COMBIVERT

USA

INSTRUCTION MANUAL

CONTROL STAGE from version 2.3

00.F5.GUB-K260

STOP **Read instruction manual power stage first !**

KEB

05/2003

USA

This Instruction Manual describes the control circuit of the KEBCO COMBIVERT F5 Series Motor Control. It is only valid together with the Instruction Manual Power Stage. Both Instruction Manuals must be made available to the user. Prior to performing any work on the unit the user must familiarize himself with the unit. This includes especially the knowledge and observance of the **safety and warning information of the power stage**. The pictographs used in this Instruction Manual have following meaning:

Danger
Warning
Caution

Attention,
observe at
all costs

Information
Help
Tip

Table of Contents

1. Installation and Connection

1.1 Control Circuit: F5-GENERAL

X2A

1.1.1 Terminal Strip Connections

PIN	Function	Name	Description	
1	Analog input 1 +	AN1+	Differential voltage input for speed	resolution: 12 Bit
2	Analog input 1 -	AN1-	0...±10 VDC (0...± CP.11)	(B-housing: 11 Bit),
3	Analog input 2 +	AN2+	0...±10 VDC (0...±100 %)	scan time: 1 ms
4	Analog input 2 -	AN2-		
5	Analog output 1	ANOUT1	Analog output of the real speed	Voltage range: 0...±10V
			0...±10 VDC (0...±100 Hz)	Ri=100 kOhm, resolution: 12Bit
6	Analog output 2	ANOUT2	Analog output of the phase current	PWM frequency: 3,4 kHz
			0 ... 10 VDC (0 ... 2 x I_N)	filter response 1. order: 178 Hz
7	+10V Output	CRF	Analog supply voltage for speed ref.	+10 VDC +5%, max. 4 mA
8	Analog Common	COM	Common for analog in- and outputs	
9	Analog Common	COM	Common for analog in- and outputs	
10	Fixed frequency 1	I1	I1+I2 = Fixed frequency 3 (default: 70 Hz)	
11	Fixed frequency 2	I2	no input = analog voltage (speed) ref.	
12	External fault	I3	Input for external fault stopping mode	
13	DC-braking	I4	Activates the DC-braking	Ri = 2.1 kOhm
14	Forward	F	Preset rotation;	scan time: 1 ms
15	Reverse	R	Forward has priority	
16	Control release, Reset	ST	Inverter enable, disable;	
			Error Reset at opening	
17	Reset	RST	Reset; only useable when an error occurs	
18	Speed dependent	O1	Transistor output frequency switched at $f_{actual} = f_{set}$	
19	Ready signal	O2	Transistor output switched, as long as no error occurs	
20	24V-Output	V_{out}	Approx. 24V output (max.100 mA)	
21	20...30V-Input	V_{in}	Voltage input for external supply	
22	Digital Common	0V	Common for digital in-/outputs	
23	Digital Common	0V	Common for digital in-/outputs	
24	Relay 1, NO contact	RLA	Relay output; fault relay (default);	
25	Relay 1, NC contact	RLB	Function can be	
26	Relay 1, switching contact	RLC	changed with CP.31	max. 30 V DC, 1 A;
27	Relay 2, NO contact	FLA	Relay output;	
28	Relay 2, NC contact	FLB	frequency dependent switch (default);	
29	Relay 2, switching contact	FLC	Function can be changed with CP.32	

1.1.2 Connection of the control signals

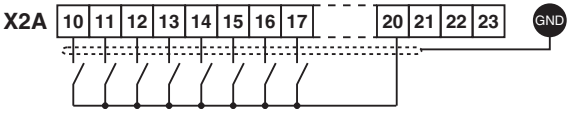
In order to prevent a malfunction caused by interference voltage supply on the control inputs, the following steps should be observed:

- Establish a true earth ground for all ground connections.
- Use shielded cable with twisted pair wires.
- Terminate shield wires to earth ground, only at inverter.
- Separate control and power wires 8" or more apart.
- Control and power wires to cross at a right angle.

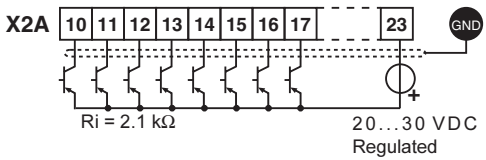
EMC

1.1.3 Digital Inputs

Use of **internal** voltage supply



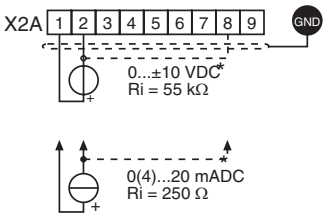
Use of **external** voltage supply



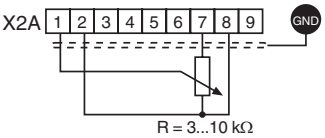
1.1.4 Analog Inputs

Connect unused analog inputs to common to eliminate noise signals!

External analog speed ref. setting



Internal analog speed ref. setting (see CP.35)

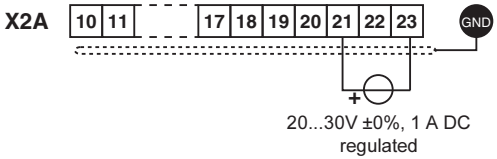


EMC

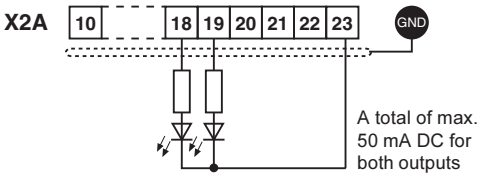
*) Generally when using multiple units, connect the commons (pins 2, 8) only if a potential difference between them is greater than 30 Vdc.

1.1.5 Voltage Input / External Power Supply

The supply to the control circuit through an external voltage source keeps the control in operational condition even if the power stage is switched off. To prevent undefined conditions (false triggering), first switch on the power supply than the inverter.

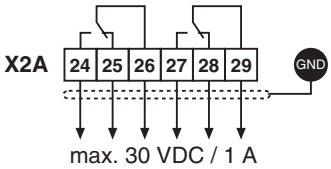


1.1.6 Digital Outputs

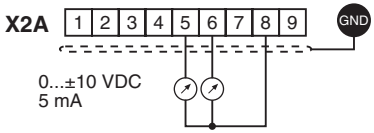


1.1.7 Relay Outputs

In case of inductive load on the relay outputs, protective wiring must be provided (e.g. free-wheeling diode, see figure in section 1.2.6)!

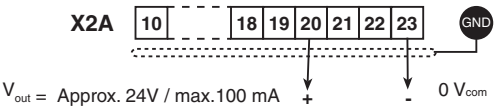


1.1.8 Analog Outputs



1.1.9 Voltage Output

The voltage output serves for setting the digital inputs as well as for the supply of external control elements. Do not exceed the maximum output current of 100 mA. This output is short circuit protected.



1.2 Control Circuit: F5-BASIC

X2A

1.2.1 Terminal Strip Connections

PIN	Function	Name	Description	
1	± Analog input 1	AN1	Voltage input for speed 0...±10 VDC ^ 0...±CP.11	resolution: 11 Bit, scan time: 2 ms
5	Analog output 1	ANOUT1	Analog output of the real speed 0...±10 VDC ^ 0...±100 Hz	voltage range: 0...±10V Ri = 100 kΩ, resolution: 12bit
7	+10V Output	CRF	Analog supply voltage for speed ref.	+10 VDC +5%, max. 4 mA
8	Analog Common	COM	Common for analog In- and Outputs	
10	Fixed frequency 1	I1	I1 + I2 = Fixed frequency 3;	
11	Fixed frequency 2	I2	no input = analog voltage (speed) ref.	
14	Forward	F	Preset rotation;	Ri = 2.1 k Ohm
15	Reverse	R	Forward has priority	scan time: 2 ms
16	Control release, Reset	ST	Inverter enable, disable; Error Reset at opening	
20	24V-Output	V_{out}	Approx. 24V Output (max.100 mA)	
22	Digital Common	0V	Common for digital In-/Outputs	
24	Relay 1, NO contact	RLA	Relay output; fault relay(default)	
25	Relay 1, NC contact	RLB	Function can be	
26	Relay 1, switching cont.	RLC	changed with CP.31; max. 30 V DC, 1 A	
27	Relay 2, NO contact	FLA	Relay output;	
28	Relay , NC contact	FLB	frequency dependent switch (default);	
29	Relay 2, switching cont.	FLC	Function can be changed with CP.32; max. 30 V DC, 1 A	

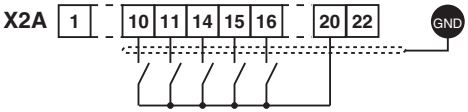
1.2.2 Connection of the control signals

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

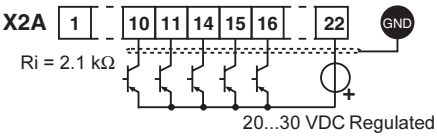
- Establish a true earth ground for all ground connections.
- Use shielded cable with twisted pair wires.
- Terminate shield wires to earth ground, only at inverter.
- Separate control and power wires 8" or more apart.
- Control and power wires to cross at a right angle.

1.2.3 Digital Inputs

Use of **internal** voltage supply

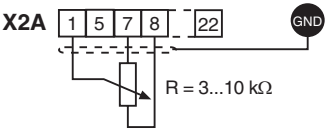


Use of **external** voltage supply

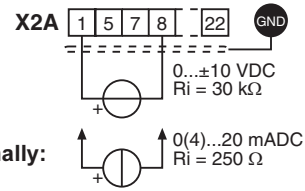


1.2.4 Analog Inputs

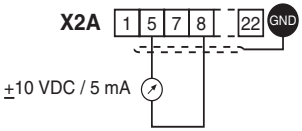
Internal analog speed ref. setting



External analog speed ref. setting

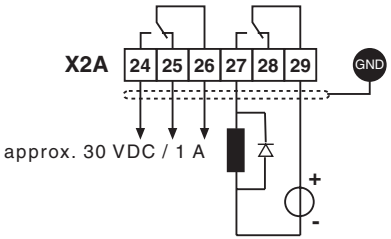


1.2.5 Analog Output



1.2.6 Relay Outputs

In case of inductive load on the relay output, protective wiring must be provided (e.g. free-wheeling diode)!

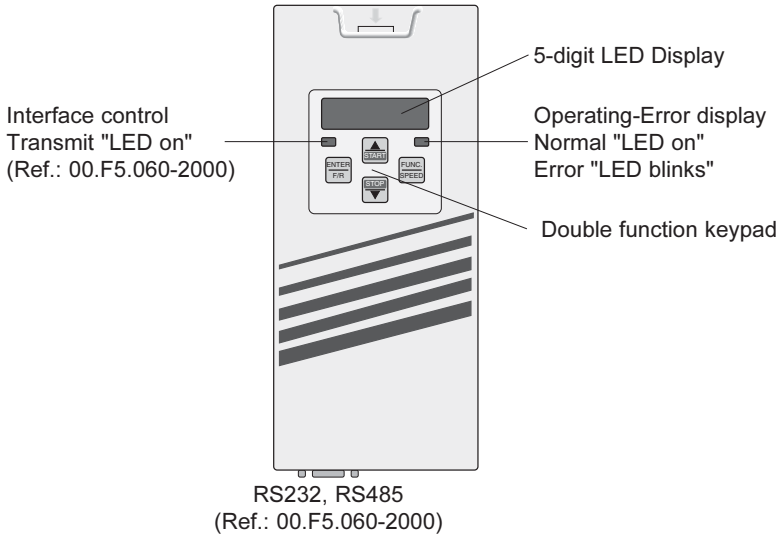


2. Operation of the inverter

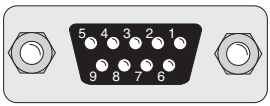
As an accessory for displaying and editing "CP" parameter values, a "digital operator" is necessary. To remotely mount the digital operator, a operator remote cable is required (option: cable 00.F5.0C0-1xxx). To prevent malfunctions, the inverter must be brought into ***nOP*** status *(remove signal from control release terminal 16)* before connecting / disconnecting the operator. When starting the inverter without an operator, it is started with the last stored values.

2.1 Digital Operator

Standard Operator: Part No. 00.F5.060-1000
Serial Operator: Part No. 00.F5.060-2000



Only use the **operator interface** for the serial data transfer to RS232, 485. The direct connection from PC to the inverter is only valid with a **special cable (HSP5 Part No. 00.F5.0C0-0001)**, otherwise it will lead to the destruction of the PC-interface.



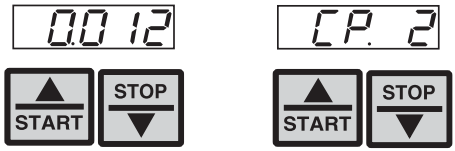
PIN	RS485	Signal	Meaning
1	–	–	reserved
2	–	TxD	Transmitter signal, RS232
3	–	RxD	Receiver signal, RS232
4	A'	RxD-A	Receiver signal A, RS485
5	B'	RxD-B	Receiver signal B, RS485
6	–	VP	Voltage supply-Plus +5V (I_{max} = 10 mA)
7	C, C'	DGND	Data reference potential
8	A	TxD-A	Transmitter signal A, RS485
9	B	TxD-B	Transmitter signal B, RS485

2.1.1 Keypad

When switching on the KEB COMBIVERT F5, the value of parameter CP.1 appears in the operator display. (see "Drive Mode" to switch the keypad function)

The **function key** (FUNC) changes between the parameter value and parameter number.

With **UP** and **DOWN**, the value of the parameter number is increased/decreased.



Generally; when a value is changed, parameter values are immediately accepted and stored non-volatile. However, with some parameters it is not useful that the adjusted value is accepted immediately. In these cases (CP.17, CP.18, CP.22, CP.26, CP.29, CP.31, CP.32, CP.34, CP.35) the adjusted value is accepted an stored non-volatile by pressing **ENTER**.

If a drive fault occurs during operation, the current display changes to the drive fault message. The drive fault message in the display is cleared by pressing **ENTER**.

Pressing **ENTER** only clears the fault message in the display. In the Inverter status display (CP. 3), the fault is still displayed until the inverter has been reset. In order to reset the fault itself the cause must be identified and removed, than a reset signal applied to terminal 17 {terminal 16, F5-Basic} or a power-on reset (cycle supply voltage off and then on) must occur.

2.2 Parameter Summary

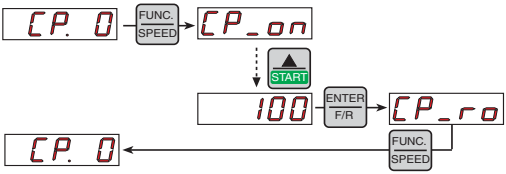
Display	Parameter	Setting range	Resolution	Factory setting
CP. 0	Password input	0...9999	1	–
CP. 1	Actual frequency display	–	0.0125 Hz	–
CP. 2	Set frequency display	–	0.0125 Hz	–
CP. 3	Inverter status display	–	–	–
CP. 4	Phase current	–	0.1 A	–
CP. 5	Phase current, Peak value	–	0.1 A	–
CP. 6	Actual load	–	1 %	–
CP. 7	Actual DC voltage	–	1 V	–
CP. 8	Actual DC voltage, Peak value	–	1 V	–
CP. 9	Output voltage	–	1 V	–
CP.10	Minimal frequency	0…400 Hz	0.0125 Hz	0 Hz
CP.11	Maximal frequency	0…400 Hz	0.0125 Hz	70 Hz
CP.12	Acceleration time	0.01…300.00 s	0.01 s	5.00 s
CP.13	Deceleration time(-1 see CP.12)	-1; 0.01…300.00 s	0.01 s	5.00 s
CP.14	S-curve time	0.00 (off)…5.00 s	0.01 s	0.00 s (off)
CP.15	Torque boost	0.0…25.5 %	0.1 %	2.0 %
CP.16	Rated frequency	0…400 Hz	0.0125 Hz	50 Hz
CP.17 [1)]	Voltage stabilization	1…650 V (off)	1 V	650 (off)
CP.18 [1)]	Carrier frequency	2/4/8/12/16 kHz	–	– [2)]
CP.19	Fixed frequency 1	-400...400 Hz	0.0125 Hz	5 Hz
CP.20	Fixed frequency 2	-400...400 Hz	0.0125 Hz	50 Hz
CP.21	Fixed frequency 3	-400...400 Hz	0.0125 Hz	70 Hz
CP.22 [1)]	DC-braking, Mode	0…9	1	7
CP.23	DC-braking, Time	0.00…100.00 s	0.01 s	10.00 s
CP.24	Max. ramp current	0…200 %	1 %	140 %
CP.25	Max. constant current	0…200 % (off)	1 %	200 % (off)
CP.26 [1)]	Speed search condition	0…15	1	8
CP.27	Quick stop time	0.00…300.00 s	0.01 s	2.00 s
CP.28	Response of ext. overtemperature	0…7	1	7
CP.29 [1)]	Analog output 1	0…12...20 {F5G}	1	2
CP.30	Analog output 1, Amplification	-20.00…20.00	0.01	1.00
CP.31 [1)]	Relay output 1	0…75	1	4
CP.32 [1)]	Relay output 2	0…75	1	27
CP.33	Relay output 2, Switching level	±30000.00	0.01	4.00
CP.34 [1)]	Source of rotation direction	0…9	1	2
CP.35 [1)]	AN1 interface selection	0…2	1	0
CP.36	AN1 zero point hysteresis	-10.0…10.0 %	0.1 %	0.2 %

1) Enter-Parameter
2) depending on power circuit

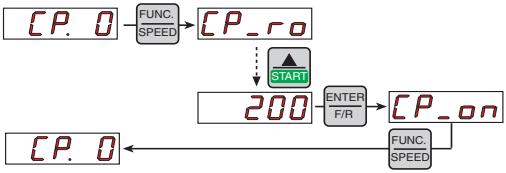
2.3 Password Input

From the factory, the frequency inverter is supplied without password protection, this means that all parameters can be adjusted. After programming, the unit can be protected against unauthorized access thus preventing the values from being changed.

Locking the CP-Parameters (Read only)



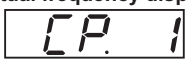
Releasing the CP-Parameters (Read & Write)



2.4 Operating Display

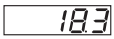
The parameters below serve for thecontrolling of the frequency inverter during operation.

Actual frequency display

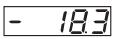


Display of the actual output frequency with a resolution of 0.0125 Hz. The digital operator will display "noP" or "LS" if the control release (terminal 16) or the direction of rotation (terminal 14 or 15) are not energized (see CP.3). The rotation of the motor is indicated by the sign.

Examples:

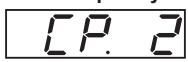


Output frequency 18.3 Hz, rotation forward



Output frequency 18.3 Hz, rotation reverse

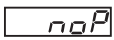
Set frequency



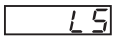
Display of actually set frequency. The indication is done in the same manner as at CP.1. For control reasons the set frequency is displayed even if control release or direction of rotation are not switched. If no direction of rotation is set, the set frequency for clockwise rotation (forward) is displayed.

Inverter status display

The status display shows the actual working conditions of the inverter. Possible displays and their meanings are:



"no Operation" control release (terminal 16) signal removed, modulation off, output voltage = 0 V, drive is disabled.



" Low Speed " no direction signal at F or R (terminal 14 or 15), modulation off, output voltage = 0 V.

FAcc	"Forward Acceleration" drive accelerates with direction of rotation forward .
FdEc	"Forward Deceleration" drive decelerates with direction of rotation forward.
rAcc	"Reverse Acceleration" drive accelerates with direction of rotation reverse.
rdEc	"Reverse Deceleration" drive decelerates with direction of rotation reverse.
Fcon	"Forward Constant" drive runs with a constant speed and direction of rotation forward.
rcon	"Reverse Constant" drive runs with constant speed and direction of rotation reverse.

Other status messages; such as error(E.xxx) and malfunction (A.xxx) codes, are described towards the end of this manual.

Phase current

CP. 4

Display of the actual real-time running current in ampere, during an index or at dwell (see CP.5).

Phase current / Peak value

CP. 5

CP.5 makes it possible to display the max. real-time current within an operating cycle. The highest value of CP.4 is stored in CP.5. The peak value in memory can be cleared by pressing the"UP, DOWN or ENTER" key or by writing via serial communication any value you like to the address of CP.5. Switching off the inverter also clears the memory.

Actual load utilization

Display of the actual inverter loading in percent. 100% rate of utilization is equal to the inverter rated current. Only positive values are displayed, meaning there is no differentiation between motor and regenerative operation.

Intermediate circuit voltage

CP. 7

Display of actual DC voltage in volt.
Typical values:

V-class	Normal operation	Over volt. (E.OP)	Under volt. (E.UP)
230 V	300…330 V DC	approx. 400 V DC	approx. 216 V DC
460 V	530…700 V DC	approx. 800 V DC	approx. 240 V DC

Actual DC voltage/Peak value

CP. 8

This display makes it possible to recognize instantaneous voltage peaks within an operating cycle. The highest value of CP.7 is stored in CP.8.

The peak value in memory can be cleared by pressing the UP, DOWN or ENTER key or by writing any value you like to the address of CP.8. Switching off of the inverter also clears the peak value.

Output voltage

CP. 9

Display of the actual output voltage in volts.

2.5 Basic Adjustment of the Drive

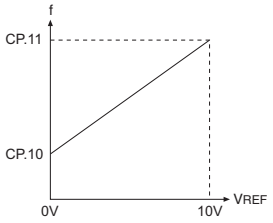
The following parameters determine the fundamental operating data of the drive. They should be checked and/or adjusted for the application.

Minimum frequency

CP.10

The frequency the inverter outputs with 0V applied to the analog input or if the activated fixed frequency (CP.19…CP.21) is lower than this value.

Adjustment range:	0...400 Hz
Resolution:	0.0125 Hz
Factory setting:	0.0 Hz



Maximum frequency

CP.11

The frequency the inverter outputs with 10V applied to the analog input or if the activated fixed frequency (CP.19…CP.21) is greater than this value.

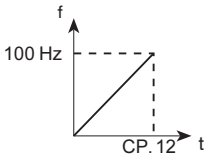
Adjustment range:	0...400 Hz
Resolution:	0.0125 Hz
Factory setting:	70 Hz

Acceleration time

CP. 12

The parameter determines the time needed to accelerate from 0 Hz to 100 Hz. The actual acceleration time is proportional to the frequency change.

$$\frac{100\ \text{Hz}}{\text{delta f}} \times \text{actual acceleration time} = \text{CP.12}$$



Adjustment range:	0.01...300.00 s
Resolution:	0.01 s
Factory setting:	5.00 s

Example: actual acceleration time = 5s; the drive should accelerate from 10 Hz to 60 Hz., delta f = 60 Hz - 10 Hz = 50 Hz

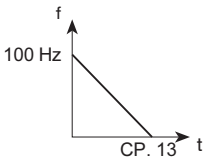
CP.12 = (100 Hz / 50 Hz) x 5 s = 10 s

Deceleration time

CP. 13

The parameter determines the time needed to decelerate from 100 Hz to 0 Hz. The actual deceleration time is proportional to the frequency change.

$$\frac{100\ \text{Hz}}{\text{delta f}} \times \text{actual deceleration time} = \text{CP.13}$$



Adjustment range:	-1; 0.01...300.00 s
Resolution:	0.01 s
Factory setting:	5.00 s

By depressing DOWN arrow key, one increment passed the 0.0 time will display "**=Acc**". This is the same value stored in CP.12 (Decel=Accel time)!

Example: actual deceleration time = 5s; the drive should decelerate from 60 Hz to 10 Hz. delta f = 60 Hz - 10 Hz = 50 Hz

CP.13 = (100 Hz / 50 Hz) x 5 s = 10 s

S-curve time

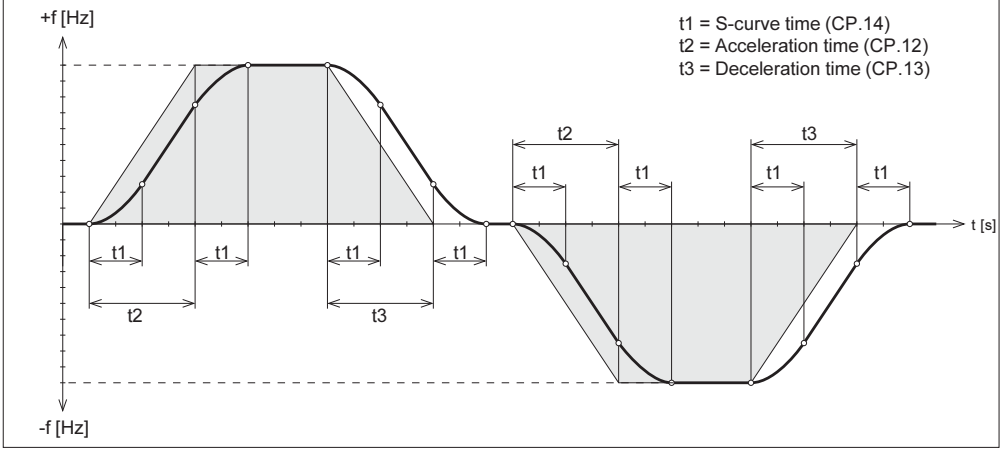
CP. 14

For some applications it is advantageous when the drive starts and stops jerk-free. This is achieved by modifying the acceleration and deceleration ramps. This modification time; also called S-curve time, can be adjusted with CP.14.

Adjustment range:	0.00 (off)...5.00 s
Resolution:	0.01 s
Factory setting:	0.00 s (off)

In order to define the ramps with the activated S-curve time, the acceleration and deceleration times (CP.12 and CP.13) must be adjusted higher than the S-curve time (CP.14).

Ramp adjustment with S-curves

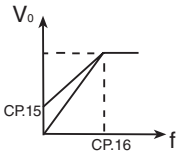


Boost

CP. 15

In the lower speed range losses in the motor become greater. This parameter can be used to boost the voltage in order to overcome these losses. With proper adjustment, the torque output of the motor will remain constant even at the lowest speeds.

Adjustment range:	0.0...25.5 %
Resolution:	0.1 %
Factory setting:	2.0 %



Adjustment:
- Determine the rate of utilzation (CP.6) in no-load operation with rated frequency.
- Preset about 10 Hz and adjust the torque boost, so that about the same rate of utilization (CP.6) is reached as with the rated frequency.

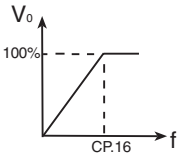
During continuous operation; if the motor operates at low speed and to much voltage, it can lead to overheating of the motor.

Rated frequency

CP. 16

The inverter produces maximum voltage to the motor at the frequency set in this parameter. This parameter is typically adjusted for the motor rated frequency. **Note: Motors can overheat when the rated frequency is incorrectly adjusted!**

Adjustment range:	0...400 Hz
Resolution:	0.0125 Hz
Factory setting:	60 Hz



2.6 Special Adjustments

The following parameters serve for the optimization of the drive and the adaption to certain applications. These adjustments can be ignored at the initial startup.

Voltage stabilization

CP.17

This parameter can be used to regulate the output voltage in relation to the rated frequency. With this function active, voltage variations at the input as well as in the DC bus will have only a small influence on the output voltage (V/Hz-characteristic). This function can be used to adapt the output voltage for special motors.

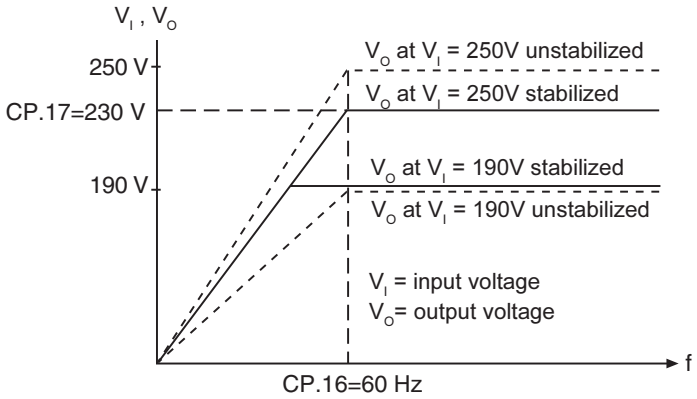
Adjustment range:	1...650 V (off)
Resolution:	1 V
Factory setting:	650 V (off)
Note:	Enter-Parameter

In the example below with a motor rated at 230 V / 60Hz, the output voltage is unstabilized due to our supply being 250 V and CP.17 off. By setting CP.17 to the correct rated motor voltage of 230 V, we have clamped the voltage thereby given the motor the correct V /Hz curve. This parameter will prevent possible motor damage, do to the extra voltage onto the motor for any given speed.

With the incoming supply of 190 V and CP.17=230 V, the motor will still follow the the correct V/Hz curve. With the slope (V/Hz) being constant, our speed at 190 V will be calculated as follows:

f = (60Hz/ 230 V)*190 V= 50 Hz

* Both senarios above, we have assummed no boost (CP.15=0%).



Carrier frequency

The switching frequency; with which the power modules are clocked, can be changed depending on the application. The employed power stage determines the maximum switching frequency as well as the factory setting ("Power Stage Manual", Part 2). Refer to following list to learn about influences and effects of the switching frequency.

Low Switching Frequency	High Switching Frequency
• Less inverter heating • Less H.F. ground current • Less switching losses • Less radio interferences • Improved concentricity at low speed	• Less audible noise produced • Improved sine-wave simulation • Less motor losses

Adjustment range:	2/4/8/12/16 kHz
Factory setting:	depending on power circuit
Note:	Enter-Parameter

At switching frequencies above 4 kHz pay absolute attention to the max. motor line length in the "Technical Data" of the "Power Stage Manual" (Part 2).

Fixed frequency 1...3

Three fixed frequencies can be adjusted. The fixed frequencies are selected with the inputs I1 (terminal 10), I2 (terminal 11) and I1 + I2.

Input I1

Input I2

Input I1 and I2

Adjustment range:	-400...400 Hz
Resolution:	0.0125 Hz
Factory setting, CP.19:	5 Hz
Factory setting, CP.20:	50 Hz
Factory setting, CP.21:	70 Hz

If the adjusted values are outside of the fixed limits of CP.10 and CP.11, then the actual run frequency is internally limited to the values of CP.10 and CP.11. The negative rotation values (i.e. -50Hz) are only available in the "application mode". The rotation source of the fixed frequencies is not changed by CP.34, it always corresponds to CP.34 = 2 (Fwd/Rev direction selectable by terminal 14 or 15).

DC-braking Mode

CP.22

During DC-braking, the motor is not decelerated by a controlled ramp. Quick braking without regen voltage can be achieved by applying a DC voltage to the motor winding. Parameter values; listed below, determine how the DC-braking is triggered.

Value	DC-Braking Activation
0	Deactivated
1	Activates when direction signal is removed and the output frequency has reached 0Hz. The braking time is dependent on CP.23 or until the next direction of rotation.
2*	Activates as soon as the direction signal is removed.
3*	Activates as soon as the direction signal is removed or changes.
4*	Activates as soon as the direction signal is removed and if the real frequency goes below 4 Hz.
5*	Activates when the real frequency goes below 4 Hz.
6*	Activates as soon as the set value goes below 4 Hz.
7*	Activates when input I4(terminal 13) is switched.
8	Activates as long as input I4 is switched.
9	Activates before the acceleration ramp when a direction signal is given. The time is dependent on CP.23.

* Braking time depends on the actual frequency.

Adjustment range:	0...9
Resolution:	1
Factory setting:	7
Note:	Enter-Parameter

DC-braking Time

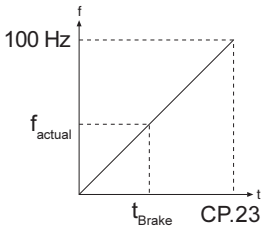
CP.23

If the braking time depends on the actual frequency (CP.22 = 2...7), it is calculated as follows:

$$t_{Brake} = \frac{CP.23 \times f_{real}}{100\ Hz}$$

Otherwise the braking time corresponds to CP.23.

Adjustment range:	0.00...100.00 s
Resolution:	0.01 s
Factory setting:	10.00 s



Max. ramp current

CP.24

This function acts as an adjustable current limit during acceleration or deceleration. It can be used to prevent the load current from exceeding the inverters peak current rating, thereby preventing shut down of the inverter with an E.OC fault. When the load level reaches the adjusted value, the acceleration or deceleration is stopped until the load drops below the adjusted value. CP.3 displays "LAS" when the function is active.

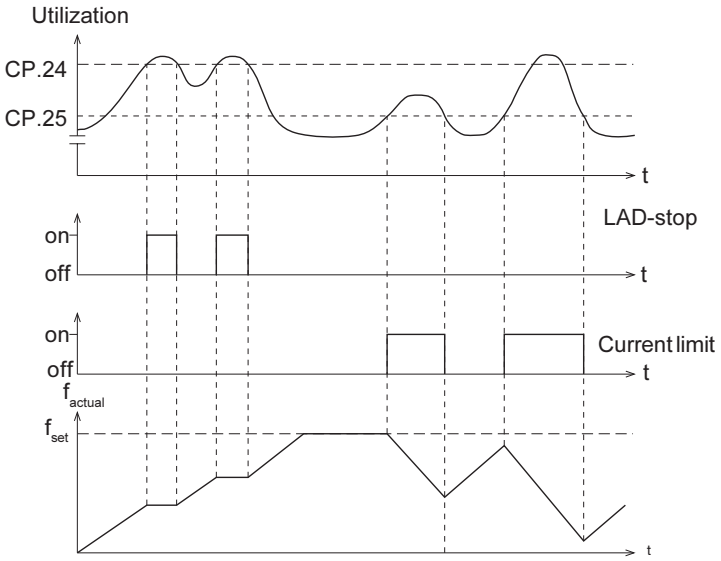
Adjustment range:	0...200 %
Resolution:	1 %
Factory setting:	140 %

Max. constant current

CP.25

This function acts as an adjustable current limit when operating at a constant speed. It can be used to prevent the load current from exceeding the inverters over current level, thereby preventing shut down of the inverter with an E.OC fault. When the load level reaches the adjusted value, the output frequency is reduced until the load drops below the adjusted value, after which the frequency is increased again to the previous value. CP. 3 displays "SSL" when the function is active.

Adjustment range:	0...200 % (off)
Resolution:	1 %
Factory Setting:	200 % (off)



Speed search condition

CP.26

When starting the frequency inverter into a spinning motor, an E.OC fault can be triggered because of the difference between the actual motor speed and the inverter set speed. By activating speed search, the inverter searches for the actual motor speed, adjusts its output frequency to match. It will then accelerate with the adjusted ramp time to the given set value. During speed search CP.3 displays "SSF". This parameter determines under which conditions the function will operate. Parameter values can be selected individually or any combinations.

Example: CP.26=12 means after reset **and** after auto-restart (E.UP).

Value	Condtion
0	Function off
1	Control release enabled (terminal 16)
2	Power on
4	After fault reset
8	After auto-restart (reset) E.UP

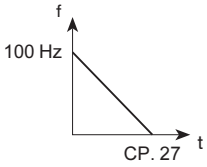
Adjustment range:	0...15
Resolution:	1
Factory setting:	8
Note:	Enter-Parameter

Quick stop time

CP.27

The fast-stop function is activated depending on CP.28. This parameter determines the time needed to decelerate from 100 Hz to 0 Hz. The actual deceleration time is proportional to the frequency change. The response to overtemperature (CP.28) is disabled in the factory default setting. If it is activated, the modulation switches off automatically after 10 s if the motor is still too hot.

$$\frac{100\ \text{Hz}}{\text{delta f}} \times \text{actual deceleration time} = \text{CP.27}$$



Adjustment range:	0.00...300.00 s
Resolution:	0.01 s
Factory setting:	2.00 s

Example: actual deceleration time = 5s; the drive should decelerate from 50 Hz to 0 Hz. delta f = 50 Hz - 0 Hz = 50 Hz

CP.27 = (100 Hz / 50 Hz) x 5 s = 10 s

Response to external overtemperature

This parameter determines the response of the drive to the external temperature monitoring circuit. In order to activate this function, the power circuit terminals T1, T2 must be connected in accordance with the instructions in the power stage manual. Next, select the response desired according to following table:

Factory setting = off

If overheat error no longer exists, the message E.ndOH (or A.ndOH) is displayed. Only then can the error be reset or the automatic restart initiated.

CP.28	Display	Response	Solution
0	E.dOH	Immediate disabling of modulation	Remove fault; Actuate reset
1*	A.dOH	Quick stopping, disabling of modulation after reaching speed 0	
2*	A.dOH	Quick stopping,holding torque at speed 0	
3	A.dOH	Immediate disabling of modulation	Automatic reset, if the fault is no longer present
4*	A.dOH	Quick stopping, disabling of modulation after reaching speed 0	
5*	A.dOH	Quick stopping, holding torque at speed 0	
6*	none	No effect on the drive; With CP.31, 32=9 an external module can be controlled (e.g. fan)	- inapplicable -
7	none	No effect on the drive; **!Fault do not exists!** External Temperature monitoring is not activated	

*) If the motor is still too hot after 10 seconds, the error E.dOH is triggered and the modulation is switched off!

Adjustment range:	0...7
Resolution:	1
Setting range:	7

Analog ouput 1

CP.29

CP.29 defines the function of analog output 1.

Value	Function	
0	Absolute actual frequency (CP.1)	100Hz = 100%
1	Absolute set frequency (CP.2)	100Hz = 100%
2	Actual frequency (CP.1)	±100Hz = 100%
3	Set frequency (CP.2)	±100Hz = 100%
4	Output voltage (CP.9)	500V = 100%
5	Actual DC voltage (CP.7)	1000V = 100%
6	Phase current (CP.4)	2 x inverter rated current = 100%
7	Active current	± 2 x inverter rated current = 100%
8	Digital	±100Hz = 100%
9	External PID output	±100Hz = 100%
10	Absolute external PID output	100Hz = 100%
11	Absolute active current	2 x inverter rated current = 100%
12	Power module temperature	100 °C = 100%
13	Motor temperatue {F5G}	150 °C = 100%
14	Actual torque {F5G}	
15	Absolute actual torque {F5G}	
16	Reference torque {F5G}	
17	Absolute reference torque {F5G}	
18	Regulator difference {F5G}	
19	Reference frequency {F5G}	±140Hz = 100%
20	Absolute reference frequency {F5G}	140Hz = 100%

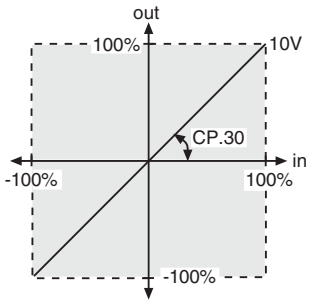
Adjustment range:	0...12
Resolution:	1
Factory setting:	2
Note:	Enter-Parameter

Analog output 1 Amplification

CP.30

With the amplification (gain), the output voltage of the analog output can be tuned with respect to the signal. An amplification of 1 corresponds to ± 100 % = ±10 V.

Adjustment range:	-20.00...20.00
Resolution:	0.01
Factory setting:	1.00



Setting aid:
CP.30 = 1.43, the analog output shall give out +10 V at 70 Hz instead at 100 Hz:

$$CP.30 = \frac{100\ Hz}{70\ Hz} = 1.43$$

Relay output 1

Relay output 2

CP.31 and CP.32 determine the function of the two outputs.
CP.31 for relay output 1 (terminal X2A.24...X2A.26)
CP.32 for relay output 2 (terminal X2A.27...X2A.29)

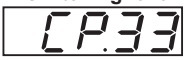
The switching level of CP.32 is CP.33!

Value	Function
0	No function
1	On; active when unit has voltage applied to it
2	Run signal; also by DC-braking
3	Ready signal (no error)
4	Fault relay
5	Fault relay (no auto-reset)
6	Warning or error message at abnormal stopping
7	Overload alert signal
8	Overtemperature alert signal power modules
9	External Overtemperature alert signal motor
10	Electronic motor protection tripped (OH2)
11	Overtemperature alert signal within inverter interior (OHI)
12	Cable breakage on analog input 1 (4...20 mA)
13	Cable breakage on analog input 2 (4...20 mA) {F5G only}
14	Max. constant current (stall, CP.25) exceeded
15	Max. ramp current (LA-Stop CP.24) exceeded
16	DC-braking active
17	Power off
18	Motor brake control
19	PID control difference > switching level {F5G only}
20	Actual value=set value (CP.3=Fcon, rcon; not at noP, LS error,SSF)
21	Accelerate (CP.3 = FAcc, rAcc, LAS)
22	Decelerate (CP.3 = FdEc, rdEc, LdS)
23	Actual direction of rotation = set direction of rotation
24	Actual load utilization (CP.6) > 100%
25	Active current > switching level
26	Actual DC voltage (CP.7)> switching level
27	Actual frequency (CP.1) > switching level
28	Set frequency (CP.2) > switching level
29	Ref. point run complete {F5G only}
30	Actual torque > level {F5G only}
31	Absolute speed on AN1 > switching level
32	Absolute speed on AN2 > switching level {F5G only}
33	Absolute. speed on AN3 > switching level {F5G only}
34	Set value on AN1 > switching level
35	Set value on AN2 > switching level {F5G only}
36	Set value on AN3 > switching level {F5G only}

Value	Function
37	Timer 1 > switching level
38	Timer 2 > switching level
39	Angular difference > switching level {F5G only}
40	Hardware current limit active
41	Modulation on-signal
42	ANOUT3 PWM
43	ANOUT4 PWM {F5G only}
44	Inverter status (ru.0) = switching level
45	Power transistor temperature > switching level
46	Motor temperature > switching level
47	Ramp output > switching level
48	Phase current > switching level
49	Rotation forward
50	Rotation reverse
51	OL2 warning {F5G only}
52	Reserved {F5M}
53	Reserved {F5M}
54	Reserved {F5M}
55	Reserved {F5M}
56	Reserved {F5M}
57	Reserved {F5M}
58	Reserved {F5M}
59	Digital input (ru.22} "AND" > switching level
60	Digital input (ru.22} "OR" > switching level
61	Digital input (ru.22} "NAND" > switching level
62	Digital input (ru.22} "NOR" > switching level
63	Absolute value ANOUT1 > switching level
64	Absolute value ANOUT2 > switching level {F5G only}
65	ANOUT1 > switching level
66	ANOUT2 > switching level {F5G only}
67	Reserved {F5M}
68	Reserved {F5M}
69	Reserved {F5M}
70	Driver voltage aktiv (safety relais)
71	Reserved {F5M}
72	Reserved {F5M}
73	Absolute value active power > switching level
74	active power > switching level
75	Reserved {F5M}

Factory setting CP.31:	4
Factory setting CP.32:	27
Note:	Enter-Parameter

Relay output 2 Switching level



This parameter determines the switching point for the relay output 2 (CP.32). After the switching of the relay, this value can move within a 0.5 Hz window (hysteresis), without the relay changing states. Since the operator display can only view 5 characters, the last digits are not displayed for the higher values.

Adjustment range:	-30000.00...30000.00
Resolution:	0.01
Factory setting:	4.00
Hysteresis:	
Frequency:	0.5 Hz
Actual DC voltage:	1 V
Analog set value:	0.5 %
Active current:	0.5 A

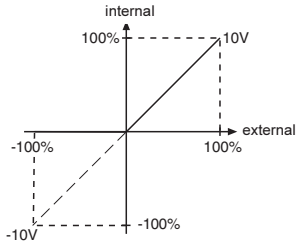
Source of rotation direction

The source rotation setting and the mode of evaluating the rotation setting is defined with this parameter (Enter-Parameter). With CP.34 one does not modify the rotation source of the fixed frequencies (CP.19... 21).

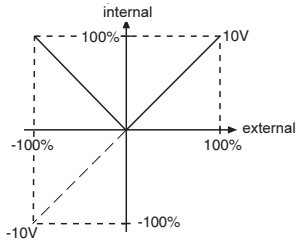
Value	Function
0*	Programmed digital direction {0-Limited}.
1*	Programmed digital direction {Absolute}.
2	Selection by forward /reverse terminal 14 or 15 {0-Limited} {factory default setting}.
3	Selection by forward /reverse terminal 14 or 15 {Absolute}.
4	Selection of run /stop by use of the forward /reverse terminal 14 or 15 {0-Limited}.
5	Selection of run /stop by use of the forward /reverse terminal 14 or 15 {Absolute}.
6	Set value dependent, positive value - clockwise rotation; negative value-counterclockwise rotation; with set value "0" it is switched into status "Low speed" (LS).
7	Set value dependent, positive value - clockwise rotation; clockwise rotation is indicated.
8	Direction set via serial bus communication {0-Limited}.
9	Direction set via serial bus communication {Absolute}.

{0-Limited}: Negative speed values are set to zero (see figure).
{Absolute}: Positive or negative speed values have no effect on the direction of rotation (see figure).
{ * }: In "application mode" see parameter "op.2".

Set value
0-limited
(Value 2 and 4)



Set value
absolute
(Value 3 and 5)



Adjustment range:	0...9
Resolution:	1
Factory setting:	2
Note:	Enter-Parameter

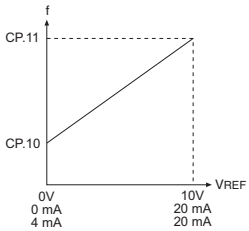
AN1 Interface selection

CP.35

The set value input 1 (AN1) can respond to various types of signals. In order to correctly evaluate the signal, this parameter must be adapted to the signal source.

Value	Analog reference signal
0	0...±10 V DC, Ri=56 kOhm
1	0...±20 mA DC, Ri=250 Ohm
2	4...20 mA DC, Ri=250 Ohm

Ri = Input impedence



Adjustment range:	0...2
Resolution:	1
Factory setting:	0
Note:	Enter-Parameter

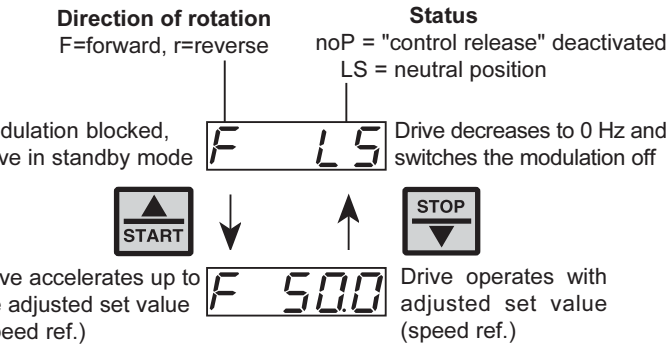
AN1 Zero point hysteresis

Through capacitive as well as inductive coupling on the input lines or voltage fluctuations; of the signal source, the motor connected to the inverter may start to drift at zero speed. I t is the function of the zero point hysteresis to suppress this drifting.
With parameter CP.36 the analog signal for the input REF can be blocked in the range of 0...±10%. The adjusted value is valid for both directions of rotation.
If a negative percentage value is adjusted then the hysteresis is not only effective on the zero point but also around the actual set value. Set value changes during constant operation are accepted only when they are larger than the adjusted hysteresis.

Adjustment range:	-10.0...10.0 %
Resolution:	0.1 %
Factory setting:	0.2 %

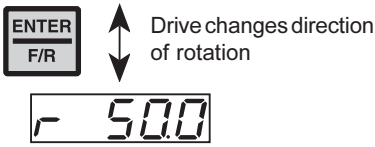
2.7 The "Drive Mode"

The "Drive Mode" is one of the operating modes of the KEB COMBIVERT that permits manual starting of the motor by the operator. After applying a signal to the control release terminal 16, the speed reference and rotation setting are adjusted through the keypad. In order to activate the "Drive Mode", the corresponding **password** must be entered **in CP.0**. The display switches over as follows.

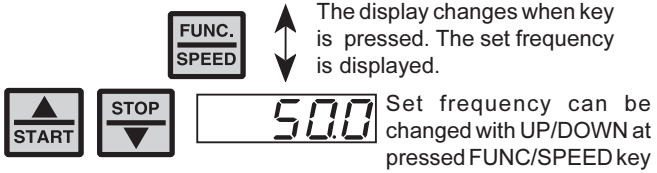


2.7.1 Start / Stop Drive

2.7.2 Changing the Direction of Rotation



2.7.3 Speed setting



2.7.4 Leaving the "Drive Mode"

To exit the Drive Mode the inverter must be in status “stop” (Display noP or LS). Press the "FUNC and ENTER" keys simultaneously for about 3 seconds to leave the Drive Mode. The CP-parameters appear in the display.

3. Error Diagnosis

KEB COMBIVERT **"Error messages"** are represented with an "E.xxx" and the appropriate error in the display. Error messages will cause the immediate voltage supply to the motor to be turned off. Restart is possible only after reset.
"Malfunctions" are represented with an "A.xxx" with the appropriate message. Responses to malfunctions can vary depending on the programmed condition. The 'value' column displays the numeric message for CP.3 (inverter status).

Display	Combivis software display	Value	Description and causes
E. OP	ERROR overvoltage	1	Error: Overvoltage (DC-bus circuit) Occurs, if DC-bus voltage rises above the permissible value (230V units: 400 VDC and for 460V units: 800 VDC): • poor control adjustment (overshooting) • input voltage spikes, too high or interference voltages. • deceleration ramps too short • braking resistor damaged, undersized or not connected • PF correction capacitor switching at sub-station
E. UP	ERROR undervoltage	2	Error: Undervoltage (DC-bus circuit). Occurs, if DC-bus voltage falls below the permissible value. (230V units: 255 VDC and for 460V units: 240 VDC): • input voltage too low, unstable or wire gauge too small. • inverter sized too small for given application. • supply voltage drops intermittently via generator / transformer. • missing input phase or input not connected properly. • connection to an unbalanced supply (i.e. corner ground delta). • separate control power supply and switched off power circuit.
E. OC	ERROR overcurrent	4	Error: Overcurrent > Occurs, if peak current is exceeded: • accel. or decel. time too short and /or the the load is too big. • short-circuit and/or ground fault at the output. • motor larger than recommended for inverter size. • motor cable too long and /or EMC problems. • voltage boost (CP.15) set too high. • 50 Hz 400V motor running on inverter connected to 480V. • inverter rated frequency (CP.16) not adjusted correctly.
E.OHI	ERROR overheat internal	6	Error: Overheating in the inverter interior: error can only be reset at E.nOHI, if the interior temperature has fallen by at least 3°C.
E.nOHI	no ERROR overheat inter.	7	No longer overheating in the inverter interior E.OHI, interior temperature has fallen by at least 3°C.
E. OH	ERROR overheat pow.mod.	8	Error: Overtemperature of power module. Error can only be reset at E.nOH: • insufficient air flow at the heat sink (dirty). • ambient temperature too high or fan clogged or not functioning.
E.dOH	ERROR drive overheat	9	Error: Overtemperature signal from motor temperature sensor. Error can only be reset at E.ndOH, when sensor resistance decreases: • terminals T1, T2; resistor>650 Ohm or factory jumpers loose.

			• motor overloaded, see also E.OC and E.OL. • temperature sensor cable broken.
E.nEd	no ERROR detected	10	No defined error recognized (should not occur).
E.ndOH	no ERROR drive overheat	11	No longer overtemperature of motor temperature sesnor. Sensor is again low-resistance.
E. PU	ERROR power unit	12	Error: General power circuit fault
NO.PU	power unit not ready	13	Power circuit not ready.
E.PUIN	ERROR power unit invalid	14	Error: Software version for power circuit and control card are different. Error cannot be reset.
E.LSF	ERROR load shunt fault	15	Error: charging relay does not close after the DC bus voltage reaches its normal operating level. Occurs for a short time during the switch-on phase, but must automatically be reset immediately (after 10 sec's E.UP). If the error message remains, the following causes may be applicable: • charging resistor defective. • input voltage incorrect or too low. • high losses in the supply cable. • braking resistor incorrectly connected or damaged. • braking module defective.
E. OL	ERROR overload	16	Error: Overload error can only be reset at E.nOL, if OL-counter has again reached 0%. Occurs, if an excessive load is applied longer than the permissble time (see technical data): • poor control adjustment (overshooting). • increased friction or jam in the mechanical system. • inverter not correctly sized for application. • motor larger than recommended for inverter size. • motor incorrectly wired. • encoder dammaged. • inverter rated frequency (CP.16) is not adjusted correctly. • 50 Hz, 400V motor running on inverter that is connected to 480V.
E.nOL	no ERROR overload	17	No more overload, OL-counter has reached 0%; after the error E.OL a cooling phase must elapse. This message appears upon completion of the cooling phase. The error can be reset. The inverter must remain switched on during the cooling phase.
E.buS	ERROR bus	18	Error: Adjusted monitoring time (Watchdog) of communication between operator and PC has been exceeded.
E.OL2	ERROR overload 2	19	Error: Overload can only be reset at E.nOL2, if cool-down time has elapsed.
E.nOL2	no ERROR overload 2	20	No more overload, the cool-down time is terminated.
E.EEP	E. EEPROM defective	21	Error: EEPROM defective. After reset the error is repeated. (parameter values changed are erased in the EEPROM)
E.PUCO	E. power unit identity invalid	22	Error: Parameter value could not be written to the power circuit. Acknowledgement from PC <> OK
E.OH2	ERROR motor protection	30	Error: Electronic motor protection has tripped.
E. EF	ERROR external fault	31	Error: External error is triggered when a digital input is being programmed as an external error input.
E.ENC	ERROR encoder	32	Error: Encoder cable and/or connection wiring

E.nOH	no E. over heat pow. mod.	36	Internal or external temperature has dropped to a safe level.
E.SET	ERROR set	39	Error: Set selection: It has been attempted to select a locked parameter set.
E.PRF	ERROR prot. rot. for.	46	Error: Locked direction of rotation clockwise
E.PRR	ERROR prot. rot. rev.	47	Error: Locked direction of rotation counter-clockwise
E.PUCI	E. power unit code inv.	49	Error: during the initialization the power circuit could not be recognized or was identified as invalid.
E.PUCH	E. power unit changed	50	Error: Power circuit identification was changed; with a valid power circuit this error can be reset by writing to SY.3 (application mode).
E.DRI	ERROR driver relay	51	Error: Driver relay. Relay; for drive voltage on power circuit, has not energized even with control release signal enabling drive.
E.HYB	ERROR hybrid	52	Error: Invalid encoder interface identifier
E.CO1	ERROR counter overrun 1	54	Error: Counter overflow encoder channel 1
E.CO2	ERROR counter overrun 2	55	Error: Counter overflow encoder channel 2
E. BR	ERROR brake	56	Error: This error can occur in the case of switched on brake control, if the load is below the minimum load level Pn.58 (application mode) at start up.
E.INI	ERROR initialisation MFC	57	Error: MFC not booted
E.HYBc	ERROR hybrid changed	59	Error: Encoder interface identifier has changed, it must be confirmed over ec.0 or ec.10 (application mode).
E.ccd	ERROR calculation drive	60	Error: during the automatic motor stator resistance measurement
E.OS	ERROR over speed	105	Error: Real frequency is bigger than the max. Output frequency
A.OHI	ABN.STOP overheat int.	87	Warning: overtemperature in the interior
A.nOH	no A. overheat pow.mod.	88	Warning: no more overtemperature of power module
A. OH	A.STOP overheat pow.mod	89	Warning: Overtemperature of power module
A. EF	ABN.STOP external fault	90	Warning: external error
A.ndOH	no A. drive overheat	91	Warning: no more overtemperature of motor TEMPERATURE SENSOR. Motor SENSOR is low-resistance again.
A.nOHI	no A.STOP overheat int.	92	Warning: no more overtemperature in the interior
A.buS	ABN.STOP bus	93	Warning: Watchdog for communication between operator/control card has responded
A.PRF	ABN.STOP prot. rot. for.	94	Warning: locked direction of rotation clockwise
A.PRR	ABN.STOP prot. rot. rev.	95	Warning: locked direction of rotation counter-clockwise
A.dOH	ABN.STOP drive over heat	96	Warning: overtemperature of motor TEMPERATURE SENSOR
A.OH2	ABN.STOP motor protect.	97	Warning: electronic motor protective relay has tripped
A.nOL	no ABN.STOP overload	98	Warning: no more overload, OL counter has reached 0 %.
A. OL	ABN.STOP overload	99	Warning: Overload can only be reset at A.nOL, if OL counter has again reached 0 %
A.OL2	ABN.STOP overload 2	100	Warning: Overlodd can only be reset at A.nOL2, if cool-down time has elapsed
A.nOL2	no ABN.STOP overload 2	101	Warning: no more overload, the cool-down time has elapsed.
A.SET	ABN.STOP set	102	Warning: set selection: It has been attempted to select a locked parameter set.

4. Quick Reference - CP Parameter's

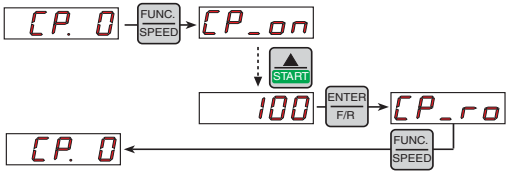
Display	Parameter	Setting range	Resolution	Factory setting
CP. 0	Password input	0...9999	1	–
CP. 1	Actual frequency display	–	0.0125 Hz	–
CP. 2	Set frequency display	–	0.0125 Hz	–
CP. 3	Inverter status display	–	–	–
CP. 4	Phase current	–	0.1 A	–
CP. 5	Phase current, Peak value	–	0.1 A	–
CP. 6	Actual load	–	1 %	–
CP. 7	Actual DC voltage	–	1 V	–
CP. 8	Actual DC voltage, Peak value	–	1 V	–
CP. 9	Output voltage	–	1 V	–
CP.10	Minimal frequency	0…400 Hz	0.0125 Hz	
CP.11	Maximal frequency	0…400 Hz	0.0125 Hz	
CP.12	Acceleration time	0.01…300.00 s	0.01 s	
CP.13	Deceleration time(-1 see CP.12)	-1; 0.01…300.00 s	0.01 s	
CP.14	S-curve time	0.00 (off)…5.00 s	0.01 s	
CP.15	Torque boost	0.0…25.5 %	0.1 %	
CP.16	Rated frequency	0…400 Hz	0.0125 Hz	
CP.17 [1)]	Voltage stabilization	1…650 V (off)	1 V	
CP.18 [1)]	Carrier frequency	2/4/8/12/16 kHz	-	
CP.19	Fixed frequency 1	-400...400 Hz	0.0125 Hz	
CP.20	Fixed frequency 2	-400...400 Hz	0.0125 Hz	
CP.21	Fixed frequency 3	-400...400 Hz	0.0125 Hz	
CP.22 [1)]	DC-braking, Mode	0…9	1	
CP.23	DC-braking, Time	0.00…100.00 s	0.01 s	
CP.24	Max. ramp current	0…200 %	1 %	
CP.25	Max. constant current	0…200 % (off)	1 %	
CP.26 [1)]	Speed search condition	0…15	1	
CP.27	Quick stop time	0.00…300.00 s	0.01 s	
CP.28	Response of ext. overtemperature	0…7	1	
CP.29 [1)]	Analog output 1	0…12...20 {F5G}	1	
CP.30	Analog output 1, Amplification	-20.00…20.00	0.01	
CP.31 [1)]	Relay output 1	0…75	1	
CP.32 [1)]	Relay output 2	0…75	1	
CP.33	Relay output 2, Switching level	±30000.00	0.01	
CP.34 [1)]	Source of rotation direction	0…9	1	
CP.35 [1)]	AN1 interface selection	0…2	1	
CP.36	AN1 zero point hysteresis	-10.0…10.0 %	0.1 %	

[1)] Enter-Parameter

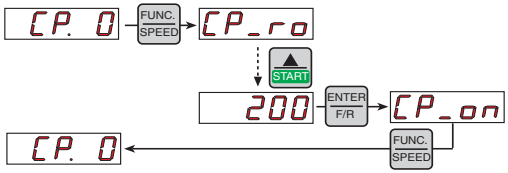
5. Quick Reference - Password Input

From the factory, the frequency inverter is supplied without password protection, this means that all parameters can be adjusted. After programming, the unit can be protected against unauthorized access thus preventing the values from being changed.

Locking the CP-Parameters (Read only)



Releasing the CP-Parameters (Read & Write)



US

Special Notice to Customer

Prior to delivery all products pass several quality and performance inspections in order to guarantee the product is free from defects in manufacturing. When used in accordance with the operating instructions, failure of the unit is not likely. However, if you have reason for concern please contact KEBCO at 651-454-6162 and ask for "inverter technical support". From this point our technical support engineers can help you determine the cause of the problems and also the proper solution.

Listed values in this manual are standard values only and do not pertain to special units. We reserve the right to make technical changes without notification.

KEBCO Limited Warranty

KEBCO Inc. will repair or replace, at KEBCO's discretion, any inverter which shows signs of defect in material, workmanship or fails to meet factory specifications with in one year from original date of shipment from KEBCO in St. Paul. Operation of the inverter outside the rated specifications printed in the instruction manuals will void the warranty.

KEBCO does not assume any liability for cost of removal, cost of installation, down time, production delays, return shipping, or damage to other items associated with the inverter, for failures which occur during or after the warranty period.

To make a warranty claim contact the Electronic repair department at the number listed above, and request a Return Goods Authorization (RGA) number. The inverter is to be shipped prepaid to the address listed below. Suitable packaging must be provided to prevent the inverter from incurring damages during shipping as damages of this nature will void the warranty.

KEBCO will inspect the inverter to determine the cause of the problems in the inverter and will repair or replace the inverter at its discretion.

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St. Paul, MN 55120

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