



# COMBIVERT F5/F6

INSTRUCTIONS FOR USE |  
PROGRAMMING ACTIVE FRONT END HOUSING V

Translation of the original manual  
Document 20136715 EN 02



# Preface

The described hard- and software are developments of the KEB Automation KG. The enclosed documents correspond to conditions valid at printing. Misprint, mistakes and technical changes reserved.

## Signal words and symbols

Certain operations can cause hazards during the installation, operation or thereafter. There are safety informations in the documentation in front of these operations. Security signs are located on the device or machine. A warning contains signal words which are explained in the following table:

<b>DANGER</b>	Dangerous situation, which will cause death or serious injury in case of non-observance of this safety instruction.
<b>WARNING</b>	Dangerous situation, which may cause death or serious injury in case of non-observance of this safety instruction.
<b>CAUTION</b>	Dangerous situation, which may cause minor injury in case of non-observance of this safety instruction.
<b>NOTICE</b>	Situation, which can cause damage to property in case of non-observance.

### RESTRICTION

Is used when certain conditions must meet the validity of statements or the result is limited to a certain validity range.

	Is used when the result will be better, more economic or trouble-free by following these 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/nc/search](http://www.keb.de/nc/search)



## Laws and guidelines

KEB Automation KG confirms with the EC declaration of conformity with the CE mark on the unit name plate, that the device 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

The warranty on design, material or workmanship for the acquired device is given in the current terms and conditions.



Here you will find our current terms and conditions.  
[www.keb.de/terms-and-conditions](http://www.keb.de/terms-and-conditions)



Further agreements or specifications require a written confirmation.

## Support

Through multiple applications not every imaginable case has been taken into account. If you require further information or if problems occur which are not treated detailed in the documentation, you can request the necessary information via the local KEB Automation KG agency.

**The use of our units in the target products is beyond of our control and therefore exclusively the responsibility of the machine manufacturer, system integrator or 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 application. However, they are considered for information only without responsibility. This also applies to any violation of industrial property rights of a third-party.

Selection of our units in view of their suitability for the intended use must be done generally by the user.

**Tests can only be done within the application by the machine manufacturer. They must be repeated, even if only parts of hardware, software or the unit adjustment are modified.**

## Copyright

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

Other wordmarks or/and logos are trademarks (™) or registered trademarks (®) of their respective owners and are listed in the footnote on the first occurrence.

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## Glossary

0V	Earth-potential-free common point	MCM	American unit for large wire cross sections
1ph	1-phase mains	Modulation	Means in drive technology that the power semiconductors are controlled
3ph	3-phase mains	MTTF	Mean service life to failure
AC	AC current or voltage	NN	Sea level
AFE	Active Front End	OC	Overcurrent
AFE filter	Filter for the AFE device	PA	Potential equalization
ASCL	Asynchronous sensorless closed loop	PDS	Power drive system incl. motor and measuring probe
AW heat exchanger	Air-water heat exchanger	PE	Protective earth
AWG	American wire gauge	PELV	Protective Extra Low Voltage
B2B	Business-to-business	PFC	Power factor correction
CAN	Fieldbus system	PFD	Term used in the safety technology (EN 61508-1...7) for the size of error probability
CDM	Complete drive module including auxiliary equipment (control cabinet)	PFH	Term used in the safety technology (EN 61508-1...7) for the size of error probability per hour
COMBIVERT	KEB drive converters	PLC	Programmable logic controller
COMBIVIS	KEB start-up and parameterizing software	Port	Part of a network address to the assignment of TCP and UDP connections
DC	DC current or voltage	PT100	Temperature sensor with R0=100Ω
DEIF	Producer of control boards	PT1000	Temperature sensor with R0=1000Ω
DI	Demineralized water, also referred to as deionized (DI) water	PTC	PTC-resistor for temperature detection
DIN	German Institut for standardization	PWM	Pulse width modulation
EMC	Electromagnetic compatibility	RJ45	Modular connector with 8 lines
Emergency stop	Shutdown of a drive in emergency case (not de-energized)	SCL	Synchronous sensorless closed loop
Emergency switching off	Switching off the voltage supply in emergency case	SELV	Safety Extra Low Voltage (<60V)
EN	European standard	SF filter	Sine-wave filter
EtherCAT	Real-time Ethernet bus system of the company Beckhoff	SS1	Safety function „Safe stop 1“ in accordance with IEC 61800-5-2
Ethernet	Real-time bus system - defines protocols, plugs, types of cables	SSI	Synchronous serial interface for encoder
FE	Functional earth	STO	Safety function „Safe Torque Off“ in accordance with IEC 61800-5-2
FU	Drive converter	TTL	Incremental signal with an output voltage up to 5V
GND	Reference potential, ground	UCE	Monitoring the saturation voltage of the power switch
GTR7	Braking transistor	USB	Universal serial bus
HF filter	High frequency filter to the mains	VARAN	Real-time Ethernet bus system
HMI	Human machine interface (touch screen)	WRA	Inverter A
HSP5	Fast, serial protocol	WRB	Inverter B
HTL	Incremental signal with an output voltage (up to 30V) -> TTL		
I <sup>2</sup> t-monitoring	Software function for thermal monitoring of the motor winding		
IEC	International standard		
IP xx	Degree of protection (xx for level)		
KTY	Silicium temperature sensor (polarized)		





## Standards for drive converters / control cabinets

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
EN 1037	Safety of machinery - Prevention of unexpected start-up; German version EN 1037
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 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 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

## STANDARDS FOR DRIVE CONVERTERS/CONTROL CABINETS

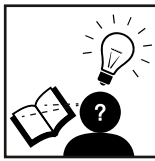
EN61000-4-5	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test (IEC 61000-4-5); German version EN 61000-4-5
EN61000-4-6	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields (IEC 61000-4-6); German version EN 61000-4-6
EN61000-4-34	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
EN61373	Railway applications - Rolling stock equipment - Shock and vibration tests (IEC 61373); German version EN 61373
EN61439-1	Low-voltage switchgear and controlgear assemblies - Part 1: General rules (IEC 121B/40/CDV); German version FprEN 61439-1
EN61508-1...7	Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 1...7 (VDE 0803-1...7, IEC 61508-1...7)
EN61800-2	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)
EN61800-3	Speed-adjustable electrical drives. Part 3: EMC requirements and specific test methods (VDE 0160-103, IEC 61800-3)
EN61800-5-1	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
EN61800-5-2	Adjustable speed electrical power drive systems - Part 5-2: Safety Requirements - Functional (IEC 22G/264/CD)
EN62061	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
UL61800-5-1	American version of the EN61800-5-1 with „National Deviations“

# 1 Basic Safety Instructions

The COMBIVERT is designed and constructed in accordance with state-of-the-art technology and the recognised 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. Non-observance will lead to the loss of any liability claims.

## NOTICE



### Hazards and risks through ignorance.

- ▶ Read the instruction manual!
- ▶ 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 (e.g. *DGUV regulation 3*).

## 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.




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**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**




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**Do not operate in an explosive environment!**

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

**⚠ CAUTION**




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**Design-related 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. Non-compliance with the applicable standards.
- 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.
- The safety instructions are to be kept!

## 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.
- ▶ Wait until the drive has stopped in order, that perhaps 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).
- ▶ Connect the protective earth conductor to drive converter and motor everytime.
- ▶ 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 accordly to the specified minimum / maximum values for the operation.
- 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*.
- Connection of the drive converter is only permissible on symmetrical networks with a maximum line voltage (L1, L2, L3) with respect to earth (N/PE) of max. 300 V. An isolating transformer must be used for supply networks which exceed this value. In case of non-compliance the control is not longer considered as "PELV circuit".
- With existing or newly wired circuits the person installing the units or machines must ensure the EN 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 equalizing currents.



If personnel protection is required during installation of the system, suitable protective devices must be used for drive converters.

[https://www.keb.de/fileadmin/media/Manuals/knowledge/04\\_techinfo/00\\_general/ti\\_rcd\\_0400\\_0002\\_gbr.pdf](https://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 manufacturer of the installation or machine.



Notes on EMC-compatible installation can be found here.

<https://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 converter.



Because of the noise suppression capacitors the test generator will immediately trigger with current error.



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.

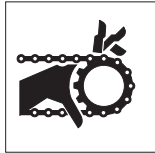
### 1.4.3 Insulation measurement

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. At any unit it can be expected with an insulating resistance > 5 MΩ!

## 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 cooling water 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.



Observe the following instructions if the drive converter for more than one year was not in operation before start-up.

[https://www.keb.de/fileadmin/media/Manuals/knowledge/04\\_techinfo/00\\_general/ti\\_format\\_capacitors\\_0400\\_0001\\_gbr.pdf](https://www.keb.de/fileadmin/media/Manuals/knowledge/04_techinfo/00_general/ti_format_capacitors_0400_0001_gbr.pdf)



#### Switching at the output

Switching between motor and drive converter is prohibited for single drives during operation as this may trigger the protection gear of the device. Function “speed search” must be activated if switching can not be avoided. Control release may only be triggered after closing the motor contactor (e.g. by switching the control release).

Connecting and disconnecting is permissible with multiple motor drives if at least 1 motor is running during the switch-over process. The drive converter must be dimensioned to the occurring starting currents.

The “speed search” function must be activated if the motor is still running during a restart of the drive converter (mains on) (e.g. due to large rotating masses).

**Switching on the input**

For applications that require cyclic switching on and off 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 proof**

The drive converters are conditional short-circuit proof. After resetting the internal protection devices, the function as directed is guaranteed.

Exceptions:

- If an earth-leakage fault or short-circuit often occurs at the output, this can lead to a defect in the unit.
- If a short-circuit occurs during regenerative operation (2nd or 4th quadrant, regeneration into the DC link), this can lead to a defect in the unit.

**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.
- ▶ 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.
- ▶ Make a visual leak test of the cooling circuit for water-cooled inverters.

**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

Drive converters with safety function are limited to a service life of 20 years. Then the devices must be replaced.

Drive converters of the KEB Automation KG are professional, electronic devices exclusively for further industrial processing (so-called B2B devices). Thus the marking does not occur with the symbol of the crossed-out wheeled bin, but by the word mark and the date of manufacture.

Unlike devices mainly used in private households, these devices may not be disposed at the collection centres of public sector disposal organisations. They must be disposed after the end of use in accordance with national applicable law to environmentally correct disposal of electrical and electronic equipment.

## 2 Product Description

The KEB COMBIVERT AFE is an universal useable power supply and regenerative unit. Based on the hardware of COMBIVERT F5 drive converters, which are delivered with AFE software. The main application areas are industrial applications, single-axis applications, test systems and special projects.

### Features:

- On the mains side, the KEB COMBIVERT AFE is connected to a three-phase AC voltage supply via AFE filter.
- On the output side, a stabilised DC supply is provided for connected units.
- For motor and regenerative operation, the active modulation on the mains side leads to sine-wave line currents only.
- The DC connection can be used to supply one or more DC consumers such as, for example, individual drive converter with DC input, or a DC interconnection of more than one unit.
- This ensures a central mains supply and with the energy being exchanged between all units in the DC interconnection, energy savings can be achieved.
- Depending on the operating condition of the connected units, these units can be supplied with energy in motor operation or the produced regenerative energy can be fed back into the mains.
- Thus, braking resistors are no longer required but can be used as an additional safety device in case of a mains power failure or other faults.
- Furthermore, the AFE provides power factor correction of the mains supply (PF = 1) minimising any occurring reactive power pulses.
- The fundamental-frequency reactive power  $\cos \Phi$  is = 1. If required, an additional control system can be used to provide  $\cos\text{-}\phi$  control.
- The active control of the DC link voltage stabilises the voltage even if the mains voltage fluctuates and step-up controllers are used to increase the voltage to a value above the mains level.
- In this process, the adjusted DC voltage must always be set above the maximum occurring AC mains voltage.

### 2.1 Specified application

The software for the operation of the COMBIVERT F5 AFE is intended for the use of power supply and regenerative units.

- The operation is permitted only on symmetrical three-wire systems in connection with special AFE filters.
- The used semiconductors and components of KEB are developed and dimensioned for the use in industrial products.
- 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.
- The operation of our products outside the indicated limit values of the technical data leads to the loss of any liability claims.
- Voltage drops to the motor, caused by the use of motor chokes, as well as sine-wave or  $dv/dt$  filters can be compensated accordingly.

### 2.1.1 Requirements for operation

- AFE filters
- symmetrical three-wire system (see Installation manual)
- EMC filter (for observance of EMC standard)
- Isolated operation after consulting KEB
- Drive converter without DC link ground impedance (leakage capacitors) respectively using a sinus EMC level or ALL Mode Filter.

#### **ATTENTION**

#### **View from Active Front End**

Depending on the actual operating condition (power supply or regeneration), the terminals of an Active Front End unit can either be the input or the output. For the standardization of the view the line side is always regarded as input and the DC voltage side is always regarded as output.

#### **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.

### 2.1.2 Residual risks

In spite of the intended use, the drive converter may assume unpredictable operating conditions in the event of a fault, wrong parameterisation, wrong connection or unauthorized intervention and repairs. This can be:

- Wrong direction of rotation
- High motor speed
- Motor is running into limitation
- Motor can also be under voltage also at standstill
- Automatic restart

## 2.2 Improper use

Operation of other electrical consumers is prohibited and can lead to the destruction of the units. The operation of our products outside the indicated limit values of the technical data leads to the loss of any liability claims.

### 3 Control terminal block X2A for F5 AFE devices

1 2 3 4 5 6 7 8 9									10 11 12 13 14 15 16 17 18 19 20 21 22 23														24 25 26 27 28 29				
[Terminal 1-9]									[Terminal 10-23]														[Terminal 24-29]				
PIN	Function	Name	Default assignment	Description																							
1	+ Setpoint input 1	AN1+		The input signal 0...±10V; 0...±20 mA u. 4...20 mA is determined with An.00/An.10. Resolution: 12 Bit, Ri = 30 kΩ, scan time: 1 ms 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 analog output is set with An.31/ An.36. Voltage range: 0...±10V, Ri = 100Ω, resolution: 10Bit, PWM frequency: 3.4 kHz, limiting frequency filter 1. Order: 178 Hz																							
6	Analog output 2	ANOUT2																									
7	+10V output	CRF		Reference voltage output +10 VDC +5% / max. 4 mA for setpoint potentiometer																							
8	Analog ground	COM		Ground for analog in- and outputs																							
9	Analog ground	COM																									
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. Ri = 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	main contactor control (dc > level)	Max. 50mA DC for both outputs are available.																							
19	Transistor output 2	O2	ready for operation (uic loaded)																								
20	+24 V-output	U <sub>out</sub>		approx. 24 VDC output (max.100 mA), voltage input for ext. supply, reference potential 0V X2A.22/23																							
21	20...30 V input	U <sub>in</sub>																									
22	Digital ground	0V		Potential for digital in-/outputs																							
23	Digital ground	0V																									

continued on the next page

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) Specifications, control and pro- gramming of the relay outputs max. 30VDC, 0.01...1A
25	Relay 1 / NC contact	RLB		
26	Relay 1 / switching contact	RLC		
27	Relay 2 / no contact	FLA	ready for operation (uic loaded)	
28	Relay 2 / NC contact	FLB		
29	Relay 2 / switching contact	FLC		
<i>Table 1: Control terminal block X2A for the control circuits F5-AFE</i>				

## 4 Start-Up

**ATTENTION**

To prevent damage to the hardware, the initial settings need to be parameterised before switching on the AC voltage for the first time!

### 4.1 Factory setting F5-AFE

**Control type:**

ud.02: 8: F5R-S

**Inputs:**

I1: 2. Setpoint of control voltage (oP.21)

ST+I2: Control release with start of a delay time for modulation (di.42)

RST: Error reset

I3: Monitoring of the volume flow for housing V

**Outputs:**

O1: Main contactor control (dc > level)

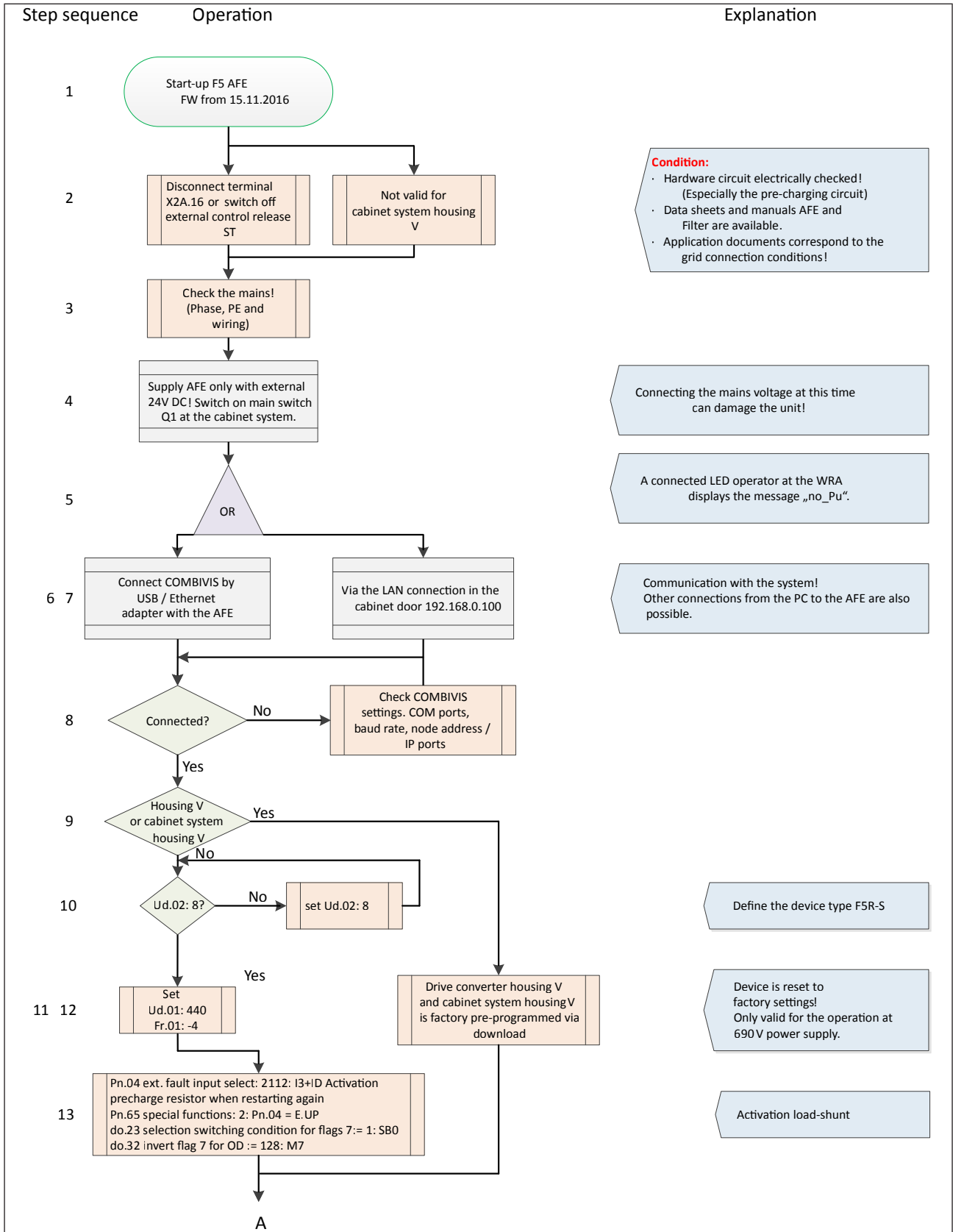
O2: Ready for operation (uic loaded)

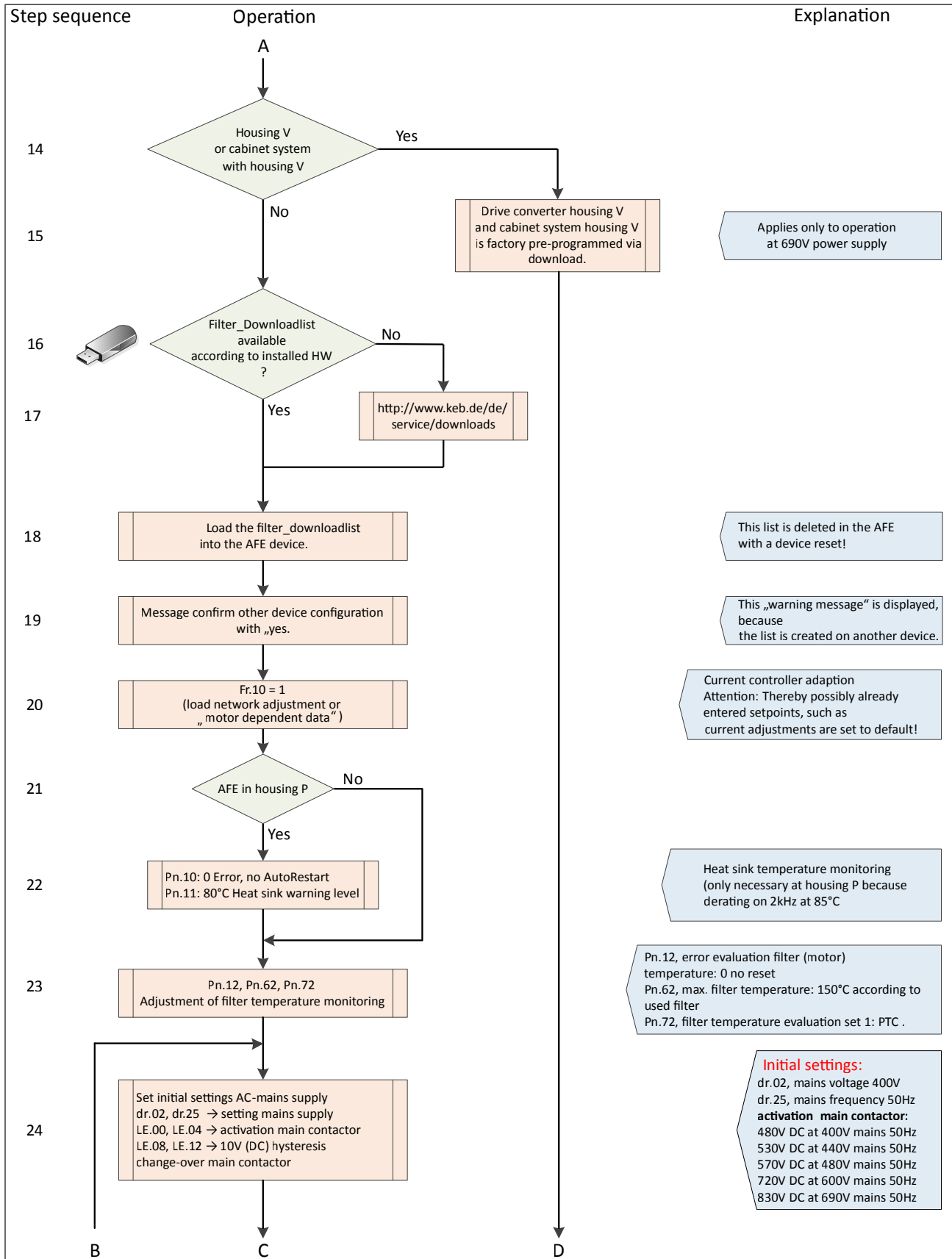
R1: Error output (error)

R2: Ready for operation (uic loaded)

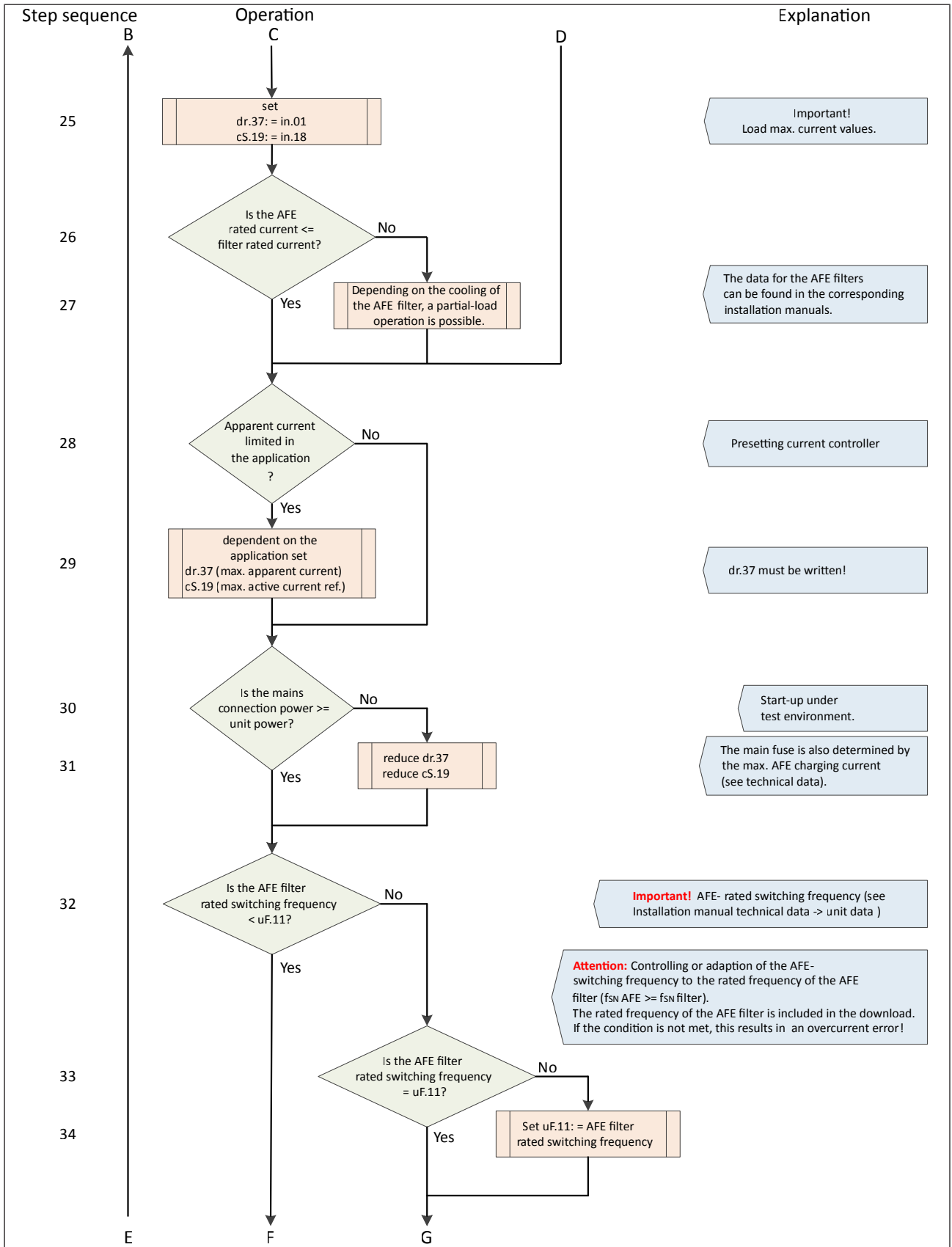
- The WRA (AFE) is factory pre-programmed via a download in housing V. No further settings need to be made.
- Adjustments must only be made if the cabinet system is not operated at 690 V AC.
- Further information can be found in the following chapters.

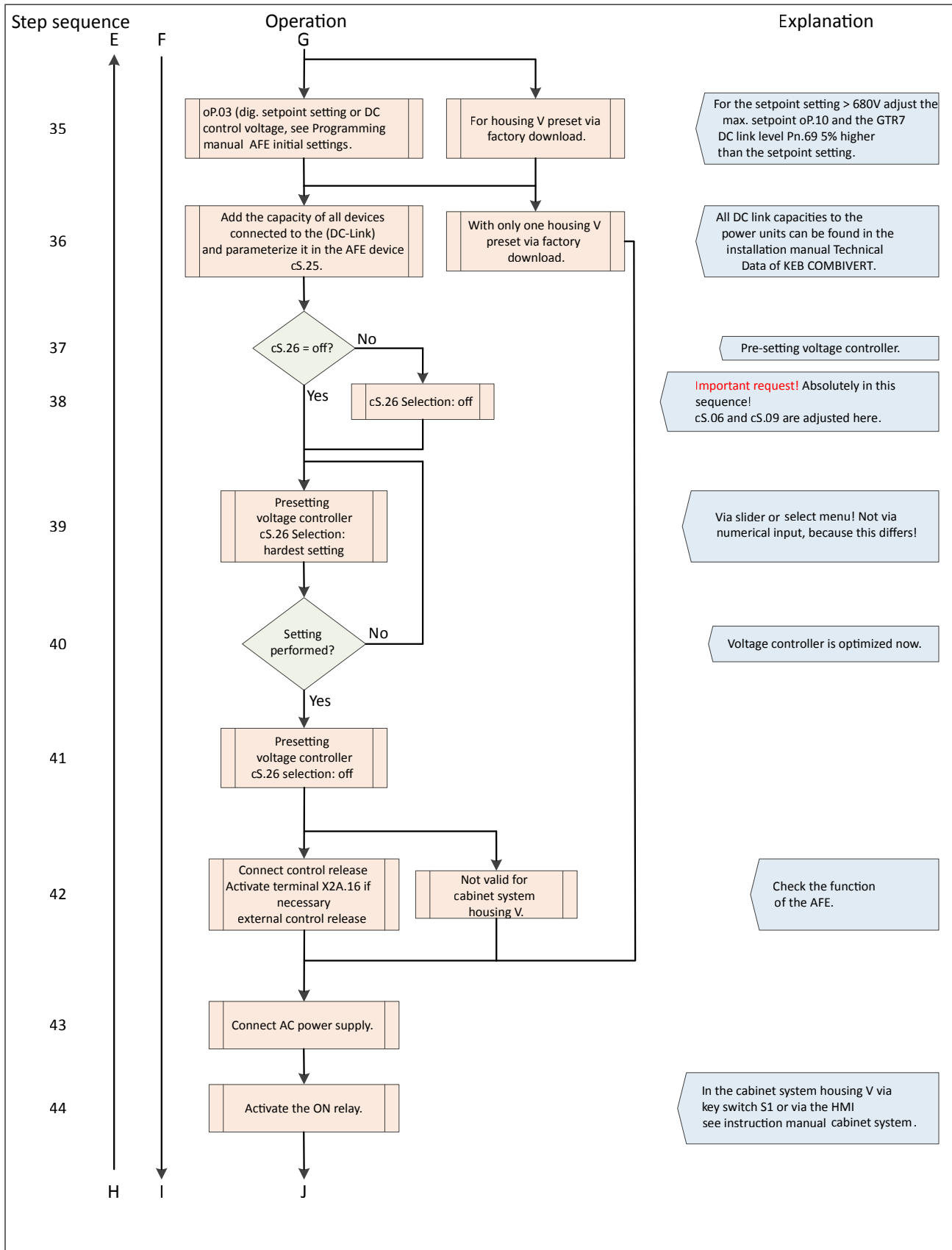
### 4.2 Step-by-step start-up for drive converters as AFE











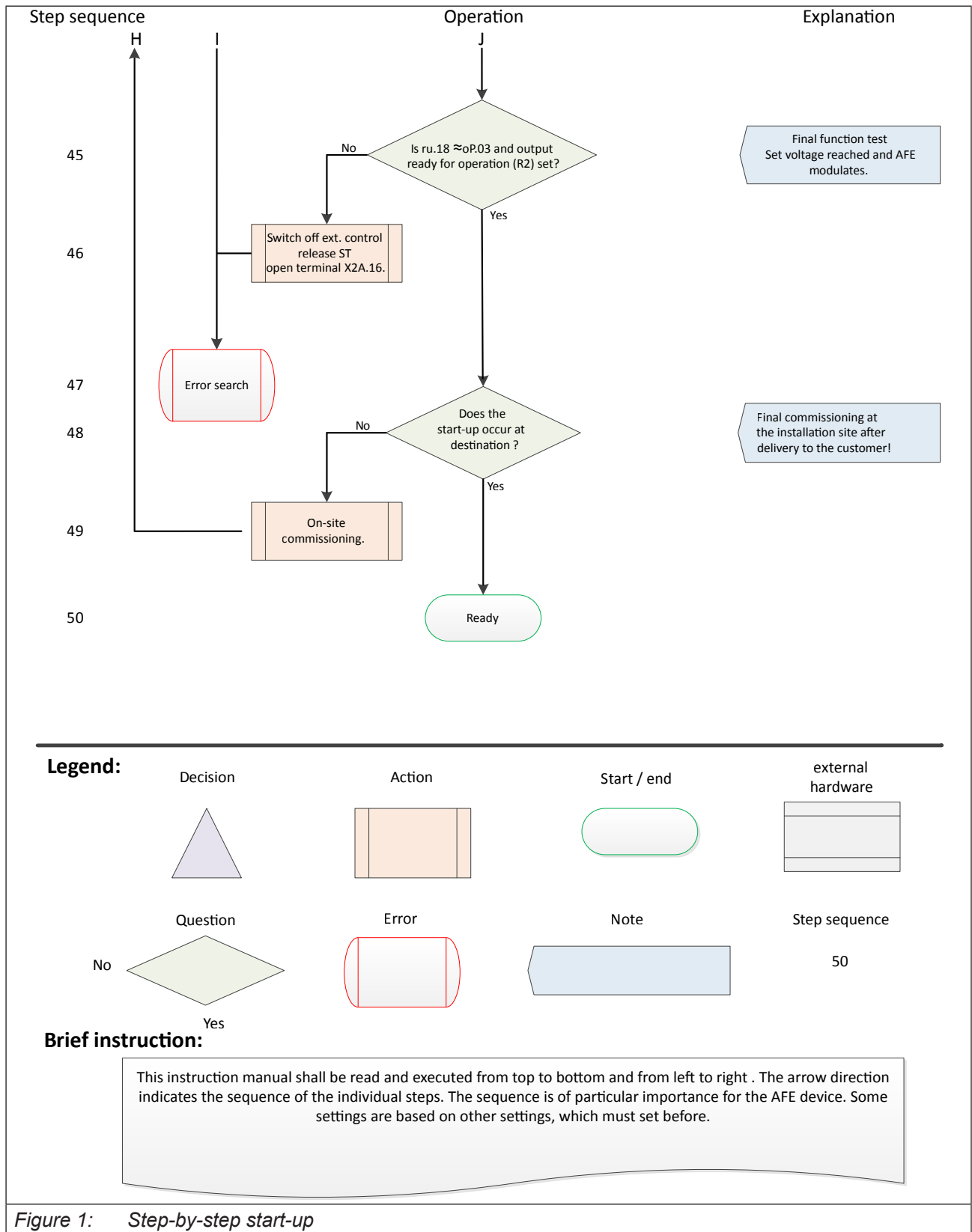


Figure 1: Step-by-step start-up

## 5 Parameterisation of the Unit

### 5.1 Initial settings


The following parameters determine the operating point of the COMBIVERT F5-AFE. The parameters are preset. They must be checked and, if necessary, adapted to the application.

Parameter	Designation	Value range	Default value
cS.19	Absolute active current setpoint	±32000.00A	0.00A
dr.02	Rated voltage	400...690V	400V
dr.25	Rated frequency	0.0...1600.0Hz	50.0Hz
dr.37	Maximum Current	0.0...1025.0A	0.0A
Fr.01	Copy parameter set	-9...7	-4
oP.03	Digital setpoint setting	±32000V	680V
oP.21	Fixed value 1	±32000V	620V
Ud.01	Password	0...9999	0
Ud.02	Control type	0...8	0

Table 2: Parameter initial settings


### 5.2 Parameter description

cS.19	Absolute active current setpoint	Parameter address	<b>0x0F13</b>
Value range	Meaning		
±32000.00A	Limitation of the active current. The unit-dependent rated current is preset (cS.19 ≤ dr.37).		

dr.02	Rated voltage	Parameter address	<b>0x0602</b>
Value range	Meaning		
400...690V	Setting of mains voltage with which the unit is operated.		
	A tolerance of +20 %/-15 % should neither be exceeded nor fallen below.		

dr.25	Rated frequency	Parameter address	<b>0x0619</b>
Value range	Meaning		
0.0...1600.0Hz	Setting of mains frequency with which the unit is operated. A tolerance of up to 10 % is possible as otherwise the E.OS error would be triggered within 20 ms.		

dr.37	Maximum current	Parameter address	<b>0x0625</b>
Value range	Meaning		
0.0...1500.0A	Adjustment of the total current. The value is unit-dependent and can be seen in parameter In.18. The limit value must be adapted to the AFE filter ≥ in In.18 (dr.37 = max. I_AFE filter).		

Fr.01	Copy parameter set	Parameter address	0x0901
Value range	Meaning		
-1...-9	Loading the default parameters.		
Value	Source default values	Copied parameters	Target sets
-1	KEB	Customer parameters	selected
-2	KEB	Customer parameters	all
-3	KEB	Customer and system parameters	selected
-4	KEB	Customer and system parameters	all
-5	custom-specific	Customer parameters	selected
-6	custom-specific	Customer parameters	all
-7	custom-specific	Customer and system parameters	selected
-8	custom-specific	Customer and system parameters	all
-9	Storing of the current parameter setting as custom-specific default values	Customer and system parameters	all
	By loading the factory setting all definitions defined by the mechanical engineer are reset! This can comprise the terminal assignment, set changeover or operating states. Before loading the default set it is to be ensured that no unintended operating states occur.		

According to the presetting of COMBIVERT F5-AFE, the voltage setpoint is determined by parameter oP.03.

oP.03	Digital setpoint setting	Parameter address	0x0303
Value range	Meaning		
±32000.00 V	The setpoint setting must be between the peak value, the input voltage $U_{in}$ and the OP level (840 V DC for 400 V mains supply and 1200 V DC for 690 V mains supply). To guarantee a stable control, a control reserve of approx. +/-10% is to be taken into consideration. To select the setpoint, other factors such as, for example, the maximum motor voltage (output voltage of the drive converter) are decisive.		
Example			
	$U_{zkmin} = (U_{ACrated} + 10\% \text{ mains tolerance} + 10\% \text{ control reserve}) * \sqrt{2}$ $= 1100 \text{ VDC at } 690 \text{ V mains voltage}$		

If a second voltage setpoint is to be applied, it can be entered in oP.21. This value is selected via digital input I1.

oP.21	Fixed value 1	Parameter address	0x0315
Value range	Meaning		
±32000.00 V	Presetting of a second DC link voltage setpoint. This value depends on the application but must be within the range specified for oP.03.		

Ud.01	Password	Parameter address	<b>0x0801</b>
Value range	Meaning		
0...9999	Setting range for the password.		

Ud.02	Control type	Parameter address	<b>0x0802</b>
Value range	Meaning		
0...8	Selection of the control type.		
Value	Function		
0: F5R-G	F5 AFE device in open-loop mode		
1...7: reserved	reserved		
8: F5R-S	F5 AFE device in synchronous mode		

### 5.3 Sequence control system parameters

The COMBIVERT F5-AFE sequence control system parameters are preset and should not be changed. If required, the levels and the times can be adapted.

#### 5.3.1 Precharging

These parameters are used to set the time when the pre-charging contactor is to be switched off and the main charging contactor is to be switched on.

Parameter	Designation	Value range	Default value
do.00	Switching condition output O1	0...100	26
LE.00	Switching level 0	-10737418.24... 10737418.23	see text
LE.08	Hysteresis 0	0.00...300.00	100.00

*Table 3: Parameter precharging*

#### ATTENTION

##### Observe the maximum precharging capacity !

When dimensioning the entire system, make sure that the maximum pre-charging capacity of the device is not exceeded (see "Instruction Manual").

#### ATTENTION

##### Always use the same power circuits of FI and AFE !

Due to different variations of input rectifications and pre-charging circuits of the connected drive converters, the same power circuits must always be combined for AFE and motor inverters. Several motor drive converters on a single AFE should only be operated in consultation with KEB!

do.00	Switching condition output O1	Parameter address	<b>0x0C00</b>
Value range	Meaning		
0...100	Setting of the switching condition for output O1. Switching condition 26 "DC link voltage" is preset. The output switches when the adjusted value in LE.00 is exceeded. The output is pre-programmed to switch over from pre-charging contactor to main contactor.		

LE.00	Switching level 0	Parameter address	<b>0x0D00</b>
Value range	Meaning		
-10737418.23... + 10737418.24	Setting of the switching level to switch over from pre-charging contactor to main contactor.		
Value	Function		
460 V	for 380 V mains supply		
480 V	for 400 V mains supply		
530 V	for 440 V mains supply		
720 V	for 600 V mains supply		
830 V	for 690 V mains supply		

**ATTENTION**

Improper settings can result in damage to the hardware.

LE.08	Hysteresis 0	Parameter address	<b>0x0D08</b>
Value range	Meaning		
0.00...300.00	The hysteresis for the switching level 0 must be set to 10.00.		

5.3.2 Blocking release during precharging

This function can be used to block the modulation for an adjustable waiting time after a parameterised DC link voltage has been reached. This allows to prolong the precharging and settling process after switching over to the main contactor. After a brief mains power failure (ru.18 > LE.00 or LE.04) and resetting/setting of the control release, the modulation is delayed by di.42. This ensures the recharging of the DC link via the LCL filter, before the modulation starts.

Parameter	Designation	Value range	Default value
di.15	IA function	-2147483648... 2147483647	-2147483648
di.28	IA+ function	0...21	5
di.48	IA switch-on delay	0.00...32.00 s	5.00 s
do.04	Switching condition OA	0...100	26
LE.04	Switching level 4	-10737418.24... 10737418.23	480 V
LE.12	Hysteresis 4	0.00...300.00	100.00

*Table 4: Parameter release*



The parameters di.15 and di.28 are used for internal interconnection of the outputs and must not be changed for the function described.

di.15	IA function	Parameter address	<b>0x0B0F</b>
Value range	Meaning		
-2147483648... 2147483647	Internal digital inputs.		

di.28	IA+ function	Parameter address	<b>0x0B1C</b>
Value range	Meaning		
0...21	Setting how the internal digital input should respond to a signal.		

di.48	IA switch-on delay	Parameter address	<b>0x0C04</b>
Value range	Meaning		
0.00...32.00 s	Setting of the waiting time after which the software control release is enabled.		

do.04	Switching condition OA	Parameter address	<b>0x0C04</b>
Value range	Meaning		
0.00...32.00 s	Setting of the switching condition for output OA. Switching condition 26 "DC link voltage" is preset. The output switches when the adjusted value in LE.04 is exceeded. The adjusted waiting time in di.48 elapses and sets afterwards the software control release. The device can modulate.		



LE.04	Switching level 4	Parameter address	<b>0x0D04</b>
Value range	Meaning		
-10737418.23... + 10737418.24	Setting of the switching level at which the switch-on delay starts. The default setting (480.00 V) corresponds to the switchover from the pre-charging contactor to the main contactor and should be adapted to the level from LE.00.		
Value	Function		
460 V	for 380 V mains supply		
480 V	for 400 V mains supply		
530 V	for 440 V mains supply		
570 V	for 480 V mains supply		
720 V	for 600 V mains supply		
830 V	for 690 V mains supply		

LE.08	Hysteresis 4	Parameter address	<b>0x0D0C</b>
Value range	Meaning		
0.00...300.00	The hysteresis for the switching level 4 must be set to 10.00.		

### 5.3.3 Time delay for control release

If the control release is switched off for a short time during operation (for example, when switching off the main contactor for a short time), a delay might be necessary when switching the control release back on to wait for the DC link to recharge or the contactor to chatter.

Parameter	Designation	Value range	Default value
di.12	I2 function	-2147483648... 2147483647	-2147483648
di.25	I2+ function	0...21	11
di.42	I2 switch-on delay	0.00...32.00 s	5.00 s

*Table 5: Parameter control release*

di.12	I2 function	Parameter address	<b>0x0B0C</b>
Value range	Meaning		
-2147483648... 2147483647	External digital input.		

di.25	I2+ function	Parameter address	<b>0x0B19</b>
Value range	Meaning		
0...21	Setting how the external digital input should respond to a signal.		



The parameters di.12 and di.25 are used for internal interconnection of the outputs and must not be changed for the function described.

di.42	I2 switch-on delay	Parameter address	<b>0x0B2A</b>
Value range	Meaning		
0.00...32.00 s	Setting of the waiting time after which input I2 which is internally linked with the control release is set.		

### 5.3.4 Display of the operating state

Digital output O2 and relay output R2 are set when the DC link has reached the preset setpoint.

Parameter	Designation	Value range	Default value
do.01	Switching condition SB4	0...100	71

*Table 6: Parameter operating state*

do.01	Switching condition SB4	Parameter address	<b>0x0C01</b>
Value range	Meaning		
0...100	Switching condition „71: DC link loaded“ is set, when <ul style="list-style-type: none"> <li>the modulation is activated.</li> <li>ramp output display (ru.02) = set value display (ru.01).</li> <li>setpoint-actual value was once smaller than 10 V.</li> <li>a time of 1 s which cannot be changed has elapsed.</li> </ul> When changing the DC link voltage setpoint during operation, the output is reset until the conditions listed above are met again.		

### 5.3.5 Mains identification

Each time the F5-AFE is started, the mains are identified (angle and rotating field) after the completion of the precharging process and the release of the modulation. Afterwards, the DC link voltage is adjusted to the preset setpoint. The current used for identification can be adapted as necessary.

Parameter	Designation	Value range	Default value
dr.69	Frequency search at max. current (AFE)	0.0...100.0%	25.0%

*Table 7: Parameter mains identification*

dr.69	I2 switch-on delay	Parameter address	<b>0x0645</b>
Value range	Meaning		
0.0...100.0%	Frequency search at max. current (AFE)		

## 5.4 Operating and control parameters

The adjustments of the controller will be set with the filter download. The filter downloads are available at: [www.keb.de/de/service/downloads](http://www.keb.de/de/service/downloads).

Parameter	Designation	Value range	Default value
Fr.10	load "mains" mot. dependent para.	0...3	0

*Table 8: Parameter operating state*

Fr.10	load "mains" mot. dependent para.	Parameter address	<b>0x090A</b>
Value range	Meaning		
0...3	By writing "1" to Fr.10, the current controllers and other parameter-dependent values such as, for example, the current limits are loaded (filter download list must be loaded before).		

### 5.4.1 Compensation of the reactive filter current

Parameter	Designation	Value range	Default value
nn.13	C-Filter [uF]	0 (OFF)...655.35	0 (OFF)

*Table 9: Parameter compensation of the reactive filter current*

nn.13	C-Filter [uF]	Parameter address	<b>0x140D</b>
Value range	Meaning		
0...3	The capacity value of the AFE filter is entered in this parameter. This determines the capacitor current of the AFE filter. The value corresponds to the selected filter downloads.		

### 5.4.2 Adjusting the switching frequency

Parameter	Designation	Value range	Default value
uF.11	Switching frequency	2/4/8/12/16 kHz	4 kHz

*Table 10: Parameter switching frequency*

uF.11	Switching frequency	Parameter address	<b>0x050B</b>
Value range	Meaning		
2/4/8/12/16	Setting of the clock frequency for the converter.		



The setting of the min. switching frequency is normally contained in the filter download. Check is required!

## ATTENTION

### Observe the min. switching frequency

Switching frequencies which are too low can result in resonances and destruction of the hardware! Always observe the technical data specified in the installation manual!

5.4.3 Setting the DC link voltage controller

Parameter	Designation	Value range	Default value
cS.06	KP DC link voltage	0...32767	300
cS.09	KI DC link voltage	0...32767	100
cS.25	DC link capacity (uF)	0.00... 10737418.23	LTK
cS.26	symmetrical optimum	1.9 (OFF), 2.0...15.0	1,9
ru.02	ramp output display	±32000	0
ru.11	active current setpoint display	±32000.00	0.00
ru.18	DC link voltage	0...1500	0

Table 11: Parameter DC-link voltage controller

The DC-link voltage controller is implemented as a PI controller with cS.06 as the proportional factor and cS.09 as the integral factor.

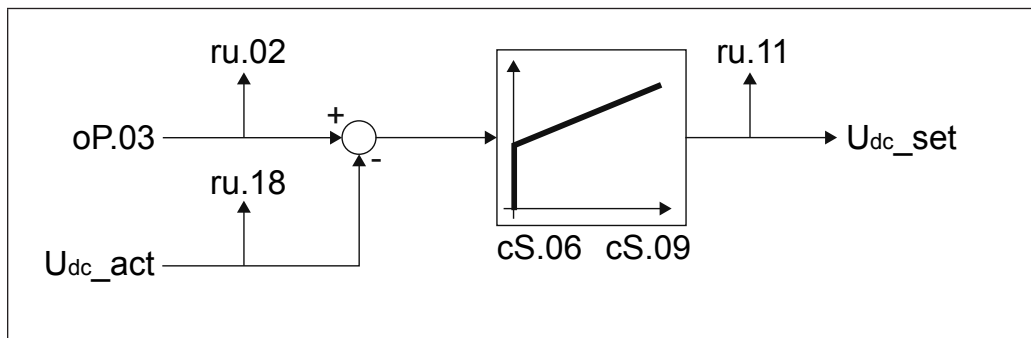


Figure 2: Principle of the DC-link voltage controller

Some units of the 6. generation contain the capacity value in its parameters which can be seen in COMBIVIS.

Should the DC link capacity be unknown, the following rule of thumb applies:

$$CDC \text{ link } [\mu\text{F}] \approx \text{rated current} \cdot 50$$

cS.06	KP DC link voltage	Parameter address	0x0F06
Value range	Meaning		
0... 32767	Adjustment of the P-component in the controller for the DC link voltage. The value is automatically calculated by writing cS.26 and can be adapted manually as required.		

cS.09	KI DC link voltage	Parameter address	<b>0x0F09</b>
Value range	Meaning		
0... 32767	Adjustment of the I-component in the controller for the DC link voltage. The value is automatically calculated by writing cS.26 and can be adapted manually as required.		

cS.25	DC link capacity (uF)	Parameter address	<b>0x0F19</b>
Value range	Meaning		
0.00... 10737418.23	Input of the DC link capacity of the entire system for AFE and other drive converters.		

cS.26	Symmetrical optimum	Parameter address	<b>0x0F1A</b>
Value range	Meaning		
1.9 (OFF), 2.0...15.0	The DC link controller cS.06 and cS.09 are calculated and adjusted to the symmetrical optimum by writing of value "20". Larger values result in a "softer" controller setting. Upon confirmation, the parameter is to be reset to 19.		
Values	Function		
19	Off		
20	Hardest setting		
21	Softest setting		

**ATTENTION****Observe the min. switching frequency**

By writing Fr.10, cS.25 is set to the factory settings and 20 is automatically calculated for cS.26. For this reason, first execute Fr.10, then enter the values for cS.25 and cS.26 !

ru.02	Ramp output display	Parameter address	<b>0x0202</b>
Value range	Meaning		
±32000	The displayed speed corresponds to the issued synchronous speed at the ramp output.		

ru.11	Active current setpoint display	Parameter address	<b>0x020C</b>
Value range	Meaning		
±32000.00	Display of the active current.		

ru.18	DC link voltage	Parameter address	<b>0x0212</b>
Value range	Meaning		
0...1500	Display of the actual DC link voltage.		

5.4.4 Presetting of the reactive mains current (inductive or capacitive)

Parameter	Designation	Value range	Default value
nn.01	Stabilisation current	±1500.0A	0.0A

*Table 12: Parameter reactive mains current*

nn.01	Stabilisation current	Parameter address	<b>0x1401</b>
Value range	Meaning		
2/4/8/12/16	This parameter specifies the reactive mains current. It can be used to indirectly preset the cos-phi value. For optimisation of parameter nn.13, the value of nn.01 should be 0A.		

5.4.5 Setting the dead time compensation

Parameter	Designation	Value range	Default value
uF.18	Dead time compensation mode	0...3	2

*Table 13: Parameter dead time compensation*

uF.18	Dead time compensation mode	Parameter address	<b>0x0512</b>
Value range	Meaning		
0...3	Depending on the operating mode, the dead time of the output stage can be optimised in various ways. Depending on the hardware and the line supply impedance, the ratio of harmonics (THDi) can be influenced by changing the value. The recommended setting is "0" = off.		
Values	Function		
0	off		
1	linear		
2	e-function		
3	automatic detection		

## 5.4.6 Load-shunt activation

**ATTENTION**

Incorrect settings may result in damage to the hardware !  
Observe the minimum times between two switch-on procedures !

After switching off the power supply, the discharging of the DC takes some minutes. If the power supply is switched on again during this discharging period, the load-shunt must be activated as long as the pre-charging contactor is activated.

To this end, an "external error" is generated below the switchover voltage for switching from pre-charging contactor to main contactor which activates the load-shunt:

Parameter	Designation	Value range	Default value
Pn.65	Special functions	0...65535	0
Pn.04	Input selection ext. error	0...4095	64
do.23	Condition selection for flag 7	0...255	128
do.32	Inverted flags for OD	0...255	0

*Table 14: Parameter load-shunt activation*

Pn.65	Special functions	Parameter address	<b>0x0441</b>
Value range	Meaning		
0...65535	Adjust load-shunt activation to value „2: Pn.04-E.UP“.		

Pn.04	Input selection ext. error	Parameter address	<b>0x0404</b>
Value range	Meaning		
0...4095	Use the load-shunt activation, adjust value „2112: I4+ID“.		

do.23	Condition selection for flag 7	Parameter address	<b>0x0C17</b>
Value range	Meaning		
0...255	Use the load-shunt activation, adjust value „1: SB0“.		

do.32	Inverted flags for OD	Parameter address	<b>0x0C20</b>
Value range	Meaning		
0...255	Use the load-shunt activation, adjust value „128: M7“.		

## 6 Additional Functions

### 6.1 Temperature monitoring of the AFE filter

The sensor type for the temperature evaluation can be adjusted in parameter Pn.62 depending on the AFE filter. In addition, the filter temperature can be output via the analogue output as a standard signal for further evaluation. Parameter An.31 must be set to value 13 "motor temp. (ru.46)".

Parameter	Designation	Value range	Default value
Pn.62	Filter- dOH warning level	0...200 °C	100 °C
Pn.72	set prog. spec. functions	0...1	0

*Table 15: Parameter compensation of the reactive filter current*

Pn.62	Filter- dOH warning level	Parameter address	0x043E
Value range	Meaning		
0...200 °C	A temperature in the range of 0...200 °C is defined in Pn.62 "motor overtemperature level". Overtemperature is displayed on exceeding.		

Pn.72	set prog. spec. functions	Parameter address	0x0448
Value range	Meaning		
0...200 °C	A temperature in the range of 0...200 °C is defined in Pn.62 "motor overtemperature level". Overtemperature is displayed on exceeding.		
Value	Function		
0: Motor sensor (AFE filter) = KTY	KTY monitoring is active.		
1: Motor sensor (AFE filter) = PTC	PTC monitoring is activ.		

#### ATTENTION

#### Digital output for temperature control

It is not allowed to use a digital output for temperature control without basic knowledge of the application because all digital outputs are assigned by default.



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