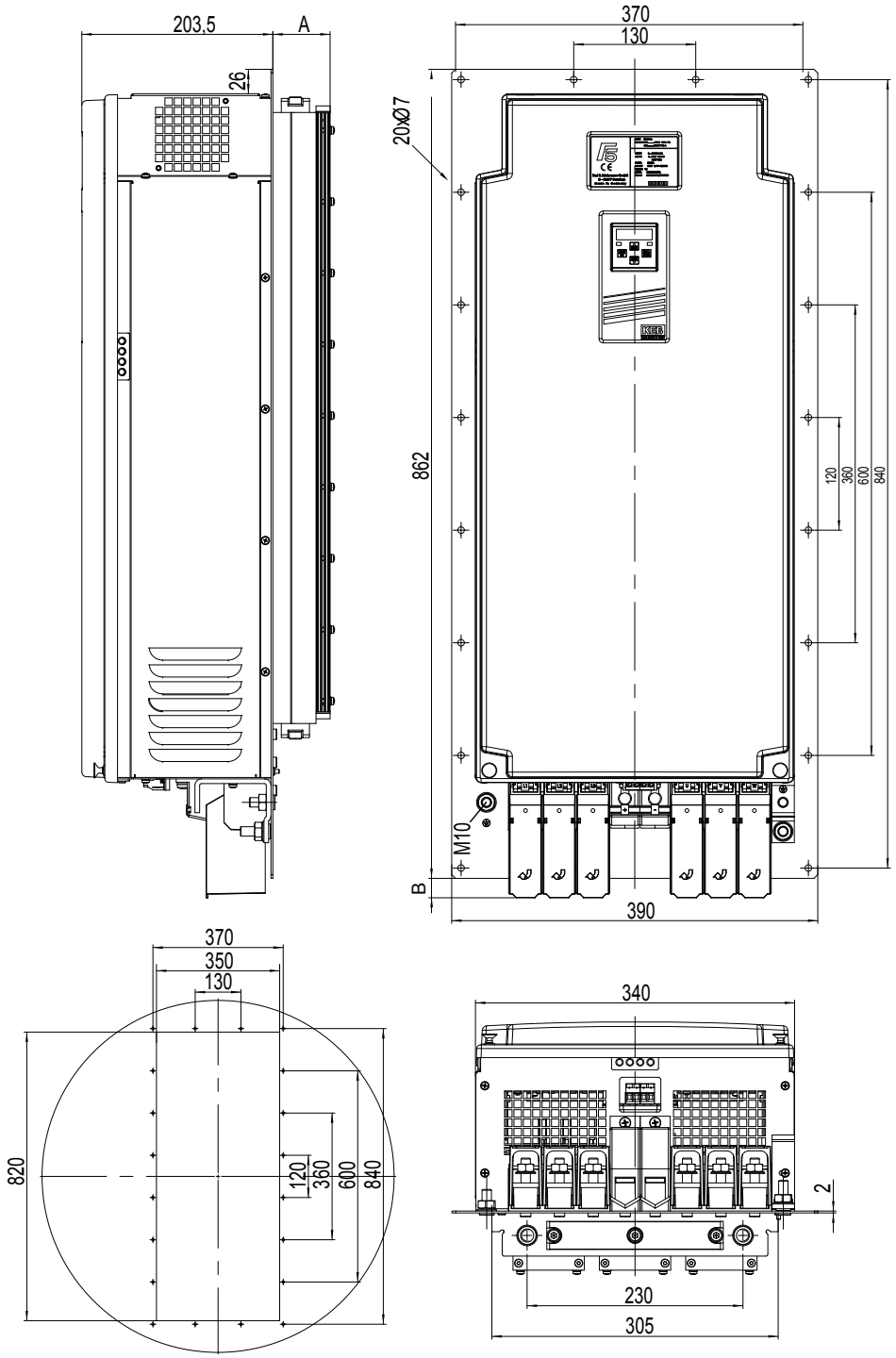


2.4.4 Through-mount version water-cooled heat sink



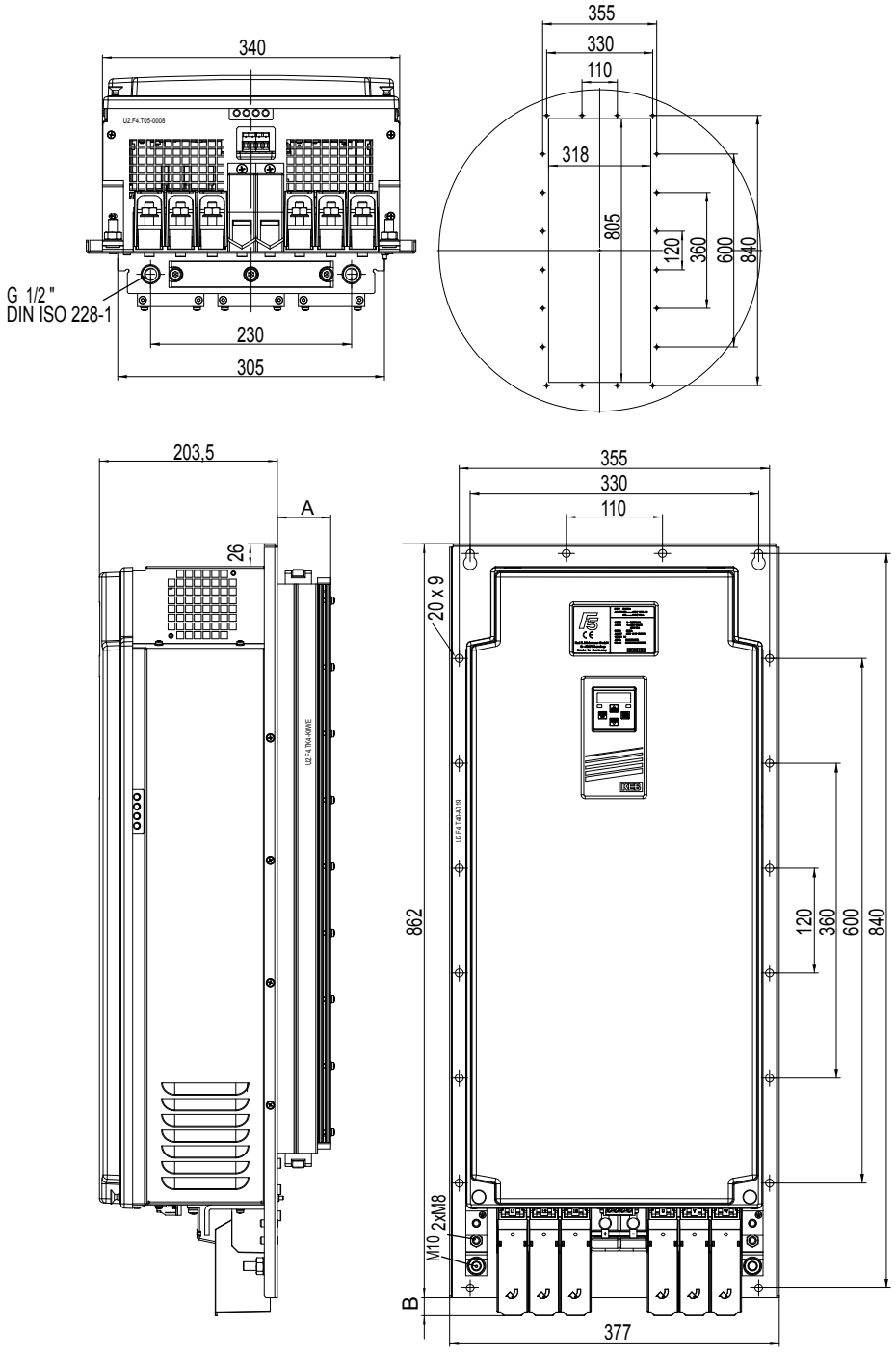
Housing type	A	B	C	Weight
Water-cooled heat sink	862	390	46	58 kg
Water-cooled heat sink with braking resistor	862	390	61	63 kg
Primary and secondary water-cooled heat sink	862	390	83.2	–
Primary and secondary water-cooled heat sink with braking resistor	862	390	98.2	–

2.4.5 Through-mount version water-cooled heat sink with stud



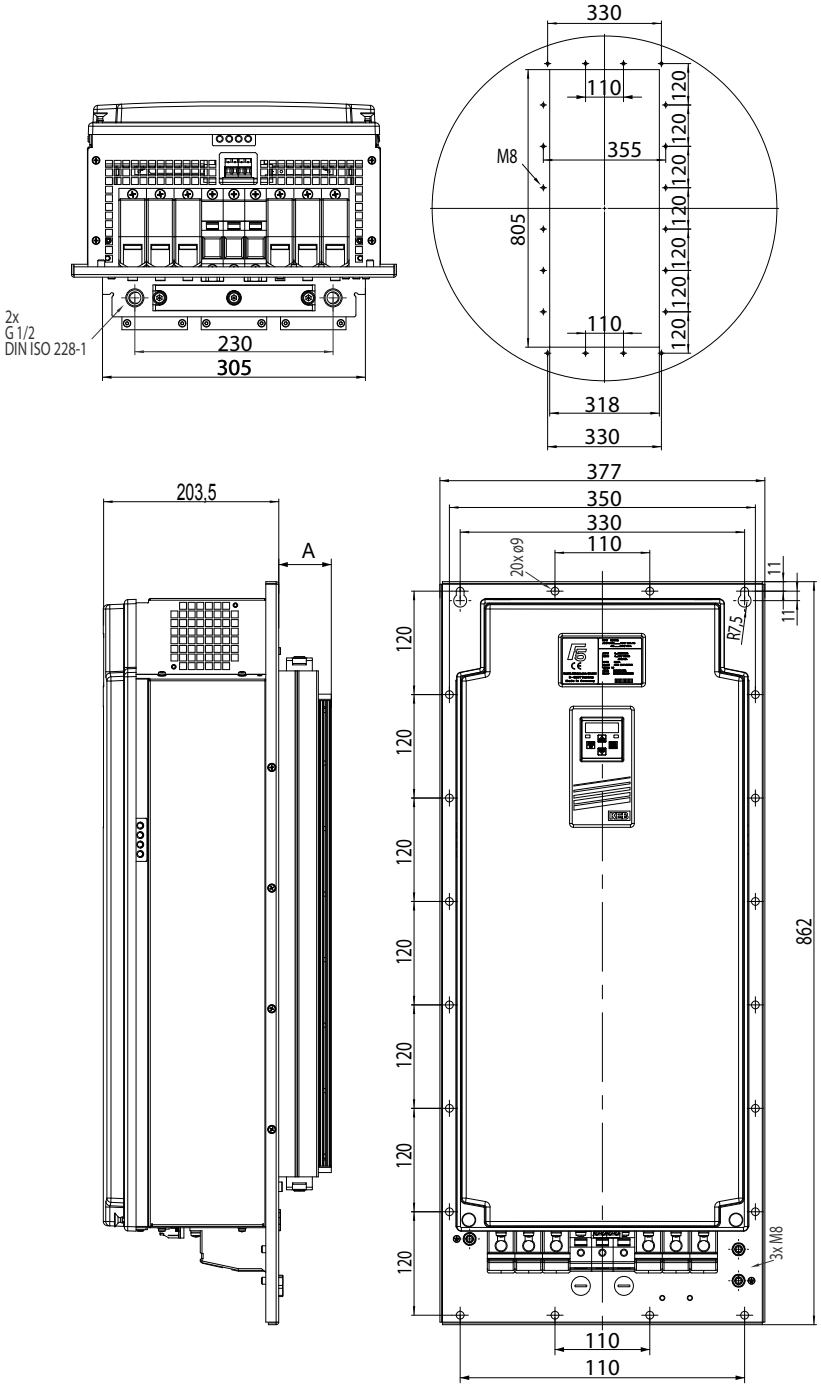
Housing type	A	B *)	Weight
Water-cooled heat sink	46	55	58 kg
Water-cooled heat sink with braking resistor	61	55	63 kg
Primary and secondary water-cooled heat sink	83.2	55	–
Primary and secondary water-cooled heat sink with braking resistor	98.2	55	–
*) only at plug-on terminal cover			

2.4.6 Through-mount version water-cooled heat sink with stud (small design)



Housing type	A	B *)	Weight
Water-cooled heat sink	46	55	58 kg
Water-cooled heat sink with braking resistor	61	55	63 kg
*) only at plug-on terminal cover			

2.4.7 Through-mount version water-cooled heat sink without stud (small design)

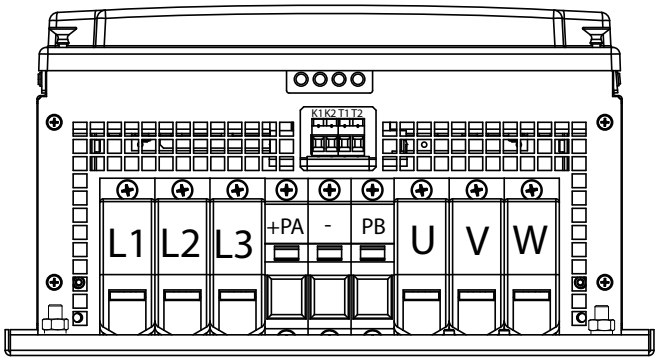


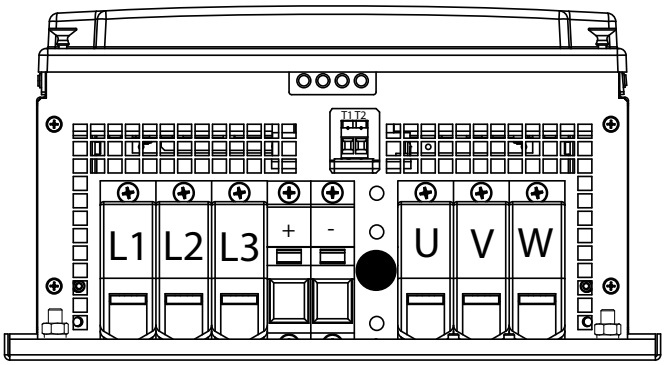
Housing type	A	B *)	Weight
Water-cooled heat sink	46	55	58 kg
Water-cooled heat sink with braking resistor	61	55	63 kg
*) only at plug-on terminal cover			

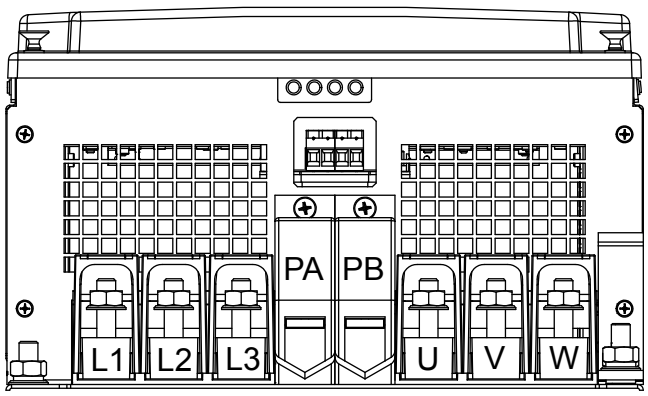
2.5 Terminal strips of the power circuit

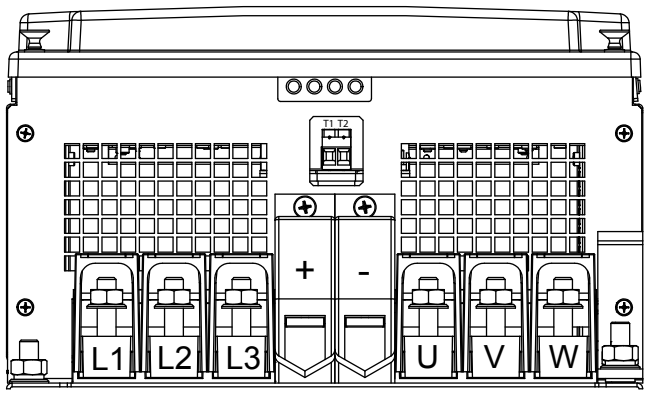
2.5.1 Terminal strips for 400V units

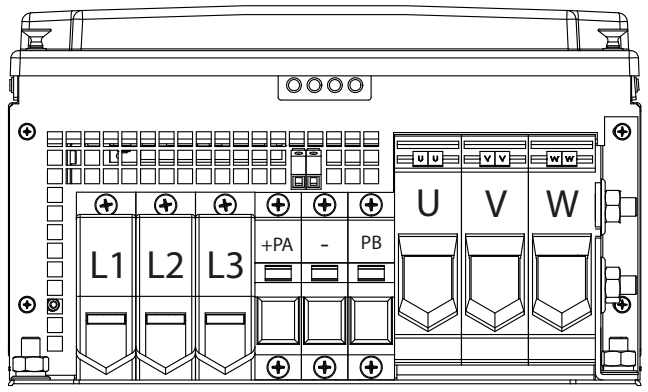
All terminal strips following the requirements of the EN 60947-7-1 (IEC 60947-7-1)

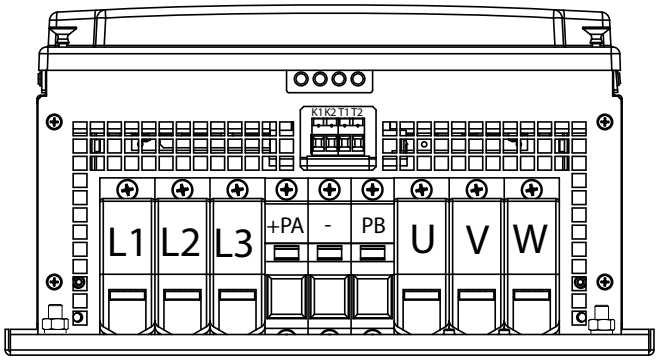
Unit size 23…25 default with GTR7	Terminal in acc. with table 2.5		
	**Name**	Function	**No.**
	L1, L2, L3	3-phase mains connection	1
	U, V, W	Motor connection	
	PA, PB	Connection for braking resistor	4
	+PA, –	DC link voltage 420…746 V DC (400V class) Connection for braking module, filter or DC link coupling (unsuitable for DC supply)	
	T1, T2	Connection for temperature sensor	3
	K1, K2	GTR7 monitoring (optional)	
	⏚	Connection for shielding / earthing	5

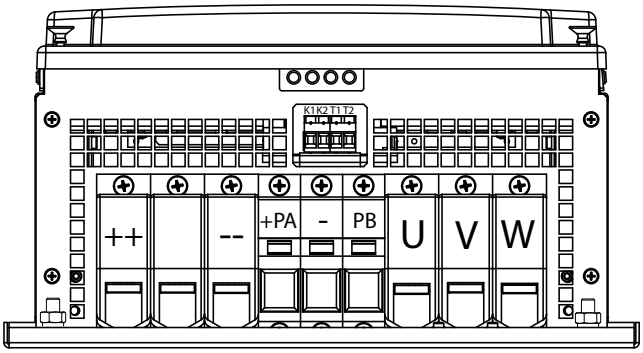
Unit size 23…25 default with GTR7	Terminal in acc. with table 2.5		
	**Name**	Function	**No.**
	L1, L2, L3	3-phase mains connection	1
	U, V, W	Motor connection	
	+, -	DC link voltage 420…746 V DC (400V class) Connection for braking module, filter or DC link coupling (unsuitable for DC supply)	4
	T1, T2	Connection for temperature sensor	3
	⏚	Connection for shielding / earthing	5

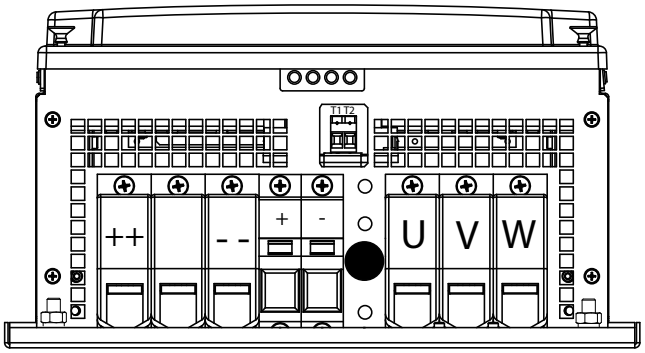
Unit size 26…27 28 default with GTR7	Terminal in acc. with table 2.5		
	**Name**	**Function**	**No.**
	L1, L2, L3	3-phase mains connection	5
	U, V, W	Motor connection	
	PA, PB	Connection for braking resistor	1
	T1, T2	Connection for temperature sensor	3
	K1, K2	GTR7 monitoring (optional)	
	⏚	Connection for shielding / earthing	5

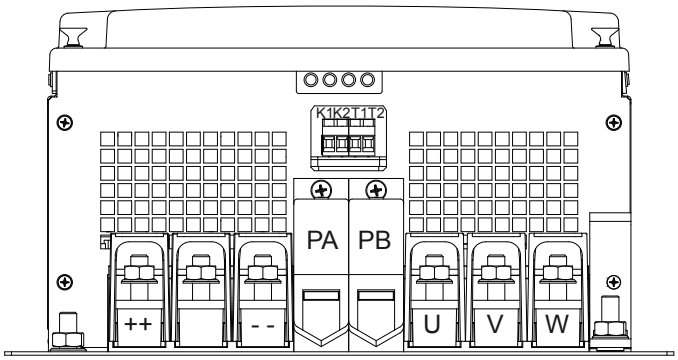
Unit size 26…27 28 default with GTR7	Terminal in acc. with table 2.5		
	**Name**	**Function**	**No.**
	L1, L2, L3	3-phase mains connection	5
	U, V, W	Motor connection	
	+, -	DC link voltage 420…746 V DC (400V class) Connection for braking module, filter or DC link coupling (unsuitable for DC supply)	1
	T1, T2	Connection for temperature sensor	3
	⏚	Connection for shielding / earthing	5

Unit size 27 advanced special version	Terminal in acc. with table 2.5		
	**Name**	**Function**	**No.**
	L1, L2, L3	3-phase mains connection	1
	U, V, W	Motor connection	2
	PA, PB	Connection for braking resistor	4
	+PA, –	DC link voltage 420…746 V DC (400V class) Connection for braking module, filter or DC link coupling (unsuitable for DC supply)	
	T1, T2	Connection for temperature sensor	3
	K1, K2	GTR7 monitoring (optional)	
	⏚	Connection for shielding / earthing	5

Unit size 26, 27 advanced special version	Terminal in acc. with table 2.5		
	**Name**	Function	**No.**
	L1, L2, L3	3-phase mains connection	1
	U, V, W	Motor connection	
	PA, PB	Connection for braking resistor	4
	+PA, –	DC link voltage 420…746 V DC (400V class) Connection for braking module, filter or DC link coupling (unsuitable for DC supply)	
	T1, T2	Connection for temperature sensor	3
	K1, K2	GTR7 monitoring (optional)	
	⏚	Connection for shielding / earthing	5

Housing size 23…27 DC version Special version	Terminal in acc. with table 2.5		
	**Name**	**Function**	**No.**
	++, – –	DC voltage input 420…746 V DC (400V class)	1
	U, V, W	Motor connection	
	PA, PB	Connection for braking resistor	4
	+PA, –	DC link voltage 420…746 V DC (400V class) Connection for braking module, filter or DC link coupling (unsuitable for DC supply)	
	T1, T2	Connection for temperature sensor	3
	⏚	Connection for shielding / earthing	5

Housing size 23…27 DC version Special version without GTR7	Terminal in acc. with table 2.5		
	**Name**	**Function**	**No.**
	++, – –	DC voltage input 420…746 V DC (400V class)	1
	U, V, W	Motor connection	
	+, -	DC link voltage 420…746 V DC (400V class) Connection for braking module, filter or DC link coupling (unsuitable for DC supply)	4
	T1, T2	Connection for temperature sensor	3
	⏚	Connection for shielding / earthing	5

Housing size 23…28 DC version with GTR7	Terminal in acc. with table 2.5		
	**Name**	**Function**	**No.**
	++, – –	DC voltage input 420…746 V DC (400V class)	5
	U, V, W	Motor connection	
	PA, PB	Connection for braking resistor	1
	T1, T2	Connection for temperature sensor	3
	K1, K2	GTR7 monitoring (optional)	
	⏚	Connection for shielding / earthing	5

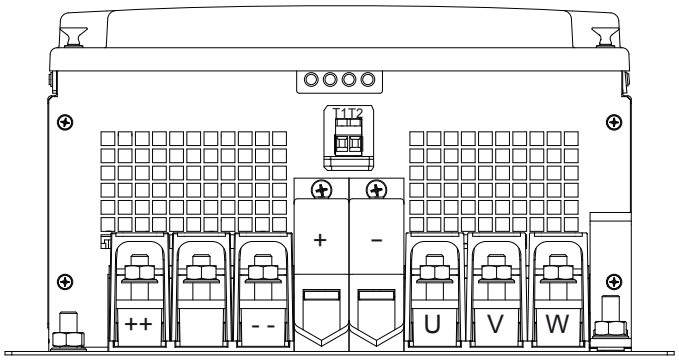
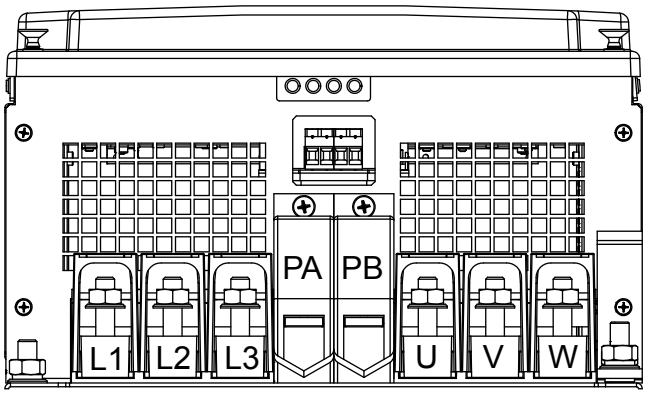
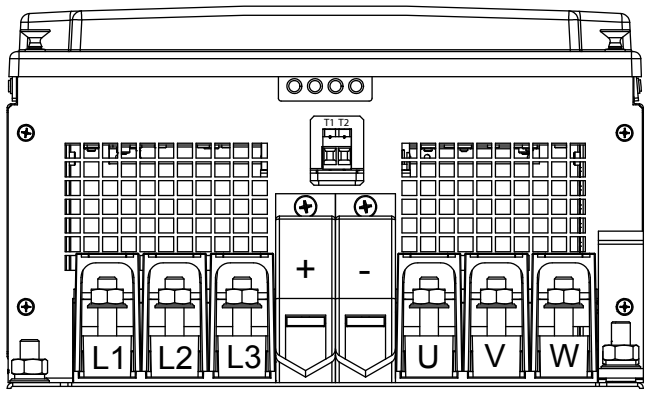
Housing size 23…28 DC version without GTR7	Terminal in acc. with table 2.5		
	**Name**	**Function**	**No.**
	++, – –	DC voltage input 420…746 V DC (400V class)	5
	U, V, W	Motor connection	
	+, -	DC link voltage 420…746 V DC (400V class) Connection for braking module, filter or DC link coupling (unsuitable for DC supply)	1
	T1, T2	Connection for temperature sensor	3
	⏚	Connection for shielding / earthing	5

Table 2.5 Permissible cable cross-sections and tightening torques of the terminals

	permissible cross-section flexible with wire-end ferrule				Maximum tightening torque	
	mm²		AWG/MCM		Nm	lb inch
No.	min	max	min	max		
1	50	150	1/0 AWG	300 MCM	25…30	270
2	70	240	2/0 AWG	500 MCM	25…30	270
3	0,2	4	24 AWG	10 AWG	0,6	5,3
4	35	95	2 AWG	3/0 AWG	15...20	180
5	10 mm stay bolt for ring thimble				25	220

2.5.2 Terminal strips for 230V units

Unit size 22…24 default with GTR7	Terminal in acc. with table 2.6		
	**Name**	**Function**	**No.**
	L1, L2, L3	3-phase mains connection	5
	U, V, W	Motor connection	
	PA, PB	Connection for braking resistor	1
	T1, T2	Connection for temperature sensor	3
	K1, K2	GTR7 monitoring (optional)	
	⏚	Connection for shielding / earthing	5

Unit size 22…24 default without GTR7	Terminal in acc. with table 2.6		
	**Name**	**Function**	**No.**
	L1, L2, L3	3-phase mains connection	5
	U, V, W	Motor connection	
	+, -	DC link voltage 250…370 V DC (200V class) Connection for braking module, filter or DC link coupling (unsuitable for DC supply)	1
	T1, T2	Connection for temperature sensor	3
	⏚	Connection for shielding / earthing	5

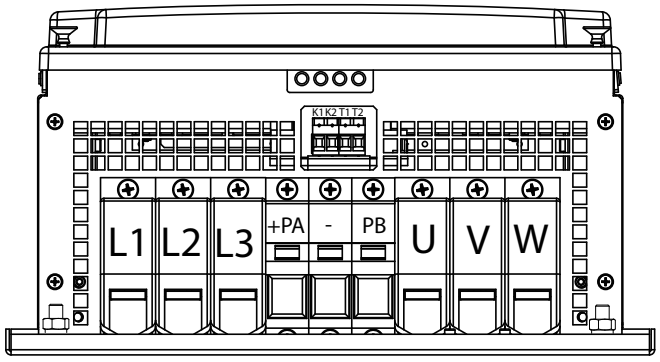
Unit size 22…24 special version with GTR7	Terminal in acc. with table 2.6		
	**Name**	**Function**	**No.**
	L1, L2, L3	3-phase mains connection	1
	U, V, W	Motor connection	
	PA, PB	Connection for braking resistor	
	+PA, –	DC link voltage 250…370 V DC (200V class) Connection for braking module, filter or DC link coupling (unsuitable for DC supply)	4
	T1, T2	Connection for temperature sensor	3
	K1, K2	GTR7 monitoring (optional)	
	⏚	Connection for shielding / earthing	5

Table 2.6 Permissible cable cross-sections and tightening torques of the terminals

No.	permissible cross-section flexible with wire-end ferrule				Maximum tightening torque	
	mm²		AWG/MCM		Nm	lb inch
	min	max	min	max		
1	50	150	1/0 AWG	300 MCM	25…30	270
3	0,2	4	24 AWG	10 AWG	0,6	5,3
4	35	95	2 AWG	3/0 AWG	15...20	180
5	10 mm stay bolt for ring thimble				25	220

2.6 Connection Accessories

2.6.1 Filter and chokes

For further information about filters and chokes for 230V units are available upon request.

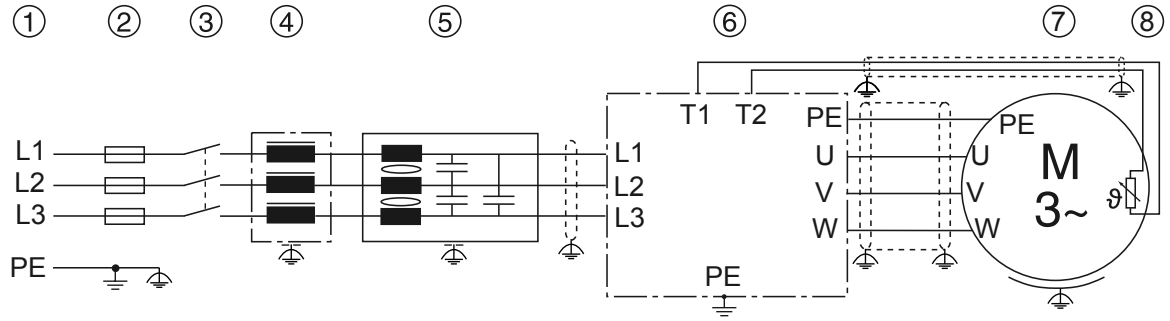
Voltage class	Inverter size	Mains choke 50 Hz / 4 % Uk	Motor choke 100 Hz / 4 % Uk
400 V	23	23DRB18-1741	23DRC18-8231
	24	24DRB18-1541	24DRC18-6831
	25	25DRB18-1341	25DRC18-5831
	26	26DRB28-1141	26DRC18-4931
	27	27DRB28-1041	27DRC18-3631
	28	28DRB28-8031	28DRC18-3131

Voltage class	Inverter size	Filter assembly kit	incorporated filter	Instruction manual
400 V	23	23U5B0U-3000	23E4T60-1001	23U5B0U-3000
	24	25U5B0U-3000	25E4T60-1001	00U500U-K300
	25	25U5B0U-3000	25E4T60-1001	00U500U-K300
	26	26U5A0U-3000	26E4T60-1001	00U400R-KM01
	27	27U5B0U-3000	27E4T60-1001	00U500U-K300
	28	23U5A0W-3000	28E4T60-1001	00U501P-K301

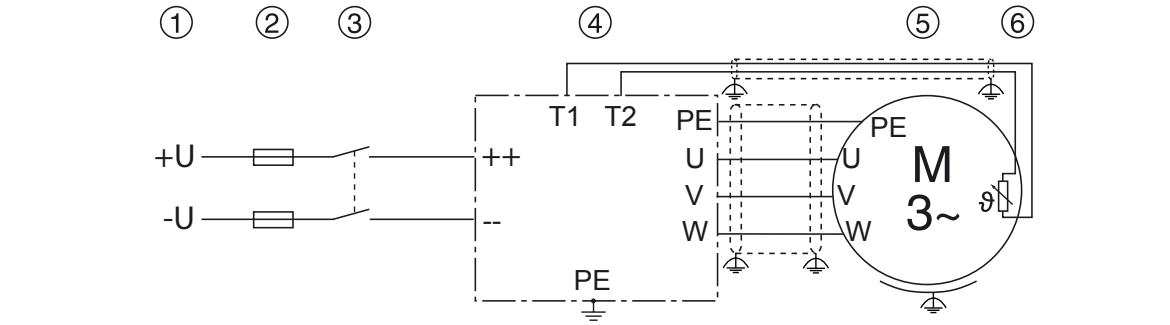
2.7 Connection Power Unit

2.7.1 Mains and motor connection

⚠	Exchanging mains and motor connection leads to immediate destruction of the unit.
⚠	Pay attention to the supply voltage and the correct polarity of the motor!



Legend	1	Mains supply
	2	Mains fuses
	3	Mains contactor
	4	Mains choke
	5	HF filter
	6	KEB COMBIVERT F5/F6
	7	Motor (see also 2.7.3)
	8	Motor protection temperature sensor (also see 2.7.4)

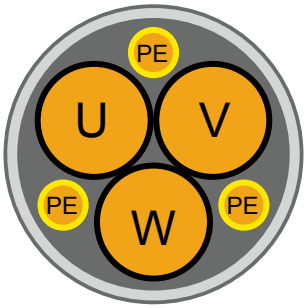


Legend	1	DC supply
	2	DC fuses
	3	Mains contactor
	4	KEB COMBIVERT F5/F6 with DC input
	5	Motor (see also 2.7.3)
	6	Motor protection temperature sensor (also see 2.7.4)

2.7.2 Selection of the motor cable

Correct selection and wiring of the motor cable is very important:

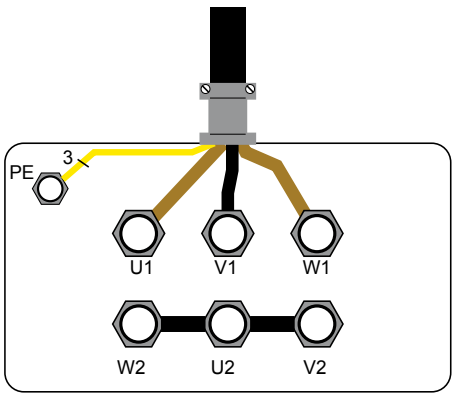
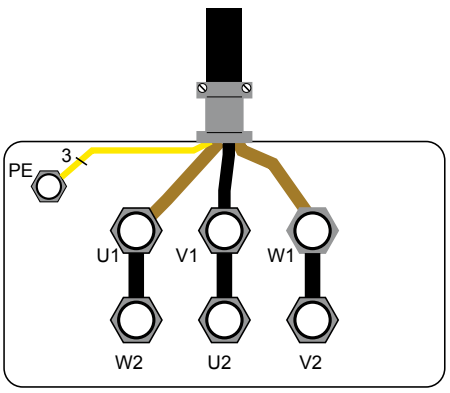
- lower abrasion of the motor bearings by leakage currents
- improved EMC characteristics
- lower symmetrical operating capacities
- less losses by transient currents

Picture 2.7.2	Cross section of a shielded motor cable with tripartited protective earth conductor
	It is recommended to use symmetric shielded motor cables at high motor ratings (>30 kW). At these cables the protective earth conductor is tripartited and uniformly placed between the phase lines. A cable without protective earth conductor can be used if the local regulations allow this. Then this protective earth conductor must be placed externally. Certain cables accept also the shielding as protective earth conductor. Pay attention to the data of the cable manufacturer!

2.7.3 Connection of the motor

As a standard the connection of the motor must be carried out in accordance with the following table:

Connection of the motor			
230/400 V motor		400/690 V motor	
230 V	400 V	400 V	690 V
Delta	Star	Delta	Star

Motor connection in star connection	Motor connection in delta connection
	

	The connecting-up instructions of the motor manufacturer are generally valid!

	Protect motor against voltage peaks!	Inverter switch at the output with a du/dt of approx. 5kV/µs. Voltage peaks that endanger the insulation system at the motor can occur especially in case of long motor cables (> 15 m). A motor choke, a du/dt filter or sine-wave filter can be used to protect the motor.

2.7.4 Temperature detection T1, T2

Parameter In.17 displays in high byte the installed temperature input of the inverter. The F5/F6 COMBIVERT is delivered as standard with switchable PTC evaluation. A switchable KTY/PTC evaluation is optionally available. The desired function is adjusted with Pn.72 (dr33 at F6) and operates in accordance with the following table:

In.17	Function of T1, T2	Pn.72 (dr33)	Resistance	Display ru.46 (F6 => ru28)	Error/ Warning [1]
5xh	KTY84	0	< 215 Ω	Detection error 253	x
			498 Ω	1°C	– [2]
			1 kΩ	100°C	x [2]
			1.722 kΩ	200°C	x [2]
			> 1811 Ω	Detection error 254	x
	PTC (in accordance with DIN EN 60947-8)	1	< 750 Ω	T1-T2 closed	–
			0.75…1.65 kΩ (reset resistance)	T1-T2 closed	–
			1.65…4 kΩ (tripping resistance)	T1-T2 open	x
			> 4 kΩ	T1-T2 open	x
6xh	PT100	–	upon request		
1)	The column is valid at factory setting. The function must be programmed accordingly with parameters Pn.12, Pn.13, Pn.62 and Pn.72 for F5 in operating mode GENERAL.				
2)	Disconnection is depending on the adjusted temperature in Pn.62 (F6 => pn11/pn14).				

The behaviour of the inverter in case of error/warning is defined with parameters Pn.12 (CP.28), Pn.13 (F6 → pn12pn13/).

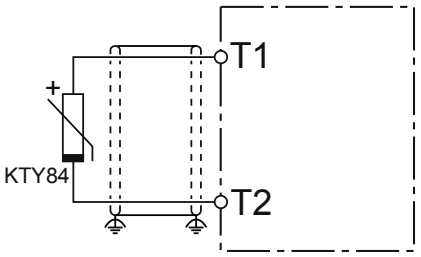
Dependent on the application the temperature input can be used for the following functions:

Function	Mode (F5 → Pn.72; F6 → dr33)
Motor temperature display and monitoring	KTY84
Motor temperature monitoring	PTC
Temperature control for water-cooled motors 1)	KTY84
General fault sensing	PTC
1) If the temperature input is used for other functions, the motor temperature control at water-cooled inverters can be done indirectly via the water cooling circuit of the inverter.	

- Do not lay KTY or PTC cable of the motor (also shielded) together with control cable!
- KTY or PTC cable only permissible with double shielding within the motor cable!

The error message E.dOH should never be disabled, otherwise the load shunt is no longer evaluated. This can cause damage to the hardware!

2.7.4.1 Use of the temperature input in KTY mode

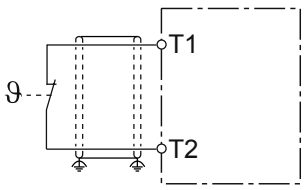
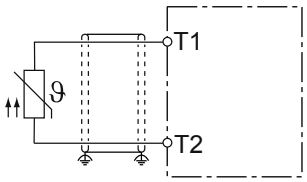
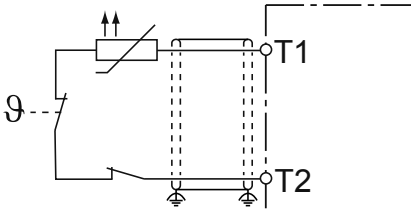
Connection of a KTY sensor


	KTY sensors are poled semiconductors and must be operated in forward direction! Connect anode to T1 ! Non-observance leads incorrect measurement in the upper temperature range. Protection of the motor winding is no longer guaranteed.
	KTY sensors may not be combined with other devices. Otherwise wrong measurements would be the consequence.

	Examples for the construction and programming of a temperature control with KTY84 evaluation can be taken from the application manual.

2.7.4.2 Use of the temperature input in PTC mode

If the temperature input is operated in PTC mode, all possibilities are available for the user within the specified resistance range. This can be:

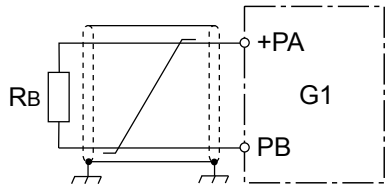
Wiring example in PTC mode	
Thermal contact (NC contact)	
Temperature sensor (PTC)	
Mixed sensor chain	

The function can be switched off with Pn.12 = “7“ (CP.28) if no evaluation of the input is desired (standard in operating mode GENERAL). Alternatively a bridge can be installed between T1 and T2.

2.7.5 Connection of a braking resistor

	Braking resistors dissipate the produced energy of the motor into heat during generatoric operation. Thus braking resistors can cause very high surface temperatures. During assembly pay attention to appropriate protection against contact and fire.
	The use of a regenerative unit is reasonable for applications which produce a lot of regenerative energy. Regeneration of excess energy into the mains.
	The mains voltage must always be switched off in order to guarantee fire protection in case of a defective braking transistor.
	The frequency inverter remains in operation in spite of switched off power supply in generatoric operation. An error must be released by external wiring which switches the modulation off in the inverter. This can occur e.g. at terminals T1/T2 or via digital input. The frequency inverter must be programmed accordingly in each case.
	The response threshold of the braking transistsor (Pn.69) for all controls without safety technology must be adjusted at least to 770 Vdc (see annex D).

2.7.5.1 Braking resistor without temperature monitoring

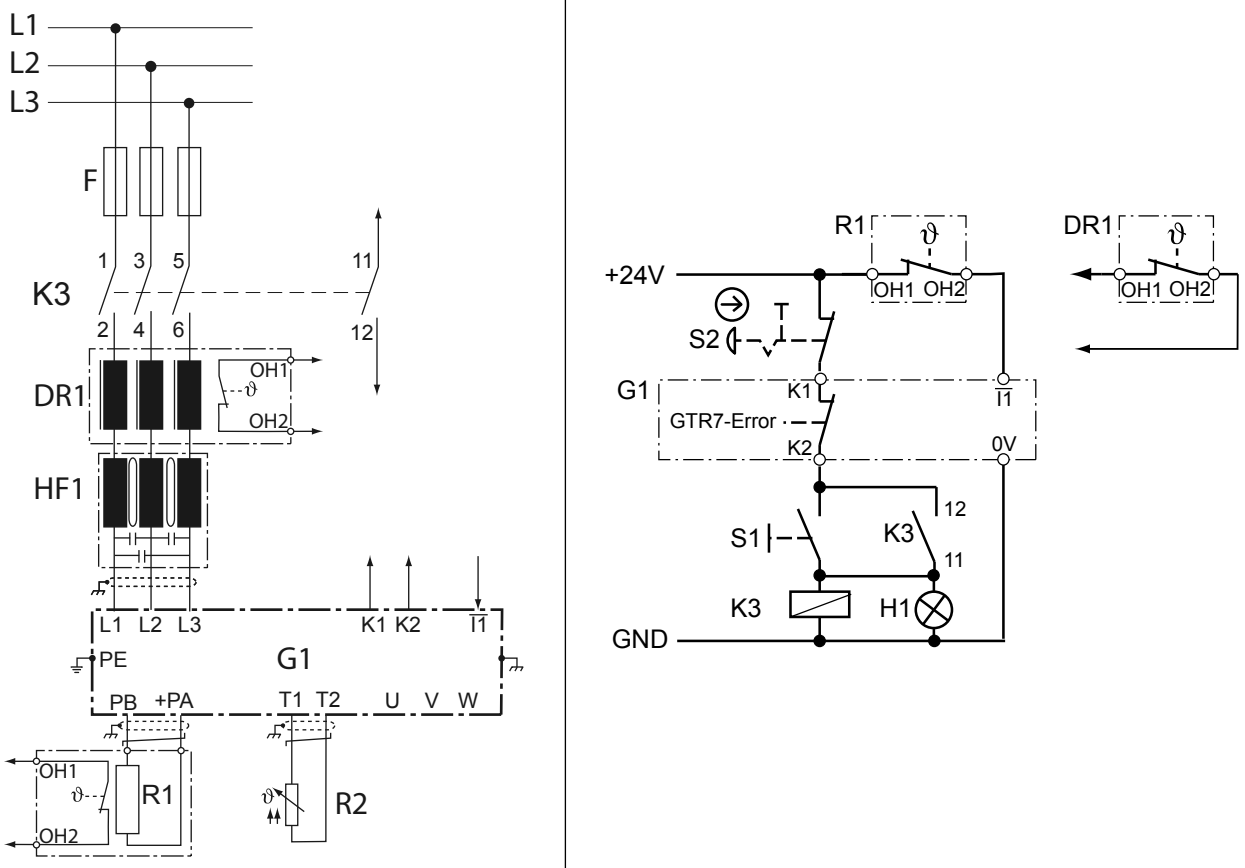
Intrinsically safe braking resistor without temperature monitoring

Only "intrinsically safe" braking resistors are permissible for operation without temperature monitoring.

2.7.5.2 Braking resistor with over-heat protection and GTR7 monitoring

This circuit offers a direct protection with defective GTR7 (braking transistor). At defective braking transistor an integrated relay opens the terminals K1/K2 and error „E.Pu“ is released. Terminals K1/K2 are integrated into the holding circuit of the input contactor, so the input voltage is switched off in error case. Regenerative operation is also secured by the internal fault disconnection. All other errors of the braking resistor and the input choke are intercepted via a digital input. The input must be programmed to "external error".

If the PTC/KTY evaluation of the motor at terminals T1/T2 is not used, these terminals can be used instead of the programmable input. The temperature input must be operated in PTC mode.

Braking resistor with over-heat protection and GTR7 monitoring



K3	Line contactor with auxiliary contacts	R1	Braking resistor with temperature switch
S1	Key for switch on	R2	PTC or KTY84 sensor e.g. of the motor
S2	Emergency stop circuit braker for switch off	DR1	Mains choke with temperature switch (optional)
H1	Tripping control	HF1	HF filter
G1	Inverter with GTR7 evaluation (relay 30 V DC/ 1 A) and programmable input I1		

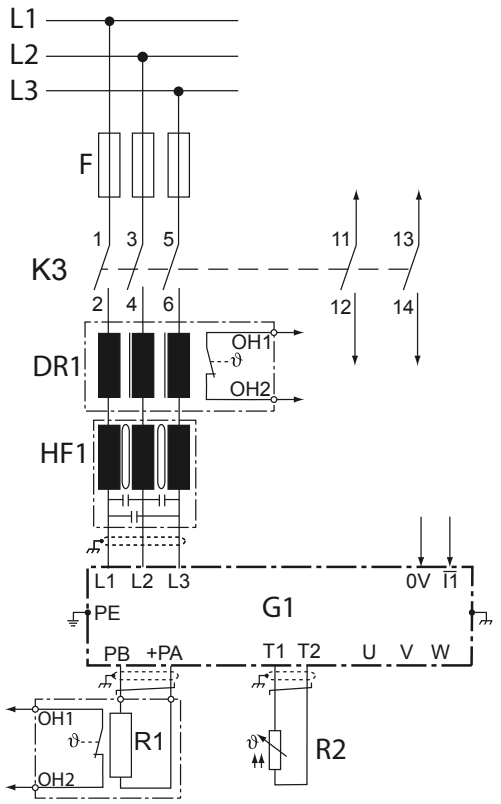
The figure serves only as an example and must be adjusted according to the application.

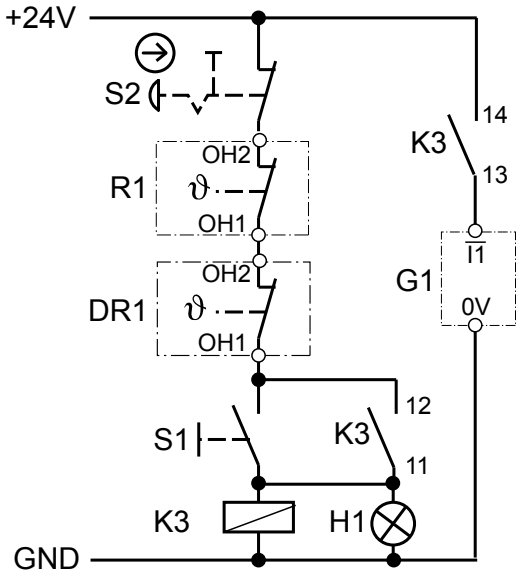
2.7.5.3 Braking resistor with over-heat protection without GTR7 monitoring

This circuit offers a direct protection with defective GTR7 (braking transistor). The braking resistor overheats and opens the OH terminals with defective GTR7. The OH terminals open the holding circuit of the input contactor, so that the input voltage is switched off in error case. An error in inverter is released by opening the auxiliary contacts of K3. Regenerative operation is also secured by the internal fault disconnection. The input must be programmed and inverted to "external error". Automatic restarting after cooling of the braking resistor is prevented by the self-holding circuit of K3.

If the PTC/KTY evaluation of the motor at terminals T1/T2 is not used, these terminals can be used instead of the programmable input. The temperature input must be operated in PTC mode.

Braking resistor with over-heat protection without GTR7 monitoring



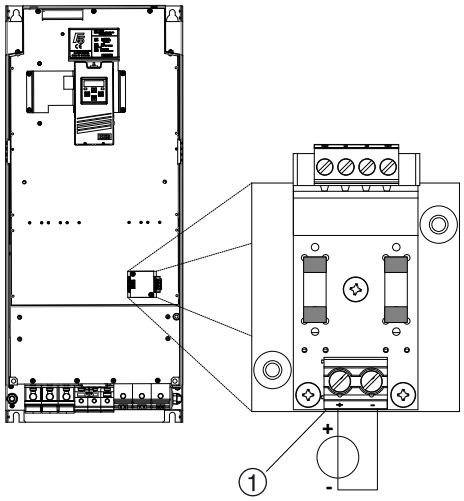


K3	Line contactor with auxiliary contacts	R1	Braking resistor with temperature switch
S1	Key for switch on	R2	PTC/KTY84 sensor e.g. of the motor
S2	Emergency stop circuit braker for switch off	DR1	Mains choke with temperature switch (optional)
H1	Tripping control	HF1	HF filter
G1	Inverter with programmable input I1		

The figure serves only as an example and must be adjusted according to the application.

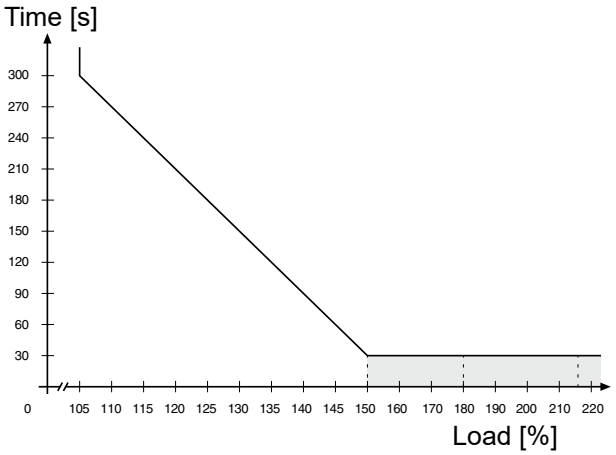
2.7.6 External heat sink fan power supply

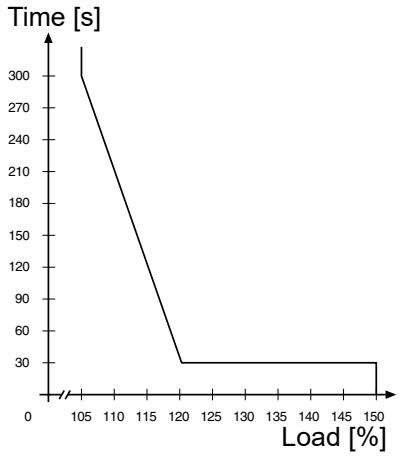
Terminal strip	X1F ①
Connection terminals	+, -
Voltage supply	+24 Vdc ± 10 %
Current draw *	2.5 A or 4.0 A
Spare fuse(s)	3.15A Type gG
* The current draw depends on the heat sink fans installed.	



Annex A

A.1 Overload characteristic





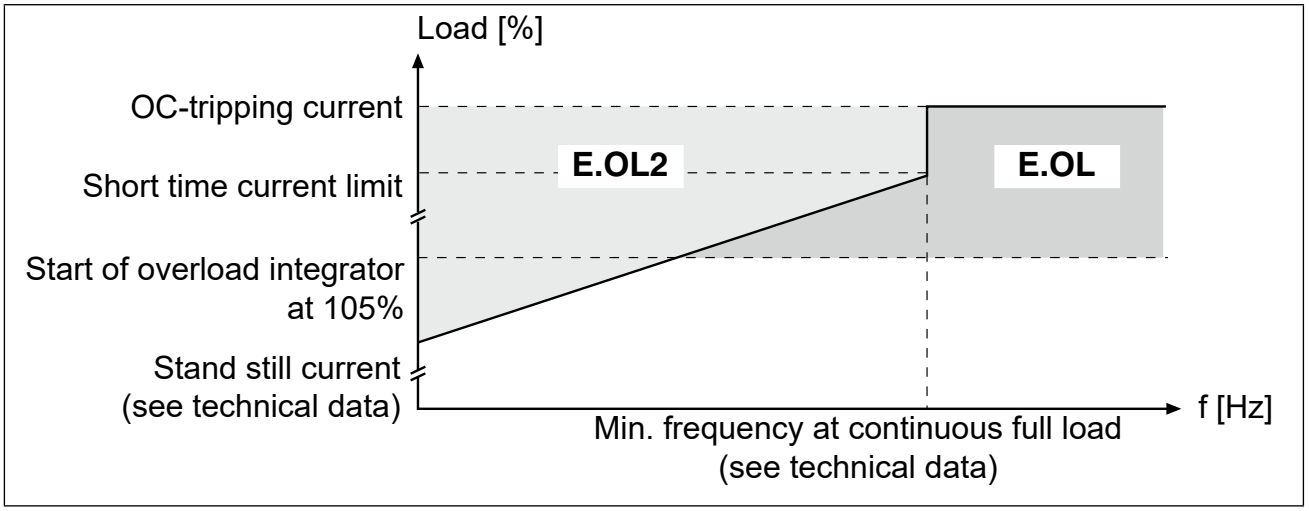
Characteristic 1	Characteristic 2

	The characteristic declines device-dependently in this range (see unit identification).

On exceeding a load of 105% the overload integrator starts. When falling below the integrator counts backwards. If the integrator achieves the overload characteristic that corresponds to the inverter, the error E.OL is triggered.

A.2 Overload protection in the lower speed range

(only operating mode MULTI and SERVO)



A PT1 element ($\tau = 280\,ms$) starts if the permissible current is exceeded. After its sequence of operation the error E.OL2 is triggered.

A.3 Calculation of the motor voltage

The motor voltage for dimensioning of the drive is depending on the used components. The mains voltage reduces according to the following table:

Mains choke Uk	4 %	Example:
Inverter open loop	4 %	Closed loop inverter with mains- and motor choke at non-rigid supply system: 400 V mains voltage - 15 % = 340 V motor voltage
Inverter closed loop	8 %	
Motor choke Uk	1 %	
Non-rigid supply system	2 %	

A.4 Maintenance

All work may only be done by qualified personnel. The security must be ensured as follows:

- Disconnect power supply at MCCB
- Secure against restarting
- Await discharge time of capacitors (if necessary controlling by measurement at „+PA“ and „-“, respectively “++“ and „--“)

- Ensure loss of voltage by measurement

In order to avoid premature ageing and avoidable malfunctions, the measures mentioned below must be carried out in the appropriate cycle.

Cycle	Function
Constant	Pay attention to unusual noises of the motor (e.g. vibrations) as well as of the frequency inverter (e.g. fan).
	Pay attention to unusual smells of the motor or frequency inverter (e.g. evaporation of capacitor electrolyte, braise of the motor winding)
Monthly	Check unit for loose screws and plugs and if necessary tighten up.
	Clean frequency inverter from dirt and dust deposits. Pay attention especially to cooling fins and protective grid of the fans.
	Examine and clean extracted air filter and cooling air filter of the control cabinet.
	Examine function of the fans of the KEB COMBIVERT. The fans must be replaced in case of audible vibrations or squeak.
Annual	Check the connecting ducts for corrosion and change it if necessary for units with water cooling.

A.5 Storage

The DC link of the KEB COMBIVERT is equipped with electrolytic capacitors. If the electrolytic aluminium capacitors are stored de-energized, the internal oxide layer is removed slowly. Due to the leakage current the oxide layer is unrenewed. If the capacitor starts running with rated voltage there is a high leakage current which can destroy the capacitor.
In order to avoid defectives, the KEB COMBIVERT must be started up depending on the storage period in accordance with the following specification:

Storage period < 1 year			
• Start-up without special measures			
Storage period 1…2 years			
• Operate frequency inverter one hour without modulation			
Storage period 2…3 years			
• Remove all cables from the power circuit; especially of braking resistor or module			
• Open control release			
• Connect variable transformer to inverter input			
• Increase variable transformer slowly to indicated input voltage (>1 min) and remain at least on the specified time.			
	Voltage class	Input voltage	Residence time
	400 V	0…280 V	15 min
		280…400 V	15 min
		400…500 V	1 h
Storage period > 3 years			
• Input voltages as before, however double the times per year. Eventually change capacitors.			

After expiration of this start-up the KEB COMBIVERT can be operated on nominal rating conditions or delivered to a new storage.

A.5.1 Cooling circuit

The cooling circuit must be completely empty if a unit shall be switched off for a longer period. The cooling circuit must be blown out additionally with compressed air at temperatures below 0°C.

Annex B

B.1 Certification

B.1.1 CE Marking

CE marked drive converters and servo drives were developed and manufactured to comply with the regulations of the Low-Voltage Directive 2006/95/EC.
The inverter or servo drive must not be started until it is determined that the installation complies with the Machine directive (2006/42/EC) as well as the EMC-directive (2004/108/EC) (note EN 60204).
Drive converters and servo drives meet the requirements of the Low-Voltage Directive 2006/95/EC. The harmonized standards of the series EN 61800-5-1 in connection with EN 60439-1 and EN 60146 were used.
This is a product of limited availability in accordance with IEC 61800-3. This product may cause radio interference in residential areas. In this case the operator may need to take corresponding measures.

B.1.2 UL Marking

c UL us	Acceptance according to UL is marked at KEB inverters with the adjacent logo on the type plate.

To be conform according to UL for the use on the North American and Canadian Market the following instructions must be observed (original text of the UL):

- Control Board Rating (max. 30Vdc, 1A)
- „Maximum Surrounding Air Temperature 45°C“
- Degree of Overload Protection provided internally by the Drive, in percent of full load current.
- Motor protection by adjustement of inverter parameters. For adjustement see application manual parameters Pn.14 and Pn.15.
- Wiring Terminals marked to indicate proper connections for the power supply, load and control circuit.
- „Use 75°C Copper Conductors Only“
- Terminals - Torque Value for Field Wiring Terminals, the value to be according to the R/C or Unlisted Terminal Block used.
- Ground Terminals - „Ground Stud and Nut shall be connected with UL Listed Ring Connectors (ZMVV), rated suitable“. The suitable Torque Value of the Nuts in Nm.
- „Devices are intended for use in pollution degree 2 environment“ (or similar wording)
- ”Integral solid state short circuit protection does not provide branch circuit protection. Branch circuit protection must be provided in accordance with the Manufacturer Instructions, National Electrical Code and any additional local codes”, or the equivalent“.

Short Circuit rating and Branch Circuit Protection:
Following marking shall be provided:

22F5 / 22F6 and 23F5 / 23F6 240V models:
„Suitable For Use On A Circuit Capable Of Delivering Not More Than 100 kA rms Symmetrical Amperes, 240 Volts Maximum when Protected by Class ___ Fuses, rated ____ Amperes as specified in table I":

or when Protected by A Circuit Breaker Having an Interrupting rating Not Less than 100 kA rms Symmetrical Amperes, 480V maximum, rated ____ Amperes as specified in table I":

All 480V Models:
„Suitable For Use On A Circuit Capable Of Delivering Not More Than 100 kA rms Symmetrical Amperes, 480 Volts Maximum when Protected by Class ____ Fuses, rated ___ Amperes as specified in table I":

or when Protected by A Circuit Breaker Having an Interrupting rating Not Less than 100 kA rms Symmetrical Amperes, 480V maximum, rated ___ Amperes as specified in table I":

Table I Branch Circuit Protection for KEB inverters F5-U/F6–U housing:
a) UL 248 Fuses; Class RK5, J or L as specified below

Inverter F5/F6	Input Voltage [V]	UL 248 Fuse Class RK5 or J [A]	UL 248 Fuse Class L max. [A]
22.	240 / 3ph	300	–
23.	240 / 3ph	350	–
23.	480 / 3ph	200	500
24.	480 / 3ph	225	600
25.	480 / 3ph	275	700
26.	480 / 3ph	300	800
27.	480 / 3ph	350	1000
28.	480 / 3ph	400	–

b) UL 489 Circuit Breaker

Inverter F5/F6	Input Voltage [V]	UL 489 MCCB [A]	Siemens Cat. No.
22.	240 / 3ph	400	3VL400 / JG-frame
23.	240 / 3ph	400	3VL400 / JG-frame
23.	480 / 3ph	250	3VL250 / FG-frame
24.	480 / 3ph	250	3VL250 / FG-frame
25.	480 / 3ph	400	3VL400 / JG-frame
26.	480 / 3ph	400	3VL400 / JG-frame
27.	480 / 3ph	400	3VL400 / JG-frame
28.	480 / 3ph	400	3VL400 / JG-frame

Annex C

C.1 Installation of water-cooled units

In continuous operation water-cooled inverters are operated with lower temperature than air-cooled inverters. This has positive effects on lifetime-relevant components such as fan and DC link circuit capacitors and power modules (IGBT). Also the temperature dependent switching losses are positively effected. The use of water-cooled KEB COMBIVERT frequency inverters is offered in the drive technology, because there are process-caused coolants available with some applications. The following instructions must be observed absolutely when this units are used.

C.1.1 Heat sink and operating pressure

Design system	Material (voltages)	Max. operating pressure	Connecting duct
Extrusion casting heat sink	Aluminium (-1.67 V)	10 bar	0000650-G140

The heat sinks are sealed with sealing rings and posses a surface protection (anodized) even in the ducts.

	In order to avoid a deformation of the heat sink and the damages involved, the indicated max. operating pressure may not be exceeded briefly also by pressure peaks.
	Pay attention to the guidelines 97/23/EG of pressure units.

C.1.2 Materials in the cooling cicuit

For the screw connections and also for the metallic articles in the cooling circuit which are in contact with the coolant (electrolyte) a material is to be selected, which forms a small voltage difference to the heat sink in order to avoid contact corrosion and/or pitting corrosion (electro-chemical voltage series, see table 1.5.2). An aluminum screw connection or ZnNi coated steel screw connection is recommended. Other materials must be examined in each case before employment. The specific case of application must be checked by the customer in tuning of the complete cooling circuit and must be classified according to the used materials. With hoses and seals take care that halogen-free materials are used.
A liability for occuring damages by wrongly used materials and from this resulting corrosion cannot be taken over!

Table 1.5.2 Electro-chemical voltage series / standard potentials against hydrogen

Material	generated Ion	Standard potential	Material	generated Ion	Standard potential
Lithium	Li^+	-3.04 V	Cobald	Co^{2+}	-0.28 V
Potassium	K^+	-2.93 V	Nickel	Ni^{2+}	-0.25 V
Calcium	Ca^{2+}	-2.87 V	Tin	Sn^{2+}	-0.14 V
Sodium	Na^+	-2.71 V	Lead	Pb^{3+}	-0.13 V
Magnesium	Mg^{2+}	-2.38 V	Iron	Fe^{3+}	-0.037 V
Titan	Ti^{2+}	-1.75 V	Hydrogen	$2H^+$	0.00 V

Table 1.5.2 Electro-chemical voltage series / standard potentials against hydrogen					
Material	generated Ion	Standard potential	Material	generated Ion	Standard potential
Aluminium	Al^{3+}	-1.67 V	Copper	Cu^{2+}	0.34 V
Manganese	Mn^{2+}	-1.05 V	Carbon	C^{2+}	0.74 V
Zinc	Zn^{2+}	-0.76 V	Silver	Ag^{+}	0.80 V
Chrome	Cr^{3+}	-0.71 V	Platinum	Pt^{2+}	1.20 V
Iron	Fe^{2+}	-0.44 V	Gold	Au^{3+}	1.42 V
Cadmium	Cd^{2+}	-0.40 V	Gold	Au^{+}	1.69 V

C.1.3 Requirements on the coolant

The requirements on the coolant are depending on the ambient conditions, as well as from the used cooling system. General requirements on the coolant:

Standards	TrinkwV 2001, DIN EN 12502 part 1-5, DIN 50930 part 6, DVGW work sheet W216
VGB Cooling water directive	The VGB cooling water directive (VGB-R 455 P) contains instructions about common process technology of the cooling. Particulary the interactions between cooling water and components of the cooling system are described.
pH-value	Aluminum is particularly corroded by lixiviums and salts. The optimal pH value for aluminum should be in the range of 7.5… 8.0.
Abrasive substances	Abrasive substances as used in abrasive (quartz sand), clogging the cooling circuit.
Copper cuttings	Copper cuttings can attach the aluminum and this leads to a galvanic corrosion. Copper should not be used together with aluminum due to electro-chemical voltage difference.
Hard water	Cooling water may not cause scale deposits or loose excretions. It shall have a low total hardness (<20°d) especially carbon hardness.
Soft water	Soft water (<7°dH) corrodes the material.
Frost protection	An appropriate antifreeze must be used for applications when the heat sink or the coolant is exposed temperatures below zero. Use only products of one manufacturer for a better compatibility with other additives.
Corrosion protection	Additives can be used as corrosion protection. In connection with frost protection the antifreeze must have a concentration of 20…25 Vol %, in order to avoid a change of the additives.

Special requirements for open and half-open cooling systems:

Impurities	Mechanical impurities in half-open cooling systems can be counteracted when appropriate water filters are used.
Salt concentration	The salt content can increase through evaporation at half-open systems. Thus the water is more corrosive. Adding of fresh water and removing of process water works against.
Algae and myxobacteria	Algae and myxobacteria can arise caused by increased water temperature and contact with atmospheric oxygen. The algae and myxobacteria clog the filters and obstruct the water-flow. Biocide containing additives can avoid this. Especially at longer OFF periods of the cooling circuit preventive maintenance is necessary.
Organic materials	The contamination with organic materials must be kept as small as possible, because separate slime can be caused by this

	Damages at the unit which are caused by clogged, corroded heat sinks or other obvious operating errors, leads to the loss of the warranty claims.

C.1.4 Connection to the cooling system

- Screw in connecting duct in accordance with the manual
- The connection to the coolant must be carried out with flexible, pressure-resistant hoses and secured with clamps.
- The valves must be installed in the flow pipe to keep the return flow pipe pressure free.
- Pay attention to flux direction and check tightness!
- The cooling flow must always be started before starting the KEB COMBIVERT.

The connection to the cooling system can occur as closed or open cooling circuit. The connection to a closed cycle cooling circuit is recommended, because the danger of contamination of coolant is very small. Preferably also a monitoring of the pH value of the coolant should be installed.
Pay attention to a corresponding cable cross section at required equipotential bonding in order to avoid electro-chemical procedures.

C.1.5 Coolant temperature and moisture condensation

The inlet temperature may not exceed 40°C. The maximum heat sink temperature is 60 °C, 70 °C or 90 °C depending on the power unit and overload capacity (see „Technical data“). The flow temperature should be selected depending on the volume flow by way that the heat sink temperature is always 10K below the over-temperature level (OH) at rated operation. This avoids sporadic shutdown.
Due to high air humidity and high temperatures it can lead to moisture condensation. Moisture condensation is dangerous for the inverter, because the inverter can be destroyed through eventual occuring short-circuits.

The user must guarantee that any moisture condensation is avoided!

In order to avoid a moisture condensation the following possibilities can be done. The application of both methods is recommended.

Supply of temper coolant

This is possible by using heatings in the cooling circuit for the control of the coolant temperature. The following dew point table is available for this:

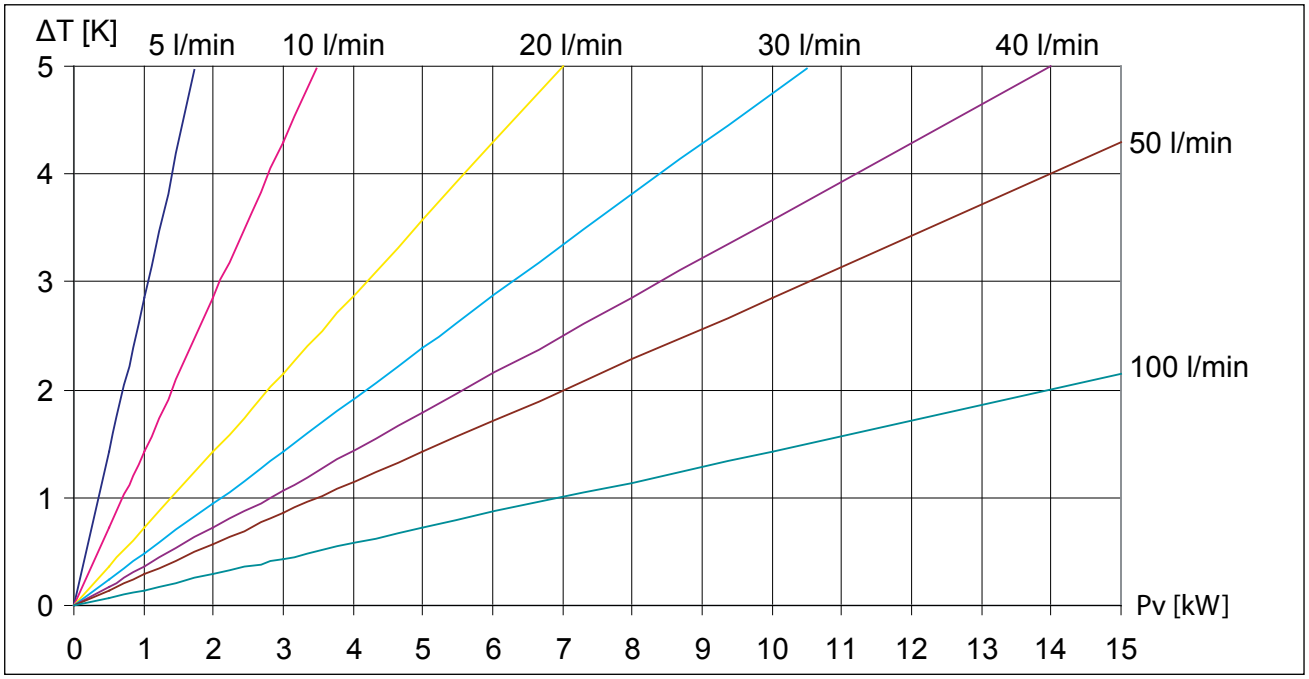
Coolant inlet temperature [°C] is depending on ambient temperature and air humidity

Air humidity [%] / Surrounding temperature [°C]	10	20	30	40	50	60	70	80	90	100
-25	-45	-40	-36	-34	-32	-30	-29	-27	-26	-25
-20	-42	-36	-32	-29	-27	-25	-24	-22	-21	-20
-15	-37	-31	-27	-24	-22	-20	-18	-16	-15	-15
-10	-34	-26	-22	-19	-17	-15	-13	-11	-11	-10
-5	-29	-22	-18	-15	-13	-11	-8	-7	-6	-5
0	-26	-19	-14	-11	-8	-6	-4	-3	-2	0
5	-23	-15	-11	-7	-5	-2	0	2	3	5
10	-19	-11	-7	-3	0	1	4	6	8	9
15	-18	-7	-3	1	4	7	9	11	13	15
20	-12	-4	1	5	9	12	14	16	18	20
25	-8	0	5	10	13	16	19	21	23	25
30	-6	3	10	14	18	21	24	26	28	30
35	-2	8	14	18	22	25	28	31	33	35
40	1	11	18	22	27	31	33	36	38	40
45	4	15	22	27	32	36	38	41	43	45
50	8	19	28	32	36	40	43	45	48	50

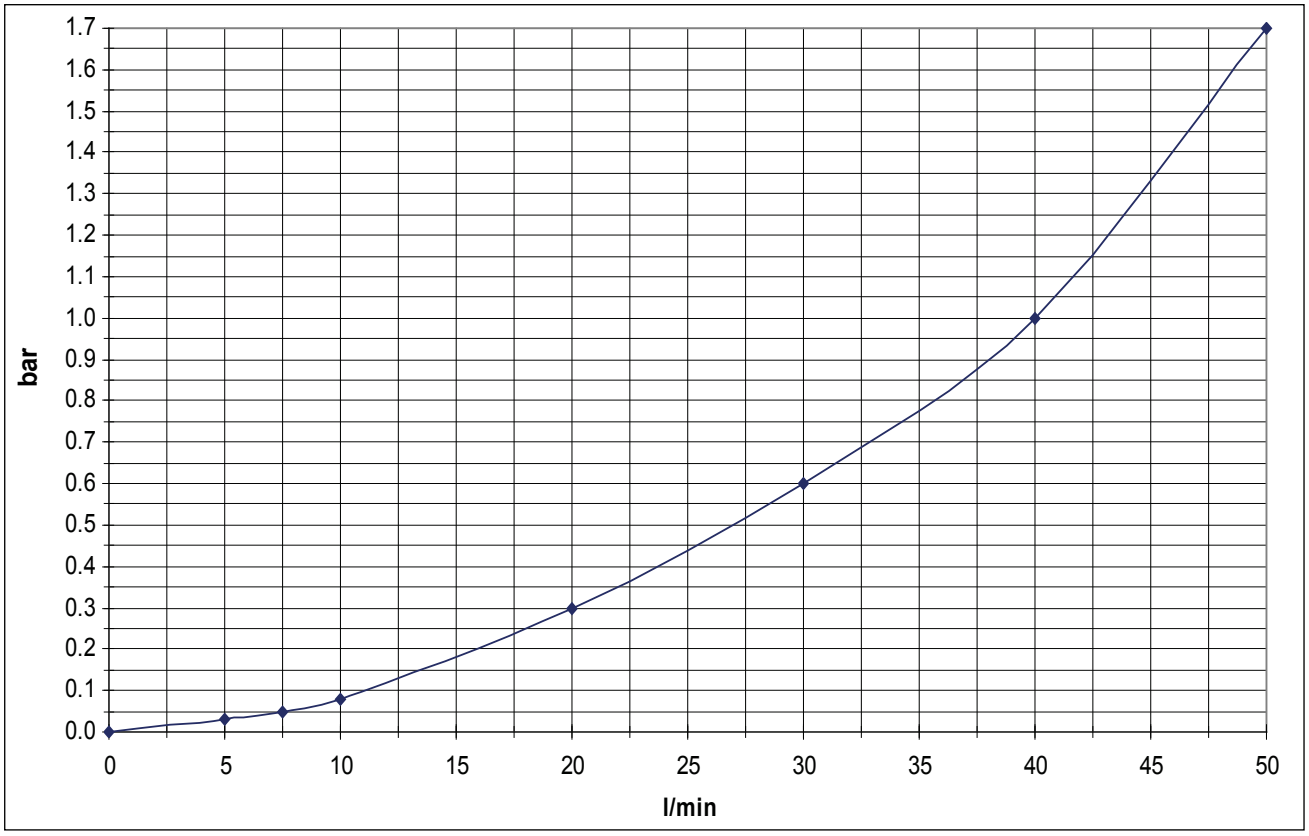
Temperature control

The cooling system can be connected by means of pneumatic or magnetic valves. A relay is frontend. In order to avoid pressure surges, the valves for the temperature control must be inserted in the flow line of the cooling circuit. All usual valves can be used. Pay attention that the valves are faultless and do not clamp. Monitoring of the system is possible with a flow monitor.

C.1.6 Coolant heating depending on power loss and flow rate with water



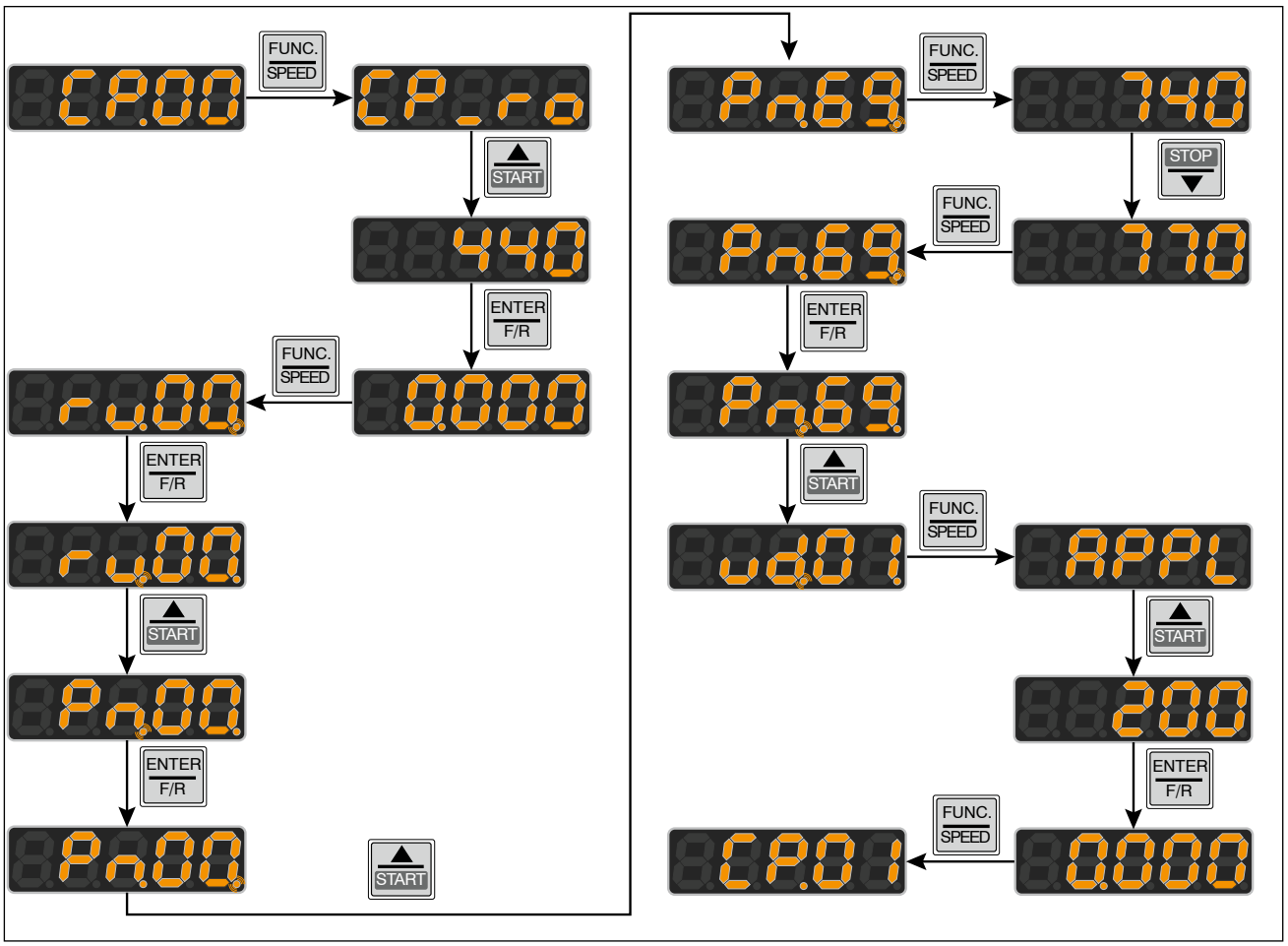
C.1.7 Typically fall of pressure depending on the rate of flow



Annex D

D.1 Changing the response threshold of the braking transistor

To avoid a premature switching of the brake transistor at an input rated voltage of 480 Vac, the response threshold must be controlled or adjusted according to the following graphic.



KEB Automation KG
Südstraße 38 • 32683 Barntrup
fon: +49 5263 401-0 • fax: +49 5263 401-116
net: www.keb.de • mail: info@keb.de

KEB worldwide…

KEB Automation GmbH
Ritzstraße 8 • 4614 Marchtrenk
fon: +43 7243 53586-0 • fax: +43 7243 53586-21
net: www.keb.at • mail: info@keb.at

KEB Automation KG
Herenveld 2 • 9500 Geraadsbergen
fon: +32 5443 7860 • fax: +32 5443 7898
mail: vb.belgien@keb.de

KEB Power Transmission Technology (Shanghai) Co.,Ltd.
No. 435 Qianpu Road, Chedun Town, Songjiang District,
Shanghai 201611, P.R. China
fon: +86 21 37746688 • fax: +86 21 37746600
net: www.keb.de • mail: info@keb.cn

KEB Automation GmbH
Organizační složka
Suchovrbenske nam. 2724/4 • 370 06 České Budějovice
fon: +420 387 699 111 • fax: +420 387 699 119
mail: info@keb.cz

KEB Antriebstechnik GmbH
Wildbacher Str. 5 • 08289 Schneeberg
fon: +49 3772 67-0 • fax: +49 3772 67-281
mail: info@keb-drive.de

KEB España
C/ Mitjer, Nave 8 - Pol. Ind. LA MASIA
08798 Sant Cugat Sesgarrigues (Barcelona)
fon: +34 93 897 0268 • fax: +34 93 899 2035
mail: vb.espana@keb.de

Société Française KEB
Z.I. de la Croix St. Nicolas • 14, rue Gustave Eiffel
94510 LA QUEUE EN BRIE
fon: +33 1 49620101 • fax: +33 1 45767495
net: www.keb.fr • mail: info@keb.fr

KEB (UK) Ltd.
Morris Close, Park Farm Industrial Estate
Wellingborough, NN8 6 XF
fon: +44 1933 402220 • fax: +44 1933 400724
net: www.keb.co.uk • mail: info@keb.co.uk

KEB Italia S.r.l.
Via Newton, 2 • 20019 Settimo Milanese (Milano)
fon: +39 02 3353531 • fax: +39 02 33500790
net: www.keb.de • mail: kebitalia@keb.it

KEB Japan Ltd.
15–16, 2–Chome, Takanawa Minato-ku
Tokyo 108-0074
fon: +81 33 445-8515 • fax: +81 33 445-8215
mail: info@keb.jp

KEB Korea Seoul
Room 1709, 415 Missy 2000
725 Su Seo Dong, Gang Nam Gu
135-757 Seoul/South Korea
fon: +82 2 6253 6771 • fax: +82 2 6253 6770
mail: vb.korea@keb.de

KEB RUS Ltd.
Lesnaya Str. House 30, Dzerzhinsky (MO)
140091 Moscow region
fon: +7 495 632 0217 • fax: +7 495 632 0217
net: www.keb.ru • mail: info@keb.ru

KEB America, Inc.
5100 Valley Industrial Blvd. South
Shakopee, MN 55379
fon: +1 952 224-1400 • fax: +1 952 224-1499
net: www.kebamerica.com • mail: info@kebamerica.com

More and latest addresses at http://www.keb.de

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