Training RACING KIT 2015/2016

Day 1: 08:30 – 14:00 Training RACING KIT 2015/2016 Mr. Jan Körner (training department)
PP: Product overview, interface, functionality, CAN
14:00 – 16:00 Software AIPEX PRO and setup inverter (J. Körner)
16:00 – 16:30 Mr. Dr. Kohlhaas (leadership development of servo technology)
(question and answer session, by agreement)

Day 2: 09:00 – 12:30 Connection CAN controller, communication (J. Körner)
13:15 – 14:00 Mr. Peter Schmid (motor design e-Mobility / question and answer session)
14:00 – 16:30 Open points, practical tests

AMK





Training RACING KIT 2015

Product overview

Interfaces, status LED and wiring

Assembly and liquid cooling

Functionality FSE

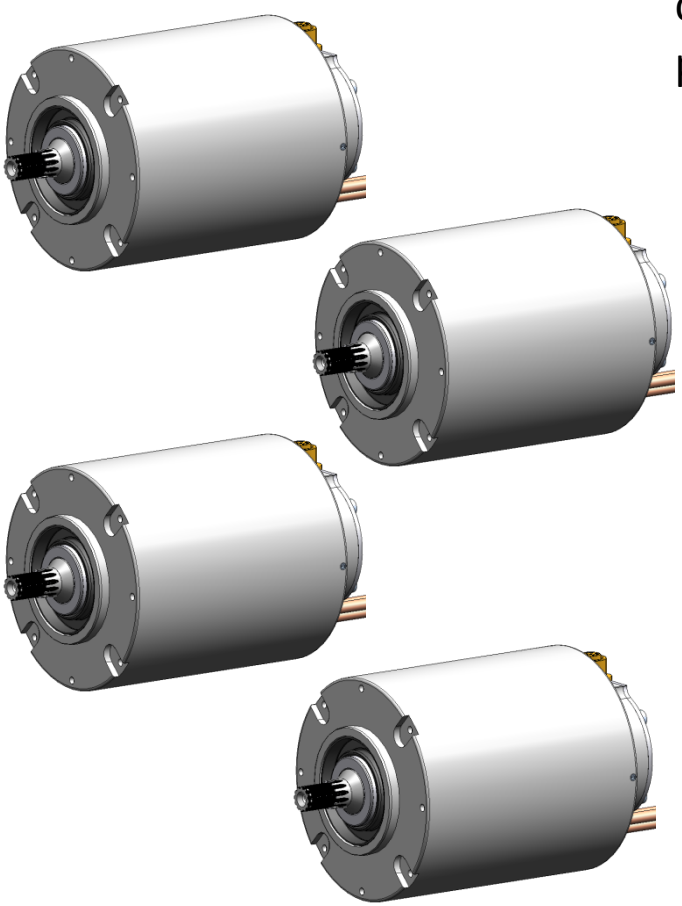
CAN communication

Set up

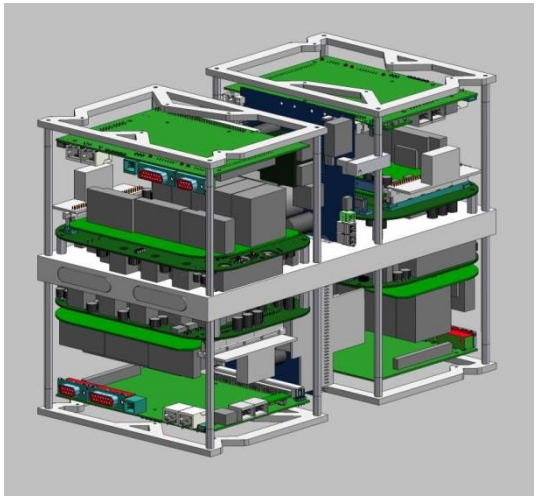
For your safety

Product overview RACING KIT

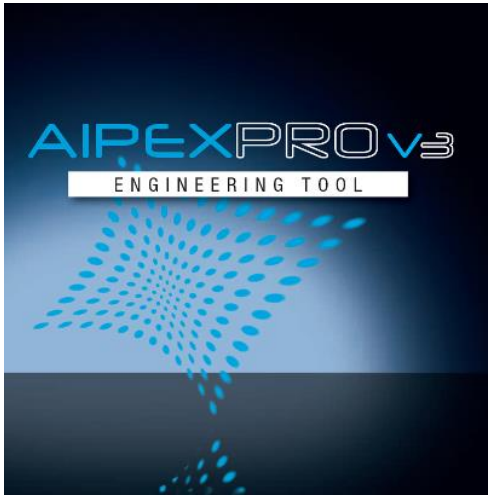
4 synchronous servo motor
with permanent magnets



Quad inverter with
controller board,
power board and FSE firmware



AMK setup -
software AIPEX PRO



USB cable

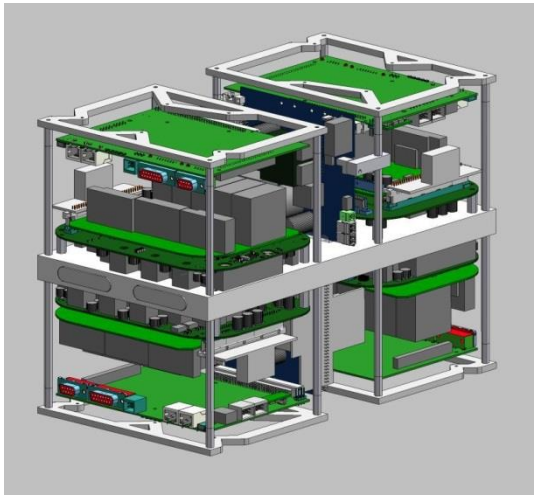
Functionality FSE firmware

Setpoint
Accelerator pedal

CAN
CONTROLLER

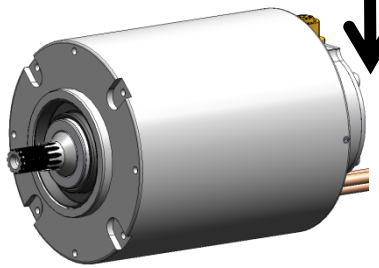
Control bits
Speed setpoint
Torque setpoint

Status bits
Actual values



Actual values

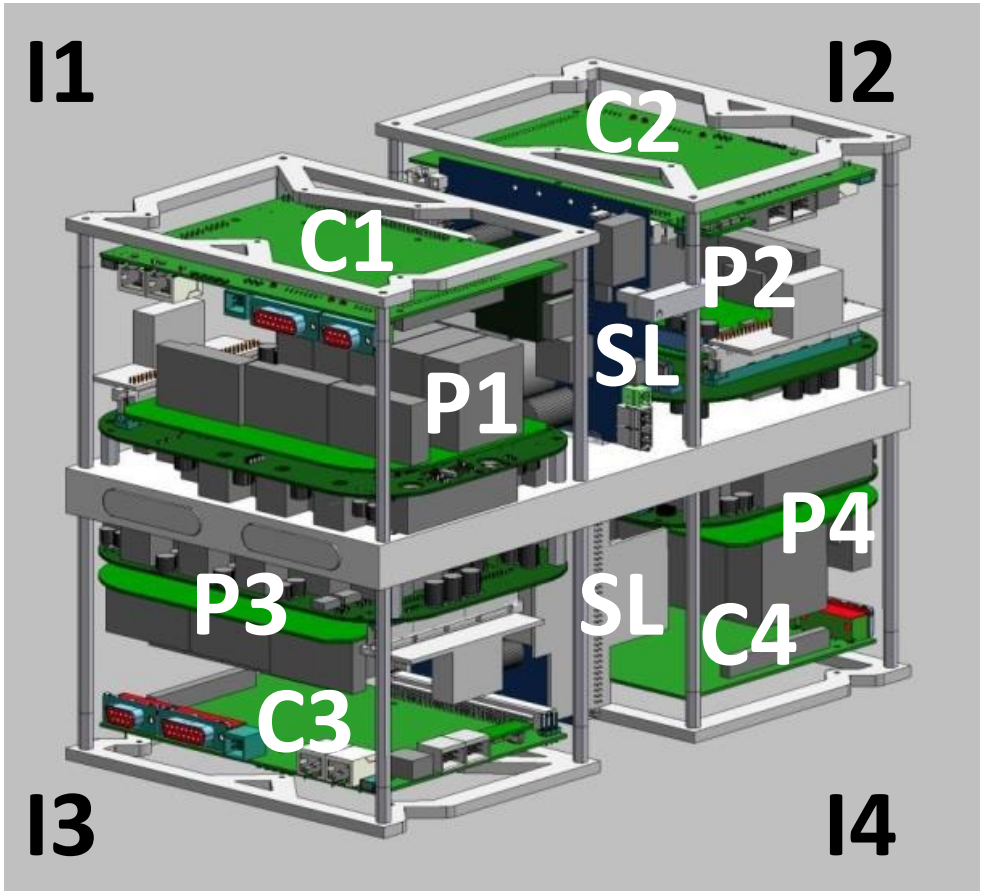
Motor current controlled through ‘Pulse Width Modulation’



Inverter operational mode:
Speed control

Advantage speed control:
In addition to torque limitation you can dynamical limit the speed of the motor.

Quad inverter



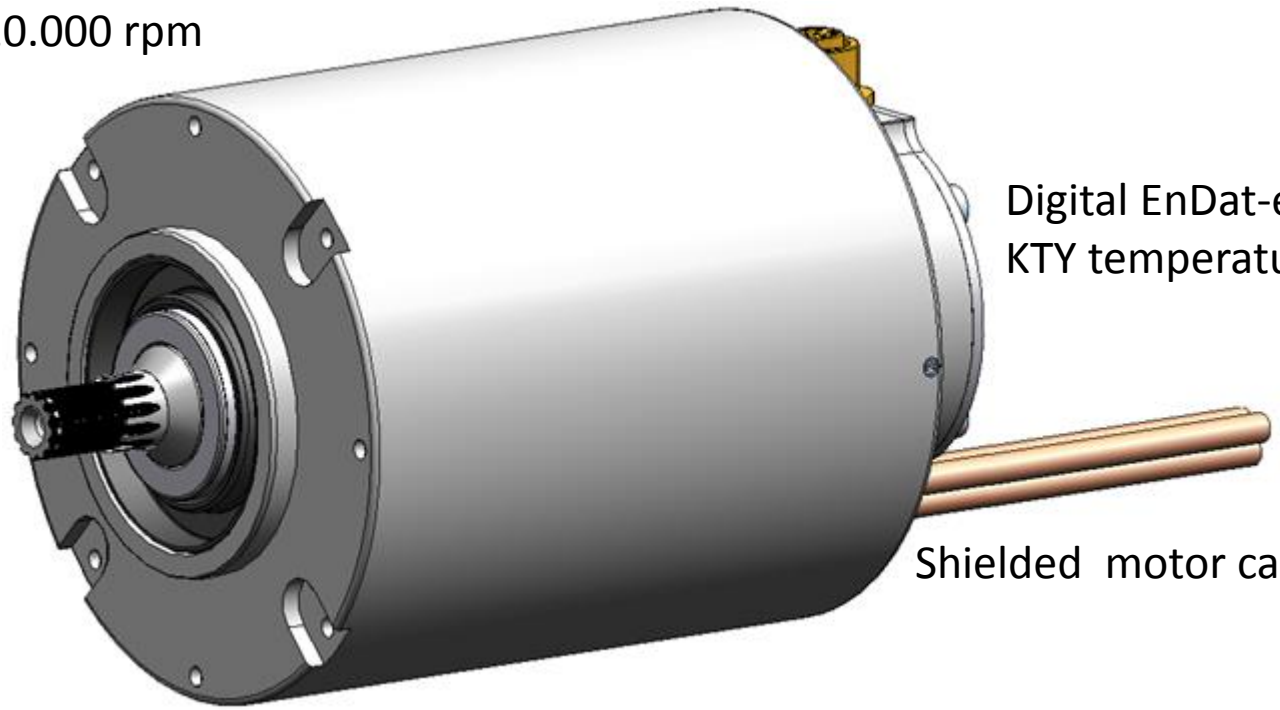
- Speed control with torque limitation for motor and generator operation (braking operation)
- I/O-interface (hardware enable motor controller and motor torque)
- Interface: CAN Bus 2.0 B - ISO 11898
- Service interface (AMK software AIPEX PRO)
- Mounted onto a liquid cooling plate

I - Inverter
C - Controller card
P - Power board
SL - Supply, logic and connection board

Synchronous servo motor

M12 plug for encoder signals and temperature monitoring

Mmax/MN = 2,1
Speed values up to 20.000 rpm



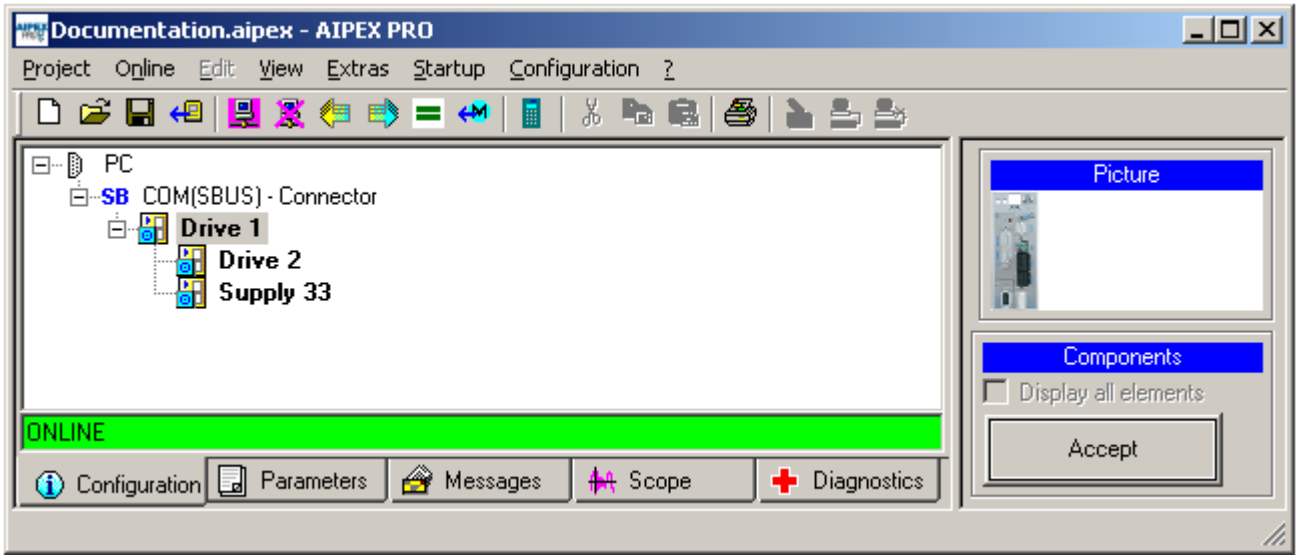
Digital EnDat-encoder
KTY temperature sensor

Motor shaft with spline according to DIN 5480

Shielded motor cable

Motor housing made of aluminum 3.4365 / EN AW-7075

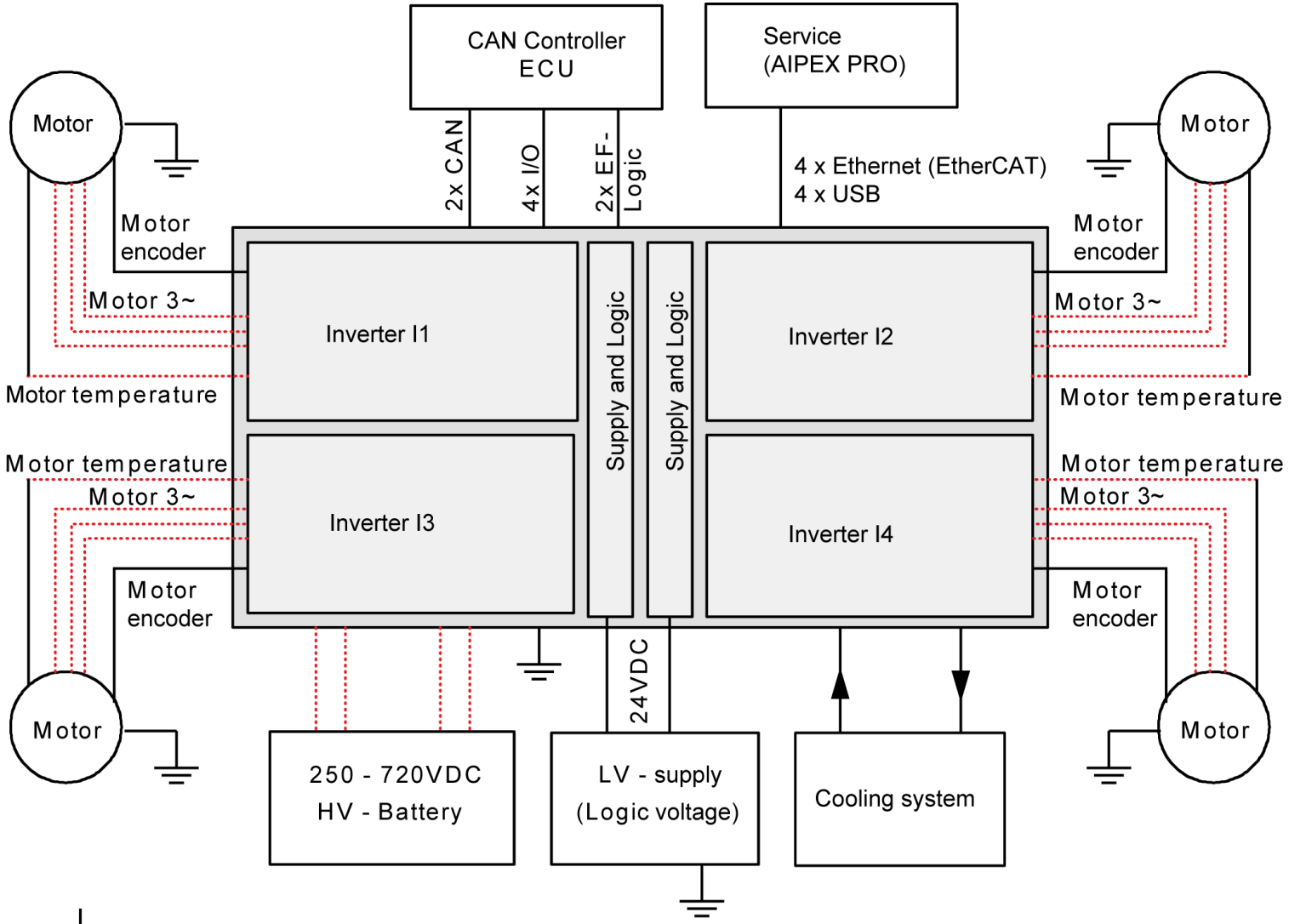
AMK Software AIPEX PRO



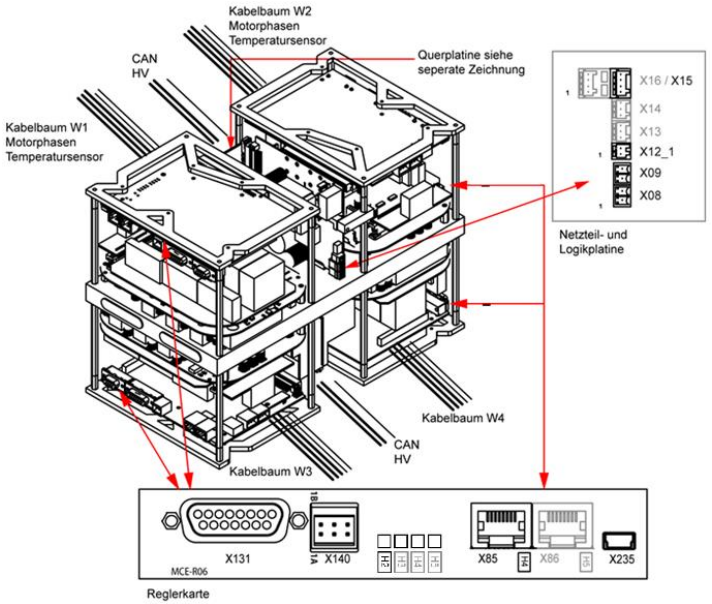
Configuration	Display and input possibility for device properties
Parameters	Display and input possibility for parameter values
Messages	Display and input possibility for network data transfer
Scope	Oscilloscope function to measure drive values
Diagnostics	Diagnostic module

Communication connection to the inverter EtherCAT (X85) or USB (X235)

System overview



Interface, status LED and wiring

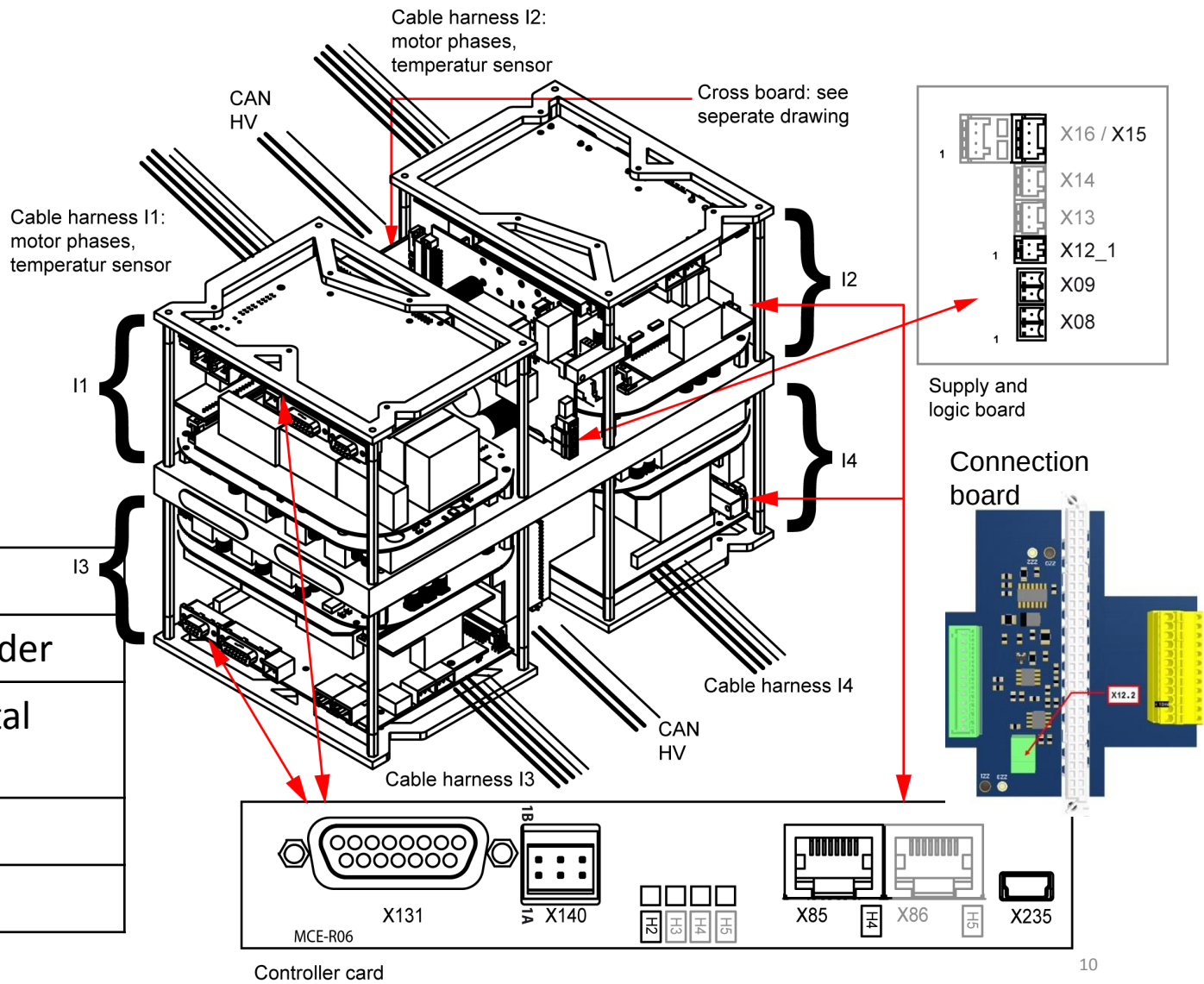


Connection overview

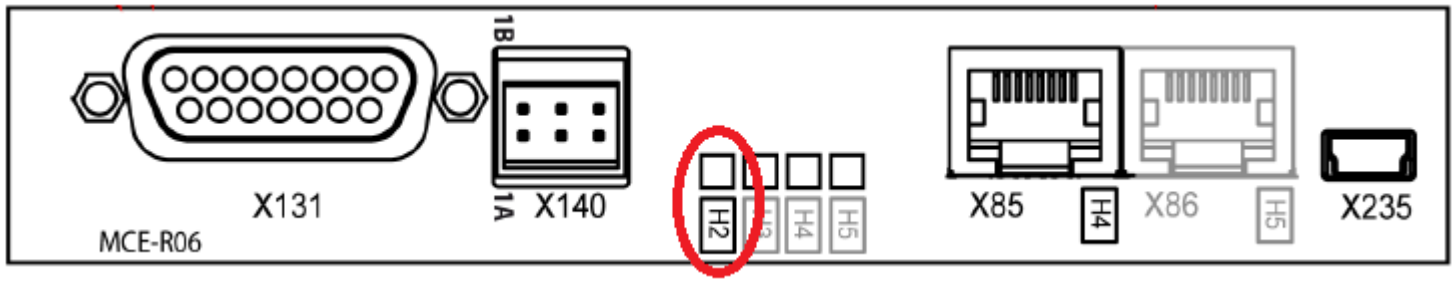
Status LED H2
Drive status

Cables
4 x cable harness Ix • Motor phases • Temperature sensor
2 x CAN
2 x HV

Connections	
X08/X09 – 24 VDC	X131 – Encoder
X12_x – Temp-sensor Motor	X140 – Digital inputs
X15 – EF Logic	X235 – USB
X85 – EtherCAT	



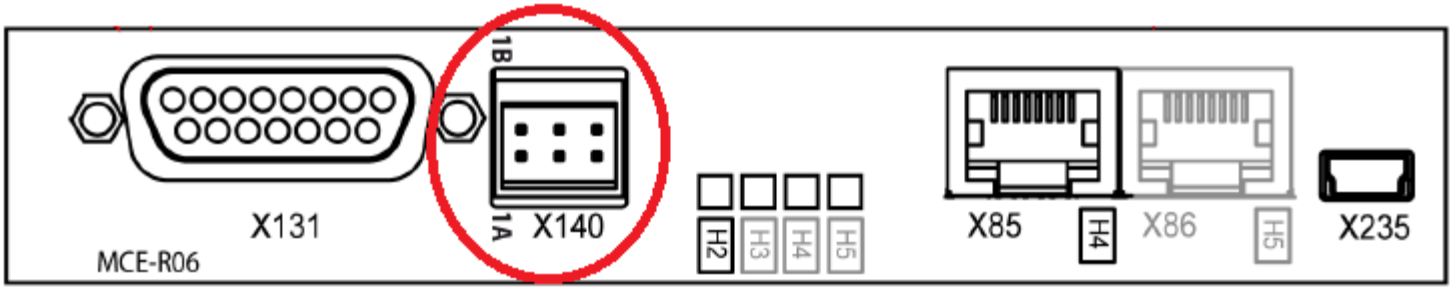
Status LED H2



Controller card

LED	Class	Status	Note
H2	Drive status	Green	System ready (SBM)
		Green flashing	Drive under control (SBM and QRF)
		Orange flashing	Warning occurs during active controller enable
		Orange	Warning occurs during inactive controller enable / flash mode
		Red	Error with reaction depending on the error number

Functionality digital inputs X140



Controller card

FSE functionality digital input DI1 (X140 3B)

To activate the controller enable you have to set the digital input DI1 additional the can signals ('AMK_bInverterOn' und 'AMK_bEnable').

DI1 = 1 : Controller enable RF possible

DI1 = 0 : Controller enable RF locked

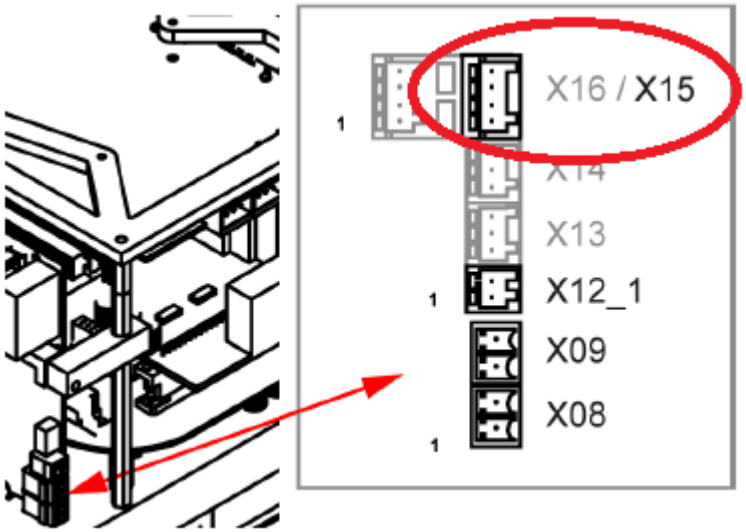
FSE functionality digital input DI2 (X140 2B)

To activate the torque limits, you have to set digital input DI2

DI2 = 1 : Torque limits active, setpoints via can possible

DI2 = 0 : Torque limits deactivate, Motor torque less

EF output stage enable X15

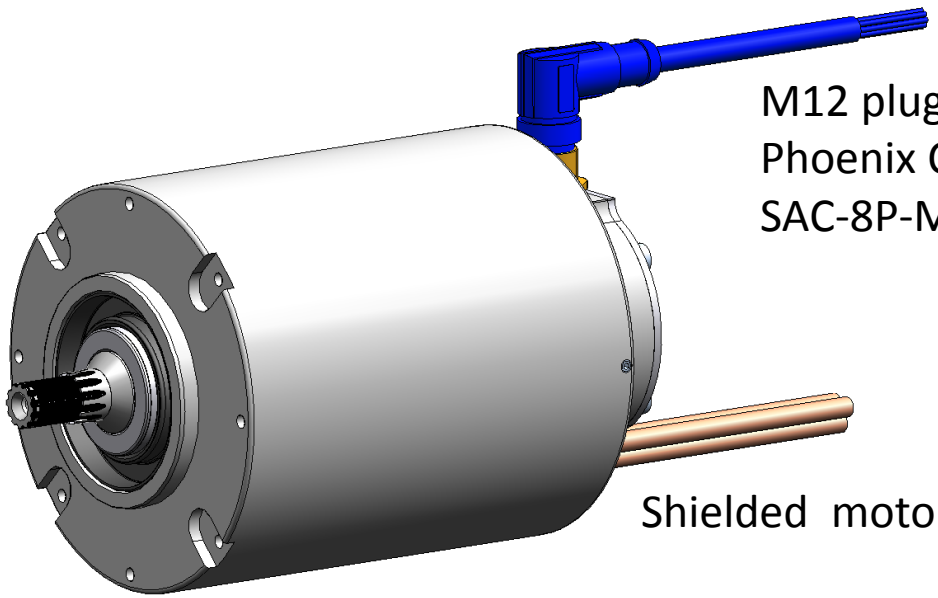


In normal operation, the inputs “EF” and “EF2” must be set simultaneously. The output stage is then enabled.

An interruption of “EF” or “EF2” leads to an immediate blocking of the clock pulses for the output stage and to a protection against restarting.
In the case of a set controller enable (RF), an error message is generated and the output stage is blocked.

[X15]	Connection	Signal	Description
front view, device side PIN 4 PIN 3 PIN 2 PIN 1	1	EF2	Power output stage enable EF2
	2,4	EF	Power output stage enable EF
	3	WEF	Reference potential 0 V ext.

Motor connection



M12 plug, 8 pols
Phoenix Contact, designation:
SAC-8P-M12MR/5,0-PUR SH

Shielded motor cable

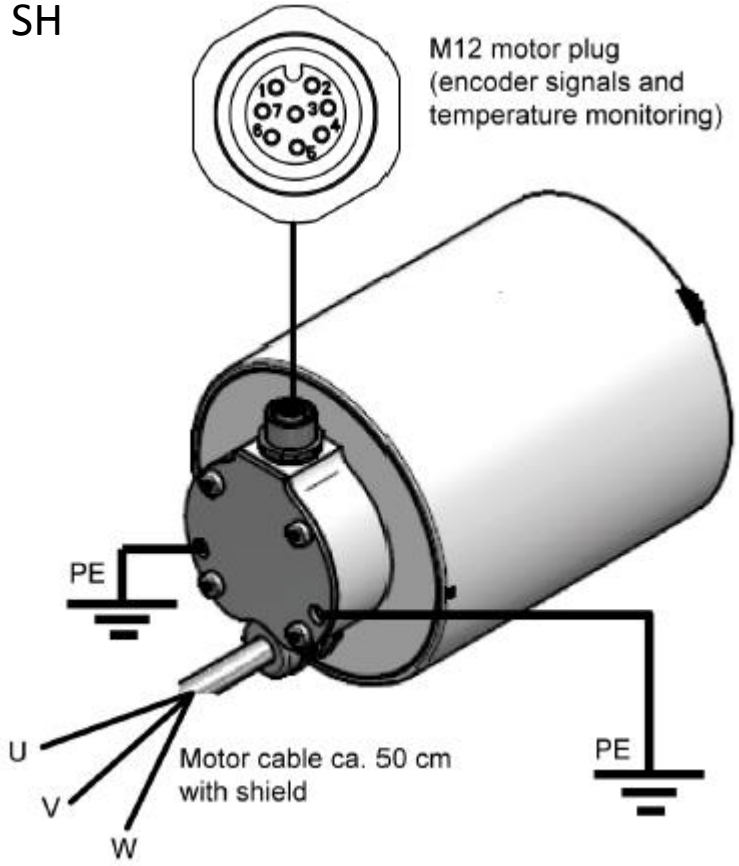
Color coding motor phases

DD5

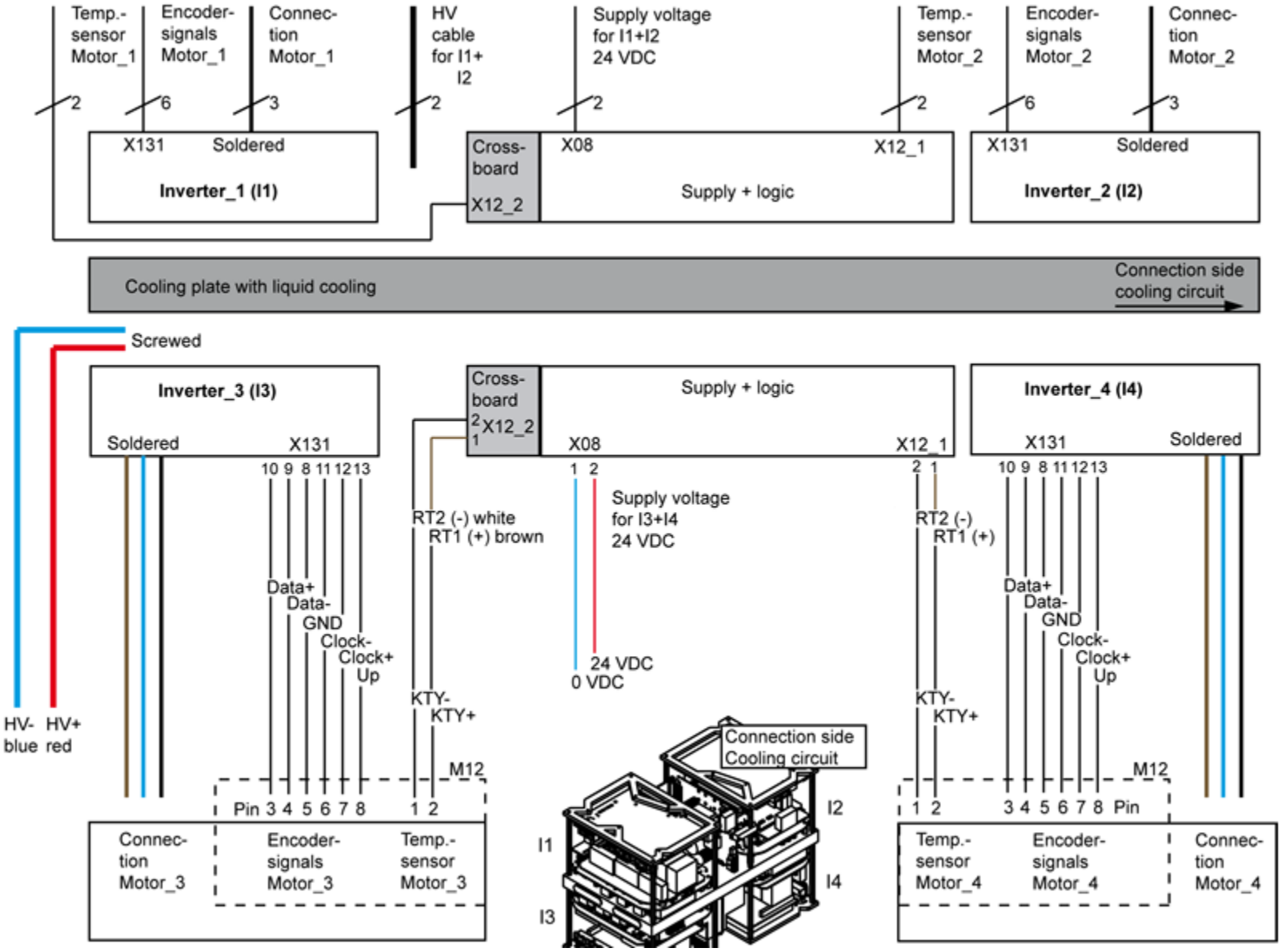
U	-	Black
V	-	Blue
W	-	Brown

DT5

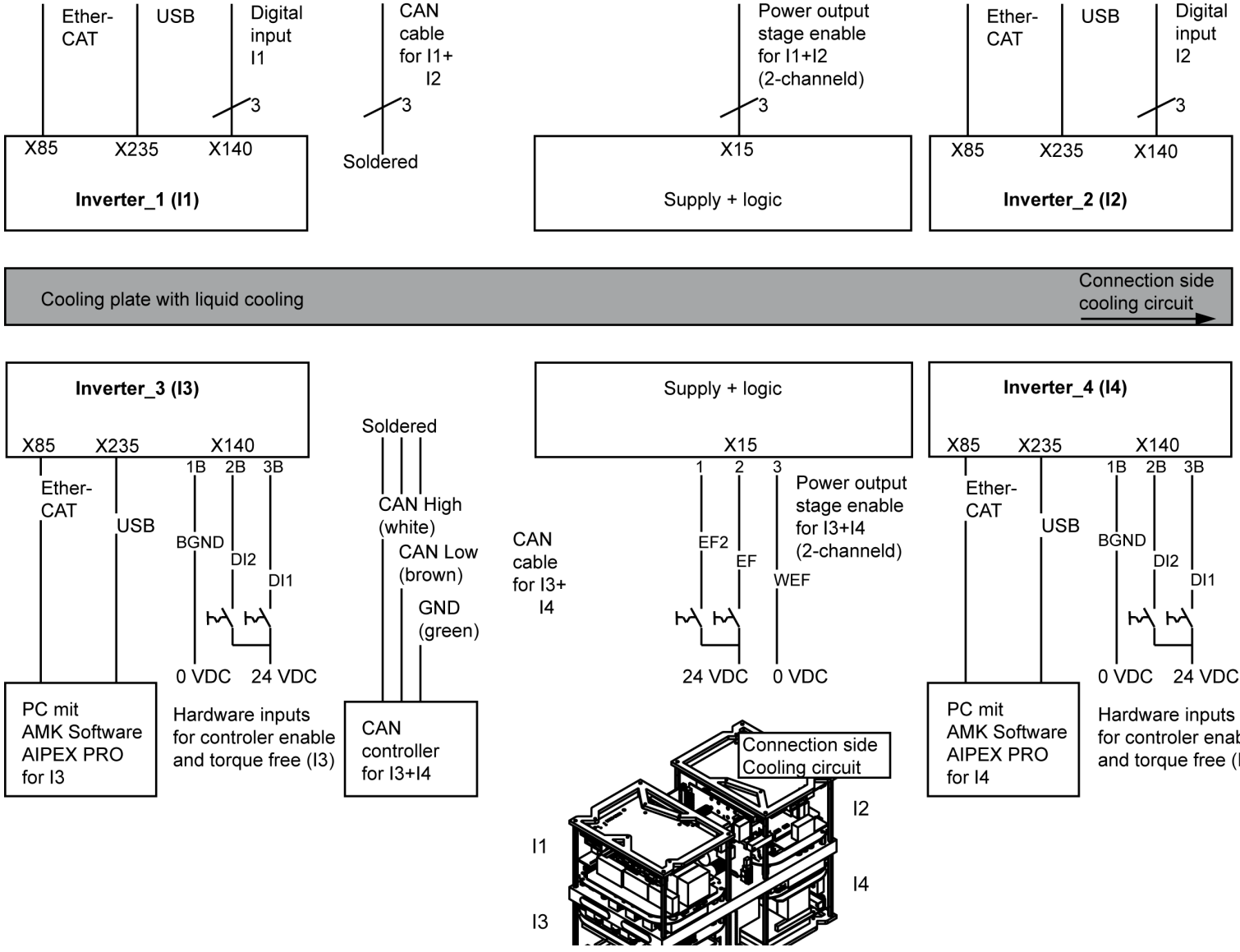
U	-	Brown
V	-	Blue
W	-	Black



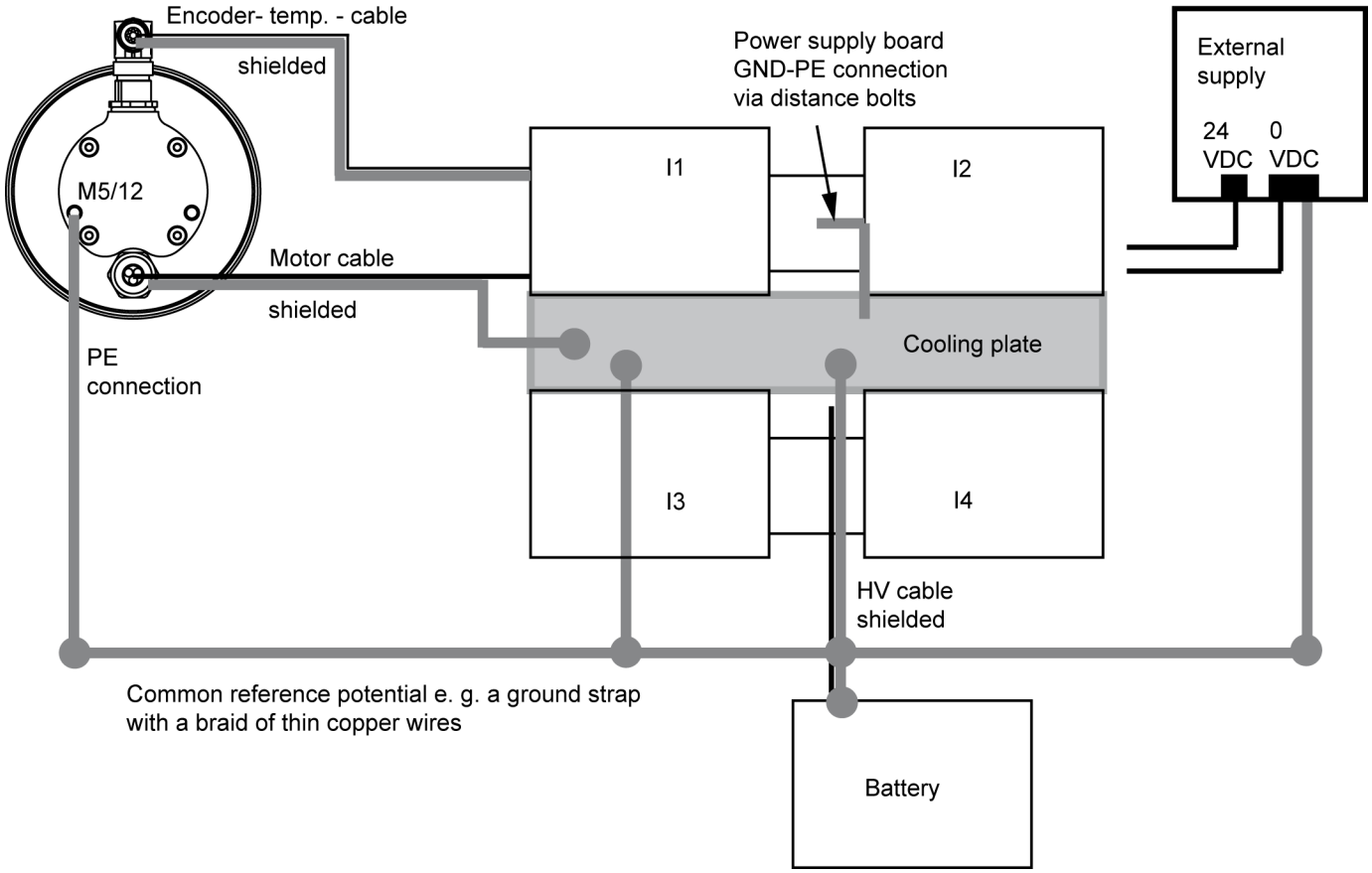
Wiring motor and supply connections



Wiring interfaces and logic connections

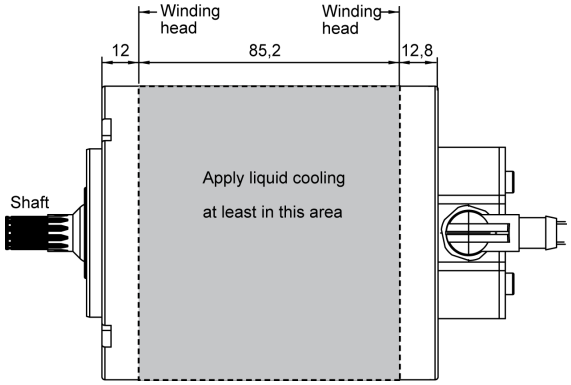


Ground terminal PE - Overview



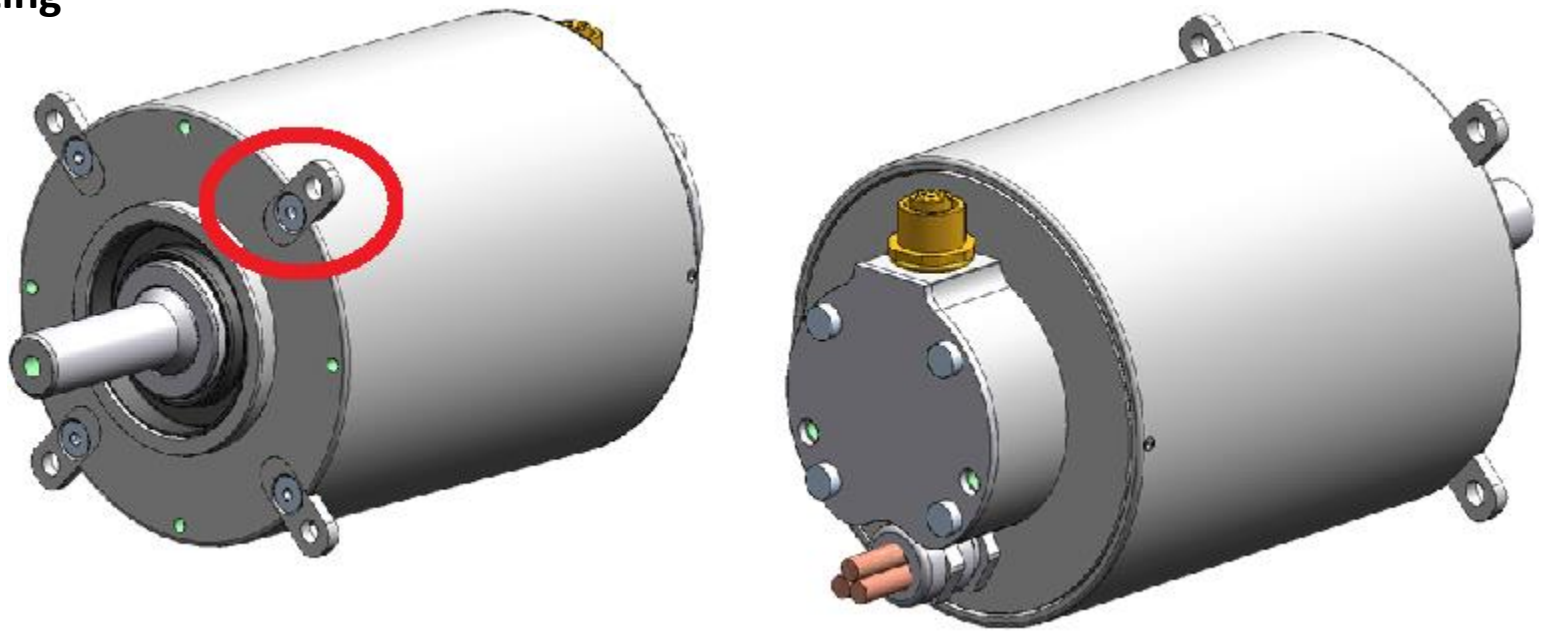
The shield of the motor cable can prevent most of the electrical interferences.

Assembly and liquid cooling



Mounting options

Front mounting

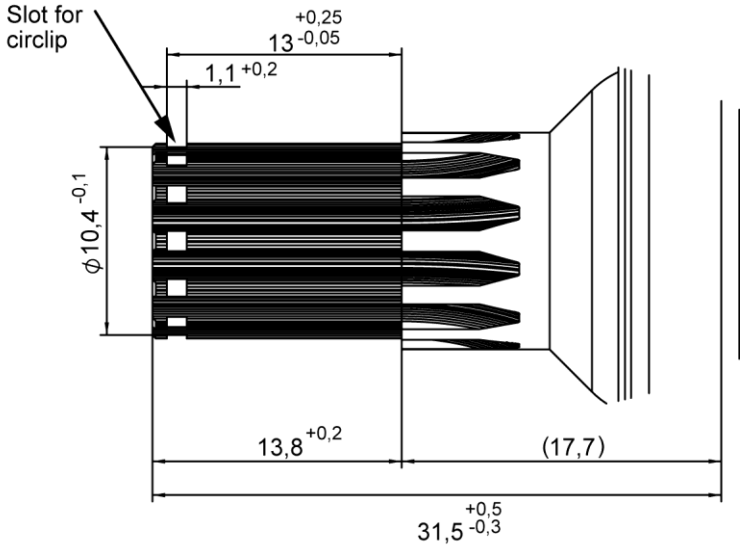


The mounting plates are not included in the scope of delivery and must be provided by the user.

Rear mounting

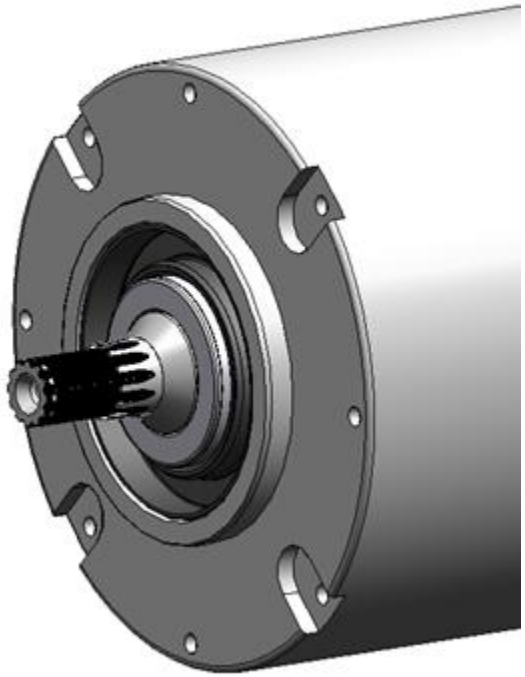
Fixation via 8 x M4 threads

Spline



Spline on Shaft: DIN 5480 - W11x0,8x30°x12x7h

DIN 5480 –
W11 x 0,8 x 30° x 12 x 7h

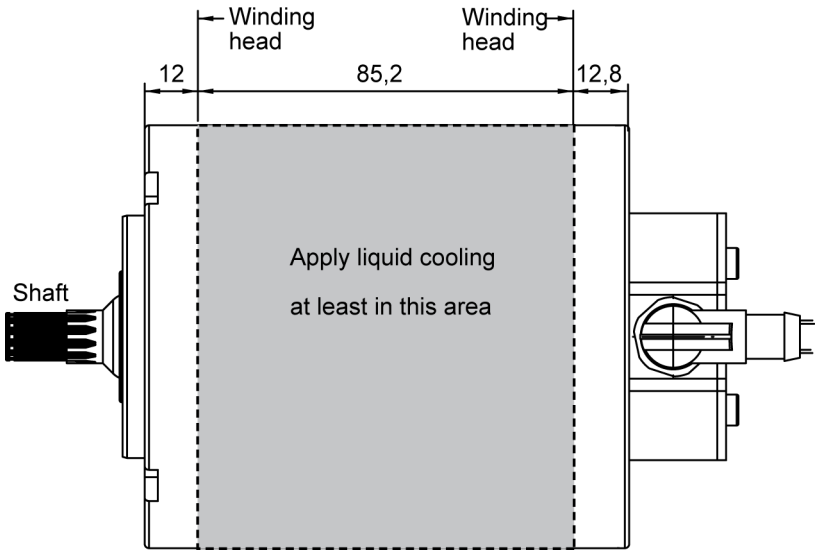


NOTICE	
Material Damage!	**Mechanical damage due to pressure on the motor shaft** Pressure on the motor shaft can damage the motor bearings or cause the motor shaft to move out of its fixing and into the motor casing. **Preventive measures:** Mounting parts such as toothed wheels or shafts must be attached without force (not pressed in) and must then be secured with a screw or a retaining ring.

B-bearing shield

NOTICE	
Material Damage!	**Mechanical damage due to pressure on the B-bearing shield** By pressing on the B-bearing shield the housing screws may break. The motor housing is damaged and the B-bearing shield is moving into the motor housing. **Preventive measures:** Support mechanically the motor housing (picture pos. 1 + 2) so that during assembly of attachments e. g. the external liquid cooling no pressure on the B-bearing shield is applied. 

Liquid cooling motor



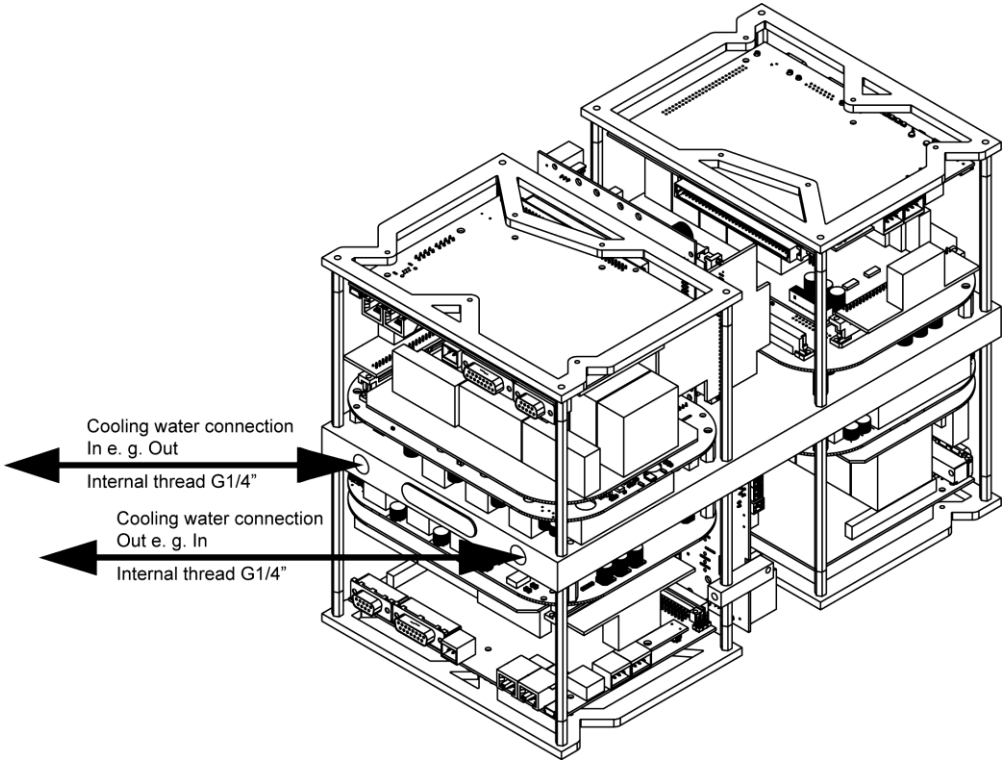
The liquid cooling must be designed by the customer.

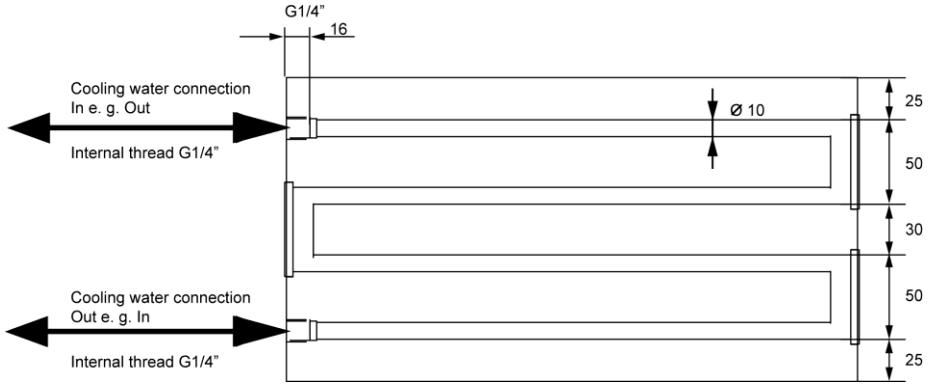
Conditions:

- Max. inlet temperature of 40 °C
- Min. flow rate must be 2 l / min
- Max. temperature rise of the coolant < 10 K

NOTICE	
Material Damage!	**Material damage due to overheating!** The drive system is intended solely for operation in a closed cooling circuit with a heat exchanger. Operation without the specified cooling system is not permitted. The drive system will overheat, causing it to be destroyed. **Preventive measures:** • Only operate the drive system with the specified cooling system • Connect the PTC thermistor from the servo motor to the temperature monitoring equipment • Activate the I²t monitoring of the servo motor in ID32773 'Service bits', bit 14

Liquid cooling inverter





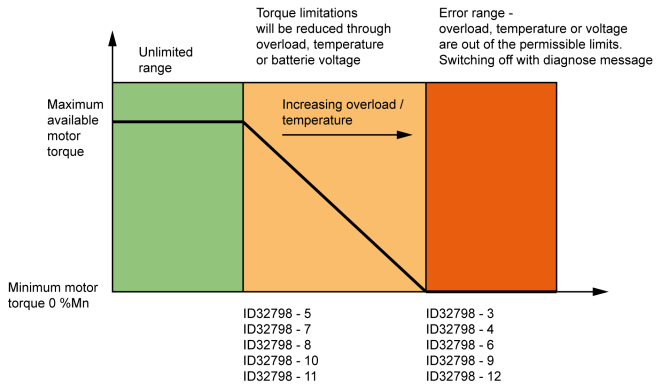
Conditions inverters:

- Max. inlet temperature of 30 °C
- Flow rate approx. 10 l/min
- Max. permissible surface temperature 40 °C

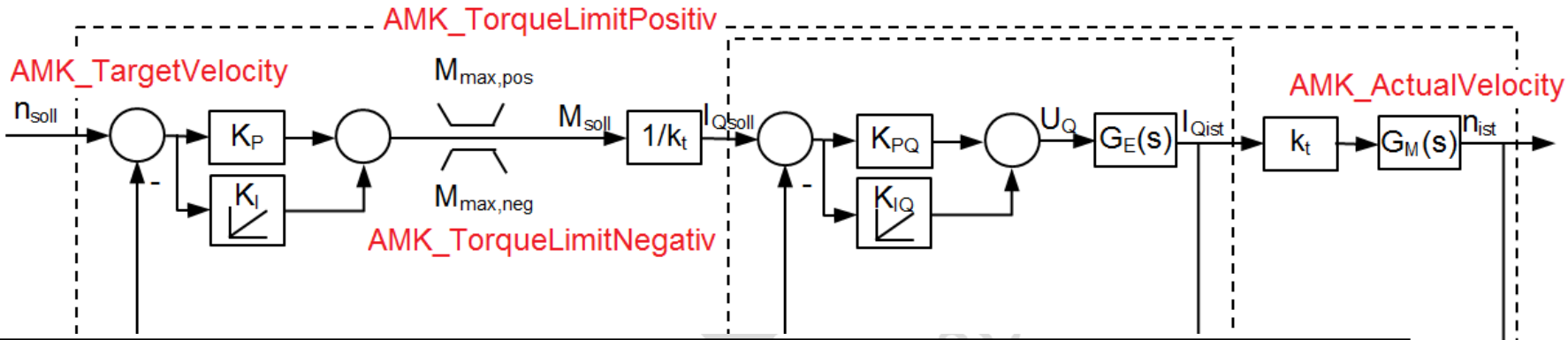
PE fittings

Do not damage the cooling channels during the pre-drilling

Functionality FSE



Structure controller



Unit	Description	CAN Variable
n_{soll}	Speed setpoint	AMK_TargetVelocity
n_{ist}	Actual speed value	AMK_ActualVelocity
$M_{max,pos}$	Positive torque limitation	AMK_ TorqueLimitPositiv
$M_{max,neg}$	Negative torque limitation	AMK_ TorqueLimitNegativ
K_P	Gain of the speed controller (P-part) (ID100 'Speed control proportional gain KP')	-
K_I	Integration constant of the speed controller (I-part) (as integral Tn in ID101 'Integral-action time speed control TN')	-
M_{soll}	Torque setpoint	-
kt	Torque constant of the motor (ID32771 'Nominal torque'/ ID111 'Motor nominal current IN')	-
K_{PQ}	Verstärkung des Stromreglers (P-part) (ID34151 'Current path Q proportional gain KP')	-
K_{IQ}	Gain of the current controller (I-part) (as integral Tn in D34050 'Current path Q integral-action time TN')	-
$G_E(S)$	Transfer function of the electrical control system	-
$G_M(S)$	Transfer function of the mechanical control system	-

Units

In the FSE firmware following units and scales apply.

Torque
All torque values of the system are related to the ID32771 'Nominal torque' and displayed in 0.1% of the value of MN.

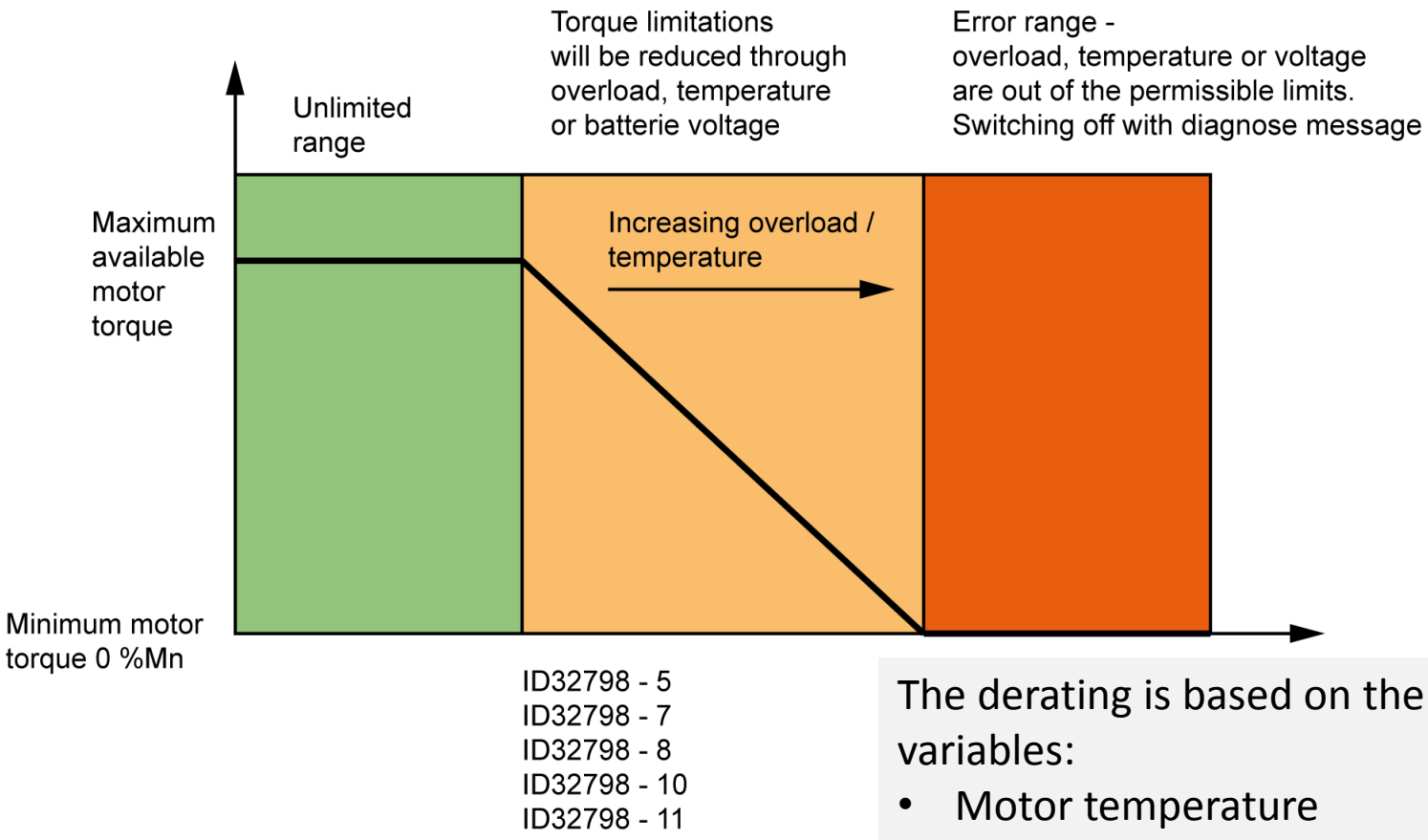
Speed
All speed values are displayed in 1/min.

Temperature
All temperature values are displayed in 0.1 ° C.

Id and Iq
The currents are related to the device-specific value in ID110 ‘Inverter peak current'. The actual current in A is calculated as follows:

$$Iq = \frac{AMK\_TorqueCurrent \times ID110}{16384} \qquad Id = \frac{AMK\_MagnetizingCurrent \times ID110}{16384}$$

Torque limitation



Parameterization: ID32798
Status: AMK_bDerating

The derating is based on the following measured variables:

- Motor temperature
- Temperature of the inverter power elements
- Temperature of the inverter housing
- Overload after inverter current integral
- Overload after motor current integral
- Under / over-voltage in the HV circuit

Driving status

Driving status	Description	CAN Variable
Acceleration forward	Speed setpoint = required positive speed [1/min]	AMK_ TargetVelocity
	Positive torque limitation = required positive acceleration torque [0,1 %M_N]	AMK_ TorqueLimitPositiv
	Negative torque limit = (negative sign) required negative deceleration torque [0,1 %M_N] 1)	AMK_ TorqueLimitNegativ
Roll	Speed setpoint = any speed [1/min]	AMK_ TargetVelocity
	Positive torque limitation = 0 [0,1 %M_N]	AMK_ TorqueLimitPositiv
	Negative torque limitation = 0 [0,1 %M_N]	AMK_ TorqueLimitNegativ
Brakes on 0 1/min with positive speed value	Speed setpoint = 0 [1/min]	AMK_ TargetVelocity
	Positive torque limitation = 0 [0,1 %M_N]	AMK_ TorqueLimitPositiv
	Negative torque limitation = (negative sign) required negative deceleration torque [0,1 %M_N]	AMK_ TorqueLimitNegativ

Unacceptably high torque setpoints, especially in the field weakening affect the normal controller behavior and destroy the battery

Torque setpoint

⚠ WARNING

Risk of unstable controller behavior

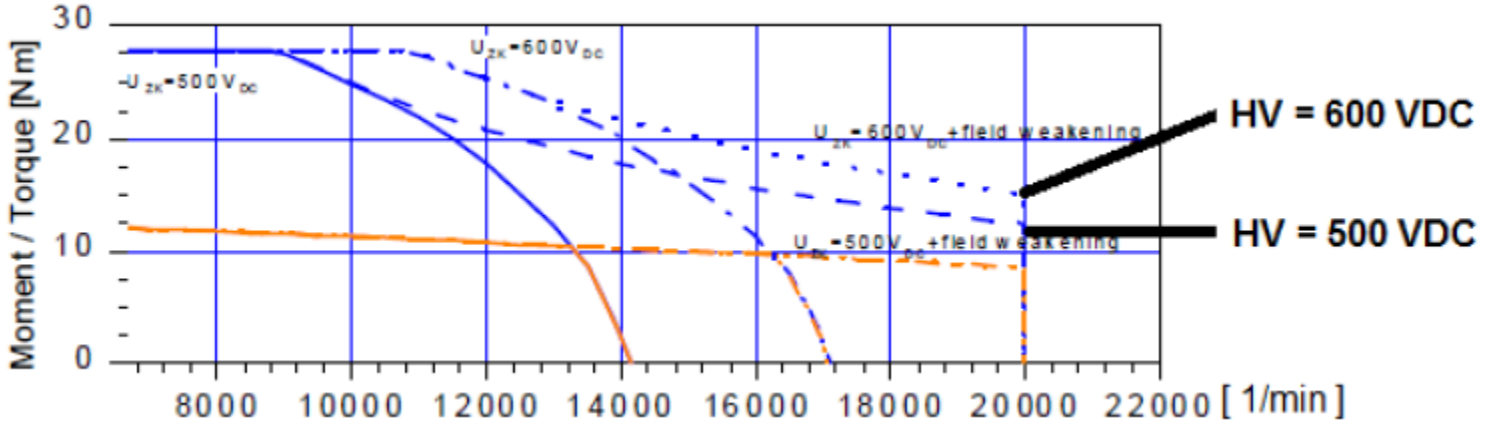
The torque setpoint may not be higher than the maximum torque that can be made available from the motor at the current operating point.

Possible consequences:

- Output terminal overcurrent (diagnoses-no. 2334), drive runs down
- Drive runs down (induced voltage > HV voltage = DC braking)

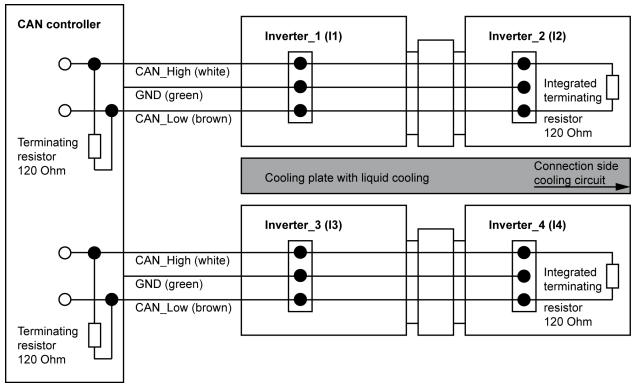
Steps to prevent:

- Calculate maximum nominal torque specification and limit online



The maximum motor torque in the field weakening depends on the HV voltage. Change in the HV voltage,
especially when accelerating must be taken into account by the user.

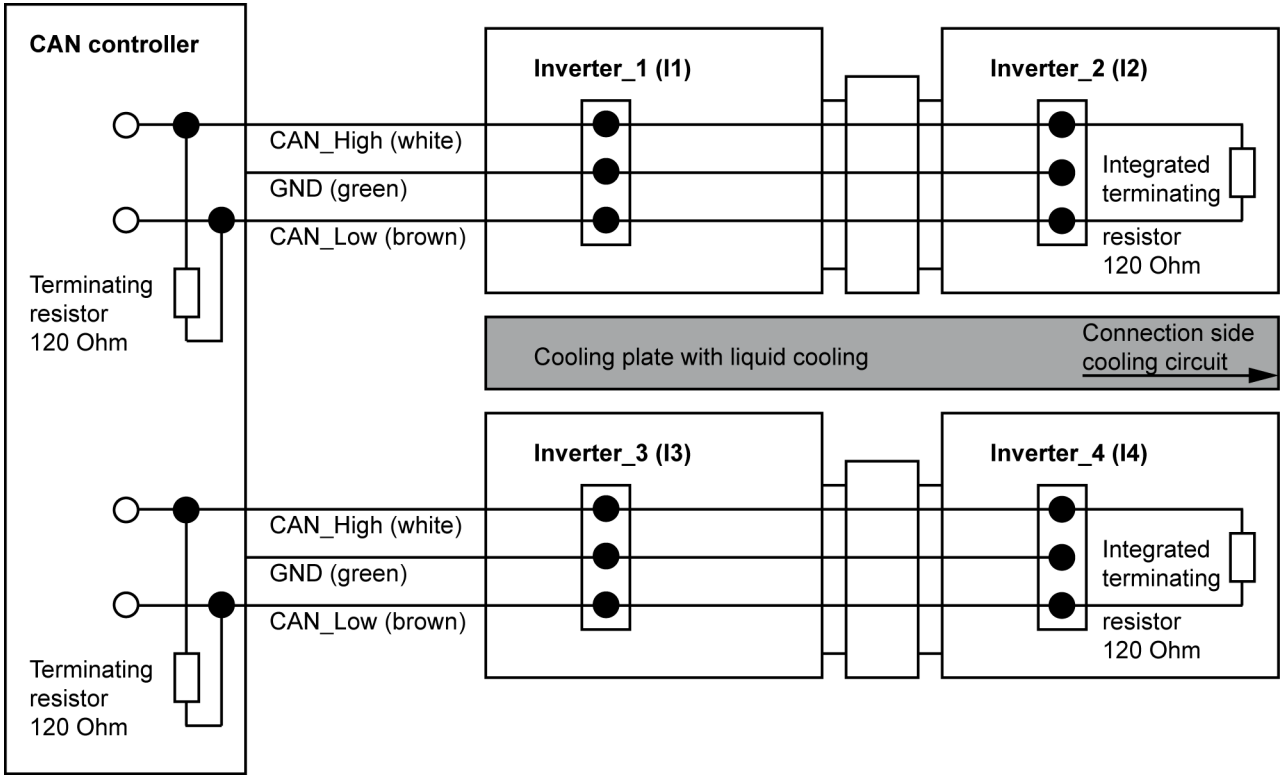
CAN communication



AMK

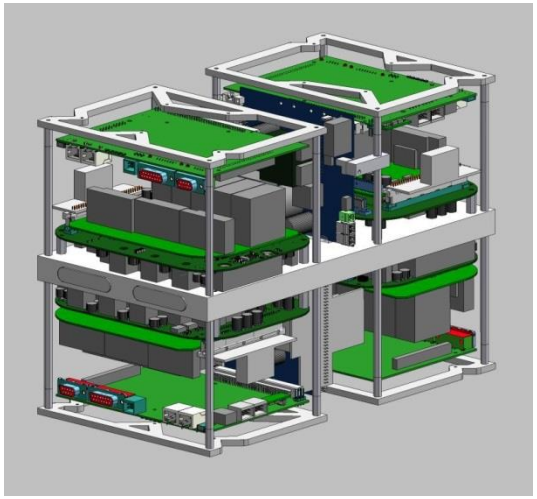
Wiring

Each inverter pair (I1 + I2, and I3 + I4) is operated on a common CAN.



Data messages

The data messages are 8 bytes long and are transmitted in Intel format.



Control bits and setpoints
Query 1 ms cycle (fix)

Status and actual values
ID34028 BUS output rate

CAN CONTROLLER

Telegram failure monitoring:
Enable: Automatic with first received data telegram
Error message when telegram failure > 50 ms
Reaction: Coast (setpoint torque 0 %MN)

Data message description

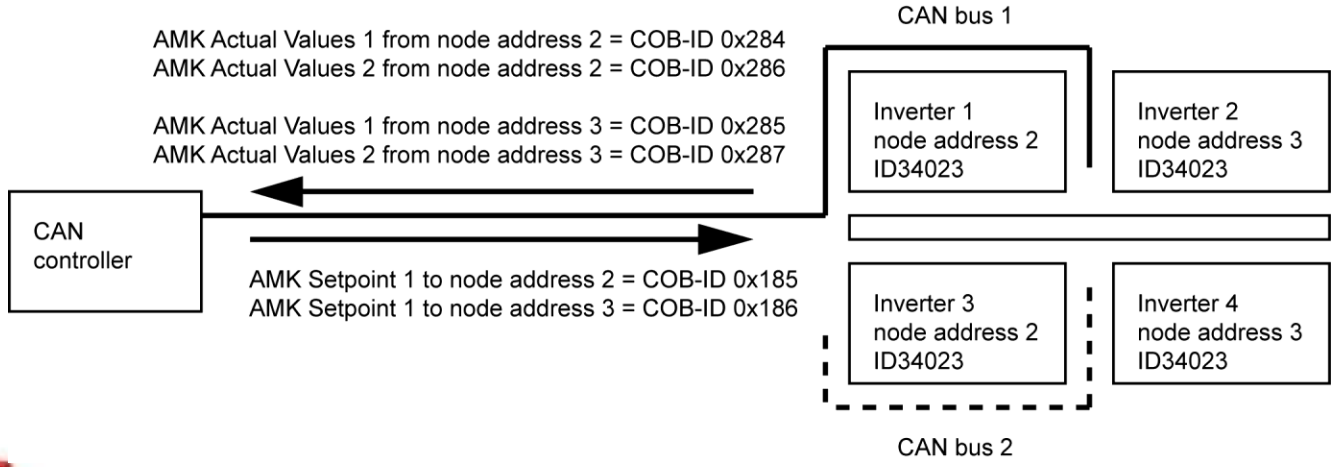
Control bits and setpoints (CAN controller → Inverter)	
AMK Setpoints 1 (0x183)	• Control word (Controller enable, HV enable, drive enable, clear error) • Speed setpoint • Torque limitation positive • Torque limitation negative

Status bits and actual values (Inverter → CAN controller)	
AMK Actual Values 1 (0x282)	• Status word (System ready, error, warning, feedback and mirror HV enable and controller enable, derating active) • Actual speed • Actual torque current (Iq) • Actual magnetic current (Id)
AMK Actual Values 2 (0x284)	• Motor temperature • Coldplate temperature • Diagnosis number • IGBT temperature

Calculation CAN identifier (COB-ID)

The different inverter (node addresses) are using the
base address + offset (current ID34023 'BUS station address') addressed.

Examples:
Calculation of the CAN identifier (COB-ID) for
AMK Actual Values 1 from the inverter with the node address 2
0x282 (AMK Actual Values 1) + 0x2 (Knotenadresse) = 0x284 (CAN Identifier)



The ID34023 'BUS address participant' must be selected,
that no same COB-IDs in the same CAN bus system may occur more than once.

Little-Endian / Intel-Format

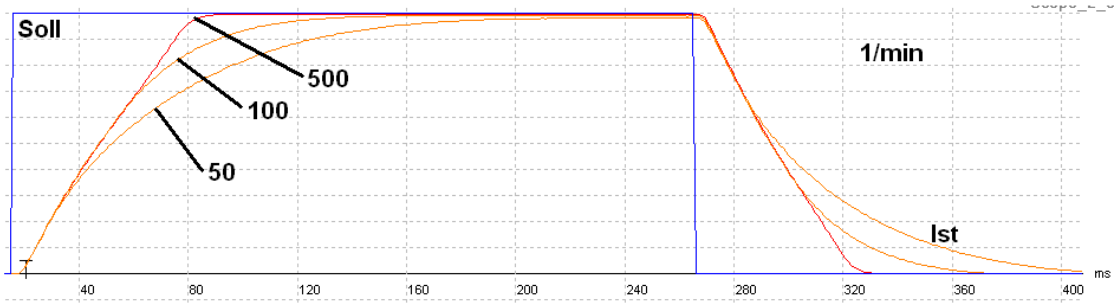
When transmitting data, the low-order value is listed first.
Example for positive and negative values:

1.	Setpoint value <Torque limitation positive>	30 %MN
2.	The torque scaling is 0.1 %MN	300 (dec)
3.	Conversion into hex (Big-Endian / Motorola-Format)	01 2C (hex)
4.	Switch to Little-Endian / Intel-Format	2C 01 (hex)
1.	Setpoint value <Torque limitation positive>	30 %MN
2.	The torque scaling is 0.1 %MN	300 (dec)
3.	Conversion into hex (2 BYTE = 1 WORD!) (Big-Endian / Motorola-Format)	FE D4 (hex)
4.	Switch to Little-Endian / Intel-Format	D4 FE (hex)

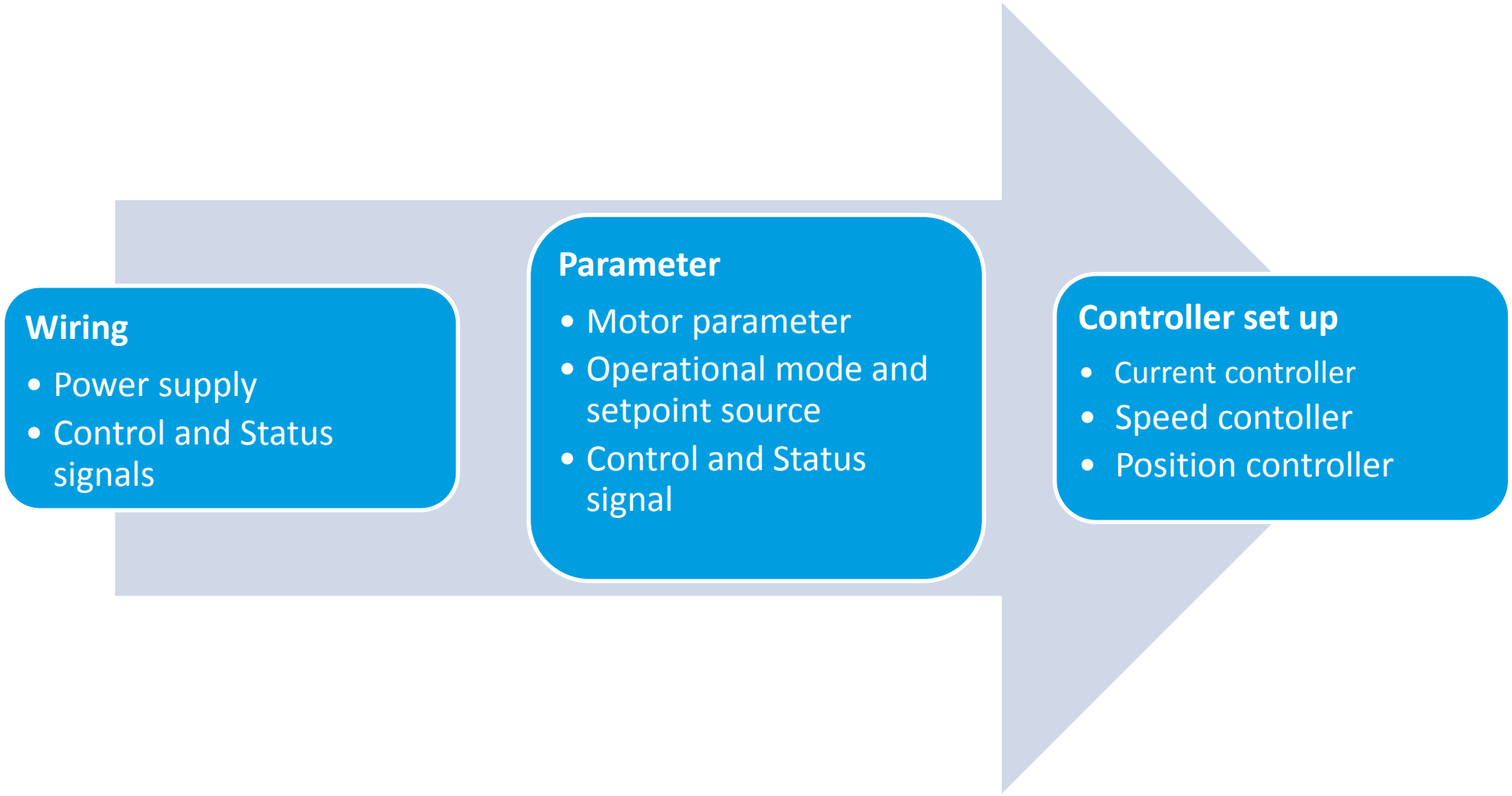




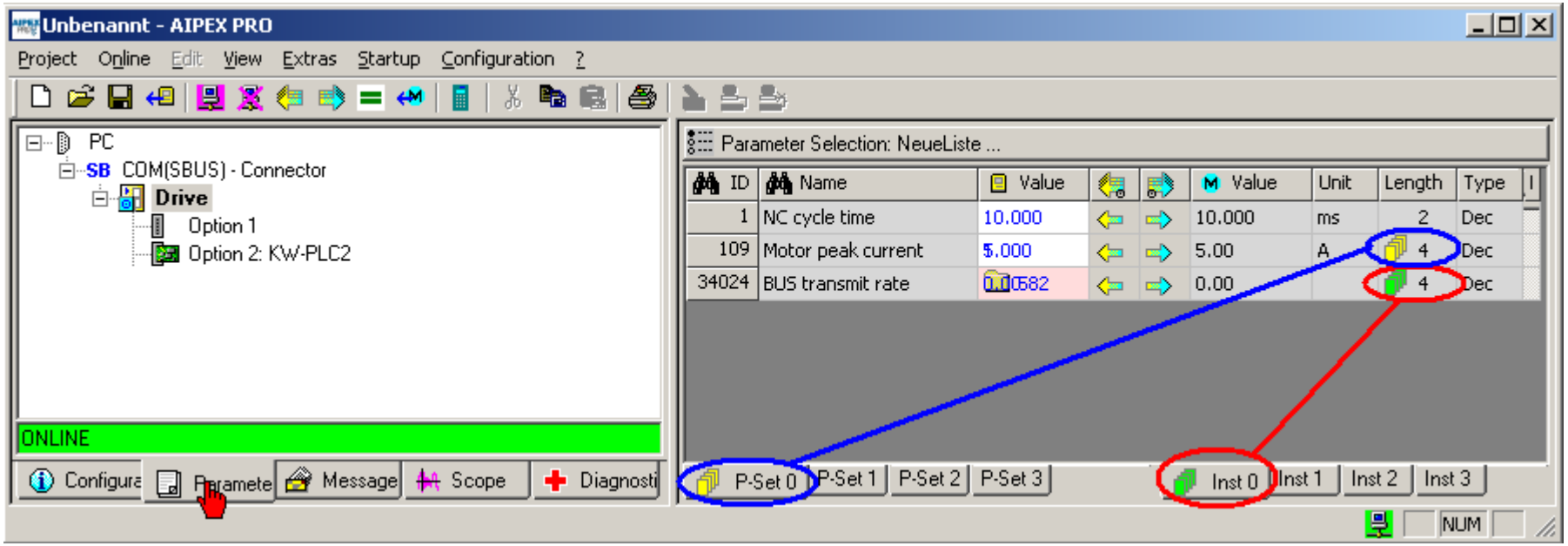
Set up



Set up – Step by Step



Parameter Display AIPEX PRO



Value Offline value (PC) **Value** Online value (AMK device)

(Example: KW-R03)

Inst 0

Instance 0 = Field bus (ACC-Bus)

Instance 1 = Option slot 1

Instance 2 = Option slot 2 (KW-PLC2)

P-Set 0

P-Set = Parameter set (RF 0->1 edge after Parameter set change necessary)

Parameter

All AMK parameters are based on SERCOS standard and are displayed as ID numbers.

- **Parameter groups (filters)**
  - System parameters
  - Motor parameters
  - Operation mode parameters
  - Velocity parameters
  - Position parameters
  - Communication parameters...

The parameters will be saved on the controller card.

Global parameters

ID265 Language

Change active after 24 VDC OFF/ON

Instance parameters

ID34023 Bus station address

Change active after 24 VDC OFF/ON

Drive specific parameters

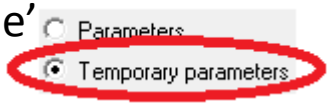
ID32800 main operation mode

Change active after RF OFF/ON

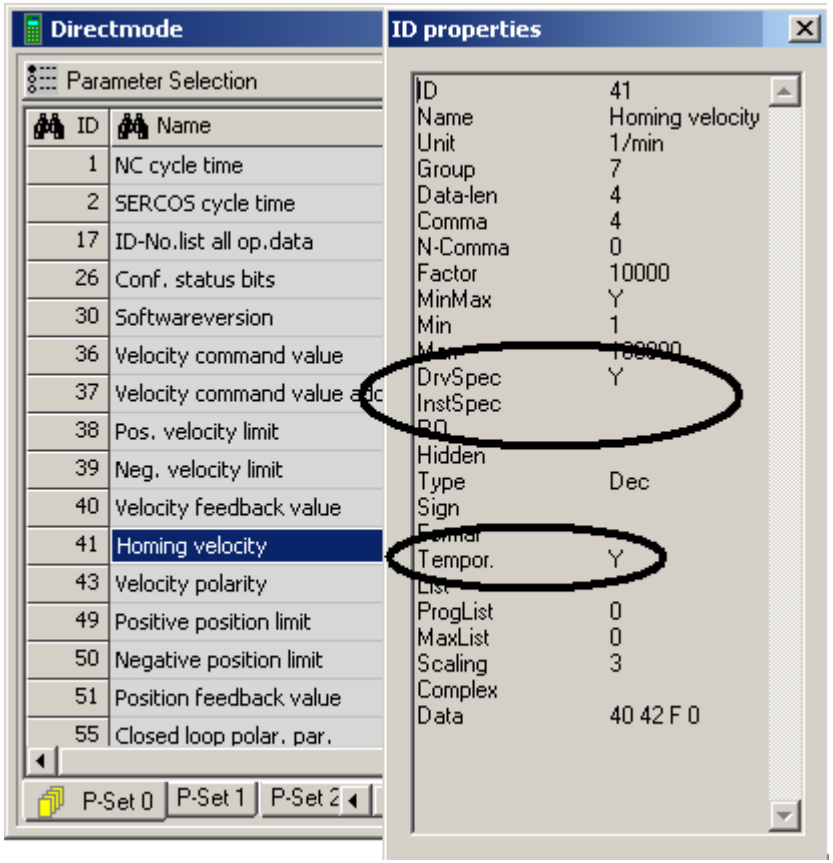
Temporary parameters *

Change immediately active

* Change must take place in the 'Temporary parameters'
e. g. AIPEX PRO 'Direct mode'



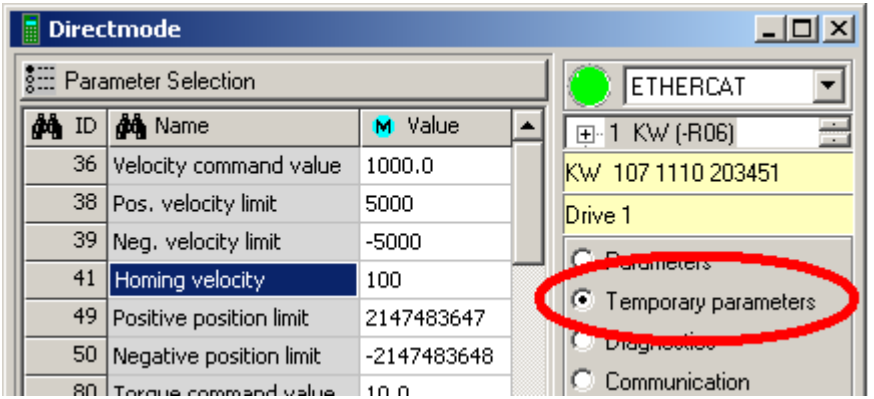
Parameter properties



Open ID properties
Key **ALT** + **ENTER**

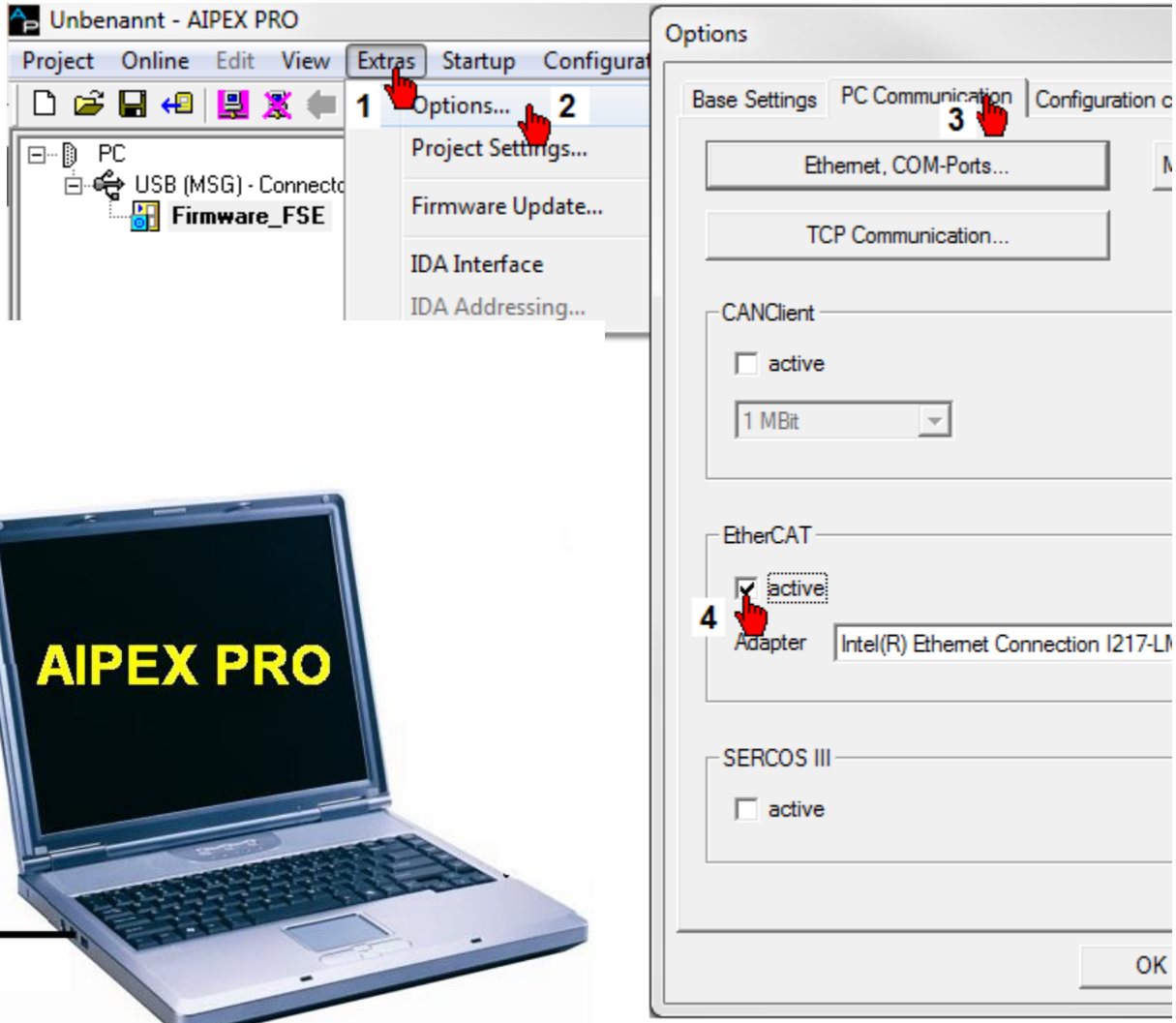
Information:
NOT DrvSpec AND NOT InstSpec =
GLOBAL parameter

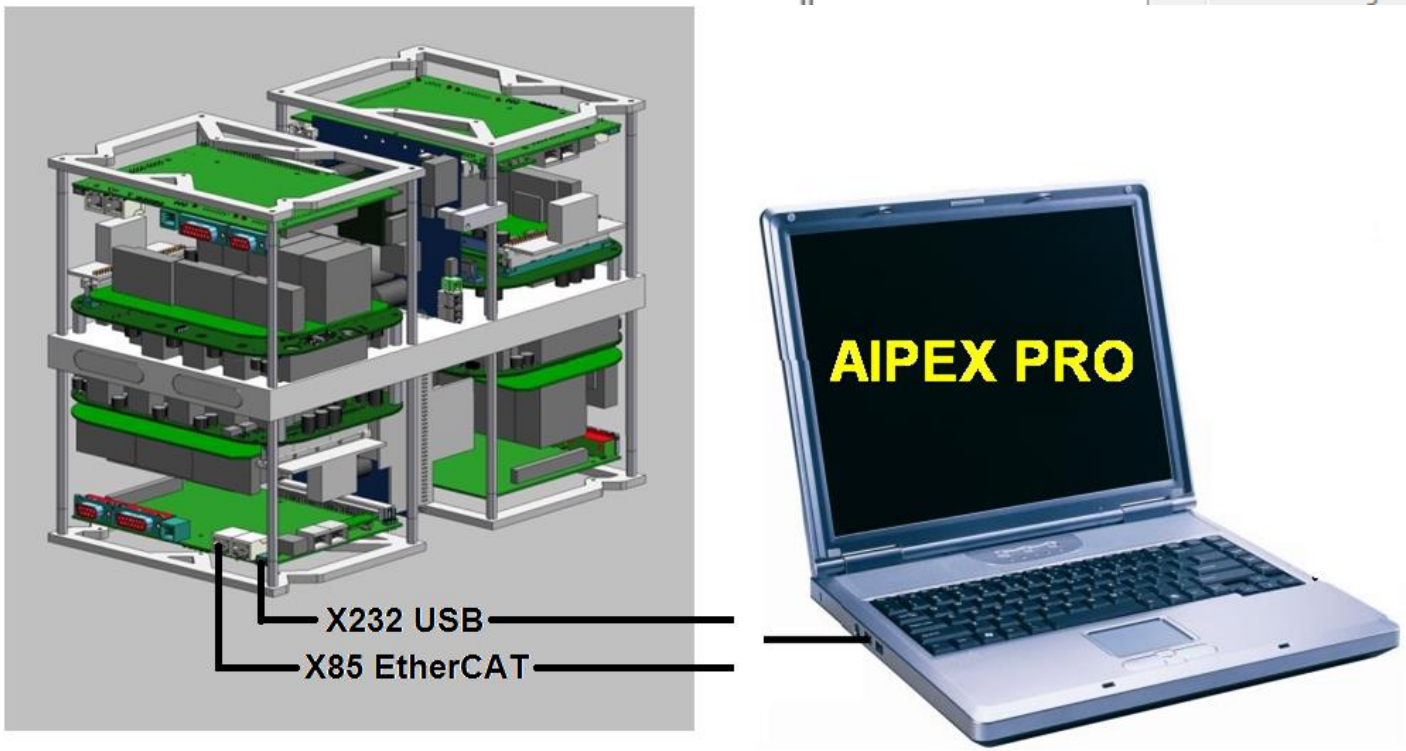
For online change use group
„Temporary parameters“



Example: Direct mode

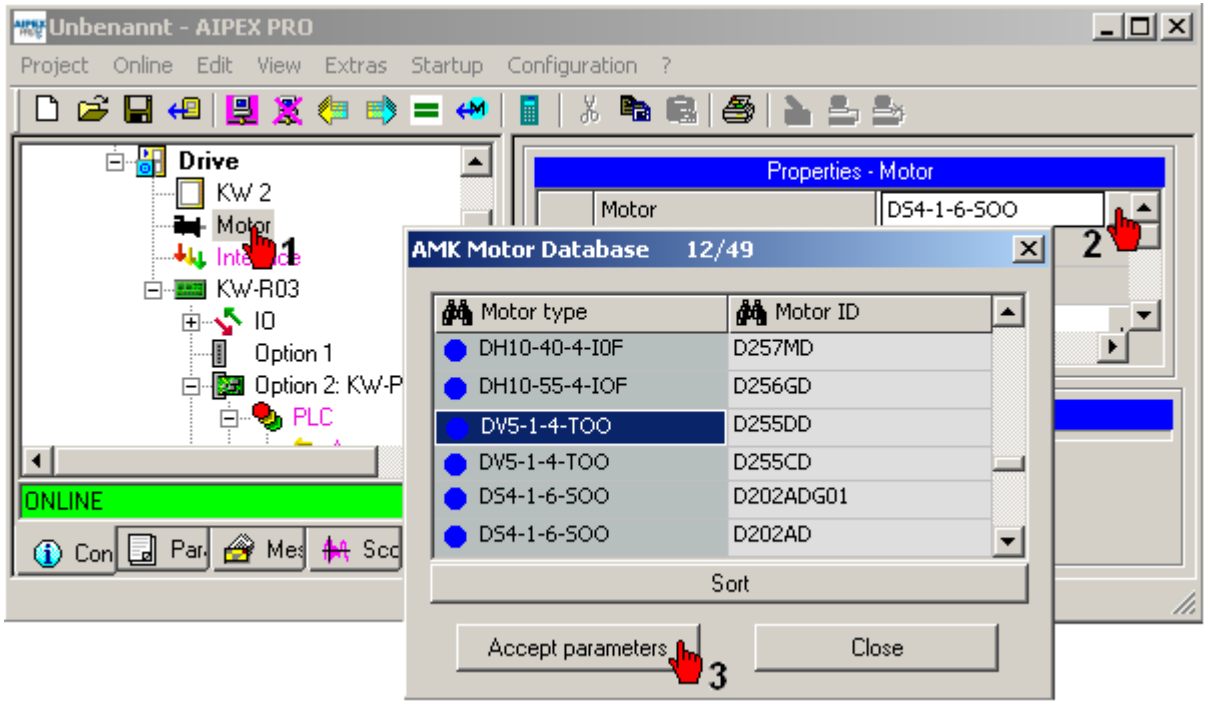
EtherCAT communication settings





The USB interface is always active, no settings required!

Set up motor



Encoder with memory
The motor parameter will automatically upload into a initial load device

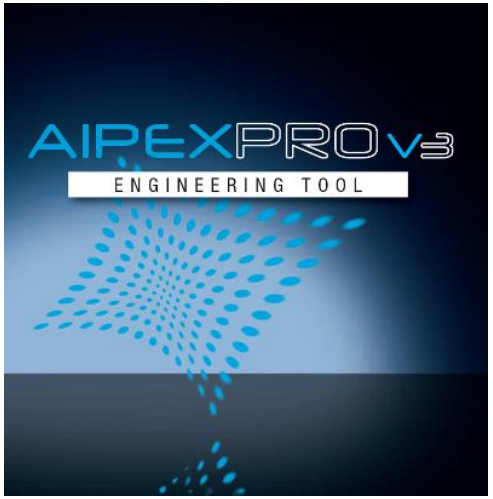
NOTICE

The I^2t motor must be activate manually.

32773 Bit 14 = 1

Parameterization

The parameterization of the inverter will be done with the AMK commissioning software AIPEX PRO.



Motor parameter
ID109 Motor peak current, ID111 Motor nom. current …

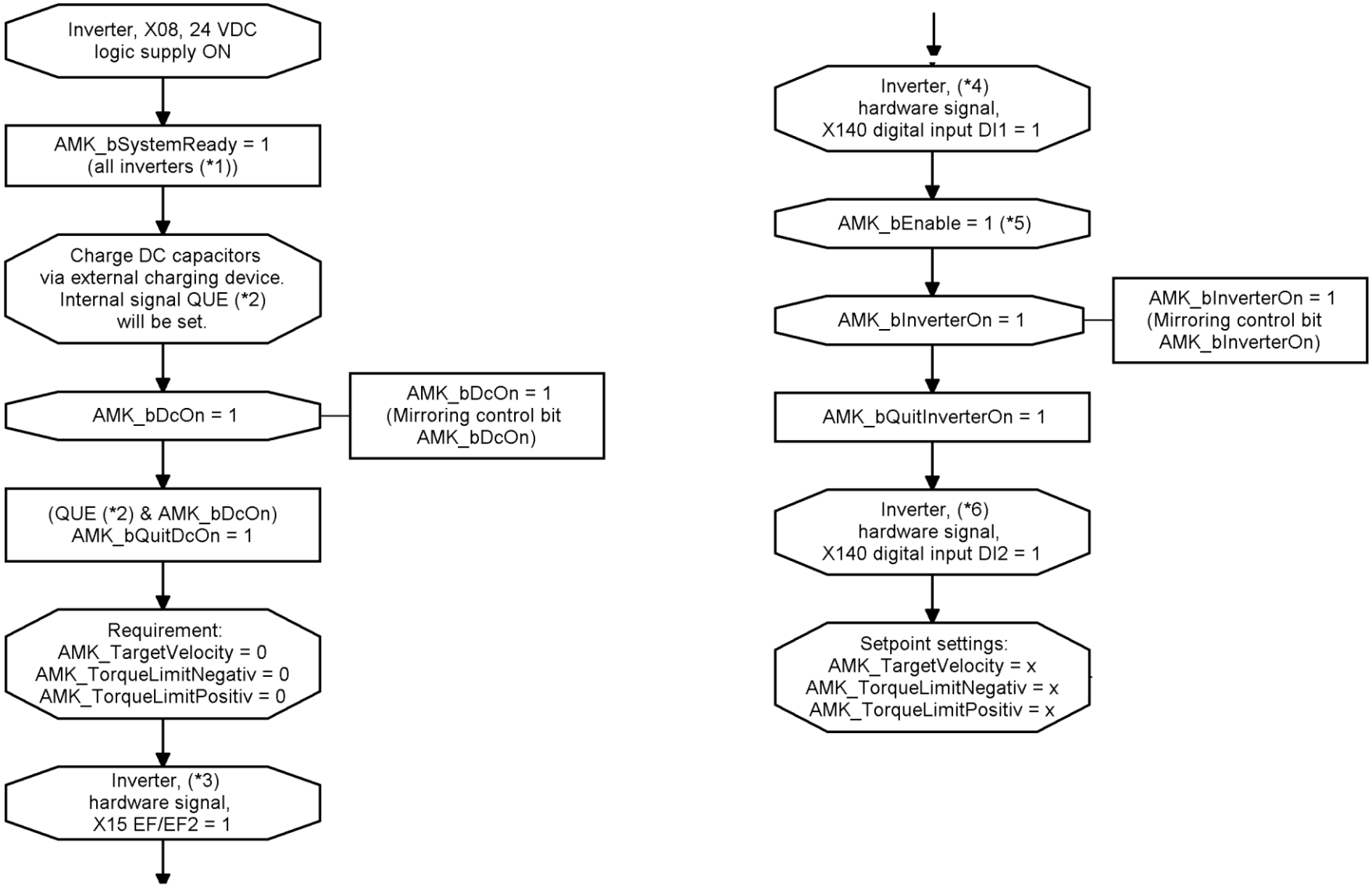
Communication parameter CAN Bus
ID34023 BUS address part. , ID34024 ' BUS transmit rate …

Parameter FSE
ID32798 User list 1

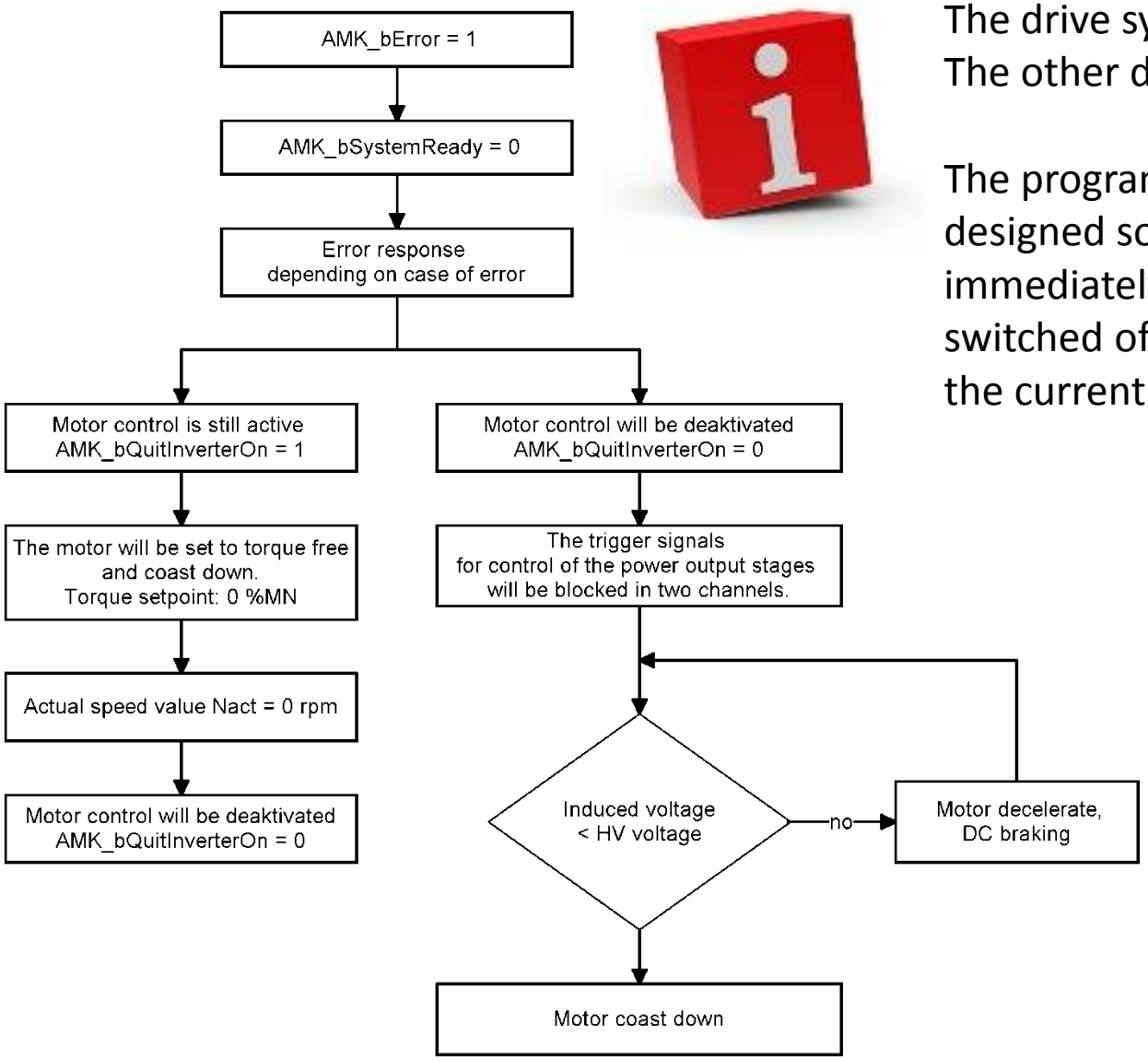
Standard parameter
ID32800 AMK main op. mode, ID32796 Source RF …

For further documentation see:
PDK_205481_KW26-S5-FSE-4Q

Switch on diagram



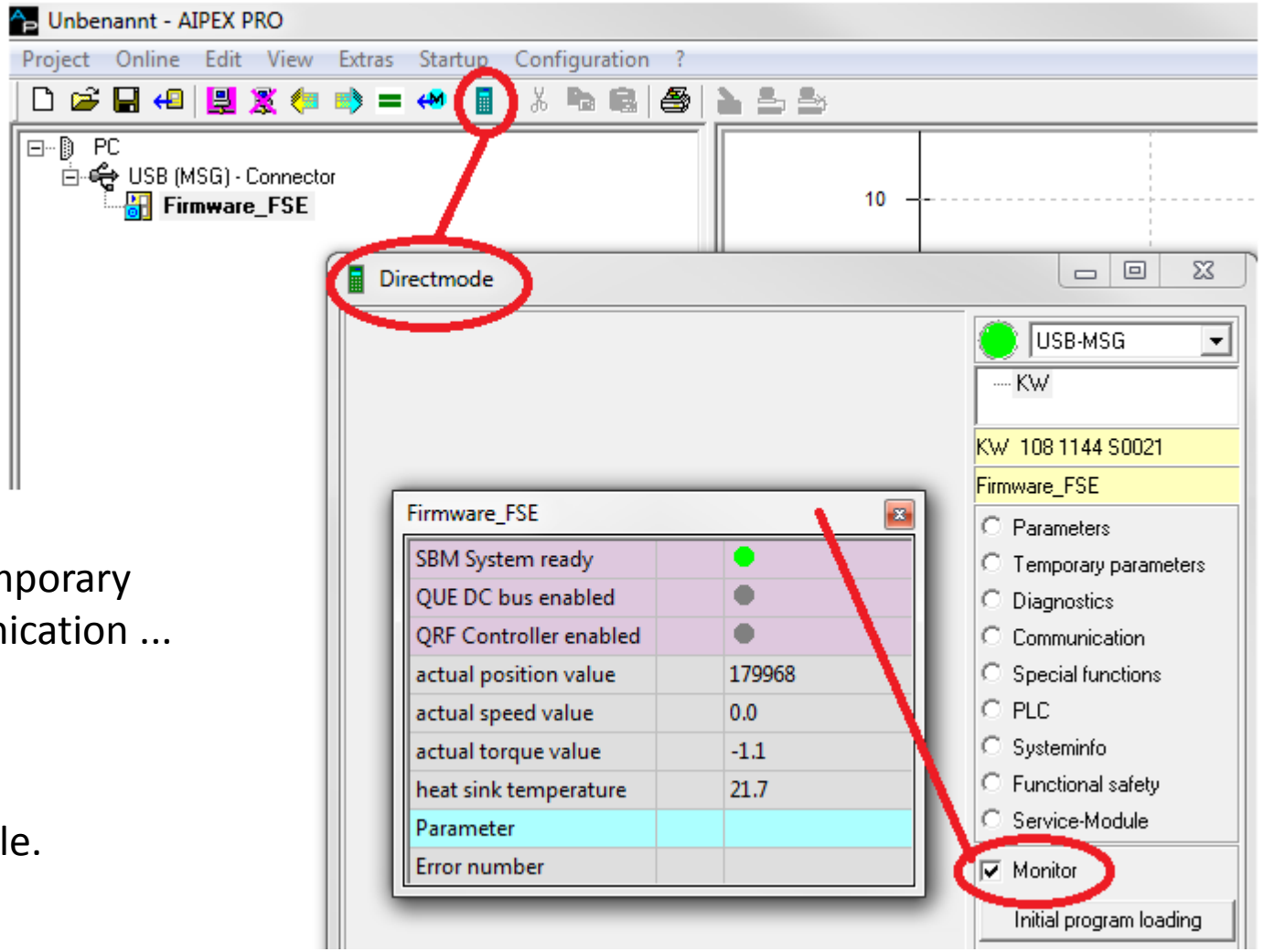
Drive behavior in case of error



The drive system with a fault is switched off. The other drive systems will remain in control.

The program of the CAN controller must be designed so that a fault is detected and immediately the rest of the drive systems are switched off. Torque free or control off depend on the current situation

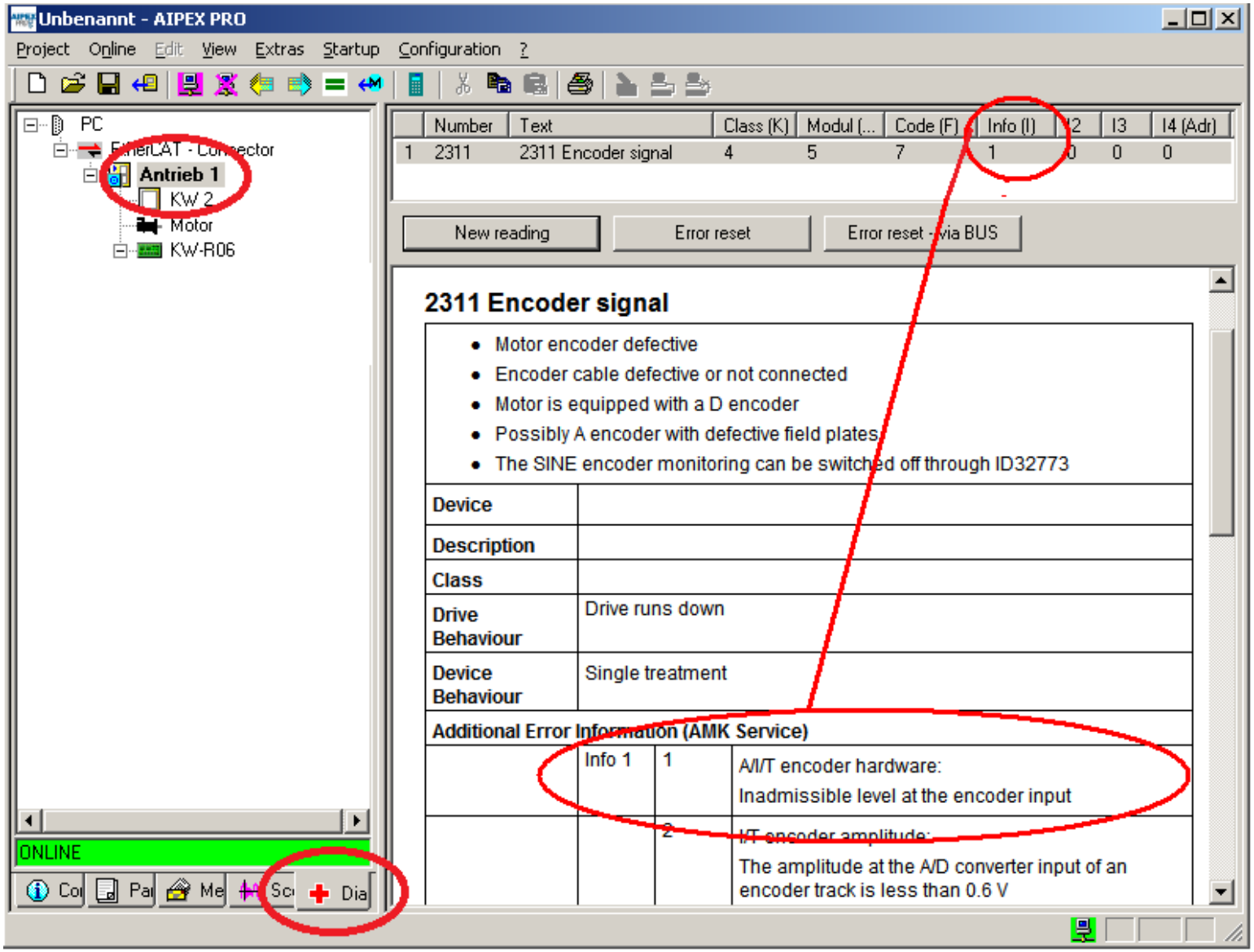
Direct mode and Monitor



Direct mode
Online access to Parameter, Temporary Parameters, Diagnose, Communication ...

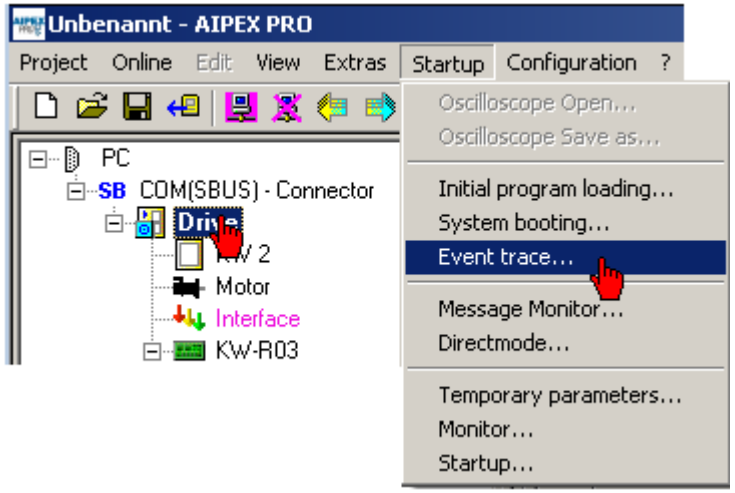
Monitor function
Displays cyclic actual values.
Displayed values are configurable.

Diagnostic with AIPEX PRO



Pay attention to the additional information

Event trace

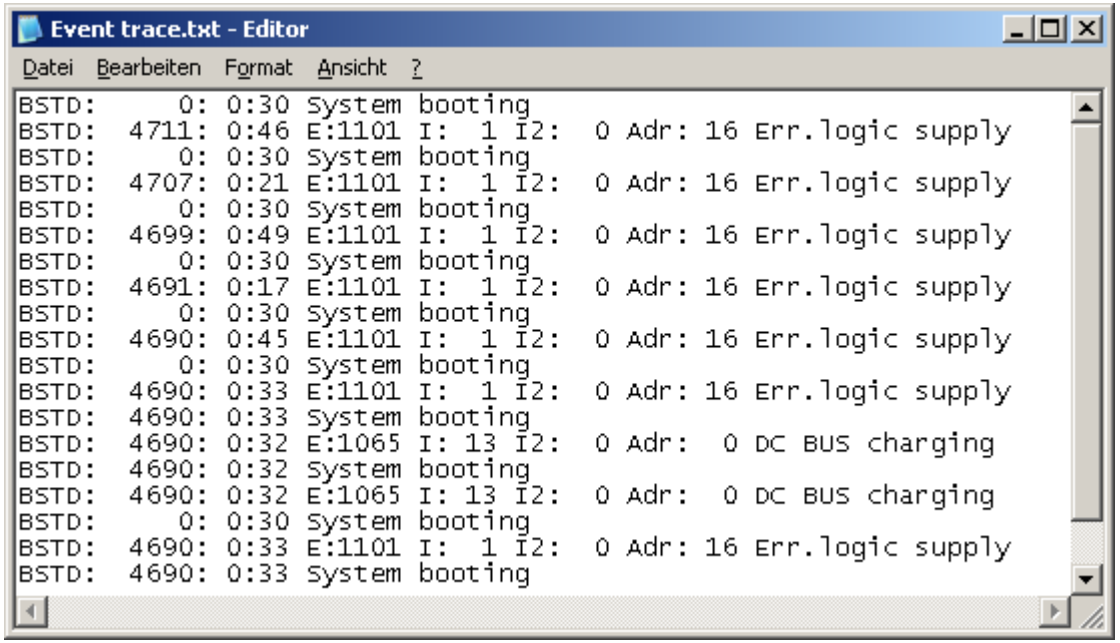


FiFo memory

The size of the memory dependent of the device.

Parameter

ID34088 Event trace



Adjustment Speed Controller (P-part)-Example

Direct mode

temporary parameters

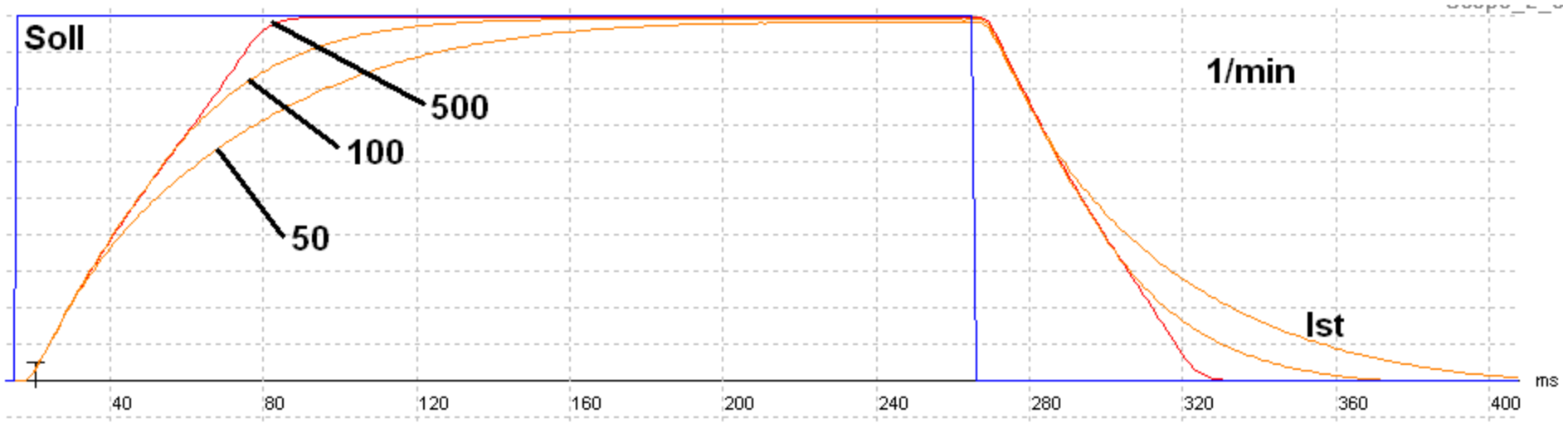
ID100 = 50, 100, 500

ID101 = 0

ID102 = 0

Rectangle setpoint

- Amplitude High = 1000 1/min
- Time High = 250 ms
- Number of periods= 1



Adjustment Speed Controller (I-part)-Example

Direct mode

temporary parameters

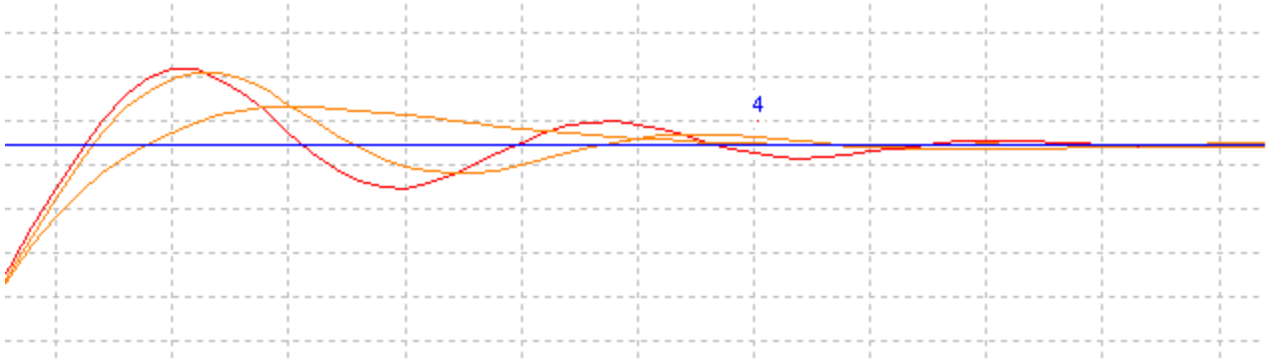
ID100 = 500

ID101 = 10,3,2

ID102 = 0

Rectangle setpoint

- Amplitude High = 1000 1/min
- Time High = 250 ms
- Number of periods= 1



For your safety

For your safety

Safety alert symbols and signal words

DANGER indicates a hazardous situation which, if not avoided,
will result in death or serious injury

WARNING indicates a hazardous situation which, if not avoided,
could result in death or serious injury

CAUTION, used with the safety alert symbol, indicates a hazardous situation which, if not avoided, could result in minor or moderate injury

NOTICE is used to address preventions to avoid material damage, but not related to personal injury.

For your safety

Safety Rules

In particular on drive systems, the instructions pertaining to safety and the following five safety rules have to be kept in the specified sequence:

1. Switch off electrical circuits (also electronic and auxiliary circuits).
2. Secure against being switched on again.
3. Determine that there is no voltage.
4. Earth and short circuit.
5. Cover or close off neighbouring parts that are under voltage.

Reverse the measures taken in reverse order after completing the work.

For your safety

DANGER	
	**Lethal electrical hazard when touching electrical connections!** Electrical terminals and connectors carry voltages that may cause death or serious injury upon contact. The terminals of the DC circuit capacitors (UZP, UZN) on the front panel of the device may retain hazardous DC voltage for up to 5 minutes after switching off the device! In OFF state, the LED indicators on the device front panels do not indicate the voltage status of the terminals. **Steps to prevent:** Wait at least 5 minutes for components to discharge. At each work at the units the five safety rules have to be keeping in. Measure the voltage at the clamps. They must be free of voltage. Connection or disconnection of terminals is only allowed if they are free of voltage.

For your safety

DANGER	
	**Risk of death by electrical shock** In the event of an interruption to the PE connection, avoid touching the casing because life-threatening levels of voltage may be present! **Steps to prevent:** EN50178 requires that the devices be firmly connected on the power side. The PE conductor must have a cross-section of at least 10 mm2.

For your safety

DANGER	
	**Lethal electrical hazard when touching electrical connections!** The permanent magnets of the rotor of a synchronous machine induce dangerous direct current at the motor connections when the axis rotates. **Steps to prevent:** • Make sure that the motor shaft does not rotate. • Prior to any work on the device: Observe the 5 safety rules.

For your safety

WARNING	
	**Risk of burns when touching hot surfaces!** The casing temperature, for example of the line filter, the choke or the braking resistance, can be more than 60 degrees Celsius during and even after operation. Contact causes burns. **Steps to prevent:** • Make sure that the surfaces have cooled down. • Wear protective clothing such as gloves if hot parts need to be touched. • Fit a warning shield with warning hot surface.

For your safety

NOTICE	
Material Damage!	**Electronic components could be destroyed through static discharge!** Therefore touching of the electrical connections (e.g. signal and power supply cable or option and controller cards) must be avoided. **Steps to prevent:** • Avoid touching electrical connections and contacts during handling the electronic component discharge yourself by touching PE • Pay attention to the ESD-notes (electrostatic discharge)