COMBIVERT **F5**

INSTRUCTIONS FOR USE | **INSTALLATION ACTIVE INFEED CONVERTER**

Translation of the original manual
Document 20132138 EN 04

Preface

The hardware and software described in this document are products of KEB. The information contained in this document is valid at the time of publishing. KEB reserves the right to update this document in response to misprints, mistakes or technical changes.

Signal words and symbols

Certain procedures within this document can cause safety hazards during the installation or operation of the device. Refer to the safety warnings in this document when performing these procedures. Safety signs are also located on the device where applicable. A safety warning is marked by one of the following warning signs:

⚠ DANGER	Dangerous situation, which will cause death or serious injury iif this safety warning is ignored.
⚠ WARNING	Dangerous situation, which may cause death or serious injury if this safety warning is ignored.
⚠ CAUTION	Dangerous situation, which may cause minor injury if this safety warning is ignored.
NOTICE	Situation, which can cause damage to property if this safety warning is ignored.

RESTRICTION

Used when the following statements depend on certain conditions or are only valid for certain ranges of values.

Used for informational messages or recommended procedures.

More symbols

►	This arrow starts an action step.
• / -	Enumerations are marked with dots or indents.
=>	Cross reference to another chapter or another page.

Note to further documentation.
www.keb.de/service/downloads

Laws and guidelines

KEB Automation KG confirms with the EC declaration of conformity and the CE mark on the device nameplate that it complies with the essential safety requirements.

The EC declaration of conformity can be downloaded on demand via our website. Further information is provided in chapter "Certification".

Warranty and liability

The warranty and liability on design, material or workmanship for the acquired device is given in the general sales conditions.

Here you will find our general sales conditions.
www.keb.de/terms-and-conditions

Further agreements or specifications require a written confirmation.

Support

Although multiple applications are referenced, not every case has been taking into account. If you require further information or if problems occur which are not referenced in the documentation, you can request the necessary information via the local KEB agency.

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 customer.

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 intended use. However, they are regarded as being only informal and changes are expressly reserved, in particular due to technical changes. 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 intended end use of the product (application) by the customer. They must be repeated, even if only parts of hardware, software or the unit adjustment are modified.

Copyright

The customer may use the instructions for use as well as further documents or parts from it for internal purposes. Copyrights are with KEB and remain valid in its entirety.

This KEB product or parts thereof may contain third-party software, including free and/or open source software. If applicable, the license terms of this software are contained in the instructions for use. The instructions for use are already available to you, can be downloaded free of charge from the KEB website or can be requested from the respective KEB contact person.

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Glossary

0V	Earth-potential-free common point
1ph	1-phase mains
3ph	3-phase mains
AC	AC current or voltage
AFE	From 07/2019 AIC replaces the previous name AFE
AFE filter	From 07/2019 AIC filter replaces the previous name AFE filter
AIC	Active Infeed Converter
AIC filter	Filter for Active Infeed Converter
Application	The application is the intended use of the KEB product
ASCL	Asynchronous sensorless closed loop
Auto motor ident.	Automatically motor identification; calibration of resistance and inductance
AWG	American wire gauge
B2B	Business-to-business
BiSS	Open source real-time interface for sensors and actuators (DIN 5008)
CAN	Fieldbus system
CDF	Cyclic duration factor
CDM	Complete drive module including auxiliary equipment (control cabinet)
COMBIVERT	KEB drive converters
COMBIVIS	KEB start-up and parameterizing software
Customer	The customer has purchased a KEB product from KEB and integrates the KEB product into his product (customer product) or resells the KEB product (dealer)
DC	DC current or voltage
DI	Demineralized water, also referred to as deionized (DI) water
DIN	German Institut for standardization
DS 402	CiA DS 402 - CAN device profile for drives
EMC	Electromagnetic compatibility
Emergency stop	Shutdown of a drive in emergency case (not de-energized)
Emergency switching off	Switching off the voltage supply in emergency case
EMS	Energy Management System
EN	European standard
Encoder emulation	Software-generated encoder output
End customer	The end customer is the user of the customer product
Endat	Bidirectional encoder interface of the company Heidenhain
EtherCAT	Real-time Ethernet bus system of the company Beckhoff
Ethernet	Real-time bus system - defines protocols, plugs, types of cables
FE	Functional earth
FSoE	Functional Safety over Ethernet
FU	Drive converter
GND	Reference potential, ground
GTR7	Braking transistor
HF filter	High frequency filter to the mains
Hiperface	Bidirectional encoder interface of the company Sick-Stegmann
HMI	Human machine interface (touch screen)
HSP5	Fast, serial protocol
HTL	Incremental signal with an output voltage (up to 30V) -> TTL
IEC	International standard
IP xx	Degree of protection (xx for level)
KEB product	The KEB product is subject of this manual
KTY	Silicium temperature sensor (polarized)
Manufacturer	The manufacturer is KEB, unless otherwise specified (e.g. as manufacturer of machines, engines, vehicles or adhesives)
MCM	American unit for large wire cross sections
Modulation	Means in drive technology that the power semiconductors are controlled
MTTF	Mean service life to failure
NN	Sea level
OC	Overcurrent
OH	Overheat
OL	Overload
OSSD	Output signal swithching device; - an output signal that is checked in regular intervals on its shutdown. (safety technology)
PDS	Power drive system incl. motor and measuring probe
PE	Protective earth
PELV	Protective Extra Low Voltage
PFD	Term used in the safety technology (EN 61508-1...7) for the size of error probability

PFH	Term used in the safety technology (EN 61508-1...7) for the size of error probability per hour
PLC	Programmable logic controller
PT100	Temperature sensor with R0=100Ω
PT1000	Temperature sensor with R0=1000Ω
PTC	PTC-resistor for temperature detection
PWM	Pulse width modulation
RJ45	Modular connector with 8 lines
SCL	Synchronous sensorless closed loop
SELV	Safety Extra Low Voltage (< 60 V)
SIL	The security integrity level is a measure for quantifying the risk reduction. Term used in the safety technology (EN 61508 -1...7)
SS1	Safety function „Safe stop 1“ in accordance with IEC 61800-5-2
SSI	Synchronous serial interface for encoder
STO	Safety function „Safe Torque Off“ in accordance with IEC 61800-5-2
TTL	Incremental signal with an output voltage up to 5 V
USB	Universal serial bus
VARAN	Real-time Ethernet bus system

Standards for drive converters / control cabinets

Product standards that apply directly to the drive converter

EN 61800-2	Adjustable speed electrical power drive systems - Part 2: General requirements - Rating specifications for low voltage adjustable frequency a.c. power drive systems (VDE 0160-102, IEC 61800-2)
EN 61800-3	Speed-adjustable electrical drives. Part 3: EMC requirements and specific test methods (VDE 0160-103, IEC 61800-3)
EN 61800-5-1	Adjustable speed electrical power drive systems - Part 5-1: Safety requirements - Electrical, thermal and energy (IEC 61800-5-1); German version EN 61800-5-1
EN 61800-5-2	Adjustable speed electrical power drive systems - Part 5-2: Safety Requirements - Functional (IEC 22G/264/CD)
UL 61800-5-1	American version of the EN 61800-5-1 with „National Deviations“

Basic standards to which drive converter standards refer directly

EN 55011	Industrial, scientific and medical equipment - Radio frequency disturbance characteristics - Limits and methods of measurement (CISPR 11); German version EN 55011
EN 55021	Interference to mobile radiocommunications in the presence of impulse noise - Methods of judging degradation and measures to improve performance (IEC/CISPR/D/230/FDIS); German version prEN 55021
EN 60529	Degrees of protection provided by enclosures (IP Code) (IEC 60529)
EN 60664-1	Insulation coordination for equipment within low-voltage systems Part 1: Principles, requirements and tests (IEC 60664-1)
EN 60721-3-1	Classification of environmental conditions - Part 3-1: Classification of groups of environmental parameters and their severities - Section 1: Storage (IEC 60721-3-1); German version EN 60721-3-1
EN 60721-3-2	Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities - Section 2: Transportation and handling (IEC 104/670/CD)
EN 60721-3-3	Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities; section 3: Stationary use at weatherprotected locations; Amendment A2 (IEC 60721-3-3); German version EN 60721-3-3
EN 61000-2-1	Electromagnetic compatibility (EMC) - Part 2: Environment - Section 1: Description of the environment - Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems
EN 61000-2-4	Electromagnetic compatibility (EMC) - Part 2-4: Environment; Compatibility levels in industrial plants for low-frequency conducted disturbances (IEC 61000-2-4); German version EN 61000-2-4
EN 61000-4-2	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test (IEC 61000-4-2); German version EN 61000-4-2
EN 61000-4-3	Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test (IEC 61000-4-3); German version EN 61000-4-3
EN 61000-4-4	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test (IEC 61000-4-4); German version EN 61000-4-4

EN 61000-4-5	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test (IEC 61000-4-5); German version EN 61000-4-5
EN 61000-4-6	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields (IEC 61000-4-6); German version EN 61000-4-6
EN 61000-4-34	Electromagnetic compatibility (EMC) - Part 4-34: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests for equipment with mains current more than 16 A per phase (IEC 61000-4-34); German version EN 61000-4-34
EN 61508-1...7	Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1...7 (VDE 0803-1…7, IEC 61508-1…7)
EN 62061	Safety of machinery - functional safety of electrical, electronic and programmable electronic safety-related systems (VDE 0113-50, IEC 62061)
EN ISO 13849-1	Safety of machinery - safety-related parts of control systems - Part 1: General principles for design (ISO 13849-1); German version EN ISO 13849-1

Standards that are used in the environment of the drive converter

DGUV regulation 3	Electrical installations and equipment
DIN 46228-1	Wire-end ferrules; Tube without plastic sleeve
DIN 46228-4	Wire-end ferrules; Tube with plastic sleeve
DIN IEC 60364-5-54	Low-voltage electrical installations - Part 5-54: Selection and erection of electrical equipment - Earthing arrangements, protective conductors and protective bonding conductors (IEC 64/1610/CD)
DIN VDE 0100-729	Low-voltage electrical installations - Part 7-729: Requirements for special installations or locations - Operating or maintenance gangways (IEC 60364-7-729:2007, modified); German implementation HD 60364-7-729:2009
DNVGL-CG-0339	Environmental test specification for electrical, electronic and programmable equipment and systems
EN 1037	Safety of machinery - Prevention of unexpected start-up; German version EN 1037
EN 12502-1...5	Protection of metallic materials against corrosion - Part 1...5
EN 60204-1	Safety of machinery - electrical equipment of machines Part 1: General requirements (VDE 0113-1, IEC 44/709/CDV)
EN 60439-1	Low-voltage switchgear and controlgear assemblies - Part 1: Type-tested and partially type-tested assemblies (IEC 60439-1); German version EN 60439-1
EN 60947-7-1	Low-voltage switchgear and controlgear - Part 7-1: Ancillary equipment - Terminal blocks for copper conductors (IEC 60947-7-1:2009); German version EN 60947-7-1:2009
EN 60947-8	Low-voltage switchgear and controlgear - Part 8: Control units for built-in thermal protection (PTC) for rotating electrical machines (IEC 60947-8:2003 + A1:2006 + A2:2011)
EN 61373	Railway applications - Rolling stock equipment - Shock and vibration tests (IEC 61373); German version EN 61373
EN 61439-1	Low-voltage switchgear and controlgear assemblies - Part 1: General rules (IEC 121B/40/CDV); German version FprEN 61439-1
VGB R 455 P	Water treatment and use of materials in cooling systems
DIN EN 60939-1	Passive filter units for electromagnetic interference suppression - Part 1: Generic specification (IEC 60939-1:2010); German version EN 60939-1:2010

1 Basic Safety Instructions

The COMBIVERT is designed and constructed in accordance with state-of-the-art technology and the recognized safety rules and regulations However, the use of such devices may cause functional hazards for life and limb of the user or third parties, or damages to the system and other material property.

The following safety instructions have been created by the manufacturer for the area of electric drive technology. They can be supplemented by local, country- or application-specific safety instructions. This list is not exhaustive. Violation of the safety instructions by the customer, user or other third party leads to the loss of all resulting claims against the manufacturer.

NOTICE

Hazards and risks through ignorance.

► Read the instructions for use !

► Observe the safety and warning instructions !

► If anything is unclear, please contact KEB Automation KG !

1.1 Target group

This instruction manual is determined exclusively for electrical personnel. Electrical personnel for the purpose of this instruction manual must have the following qualifications:

- Knowledge and understanding of the safety instructions.
- Skills for installation and assembly.
- Start-up and operation of the product.
- Understanding of the function in the used machine.
- Detection of hazards and risks of the electrical drive technology.
- Knowledge of *DIN IEC 60364-5-54.*
- Knowledge of national safety regulations.

1.2 Transport, storage and proper use

The transport is carried out by qualified persons in accordance with the environmental conditions specified in this manual. Drive converter shall be protected against excessive strains.

Transport of drive converters with an edge length >75 cm

The transport by forklift without suitable tools can cause a deflection of the heat sink. This leads to premature aging or destruction of internal components.

► Transport of drive converters on suitable pallets.

► Do not stack drive converters or burden them with other heavy objects.

Drive converters contain electrostatic sensitive components.

► Avoid contact.

► Wear ESD-protective clothing.

Do not store drive converters

- in the environment of aggressive and/or conductive liquids or gases.
- with direct sunlight.
- outside the specified environmental conditions.

1.3 Installation

⚠ DANGER

Do not operate in an explosive environment!

► The COMBIVERT is not intended for the use in potentially explosive environment.

⚠ CAUTION

Maximum design edges and high weight!

Contusions and bruises!

► Never stand under suspended loads.

► Wear safety shoes.

► Secure drive converter accordingly when using lifting gear.

- To prevent damages to the device:
- Make sure that no components are bent and/or isolation distances are changed.
- The device must not be put into operation in case of mechanical defects.
- Do not allow moisture or mist to penetrate the unit.
- Avoid dust permeating the device. Allow for sufficient heat dissipation if installed in a dust-proof housing.
- Note installation position and minimum distances to surrounding elements. Do not cover the ventilation openings.
- Mount the drive inverter according to the specified degree of protection.
- Make sure that no small parts fall into the COMBIVERT during assembly and wiring (drilling chips, screws etc.). This also applies to mechanical components, which can lose small parts during operation.
- Check the reliable fit of the device connections in order to avoid contact resistances and sparking.
- Do not walk-on drive converter.
- Follow all safety instructions!

1.4 Electrical connection

⚠ DANGER

Voltage at the terminals and in the device!

Danger to life due to electric shock!

- ► Never work on the open device or never touch exposed parts.
- ► For any work on the unit switch off the supply voltage and secure it against switching on.
- ► In spite of missing supply voltage, the Active Front End can continue to modulate, e.g. in regenerative operation. The isolation from supply must be checked.
- ► Wait until all drives has stopped in order that no regenerative energy can be generated.
- ► Await capacitor discharge time (5 minutes) if necessary, measure DC voltage at the terminals.
- ► If personal protection is required, install suitable protective devices for drive converters.
- ► Never bridge upstream protective devices (also not for test purposes).
- ► Always connect the protective earth conductor to drive converter and motor.
- ► Install all required covers and protective devices for operation.
- ► The control cabinet shall be kept closed during operation.

For a trouble-free and safe operation, please pay attention to the following instructions:

- The electrical installation shall be carried out in accordance with the relevant requirements.
- Cable cross-sections and fuses must be dimensioned by the user according to the specified minimum / maximum values for the application.
- Drive converters are only intended for permanent connection. Cross-sections of protective earth conductors should be interpreted in accordance with *DIN IEC 60364-5-54* .
- Power systems in which a phase conductor is grounded (e.g. delta mains) are not allowed for the Active-Front-End.
- With existing or newly wired circuits the person installing the units or machines must ensure that the PELV requirements are met.
- For drive converters that are not isolated from the supply circuit (in accordance with *EN 61800-5-1*) all control lines must be included in other protective measures (e.g. double insulation or shielded, earthed and insulated).
- When using components without isolated inputs/outputs, it is necessary that equipotential bonding exists between the components to be connected (e.g. by the equipotential line). Disregard can cause destruction of the components by the equalizing currents.
- Use only the KEB specified AFE-/LCL filter.

- When connecting several drive converters to the COMBIVERT F5-AFE, the maximum permissible DC link capacities or the charging currents of all connected drive converters, as well as their interconnection must be observed.

If personnel protection is required during installation of the system, suitable protective devices must be used for drive converters.
www.keb.de/fileadmin/media/Manuals/knowledge/04_techinfo/00_general/ti_rcd_0400_0002_gbr.pdf

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. They must always be complied with, also for drive converter bearing a CE marking.

1.4.1 EMC-compatible installation

Observance of the limit values required by EMC law is the responsibility of the customer.

Notes on EMC-compatible installation can be found here.
www.keb.de/fileadmin/media/Manuals/emv/0000neb0000.pdf

1.4.2 Voltage test

Testing with AC voltage (in accordance with *EN 60204-1* chapter 18.4) may not be executed, since there is danger for the power semiconductors in the drive inverter.

Due to the radio interference suppression capacitors, the test generator will switch off immediately with a current fault.

According to *EN 60204-1* it is permissible to disconnect already tested components. Drive converters of the KEB Automation KG are delivered ex works voltage tested to 100% according to product standard.

1.4.3 Insulation measurement

An insulation measurement (in accordance with *EN 60204-1* chapter 18.3) with DC 500 V is permissible, if all power unit connections (grid-connected potential) and all control connections are bridged with PE. The insulation resistance of the respective device can be found in the technical data.

1.5 Start-up and operation

The drive converter must not be started until it is determined that the installation complies with the machine directive; Account is to be taken of *EN 60204-1*.

⚠ WARNING

Software protection and programming!

Hazards caused by unintentional behavior of the drive!

- ► Check especially during initial start-up or replacement of the drive converter if parameterization is compatible to application.
- ► Securing a unit solely with software-supported functions is not sufficient. It is imperative to install external protective measures (e.g. limit switch) that are independent of the drive converter.
- ► Secure motors against automatic restart.

⚠ CAUTION

High temperatures at heat sink and coolant!

Burning of the skin!

- ► Cover hot surfaces safe-to-touch.
- ► If necessary, attach warning signs on the system.
- ► Before touching, check the surface and coolant lines.
- ► Before working let the unit cool down.

- During operation, all covers and doors shall be kept closed.
- Use only approved accessories for this device.
- Never touch terminals, busbars or cable ends.

If a drive converter with electrolytic capacitors in a DC link (see technical data) has not been in operation for more than one year, observe the following instructions.

www.keb.de/fileadmin/media/Manuals/knowledge/04_techinfo/00_general/ti_format_capacitors_0400_0001_gbr.pdf

Switching an the input

For applications that require cyclic switching off and on of the drive converter, maintain an off-time of at least 5 min after the last switch on. If you require shorter cycle times please contact KEB Automation KG.

Short-circuit resistance

The drive converters are conditional short-circuit proof. After resetting the internal protective devices the intended function is guaranteed.

Exceptions:

- Repeatedly occurring ground faults or short-cicuits at the input can lead to the devective of the unit.
- The COMBIVERT F5-AIC is not short-circuit proof at the mains input in case of an error or in status nOP! Conditional protection at the mains input is possible with a semiconductor fuse.
- The short-circuit protection at the DC output must be ensured by external aR or gR fuses.

1.6 Maintenance

The following maintenance work has to be carried out when required, but at least once per year by authorized and trained personnel.Check unit for loose screws and plugs and tighten if necessary.

► Check system for loose screws and plugs and tighten if necessary.

► Clean drive converter 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.

► Check the function of the fans of the drive converter. The fan must be replaced in case of audible vibrations or squeak.

► In the case of liquid-cooled drive converters a visual test of the cooling circuit for leaks and corrosion must be carried out.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.

1.7 Repair

In case of malfunction, unusual noises or smells inform a person in charge!

⚠ DANGER

Unauthorized exchange, repair and modifications!

Unpredictable malfunctions!

► The function of the drive converter is dependent on its parameterization. Never replace without knowledge of the application.

► Modification or repair is permitted only by KEB Automation KG authorized personnel.

► Only use original manufacturer parts.

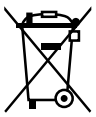
► Infringement will annul the liability for resulting consequences.

In case of failure, please contact the machine manufacturer. Only the machine manufacturer knows the parameterisation of the used drive converter and can provide an appropriate replacement or induce the maintenance.

1.8 Disposal

Electronic devices of the KEB Automation KG are exclusively professional devices for further industrial processing (so-called B2B devices).

Manufacturers of B2B devices are obliged to take back and recycle devices manufactured after 14.08.2018. These devices may not be disposed at the collection centres of public sector disposal organisations.



If no deviating agreement has been made between the customer and KEB or no deviating mandatory legal regulation exists, KEB products marked in this way can be returned. Company and keyword to the return point can be taken from the list below. Shipping costs are paid by the customer. Thereupon the devices will be professionally recycled and disposed.

The entry numbers are listed country-specific in the following table. The corresponding KEB return addresses can be found on our website.

Withdrawal by	WEEE-Reg.-No.		Keyword
Austria			
KEB Automation GmbH	ERA:	51976	Stichwort „Rücknahme WEEE“
France			
RÉCYLUM - Recycle point	ADEME:	FR021806	Mots clés „KEB DEEE“
Germany			
KEB Automation KG	EAR:	DE12653519	Stichwort „Rücknahme WEEE“
Italy			
COBAT	AEE: (IT)	19030000011216	Parola chiave „Ritiro RAEE“
Spain			
KEB Automation KG	RII-AEE	7427	Palabra clave „Retirada RAEE“
Česko			
KEB Automation KG	RETELA	09281/20 ECZ	Klíčové slovo: Zpětný odběr OEEZ

The packaging must be feed to paper and cardboard recycling.

2 Product Description

The COMBIVERT F5-AIC is based on the hardware of COMBIVERT F5 drive controllers, which are programmed with a special AIC software. The main application areas are industrial applications, single-axis applications, test systems and special projects.

Features:

- Converts a 3-phase input voltage into adjustable DC voltage.
- Step-up controller for DC link voltage stabilization.
- Lower network reactions, harmonic oscillations and commutation notches.
- No synchronization unit required.
- Single precharging of the DC link via AC input.
- Regenerates excess energy from regenerative operation into the supply system.
- Replaces braking resistor and braking transistor; thus reduces the heat emission; however optional possible as protection in case of mains power failure.
- Supplies single KEB drive controller or after consulting via DC-bus connection.
- Active power factor correction (PFC) and cos phi control possible.
- Internal protection against overcurrent, ground fault and overtemperature.
- Appropriate dimensioned DC fuses protect the DC link circuit against short-circuit.

Requirements for operation:

- AIC / LCL filter.
- Symmetric three-wire system with earthed star point.
- EMC filter (for observance of EMC standard).
- Drive controller without DC link-ground impedance (leakage capacitors).

NOTICE

View of an Active Infeed Converter

The terminals of an Active Infeed Converter can be input or output dependent on the actual operating status (power supply or regeneration). For the standardization of the view the line side is always regarded as input and the DC voltage side is always regarded as output.

2.1 Specified application

The COMBIVERT F5 Active Infeed Converter (hereafter referred F5-AIC) is an independent power supply and regenerative unit for DC supplied drive controllers. It provides on line-side for a sinusoidal current input. The operation is permitted only on symmetrical three-wire systems in connection with special LCL or AIC filters.

The used semiconductors and components of KEB are developed and dimensioned for the use in industrial products, such as the Active Infeed Converter.

Restriction

If the KEB COMBIVERT F5 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.

2.1.1 Residual risks

Despite intended use, the Active Infeed Converter can reach unexpected operating conditions in case of error, with wrong parameterization, by faulty connection or unprofessional interventions and repairs. This can be:

- Automatic start
- Overvoltage at the mains connection point in case of supply network failure

2.2 Unintended use

The operation of other electric consumers is prohibited and can lead to the destruction of the devices. The operation of our products outside the indicated limit values of the technical data leads to the loss of any liability claims.In particular, these are not required for applications with renewable energies or stand-alone systems.

2.3 Type code

xx xx x x x-x x x x			
	Cooling	A	Air-cooling
		D	External fan power supply (P housing)
		H	Water-cooling system
	Design system	1	Standard F5 "Plus“
		E	stainless steel
	Serial number for special version	0	Standard
		S	Certified according to CEI 0-21 and VDE AR N 4105
	Version	Y	Special version
	Housing type	E, G, H, R, U, P	
	Accessories	0	without
		1	Braking transistor
	Control type	R	Active Infeed Converter (AIC)
	Series	F5	
	Device size	14...38	

Table 1: Type code

3 Technical Data

Unless otherwise indicated, all electrical data in the following chapter refer to a 3-phase AC voltage supply.

3.1 Operating conditions

3.1.1 Climatic environmental conditions

Storage		**Standard**	**Class**	**Notes**
Ambient temperature		*EN 60721-3-1*	1K4	-25…55 °C
Relative humidity		*EN 60721-3-1*	1K3	5…95 % (without condensation)
Storage height		–	–	Max. 3000 m above sea level
Transport		**Standard**	**Class**	**Notes**
Ambient temperature		*EN 60721-3-2*	2K3	-25…70 °C
Relative humidity		*EN 60721-3-2*	2K3	95 % at 40 °C (without condensation)
Operation		**Standard**	**Class**	**Notes**
Ambient temperature		*EN 60721-3-3*	3K3	5…40 °C (extended to -10…45 °C) With temperature over 45 °C to max. 55 °C a derating of 5 % per 1 K must be taken into consideration.
Coolant inlet temperature	Air	–	–	0…40 °C (-10…45 °C)
	Water	–	–	5…40 °C
Relative humidity		*EN 60721-3-3*	3K3	5…85 % (without condensation)
Version and degree of protection		*EN 60529*	IP20	Protection against foreign material > ø12.5 mm No protection against water Non-conductive pollution, occasional condensation when PDS is out of service.
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. • With site altitudes over 2000 m, the control board to the mains has only basic isolation. Additional measures must be taken when wiring the control.

Table 2: Climatic environmental conditions

3.1.2 Mechanical environmental conditions

Storage	**Standard**	**Class**	**Notes**
Vibration limits	*EN 60721-3-1*	1M2	Vibration amplitude 1.5 mm (2…9 Hz) Acceleration amplitude 5 m/s² (9…200 Hz)
Shock limit values	*EN 60721-3-1*	1M2	40 m/s²; 22 ms
Transport	**Standard**	**Class**	**Notes**
Vibration limits	*EN 60721-3-2*	2M1	Vibration amplitude 3.5 mm (2…9 Hz) Acceleration amplitude 10 m/s² (9…200 Hz) Acceleration amplitude 15 m/s² (200…500 Hz)
Shock limit values	*EN 60721-3-2*	2M1	100 m/s²; 11 ms
Operation	**Standard**	**Class**	**Notes**
Vibration limits	*EN 60721-3-3*	3M4	Vibration amplitude 3.0 mm (2…9 Hz) Acceleration amplitude 10 m/s² (9…200 Hz)
	EN 61800-5-1	–	Vibration amplitude 0.075 mm (10…57 Hz) Acceleration amplitude 10 m/s² (57…150 Hz)
Shock limit values	*EN 60721-3-3*	3M4	100 m/s²; 11 ms
Pressure in the water cooler	–	–	Max. operating pressure: 10 bar

Table 3: Mechanical environmental conditions

3.1.3 Chemical / mechanical active substances

Storage		**Standard**	**Class**	**Notes**
Contamination	Gases	*EN 60721-3-1*	1C2	–
	Solids		1S2	–
Transport		**Standard**	**Class**	**Notes**
Contamination	Gases	*EN 60721-3-2*	2C2	–
	Solids		2S2	–
Operation		**Standard**	**Class**	**Notes**
Contamination	Gases	*EN 60721-3-3*	3C2	–
	Solids		3S2	–

Table 4: Chemical / mechanical active substances

3.1.4 Electrical operating conditions

3.1.4.1 Device classification

Requirement	Standard	Class	Notes
Overvoltage category	*EN 61800-5-1*	III	–
	EN 60664-1		–
Pollution degree	*EN 60664-1*	2	Non-conductive pollution, occasional condensation when PDS is out of service

Table 5: Device classification

3.1.4.2 Electromagnetic compatibility

The indicated values are only valid for devices with external filter.

EMC emitted interference	Standard	Class	Notes
Cable-conducted interferences	*EN 61800-3*	C2	–
Radiated interferences	*EN 61800-3*	C2	–
Interference immunity	**Standard**	**Level**	**Notes**
Static discharges	*EN 61000-4-2*	8 kV 4 kV	AD (air discharge) CD (contact discharge)
Burst - Ports for process measuring and control functions and signal interfaces	*EN 61000-4-4*	2 kV	–
Burst - Power ports	*EN 61000-4-4*	4 kV	–
Surge - Power ports	*EN 61000-4-5*	1 kV 2 kV	Phase-phase Phase-ground
Conducted disturbances, induced by high-frequency fields	*EN 61000-4-6*	10 V	0.15...80 MHz
Electromagnetic fields	*EN 61000-4-3*	10 V/m 3 V/m 1 V/m	80 MHz...1 GHz 1.4...2 GHz 2...2.7 GHz
Voltage fluctuations/ voltage drop	*EN 61000-2-1* *EN 61000-4-34*	–	-15 %...+10 % 90 %
Frequency changes	*EN 61000-2-4*	–	≤ 2 %
Voltage deviations	*EN 61000-2-4*	–	±10 %
Voltage unbalance	*EN 61000-2-4*	–	≤ 3 %

Table 6: Electromagnetic compatibility

4 Device data

Information on the dimensioning => *„Dimensioning“*.

Device size			**14**	**16**	**18**	**20**	**22**	
Housing size			**E**	**G**	**H**	**R**	**R**	
Cooling mode (L=air; W=water)			**L**	**L**	**L**	**L**	**L**	**W**
Input data								
Mains phases			3					
Permitted mains forms	1)		TN system					
Rated input voltage		U_N / V	400					
Input voltage range		U_{in} / V	340…480 ±0%					
Mains frequency		f_N / Hz	50/60 ±5					
Rated input power		S_N / kVA	11	23	35	52	80	
Rated input current		I_N / A	16.5	33	50	75 2)	115 2)	
Max. permissible mains fuse type gR / aR			25	50	80	100	160	
Output data								
Rated output voltage		U_{outN_dc} / V	680					
Output voltage range	3)	$U_{\_dc}$ / V	530…840					
Overvoltage switch-off (E.OP)		U_{OP_dc} / V	840					
Power supply/regenerative rated current	4)	I_{outN_dc} / A	16.5	33	50	75	115	
Max. regenerative DC current 30 s		$I_{out\_max\_dc}$ / A	29.7	49.5	75	112	172	207
Rated switching frequency	5)	f_{SN} / kHz	8					
Max. switching frequency		f_{S_max} / kHz	16					
Other data (referring to the rated data)								
Overcurrent cut-off (E.OC)		I_{OC} / %	216	180	180	180	180	216
Overload current (E.OL) 30 s		I_{OL} / %	180	150	150	150	150	180
Max. permissible DC link capacity		C_{ext} / mF	–	–	–	50	50	
Max. AIC charging current (=> *6.5*)		I_{AIC} / A	29 6)	57	29	226	226	
Max. external charging current (=> *6.5*)		I_{ext} / A	75 6)	135	322	–	–	
Max. permissible total charging current (=> *6.5*)		I_{pre} / A	104 6)	192	351	226	226	
Mains input circuit (=> *6.5*)		*Type*	A1	A2	A1	D1		
Permissible DC fuses			=> *„DC fuses“*					
Short-circuit factor at the connection point (S_{kn}/S_N)			15 < S_{kn}“ < 350					
Power dissipation at rated operation		P_{BR} / W	295	449	525	830	1400	
Max. heat sink temperature		t_{HS_max} / °C	90	90	90	90	90	60

Table 7: Device data housing E, G, H, R

1) *Operation on a local limited IT system with sine-wave EMC filter is possible.*
2) *The input current of the drive controller is limited, if necessary to the rated current of the AIC / LCL filter.*
3) *The operation is dependent on the voltage setpoint and the U_{OP}limit (=> Programming manual).*
4) *Measured at a reference voltage of 680 V DC.*
5) *Must be set to 8 kHz for AIC operation (factory setting 4 kHz)!*
6) *At ambient temperature T_a of 45 °C.*

Device size		**24**	**26**		**27**		**28**	**29**
Housing size		**U**	**U**		**U**		**P**	**P**
Cooling mode (L=air; W=water)		**L**	**L**	**W**	**L**	**W**	**L**	**W**
Number of modules for master/slave		**–**	**–**	**–**	**–**		**–**	**–**
Input data								
Mains phases		3						
Permitted mains forms		TN system						
Rated input voltage	U_N / V	400						
Input voltage range	U_{in} / V	340…480 ±0%						
Mains frequency	f_N / Hz	50/60 ±5						
Rated input power	S_N / kVA	125	173		208		256	319
Rated input current	I_N / A	180	250		300 [1]		370	460
Max. permissible mains fuse type gR / aR		250	350		400		500	630
Output data								
Rated output voltage	U_{outN_dc} / V	680						
Output voltage range [2]	$U_{\_dc}$ / V	530…840						
Overvoltage switch-off (E.OP)	U_{OP_dc} / V	840						
Power supply/regenerative rated current [3]	I_{outN_dc} / A	180	250		300 [4]		370	460
Max. regenerative DC current 30 s	$I_{out\_max\_dc}$ / A	270	313		375		462	575
Rated switching frequency	f_{SN} / kHz	8	4	8	4	8	4 [5]	4 [5]
Max. switching frequency	f_{S_max} / kHz	8	8	8	8	8	4	4
Other data (referring to the rated data)								
Overcurrent cut-off (E.OC)	I_{OC} / %	180	150		150		150	150
Overload current (E.OL) 30 s	I_{OL} / %	150	125		125		125	125
Max. permissible DC link capacity	C_{ext} / mF	45	43		40		35	35
Max. AIC charging current (=> *6.5*)	I_{AIC} / A	226	226		226		98	98
Max. external charging current (=> *6.5*)	I_{ext} / A	–	–		–		–	
Max. permissible total charging current (=> *6.5*)	I_{pre} / A	226	226		226		98	98
Mains input circuit (=> *6.5*)	*Type*	D1					D1	
Permissible DC fuses		=> *„DC fuses“*						
Short-circuit factor at the connection point (S_{kn} / S_N)		15 < S_{kn}“ / < 350					10 < S_{kn}“ / < 350	
Power dissipation at rated operation	P_{BR} / W	2230	2550	3500	4500		3000	3800
Max. heat sink temperature	t_{HS_max} / °C	90	90	60	90	60	90 [6] [7]	90 [6]

Table 8: Device data housing U, P

[1] *The input current of the drive controller must be limited to the rated current of the AIC / LCL filter, if necessary.*

[2] *The operation is dependent on the voltage setpoint and the U_{OP}limit (=> Programming manual).*

[3] *Measured at a reference voltage of DC 680 V.*

[4] *Limited by the rated current of the DC-terminal! The input current must be limited to 300A for input voltages < 400 V.*

[5] *Must be set to 4 kHz for AIC operation (factory setting 2 kHz)!*

[6] *Special settings are required for this device sizes (Reduction of the max. heat sink temperature to 85°C, => Programming manual).*

[7] *Max. ambient temperature T_a of 35 °C.*

Device size		**30**	**33**	**34**	**38**
Housing size		**P**	**P**	**P**	**P**
Cooling mode (L=air; W=water)		**L**	**L**	**W**	**W**
Number of modules for master/slave		**2**	**3**	**2**	**3**
Input data					
Mains phases		3			
Permitted mains forms		TN system			
Rated input voltage	U_N / V	400			
Input voltage range	U_{in} / V	340…480 ±0%			
Mains frequency	f_N / Hz	50/60 ±5			
Rated input power	S_N / kVA	395	554	616	1005
Rated input current	I_N / A	2x285	3x267	2x445	3x483
Max. permissible mains fuse type gR / aR		2x400	3x350	2x630	3x630
Output data					
Rated output voltage	U_{outN_dc} / V	680			
Output voltage range [2]	$U_{\_dc}$ / V	530...840			
Overvoltage switch-off (E.OP)	U_{OP_dc} / V	840			
Power supply/regenerative rated current [3]	I_{outN_dc} / A	570	800	890	1450
Max. regenerative DC current 30 s	$I_{out\_max\_dc}$ / A	712	1000	1112	1813
Rated switching frequency	f_{SN} / kHz	4 [5]	4 [5]	4 [5]	4 [5]
Max. switching frequency	f_{S_max} / kHz	4	4	4	4
Other data (referring to the rated data)					
Overcurrent cut-off (E.OC)	I_{OC} / %	150	150	150	150
Overload current (E.OL) 30 s	I_{OL} / %	125	125	125	125
Max. permissible DC link capacity	C_{ext} / mF	150 [6]	250 [6]	150 [6]	250 [6]
Max. AIC charging current (=> *6.5*)	I_{AIC} / A	98 [6]	145 [6]	98 [6]	146 [6]
Max. external charging current (=> *6.5*)	I_{ext} / A	–	–	–	–
Max. permissible total charging current (=> *6.5*)	I_{pre} / A	98 [6]	145 [6]	98 [6]	146 [6]
Mains input circuit (=> *6.5*)	*Type*	D1			
Permissible DC fuses		=> *„DC fuses“*			
Short-circuit factor at the connection point (S_{kn}/S_N)		10 < S_{kn}“ / < 350			
Power dissipation at rated operation	P_{BR} / W	4700	6900	7400	12000
Max. heat sink temperature	t_{HS_max} / °C	90 [7]	90 [7]	90 [7]	90 [7]

Table 9: Device data housing P-system

[1] *The input current of the drive controller must be limited to the rated current of the AIC / LCL filter, if necessary.*

[2] *The operation is dependent on the voltage setpoint and the U_{OP} limit (=> Programming manual).*

[3] *Measured at a reference voltage of DC 680 V.*

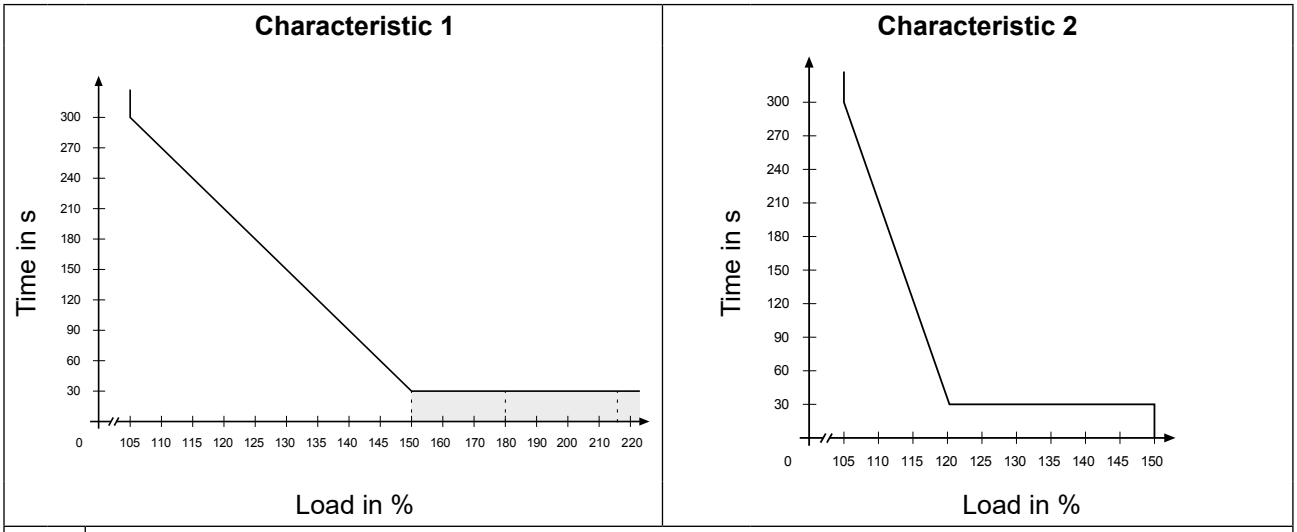
[4] *Limited by the rated current of the DC-terminal! The input current must be limited to 300A for input voltages < 400 V.*

[5] *Must be set to 4 kHz for AIC operation (factory setting 2 kHz)!*

[6] *Option precharging resistor => „Additional precharging resistor at master-slave operation“.*

[7] *Special settings are required for this device sizes (Reduction of the max. heat sink temperature to 85 °C, => Programming manual).*

4.1 Overload characteristic



▭	The characteristic declines device-dependently in this range.

Figure 1: Overload characteristic

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 drive controller, the error E.OL is triggered.

4.2 Accessories

4.2.1 AIC, LCL and EMC filters

The line-side AIC or LCL filters are required for the characteristic of sinusoidal currents. They filter the switching frequency of the drive controller. The basic assembly consists of two inductors and capacitors (LCL filter). An EMC filter is additionally integrated at the AIC filters.

Size	Housing	Cooling	AIC / LCL filter			EMC filter	
			Material number	f_{SN} / kHz	I_N / A	Material number	I_N / A
14	E	Air	14H6J4E-1000	8	16.5	integrated	–
16	G	Air	19H6J4E-1000	8	36	integrated	–
18	H	Air	19H6J4F-1000	8	60	integrated	–
20 [1)]	R	Air	19H6J4F-1000	8	60	integrated	–
20	R	Air	21H6J4F-1001	8	90	integrated	–
22 [1)]	R	Air/water	24H6J4F-1000	8	108	integrated	–
24	U	Air	24H6J4G-1000	8	180	integrated	–
26	U	Air/water	26Z1K04-1000	4 / 8	250	26E4T60-1001	300
27 [1)]	U	Air/water	26Z1K04-1000	4 / 8	275	26E4T60-1001	300
28	P	Air	29Z1K04-A000	4	460	28E4T60-1001	410
29	P	Water	29Z1K04-A000	4	460	30U5A0W-3000	650

Table 10: AIC, LCL and EMC filters

[1)] *LCL filter limits the AIC current.*

The secondary LCL filter connections of size 14...24H6 are designed with shielded lines for U, V, W and Fan 1/2 (AWG 16), FT 1/2 (AWG 18). At size 26Z1 there are ring crimp connectors M8 and two terminal blocks (4mm²) for fan and temperature sensor (KTY +/-) / switch (T1/T2) installed.

At size 29Z1 there are ring crimp connectors M10 (connection PE M12) and two terminal blocks (4mm²) for fan and temperature sensor (KTY +/-) / switch (T1/T2) installed.

4.2.2 Common mode filter

The common mode filter reduces the leakage current and the ripple current by coupling to the DC bus. The common mode filter consists of a compensation choke and a capacitor set.

Size	Housing	Filter combination	f_{SN} / kHz	I_N / A	Consisting of	
					AIC/LCL filter	Common mode filter
22	R	22Z1I04-1000	8...16	115	24H6J4F-1001	22Z1H04-1000
26	U	–	4...16	250	26Z1K04-1000	26Z1H04-1000
29	P	29Z1I04-1000	4...16	460	29Z1K04-1000	29Z1H04-1000

Table 11: Common mode filter

Sine-wave EMC filters with DC regeneration and mains chokes can be used alternatively.

Sine-wave EMC filters	Mains choke	Rated current I_N / A	Switching frequency f_S / kHz
0DZ1I05-1001	12Z1B04-1000	9.5	8...16
0HZ1I05-1001	14Z1B04-1000	16.5	
0LZ1I05-1001	18Z1B04-1000	50	
0PZ1I05-1001	22Z1B04-1000	115	
0SZ1I05-1001	24Z1B04-1000	180	
0XZ1I05-1001	27Z1B04-1000	300	4...16
0YZ1I05-1001	29Z1B04-1000	460	

Table 12: Sinus EMC filters and mains chokes

Further information can be found under the following link:

Installation sinus EMC filter.
www.keb.de/fileadmin/media/Manuals/dr/ma_dr_z1-inst-sinus-emv-filter_20146892_en.pdf

Programming manual COMBIVERT F5-AIC.
www.keb.de/fileadmin/media/Manuals/f5afe/prog/F5_AFE_programm_20104270_gbr.pdf

4.2.3 DC fuses

Size	Assembly kit (holders and fuses)	Fuse	Fuse body in mm	*U*/ VDC	*I*/ A
14	14U42EG-3W00	2 x 0090249-5419	Ø27 x 60.3	660	25
16	16U42GH-3W00	2 x 0090249-5459	Ø27 x 60.3	660	50
18	18U420H-3W00	2 x 0090249-5519	Ø27 x 60.3	660	80
19	19U42HR-3W00	2 x 0090249-5529	Ø27 x 60.3	660	100
20	20U420R-3W00	4 x 0090249-5479	Ø27 x 60.3	660	63
22	22U420R-3W00	4 x 0090249-5529	Ø27 x 60.3	660	100
24	24U42RU-5W00	2 x 0090249-5609	129 x 60	750	250
26	26U420U-5W00	2 x 0090249-5639	129 x 60	750	350
27	27U420U-5W00	2 x 0090249-5659	129 x 60	750	400
28	28U420W-5W00	2 x 0090249-5679	129 x 75	750	500
29	29U420W-5W00	2 x 0090249-5689	129 x 75	750	630
30	2 x 27U420U-5W00	4 x 0090249-5659	129 x 60	750	400
33	2 x 29U420W-5W00	6 x 0090249-5659	129 x 60	750	400
34	2 x 29U420W-5W00	4 x 0090249-5689	129 x 75	750	630
38	3 x 29U420W-5W00	6 x 0090249-5689	129 x 75	750	630

Table 13: DC fuses

4.2.3.1 Alternative DC-fusing

Size	Fuse holder with protective cover for NH00 and NH000	Fuse	Fuse body	*U*/ VDC	*I*/ A
14	2 x 0090574-0001	2 x 009025H-3459	NH000	690	50
16	2 x 0090574-0001	2 x 0090256-4531	NH000	700	100
18	2 x 0090574-0001	2 x 009025H-3559	NH000	690	125
20	2 x 0090574-0001	2 x 009025H-3559	NH000	690	125
22	2 x 0090574-0001	2 x 00902564581 / 0090256-4621	NH000	700	200/315
24	2 x 0090574-0001	2 x 009025H-4651 [1)]	NH00	690	400

Table 14: Alternative DC-fusing

[1)] *Due to the gripping lugs, the protective cover of 0090574-0001 can not be used. The compatible microswitch has the following material number: 0090278-0001.*

4.2.4 Additional precharging resistor at master-slave operation

The external precharging resistor is required from housing size 29. The resistor is used for additional energy input and limitation of the charging current. The external resistor is switched into phase L1 at the precharge input (=> *„Circuit example for the master-slave operation with AIC/LCL filter and common mode filter“*).

Material number	Resistance R_V	Power	Voltage
0090013-0048	5.8 Ω	165 W	1100 V

Table 15: Additional precharging resistor at master-slave operation

4.3 Dimensions and weights

The COMBIVERT F5-AIC have identical housings with the COMBIVERT F5 drive converters. Dimensions, weights and terminal descriptions can be found in the following instruction manuals:

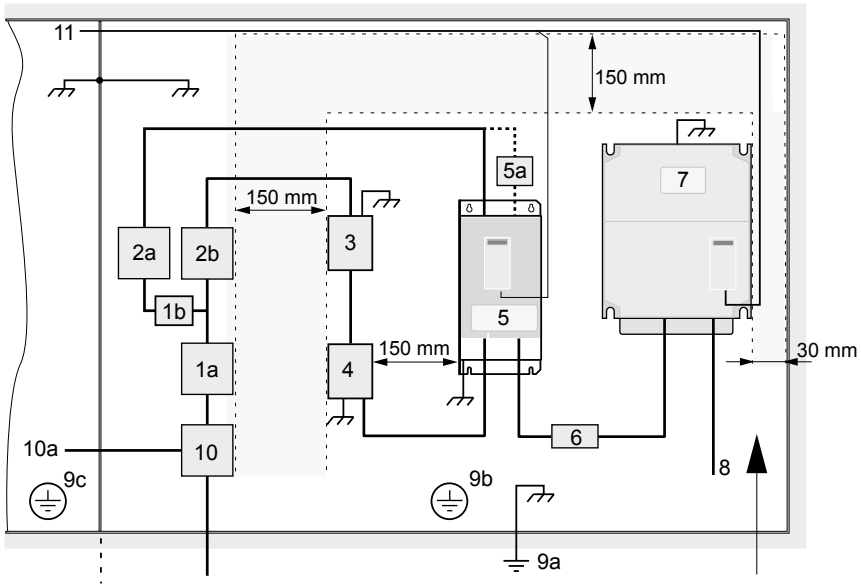
Size	Housing	Instruction manual
14	E	*Housing E*
16	G	*Housing G*
18	H	*Housing H*
20, 22	R	*Housing R*
24, 26, 27	U	*Housing U*
28, 29, 30, 33, 34, 38	P	*Housing P*

Table 16: Dimensions and weights

The instruction manuals can be found in the specified links or under *www.keb.de/de/service/downloads*.

5 Installation

5.1 EMC-compatible control cabinet installation



Control circuit **Power circuit** **Direction of the cooling fins**

Legend			
1a	Mains fuse	7	Drive controller
1b	Pre-charging fuse	8	Motor cable
2a	Pre-charging contactor	9a	Power unit equipotential bonding with the housing earth
2b	Main contactor (before LCL filter)	9b	Protective Earth (PE) on the mounting plate power circuit
3	EMC filter	9c	Protective Earth (PE) on the mounting plate control circuit
4	AIC/LCL filter (if necessary integrated in 4)	10	Mains connection power circuit
5	COMBIVERT F5-AIC	10a	Mains connection control circuit
5a	If necessary external load-shunt	11	Control lines
6	External DC fuses	⏚	Large area contact at the mounting plate

Table 17: EMC-compatible control cabinet installation

5.2 Installation instructions

- Stationarily install and earth COMBIVERT.
- Allow for sufficient heat dissipation if installed in a dust-proof housing.
- Install the COMBIVERT in an appropriate housing in accordance with the local regulations when operating it in explosion-endangered spaces.
- Protect COMBIVERT against conductive and aggressive gases and liquids.
- The AIC/LCL filter must be placed in the immediate vicinity of the AIC.
- The drive controllers must be placed in the immediate vicinity of the AIC.
- The DC connection lines must be kept as short as possible.
- The use of ferrites on the DC line is not permitted.

6 Connection of the COMBIVERT F5-AIC

6.1 Description of the input terminals at the drive controller

NOTICE

Starting current limiting

When connecting drive controllers to a DC bus pay attention to the internal wiring of the DC voltage inputs!Drive controllers that directly output the DC link bus to the DC terminals must be integrated into the DC bus-connection by way that the supply unit(s) limit the starting current.

Maximum DC link capacity

The maximum DC link capacity can be calculated by adding the DC link capacities of all drive controllers in the DC-bus connection.
=> *„Technical data of COMBIVERT drive controllers“*. The AIC must be suitable for this value.

Terminal	Description
++, – –	DC voltage input with starting current limiting; usable as output only if all devices supplied by the DC bus have a starting current limiting at the DC voltage input.
+(PA), -	DC voltage output with starting current limiting; usable as input only if the starting current is limited by the supply source.
PA, PB	Connection for braking resistor; optionally, only if a braking transistor is installed. In this case additional terminals are available for the monitoring of the braking transistor. If necessary, please contact KEB!
L1, L2, L3	Mains input 3-phase
U, V, W	Motor connection or input terminals for AIC devices

Table 18: Description of the input terminals at the drive controller

6.2 Terminal blocks of the devices

The assignment of the numbering under "Terminal" for cross sections and tightening torques => *„Cross-sections and tightening torques of the terminals“*.

The + contact of the temperature evaluation must be connected to terminal T1 to terminal block X1A! For more information
=> *„Temperature detection T1, T2“*.

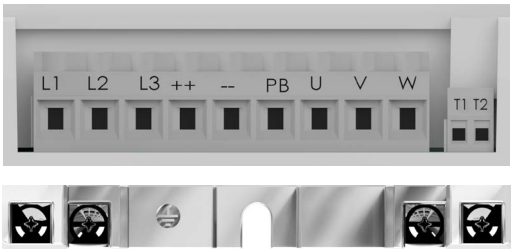
Housing E	Name	Function	Terminal
	L1, L2, L3	3-phase mains connection	1
	U, V, W	AIC mains connection	
	++, PB	Connection for braking resistor	
	++, – –	Connection for DC-bus connection	
	T1, T2	Connection for temperature sensor	2
	PE, ⏚	Connection for protective earth	3

Figure 2: Terminal blocks housing E

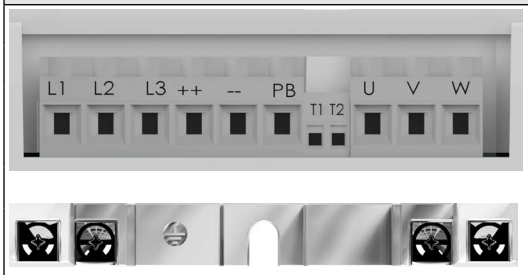
Housing G	Name	Function	Terminal
	L1, L2, L3	3-phase mains connection	4
	U, V, W	AIC mains connection	
	++, PB	Connection for braking resistor	
	++, – –	Connection for DC-bus connection	
	T1, T2	Connection for temperature sensor	2
	PE, ⏚	Connection for protective earth	3

Figure 3: Terminal blocks housing G

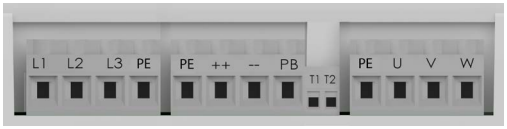
Housing H	Name	Function	Terminal
	L1, L2, L3	3-phase mains connection	5
	U, V, W	AIC mains connection	
	++, PB	Connection for braking resistor	
	++, – –	Connection for DC-bus connection	
	T1, T2	Connection for temperature sensor	6
	PE, ⏚	Connection for protective earth	5

Figure 4: Terminal blocks housing H

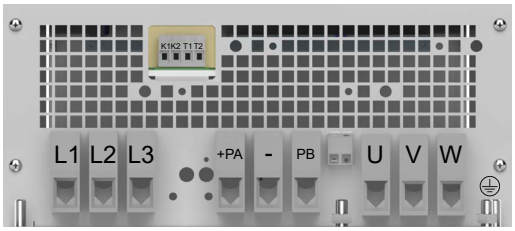
Housing R	Name	Function	Terminal
	L1, L2, L3	3-phase mains connection	7 / 8
	U, V, W	AIC mains connection	
	+PA, PB	Connection for braking resistor	
	+PA, –	Connection for DC-bus connection	
	T1, T2	Connection for temperature sensor	9
	K1, K2	Monitoring of the braking transistor in connection with terminals T1, T2 (only with water cooling)	
	PE, ⏚	Connection for protective earth	10

Figure 5: Terminal blocks housing R

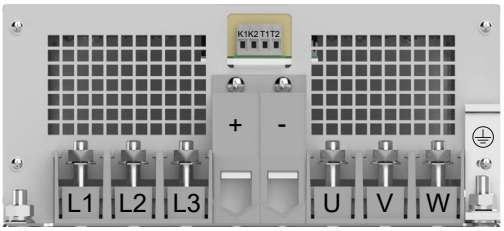
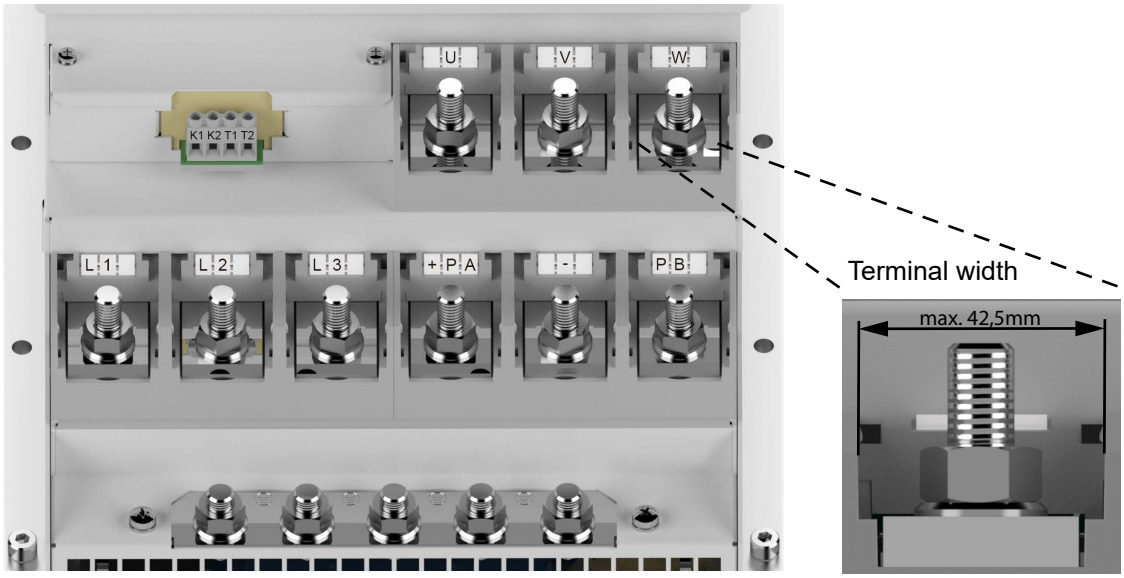
Housing U	Name	Function	Terminal
	L1, L2, L3	3-phase mains connection	12
	U, V, W	AIC mains connection	
	+, –	Connection for DC-bus connection	
	T1, T2	Connection for temperature sensor	9
	K1, K2	Monitoring of the braking transistor	
	PE, ⏚	Connection for protective earth	10

Figure 6: Terminal blocks housing U

Housing P



Terminal block	Name	Function	Terminal
X1A	L1, L2, L3	3-phase mains connection	13
	U, V, W	AIC mains connection	
	+PA, PB	Connection for braking resistor	
	+PA, –	Connection for DC-bus connection	
X1D	T1, T2	Connection for temperature sensor (only master)	9
	K1, K2	Monitoring of the braking transistor (only for water-cooled devices)	
X1A	PE, ⏚	Connection for protective earth	13

Figure 7: Terminal blocks housing P

6.2.1 Cross-sections and tightening torques of the terminals

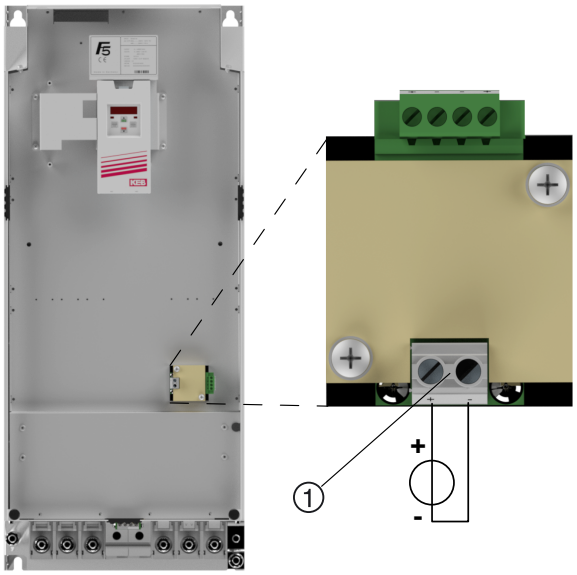
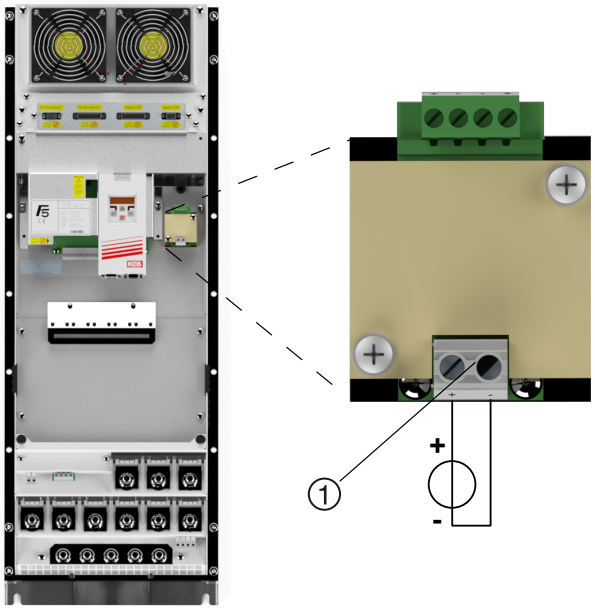
No.	Permissible cross-section flexible with wire-end ferrule				Tightening torques	
	mm²		AWG		Nm	lb inch
	min	max	min	max		
1	0.25	4	24	10	0.6	5
2	0.25	1.5	26	14	0.6	5
3	Screw M4 for ring crimp connector				1.3	11
4	6	16	22	8	1.2	11
5	2.5	35	12	2	4.5	40
6	0.5	2.5	21	12	0.6	6
7 [1)]	16	50	6 AWG	1/0 MCM	6…8	75
8 [2)]	35	95	4 AWG	2/0 MCM	15...20	180
9	0.2	4	24 AWG	10 AWG	0.6	5.3
10	10 mm stud for ring crimp connector				25	220
11	50	150	1/0 AWG	300 MCM	25…30	270
12	10 mm stud for ring crimp connector and for DC connection 50...150 qmm				25	220
13	12 mm stud for ring crimp connector max. 2 ring crimp connectors with 240 mm² for each				35	310

Table 19: Cross-sections and tightening torques of the terminals

[1)] *Line applies to F5 housing R device size 20.*

[2)] *Line applies to F5 housing R device size 22.*

6.3 External fan supply for housing P and U

Housing U	Housing P
	

Legend			
Terminal block		X1F ①	
Connection terminals		+, -	
Voltage supply		+24 V DC ± 10 %	
Current consumption per module	Housing U	Device size 24...26	2.5A
		Device size 27	4A
	Housing P	Device size 28, (30, 33)	4A
Spare fuse(s)		3.15A Type gG	

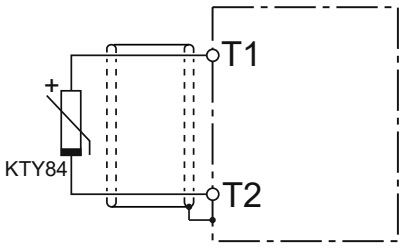
Figure 8: External fan supply for housing P and U

6.4 Temperature detection T1, T2

NOTICE

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

6.4.1 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.

NOTICE

No protection of the motor winding in case of incorrect connection!

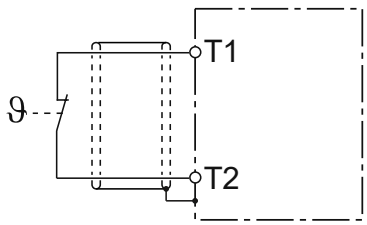
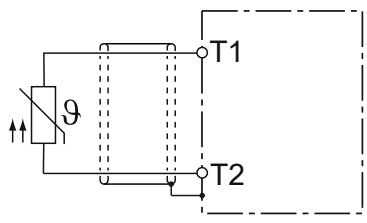
► Operate KTY sensors in forward direction.

► Do not combine KTY sensors with other devices.

Examples for the construction and programming of a temperature control with KTY84 evaluation can be taken from the F5-AIC *Programming manual*.

6.4.2 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)	

continued on the next page

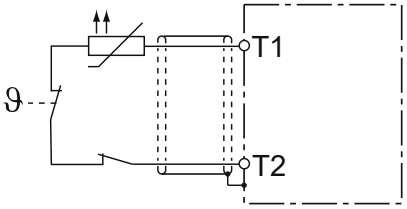
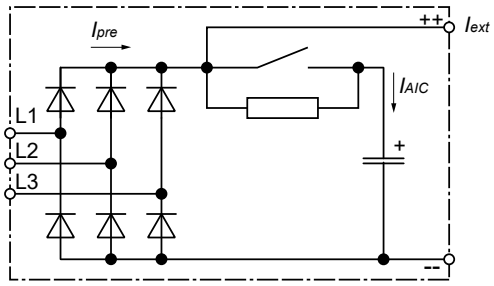
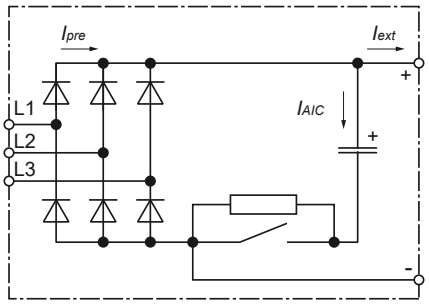
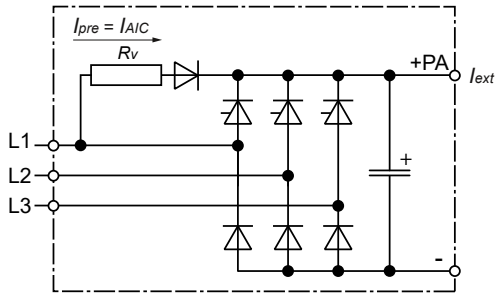
Wiring example in PTC mode	
Mixed sensor chain	

Table 20: Wiring example in PTC mode

6.5 Input and pre-charging circuits

Type A1: AC / DC drive controller	Type A2: AC / DC drive controller
	

Type A1 or A2 can be supplied by mains and by DC circuit. The starting current limiting is designed after the input terminals. When used as output, parallel connected drive controllers must have an own starting current limiting at the DC voltage input. The maximum charging current must be observed!

Type D1: AC drive controller	
	Type D1 can be supplied by mains. In consideration of the DC link capacity the DC voltage terminals can be used as output. When used as input ensure that the starting current is externally limited.

=> *„Dimensioning instructions“*.

NOTICE

Leakage capacitors against earth in the DC link

Drive controllers with leakage capacitors in the DC link against earth are not allowed for F5-AIC operation and can be destroyed. Only released units by KEB may be connected.

6.6 Circuit examples

6.6.1 Instructions to the following circuit example

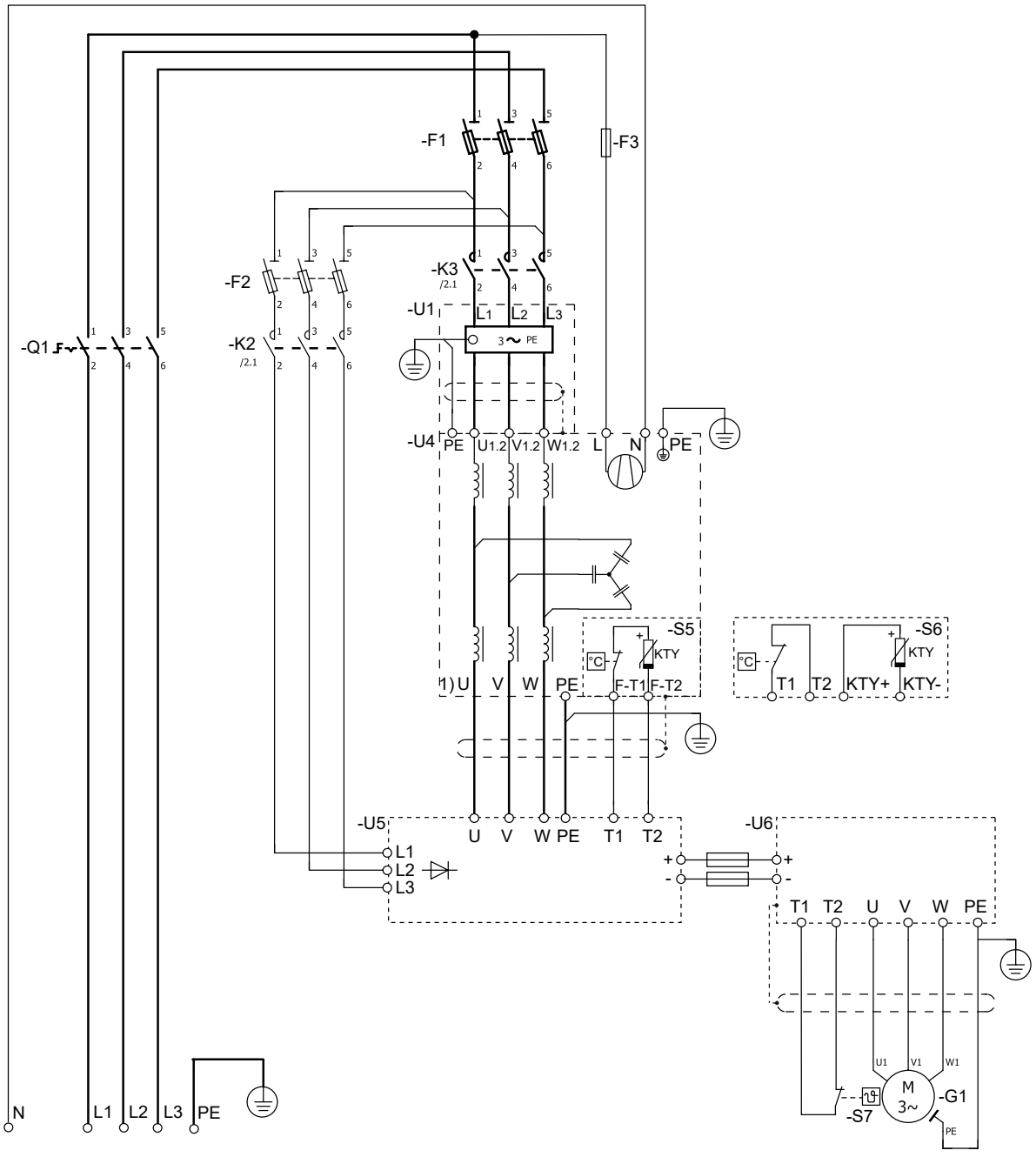
In the following circuit example the drive controller is connected via the F5-AIC with a LCL filter to the supply system. The temperature monitoring of the LCL filter is done by the F5-AIC.

The inputs and outputs are pre-programmed for the following circuit example.

NOTICE

For a safe function of the AIC system use models with positively driven auxiliary contacts for power contactors K2 and K3 (pre-charging and main contactor). Thus, safe interlocking at defective contactor is guaranteed even in case of failure.

6.6.2 Circuit example for the power unit with AIC/LCL filter



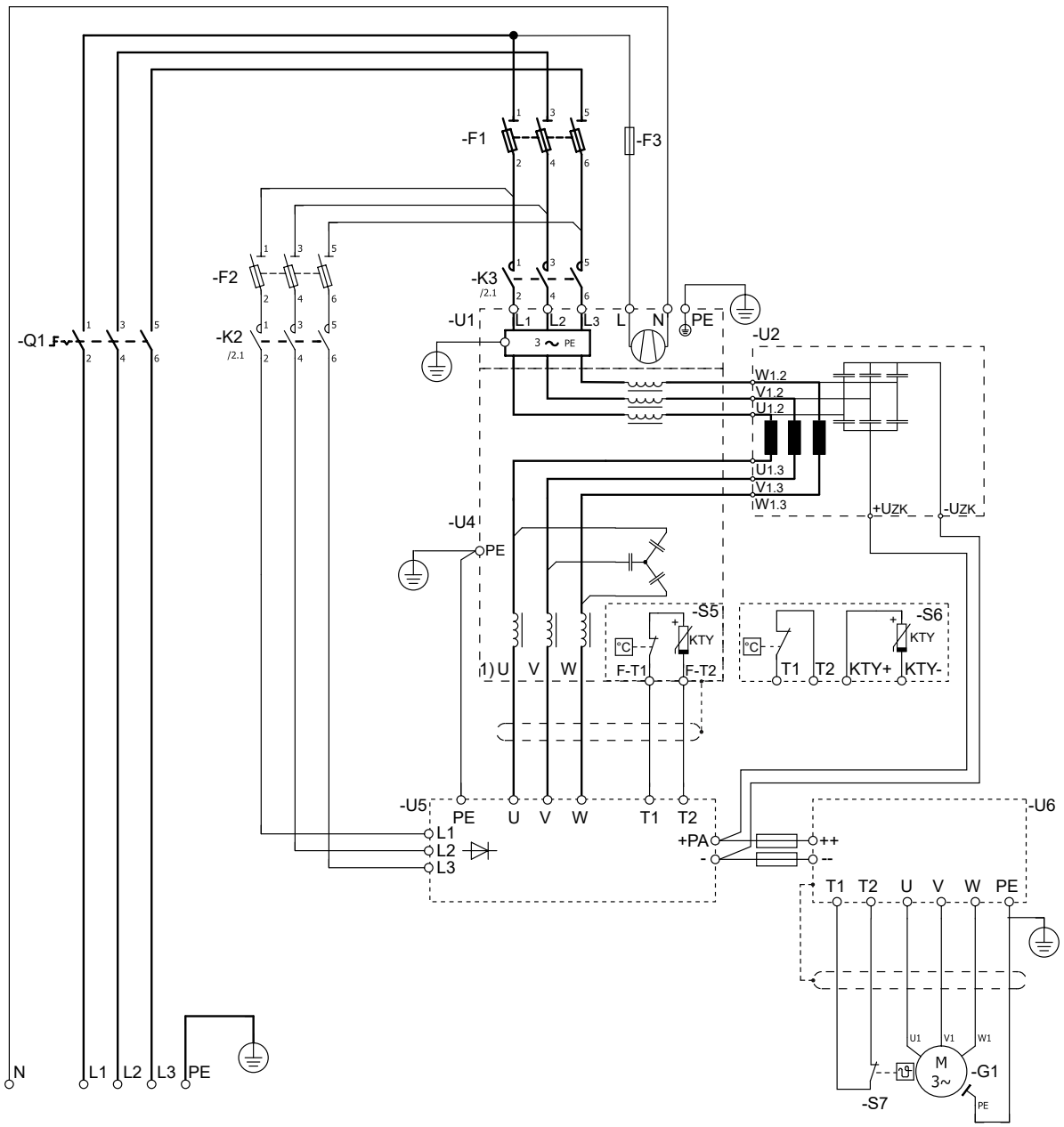
Legend			
Q1	Main switch	S5 / S6	Temperature detection NC contact and KTY84 sensor [2]
F1	Main fuses	S7	Motor temperature switch
F2	Pre-charging fuses 20A (slow)	U5	COMBIVERT F5-AIC
F3	Fuse for filter fan	U6	Drive controller
K2	Pre-charging contactor	G1	Motor
K3	Main contactor	U4	LCL filter
U1	EMC filter (integrated into U4 up to size 24)		Fan control => *Programming manual*

Figure 9: Circuit example for the power unit with AIC/LCL filter

[1] *Output terminals U, V, W for size 26 and 29 => U2, V2, W2*

[2] *Design dependent on filter size. Attention, observe polarity!*

6.6.3 Circuit example for the power unit with AIC/LCL filter and common mode filter



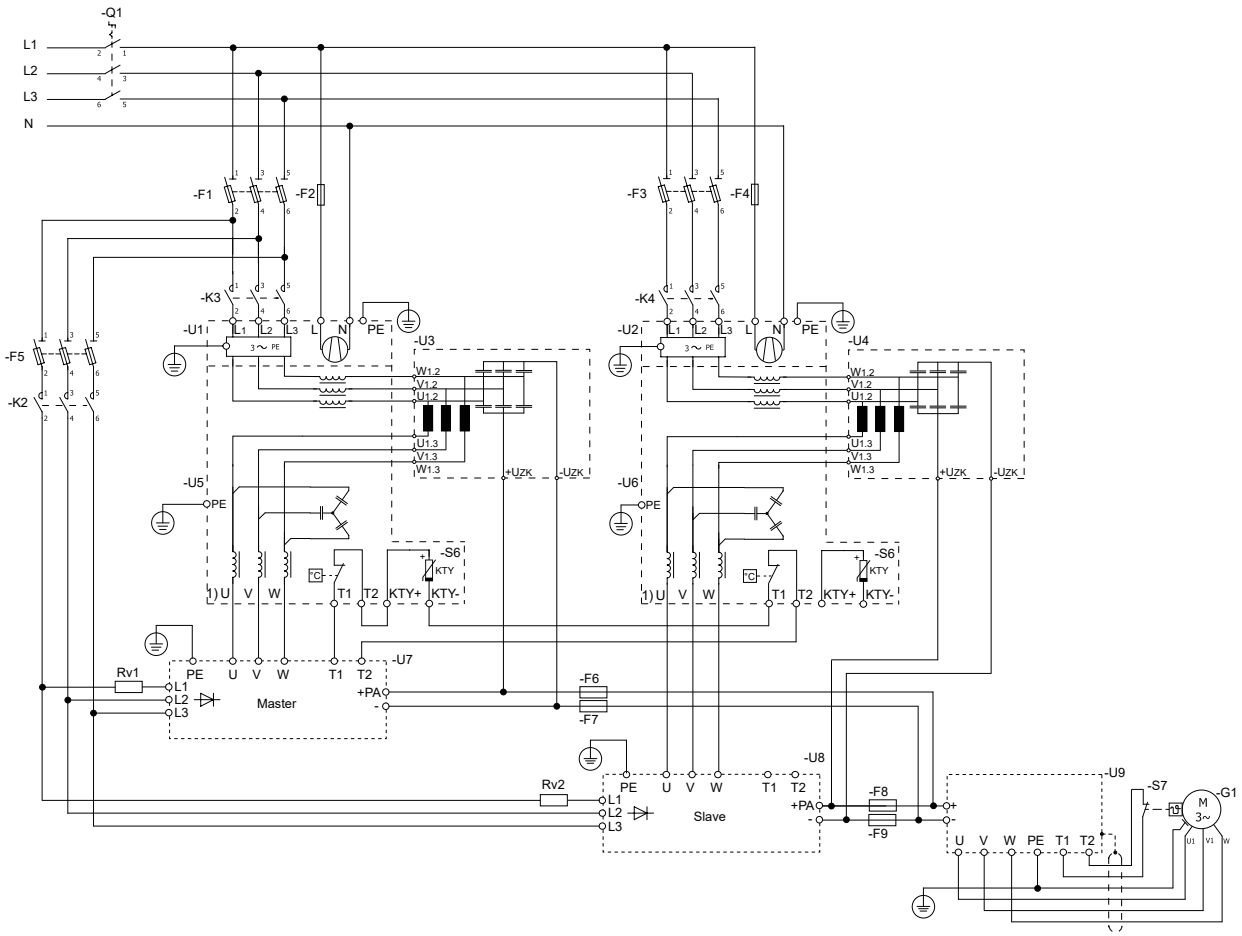
Legend			
Q1	Main switch	U2	Common mode filter
F1	Main fuses	G1	Motor
F2	Pre-charging fuses 20A (slow)	S5 / S6	Temperature detection NC contact and KTY84 sensor [2]
F3	Fan fuse	S7	Motor temperature switch
K2	Pre-charging contactor	U5	COMBIVERT F5-AIC
K3	Main contactor	U6	Drive controller
U1	EMC filter (integrated into U4 up to size 24)	U4	LCL filter
Fan control => *Programming manual*			

Figure 10: Circuit example for the power unit with AIC/LCL filter and common mode filter

[1] *Output terminals U, V, W for size 26 and 29 => U2, V2, W2*

[2] *Design dependent on filter size. Attention, observe polarity!*

6.6.4 Circuit example for the master-slave operation with AIC/LCL filter and common mode filter



Legend			
Q1	Main switch	G1	Motor
F1, F2	Main fuses [2]	S6	Temperature detection NC contact and KTY84 sensor [3]
F3, F4	Fan fuse	S7	Motor temperature switch
F5	Pre-charging fuses 20 A (slow)	U3, U4	Common mode filter
F6, F7 F8, F9	DC fuses [2]	U7, U8	COMBIVERT F5-AIC
K3, K4	Main contactor	U9	Drive controller
K2	Pre-charging contactor	U5, U6	LCL filter
Rv1, Rv2	Pre-charging resistors		
U1, U2	EMC filter (integrated into U4 up to size 24)		
Fan control => *Programming manual*			

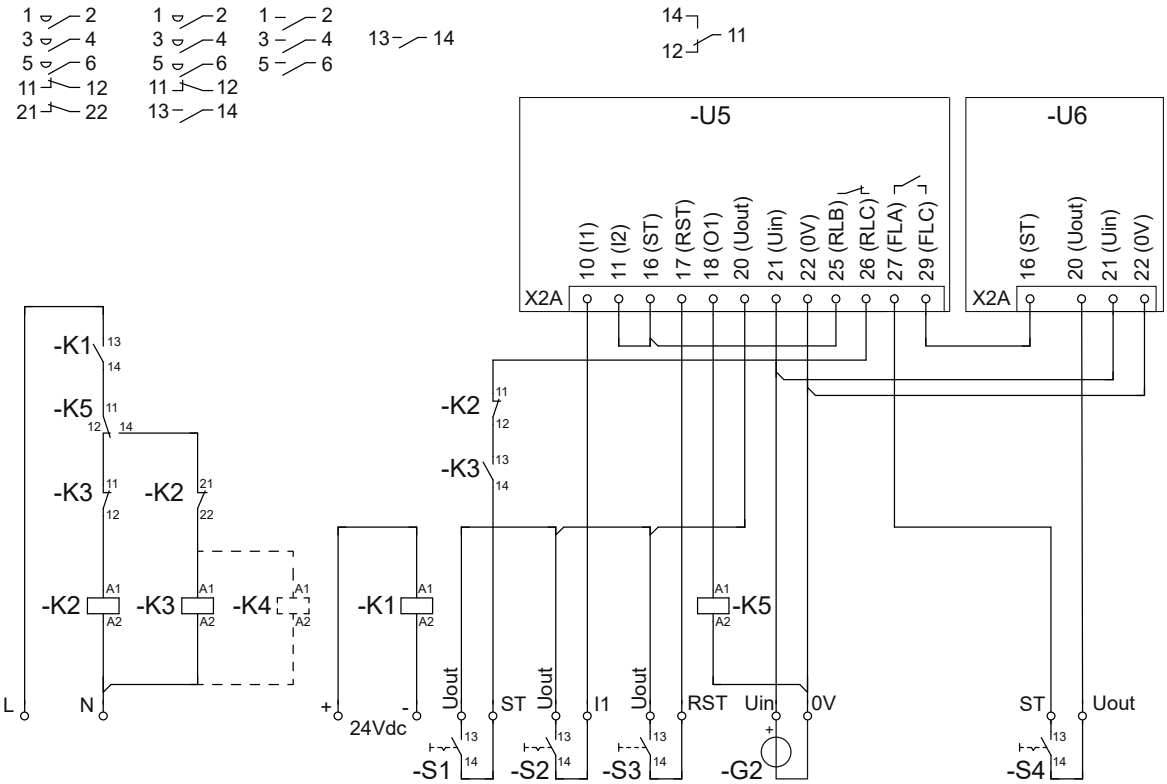
Figure 11: Circuit example for the master-slave operation with AIC/LCL filter and common mode filter

[1] *Output terminals U, V, W for size 26 and 29 => U2, V2, W2*

[2] *Mains and DC fuses must be monitored.*

[3] *Design dependent on filter size. Attention, observe polarity!*

6.6.5 Circuit example for the control circuit



Legend			
K1	Coupling relay (control on/off)	S2	Second setpoint (customer)
K2	Pre-charging contactor	S3	Error reset
K3 / K4	Main contactor	S4	External release for drive controller
K5	Coupling relay (max. 50 mA) for main contactor	U5	COMBIVERT F5-AIC
S1	External control release	U6	Drive controller
G2	24 V DC supply (recommended)		

Figure 12: Circuit example for the control circuit

Avoidance of overvoltage at the mains connection point in case of mains power failure

For switching off the modulation (ST+I2) in case of mains power failure, a mains and system protection or an external control can also be used instead of the control card relay R1. These two types of modulation switching off are the responsibility of the customer.

6.6.6 Functional description

The pre-charging contactor (K2) is switched by applying a 24 V DC voltage to the coupling relay (K1). If the DC link voltage reaches an adjustable value (480 V DC at factory setting LE.04) output O1 is set and the coupling relay switches (K5). K5 disconnects the pre-charging contactor K2 and switches the main contactor K3. Further charging of the DC link is done via the main contactor and AIC or LCL filter.

The modulation is suppressed via internal programming (OA, IA) as long as an adjustable threshold value (LE.04) is reached and a responding waiting period (di.48) has expired.

The control release is set by switch (S1), if the pre-charging contactor K2 drops out and the main contactor has tightened. A delay time (di.42) starts simultaneously with the control release by input I2 after that the modulation is released.

Phase position and phase sequence (counterclockwise/clockwise) of the mains voltage are detected now. Thereafter, the DC link voltage is controlled to the preset setpoint (oP.03). If this value is reached, the relay output 2 (R2) switches after one second. The drive controller can modulate if the external control release of the drive controller (S4) is set.

Flow chart switch-on procedure

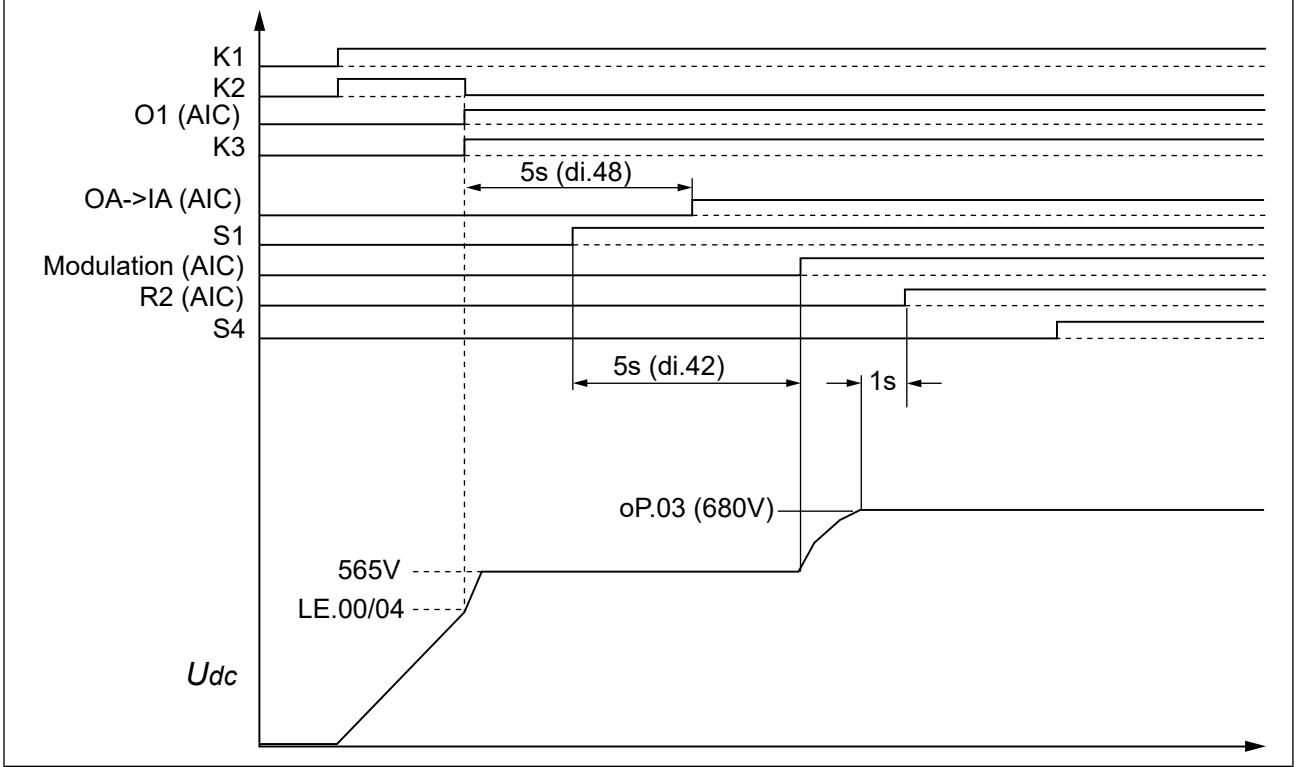
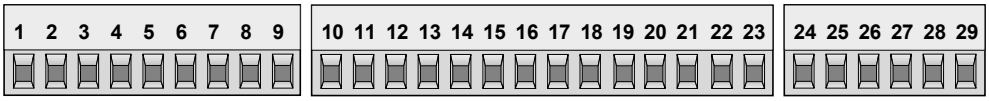


Figure 13: Flow chart switch-on procedure

7 Connection of the Control

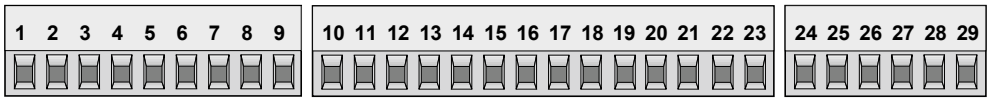
7.1 Control board for F5 AIC devices

7.1.1 Assignment of the terminal block X2A



PIN	Function	Name	Default assignment	Description
1	+ Setpoint input 1	AN1+	—	The input signal 0...±10V; 0...±20 mA and 4...20mA is determined with An.00 / An.10. Resolution: 12 Bit, R_i = 30 kΩ, scan time: 1ms/ at fast setpoint setting: 250 µs
2	- Setpoint input 1	AN1-		
3	+ Setpoint input 2	AN2+		
4	- Setpoint input 2	AN2-		
5	Analog output 1	ANOUT1	—	The output at the analog output is set with An.31 / An.36. Voltage range: 0...±10 V, R_i = 100 Ω, resolution: 10 Bit, PWM frequency: 3.4kHz, limiting frequency filter 1. Order: 178 Hz
6	Analog output 2	ANOUT2	—	
7	+10 V output	CRF	—	Reference voltage output +10V DC +5% / max. 4mA for setpoint potentiometer
8	Analog ground	COM	—	Ground for analog inputs and outputs
9				
10	Progr. input 1	I1	2. Setpoint of the control voltage	All digital inputs are freely programmable. The control release is firmly linked with the input ST, but can be assigned with additional functions. R_i = 2.1 kΩ Scan time: 1 ms
11	Progr. input 2	I2	Switch-on delay, control release ST	
12	Progr. input 3	I3	—	
13	Progr. input 4	I4	—	
14	Progr. input forward	F	—	
15	Progr. input reverse	R		
16	Progr. input control release	ST	ST	
17	Progr. input reset	RST	RST	
18	Transistor output 1	O1	Control main contactor (DC > level)	Max. 50mA DC for both outputs are available.
19	Transistor output 2	O2	Ready for operation (U_{ic} loaded)	
20	+24 V output	U_{out}	—	approx. 24V DC output (max. 100mA), voltage input for ext. supply, reference potential 0V X2A.22/23
21	20...30 V input	U_{in}	—	
22	Digital ground	0V	—	Reference potential for digital inputs/outputs
23				

continued on the next page



PIN	Function	Name	Default assignment	Description
24	Relay 1 / NO contact	RLA	Error messages (error)	Programmable relay output 1 (terminal X2A.24...26); Programmable relay output 2 (terminal X2A.27...29) Specification, control and programming of the relay outputs max. 30V DC, 0.01...1A
25	Relay 1 / NC contact	RLB		
26	Relay 1 / switching contact	RLC		
27	Relay 2 / NO contact	FLA	Ready for operation (U_{ic} loaded)	
28	Relay 2 / NC contact	FLB		
29	Relay 2 / switching contact	FLC		

Figure 14: Assignment of the terminal block X2A

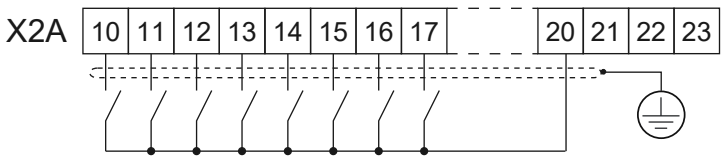
7.1.2 Connection of the control

In order to prevent a malfunction caused by interference voltage supply on the control inputs, the following directions should be observed:

- Use shielded / drilled cables.
- Lay shield on **one side** of the drive controller onto earth potential.
- Lay control and power cable **separately** (about 10...20 cm apart); Lay crossings in a right angle.

7.1.3 Digital inputs

Using the internal voltage supply



Using of an external voltage supply (e.g. PLC)

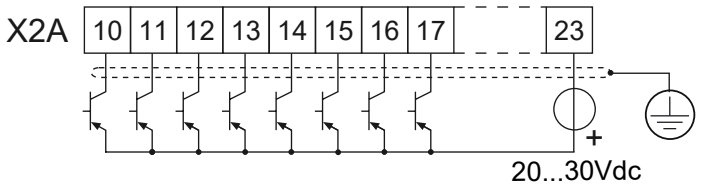


Figure 15: Digital inputs

7.1.4 Analog inputs

Connect not connected setpoint inputs to the analog ground to avoid setpoint changes!

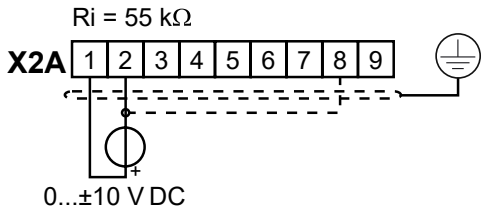
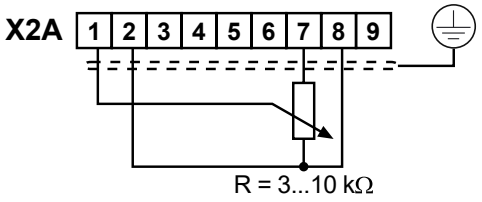
Analog setpoint setting external	Analog setpoint setting internal
	

Figure 16: Analog inputs

7.1.5 Voltage input external power supply

When the power unit is switched off the control remains in operation by an external voltage supply of the control board. To prevent undefined conditions at external power supply, generally the supply unit and then the AIC unit should be switched on.

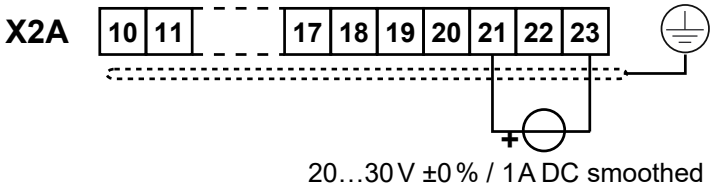


Figure 17: Voltage input external power supply

7.1.6 Digital outputs

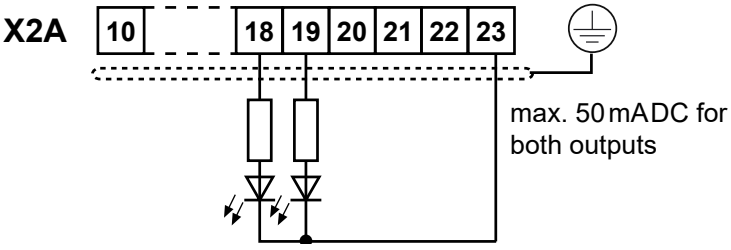


Figure 18: Digital outputs

7.1.7 Relay outputs

In case of inductive load on the relay outputs a protective circuit must be provided (e.g. free-wheeling diode)!

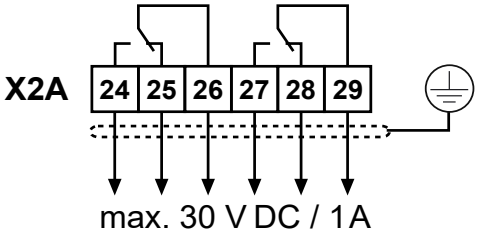


Figure 19: Relay outputs

7.1.8 Analog outputs

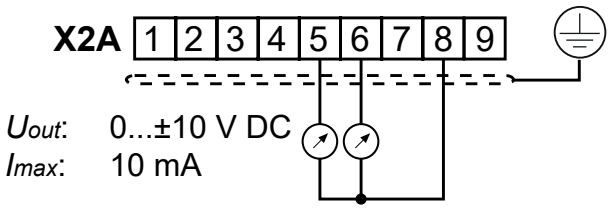


Figure 20: Analog outputs

7.1.9 Voltage output

The voltage output is used to control the digital inputs and for the supply of external control elements. The maximum output current of 100 mA mA may not be exceeded.

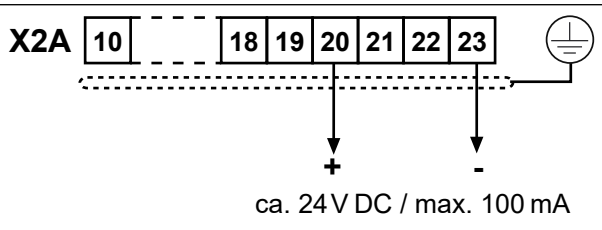


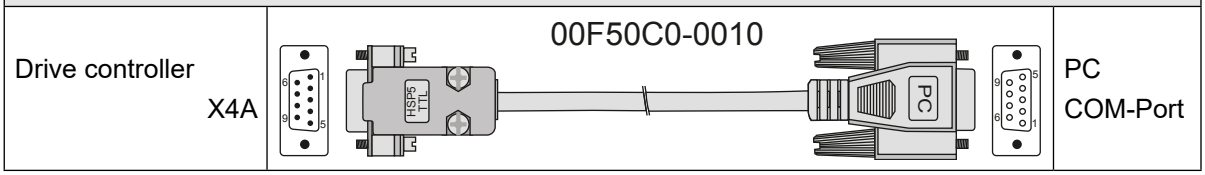
Figure 21: Voltage output

8 Operation of the Control

8.1 Operation without operator

A special HSP5 cable (material number 00F50C0-0010) is available for operating the COMBIVERT without operator. The cable is connected between HSP5 interface X4A and serial RS232 PC interface (COM1 or COM2). Operation occurs via the program COMBIVIS 5. The KEB-USB converter or the Port-Expander is required for COMBIVIS 6.

RS232-HSP5 converter



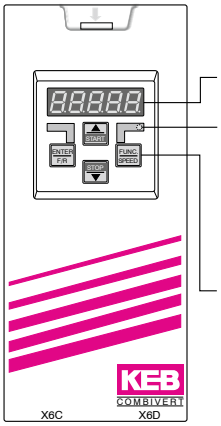
NOTICE

The RS232-HSP5 service cable has an integrated level converter. The connection of a serial standard cable would destroy the PC interface.

8.2 Operation with digital operator

A digital operator is available as an accessory for local operation of the COMBIVERT. To prevent malfunctions, the drive controller must be brought into status nOP before connecting / disconnecting the operator (open control release terminal). When starting the drive controller, it is started always with the last stored values or factory setting.

Digital operator (Mat.No. 00F5060-1000)



- 5-digit 7-segment display
- Operating/error display
- Normal "LED on"
- Error "LED blinks"
- Double function keyboard

Figure 22: Operation with digital operator

8.2.1 Keyboard operation

8.2.1.1 Parameter numbers and / values

When COMBIVERT F5 is switched on, the display shows the value of customer parameter CP.1.

The function key (FUNC) changes between the parameter value and parameter number.	0.000	FUNC. SPEED	CP. 1
With UP (▲) and DOWN (▼) the value of the parameter number is increased/decreased with changeable parameters.	START STOP		START STOP
	0.012		CP. 2

Principally during a change, parameter values are immediately accepted and stored non-volatile. However, with some parameters it is not useful that the adjusted value is accepted immediately. The value is accepted and stored non-volatile by pressing ENTER. A point is displayed behind the last digit if such a parameter is changed.

The value is accepted and stored non-volatile by pressing ENTER.	2.	ENTER F/R	2

8.2.1.2 Resetting of error messages

If a malfunction occurs during operation, then the actual display is overwritten by the error message. The error message in the display is reset by ENTER.

CP. 3	— Error —>	E. UP	ENTER F/R	CP. 3

With ENTER only the error message in the display is reset. In order to reset the error itself, the cause must be removed and a reset or a power-on-reset must be made.

8.2.1.3 Password input

The COMBIVERT is equipped with a comprehensive password protection. Depending on the entered password the following modes are possible:

Display	Mode
CP_ro	End customer menu (CP-Parameter) read-only
CP_on	End customer menu (CP-Parameter) read/write
CP_SE	Service menu (like end customer menu, however with the original parameters)
APPL	Application menu (all parameters and parameter groups visible)
–	Drive mode (COMBIVERT can be put into operation via keyboard)

Table 21: Password input

The permissible menu for the application is determined by the machine builder.

The password input generally occurs via parameter CP.0. The adjusted password / menu remains also after switching off.

Example: change of CP-Parameters from read-only to read/write

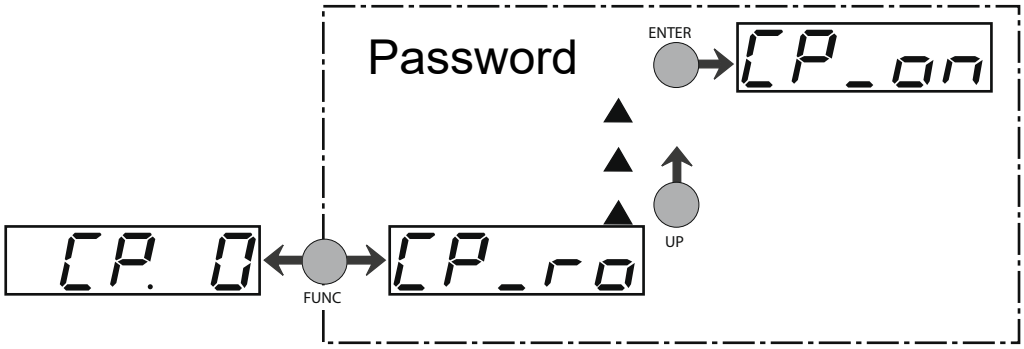
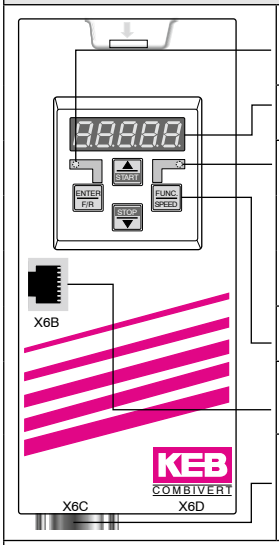


Figure 23: Password input

8.3 Interface operator

The interface operator corresponds to the functional range of the digital operator. However, it is extended by a serial RS232 / 485 interface and a diagnosis/parameter interface.

Interface operator (Mat.No. 00F5060-2000)



Interface control Bus operation "LED on“		
5-digit 7-segment display		
Operating/error display Normal "LED on" Error "LED blinks"		
Double function keyboard		
	X6B	HSP5 diagnostic and parameter interface
	X6C	RS232/485 interface

Figure 24: Interface operator

8.3.1 Description of the diagnostic and parameter interface X6B

The HSP5 interface (X6B) enables access to the drive controller for diagnostic or programming assignment. The HSP5 interface is designed as RJ45 socket. The diagnostic interface is connected to a PC via adapter (00F50C0-0020) and HSP5 cable (00F50C0-0010). Access to the drive controller parameters in the application mode is possible via the PC software KEB COMBIVIS 5. The KEB-USB converter or the Port-Expander is required for COMBIVIS 6.The operator parameters can be read out and adjusted or parameterized by download.

NOTICE

Destruction of the PC interface!

The RS232-HSP5 service cable has an integrated level converter. The connection of a serial standard cable would destroy the PC interface.

8.3.1.1 Required accessories

Adapter RJ45/DSub-9	Converter HSP5/RS232
00F50C0-0020	00F50C0-0010

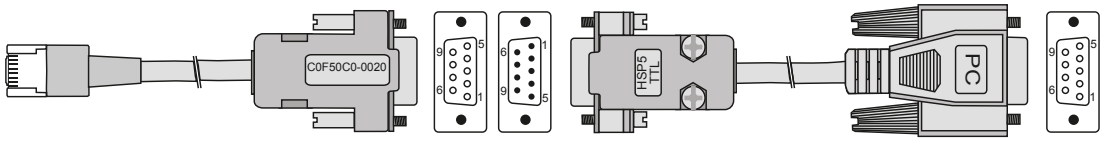


Figure 25: Required accessories

8.3.2 Description of the RS232/485 interface X6C

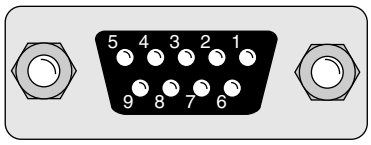
X6C	PIN	RS485	Signal	Description
	1	-	-	reserved
	2	-	TxD	Transmission signal RS232
	3	-	RxD	Receive signal RS232
	4	A‘	RxD-A	Receive signal A RS485
	5	B‘	RxD-B	Receive signal B RS485
	6	-	VP	Supply voltage +5 V (I_{max} = 50 mA)
	7	C/C‘	DGND	Data reference potential
	8	A	TxD-A	Transmission signal A RS485
	9	B	TxD-B	Transmission signal B RS485

Table 22: Description of the RS232/485 interface X6C

8.3.3 Connection of the RS232 interface

A RS232 cable is required to connect the interface operator with a PC.

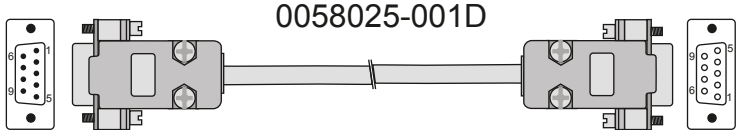


Figure 26: Connection of the RS232 interface

8.3.4 Connection of the RS485 interface

NOTICE

The following instructions must be observed to prevent malfunctions at the RS485 interface:

- Use CAT 5 cable (in pairs, twisted and shielded cable)
- Ground to one side (prior to the lower interference side)
- Attach terminating resistors of 120 Ω to both ends of the bus

If CAT 7 cable is used (by way of derogation from our recommendation) lay the interior shield each to the transmitter.

If malfunctions still occur, it is possible to use a biasing. However, this shall be done only once at the bus (preferably at the master).

8.3.4.1 Wiring RS485 full duplex

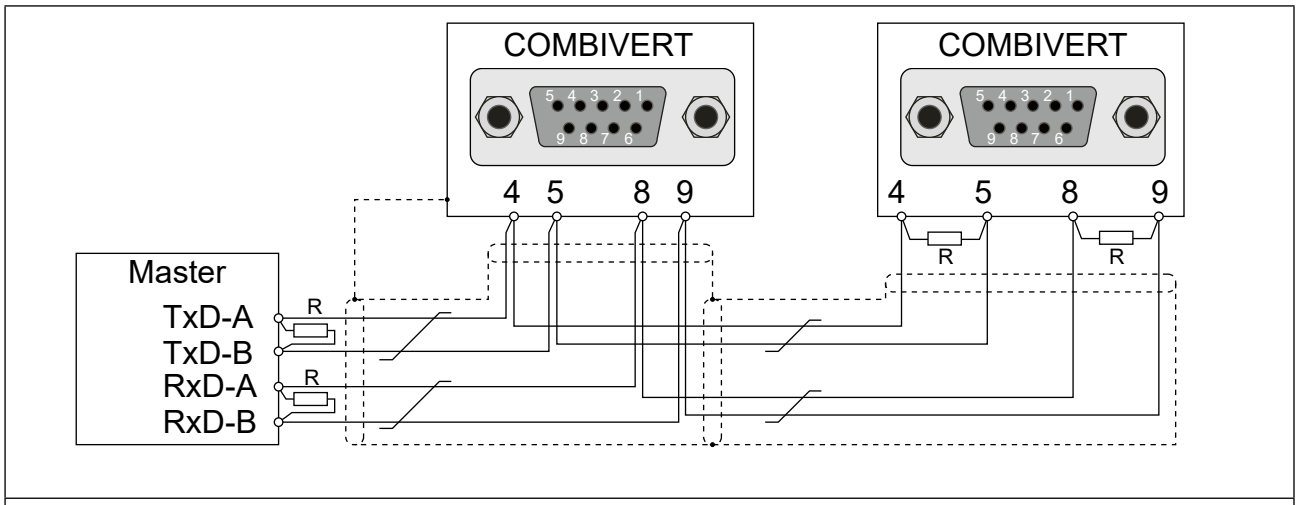


Figure 27: Wiring RS485 full duplex

8.3.4.2 Wiring RS485 half duplex

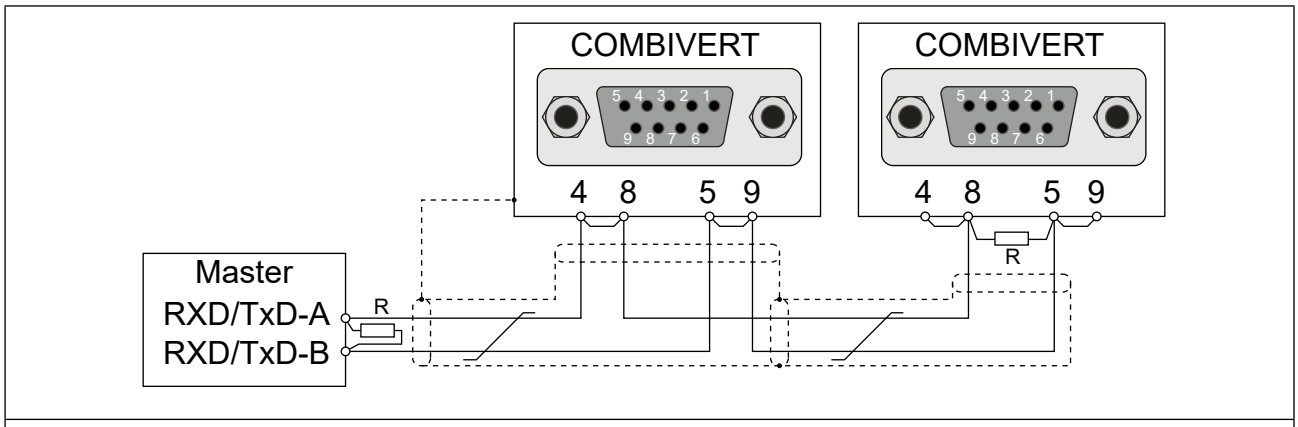


Figure 28: Wiring RS485 half duplex

8.3.5 Remote control

A special HSP5 operator is available for remote control of the COMBIVERT F5. Hereby the operator is mounted separate from the drive controller e.g. into the control cabinet door.

Operator	Material number	Suitable cable
F5 HSP5/485 connection DSUB-15	00F5060-9000	00F50C0-2xxx
F5 HSP5/485 connection screw terminal	00F5060-9001	00F50C0-3xxx

xxx The last three digits of the material number determine the cable length in dm.

8.3.6 Further operators

Additionally to the described operators, the COMBIVERT can be equipped with other operators for special applications (PROFIBUS, INTERBUS, SERCOS, CAN). Further information => *www.keb.de*.

9 Dimensioning

9.1 Dimensioning instructions

The dimensioning of the COMBIVERT F5 AIC occurs to the maximum permissible rated input current. The power specifications refer to 400 V rated input voltage.

The DC current is dependent on the adjusted DC voltage and is not measured separately.

Precharging

Depending on the mains input circuit of the AIC unit either the "max. external charging current“ *Iext*“ or the "max. permissible DC link capacity *Cext*“ must be observed (=> *„Technical data of COMBIVERT drive controllers“*)!

Furthermore observe the required waiting time between two switch-on procedures to protect the precharging resistors.

Mains input circuit type A:

No current limitation for external connected DC devices is available at DC terminals (marking ++, --) of type A. Current limitation must be ensured by the external connected devices. The maximum external charging current may not be exceeded (=> *„Device data“)*.

Mains input circuit type D1:

The current limitation of type D for the connected devices at the DC terminals (marking + PA, -) occurs by the integrated charging current limit. The specified maximum permissible DC link capacity may not be exceeded by the connected devices (=> *„Device data“)*.

Max. permissible total charging current (*Ipre*)

The current indicates the maximum expected current during the precharging procedure and can be used for dimensioning of the pre-charging contactor.

9.2 Technical data of COMBIVERT drive controllers

OMBIVERT F5 drive controller precharging by AIC at an ambient temperature T_a = 45°C and U_{N_max} = 440V. Corresponding higher charging currents are expected at higher mains voltages. In this case please contact KEB!

Size	Housing	P_N	I_N	C_{int}	Load-shunt		Max. charging current
					R	Type	
400V		kW	A	uF	Ω	–	A
5	B	0.37	1.3	180	33	NTC	19
7	B	0.75	2.6	180	33	NTC	19
9	B	1.5	4.1	300	33	NTC	19
10	B	2.2	5.8	345	10	NTC	62
12	B	4	9.5	470	10	NTC	62
7	D	0.75	2.6	180	33	NTC	19
9	D	1.5	4.1	300	10	NTC	62
10	D	2.2	5.8	345	10	NTC	62
12	D	4	9.5	470	10	NTC	62
13	D	5.5	12	580	10	NTC	62
14	D	7.5	16.5	650	10	NTC	62
12	E	4	9.5	470	20	NTC	31
13	E	5.5	12	580	20	NTC	31
14	E	7.5	16.5	650	20	NTC	31
15	E	11	24	940	20	NTC	31
16	E	15	33	1290	20	NTC	31
14	G	7.5	16.5	650	10	–	62
15	G	11	24	940	10	–	62
16	G	15	33	1290	10	–	62
17	G	18.5	42	1640	10	–	62
18	G	22	50	1875	6	–	104
16	H	15	33	1290	20	–	31
17	H	18.5	42	1640	20	–	31
18	H	22	50	1875	20	–	31
19	H	30	60	2700	20	–	31
20	H	37	75	3900	20	–	31
18	R	22	50	1875	5.0	–	–
19	R	30	60	2700	5.0	–	–
20	R	37	75	3900	5.0	–	–

continued on the next page

Size	Housing	P_N	I_N	C_{int}	Load-shunt		Max. charging current
					R	Type	
400V		kW	A	uF	Ω	–	A
21	R	45	90	4950	5.0	–	–
22	R	55	115	4950	5.0	–	–
23	R	75	150	6350	5.0	–	–
24	R	90	180	8400	5.0	–	–
23	U	75	150	6350	5.0	–	–
24	U	90	180	8400	5.0	–	–
25	U	110	210	9900	2.5	–	–
26	U	132	250	11700	2.5	–	–
27	U	160	300	14100	2.5	–	–
28	U	200	370	16800	2.5	–	–
28	P	200	370	16200	5.8	–	–
29	P	250	460	19800	5.8	–	–
30	P	315	570	19800	5.8	–	–
32	P (M/S)	400	710	39600	2.9	–	–
33	P (M/S)	450	800	39600	2.9	–	–
34	P (M/S)	500	890	39600	2.9	–	–
35	P (M/S)	560	1000	39600	2.9	–	–
36	P (M/S/S)	630	1150	59400	1.9	–	–

Legend	
P_N	Rated power
I_N	Rated current
C_{int}	Real capacity
M/S	Master/Slave
M/S/S	Master/Slave/Slave

Table 23: Technical data of COMBIVERT drive controllers

NOTICE

Destruction of the capacitors! Minimum waiting time between two switch-on procedures 5 minutes !

A restart for AIC with NTC is allowed only after 5 minutes.

9.3 Technical data of the COMBIVERT F5 AIC devices

Max. precharging AIC at an ambient temperature T_a = 45°C and U_{N_max} = 440V / 480V. Corresponding higher charging currents are expected at higher mains voltages. In this case please contact KEB!

Size	S	Cint	Cext_max at UN = 440V / 480V	R	Max. external charging current at UN = 440V / 480V	Max. total charging current at UN = 440V / 480V	Description
AIC	kVA	uF	uF	Ω	A	A	–
14	11	820	–	20	73 / 67	104	NTC as shunt
16	23	1260	–	10	130 / 120	190	–
18	35	1800	–	20	320 / 315	350	–
20	52	3900	40,000 / 35,000	2.5	–	250 / 270	–
22	80	4950	40,000 / 35,000	2.5	–	250 / 270	–
24	125	8250	35,000 / 30,000	2.5	–	250 / 270	–
26	173	11700	33,000 / 27,000	2.5	–	250 / 270	–
27	208	14100	30,000 / 24,000	2.5	–	250 / 270	–
28	256	19800	27,000 / 20,000	5.8	–	107 / 117 [1]	–
29	319	19800	27,000 / 20,000	5.8	–	107 / 117	–
30	395	39600	140,000 / 110,000	5.8 [1]	–	107 / 117 [1]	–
33	554	59400	230,000 / 180,000	3.9 [1]	–	161 / 175 [1]	–
34	616	39600	140,000 / 110,000	5.8 [1]	–	107 / 117 [1]	–
38	1005	59400	230,000 / 180,000	3.9 [1]	–	161 / 175 [1]	–

Legend	
S	Apparent power
Cint	Internal capacity
Cextmax	Maximum, connectable capacity
R	Load-shunt

Table 24: Technical data of KEB COMBIVERT F5 AIC devices

[1] *Option precharging resistor => „Additional precharging resistor at master-slave operation“.*

NOTICE

Destruction of the capacitors! Minimum waiting time between two switch-on procedures 5 minutes !

A restart for AIC with NTC is allowed only after 5 minutes.

10 Cooling System

10.1 Installation of liquid-cooled devices

In continuous operation liquid-cooled drive controllers are operated with lower temperature than air-cooled inverters. This has positive effects on lifetime-relevant components such as fan and DC link capacitors and power modules (IGBT). Also the temperature dependent switching losses are positively effected. The use of liquid-cooled COMBIVERT drive controllers is offered in the drive technology, because there are process-caused coolants available with some applications.

10.1.1 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
Cooling plate with pressed pipes	Stainless steel (-1.04V)	6 bar	upon request

Table 25: Heat sink and operating pressure

The aluminium liquid coolers are sealed by sealing rings and posses a surface protection (anodized) even in the ducts.

NOTICE

Deformation of the heat sink!

- ► 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 Pressure Equipment Directive 2014/68/EU of pressure equipment.

10.1.2 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 (electrochemical series, see table). 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!

Electrochemical 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
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

Table 26: Electrochemical series / standard potentials against hydrogen

10.1.3 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:

Requirement	Description
Standards	TrinkwV 2001, DIN EN 12502 part 1-5, DIN 50930 part 6, DVGW work sheet W216
VGB Cooling water guideline	The VGB cooling water guideline (*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°dH) 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.

Table 27: Requirements on the coolant

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.

NOTICE

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.

10.1.4 Coolant temperature

The flow temperature may not exceed 40°C. The maximum overheat temperature is 60°C or 90°C depending on the power unit and overload capacity. The coolant temperature is specified in the technical data.

The flow temperature should be chosen depending on the volume flow, so that at rated operation the heatsink temperature is always 10K below the overheat temperature level. As a result, a sporadic shutdown is avoided.

10.1.4.1 Moisture condensation

Due to high air humidity and high temperatures it can lead to moisture condensation. Moisture condensation is dangerous for the drive controller, because the drive controller can be destroyed through eventual occuring short circuits.

NOTICE

Destruction of the drive controller due to short circuit!

► The user must guarantee that any moisture condensation is avoided!

10.1.4.2 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 in % / Ambient temperature in °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
	Coolant inlet temperature in °C									

Table 28: Coolant inlet temperature [°C] is depending on ambient temperature and air humidity

10.1.5 Connection to the cooling system

- Screw in the connecting ducts according to installation instructions for fitting 0000650-G14K.
- The connection to the coolant must be carried out with flexible, pressure-resistant hoses and secured with clamps.
- Pay attention to flux direction and check tightness!
- The cooling flow must always be started before starting the 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 conductor cross-section at required equipotential bonding in order to avoid electro-chemical procedures.

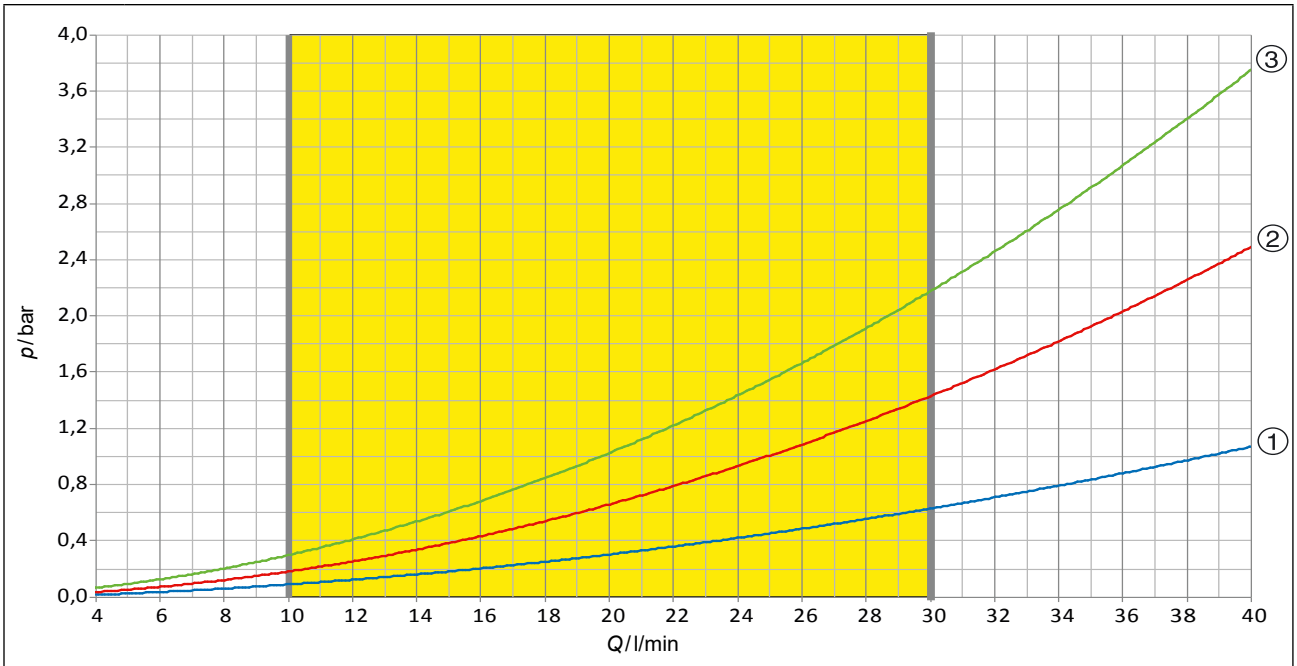
Other elements in the cooling circuit such as pumps, mixing valves, shut-off valves, ventilation etc. must be attached according to the cooling system and the local conditions.

NOTICE

A discontinuous mode is not recommended, since this leads to a reduction of the service life.

10.1.5.1 Pressure drop of the heat sink depending on the flow rate

The pump capacity required for the COMBIVERT F5 is derived from the following specifications, which are represented in => *„Connection scheme for a cooling circuit (series connection)“*.



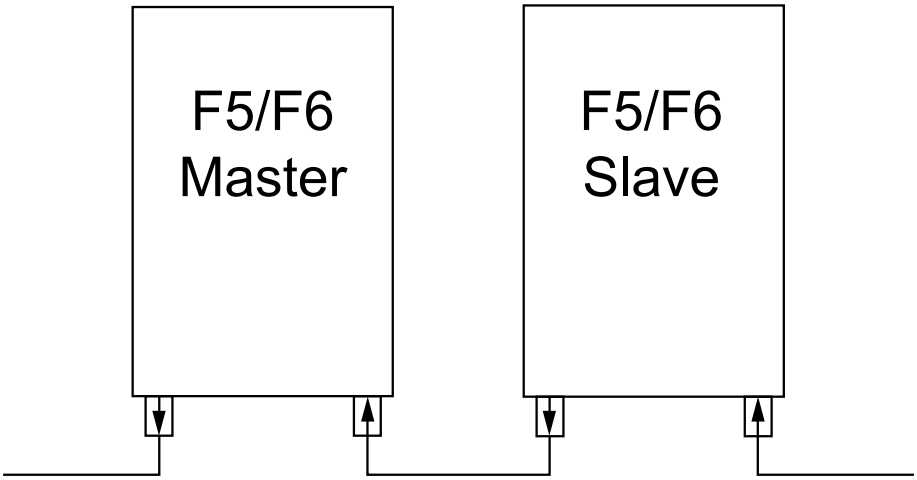
Legend	
	Recommended working range 10...30 in l/min
①	Single device
②	Series connection of two modules (Master/Slave)
③	Series connection of three modules (Master/Slave/Slave)

Figure 29: Pressure drop of the heat sink depending on the flow rate

The choice of the connection scheme (series or parallel connection) of the coolant circuit is dependent on the heat power dissipation and the selected switching frequency of the drive controller system.

10.1.5.2 Connection scheme for a cooling circuit (series connection)

Coolant connection for a master / slave system



Coolant connection for a master / slave / slave system

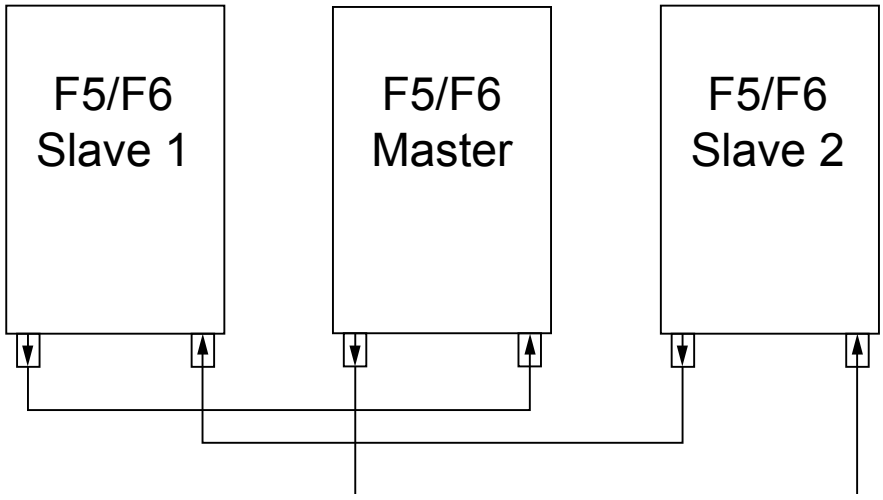


Figure 30: Coolant connection

This connection scheme is only an installation proposal and does not replace professional planning and execution!

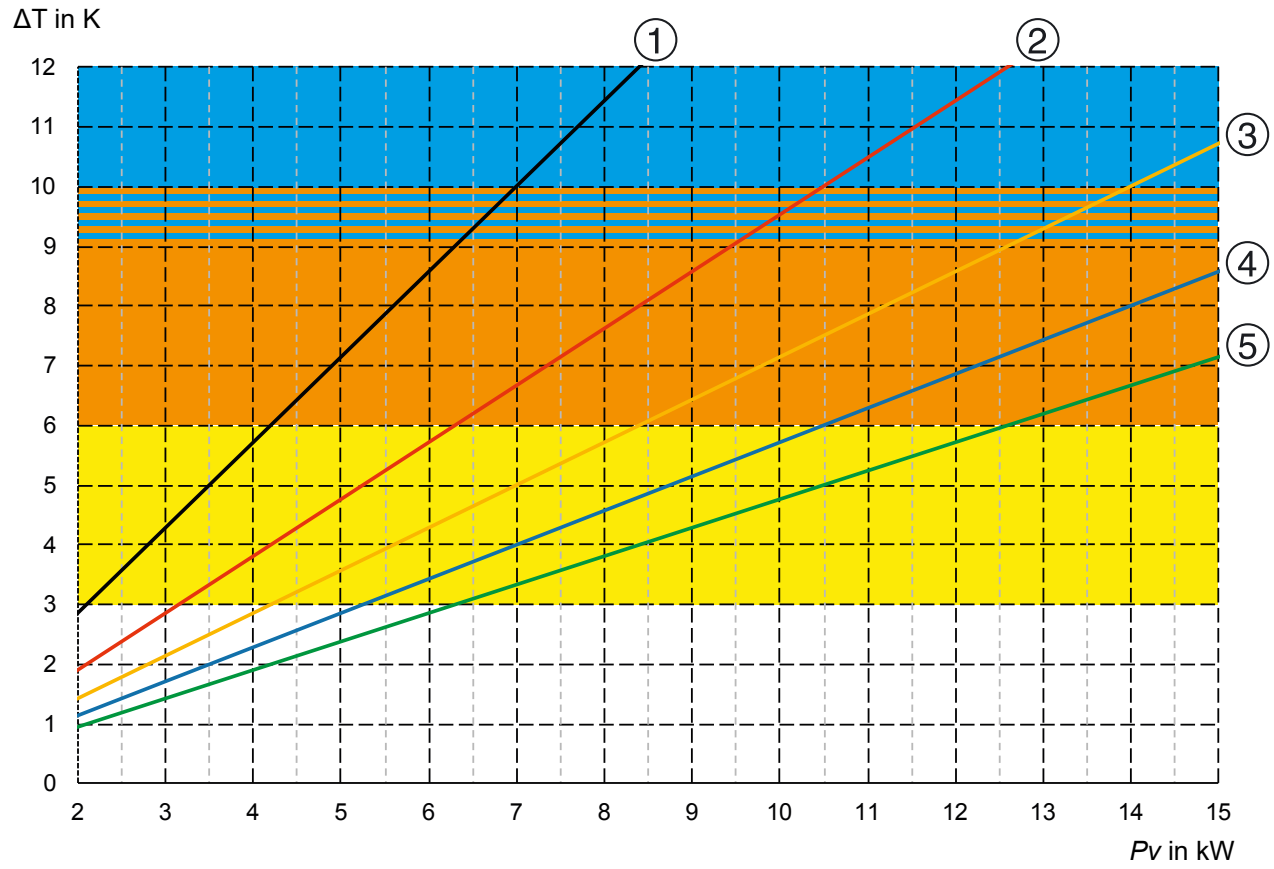
If the drive controller system operates at rated operation, the coolant circuit can be done in a series connection. It should be noted that the temperature is analog measured in the slave modules and an error signal is given digitally to the master. The water return flow should always be attached at the master in order to display real temperatures.

The heat power dissipation for each device size can be found in the technical data. The resulting volume flow has to be in the recommended operating range of the temperature difference. The relationships between heat power dissipation, flow and temperature difference => *„Volume flow in dependence of the heat power dissipation and temperature difference“*.

NOTICE

The maximum temperature difference between pre-run and return flow is specified in the technical data and should not be exceeded. If the volume flow (above 30 l/min per module) is selected too large, increases the risk of erosion in the liquid cooler.

10.1.5.3 Volume flow in dependence of the heat power dissipation and temperature difference

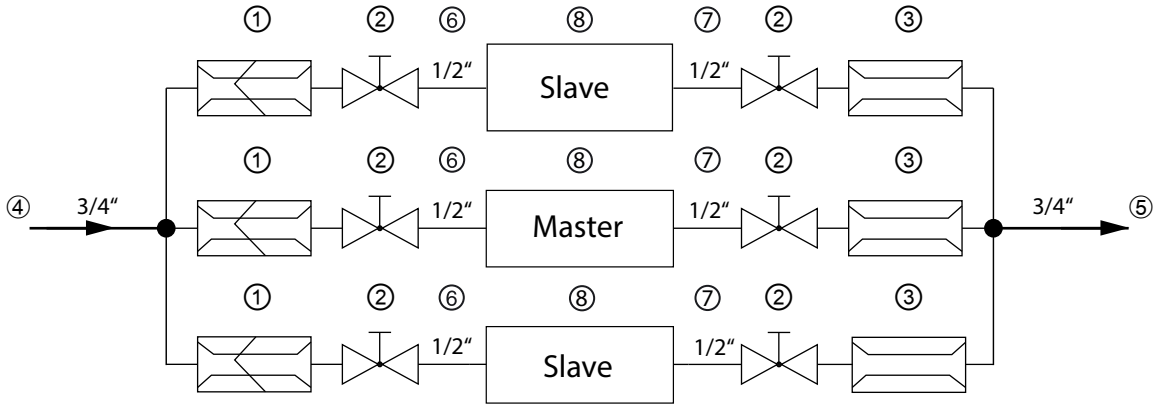


Legend		
	Master / Slave / Slave	9...12 ΔT in K
	Master / Slave	6...10 ΔT in K
	Master	3...6 ΔT in K
①	10 l/min	
②	15 l/min	
③	20 l/min	
④	25 l/min	
⑤	30 l/min	

Figure 31: Volume flow in dependence of the heat power dissipation and temperature difference

10.1.5.4 Connection scheme for a cooling circuit (parallel connection)

This connection scheme is only an installation proposal and does not replace professional planning and execution!



Legend			
①	Flow limiter 10...40 l/min	⑤	Return flow entire system
②	Ball valve/stop valve	⑥	Precharging drive controller
③	Flow switch (e.g. Sika VH/VK)	⑦	Return flow drive controller
④	Pre-run entire system	⑧	Drive controller

Figure 32: Connection scheme for a cooling circuit

The connection of the coolant circuit to the drive controller system as a parallel execution is also possible in the rated operation and mandatory for special applications.

It should be noted that the use of flow controller and a temperature monitoring is mandatory required. The cooling flow must always be started before starting the COMBIVERT. Other elements in the cooling circuit such as pumps, shut-off valves, ventilation etc. must be attached according to the cooling system and the local conditions.

The total volume flow depends on the specified heat power dissipation of the drive controller system (see technical data). The data apply for rated operation. Special applications on request. The relationships between heat power dissipation, flow and temperature difference are shown in the diagram *„Volume flow in dependence of the heat power dissipation and temperature difference“*.

NOTICE

The maximum temperature difference (ΔT) between pre-run and return flow may not exceed 7K. If the volume flow (above 30 l/min per module) is selected too large, increases the risk of erosion in the liquid cooler.

10.1.6 Decommissioning

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.

11 Certification

11.1 CE-Marking

CE marked drive controllers have been developed and manufactured in accordance with the regulations of the Low Voltage Directive and EMC Directive. The harmonised standards of the series *EN 61800-5-1* and *EN 61800-3* are applied.

For more information on the CE declarations of conformity
=> *„Further informations and documentation“*.

11.2 Further informations and documentation

You find supplementary manuals and instructions for the download under
www.keb.de/de/service/downloads

General instructions

- EMC and safety instructions
- Manuals for additional control boards, safety modules, fieldbus modules, etc.

Instruction and information for construction and development

- Input fuses in accordance with UL
- Programming manual for control and power unit
- Motor configurator to select the appropriate drive converter and to create downloads for parameterizing the drive converter

Approvals and approbations

- Declaration of conformity CE
- TÜV certificate
- FS certification

Others

- COMBIVIS, the software for comfortable parameterization of drive converters via PC (available per download)
- EPLAN drawings

12 Revision History

Version	Date	Description
00	2016-10	Completion Pre-series
01	2018-01	Changeover to new KEB-ci; general changes
02	2019-02	Certified version included, WEEE registration added; editorial changes
03	2020-10	Changing the term from AFE to AIC; editorial changes
04	2021-03	New application notes

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