COMBIVERT **F6/S6**

PROGRAMMING MANUAL | Control
Applikation / Compact / Pro – V3.0

Translation of the original manual
Document 20294260 EN 00

1 Preface

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

1.1 Signal words and symbols

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

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

RESTRICTION

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

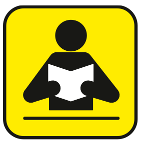
i	➢ Used for informational messages or recommended procedures.

1.2 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. Document search on www.keb.de	

1.3 Laws and guidelines

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

The CE mark is located on the name plate. The EU declaration of conformity can be downloaded from our website if required

1.4 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. AGB	

Further agreements or specifications require a written confirmation.

1.5 Support

Although multiple applications are referenced, not every case has been taking into account. If you require further information or if problems occur which are not referenced in the documentation, you can request the necessary information via the local KEB 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 by the machine manufacturer in combination with the application. They must be repeated, even if only parts of hardware, software or the unit adjustment are modified.

1.6 Copyright

The customer may use the instructions for use as well as further documents or parts from it for internal purposes. Copyrights are with KEB 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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2 Basic Safety Instructions

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

The following safety instructions have been created by the manufacturer for the area of electric drive technology. They can be supplemented by local, country- or application-specific safety instructions. This list is not exhaustive.

Violation of the safety instructions by the customer, user or other third parties will result in the loss of all claims against the manufacturer caused by this.

NOTICE	**Hazards and risks through ignorance!** ➢ Read all parts of the instructions for use! ➢ Observe the safety and warning instructions! ➢ If anything is unclear, please contact KEB!

2.1 Target group

This part of the instructions for use is intended exclusively for persons in design and development who are entrusted with the design and programming of applications.

2.2 Validity of this manual

The instructions for use for the COMBIVERT is divided into the following parts:

- Installation housing
  - Describes the installation
  - Technical data of the power units
  - Operation and maintenance

- Installation control
  - Describes the functions of the controls
  - Technical data of the controls
  - Contains only supplementary safety instructions
  - Information about interfaces

- Programming manual control
  - Describes the parameterization of the device
  - Describes the programming of functions
  - Includes the drive controller software and power unit parameters
  - Contains only supplementary safety instructions

- Safety manuals
  - Is only valid in connection with the instruction manual
  - Contains safety-related supplements and requirements for operation in safety-related applications
  - Contains references to standards that must also be observed
  - The safety manual only applies to inverters with certification

2.3 Electrical connection

⚠ DANGER

Electrical voltage at terminals and in the device!
Danger to life due to electric shock!

- ➢ For any work on the device switch off the supply voltage and secure it against switching on.
- ➢ Wait until the drive has stopped in order that no regenerative energy can be generated.
- ➢ Await capacitor discharge time (5 minutes) if necessary, measure DC voltage at the terminals.
- ➢ Never bridge upstream protective devices (also not for test purposes)

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 according to the design of the machine manufacturer. Specified minimum / maximum values may not be fallen below /exceeded.
- With existing or newly wired circuits the person installing the units or machines must ensure the EN requirements are met.
- For drive controllers 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.

2.4 Start-up and operation

The drive controller 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!
Danger due to unintentional behaviour of the drive!

- ➢ Check especially during initial start-up or replacement of the drive controller if the parameterization is compatible to the 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 controller.
- ➢ Secure motors against automatic restart.

3 Product Description

3.1 Product features

This manual describes the parameterization of the

- Device series: COMBIVERT F6 / S6
- Hardware: Control board C(ompact)
  Control board A(pplication)
  Control board P(ro)
- Software: Version 3.0

3.2 Functional overview

- Operation of asynchronous and synchronous machines
- open-loop and closed-loop operation
- Regeneration possible with encoder or encoderless
- Operation via state machine according to CiA 402
- Brake control
- Operating modes
  - Profile position mode
  - Velocity mode
  - Homing mode
  - Cyclic referencing
  - Cyclic synchronous position mode
  - Cyclic synchronous velocity mode
- Programmable behaviour to errors and warnings
- Programmable display
- Automatic motor detection
- Programmable inputs and outputs
- Different fieldbus interfaces

3.3 Used terms and abbreviations

Term	Description
0V	Earth-potential-free common point
1ph	1-phase mains
3ph	3-phase mains
AC	AC current or voltage
AFE	Active Front End
AFE filter	Filter for the AFE unit
ASCL	Asynchronous sensorless closed loop. Operation with asynchronous motor model without encoder
Auto motor ident.	Automatic motor identification; Measurement of resistance and inductance
AWG	American coding for cable cross-sections
B2B	Business-to-business
BiSS	Open source real-time interface for sensors and actuators (DIN 5008)
CAN	Fieldbus system
CDM	Complete drive module incl. auxiliary equipment (control cabinet)
COMBIVERT	KEB drive controller
COMBIVIS	KEB start-up and parameterization software
DC	DC current or voltage
DI	Demineralized water, also known as deionized (DI) water
DIN	German Institute for Standardization
DS 402	CiA DS 402 - CAN unit profile for drives
EMC	Electromagnetic compatibility
EN	European standard
EnDat	Bidirectional encoder interface of the company Heidenhain
EtherCAT®	Real-time Ethernet bus system; EtherCAT® is a registered trademark and patented technology, licensed by Beckhoff Automation GmbH, Germany. It is marked by the following logo: EtherCAT®
Ethernet	Real-time bus system - defines protocols, connectors, cable types
FE	Functional earth
FSoE	Functional safety via Ethernet
FI	Drive controller
Encoder emulation	software-generated encoder output
GND	Reference potential, ground
GTR7	Braking transistor
HF filter	High frequency filter to the mains
Hiperface	Bidirectional encoder interface of the company Sick-Stegmann
HMI	Visual user interface (Touchscreen)
HSP5	Fast, serial protocol
HTL	Incremental signal with an output voltage (up to 30V) -> TTL
I^2t-monitoring	Software function for thermal monitoring of the motor winding
IEC	International standard
IP xx	Degree of protection (xx for level)
Node address	(Also Node ID) Describes in this document the identification number with which a KEB device is addressed via the KEB own protocol DIN66019.
KTY	Silicon temperature sensor (polarised)
LW heat exchanger	Air/ water heat exchanger
MCM	American measuring unit for large cable cross-sections

Term	Description
Modulation	means in drive technology that the power semiconductors are controlled
MTTF	mean service life to failure
NN	Sea level
Emergency switching off	Switching off the voltage supply in emergency case
Emergency stop	Shutdown of a drive in emergency case (not de-energized)
Object directory	Ordered collection of parameters (objects) of the device
OC	Overcurrent
OH	Overheating
OL	Overload
OSSD	Output switching element; Output signal that is checked at regular intervals to ensure that it can be switched off. (safety technology)
PA	Potential equalization
PDS	Power drive system including motor and sensor (encoder)
PE	Protective earth
PELV	Safe protective low voltage, earthed
PFD	Term used in the safety technology (EN 61508-1…7) for the size of error probability
PFH	Term used in the safety technology (EN 61508-1…7) for the size of error probability per hour
SCL	Synchronous sensorless closed loop. Operation with synchronous motor model without encoder

Table 3-1: Used terms and abbreviations

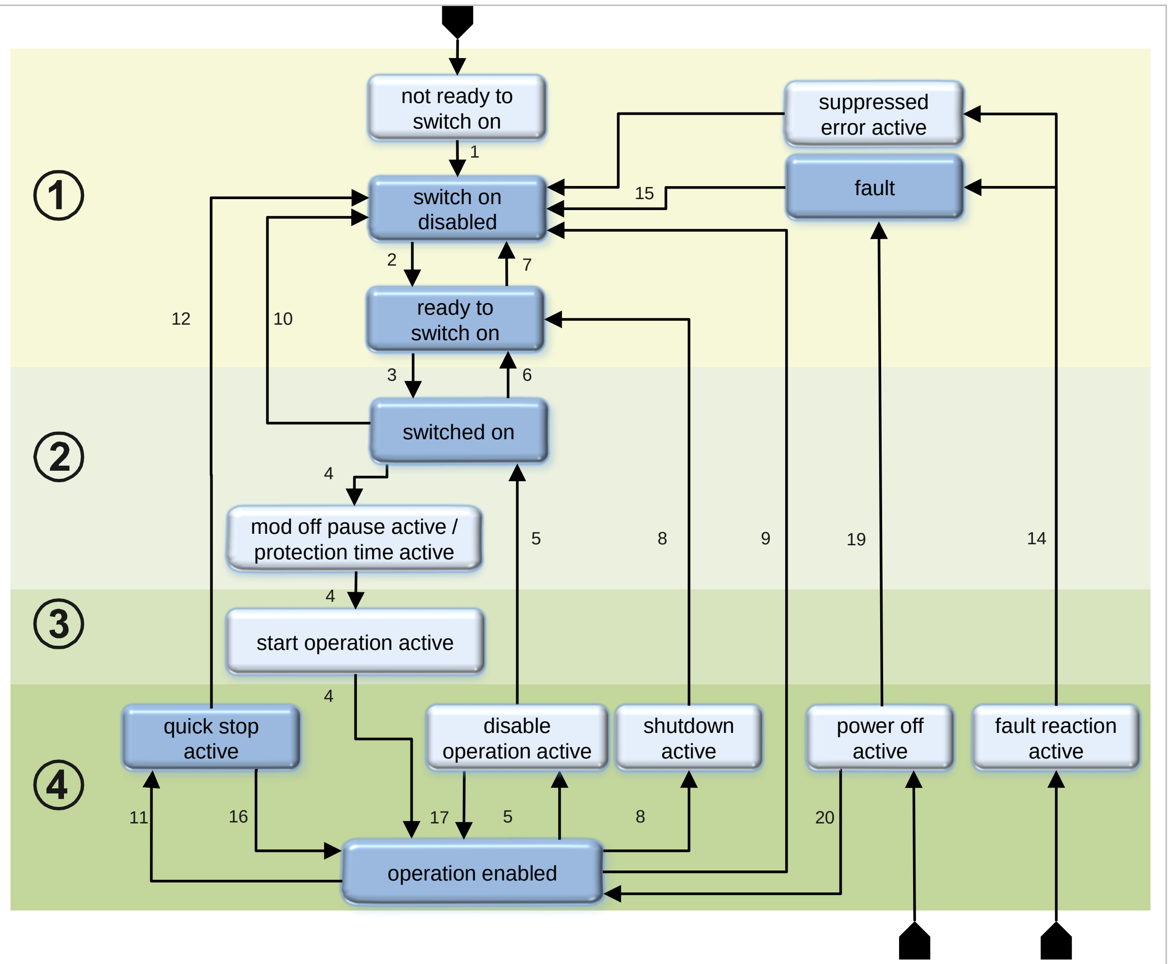
4 Motion Control

4.1 State machine

The state machine provides information about the actual operating state of the drive and describes the change between the operating states.

The state machine is controlled via the co00 (CiA 0x6040) controlword and internal events (e.g. occurrence of an error). The actual state is displayed via st00 (CiA 0x6041) statusword . The actual state can be determined additionally via st12 state machine display.

The following block diagram displays the state machine. The states are also displayed in english in the german documentation with the original english designations, since these became generally accepted also in German-speaking areas.



1 24V control voltage applied; voltage power unit can be applied.
2 Voltage power unit applied; no torque at the motor
3 Voltage power unit applied; torque can be applied (flux build-up, speed search etc.)
4 Torque at the motor

Figure 1: State machine

Not ready to switch on:

This state is pass through after switching on the control voltage (initialisation of the control hard- and software). After completion of the initialisation the unit changes automatically into state **Switch on disabled**.

Switch on disabled:

StateSwitch on disabled is reached when:

- The initialisation is completed (1).
- An error reset was successful (15).
- The bit **Enable voltage** at co00 (CiA 0x6040)controlword is set to 0 (9,10).
- The release at the safety module (STO) is not preset (9,10).
- The charging of the DC link is not completed.

Ready to switch on:

State Ready to switch on is reached when:

- In state **Switch on disabled** bit Enable voltage is set to 1(2).
- In state **Switched on** bit Switch on is set to 0 (6).
- In state **Operation enabled** bit **Switch on** is set to 0 (8).

The behaviour of change 5 can be influenced by parameters. See also: Affect the behaviour of the state machine.

Switched on:

State Switched on is reached when:

- In state Ready to switch on bit Switch on is set to 1 (3).
- In state Operation enabled bit Enable operation is set to 0 (5).

State **Switched on** can only be reached with voltage supply at the power unit. The behaviour of change 5 can be influenced by parameters. See also: Affect the behaviour of the state machine.

Mod off pause active / Protection time active / Endless protection active:

This state is reached when:

- In state **Switched on** bit **Enable operation** is set to 1 (4).

A minimum switch-off time (Mod off pause) must be kept after switching off the modulation until it can be switched on again. A protection time must be observed after some errors (OC, OL2, OP). If **Enable operation** is set to 1 and the corresponding time has not yet elapsed, the state **Mod off pause active** / **Protection time active** / **Endless protection active** is set. (For a more detailed description of the individual states, see chapter
If the minimum off time of the unit is up, the drive changes into state **Start operation active**.

Suppressed error active:

This state is reached when an error has occurred that should not be indicated as error in ru01 or st00 (CiA 0x6041) statusword.

Start operation active:

This state is reached when:

- In state Switched on bit **Enable operation** is set to 1 (4) and the minimum turn-off time of the unit is up.

In state **Start operation active** the operations which are required for the start of the drive control are done by the drive. Which operations are executed is dependent on the used motor type, the control mode and the application-dependent parameterization of the unit.

Possible functions are:

- Structure of the magnetic flux (asynchronous machine), determination of the rotor position (encoderless controlmethod), open the brake, etc.

After completion of these functions the drive changes into state **Operation Enabled**.

Operation enabled:

State **Operation enabled** is reached when:

- In state **Switched on** bit **Enable operation** is set to 1 (4) and both the minimum turn-off time is up and also the start operations were executed.

Quick stop active:

State **Quick stop active** is reached when:

- in the control word bit 2 (**no Quickstop**) is 0.
- When **Quickstop** in co32 is deactivated, bit 2 in the control word is ignored.

Fault reaction active:

State **Fault reaction active** is reached when:

- An error occurs.

The response to an error can be affected by parameters. See also: Affect the behaviour of the state machine.

Fault:

State Fault is reached when:

- The error response is completed.

shutdown operation active

State **shutdown operation active** is reached when:

- Bit **switch on** is reset in state **Operation enabled**.

disable operation active

State disable operation active is reached when:

- Bit **Enable Operation** is reset in state **Operation enabled**.

Power Off:

State **Power Off** is reached when:

- A mains power failure is detected and the Power Off function has been activated in the cu parameters (see chapter 4.4.22).

> i
> ➢ The states "shutdown operation active", "disable operation active" and "fault reaction active" are only carried out with the appropriate setting of the state machine. The behavior in these states is defined in co32.

4.1.1 Changes of the state machine

All possible changes between the different states of the state machine can be found in the picture in chapter4.1 State machine.

Setting of bit 3 ***Enable Operation*** in the controlword can deactivate the **Disable Operation** function.

Setting of bit 2 ***no Qickstop*** can deactivate **Quickstop Reaction Active**.

Disable Operation Active can be interrupted by **Shutdown Operation Active**.

Quickstop Reaction Activecan **not** be interrupted by **Shut Down Active**, independent of the selected response to the ***Switch On*** Bit.

Fault Reaction Active has the highest priority and can interrupt **Shutdown Operation Active, Disable Operation Active** and **Quickstop Reaction Active** .

Exception:

- **Fault Reaction Active** is interrupted by **Shut Down**, if shutdown mode is set as direct shutdown (shutdown option code = „0: disable drive function" or co32 state machine properties Mode shutdown mode = „0: direct").

Removal of bit 1 ***enable voltage*** always leads to an immediate shutdown of the modulation.

4.1.2 Control word

State changes of the **state machine** are requested via the object co00 (CiA 0x6040) controlword. Access to the control word is possible via two addresses:

Index	Id-Text	Name	Function
0x2500	co00	(CiA 0x6040) controlword	KEB spec. Object
0x6040			CiA402 object

This "communication control word" can be changed by other sources (e.g. digital inputs, protective functions):

Index	Id-Text	Name	Function
0x251E	co30	controlword mask	Mask to activate the internal controlword
0x251F	co31	controlword internal	Internal controlword
0x210E	st14	active controlword	displays the controlword, which results from the combination ofco31 controlword internal and the stop reactions

The controlword contains the following bits:

co00	(CiA 0x6040) controlword	0x2500
Bit	**Name**	**Note**
0	Switch on	Command to the state change (=> below)
1	Enable voltage	Command to the state change (=> below)
2	no Quick stop	0 activates quick stop (function must be activated in co32)
3	Enable operation	Command to the state change (=> below)
4…6	Operation mode specific	Meaning is depending on the operating mode
7	Fault reset	Command to the state change (=> below)
8	Halt	Halt is supported in vl, hm and pp mode
9	Operation mode specific	Meaning is depending on the operating mode
10	Reserved	
11…14	Operation mode specific	Manufacturer specific, currently supported function: • combined handling of controlword bits and digital input functions
15	Open brake	Manufacturer specific, currently supported function: • 1 => Opening of the motor brake (depending on co21 brake control mode)

Using bits 0-3 and 7 commands for changing the state:

Command	Bits in the control word					Change
	Fault reset	Enable operation	Quick stop	Enable voltage	Switch on	
Shutdown	0	x	1	1	0	2,6,8
Switch on	0	0	1	1	1	3
Disable voltage	0	x	x	0	x	7,9,10,12
Quick stop	0	x	0	1	x	7,10,11
Disable operation	0	0	1	1	1	5
Enable operation	0	1	1	1	1	4,16
Fault reset	↑	x	x	x	x	15

The effective controlword st14 active controlword is formed in several steps:

0x2500 co00 resp. 0x6040 is the bus control word released for process data.

This control word can be influenced by digital inputs. How the control word formed from the digital inputs can be seen in parameter di29 digital input controlword.

For diagnostic purposes, or if single bits shall be preset via digital inputs, the access of co00 or Adr.0x6040 to single bits of the internal controlword can be switched off in co30. The default value of 0xFFFF in co30 means that all bits are preset via the bus-controlword. Access of the bus-controlword to the internal status word is completely switched off with 0 in co30.

Parameters co28 combined controlword mask and co29 source connection definition can be used to implement a link (AND / OR / switchable) between digital input functions and the specifications in co00. The result of this link is visible in st15 combined control word.

A detailed description of the presetting via digital inputs or the combined setting via digital inputs and controlword bits is given in the chapter 7.1.9.1 Controlword functions via the digital inputs.

co31 controlword internal can be written even via bus. This parameter can not be set to process data.

However, the default case is to specify the control word via 0x2500 co00 or 0x6040.

The effective controlword can be changed by the protection functions. (see chapter 4.3.1.2.2 Error reaction)
st14 active controlword displays the controlword that results after evaluation of the stop reactions. This control word is decisive for the behaviour of the state machine.

4.1.3 Statusword

The actual state of the **state machine** is displayed via the object status word. Access to the status word is possible via two addresses:

Index	Id-Text	Name	Function
0x2100	st00	(CiA 0x6041) statusword	KEB spec. Object
0x6041			CiA402 object

The status word contains the following bits:

st00	(CiA 0x6041) statusword		0x2100
Bit	Name	Note	
0	ready to switch on	Display of the actual state (=> below)	
1	switched on	Display of the actual state (=> below)	
2	operation enabled	Display of the actual state (=> below)	
3	fault	1 = fault	
4	voltage enabled	1 = Operating voltage in the power circuit OK	
5	no quick stop	1 = quick stop not active / 0 = quick stop active	
6	switch on disabled	Display of the actual state (=> below)	
7	warning	1 = There is a warning (if a warning should also be displayed in the statusword is determined with parameter pn28 warning mask)	
8	synchron	Manufacturer-specific, 1 = Drive control synchronous to field bus	
9	remote	is not supported	
10	target reached	1 = Target position reached in pp and hm mode	
11	internal limit active	1 = Internal limitations (the speed controller output value reaches the torque or current limit)	
12	op. mode spec. 12	Setpoint acknowledge in pp-mode Drive follows command in csp, csv and cst mode	
13	op. mode spec. 13	Following error at active position controller	
14	manufacturer spec. 14	Manufacturer specific => Special function (Power Off, Suppressed Error) active	
15	manufacturer spec. 15	Braking state (=> Chapter 4.2.7 Status of the brake control)	

Determination of the actual state of the state machine from the status word:

Statusword	State of the state machine
xxxx xxxx x0xx 0000	Not ready to switch on
xxxx xxxx x1xx 0000	Switch on disabled
xxxx xxxx x01x 0001	Ready to switch on
xxxx xxxx x01x 0011	Switched on
xxxx xxxx x01x 0111	Operation enabled
xxxx xxxx x00x 0111	Quick stop active
xxxx xxxx x0xx 1111	Fault reaction active
xxxx xxxx x0xx 1000	fault

4.1.4 Display of the actual state

The current state of the state machine can be read out directly.

Index	Id-Text	Name	Note
0x210C	st12	state machine display	actual state of the state machine (KEB spec. object)ob-ject)
0x210D	st13	state and error display	Error and state machine display

The meaning of the values of st12:

st12	state machine display		0x210C
Value	State	Note	
0	Initialization	This state is pass through after switching on the control voltage (ini-tialisation of the control hardware and software).	
1	Not ready to switch on		
2	Switch on disable	The modulation cannot be enabled yet. In addition to the controlword bits, causes can be missing STO sig-nals or missing mains voltage.	
3	Ready to switch on	The bit "enable voltage" is not yet set, the preconditions STO sig-nals and mains voltage are given	
4	Switched on	The "enable operation" bit is missing to enable modulation	
5	Operation enabled	Modulation is enabled, the state machine has started, no exception (e.g. stop mode) is active for the handling of the state machine.	
6	Quick stop active	The quick stop reaction is carried out	
7	Fault reaction active	The error / fault reaction is carried out. Modulation is still active.	
8	Fault	Fault (modulation switched off)	
9	Shutdown active	"Shutdown“ or "Disable operation“ is executed according to the mode selected in co32	
10	Disable operation active		
11	Start operation active	Start function active (e.g. flux build-up, brake opening)	

st12	state machine display		0x210C
Value	State	Note	
12	Mod off pause active	Minimum switch-off time of the modulation not yet expired	
13	Power Off	Power Off function active	
14	protection time active	A protection time (minimum switch-off time after error) is active For more detailed information see chapter (4.4.23 Minimum switch-off times.	
15	protection time end		
16	endless protection time		
17	suppressed error	An applied error leads to modulation shutdown, but it is not displayed as an error in ru01 and the state parameters.	

The detailed description of the single states of the state machine and the changes can be found in chapter 4.1 State machine.

st13	state and error display		0x210D
Bit	Name	Note	
0…7	error display	Value of ru01 (see 4.3.1 Errors)	
8…15	state display	Value of st12 * 256	

This parameter is used to indicate the reason for the triggering of a stop function (Fault-Reaction / ShutDown / Quickstop / DisableOperation), even if the internal error state is no longer present during the ramp.

The display of the error is not reset via a reset, but only by the request of a new state machine change via the internal controlword.

4.1.5 Affect the behaviour of the state machine

The behaviour of the state machine can be affected via parameter co32 state machine properties.

Index	Id-Text	Name	Function
0x2520	co32	state machine properties	KEB spec. Object

The parameter contains the following bits:

co32	state machine properties		0x2520
Bit	Function	Value	Plaintext
0	Shutdown mode	0	direct change to ready to switch on
		1	Deceleration at ramp (selection bit 4…5)
1	Disable operation mode	0	direct change to switched on
		2	Deceleration at ramp (selection bit 6…7)
2	Fault reaction mode	0	If an error occurs direct change in fault mode
		4	Fault reaction depending on fault and adjustment
3	Enable operation mode	0	Change 4 if bit Enable operation is 1
		8	Change 4 at positive edge of Enable operation
4…5	Shutdown ramp mode	0	Fault reaction ramp (pn45 … pn62)
		16	Standard ramp (co48 … co60)
		32	Positioning module ramp (ps48…ps59)
		48	Reserved
6…7	Disable operation ramp mode	0	Fault reaction ramp (pn45 … pn62)
		64	Standard ramp (co48 … co60)
		128	Positioning module ramp (ps48…ps59)
		192	Reserved
8	Enable vl ramp options	0	Ramp generator options für velocity mode disabled (=> Description co00)
		256	Ramp generator options für velocity mode enabled
9	Enable Quickstop	0	Quickstop disabled
		512	Quickstop enabled
10…12	co ramp	0	Different setting for each ramp Object
		1024	Copy to ps ramp
		2048	Copy to pn ramp
		4096	Copy to cm ramp
13	enable edge after mod off pause	0	A positive edge, which is given during the minimum switch-off time or protection time in the "enable operation" bit, leads to the "Operation enabled" state after the time has elapsed.
		8192	An edge given during the minimum switch-off time or protection time in the "enable operation" bit is ineffective

The description of the influence of the "ramp generator options" (Enable vl ramp options) can be found in chapter 4.8.2.3 Controlword in the velocity mode

If the fault response ramp is used for Shutdown, Disable operation or Quickstop, also the variable change of the torque limit can be used via co61.

4.2 Brake control

⚠ WARNING

Customer evaluation of the brake control!

The brake control is influenced by other functions (e.g. position control) depending on the process.

- ➢ Always evaluate brake control in the customer application.
- ➢ List and test possible braking scenarios.
- ➢ Check scenarios again if changes are made in the application.

4.2.1 Specification brake control F6-A / S6-A or F6-P S6-P

For more information, please refer to the instruction manual of the safety module and the installation instructions of the control board.

4.2.2 Specification brake control F6-K / S6-K

The max. permissible current for the brake is 2A.

If a fault current is exceeded, error 68 "ERROR" overcurrent brake is triggered. The response threshold of the error is between 2.5A and 4A.

Thus the brake control is short-circuit protected.

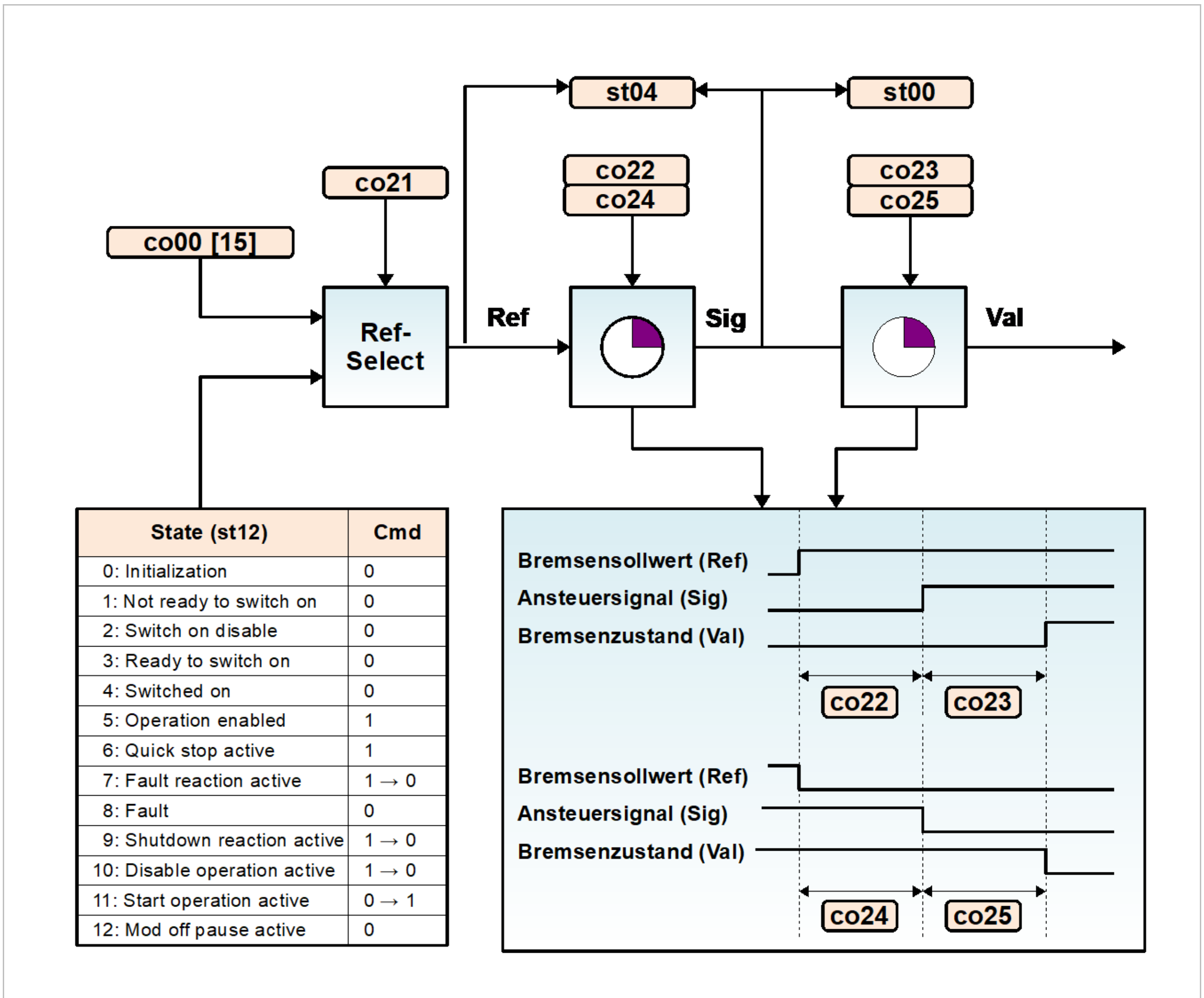
4.2.3 Functionality

The brake control basically consists of two function blocks.

The specified condition of the control (Ref) is generated from different input sources in the first function block. Bit 15 of the control word and the CIA402 status machine are available as input sources.

The deceleration times are used in the second function block and out of it the control signal of the brake (Sig) and the ***assumed*** brake condition (Val) are generated.

These values can be displayed via the st04 brake ctrl status.



State (st12)	Cmd
0: Initialization	0
1: Not ready to switch on	0
2: Switch on disable	0
3: Ready to switch on	0
4: Switched on	0
5: Operation enabled	1
6: Quick stop active	1
7: Fault reaction active	1 → 0
8: Fault	0
9: Shutdown reaction active	1 → 0
10: Disable operation active	1 → 0
11: Start operation active	0 → 1
12: Mod off pause active	0

Figure 2: Function brake control

4.2.4 Characteristics of the brake control

The generation of the setpoint of the brake control is controlled via the object co21 brake ctrl mode.

Index	Id-Text	Name	Function
0x2515	co21	brake ctrl mode	Characteristics of the brake control

co21	brake ctrl mode			0x2515
Bit	**Function**	**Value**	**Plaintext**	**Note**
0…2	mode	0	controlword	Bit15 of the control word controls the brake
		1	application	CIA402 state machine controls the brake
		2	controlword open dominant	Open command at control word overmodulated application
		3	controlword close dominant	Close command at control word overmodulated application
		4…7		Reserved
3	closed brake	0	no reaction	No reaction with engaged brake
		8	force switched on	An engaged brake forces the state to switched on
4	channel select	0	channel off	**Control type F6-A / S6-A with safety module type 1:** The function of Bit4 is written directly to the safety module. => See instruction manual of the safety module. **Control type F6-K / S6-K, F6-P or F6-A / S6-A with safety module type 3:** Without function
		16	channel on	
5	state change delay	0	sc delay off	State maschine does not wait for state change of the brake control
		32	sc delay on	State maschine waits for state change of the brake control

At mode = 0 bit 15 of the co00 control word is used as setpoint for the brake control. The state of the state machine (Cmd) is not evaluated.

At mode = 1 value (Cmd) of the state machine is used as setpoint of the brake control. The control word is not evaluated.

At mode = 2 value (Cmd) of the state machine is used, 1 in bit 15 of the control word sets the setpoint (Ref) always to 1.

At mode = 3 value (Cmd) of the state machine is used, 0 in bit 15 of the control word sets the setpoint (Ref) always to 0.

co21	brake ctrl mode			0x2515
Bit	Function	Value	Plaintext	Note
6,7	torque transfer mode	0	off	No load transfer
		64	start and stop speed	During the opening times of the brake (co22, co23) the co26[1] start speed is active to build up a torque. During the closing times (co24, co25) the co26[2] stop speed is active to guarantee a torque.
		128	position control	The position controller is automatically activated when the brake is opened and closed, the set position is automatically taken over from the actual position and kept constant.
8,9	pre torque	0	off	No pretorque
		256	pre torque setting	During the first 25% of co22 brake ctrl open delay, the precontrol torque is increased up to the value in co26[3] and then remains constant.
		512	auto adjust	In addition to the pre torque setting, the current actual torque is determined and stored as new pre-torque value in co26[3] before the brake is closed.

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- In most cases it makes sense to control the brake from the state machine. Therefore the options: application + force switch on + sc delay on + torque transfer mode should be activated in co21 brake control mode.
- For start-up or if the complete brake control shall be adapted by an external control, value 0 is recommended for co21 brake control mode. In this case, 0 should be set for the times co22 ... co25.
- For open-loop applications torque transfer with start and stop speed is recommended, for closed-loop drives torque transfer with postion control can be used.
- If you know the exact load torque, you can achieve best results with pre torque, without movement when opening the brake.
- 5-Step or Hf-Detect are suitable methods for the rotor position detection when the holding brake is closed; cvv is unsuitable when the brake is closed.

co26	brake control		0x251A[ ]
Index	Name	Function	
1	start speed	Setting of the start speed for torque setting when opening the brake, particularly suitable for drives without feedback.	
2	stop speed	Setting of the stop speed for the torque setting when closing the brake, the sign determines the torque direction.	
3	pre torque setting	Setting of the precontrol torque as a percentage value of the rated motor torque in the resolution parameterised in co84 torque resolution. The resulting precontrol torque is thus dependent on co84 and dr09 rated torque. Precontrol torque = co26[3] * co84 * dr09 Example: co26[3] = 500 und co84 = 2:0.025 precontrol torque = 500 * 0.025 = 12.5% dr09 An analog value can also be used with an31 REF selector or an34 AUX selector to configure the precontrol torque. The cs21 pretorque mode must be set to "2: reference torque“ to use the pre torque settings.	
4	speed ctrl (KI) adaption	During opening the brake (co23) the I-component of the speed controller is multiplied by this value.	
5	fadeout reducing time	After the co25 closing time has elapsed, the current limit is reduced to 0 during this time.	
6	fadeout zero time	Subsequently, a time with current limit 0 can be inserted.	

4.2.4.1 Special features brake control for control type F6-A / S6-A

The detailed description of the brake control is contained in the instruction manual for the safety module.

Control type F6-A / S6-A with safety module type 1:

The brake control is directly activated or deactivated on the safety module via co21 brake ctrl mode. If no brake is used, the channel should be deactivated.

The monitoring of the brake current can also be switched off with co82 ext. modules ctrl word. This prevents false tripping due to disturbances which can be coupled into by the open brake cable. These settings are also found in sb28 safety modul control word before they are transferred to the safety module. A power-on is required after changing these settings.

Control type F6-A / S6-A with safety module type 3:

The complete configuration of the safe brake control occurs via the special editor for the KEB safety module.

4.2.5 Influence of the brake control on the state machine

The following state changes are decelerated, if delay on is activated in co21 bit 5 sc:

State change	Description
start operation active ↓ operation enabled	The modulation is enabled in state "start operation active“ and speed = 0 is preset. Subsequently, the setpoint of the brake control (CMD) is set to 1. After the assumed state of the brake (Val) has reached value 1 (open brake), the state machine changes to "Operation enabled“.
shutdown operation active ↓ ready to switch on	Speed shutdown to 0 in state "shutdown operation active“ depending on the selected ramp (standard ramp) or pn47 fault reaction ref velocity (fault reaction ramp). Subsequently, the setpoint of the brake control (CMD) is set to 0. After the assumed condition of the brake (Val) has reached value 0 (brake closed), the state machine changes to "ready to switch on".
disable operation active ↓ switched on	Speed shutdown to 0 in state "disable operation active" depending on the selected ramp (standard ramp) or pn47 fault reaction ref velocity (fault reaction ramp). Subsequently, the setpoint of the brake control (CMD) is set to 0. After the assumed condition of the brake (Val) has reached value 0 (brake closed), the state machine changes to „switched on“.
fault reaction active ↓ fault	The speed is set to pn47 fault reaction ref velocity in the "fault reaction active" state. Subsequently, the setpoint of the brake control (CMD) is set to 0. After the assumed condition of the brake (Val) has reached value 0 (brake closed), the state machine changes to "fault“.

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The states "shutdown operation active“, “disable operation active“ and "fault reaction active“ are only carried out with the appropriate setting of the state machine.

➢ Make sure that the appropriate settings have been made in object co32 state machine properties.

4.2.6 Times of the brake control

The times of the brake control can be influenced by the following objects:

Index	Id-Text	Name	Function
0x2516	co22	brake ctrl open delay	Waiting time of Ref↑ to Sig↑
0x2517	co23	brake ctrl open time	Waiting time of Sig↑ to Val↑
0x2518	co24	brake ctrl closing delay	Waiting time of Ref↓ to Sig↓
0x2519	co25	brake ctrl closing time	Waiting time of Sig↓ to Val↓

4.2.7 Status of the brake control

The status of the brake control can be displayed via the following object:

Index	Id-Text	Name	Function
0x2104	st04	brake ctrl status	Status of the brake control

st04 contains the following bits:

st04	brake ctrl status			0x2104
Bit	Function	Value	Plaintext	Note
0	brake ctrl val	0	val off	Assumed condition of brake = closed
		1	val on	Assumed condition of brake = open
1	brake ctrl signal	0	sig off	Brake control signal = 0 (closed)
		2	sig on	Brake control signal = 1 (open)
2	brake ctrl ref	0	ref off	Setpoint of the brake control = 0 (closed)
		4	ref on	Setpoint of the brake control = 1 (open)
3	brake output	0	out off	State of the brake output
		8	out on	
4…7	State	0	closed	Brake closed
		16	open delay	Brake open delay
		32	opening	brake opening
		48	open	Brake is open
		64	close delay	Brake close delay
		80	closing	Brake closes
		96	fadeout	Current decay at closed brake
8…15	Reserved	0		

Additionally, there is an information about the brake control via the status word: Bit 15 of the status word or Bit 3 brake output in the brake status indicates whether the brake output is activated on the hardware. This corresponds to the state (opening) or (open).

Control type A or P:

1 means the brake has been activated by the safety module (brake open). This information can reach st04 with a delay of up to 10ms.

Control type K:

1 means that the brake output has been activated (brake open). The statusword bit displays only the state of the switch, the 24V supply of the brake is not monitored.

4.3 Errors and warnings

4.3.1 Errors

The status word displays via bit 3 (fault) when there is an error. The error type can be determined via objects ru01 exception state and st01 error code:

Index	Id-Text	Name	Function
0x2C01	ru01	exception state	KEB spec. Object
0x2101	st01	error code	KEB spec. Object
0x603F			CiA402 object

4.3.1.1 Error display in ru01

The faults are coded according to the following table:

ru01	Error text	Description	st01
0	no exception	No error	0x0000
3	ERROR overcurrent PU	Overcurrent detection in the power unit has triggered (e.g. short circuit, defective power module)	0x5400
4	ERROR overcurrent analog	Exceeded overcurrent level on the control board (e.g. Incorrect setting of the controller or the torque limiting characteristic)	0x2300
5	ERROR over potential	Overvoltage in DC link (e.g. deceleration ramp too fast, braking resistor not connected, braking transistor defective)	0x3210
6	ERROR under potential	Undervoltage in DC link	0x3220
7	ERROR overload	Module overload ($I^2 t$) => OL (long-term mean current load is above 100%)	0x3230
8	reset E. overload	Reset of overload possible OL counter (ru29) < 50% of the warning level	0x3230
9	ERROR overload 2	Module overload 2 (fast overload protection – defined by standstill continuous current and short time current limit - has responded)	0x1000
10	ERROR overheat powmod.	Overtemperature power components (heat sink)	0x4210
11	reset E overheat pmod.	Overtemperature power components decreased (temperature 5° below OH level)	0x4210
12	ERROR overheat internal PU	Overtemperature internal power unit	0x4110
13	reset E. overheat intern PU	Overtemperature internal power unit decreased	0x4110
14	ERROR motorprotection	electronic (software) motor protection has triggered	0x1000
15	reset E. motorprotection	Error motor protection function can be reset	0x1000
16	ERROR drive overheat	Temperature sensor in the motor (e.g. PTC or KTY) has triggered	0x4310
17	reset ERROR drive overheat	Overtemperature motor decreased	0x4310

ru01	Error text (continuation)	Description	st01
18	ERROR overspeed	Overspeed (speed > pn26 * rated speed)	0x1000
20	ERROR drive data	Error at presetting motor data (Standardization of the motor data triggers an error => motor data do not match)	0x1000
21	ERROR motordata not stored	Motor data are not confirmed by dr99	0x1000
22	ERROR ident	during identifikation an error occured (Information about the type of error in dr57)	0x1000
23	ERROR speed diff	Speed difference higher than level (the monitoring of the difference between the set-point speed and actual speed within a configurable time has responded pn38..pn41)	0x1000
24	ERROR fieldbus memory	Incorrect drive software configuration	0x1000
38	ERROR memory size		0x1000
40	ERROR FPGA conf.	Error in FPGA configuration	0x1000
41	ERROR safety module SACB comm	No communication with the safety module (only control type A or P)	0x1000
42	ERROR power unit SACB comm	No communication with the power unit (from housing size 6)	0x1000
43	ERROR enc.intf. SACB comm.	No communication with encoder interface	0x1000
44	ERROR invalid power unit data	Invalid power unit data	0x1000
47	ERROR power unit flash	The plausibility check of the Flash memory of the power unit CPU has reported an error	0x1000
52	ERROR undervoltage phase	Phase failure at the mains input (L1,L2,L3)	0x1000
55	ERROR safety	The safety module has reported an error (only for control type A or P)	0x1000
56	ERROR software switch left	Software limit switch has triggered an error	0x1000
57	ERROR software switch right		0x1000
58	ERROR fieldbus watchdog	Fieldbus watchdog has responded	0x1000
59	ERROR prg. input	External error was triggered via programmable digital input	0x1000
60	ERROR safety module type changed	The safety module has been replaced without authorisation	0x1000
61	ERROR safety module changed		0x1000
62	ERROR power unit changed	Power unit changed (de20 / de21)	0x1000
63	ERROR enc. intf. changed	Changed encoder interface (de48)	0x1000
64	ERROR power unit type changed	Power unit type changed (de26 / de27)	0x1000
65	ERROR enc. intf. version	Invalid version of the encoder interface	0x1000
66	ERROR overcurrent PU	Overcurrent	0x1000
67	ERROR max acc/dec	Max. acceleration/deceleration setting exceeded (monitoring especially necessary for cyclic synchronous operating modes)	0x1000

ru01	Error text (continuation)	Description		st01
68	ERROR overcurrent Brake	Overcurrent at the brake output		0x1000
83	ERROR Limit Switch Forward	positive (hardware) limit switch released		0x1000
84	ERROR Limit Switch Reverse	negative (hardware) limit switch released		0x1000
85	ERROR Override Limit Switch Forward	positive (hardware) limit switch override out of the range of hm19		0x1000
86	ERROR Override Limit Switch Reverse	negative (hardware) limit switch override out of the range of hm20		0x1000
87	ERROR Limit Switch	Ether both (hardware) limit switches released or one (hardware) limit switch released and only the actual direction of rotation corresponds to the limit switch direction		0x1000
89	ERROR at encoder type change	Incompatible encoder interface and drive software versions		0x1000
90	ERROR enc.intf.fast comm.	Communication error control board-encoder interface		0x1000
91	init encoder interface	Encoder interface in initialisation routine		0x1000
92	ERROR encoder A	Error encoder A	Hardware defect or incorrect setting of the encoder parameters (type, increments per revolution, etc.)	0x1000
93	ERROR encoder B	Error encoder B		0x1000
94	init encoder A	Initialisation encoder A is running		0x1000
95	init encoder B	Initialisation encoder B is running		0x1000
96	ERROR encoder missing	No encoder type is selected in ec16 in a mode that requires an encoder		0x1000
97	ERROR overspeed (EMF)	pn72 overspeed level (EMF) has been exceeded		0x1000
98	ERROR encoder A changed	Encoder A changed	Serial number read by the encoder is not equal to the stored serial number (ec48 != ec49)	0x1000
99	ERROR encoder B changed	Encoder B changed		0x1000
100	ERROR overcurrent out1	Overcurrent at digital output 1		0x1000
101	ERROR overcurrent out2	Overcurrent at digital output 2		0x1000
102	ERROR overcurrent out3	Overcurrent at digital output 3		0x1000
103	ERROR overcurrent out4	Overcurrent at digital output 4		0x1000
105	ERROR overcurrent encoder	Overcurrent at encoder interface		0x1000
106	ERROR overcurrent 24V	Overcurrent at 24V outputs of the control terminal block		0x1000
107	ERROR over frequency	The maximum output frequency de120 has been exceeded. (599Hz)		0x1000
108	reset E. overheat intern CB	Overtemperature control board decreased		0x1000
109	ERROR overheat internal CB	Overtemperature internal control board		0x1000
110	ERROR OH ramp	Maximum available time between the occurrence of an overtemperature error and the modulation switching off has expired		0x1000
111	ERROR OHI ramp			0x1000
112	ERROR 24V supply low	24V supply has dropped to a value lower than 18V		0x1000

ru01	Error text (continuation)	Description	st01
115	ERROR GTR7 always OFF	Braking transistor can no longer be switched on	0x1000
116	ERROR GTR7 OC	UCE monitoring braking transistor reports OC	0x1000
117	ERROR GTR7 always ON	Braking transistor can not be switched off	0x1000
118	OC at 5V diag	Short circuit of 5V at the diagnostic interface	0x1000
119	ERROR extreme overpotential	extreme overpotential in DC link (can lead to damage of the DC capacities)	0x3210
120	ERROR DC capacitor damaged	DC capacities have been damaged by too long / too high overvoltage in the DC link	0x1000
121	ERROR runtime	Activation of too many functions. => Runtime monitoring	0x1000
122	ERROR UP2	Error, if the change of the state machine to "switched on" is requested and after the delay time in ru04 supply unit state the state "run“ is not yet reached.	0x1000
123	ERROR LT ready	an error is triggered if the "ready" signal of the power unit disappears during activated modulation.	0x1000
124	General Fielbus Error	General Fielbus Error (Analysis via parameter fb91 fieldbus error code)	0x1000
125	ERROR fieldbus type changed	The selected fieldbus type in fb68 fieldbus selection has been changed and no PowerOn reset has been performed yet	0x1000
126	ERROR overheat 2 powmod.	Overtemperature heat sink (2)	0x4210
127	reset E. overheat 2 pmod.	Overtemperature heat sink (2) decayed	0x4210
128	ERROR overheat 3 powmod.	Overtemperature heat sink (3)	0x4210
129	reset E. overheat 3 pmod.	Overtemperature heat sink (3) decayed	0x4210
130	ERROR overheat 2 internal	Overtemperature internal (2)	0x4210
131	reset E. overheat 2 intern	Overtemperature internal (2) decayed	0x4110
132	ERROR overheat 3 internal	Overtemperature internal (3)	0x4110
133	reset E. overheat 3 intern	Overtemperature internal (3) decayed	0x4110
134	ERROR Safety Stop	Safety module signals reaction SS1 or SS2	0x1000
135	ERROR File Code	Only P card: invalid file code	0x1000
136	ERROR blockade detected	ERROR drive blockade triggered	0x1000
139	ERROR STO	STO triggered by the safety module	0x1000
140	ERROR Fail Safe	Fail Safe triggered by the safety module	0x1000
141	ERROR control hardware type	inadmissible combination of control cards hardware and software	0x1000
142	ERROR speed search and rotor detection	inadmissible combination of the "speed search" and "system position measurement" functions, only in encoder mode	0x1000
144	ERROR overheat braking resistor	The temperature of the sub-mounted braking resistor has exceeded the error level	0x1000

ru01	Error text (continuation)	Description	st01
145	ERROR invalid resistor data	invalid data for the sub-mounted braking resistor	0x1000
146	ERROR analog input 4..20mA	Monitoring of the 4..20mA interface has triggered an error (with appropriate programming)	0x1000

4.3.1.2 Programmable error response

Many errors require an immediate shutdown of the modulation. Thus the motor coasts down.

The response to errors / malfunctions which do not require immediate modulation shutdown can be set in the pn parameters.

4.3.1.2.1 Configurable errors

The behaviour can be programmed for the following errors:

Index	Id-Text	Name	Possible error response			
			Fault	Fault ramp	Stop ramp	Warning / Ignore
0x2A04	pn04	ERROR OL stop mode	x*	x		
0x2A08	pn08	ERROR OH stop mode	x*	x		
0x2A0A	pn10	ERROR OHI stop mode	x*	x		
0x2A0C	pn12	ERROR dOH stop mode	x*	x	x	x
0x2A10	pn16	ERROR OH2 stop mode	x*	x	x	x
0x2A14	pn20	ERROR SW-switch stop mode	x	x	x	x*
0x2A16	pn22	ERROR fb watchdog stop mode	x	x	x	x*
0x2A1B	pn27	ERROR overspeed stop mode	x*	x	x	x
0x2A1D	pn29	prg. error stop. mode	x	x	x	x*
0x2A22	pn34	ERROR encoder A stop mode	x*			x
0x2A23	pn35	ERROR encoder B stop mode	x			x*
0x2A25	pn37	ERROR max acc/dec stop mode	x	x	x	x*
0x2A28	pn40	ERROR speed diff stop mode	x	x	x	x*
0x2A47	pn71	E. overspeed (EMF) st. mode	x*	x	x	x
0x2A49	pn73	E.enc A changed stop mode	x		x	x*
0x2A4A	pn74	E.enc B changed stop mode	x		x	x*
0x2A4D	pn77	E.UP2 stopping mode	x			x*
0x2A4E	pn78	ERROR limit switch forward reaction	x	x	x	x*
0x2A4F	pn79	ERROR limit switch reverse reaction	x	x	x	x*
0x2A50	pn80	safety stop mode	x	x	x	x*
0x2A51	pn81	warning OH stop mode	x	x	x	x*
0x2A52	pn82	warning OHI stop mode	x	x	x	x*
0x2A56	pn86	E.AnIn stop mode	x	x	x	x*
0x2A59	pn89	warning brOH stop mode	x	x	x	x*

***** = Default value

4.3.1.2.2 Error reaction

The single error reactions are defined as follows:

Valu e	Plaintext	Description
0	fault	The drive changes directly into state FAULT. The drive coasts down.
1	dec. ramp -> fault	The set speed is controlled at the error reaction ramp to the target speed (pn47). After fault reaction time the drive changes into state FAULT.
2	quickstop	Bit 2 (no quickstop) in the controlword is set to zero => the "quickstop" reaction is executed. Only after a reset (Bit 7 fault reset in the controlword) Bit 2 is reset.
3	disable operation	The enable operation bit in the controlword is set to zero => the "disable operation" reaction is executed. If the error/malfunction signal is no longer present, the EnableOperation bit is set again according to the controlword.
4	shut down	The SwitchOn bit in the controlword is set to zero => "shut down" reaction is executed. If the error/malfunction signal is no longer present, the SwitchOn bit is set again according to the controlword.
5	dec. ramp -> fault auto retry	The reaction corresponds to value 1 with the following difference: If the error signal becomes inactive during the FAULT REACTION ACTIVE state, the fault resets itself. The drive changes to the SWITCHED ON state after the error response time.
6	warning	The fault is only displayed in the warning state. The drive does not change into state FAULT REACTION ACTIVE.
7	off	The error is ignored and not displayed in the warning state. The drive does not change into state FAULT REACTION ACTIVE.
8	quickstop auto retry	The reaction corresponds to value 2 with the following difference: If the error signal becomes inactive, the error resets itself. The quickstop function is exited.
9	fault, auto retry	The fault that triggered the stop function is automatically reset.

The settings "0: fault“, "1: dec. ramp -> fault“, "5: dec. ramp -> fault, auto retry“ and "9: fault, auto retry“ are error responses where the error is displayed in ru01 and st00 (CiA 0x6041) statusword.

The control word is manipulated for values "2: quickstop", "3: disable operation", "4: shut down" and "8: quickstop, auto retry". Bit 2 (no quick stop), bit 3 (EnableOperation) or Bit 0 (SwitchOn) is internally set to zero according to the programmed response.

Not all reactions can be selected for each error.

NOTICE

Use auto retry or stop modes without error triggering only in exceptional cases.

➢ If a reaction with auto-retry is used, or a stop mode that does not trigger an error, the drive continues to run independently as soon as the fault is no longer active. This can lead to unwanted operating states (e.g. permanent change between start and stop).

- ***Reaction 0: fault***

The drive changes directly into state **fault**, the modulation is switched off and the drive coasts down

- ***Reaction 1: dec ramp to fault***

If value "1: dec ramp to fault" is selected, the drive changes into **Fault reaction active** when the error occurs.

Bit 2 (fault reaction mode) in co32 state machine properties has the following effect:

- 0: direct => the drive changes immediately into state **Fault**. The control of the power components is inactive in this state, the motor coasts down. The adjustment of the pn parameters (fault or dec. ramp) is invalid
- 1: application specific => the behaviour of the drive for errors can be influenced by the pn parameters if immediately switching off of the drive is not required.

If "1: application specific" is selected as fault reaction mode , the setpoint speed is set to the target speed (pn47) at the fault reaction ramp. After fault reaction time the drive changes into state **Fault**. If an error reset is already carried out during fault reaction, the drive changes into the state that results from st14 active controlword.

- ***Reaction 2: quickstop***

Bit 2 ***no Quickstop*** in active controlword (st14) is set to zero. The state machine changes into the state **Quickstop Reaction Active.**

The selected reaction in 0x605A quickstop option code is executed.

The fault does not reset itself automatically. This means, only after reset (controlword Bit 7 ***Fault reset***) bit 2 is set again and the Quickstop reaction becomes inactive.

The reaction becomes only effective, if in co32 state machine properties in mode enable quickstop the setting "0200h: on" is selected.

- ***Reaction 3: disable operation***

Bit ***EnableOperation*** in active controlword (st14) is set to zero. The state machine changes into state **Disable Operation Active.**

The selected reaction in 0x605C disable operation option code or co32 state machine properties is executed.

If the fault is no longer present, the ***EnableOperation*** Bit in active controlword (st14) is set again according to the controlword internal (co31). An error reset is not necessary.

- ***Reaction 4: shut down***

Bit ***SwitchOn*** in active controlword (st14) is set to zero. The state machine changes into state **Shut Down Active.**

The selected reaction in 0x605B shut down option code or co32 state machine properties is executed.

If the fault is no longer present, the ***SwitchOn*** Bit in active controlword (st14) is set again according to the controlword internal (co31). An error reset is not necessary.

- ***Reaction 5: dec ramp to fault, auto retry***

The reaction corresponds to value 1 with the following difference: If the fault becomes inactive during the **Fault Reaction Active** state, the error resets itself. An error reset is not necessary.

The drive changes after the fault reaction time into the state defined by the setting of st14 active controlword.

- ***Reaction 6: warning***

Warnings have no reaction to the drive.

The actual warnings can be read out in object ru02 warning bits. If a bit is set in ru02 also bit 7 ***warning*** in the statusword st00 (CiA 0x6041) statusword is set, can be preset via object pn28 warning mask .

Only if the corresponding bit is set in the warning mask the warning is also displayed in the status word.

The highest-priority status message is displayed in parameter ru03 warning state. In addition to the warning messages, an ERROR state can also be displayed in this object if "6: warning" is programmed as reaction for the corresponding error.

- ***Reaction 7: ignore***

The error is ignored. There is no reaction of the drive. Neither a warning bit is set nor a warning state is displayed.

- ***Reaction 8: quickstop, auto retry***

The reaction corresponds to value 2 with the following difference: If the malfunction/error signal becomes inactive, the error resets itself.

Bit 2 in the active controlword (st14) is set again and the state **Quickstop Reaction Active** is left automatically.

- ***Reaction 9: fault, auto retry***

The reaction corresponds to value 0 with the following difference: If the malfunction/error signal becomes inactive, the error resets itself.

4.3.1.2.3 Fault reaction ramp

The used set speed ramp at fault reaction can be parameterized via the following objects.

Index	Id-Text	Name	Function
0x2A2D	pn45	fault reaction time	Waiting time after the target speed has been reached
0x2A2E	pn46	fault reaction end src	Source for abort of the fault reaction ramp => error
0x2A2F	pn47	fault reaction ref velocity	Target speed of the fault reaction ramp
0x2A30	pn48	fr acceleration for [s-2]	max. acceleration at pos. speed
0x2A31	pn49	fr deceleration for [s-2]	max. deceleration at pos. speed
0x2A32	pn50	fr acceleration rev [s-2]	max. acceleration at neg. speed
0x2A33	pn51	fr acceleration rev [s-2]	max. deceleration at neg. speed
0x2A34	pn52	fr for acc jerk ls [s-3]	max. jerk at acceleration and neg. speed (start)
0x2A35	pn53	fr for acc jerk hs [s-3]	max. jerk at acceleration and neg. speed (end)
0x2A36	pn54	fr for dec jerk hs [s-3]	max. jerk at deceleration and pos. speed (start)
0x2A37	pn55	fr for dec jerk ls [s-3]	max. jerk at deceleration and pos. speed (end)
0x2A38	pn56	fr rev acc jerk ls [s-3]	max. jerk at acceleration and neg. speed (start)
0x2A39	pn57	fr rev acc jerk hs [s-3]	max. jerk at acceleration and neg. speed (end)
0x2A3A	pn58	fr rev dec jerk hs [s-3]	max. jerk at deceleration and neg. speed (start)
0x2A3B	pn59	fr rev dec jerk ls [s-3]	max. jerk at deceleration and neg. speed (end)
0x2A3C	pn60	fault reaction ramp mode	Ramp mode (s-curves, etc.)
0x2A3E	pn62	fault reaction properties	Properties of the fault reaction ramp

If an error occurs, where **Fault reaction ramp** (dec ramp -> fault) is selected as error reaction, the drive changes into state **Fault reaction active**.

The drive accelerates or decelerates with the adjusted ramps (pn48…pn60) to the target speed (pn47 fault reaction ref velocity).

The possible settings for pn60 correspond to those in co60 and are described in detail in chapter 4.8.2.4.3 Operating modes of the ramp generator

The waiting time after fault reaction time (pn45 fault reaction time) begins after reaching the target speed.

After this time has elapsed, or if the selected terminating condition for the fault reaction (pn46 fault reaction end src) is activated, the drive changes into state **Fault**.

The following picture shows an exemplary process of a fault reaction:

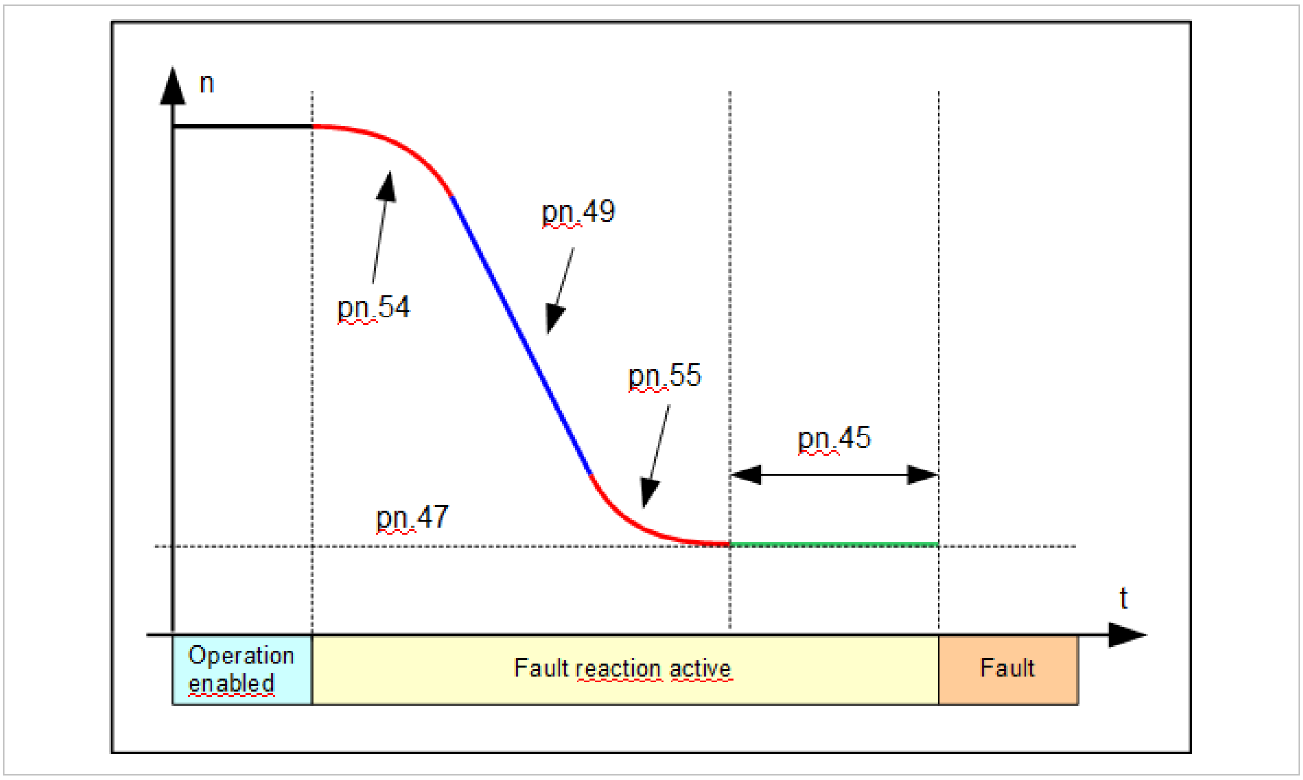


Figure 3: Process of a fault reaction

4.3.1.2.4 Fault reaction properties

The behavior of the fault reaction can be influenced via object pn62.

Index	Id-Text	Name	Function
0x2A1E	pn62	Fault reaction properties	Properties of the fault reaction

The meaning of the single bits in pn62 is defined as follows:

pn62	fault reaction properties		0x2A3E
Bit	Name	Note	
0	Speed src	Source for the starting speed of the deceleration ramp 0: Setpoint speed (output ramp generator) 1: Actual speed	

4.3.1.2.5 Error reaction/stop_function torque limit

Another (higher) torque limit is required in some applications for the state Fault reaction active.

It is often requested to decelerate with maximum torque (e.g. at the limiting characteristic), then to reduce the torque to a small residual value during the standstill phase (e.g. in order to relieve a shaft) before the modulation is then switched off.

Which torque limit shall be active during fault reaction can be selected in co61 Bit 0...5.

In co61 bit 6…8 can be selected, which torque limit shall be active during the waiting time (pn45 fault reaction time) after reaching the final speed (pn47 fault reaction ref velocity).

With co61 bit 9 and 10 it can be defined whether the change of the torque limits should be abrupt or slope-limited.

Stop functions such as Quickstop, Shut Down, Disable Operation, etc. can use the error response ramp to stop. Such a "stop process" can also be a reaction to an external error event. For this reaction the same options shall be available for torque changes as during "FAULT REACTION ACTIVE". Bits 11 and 12 can be programmed accordingly for this.

co61	torque lim mode			0x253D
Bit	Function	Value	Plaintext	Notes
0…2	source	0	no change	all torque limits valid as always
		1	cs12	Torque limit is cs12 cs13…cs16 without function
		2	cs15 / cs16	cs15 applies to positive direction of rotation cs16 applies to negative direction of rotation cs12 without function
		3	max torque charact (dr group)	cs12…cs16 without function only limiting characteristic effective
		4	co62	torque limit from co62
		5…7	reserved	
3…5	source fieldbus watch-dog	0	no change	all torque limits valid as always
		8	cs12	Torque limit is cs12 cs13…cs16 without function
		16	cs15 / cs16	cs15 applies to positive direction of rotation cs16 applies to negative direction of rotation cs12 without function
		24	max torque charact. (dr group)	cs12…cs16 without function only limiting characteristic effective
		32	co62	torque limit from co62
		40…56	reserved	
6…8	reached zero	0	same as dec.	If the setpoint ramp has reached zero, the same torque limit as in deceleration is active
		64	no change	all torque limits valid as always
		128	cs12	Torque limit is cs12 cs13…cs16 without function
		192	cs15/cs16	cs15 applies to positive direction of rotation cs16 applies to negative direction of rotation cs12 without function
		256	max torque charact. (dr group)	cs12…cs16 without function only limiting characteristic effective
		320	co62	torque limit from co62
		384…448	reserved	

co61	torque lim mode			0x253D
Bit	Function	Value	Plaintext	Notes
9…10	dM/dt	0	off	No rise limitation /reduction limitation effective
		512	On	Rise limitation /reduction limitation (co63) always effective when torque limits are changed.
		1024	Stop,reached zero	Rise limitation /reduction limitation (co63) during state "fault reaction active“ (st12 state machine display) after reaching zero speed effective.
11	torque options	0	only valid for fault reaction	The selection of the torque limits is only valid for FAULT REACTION ACTIVE
		1	setting valid for all usage of fault reaction ramp	The settings for the behavior during FAULT REACTION ACTIVE are used for all "Stop Functions" where the Fault Reaction Ramp is used.
12	Uic dep. torque curve options	0	only at fault reaction	The setting for shifting the limiting characteristic (ds11 torque mode => Uic dep. torque curve adapt) only applies to FAULT REACTION ACTIVE
		1	at usage of fault reaction ramp	The setting for shifting the limiting characteristic (ds11 torque mode => Uic dep. torque curve adapt) applies to all "Stop functions" that use the fault reaction ramp

Index	Id-Text	Name	Function
0x253E	co62	Selectable stop mode torque	selectable torque limit at error response

If co61 stop mode torque lim. src. is set to value cs12 or cs15/cs16 or co62 , the limiting characteristic remains always effective as max. physically available torque.

Example:

The fault reaction requires a higher torque limit than standard operation.

A possible procedure is: co61 = 9 => cs12 is the valid torque limit during fault reaction.

In standard mode the actual torque limit is preset via cs13.
cs14…cs16 must be set to -1 to specify the torque limits in all quadrants by cs13.
cs12 must be higher than cs13 in order to cause no limitation of the standard operation.

cs13 has no effect in state fault reaction. The torque is limited only via cs12 and the always effective limiting characteristic from the dr parameters.

Index	Id-Text	Name	Function
0x253F	co63	dM/dt Limit [Mn%/ms]	Depending on the setting in co61 Bit 9,10 dM/dt limited the rate of change of the torque limit is limited.

Example for co61 torque lim mode Bit 9,10 dM/dt = 512 = on
and change of the torque limit with co63 dM/dt Limit [Mn%/ms] = 7.00 %

$$dt[ms] = \frac{dM[\%]}{co63} = \frac{70\%}{7\%} = 10$$

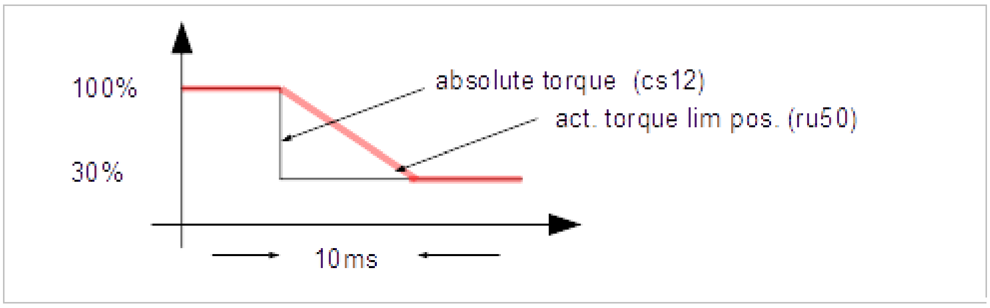


Figure 4: Example co63

4.3.2 automatic reset of errors

4.3.2.1 Auto-retry for configurable errors

For some errors for which the error reaction can be freely selected, the triggering error can be automatically reset by selecting value 5 or 9.

Valu e	Plaintext	Description
5	dec. ramp -> fault auto retry	The reaction corresponds to value 1 with the following difference: If the error signal becomes inactive during the FAULT REACTION ACTIVE state, the fault resets itself. The drive changes to the SWITCHED ON state after the error response time.
9	fault, auto retry	The fault that triggered the stop function is automatically reset.

4.3.2.2 Automatic fault reset UP

4.3.2.2.1 Activation

The fault response for an undervoltage fault is not selectable, but an auto-retry (automatic fault reset) can be programmed.

pn83	auto-retry activation		**0x2A53**
Bit	Plaintext	Note	
0	1: auto retry E.UP / Lt ready	Activation of automatic reset for the error UP and the error LT ready	

If the mains voltage breakdown is too long, an automatic restart is often not reasonable, since parts of the periphery are also not ready for operation, or the application requires a defined restart.

Therefore, the time wherein an Auto-Retry E.UP is performed can be limited.

The time within an auto reset is still reasonable for the application is set in pn84[1]auto-retry UP time. If precharging is completed after this time (ru04 supply unit state = 4:run), an automatic error reset is performed.

pn84[1]	auto-retry UP time		**0x2A54 [1]**
Value	Display	Note	
0	no time limit	automatic reset for the UP error is always performed	
1…100 0	0.01…10.00 s	Time within the execution of Auto-Retry UP is still reasonable	

NOTICE

Whether an automatic reset is performed depends only on the time the error is present. If the minimum switch-off time prevents the release of the modulation afterwards, the error is reset anyway.

Often the occurrence of an error leads to the switch off of the inverter by an external control. In order that the control can react differently to the special case of "mains voltage failure", it is possible to suppress the error display/output.

The behaviour of the error display for auto retry can be defined in pn84[2] fault suppression mode.

pn84[2]	fault suppression mode	0x2A54 [2]
Bit	Plaintext	Note
0	1: no display suppressed UP / PUready	By UP or LT ready, the "fault" bit in the statusword is not set as long as the auto retry time UP is running If the setting of pn84[1] is "0: no time limit", the "fault" bit is not suppressed.
2	4: accept manual reset	The UP error can also be reset via a hardware reset during the auto-retry time. With this setting the UP error is reset at every hardware reset. The reduced precharge time is not effective when precharging after the "Manual Reset". If this bit is not activated, the error UP cannot be reset when auto-retry UP is permanently activated (auto-retry UP time = 0: no time limit), since the error remains present until the mains voltage is switched back to the device.

4.3.2.2.2 Dosplay "suppressed error“

In order to have an indication that the drive is in a "special" operating state when the error display is suppressed, this is displayed in parameter ru75 global drive state and the statusword.

ru75	global drive state	0x2C4B
Bit	Name	Note
0 … 3	ready for modulation	Reasons that prevent a modulation release
4 …7	state machine display	Display of the state of the state machine (see below)
8 …25	Description see chapter 5.8.1 ru75 global drive state	
26	error bit suppression active	The modulation is switched off due to an error, the display of the error in the statusword and ru01 is suppressed
27…31	reserved	not used

Bits 4…7 display the actual state of the state machine.

ru75		global drive state	Bit 4…7: state machine display
Bit	Value	Plaintext	
4..7	240	suppressed error active	Indication that the modulation is switched off due to an error, but the error bit in the statusword and the error display in ru01 are not set.

In addition to the display in ru75, bit 14 "Special function active" is used in st00 (CiA 0x6041) statusword to indicate that "error supression" is active.

Bits 5 "no quick stop", 6 "switch on disabled" and 14 "special function" are set in the statusword (0x2100 st00, 0x6040).

4.3.3 Warnings

Additionally to the errors which always lead to drive stop, the drive can display warnings. Warnings have no reaction to the drive. The existance of a warning can be displayed only in bit 7 of the status word. The actual warnings can be read out in object ru02 warning bits.

Index	Id-Text	Name	Function
0x2C02	ru02	warning bits	Display of the warnings bit-coded

If a bit is set in ru02 also bit 7 in the status word is set can be preset via object pn28 warning mask.

Index	Id-Text	Name	Function
0x2A1C	pn28	warning mask	Display of warnings to perform for setting the "warning" bits in the status word (bit-coded)

The warning is displayed in bit 7 of the status word only if the corresponding bit in the warning mask is set.

The meaning of the single bits in ru02 and pn28 is defined as follows:

ru02	warning bits	0x2C02
pn28	warning mask	0x2A1C
Bit	Name	Note
0	OL	Warning level overload exceeded (pn03 / pn04)
1	OL2	Warning level overload power semiconductor exceeded (pn05)
2	OH	Warning level heat sink temperature exceeded (pn07 / pn08)
3	OHI	Warning level unit internal temperature exceeded (pn09 / pn10)
4	dOH	Warning level motor temperature exceeded (pn11 / pn12 / pn13)
5	OH2	Warning level motor protective circuit-breaker exceeded (pn15 /pn16)
6	Watchdog	Watchdog time is up (pn21 / pn22)
7	Heartbeat	Heartbeat error was triggered
8	ProgErr	Programmable external error (pn29 / pn30)
9	OS	Warning level motor protective circuit-breaker exceeded (pn26 /pn27)
10	MaxAccDec	Warning level max. acceleration exceeded (pn36 / pn37)
11	SwSwitch	Software limit switch triggered (pn18 / pn19 / pn20)
12	SpeedDiff	Warning level speed difference exceeded (pn38 / pn39 / pn40)
13	AnIn	Current at analog input 4...20mA < 2mA
14	ENC-A	Encoder A warning (pn34)
15	ENC-B	Encoder B warning (pn35)
16	Uph	Input phases failure detection
17	Limit Switch	Hardware limit switch triggered (pn78 / pn79)
18	blockage	Blockage detection (pn 87)
19	suppressed UP	Error UP has triggered, display suppressed as error (pn84)
20	suppressed PU ready	Error UPready has triggered, display suppressed as error (pn84)
21	STO	STO triggered by the safety module (sm11)
22	Fail Safe	Fail Safe triggered by the safety module (sm10)
23	brOH	Temperature at the braking resistor has exceeded the warning level

The highest-priority status message is displayed in parameter ru03. Besides the warnings, also an ERROR state can be displayed in this object (=> chapter 4.3.1 Errors), if "warning" is programmed as error response for the appropriate error.

If "Error" is selected as response in the associated stop mode, the corresponding status is displayed in ru01.

In addition the following warning messages can be displayed:

ru03	Error text	Description
27	WARNING overload	Module overload ru29 ($I^2 t$ -function) > pn03 OL warning level
29	WARNING overload 2	Module overload 2 ru27 (fast overload protection) > pn05 OL2 warning level
30	WARNING overheat powermod.	Heat sink temperature ru25[1], ru25[2] or ru25[3] > pn07
32	WARNING overheat intern.	Internal temperature ru26[1], ru26[2], ru26[3] or ru77 > pn09
34	WARNING motorpro-tection	motor protection counter ru32 > pn15 OH2 warning level
36	WARNING drive overheat	KTY: ru28 motor temperature > pn11dOH warning level PTC: PTC status (ru28) = PTC open If in pn12 "warning“ is programmed as error response, ru03 changes after expiration of the dOH delay time pn13 into ERROR state
137	WARNING blockade	Warning drive blockade
138	WARNING PUready	Warning power unit not ready
143	WARNING overheat braking resistor	The temperature of the sub-mounted braking resistor has exceeded the warning level

4.4 Protection functions

Errors and warnings are also triggered by the protection functions of the drive. The function and parameterizing of the protection functions is described in the following.

4.4.1 Overload (OL)

The monitoring of the continuous load of the inverter can be influenced via the following objects:

Index	Id-Text	Name	Function
0x2C1D	ru29	OL counter	OL(I^2 t function) actual value in % / 100% = error
0x2A03	pn03	OL warning level	OL level, where a warning is triggered
0x2A04	pn04	E. OL stop. mode	Error reaction (=> see Chapter 4.3.1 Errors)
0x2C02	ru02	warning bits	Display of the warnings bit-coded (=> 4.3.3 Warnings)
0x2A1C	pn28	warning mask	Mask for warning bit in the status word (=> 4.3.3 Warnings)

The OL function protects the inverter against permanent overload.

Depending on the cooling, the operation at higher switching frequencies or higher DC link voltage, the error "ERROR overheat powmod.“ (overtemperature power components) switches off the drive already before OL function response.

The OL function is a root mean square (RMS) function. Depending on the load profile, the RMS value can be 100%, although the arithmetic mean value of the load is significantly smaller.

In addition, the load is weighted more heavily for extreme overloads (graphic: high overload range). This means that it is provided with a factor for calculating the RMS value so that the overload protection function is triggered before the RMS value reaches 100%.

If the cycle duration of a load cycle is significantly smaller than the overload times for a constant load, it must also be observed that the OL counter always has to return to zero. The maximum utilization of an inverter can be reached, although the OL counter reaches a maximum value of less than 5% percent.

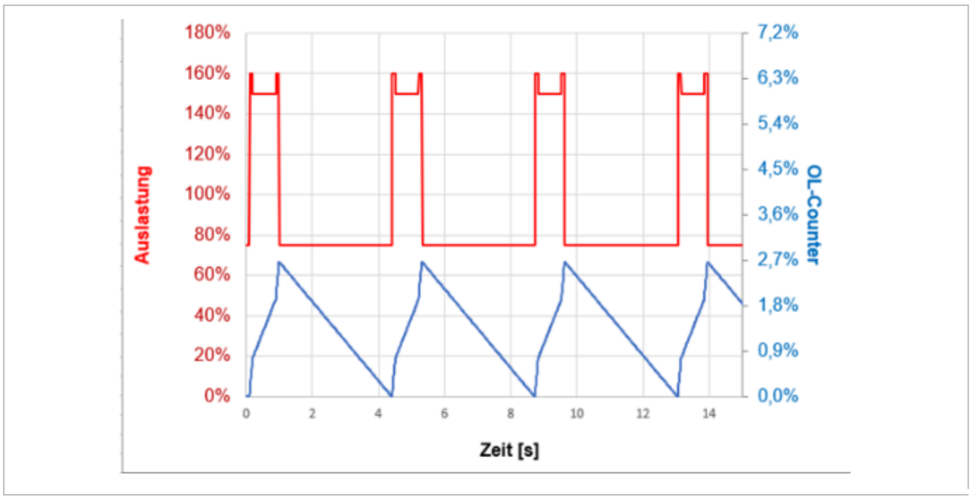
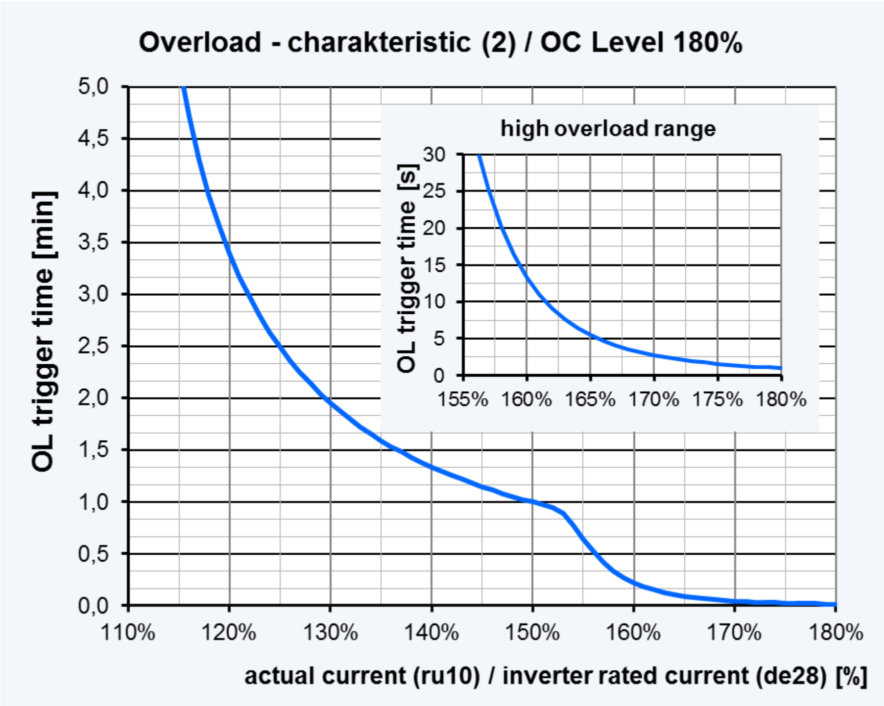


Figure 5: OL-counter

The following diagram shows the switch-off time for an inverter with overload characteristics depending on the constant load:



OL- trigger time:	OL-tripping time at constant load
actual current:	Motor current
inverter rated current:	Inverter rated current

Figure 6: Overload characteristic

The overload characteristic valid for the respective inverter can be found in the installation manual for the power unit.

The drive switches off automatically on reaching the overload limit (ru29 OL counter = 100%).

The error reaction can be programmed as described above via the object pn04 E.OL stop mode . A warning level can be programmed additionally.

On reaching this "OL-Counter“ value bit 0 is set in the warning state and with appropriate adjustment of the warning mask also bit 7 is set in the status word.

The error or warning can be reset when the OL counter has reached the value of * pn03 OL warning level / 2.

4.4.2 Overload power components (OL2)

The monitoring of the inverter load at small frequencies can be influenced via the following objects:

Index	Id-Text	Name	Function
0x2C1B	ru27	OL2 counter	OL2 actual value in % of the error-triggering level
0x2A05	pn05	OL2 warning level	OL2 level, where a warning is triggered
0x2C02	ru02	warning bits	Display of the warnings bit-coded (=> 4.3.3 Warnings)
0x2A1C	pn28	warning mask	Mask for warning bit in the status word (=> 4.3.3 Warn-ings)
0x350E	is14	overload protect mode	OL2 protection, no respectively reduced overload capacity
0x3514	is20	OL2 prot. gain	Determines the dynamic behavior in protection mode 2
0x3515	is21	OL2 safety fact.	Parameterization of the safety distance to the OL2 limit with overload protection
0x2C49	ru73	Imot/ImaxOl2	actual current / short time current limit
0x301E	ud30	OL2 current limits	Current limits resulting from the OL2 function
0x301F	ud31	OL2 diagnostic counter	OL2 diagnostic parameters

4.4.2.1 OL2 function

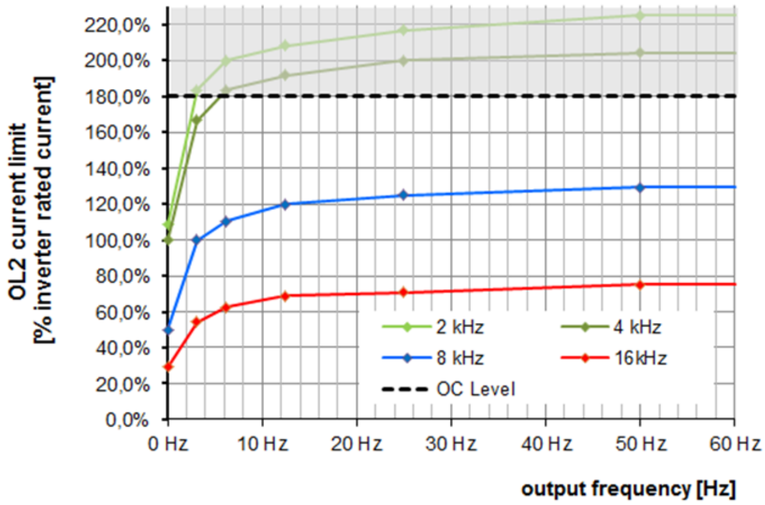
4.4.2.1.1 Output frequency dependent OL2 current limit

The power components are more loaded by current in lower frequency range than in higher output frequencies.

Therefore the permissible current (short time current limit) is lower than the maxi-mum current (de29 inverter maximum current).

The inverter normally outputs at least rated current as continuous current at 0Hz output frequency and rated switching frequency. The maximum current is available from maximum 10 Hz as standard. Detailed information can be found in the instal-lation manual for the corresponding power unit housing size.

The following diagrams show sample OL2 limiting characteristics:



output frequency: ru07 output frequency

Figure 7: Overload (OL2) limiting characteristic

The ratio of the actual output current to the permissible OL2 current at this frequency is controlled via PT1 element with a time constant of 200ms.

The output value of this PT1 element is displayed in parameter ru27 OL2 counter. The drive switches off automatically on reaching the overload limit (ru27 OL2-Counter = 100%).

ru73 Imot/ImaxOl2 displays the ratio of the actual motor current to short time current limit.

The short-time current is dependent on the actual switching frequency.

If "Derating" (automatic switching frequency reduction if the motor current exceeds the short-time current limit for the respective switching frequency) is used, then ImaxOl2 is equal to the short-time current limit for the minimum switching frequency that can be activated.

4.4.2.1.2 Heat sink temperature dependent OL2 current limit

If the actual heatsink temperature ru25[1] heatsink temperature 1 is below the OH threshold, a higher current is possible without triggering an OL2 error. The maximum possible current depends on the difference between the current temperature and the OH threshold.

The maximum current is reached at 40°C at the latest. Thereafter, a further reduction of the heat sink temperature causes no further increase of the maximum possible current.

NOTICE

The increase of the OL2 limit is intended for applications when the increased current is rarely needed (e.g. heavy starting after long standstill or other rarely occurring events). Increasing the OL2 current limit increases the load of the power module and reduces the lifetime of it.

The increase of the OL2 limit can be activated with parameter is17 temperature dependent OL2 offset.

<table>
<tr><td>is17</td><td colspan="4">temperature dependent OL2 offset</td><td>0x3511</td></tr>
<tr><td>Bit</td><td>Function</td><td colspan="2">Plaintext</td><td colspan="2">Description</td></tr>
<tr><td rowspan="3">0..2</td><td rowspan="3">temp offset</td><td>0</td><td>off</td><td colspan="2">No increase over the actual OL2 curve is possible. There is no dependence between heat sink temperature and OL2 current.</td></tr>
<tr><td>1</td><td>moderate</td><td colspan="2">The factors for a possible increase of the OL2 curve are chosen by way that the maximum current is moderately increased when the heat sink does not use the maximum temperature due to the drive cycle. The thermal load of the power module is increased. The service life of the power module is moderately reduced.</td></tr>
<tr><td>2</td><td>maximum</td><td colspan="2">The factors for a possible increase of the OL2 curve are chosen by way that the maximum current is increased as much as the thermal limits of the power module make it possible. This means that the current available for the application varies greatly depending on the heat sink temperature. In addition, the service life of the device is significantly reduced due to the increased thermal load of the power module.</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">priority</td><td>0</td><td>derating first</td><td colspan="2">The derating always occurs at the "base" OL2 limit without temperature-dependent increase. Default setting: If a lower switching frequency is also permissible for the application, it is always reasonable to use this instead of loading the inverter power module.</td></tr>
<tr><td>1</td><td>offset first</td><td colspan="2">Notice: This setting is only available for A and P cards
Offset has priority. Derating occurs only when the temperature-dependent increased OL2 current is exceeded.</td></tr>
</table>

The possible temperature-dependent increase depends on the used inverter.

NOTICE

With the increase of the heat sink temperature the temperature-dependent increase of the OL2 current reduces to zero. This must be considered when testing / designing the application.

Parameter is17 temperature dependent OL2 offset is a **PowerOn Parameter**: only if value 2 is set in is17 when switching on, this value can also be used during operation.

If is17 is 1 or zero when switching on, then a setting of is17 causes the setting "2 maximum" but only the moderate increase is activated during the current PowerOn cycle and only after PowerOn the selected setting "2 maximum" becomes effective.

The increase of the OL2 limit is adjustable in 2 steps:

- basic current (**0 = off**)

No increase over the actual OL2 curve is possible. There is no dependence between heat sink temperature and OL2 current.

- moderate increase ("1“ moderate)

The factors for a possible increase of the OL2 curve are selected in such a way that the lifetime of the power modules is only moderately reduced when the overload range is used.

- maximum increase ("2“ maximum)

The factors for a possible increase of the OL2 curve are selected in such a way that the lifetime of the power modules is significantly reduced when the overload range is used.

This setting should only be selected if it is ensured that this increased OL2 current is only rarely used.

Example:

The following graph shows the possible increase of the OL2 current limit for an air-cooled F6 housing 3 with 60A rated current and 4 kHz rated switching frequency at ru72 act. switch freq 4 kHz and a heat sink temperature (ru25[1] heatsink temperature 1) of 40°C.

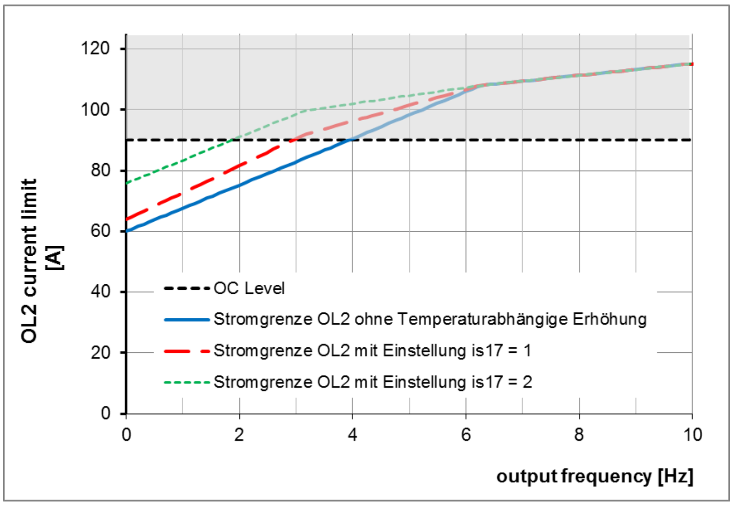


Figure 8: Increase OL2 for 60A rated current and 40°C

4.4.2.2 Diagnosis

Different current limits are displayed in ud30 OL2 current limits:

Sub-Idx	Name	Function
1	Icont offset	Value of the temperature-dependent OL2 increase
2	Icont derating	Current at which derating to a lower switching frequency is set
3	Icont act switching freq	OL2 limit at the current switching frequency
4	Imax OL2	OL2 limit at the lowest switching frequency
5	Imax control	OL2 limit for current setpoints in the control

There are 3 diagnostic counters to see how long the individual current limits have been exceeded.

Resolution 0.2 seconds / update every 4…6.5 seconds.

ud31[1] basic current => display how long the standard OL2 value has been exceeded.

The following counters are only active if the temperature-dependent OL2 increase in is17 is activated.

If mode "1 moderate“ is activated, ud31[2] counts, if mode "2 maximum“ is activated, ud31[3] counts.

ud31[2] moderate increase => display how long the moderately increased OL2 value has been exceeded

ud31[3] maximum increase => display how long the maximum increase OL2 value has been exceeded

4.4.2.3 OL2 - Warning

A warning level can be programmed additionally. On reaching this OL2-Counter value bit 1 is set in ru02 warning bits and with appropriate adjustment of the warning mask also bit 7 is set in the status wort.

The error and the warning can be reset, if the value of the OL2 counters is less than 80% of the warning level.

4.4.2.4 OL2 protection

Protection against the error OL2 can be activated via object is14 overload protect mode for current controlled operation. There are two different modes:

is14	overload protect mode	0x350E
Value	Name	Note
0	off	No protection against OL2 tripping, but overload reserves can be fully usable
1	on, limit = is21	The permissible total current is limited according to the OL2 limiting characteristic. The permissible percentage of the OL2 current, to which the current setpoint is limited, must be adjusted in is21 OL2 safety fact. The most stable OL2 protection is achieved with this function, provided the safety distance to OL2 is selected not too small. No short-term overload reserves are available in the lower frequency range. In the whole frequency range the current is limited to Imax = (de29 inverter maximum current * is21 OL2 safety fact).
2	on, limit variable	The current is not limited initially if there is sufficient distance between OL2 counter and is21 OL2 safety fact.. The current limit is reduced to the OL2 limit characteristic value only when the OL2 counter reaches the value of is21. An OL2 error can rather occur in this mode caused by too high factor is20 OL2 prot. gain or too high value for OL2 safety fact.. Therefore overload reserves are available for a short period. Permanently the current in the whole frequency range is also limited to de29 inverter maximum current * is21 OL2 safety fact.

The permissible total current is limited in mode 2 only if the OL2 counter exceeds a certain value.

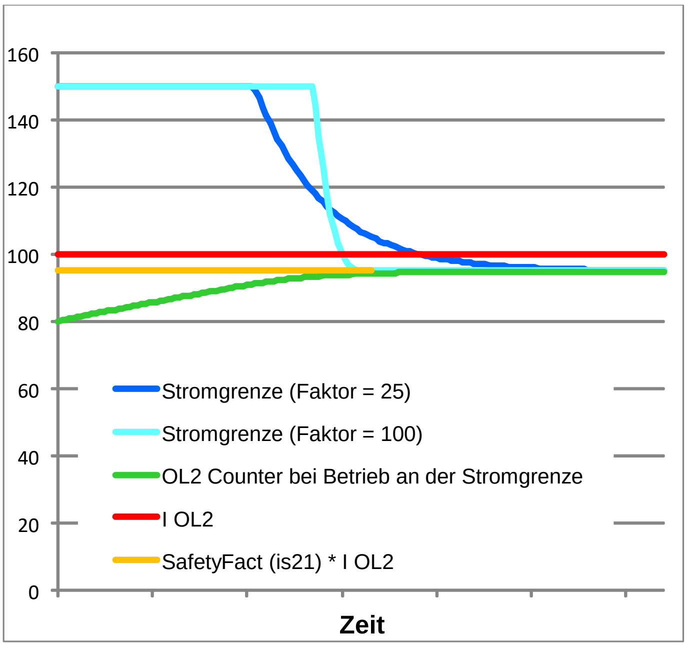


Figure 9: Characteristic of the current limit in relation to the time

Characteristic of the current limit in relation to the time when operating at the current limit for different values of is20 OL2 prot gain. The higher the factor, the steeper the descent of the current limit when the OL2 counter reaches the safety factor.

4.4.3 Overtemperature heatsink (OH)

NOTICE

the inverter is not a temperature measuring device!

- The detection of the temperature only serves to protect the inverter and is, depending on the device type and the current measuring point, subject to varying degrees of tolerance and error.

Depending on the device size, there are only one or more heat sink temperature values. If an inverter does not support heat sink temperatures 2 or 3, "5000: temperature measurement not supported" is displayed.

Each supported heat sink temperature has its own overtemperature level and its own error code.

Index	Sub -Idx	Id-Text	Name	Function
0x2C19	0	ru25	heatsink temperature values	Heat sink temperature at different measuring points (depending on the power unit size)
	1		heatsink temperature 1	Display of the heatsink temperature measuring point 1
	2		heatsink temperature 2	Display of the heatsink temperature measuring point 2
	3		heatsink temperature 3	Display of the heatsink temperature measuring point 3
	4		minimal distance to OH	Display of the difference between the heatsink temperature and the associated error trigger value
0x2A06	0	pn06	temperature warning setting mode	Selection of the reference level for generating the overtemperature warning
0x2A07	0	pn07	OH warning level	Temperature when a warning is triggered
0x2A08	0	pn08	E.OH stop mode	Error reaction (=> see Chapter 4.3.1 Errors)
0x2A51	0	pn81	warning OH stop mode	Error reaction to pre-warning (=> also chapter 4.3.1 Errors)
0x2C02	0	ru02	warning bits	Display of the warnings bit-coded (=> 4.3.3 Warnings)
0x2A1C	0	pn28	warning mask	Mask for warning bit in the status word (=> 4.3.3 Warnings)

The drive switches off automatically on reaching an unit-dependent maximum heat sink temperature. The error reaction can be programmed as described above via the object pn08 E.OH stop mode (immediate switching off, or triggering of **FAULT REACTION ACTIVE**).

The length of time required to shutdown the drive depends on many factors: e.g. the duration of the deceleration ramp and settings in brake handling (co24 brake control closing delay and co25 brake control closing time).

The maximum time between occurence overtemperature and switch-off modulation is 2 seconds.

If the time exceeds 2 seconds and the overtemperature error is still present, it will be switched off with error message 110: ERROR time OH.

If these 2 seconds are too small to ensure a meaningful completion of the machine cycle, a warning level pn07 OH warning level can be programmed.

The reaction to the warning is freely adjustable. All setting options for configurable errors are available.

The default setting is "Warning". That means: upon reaching the pre-warning temperature, bit 2 is set in ru02 warning bits and with respective setting of the warning mask also bit 7 in the status word.

pn06 defines how the reference level for generating the overtemperature warning is determined:

pn06	temperature warning setting mode	0x2A06
Value	Name	Function
0	absolute value	ru25[1] heatsink temperature 1, ru25[2] heatsink temperature 2 and ru25[3] heatsink temperature 3 are compared with pn07 OH warning level. If one of the heatsink temperatures is higher than the comparison value, the warning becomes active. If all heatsink temperatures are lower than the comparison value minus the hysteresis (5 °C), the warning is reset.
1	relative to error level	pn07 OH warning level defines the distance to the overtemperature tripping threshold whose undershooting shall trigger the warning. If one of the heatsink temperatures is closer to its associated shutdown threshold than pn07, the warning becomes active. The warning will be reset if all heatsink temperatures are outside the range of pn07 plus hysteresis (5 °C).

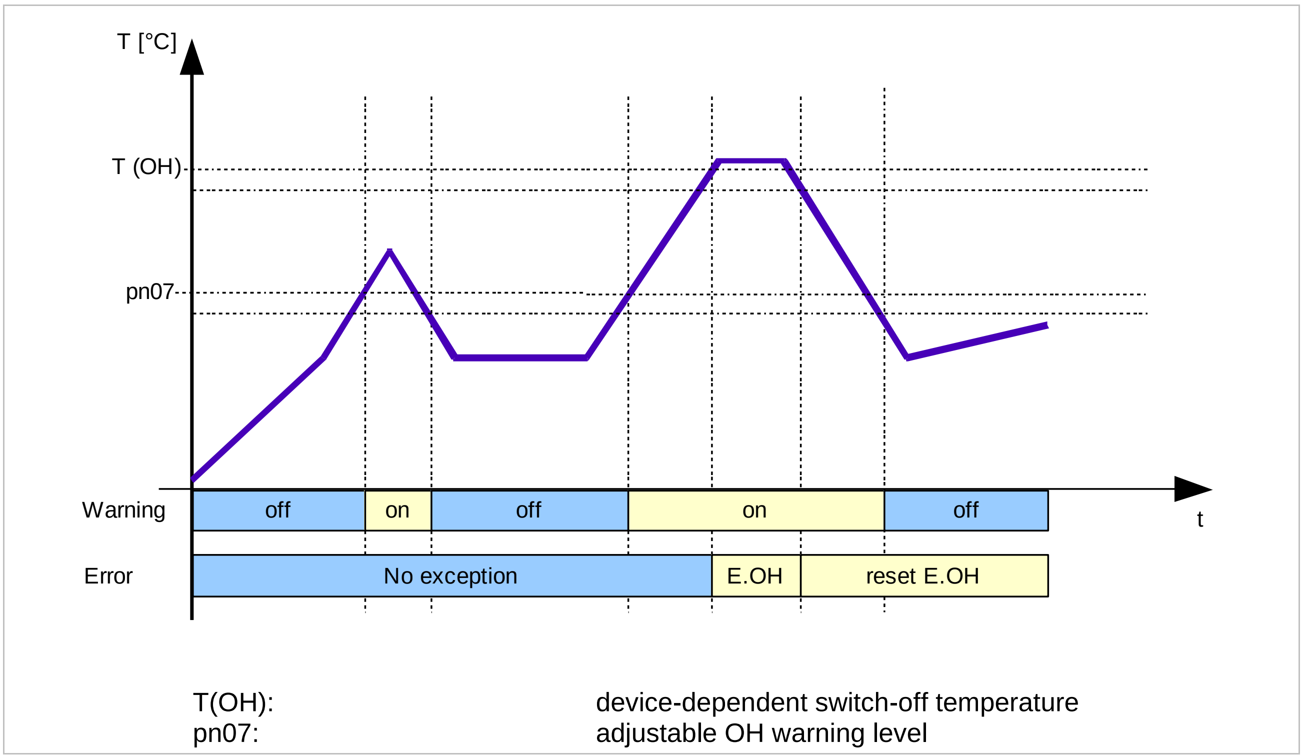


Figure 10: Overtemperature heatsink (OH)

4.4.4 Overtemperature unit (OHI)

NOTICE

The inverter is not a temperature measuring device!

- The detection of the temperature only serves to protect the inverter and is, depending on the device type and the current measuring point, subject to varying degrees of tolerance and error.

Index	Subidx	Id-Text	Name	Function
0x2C1A	0	ru26	internal temperature PU values	Internal temperature in the power unit (**P**ower**U**nit) at different points (depending on the inverter size)
	1		internal temperature PU 1	Internal temperature in the power unit measuring point 1
	2		internal temperature PU 2	Internal temperature in the power unit measuring point 2
	3		internal temperature PU 3	Internal temperature in the power unit measuring point 3
	4		minimal distance to OHI	Display of the smallest difference between an internal temperature and the associated error trigger value
0x2C4D	0	ru77	internal temperature CB	Internal temperature on the control board (**C**ontrol**B**oard)
0x2A06	0	pn06	temperature warning setting mode	Selection of the reference level for generating the overtemperature warning
0x2A09	0	pn09	OHI warning level	Internal temperature (of the power unit or control board) when OHI warning is triggered
0x2A0A	0	pn10	E.OHI stop mode	Error reaction (=> see Chapter 4.3.1 Errors)
0x2A52	0	pn82	warning OHI stop mode	Error reaction to pre-warning (=> also chapter 4.3.1 Errors)
0x2C02	0	ru02	warning bits	Display of the warnings bit-coded (=> 4.3.3 Warnings)
0x2A1C	0	pn28	warning mask	Mask for warning bit in the status word (=> 4.3.3 Warnings)

The internal temperature is measured at several points, with one sensor on the control board and one or more sensors in the power unit.

On reaching an unit-dependent maximum internal temperature, the drive behaves according to the setting of pn10 E.OHI stop mode.

The length of time required to shutdown the drive depends on many factors. The maximum time between occurence overtemperature and switch-off modulation is 2 seconds.

If the time exceeds 2 seconds and the overtemperature error is still present, it will be switched off with error message 111: ERROR time OHI.

If these 2 seconds are too small to ensure a meaningful completion of the machine cycle, a warning level pn09 OHI warning level can be programmed. Upon reaching this temperature, bit 3 is set in ru02 warning bits and with respective setting of the warning mask also bit 7 in the status word.

The reaction to the warning is freely adjustable. All setting options for configurable errors are available.

The default setting is "Warning". This means: upon reaching the pre-warning temperature, bit 2 is set in ru02 warning bits and with respective setting of the warning mask also bit 7 in the status word.

pn06 defines how the reference level for generating the overtemperature warning is determined (for the description of pn06 see chapter 4.4.3 Overtemperature heatsink (OH)).

4.4.5 Overtemperature motor (dOH)

The monitoring of the motor temperature can be influenced via the following objects:

Index	Id-Text	Name	Function
0x2C1C	ru28	motor temperature	Display of the motor temperature
0x2221	dr33	motor temp sensor type	0 = KTY 84-130, 1 = PTC, 2 = via encoder, 3 = KTY 83 110, 4 = PT1000, 5 = freely defined sensor characteristic
0x2A0B	pn11	dOH warning level	Motor temperature at which a warning is triggered (not valid for PTC evaluation)
0x2A0C	pn12	E.dOH stop mode	Error reaction (=> see Chapter 4.3.1 Errors)
0x2A0D	pn13	E.dOH delay time	Only active for PTC: time between triggering of the PTC (sets the warning bit) and triggering of error dOH
0x2A0E	pn14	dOH error level	Motor temperature at which an error is triggered (not valid for PTC evaluation)
0x2C02	ru02	warning bits	Display of the warnings bit-coded (=> 4.3.3 Warnings)
0x2A1C	pn28	warning mask	Mask for warning bit in the status word (=> 4.3.3 Warnings)
0x221E	dr30	motor sensor definition	Parameter structure for the definition of a customer-specific characteristic for detection of the motor temperature

4.4.5.1 PTC evaluation

Values of ru28 motor temperature when using a PTC sensor:

PTC according to DIN EN 60947-0		
Resistance	Description	Display ru28
< 750 Ω	T1-T2 closed	PTC closed
0.75…1.5kΩ reset resistance	Transition T1-T2 open => closed	
1.65k…4kΩ response resistance	Transition T1-T2 closed => open	
>4kΩ	T1-T2 open	PTC open

4.4.5.2 KTY / PT1000 evaluation

Values of ru28 motor temperature when using a KTY or PT1000 sensor:

KTY 84-130	KTY 83-110	PT1000	Temperature
498Ω	820Ω	1000 Ω	0°
1kΩ	1670Ω	1385 Ω	100°C
1521Ω	2535Ω	1666 Ω	175°C
1722Ω	-	1758 Ω	200°C

"Short circuit" is displayed when the resistance is too low and "no connection" is displayed when the resistance is too high.

4.4.5.3 Free-programmable sensor

If the used motor temperature sensor is an unknown sensor type for the inverter, the user can specify his own characteristic with dr30.

In order to activate this characteristic, value 5: user definition must be set in dr33 motor temp sensor typ.

Index	Id-Text	Name	Function
0x221E	dr30	user drive temp. sensor def.	Parameter structure for the definition of a customer-specific characteristic for detection of the motor temperature

ID-Text	Sub Idx	Name	Function
dr30	1…32	temp value1 … temp value 32	32 temperature values to define the application-specific resistance characteristic of the motor temperature sensor. Presetting in °C
	33	R min	Minimum resistance value of the sensor characteristic (in ohm) => resistance, which belongs to the temperature preset in temp value 1
	34	R max	Maximum resistance value of the sensor characteristic (in ohm) => resistance, which belongs to the temperature preset in temp value 32
	35	short circuit level	Resistance value (in ohm) which displays "short circuit" in ru28
	36	no connection level	Resistance in ohm which displays "no connection" in ru28
	37	act. calculated resistance	Actual calculated resistance of the sensor
	38	Rv	Display of the series resistor of the evaluation circuit (to calculate the sensor current: voltage of the measuring circuit approx. 4.7V, here series resistor 1K91 Ohm).

The user-specific characteristic is defined with sub indices 1 to 34. It consists of 32 pairs of values: resistance value of the sensor and associated temperature.

The internal table of the resistance values range from R min (subindex 33) to R max (subindex 34) in 32 equidistant steps.

The corresponding temperatures can be calculated with an EXCEL table if the sensor characteristic can be mapped by the trend line. The trend line function is used to calculate the temperature values that must be entered in subindex 1 (temp value 1) to subindex 32 (temp value 32) .

If the defined characteristic range is left, the display of the motor temperature in ru28 remains set at the final values of the characteristic (temp value 1 or temp value 32, until the resistance value short circuit level falls below (display changes to "short circuit") or the resistance value no connection level is exceeded (display changes to "no connection").

The calculated resistance value of the temperature sensor is displayed in subindex 37 actual calculated resistance. By way the user can check the characteristic definition.

The series resistor of the evaluation circuit is displayed in subindex 38 Rv, since the inverter does not provide a constant current source. This allows the user to estimate if self-heating of the sensor can falsify the measurement.

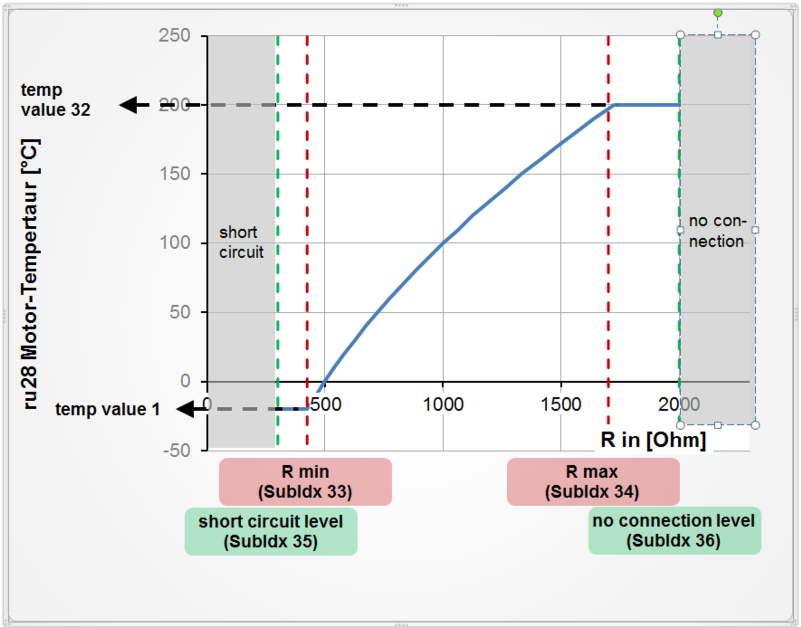
The following values must be defined for the calculation of the setting of dr30 by the EXCEL file:

2

Temp.	R (Temp)
-40	359
-30	391
-20	424
-10	460
0	498
10	538
20	581
30	626
40	672
50	722
60	773
70	826
80	882
90	940
100	1000
110	1062
120	1127
130	1194
140	1262
150	1334
160	1407
170	1482
180	1560
190	1640
200	1722

1

R_{min} [dr30 SubIdx 33]	424 Ohm
R_{max} [dr30 SubIdx 34]	1640 Ohm
$R_{ShortCircuit}$ [dr30 SubIdx 35]	300 Ohm
$R_{no\ connection}$ [dr30 SubIdx 36]	2000 Ohm



1 Resistance limits
2 Sensor characteristic (e.g. from data sheet for required measuring range)

Figure 11: Sensor calculation by Excel

⚠ CAUTION

➢ Since not all sensor characteristic curves can be emulated by a corresponding trend line, it must be checked whether the trend line mapps the characteristic curve with sufficient accuracy.

4.4.6 Motor protection switch OH2

4.4.6.1 Asynchronous motor

Index	Id-Text	Name	Function
0x2222	dr34	motorprotection curr. %	Rated current of the motor protection function (in % dr03)
0x2227	dr39	ASM prot mode	Selection of self-ventilated / forced-ventilated motor

dr39	ASM prot mode		0x2227
Value	Name	Note	
0	separate cooling	Adjustment for separate-cooled motor	
1	self cooling	Adjustment for self-cooled motor	

The motor protection function protects the connected motor against thermal destruction caused through high currents.

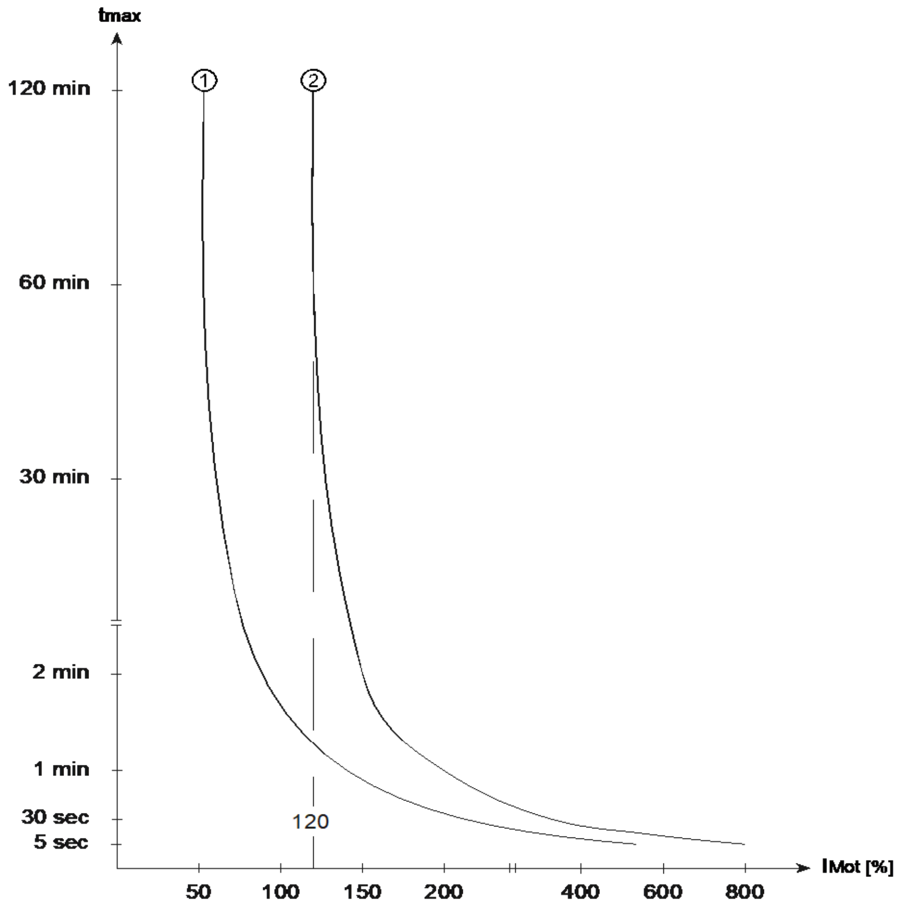
The function corresponds essentially to the mechanical motor protection components, whereby the influence of the motor speed to the cooling of the motor is additionally considered.

The load of the motor is calculated from the measured apparent current (ru10) and the adjusted motor protection rated current In (dr34motorprotection curr. %).

The following tripping times are valid for a separate cooled motor or at rated frequency of a self-cooled motor:			
1.2 • In => 2 hours	1.5 • In => 2 minutes	2 • In => 1 minute	8 • In => 5 seconds

The tripping time decreases for self-cooled motors with the frequency of the motor. The motor protection function works integrating, i.e. times with overload of the motor are added, times with underload are subtracted.

After triggering of the motor protection function the new triggering time reduces, unless the motor was not operated for corresponding time with underload.



IMot: Motor current in % of the motor protection rated current (dr34 *dr03)
tmax: tripping time
① f = 0Hz
② f ≥ rated motor frequency or external ventilated motor

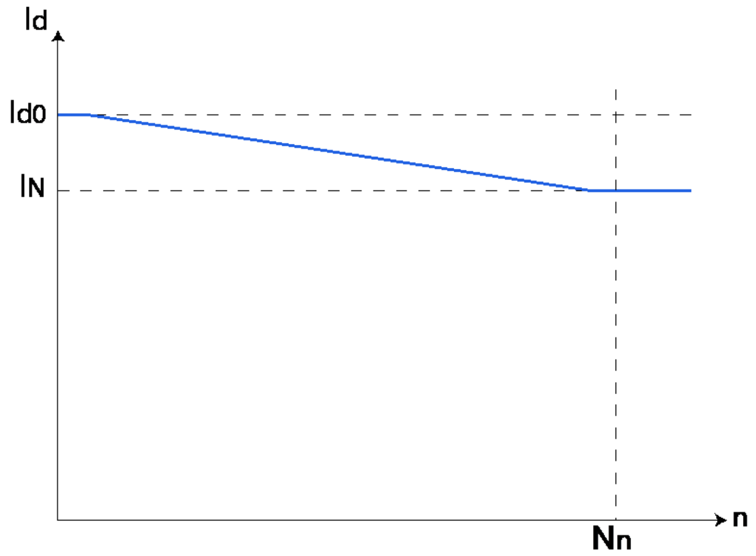
Figure 12: Tripping motor protection switch

4.4.6.2 Synchronous motor

Index	Id-Text	Name	Function
0x2203	dr03	rated current	Rated motor current (in A)
0x220C	dr12	max. current %	Maximum permissible motor current (in % dr03)
0x2222	dr34	motorprotection current %	Standstill current (in % dr03)
0x2223	dr35	SM prot. time min. Is/Id	Tripping time at the min. response threshold
0x2224	dr36	SM prot. time Imax	Tripping time at maximum current
0x2225	dr37	SM prot. recovery time	Recovery time of the motor
0x2226	dr38	SM prot. min. Is/Id	Min. response threshold of the motor protection function

The motor protection function is dependent on the actual speed (n), the actual apparent current (Is), the maximum current and the motor protection parameters (dr34…dr38).

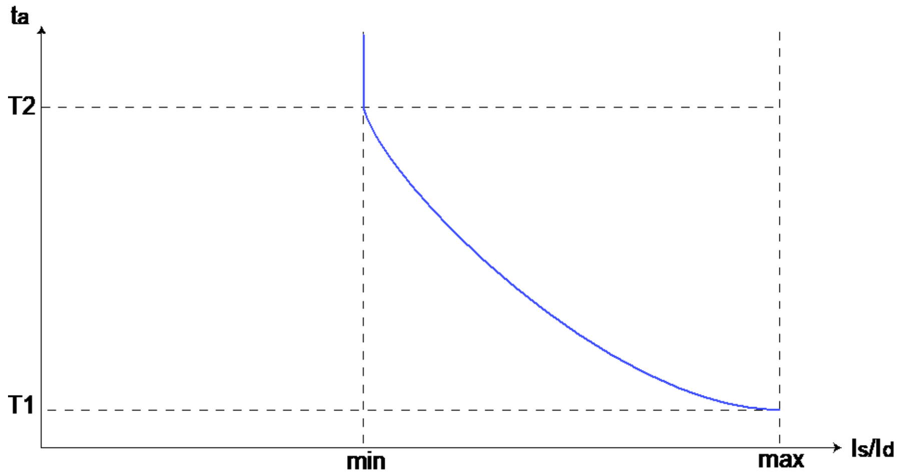
The continuous current (ID) is speed-dependent:



Id:	continuous current
Id0:	standstill current (dr34 * dr03)
In	rated current (rated current / dr03)
Nn	rated speed (rated speed / dr04)

Figure 13: Dependence of the motor protection function

The tripping time (ta) is determined by the ratio Is/Id:



Ta:	tripping time
Is/Id:	apparent current/ continuous current [%]
T2:	dr35 (SM prot time min Is/Id)
T1:	dr36 (SM prot time Imax)
Min:	dr38 (SM prot min Is/Id)
Max:	dr12 (max current %)

Figure 14: Dependence of the tripping time

Only if the ratio Is/Id is higher than the response threshold of the motor protection function (dr38 SM prot. min. Is/Id) the tripping time (ta) expires.

The tripping time at minimum threshold current is dr35 SM prot.time min. Is/Id and at maximum current (dr12) dr36 SM prot.time Imax.

A counter is increased. If the counter reaches 100%, the error "14 : ERROR motorprotection“ is triggered.

If the ratio Is/Id < dr38, the counter is decreased with a factor defined by the recovery time (dr37SM prot. recovery time). The prot.recovery time is the time, which the counter needs to count from 100% to 0%.

The triggered error by the motor protection function can be reset at 98%.

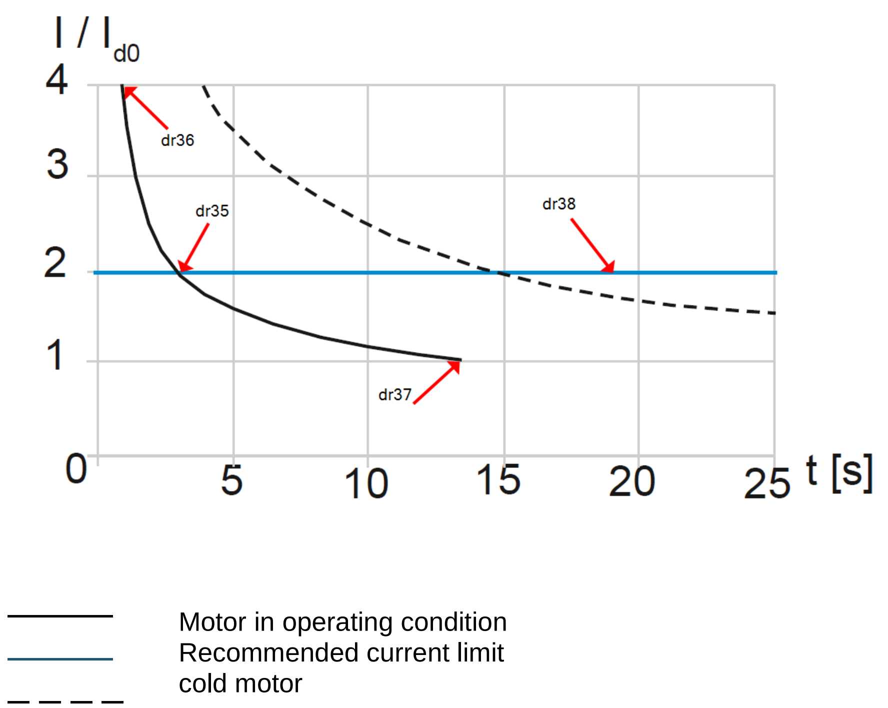


Figure 15: Determination of the motor protection function data from the characteristics of the motor manufacturer

4.4.7 Fieldbus watchdog

Independent on the control the drive can be stopped with the function fieldbus watchdog when the communication is interrupted.

The function can be parameterized via the following objects:

Index	Id-Text	Name	Function
0x2A15	pn21	fieldbus watchdog time	Max. period of the communication interruption (0 = off)
0x2A16	pn22	E.fb watchdog stop mode	Error reaction (=> see Chapter 4.3.1 Errors)
0x2C02	ru02	warning bits	Display of the warnings bit-coded (=> 4.3.3 Warnings)
0x2A1C	pn28	warning mask	Mask for warning bit in the status word (=> 4.3.3 Warnings)

A detailed description of the functionality of the fieldbus watchdog can be found from version 3.0 in the Programming Manual | Fieldbus systems.

The Programming manual | Fieldbus systems can be downloaded from the KEB website. Registration is required.

4.4.8 Maximum current

Index	Id-Text	Name	Function
0x2203	dr03	rated current	Rated motor current
0x220D	dr12	max. current %	Maximum permissible motor current (in % dr03)
0x201C	de28	inverter rated current	Inverter rated current
0x201D	de29	inverter maximum current	Inverter maximum current (only software limiting)
0x350B	is11	max. current [de28%]	Maximum permissible inverter current (in % de28)
0x3523	is35	set current limit	Software current limit in % turn-off current (OC current) of the device. Resolution 0.01%

The maximum apparent current (not for v/f operation) can be preset via parameters is35 set current limit, dr12 max. current % and is11 max. current [de28%].

de28 inverter rated current and de29 inverter maximum current are only display parameters and they display the inverter rated current and the maximum current of the inverter. Due to e.g. insufficient cooling, it may be necessary to limit the maximum inverter current additionally with is11 to prevent OH errors.

The maximum permissible motor current can be adjusted in dr12 max. current %.
The effective current limitation is the lower value of is11 and dr12.

The maximum current of the drive (de29) is always determined as fixed upper limit.

This value is determined by is35 set current limit.
The setting range is 50.00% to 95.00% of the hardware-related turn-off current of the inverter.

NOTICE

- The default value of the software current limit is 83.33% of the typical turn-off current to ensure safe operation. The displayed current is always only an average value during a power module cycle. The superimposed current ripple dependent on the motor, which is not visible in the current display, can trigger the overcurrent cut-off, although the display value of the current is clearly below the turn-off current. The specified switch-off current threshold is a typical, tolerance affected value. If the software current limit is higher than the default value, the design must be checked to prevent sporadic overcurrent cut-offs.

i

- Parameter is35 is a Power-On Parameter. i.e. a change of the value is only effective after restart.

Limitations can be considered separately by the inverter or the motor with dr12 and is11.

Example:

The motor parameter (dr12) also serves to the definition of the saturation characteristic, except for the limitation of the current (=> chapter 6.2.13 Saturation characteristic (SM) Parameter ms00). This value may not be changed in some applications.

Here it may be useful to limit the maximum current via is11.

4.4.9 Effective motor load

Index	Id-Text	Name	Function
0x2C39	ru57	eff. motor load	mean effective motor load in 0.1% resolution
0x2A11	pn17	eff load time	PT1 time for effective motor load

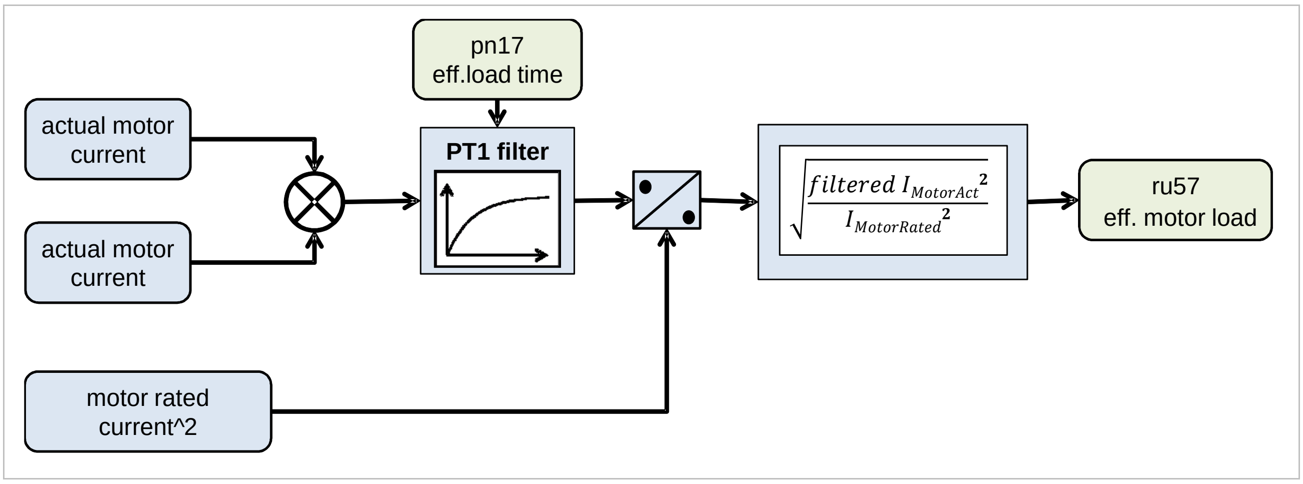


Figure 16: Effective motor load

pn17	eff load time	0x2A11
Value	Function	
0.01…300.00s	PT1 filter time	

ru57 eff. motor load is a pure information parameter, no fault response can be deducted.

The time to reach the final value of the function is a multiple PT1 time because of the root function. Trends for the effective motor utilization can be estimated quickly.

The display area for the effective utilization is limited to max. 8-fold rated motor current. If the actual motor current exceeds this value, the result behind the PT1 filter is limited. Short peaks in the motor current are detected and evaluated, only the effective utilization is limited.

4.4.10 Maximum acceleration or deceleration

Index	Id-Text	Name	Function
0x2A24	pn36	max acc/dec level [s-2]	Maximum acceleration / deceleration value
0x2A25	pn37	E.max acc/dec stop mode	Error reaction (=> see Chapter 4.3.1 Errors)

The maximum acceleration or deceleration can be monitored for all operating modes. The level in pn36 is normalized (in [s-2]) as well as the ramps.

The acceleration is additionally limited to the value in pn36 in operating modes with interpolator (8, 9, 10).

Thereby errors of the superior control can be compensated. Additionally an error reaction should be activated in pn37.

4.4.11 Monitor the speed difference

Index	Id-Text	Name	Function
0x2A26	pn38	speed difference level	Speed difference in % rated motor speed
0x2A27	pn39	speed difference time	Error is triggered if the time of the speed difference is longer than pn39
0x2A28	pn40	speed difference stop mode	Error reaction (=> see Chapter 4.3.1 Errors)
0x2A29	pn41	speed difference calculation mode	Selection which value shall be taken as reference value for the speed difference calculation.

Monitoring of the difference between the set speed (defined via pn41) and the actual speed.

By way it can be monitored e.g. whether the drive can follow a setpoint in the correct manner.

This can prevent e.g "overspeed" of a synchronous motor with wrong system position, if the pn39 speed difference time is selected sufficiently small.

Parameter pn38 speed diff level is used to define the difference at which the error flag is set.

pn38	speed diff level		0x2A26
Value	Plaintext	Note	
0 ... 8000	0.0% ... 800%	Speed difference in % rated motor speed	

With pn41 you can select which value is to be used as speed setpoint. The actual speed value is either ru08 actual value or the encoder speed of channel A (ru09 A) or channel B (ru09 B).
This selection of the actual speed value also determines the display in ru83 DiffSpeed.
ru83[1] ... ru83[4] display the 4 differences (ru84 – actual speed), (ramp output – actual speed) etc.
The selection of "actual speed" for this display is also done via pn41.

pn41	speed difference calculation mode		0x2A29
Bit	Value	Plaintext	Function
diff source			
0…7	0	ru84 – actual speed	Setpoint speed is the ramp generator input value ru84 reference speed
	1	ramp output – actual speed	Setpoint speed is the ramp generator output value
	2	ramp out after cs19 - ru08	Setpoint speed is the ramp generator output value after the Pt1 filter (cs19 ref. speed PT1 time)
	3	ru06 – actual speed	Setpoint speed is the speed controller input value (ramp output smoothed via PT1 filter + position controller)
actual value source			
8..15	0	ru08	Actual value is the actual speed value of the control ru08
	1	ru09 (A)	Actual value is the detected speed of channel A ru09 (A)
	2	ru09 (B)	Actual value is the detected speed of channel B ru09 (B)

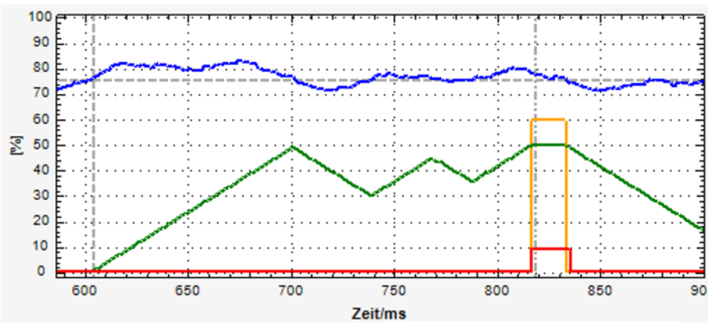
pn39 speed diff time defines the minimum time the speed deviation must be present before the error flag is set.

pn39	speed diff time		**0x2A27**
Value	Plaintext	Note	
0 ... 65535	0.0 … 16383.75 ms	Time that the speed deviation must be present (resolution 0.25ms)	

The signal (error/warning) is reset immediately when the speed deviation is no longer present. Additionally the internal response time of the monitoring is set to zero during reset, so the response time is reduced after short deactivation of the signal. As long as the signal remains inactive, the internal response time is increased until it reaches the full value again (equal to the value parameterized in pn39) after pn39 speed difference time has elapsed.

Example:

- blue graph: Speed => fluctuates around 150 rpm
- green graph: Counter => is incremented / decremented
- When the final value (100) is reached, the error flag is set.
- red graph: The error flag triggers the error in ru01
- yellow graph: As soon as the differential speed is no longer > 150 rpm, the error flag is reset => reset is possible and is executed immediately in this case.
- green graph: The counter is decremented, but not reset immediately => shortened recovery time



4.4.12 External error / warning triggering

Index	Id-Text	Name	Function
0x2A1D	pn29	prg. error stop mode	Error reaction (=> see Chapter 4.3.1 Errors)
0x2A1E	pn30	prg. error source	Selection of the inputs or events which trigger the error

Errors or warnings can also be triggered by external events. Different sources can be selected via pn30.

The meaning of the single bits in pn30 prg. error source is defined as follows:

pn30		prg. error source	0x2A1E
Bit	Value	Name	Function
0	1	I1	Input I1 triggers an error
1	2	I2	Input I2 triggers an error
2	4	I3	Input I3 triggers an error
3	8	I4	Input I4 triggers an error
4	16	I5	Input I5 triggers an error
5	32	I6	Input I6 triggers an error
6	64	I7	Input I7 triggers an error
7	128	I8	Input I8 triggers an error
8	256	IA	Input IA triggers an error
9	512	IB	Input IB triggers an error
10	1024	IC	Input IC triggers an error
11	2048	ID	Input ID triggers an error
12…15			Reserved

4.4.13 Safety Stop from safety module

Index	Id-Text	Name	Function
0x2A50	pn80	safety stopping function	Error reaction (=> see Chapter 4.3.1 Errors) On devices with safety module type 3 or higher, the SS1 or SS2 function can directly execute the reaction set in pn80. See also the instruction manual of the safety module.

4.4.14 Error underpotential (UP / PUready)

Index	Id-Text	Name	Function
0x2020	de32	inverter minimum DC voltage	Default value to trigger the undervoltage error
0x3512	is18	UP error level	Tripping level for the UP error
0x3513	is19	UP reset level	Reset level fo the UP error
0x2A4C	pn76	UP2 delay time	Delay time of error triggering of UP2
0x2A4D	pn77	E.UP2 stopping mode	Response to the UP2 error
0x2A53	pn83	auto-retry activation	Activation of an automatic error reset
0x2A54	pn84[1]	auto-retry UP time	Time limit of the automatic error reset
0x2A54	pn84[2]	fault suppression mode	Activation of a reducted precharge time
0x2A54	pn84[3]	auto retry UP acceleration	Activation of an alternative ramp after Auto-Retry UP/PUready

4.4.14.1 Precharging of the DC link

If the DC link voltage falls below the UP threshold, the circuit for the current-limited precharging of the DC link is activated.

Below the UP threshold, the switching power supplies connected to the high voltage also become inactive. This triggers error 123: ERROR PUready. Since the UP level is fallen below when the voltage is switched off before the switching power supplies become inactive, error "ERROR PUready" is normally never visible to the outside.

"5: phase failure“ is displayed in parameter ru04 supply unit state.

Precharging occurs via precharging resistors, which are bridged after completion of precharging either via a relay (case size 2) or input thyristors.

The difference between the DC link voltage and the mains input voltage is monitored from housing size 4.

The power unit ready signal is only set when the high-voltage supplied power units are in operation and the voltage difference monitoring also sends the "ready" signal.

When the power unit ready signal is applied and the UP reset threshold is exceeded, the precharge time implemented in the software **also** elapses. After this time, the precharging circuit is deactivated again and the state of parameter ru04 supply unit state changes to "4: run“.

The time until the UP reset threshold is reached or the power unit ready signal is set is only defined by the hardware (temperature-dependent precharging resistors). If the error was triggered by a short power failure, the restart time can be optimized by reducing the software waiting time. For this, bit 2 "reduced charging" must be activated in pn84[2] fault supression mode.

pn84[2]	fault suppression mode		**0x2A54 [2]**
Bit	Plaintext	Note	
1	4: reduced charging	The reduced charging time is activated with Auto Retry UP. (For a description of the function, see chapter 4.3.2.2 Automatic fault reset UP)	

This reduced charging time is only selectable for Auto-Retry UP / LTready.

4.4.14.2 Reduction of the charging currents

The two levels for the UP and the UP reset threshold are preset according to the power unit.

In case of short voltage dips where the inverter is not / only slightly loaded (e.g. modulation off or motor in no-load operation), the dip in the DC link voltage may be so small that the precharge circuit is not reactivated.

If the power recovery occurs in this state, there can be extremely high currents in the DC link.

These currents can only be reduced / avoided if the voltage level at which error UP is triggered or precharge is activated is increased.

This is possible with is18 UP error level and is19 UP reset level .

Since internal switching power supplies depend on the DC link voltage, the UP threshold can only be lowered slightly.

NOTICE

- Between **is18 UP error level** and **is19 UP reset level** must always be at a sufficient distance (for 400V devices at least 60V).

4.4.14.3 Error triggering

Only if the DC link voltage falls below the value of is18 during activated modulation, error "6: ERROR underpotential" (display in ru01) is triggered. The same applies to error 123: ERROR PUready (power unit ready - signal inactive)

Otherwise, only ru04 supply unit state changes back to the state "5: phase failure“ and the state machine cannot be beyond state "2: switch on disable“ (st12 state machine display).

If a low DC link voltage also shall trigger an error, if the modulation is not released can be parameterized by pn77 E.UP2 stopping mode.

Function with programming of pn77 to 0: fault“: an undervoltage error is triggered if ST is set and after waiting for the delay time (pn 76 E.UP2 delay time) ru04 supply unit state has not reached the state "4: run“.

The software ST (Bit 0 and 1 of co31 internal control word) and the state of the STO inputs is considered as ST.

4.4.14.4 Optimized restart time

4.4.14.4.1 Overview of necessary parameterization

In order to return the motor to "normal operation" as quickly as possible after an error UP or error LT ready, without the need for intervention by the control, the following settings must be made:

- Activation auto-retry: pn83 = 1: auto retry UP / PUready
  (see chapter 4.3.2.2 Automatic fault reset UP)
  The auto retry (auto reset) does **not** generate an edge in the "enable operation" bit of the control word. An automatic return into the state "***operation enabled***“ without intervention of an external control is only possible if the value "0:state" is selected in co32 state machine properties for „***enable operation mode“***
- Activation of reduced minimum switch-off times after auto-retry: pn85 customer time usage 1: at auto retry. (Other settings are also possible, e.g. 3: at auto retry + at low speed,
  description see chapter 4.4.23.2 Configuration of the minimum switch-off time)
- Activation of the reduced precharge time at auto-retry UP
  Setting of pn84[2] fault supression mode Bit 2 „reduced charging“

4.4.14.4.2 Reduced ramp to optimize the start-up time

If long acceleration ramps are parameterized for the "normal" start-up of the drive, these may be too long for the restart after a mains voltage failure.

Therefore, a separate ramp time can be programmed for this case in pn84[3] auto retry UP acceleration [s-2].

The alternative ramp is always a linear ramp.

Index	Subidx	Id-Text	Name	Function
0x2A54	3	pn84	auto retry UP acceleration for [s-2]	Linear acceleration / deceleration for all directions of rotation

The alternative ramp for optimized restart becomes active when:

- the drive is operated in velocity mode
- AutoRetry UP/PUready with time limit (pn84[1] unequal zero) was performed (see 4.3.2.2 Automatic fault reset UP)
- the "Fault suppression mode" in pn84[2] is activated
- bit 3 "enable operation" and bit 0 "switch on" in the controlword remain set or are set again during the restart time. (The test is only performed in the slow interrupt => 6.2.21 Interrupt structure of the software)

NOTICE	Removing bit 1 "enable voltage" has no effect on resetting the function. After bit 1 is set again, the fast ramp is used for the first acceleration after any time. However, if bit 0 or bit 3 is also set to zero when the restart is carried out, the alternative ramp is also deactivated.

This alternative ramp only applies to the first acceleration process after AutoRetry UP/PUready.

When the setpoint is reached, the standard ramp becomes active again.

If the setpoint speed at the start of the alternative ramp is zero, the standard ramp is also reactivated

pn84[3]	auto retry UP acceleration for [s-2]		0x2A54 SubIdx 3
Value	Plaintext	Function	
0	0: off	no alternative ramp	
0 .. 1747626666	0,00 .. 17476266,66	Definition of the alternative ramp	

4.4.15 Overvoltage

The modulation is switched off with ERROR overpotential if (e.g.) in regenerative operation the DC link of the inverter is charged too high by regeneration with too fast ramp.

Regeneration is completed by deactivation and the inverter is protected.

One exception is (e.g.) excessively high charge of the DC link, which can occur due to the EMF at high speed of a synchronous motor or voltage increase in an asynchronous motor with preconnected filter.

If in these cases the DC link voltage is not limited to the "overpotential" value, ERROR extreme overpotential is triggered with exceeding the next voltage limit.

Voltage class	Tripping level ERROR overpotential	Tripping level Error extreme overpotential
230 V	400 V	470 V
400 V	840 V	940 V
690 V	1200 V	1410 V

Table 4-1: Overvoltage level

This error can only be reset after 60 seconds. In order to prevent additional energy supply from the mains side, the inrush current limiting is reactivated, if the technology of the inverter allows it.

If a voltage exceeds the "extreme overpotential" (OP2) value for a longer time, it is assumed that the DC link capacitors are damaged and the inverter shall be made subject to a service.

The error display changes to "ERROR capacitor damaged" and the device can not be put into operation.

The internal switching power supplies are activated at mains voltage supply, but the starting current limiting remains active and the inverter remains in "ERROR capacitor damaged".

This error is reset only with an overhaul by the service.

The following table shows the temporal connection between the duration of the overvoltage and "ERROR capacitor damaged":

DC voltage [V]			Permanent damage after
230V	400V	690V	
470	940	1410	5 seconds
475	950	1425	5 seconds
480	960	1440	5 seconds
485	970	1455	1.48 seconds
490	980	1470	625 ms
495	990	1485	320 ms
500	1000	1500	185 ms
505	1010	1515	117 ms

Table 4-2: Permanent damage due to overvoltage

4.4.16 Overspeed (ERROR overspeed / ERROR overspeed (EMF))

Index	Id-Text	Name	Note
0x2A1B	pn26	overspeed level	Tripping level ERROR overspeed in % rated speed
0x2A1C	pn27	E.overspeed stop mode	Error reaction (=> see Chapter 4.3.1 Errors)
0x2A46	pn70	overspeed factor (EMF)	Tripping level ERROR overspeed (EMF)
0x2A47	pn71	E. overspeed EMF) st. mode	Error reaction (=> see Chapter 4.3.1 Errors)
0x2A48	pn72	overspeed level (EMF)	Tripping level ERROR overspeed (EMF) in rpm

There are 2 functions for overspeed protection (pn26 / pn27 and pn70…pn72).

- An application-specific speed limit can be set with pn26.

- It is calculated from the value of the EMF at which speed the regenerative voltage of the synchronous machine reaches a value which damage the capacitors in the inverter DC link. The safety difference to this limit is pre-set with pn70 overspeed factor (EMF). A value of 90% for pn70 means, the error is triggered at 90% of the max. theoretically permissible speed value. The level when the error is triggered is displayed in pn72 overspeed level (EMF).

$$pn72 = \frac{OPLevel}{dr14} * \frac{pn70}{100\%} * 1000 * rpm$$

The response to the error is defined with pn71 E. overspeed (EMF) st. mode.

NOTICE

➢ These errors are only triggered when the modulation is switched on.

4.4.17 Encoder monitoring

The drive can be stopped independent of the control with the function encoder monitoring when the speed measurement fails.

The function can be parameterized via the following objects:

Index	Id-Text	Name	Function
0x2A22	pn34	E.encoder A stop mode	Error reaction (=> see Chapter 4.3.1 Errors)
0x2A23	pn35	E. encoder B stop mode	Error reaction (=> see Chapter 4.3.1 Errors)
0x2C02	ru02	warning state	Display of the warnings bit-coded (=> 4.3.3 Warnings)
0x2A1C	pn28	warning mask	Mask for warning bit in the status word (=> 4.3.3 Warnings)

If an encoder is adjusted for the appropriate channel (ec16 encoder type or ec16 encoder type B unequal 0), the parameterized error response (e.g. warning or error reaction ramp) is triggered as soon as the speed measurement is no longer possible without error. (i.e. as soon as the encoder interface indicates an error in ec00).

Since channel A is used as standard for speed and position control, the default value for pn34 E. encoder A stop mode is 0 "fault (92: ERROR encoder A" is triggered) and for pn35 E. encoder B stop mode 7 "off" (no response).

If a control mode is selected which requires an encoder (cs00 control mode = 1 "encoder without model" or 2 "encoder, with model") an error is always triggered, even if value 7 "off" is selected in the encoder monitoring. Then the error type is 96 "encoder missing". When the encoder monitoring is switched off (or programming only to warning), it can only be reached, that the drive in operating modes which do not require an encoder, do not change into malfunction. This allows eventually an emergency operation.

4.4.18 Limit switch

Limit switches are used to detect a certain position, whereupon a defined reaction is carried out.

4.4.18.1 Software limit switch

Index	Id-Text	Name	Function
0x2A12	pn18	sw.- switch limit left	Software position limits
0x2A13	pn19	sw.- switch limit right	
0x2A14	pn20	E.SW-switch stop mode	Error reaction (=> see Chapter 4.3.1 Errors)
0x3110	hm16	Excluded modes of operation for software limits	Operating modes in which the software limit switches are **not** active

If st33 position actual value exceeds the software position limits while a speed is preset in the appropriate direction, the parameterised error response is triggered.

4.4.18.2 Hardware limit switch

Index	Id-Text	Name	Function
0x3106	hm06	negative limit switch source	Selection of digital inputs for the negative and positive limit switch (=> also chapter 7.1 Digital Inputs; no STO inputs)
0x3107	hm07	positive limit switch source	
0x310F	hm15	excluded modes of operation for limit switch	Operating modes in which the limit switches are **not** active
0x3111	hm17	limit switch handling	Selection of limit switch tripping conditions
0x3112	hm18	limit switch speed level	Speed level in % rated motor speed from which evaluation of the actual direction of rotation is active
0x2A4E	pn78	limit switch forward stop mode	Selection of the error reaction when the limit switch is reached (=> also chapter 4.3.1 Errors)
0x2A4F	pn79	limit switch reverse stop mode	

If no input is assigned to a limit switch in parameters hm06 / hm07 but a reaction is defined in parameters pn78 / pn79, this reaction is always triggered because the limit switches are 0-active.
If a quickstop reaction is selected in parameters pn78 / pn79, quickstop must be activated in co32, otherwise there is no reaction. The quickstop reaction can be defined via the "quickstop option code".

hm15	excluded modes of operation for limit switch		0x310F
Bit	Value	Name	Function
0…15	0	no mode of operation	Hardware limit switches are always active
0	1	profile positioning mode	Selection of the "modes of operation“ in which the hardware limit switch function shall not be effective
1	2	velocity mode	
2	4	homing mode (not available)	
3	8	cyclic sync positioning mode	
4	16	cyclic sync velocity mode	
5	32	cyclic sync torque mode	
6…15		reserved	reserved for future modes of operation

hm17	limit switch handling		0x3111
Bit	Value	Plaintext	Function
limit switch active mode			
0…2	0	standard	Standard Input: The limit switch signal is active as long as the selected input is active (= zero).
	1	hold status	In the event that a limit switch has been passed, the limit switch should remain logically active. The position at detection of the limit switch signal is stored. By way that the signal "limit switch positive" is removed again, the input must become inactive again and the position (st33) must be smaller than the position of the activation edge. The same applies to the signal "limit switch negative".
	3…7		reserved
limit switch dependence			
3…5	0	only input	Limit switch is evaluated independently of the direction of rotation
	8	only reference speed	Limit switch is only evaluated depending on the set direction of rotation (ru84)
	16	reference and actual speed	The limit switch is evaluated depending on the set direction of rotation (ru84 and the actual direction of rotation (ru08) (OR linking). The evaluation of the actual direction of rotation becomes only active above the speed level (hm18).
	24	fault at actual speed	Function as for value 16, but additionally: if it is detected that only the actual direction of rotation is in the direction of the limit switch, the "FAULT" reaction is always triggered.
	32		reserved
reserved			
6,7	64…192		reserved

The digital inputs of the hardware limit switches can be selected via parameters hm06/hm07. A signal is applied to them until they are approached (0-active). With parameter hm15 can be adjusted whether the limit switches should have no function in an operating mode. The homing mode is deactivated at the factory because it resets the positions of the system and therefore no position-dependent limit switch evaluation can be done. The tripping conditions for a limit switch must be set via parameter hm17 (default value = 8). It should be noted that in two modes (16, 24) parameter hm18 (default value = 0%) must also be set by way that the detection of the actual speed becomes active.

The reaction when the limit switch is reached is set via parameters pn78 and pn79. If "Warning" or "Ignore" are not selected as limit switch reaction, reaching the limit switch always finishes the active positioning. Thus, the set position is set to the value of the actual position and a new "Start Positioning" command is required. If index positioning is configured, the start index is restarted.

If the positive and negative limit switches are active simultaneously (both supply a 0 signal), always the fault reaction is triggered and an error is output. This should guarantee the protection of the operated system in case of defective and jammed limit switches. A reset of the error is possible as soon as the defect at the limit switch has been remedied and **both** switches are released again.

If a power-on reset is performed, the parameter settings are retained, but temporary limit switch data, such as the position when the limit switch is activated or the hold status, are reset. Therefore the position of the system must be checked before restarting after a power-on reset.

⚠ CAUTION

All reactions to the limit switch, except immediate switch-off, require that the control (with encoder / ASCL or SCL) is still functional.

In case of a defect of individual power modules, current detection or voltage measurement, a wrong system position, the set and actual position (estimated or measured) can deviate from each other.

➢ Then only switching off the modulation can protect the drive.

Index	Id-Text	Name	Function
0x3113	hm19	maximal forward limit switch override	Setting the max. difference between the position when detecting the limit switch signal and the current actual position (st33). Value "0" deactivates the function. The "limit switch active mode“ has no effect on this function.
0x3114	hm20	maximal reverse limit switch override	

If a "Stop" mode is selected as reaction to the limit switch, a maximum difference between the position when detecting the limit switch signal and the current actual position (st33) can be parameterized with hm19/hm20 maximal forward/reverse limit switchoverride. If this difference is exceeded (e.g. due to a shutdown ramp that is too slow), the drive switches to "ERROR override forward" or "ERROR override reverse". This error can only be detected if the modulation is still active. It can be reset when the modulation is deactivated.

If this function is used, no homing should be carried out during operation. This would reset/change the positions and the override function could not work properly.

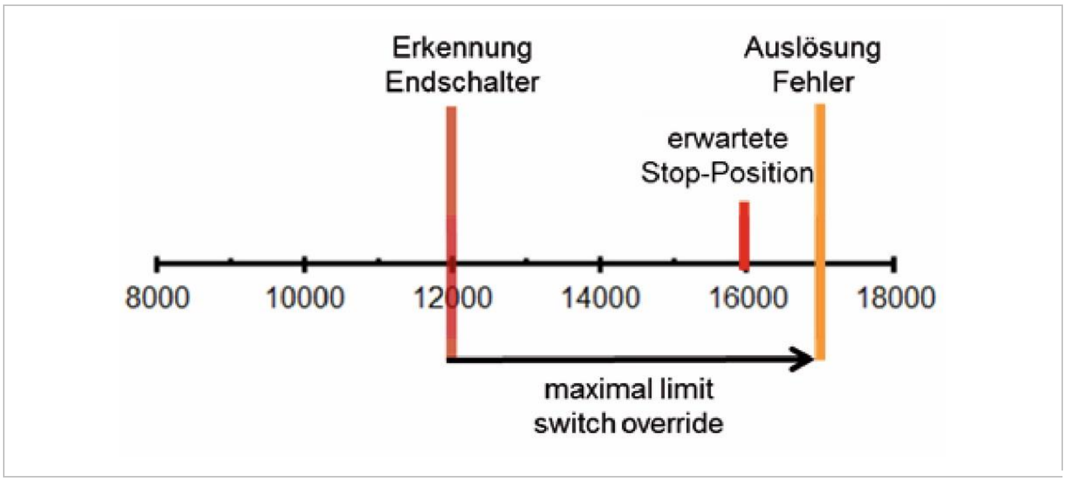


Figure 17: Limit switch

4.4.19 Input phases failure detection

Index	Id-Text	Name	Function
0x2A2A	pn42	E.Uph stop mode	Error reaction (=> see Chapter 4.3.1 Errors)

There are two internal functions which monitor the DC link voltage in order to avoid a premature ageing of the capacitors.

If the ripple of ru14 exceeds 10 times within 16 ms a power unit-dependent value (typically 120V at 400V devices), error 52: ERROR undervoltage phase (E.Uph) is triggered.

The second function is only active with 3-phase inverters. This function monitors the ripple of the DC link within a certain frequency range. Error 52: ERROR undervoltage phase (E.Uph) can also be triggered if the frequency of the fluctuation of ru14 indicates that an input phase is missing.

Since a ripple of the DC link voltage can also be triggered by the application (load cycle or oscillations of the controller), the more sensitive, frequency-dependent monitoring function can be switched off with pn42 or it can be used only as warning function.

If the UPS mode is active (chapter 4.4.21 UPS mode), the phase failure detection is generally deactivated.

4.4.20 Motor phase failure detection

Phase failure detection checks the connection between the inverter and the motor.

There are 2 different procedures for failure detection:

- DC signal
- High frequency signal

4.4.20.1 Activation

Motor phase failure detection is mostly needed in combination with brake handling: if there is a phase failure, the brake must not be opened under any circumstances. Therefore the activation occurs in parameter co21 brake ctrl mode bit 10 phase check.

However, a missing phase can also cause undefined behavior in applications without a brake. For this reason, the function is also available independently of brake handling. If bit 10 is set to "on", the phase failure detection is always activated.

The monitoring runs in the status "start operation active".

co21	brake ctrl mode			0x2515
Bit	Function	Valu e	Plaintext	Note
10	phase check	0	off	no phase check
		1024	on	Before the brake is released, it is checked whether all three motor phases are connected. A phase failure is displayed in ru01 22: ERROR ident. Since this error can have several causes, the reason is defined more precisely in dr57 ident error info.

4.4.20.2 Configuration

The mode (DC or high frequency signal) is selected in parameter co27 phase check ctrl, (co27[1] phase check mode) and an information about the test result is displayed in (co27[2] error level information).

Index	Sub-Index	Name	Function
0x251B	0	phase check control	Configuration of the motor phase failure detection
	1	phase check mode	Selection procedure for failure detection
	2	error level information	Detection quality

There are 2 different procedures to detect the motor phase failure. Depending on the application, both have their advantages and disadvantages.

- **DC signal**(Default procedure)
  - Advantages
    - No equivalent circuit data necessary. It is sufficient to estimate the data via dr99 = 2
    - Conditionally suitable for sine-wave filter operation (depending on the resonance frequency of the system)
  - Disadvantages
    - Signal generates a torque. This allows the motor to be rotated without a brake
    - slight noise emission
    - Identification time depending on the time constant of the motor, approx. 30...250ms
- **High-frequency signal**
  - Advantages
    - no torque, therefore the drive is not twisted even without a brake.
    - can be used for all motor types
    - short identification time, depending on the maximum switching frequency of the drive.
    - very silent
  - Disadvantages
    - Inductance of the motor must be known
    - **not** suitable for operation with sine-wave filter

co27 [1]		phase check mode		**0x251B [1]**
Bit	Function	Value	Plaintext	Note
0	mode	0	DC ramping	Presetting and evaluation of a DC signal Current level: Asynchronous motor: 0.5 * dr03 rated current Synchronous motor: 0.25 * dr03 rated current
		1	HF voltage	Presetting and evaluation of a high-frequency signal Based on the parameterized inductance, an excitation voltage is calculated with which a current of 0.05 * dr03 rated current shall be reached, at the Hf frequency

4.4.20.3 Error triggering

Parameter co27[2] error level information was introduced in order to recognize when the drive triggers an error.

The value of this parameter depends on the used mode. As additional information, occurring error during the phase failure check are displayed in dr57 ident error info.

The possible error displays are dependent on the used mode. **DC current setting:**

dr57	ident error info		0x2239
Value	Plaintext	Meaning	
131	least square, max. voltage reached	The maximum voltage was output for 50ms without reaching the current setting. Error, if e.g. two phases are missing.	
132	least square, current not symetrical	Current setting: • for ASM => 0.5 * dr03 • for SM / IPM / SRM => 0.25 * dr03 Evaluation of two voltage vectors Error, if not 30% of the expected value of a phase current is exceeded, or the sign of a phase current disagrees with the expectation.	
133	LeastSquareDC, current not zero	The sum of the phase currents should be ZERO, if the sum is greater than 30% of the expected total current, this error is triggered.	

High frequency signal

dr57	ident error info		0x2239
Value	Plaintext	Meaning	
140	LeastSquareHf, no information	The level of information is too low, e.g. due to the existing maximum output voltage or the minimum excitation frequency. Error: the current of 5% InMot cannot be reached.	
141	LeastSquareHf, negativ values	The detected inductance is <=NULL	
142	LeastSquareHf, differenz > limit	The inductance is calculated from the Hf signal and the maximum / minimum value is determined. Error limit: Lmax / Lmin > 10	
143	LeastSquareHf, phase current too low	A current of 5% rated motor current is expected. Error limit: the detected phase current is less than 1.5% rated current	

In addition to a real phase failure, incorrect parameterization of the motor data such as inductance, rated voltage of the motor, rated current of the motor can also lead to triggering of the phase failure errorru01 22: ERROR ident.

4.4.21 UPS mode (Not available for compact cards)

4.4.21.1.1 Voltage level

The UPS mode enables switching to a UPS system with lower voltage in case of mains failure.

The undervoltage and reset thresholds are shifted to the minimum possible values (defined by the power supplies in the inverter) and the indirect phase failure detection (see chapter 4.4.19 Input phases failure detection) is deactivated.

If, due to the application, the voltage thresholds do not have to be set to the minimum value, there is an offset parameter with which both the UP level and the UP reset level are increased. UP thresholds that are too low can unnecessarily increase the input current when switching on.

In case of improper use, the reduced thresholds can stress the precharging circuit.

pn43[3]	USV operation UP offset	0x2A2B[3]
Value	Display	Function
0...1000	0.0V... 100.0V	the definition of the UP / UP reset threshold during UPS operation is based on the power unit data. With this parameter both thresholds can be increased by an offset value.

The resulting error / reset levels that apply during UPS operation can be read out in pn43[4] USV UP error level / pn43[5] USV UP reset level.

4.4.21.1.2 Activation

UPS operation must generally be enabled. In the UPS mode parameter pn43[1] enable USV Operation it is also possible to define that the function is only active when an input is set.

pn43[1]	enable USV Operation	0x2A2B[1]
Value	Plaintext	Description
0	no usv operation	UPS operation is generally deactivated
1	generell enabled	UPS operation is generally activated As long as this parameter is set to 1, the changed UP / UP reset levels apply and ripple detection is completely deactivated
2	enabled by digital input	UPS operation is enabled if this parameter is set to 2 and the defined input in pn43[2] is active. Behavior then identical to value 1

The input (hardware, software, controlword or STO input) can be selected in parameter pn43[2] USV enable source.

If several inputs are defined, the input status OR is linked to select them.

4.4.22 Power off function

The status "Power off active" is reached when the event "Mains power failure detected" occurs:

- The DC link voltage drops below a preset level.
- Currently no further starting conditions.

If a mains power failure is detected, the following reaction may occur:

- The energy stored in the drive, is used to maintain the DC link. The DC link is controlled to a constant DC link voltage.
- The drive is brought to a standstill at a constant torque limit.

4.4.22.1 Function description

4.4.22.1.1 Function and power flow in the CDM

During operation of a CDM, the mains AC voltage is converted into DC voltage by the input rectifier and by way a DC link is kept at a constant voltage level. This DC voltage is converted by the output inverter into AC voltage which supplies the connected motor.

4.4.22.1.1.1 Motor operation

During motor operation, power is taken from the mains and converted into movement in the motor. The DC link voltage remains constant in this operating state, no energy is converted into heat in the braking resistor.

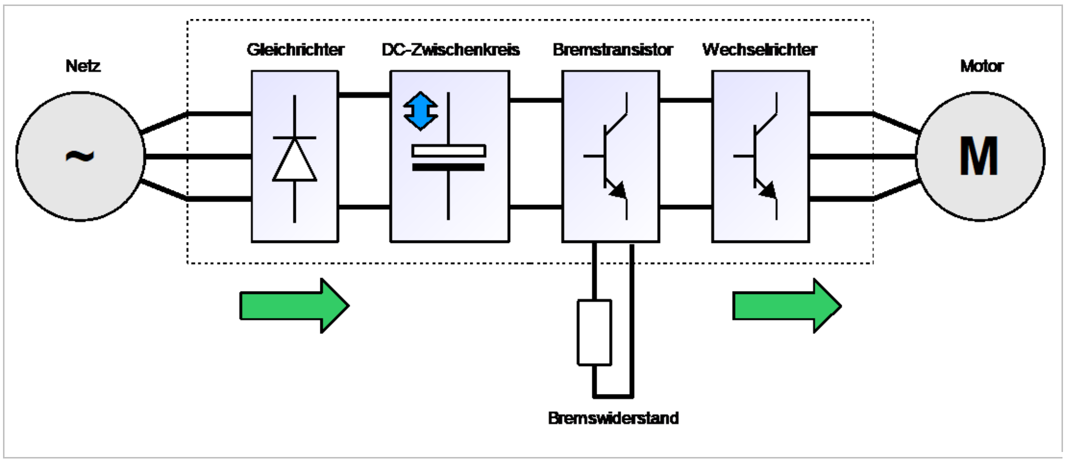


Figure 18: Motor operation

4.4.22.1.1.2 Regenerative operation

In regenerative operation, mechanical energy of the motor is converted into electrical energy in the DC link. A power flow back into the mains is not possible via the rectifier. Therefore, the voltage in the DC link increases and on exceeding the tripping voltage, the energy in the braking resistor is converted into heat. If no braking resistor is connected, the CDM switches off with overvoltage error.

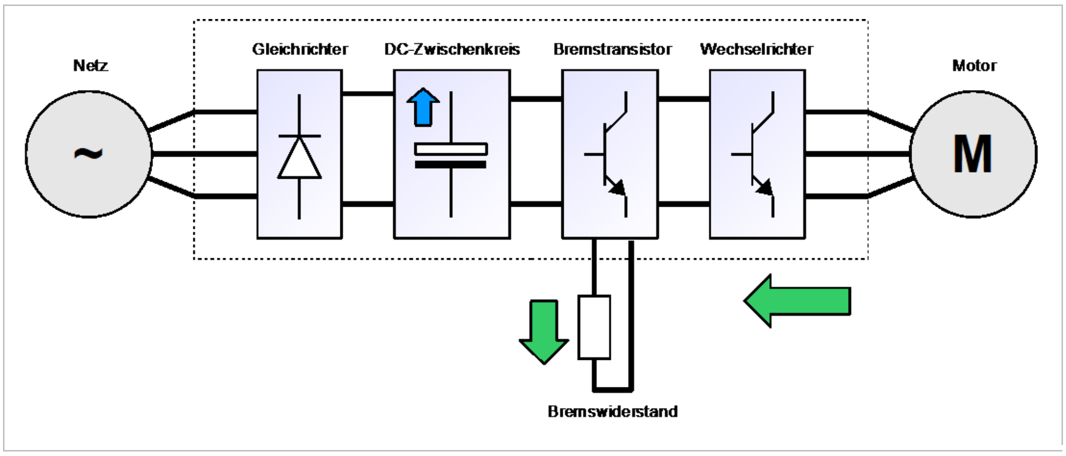


Figure 19: Regenerative operation

4.4.22.1.2 Behavior in case of mains power failure without activated power-off function

4.4.22.1.2.1 Motor operation

If the mains fails during motor operation, energy is still taken from the DC link. Since the DC link is no longer recharged from the mains, the DC link voltage drops. If the undervoltage limit is undercut, the CDM switches off with undervoltage error. The connected motor coasts down.

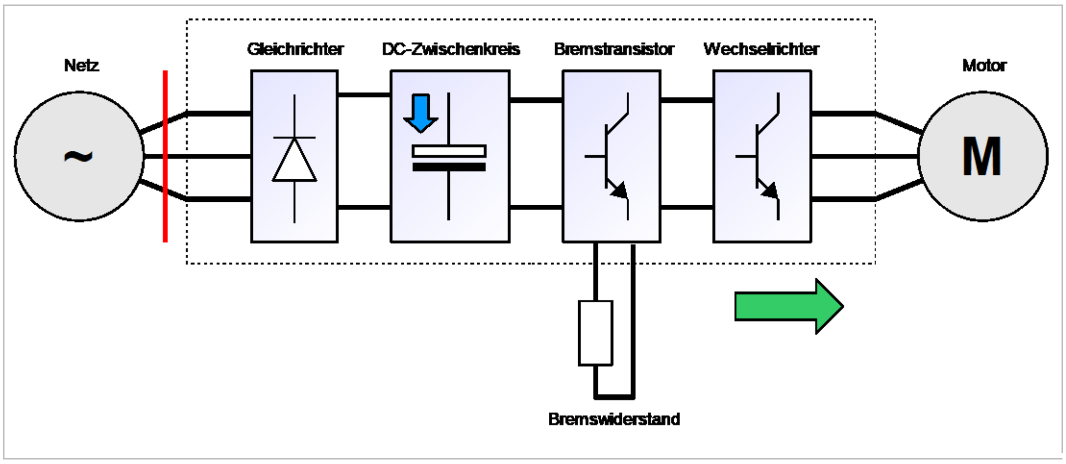


Figure 20: Motor operation without power-off function

4.4.22.1.2.2 Regenerative operation

In regenerative operation, a mains power failure will have no effect.

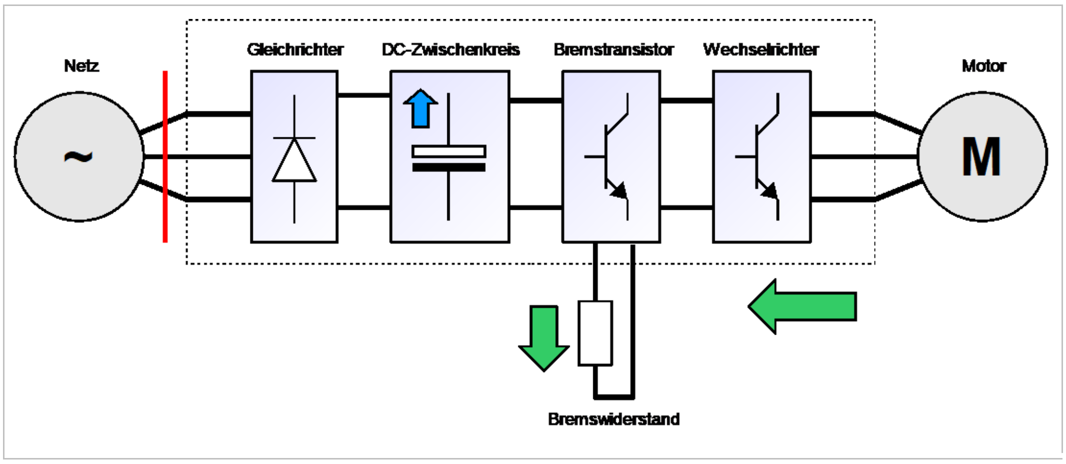


Figure 21: Regenerative operation in case of mains power failure

4.4.22.1.3 Behavior in case of mains power failure with activated power-off function

4.4.22.1.3.1 Control to constant DC link voltage

If a mains power failure is detected, the power flow to the motor is interrupted and the motor is brought into regenerative operation. The power fed back into the DC link is controlled in such a way that the DC link voltage is kept at the selected set-point. By way, external loads connected to the DC bus can be supplied with constant voltage. If the power fed back by the motor is not sufficient to cover the power requirements of the external loads, the DC link voltage will drop and switch off the CDM with undervoltage error.

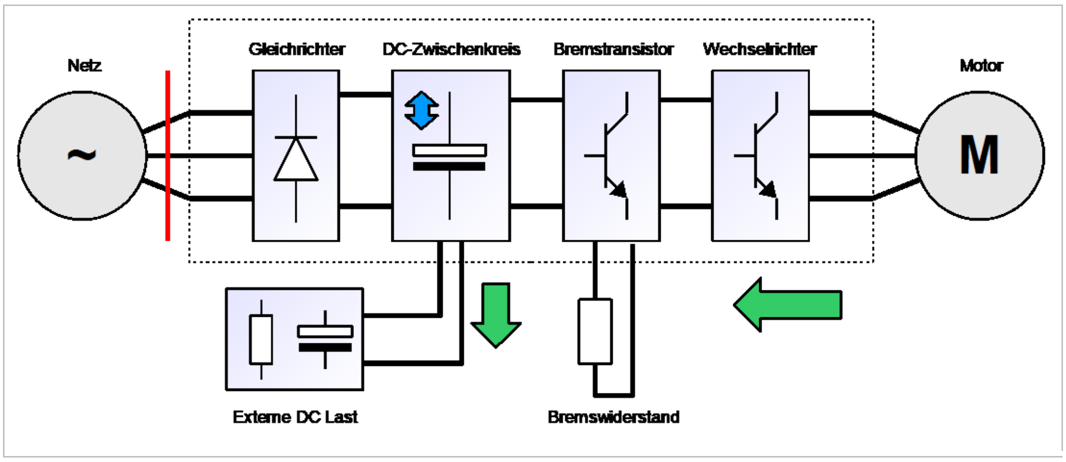


Figure 22: Control to constant DC link voltage

The deceleration of the motor results from the energy stored in the rotating masses of the motor and the power requirement of the external DC loads.

4.4.22.1.3.2 Control to constant torque

If a mains power failure is detected, the power flow to the motor is interrupted and the motor is brought into regenerative operation. The power fed back into the DC link is determined by the specified braking torque. In this operating mode, the DC link voltage increases continuously up to the tripping level of the braking transistor. If no braking resistor is used, the DC link voltage increases up to the overvoltage level.

The control to constant torque is used in applications where the drive shall be shut-down as quickly as possible when a mains power failure is detected.

i In the operating mode - control to constant torque - a braking resistor or an external braking module must be used to limit the DC link voltage.

4.4.22.2 Restrictions due to the control model

The power-off function can be used in the following modes:

cs00	control mode				0x2700
Bit	Function	Value	Plaintext	Notes	Power Off
0…3	control mode	0	uf-control	Voltage-/frequency characteristic even with activated power-off function no change into the state "Power-Off active"	--
		1	encoder, with-out model	Operation with encoder without motor model	x
		2	encoder, with model	Operation with encoder and motor model	x
		3	no encoder (ASCL/SCL)	PowerOff Uic-Ctrl only works in speed ranges where the motor model is also activated (ds41).	x

4.4.22.3 System recovery

There are two options for system recovery:

- the restart speed was not fallen below, then the drive can be operated again
- when it has left the "operational enable" state. The stopping level is irrelevant here.
- The restart speed was fallen below, starting from the stopping level, the system switches into speed-controlled operation and decelerates to low speed at the standard ramp (co-group) and the standard torque limit (cs-group).

4.4.22.4 End of power-off function

The deactivation time expires when the setpoint speed NULL is reached in the stopping mode. Afterwards the status changes to "Fault".

4.4.22.5 Parameter description

The mode of operation of the power-off function and the associated objects of the CDM are described in the following.

Index	Id-Text	Name	Function
0x2C3F	ru63	Uic voltage at Power On	The rated DC link voltage is determined after switching on the supply voltage in no-load operation and stored in object ru63. The power failure level is given as a percent value of the rated DC link voltage. This makes it possible to parameterize the function independently of the mains voltage (e.g. 400V or 480V). The power recovery is detected if the DC link is for 50ms higher than (ru63 - 50V).

Index	Id-Text	Name	Function
0x3911	cu17	intermediate capazity [uF]	The entire DC link capacity (including the own)

Index	Type	IDtxt	Name
3920h	RECORD	cu32	power-off

Subidx	Type	Name	Function
0	UINT8	number of entries	-
1	UINT8	power off mode	Activation and setting of modes
2	UINT16	DC voltage trigger level [ru63%]	Start level for power off in percentage according to ru63, depending on the DC link voltage.
3	UINT16	DC voltage ref. [ru63%]	DC setpoint, percentage to ru63. If the DC setpoint is set < start level, it is internally limited to the start value, otherwise the DC controller will try to reduce the voltage in the DC link by acceleration at the motor torque limit (see SubIdx).
4	UINT16	restart speed level [Nn%]	If the speed is above the restart level at power recovery detection, the CDM returns to "operation enable" if it has been in this state before power off.
5	UINT16	stopping speed level [Nn%]	Below this speed, the CDM changes from DC-Ctrl to Speed Ctrl (target setpoint =0 rpm, ramp values from co48-59). The standard torque limit is applied (cs group). This level must not be below the model shutdown level, otherwise control is no longer possible (ds group).

Subidx	Type	Name	Function
6	UINT16	deactivation time	The power off function is terminated when the speed setpoint has reached zero and the deactivation time has expired. The status changes to "Fault". The drive will become operational if the following conditions are met: DC voltage does not drop below the UP level (-> leads to undervoltage error). Restart speed level is set to = 0 The drive was in state "operational enable" before power off has triggered.
7	UINT8	power off state	Display of the state
10	UINT16	torque limit gen.	regenerative torque limit
11	UINT16	torque limit mot.	motor torque limit The motor torque limit should not be set to ZERO. The CDM can either accelerate unintentionally due to system/model errors, or the DC link voltage can increase up to OP error.
12	UINT16	DC-ctrl optimisation factor	The DC controller (PI controller) is designed according to the symmetrical optimum. This factor indicates the hardness of the controller (2=hard...15=soft). The DC link capacity (cu17) is used as basis for the calculation.

NOTICE

- If the "stopping speed level" is set above the "restart speed level", the energy fed back during shutdown can charge the DC link by way that system recovery is detected or the DC link is overloaded.

  Remedy: Equate both levels.

Index	Subidx	IDtxt	Name
3920h	1	cu32	power-off . option code
Bit	**Name**		**Function**
0	Activated		0 = Power – Off function deactivated 1 = Power – Off function activated
1..15	reserved		

Index	Subidx	IdTxt	Name	
3920h	7	cu32	power-off . state	
Bit	Func-tion	Value	Plaintext	Note
0	mains ok	0	OK	Assumed mains status OK
		1	phase failure	Assumed mains status FALSE
1…3	power off state	0	off	not active
		2	active (DC-ctrl)	Active
		4	active (DC-ctrl), no auto restart	Active, no auto restart possible
		6	stopping	Drive decelerates to ZERO
		8	stopping, no auto restart	Drive decelerates to ZERO, no auto restart possible
		10	end, ERROR reset	Power Off expired, error message
4…8	reserved			

4.4.22.6 Figure in the drive state machine

Since the power-off function is active while the CDM is decoupled from the setpoint setting, the power-off function is displayed as a separate state in the drive state machine.

A change into the state power-off-active (st00 bit 14 and st12 value 13) can be done from the following states:

- Operation enabled
- Shutdown active
- Disable operation active
- Quickstop active

It is **not** possible to change from "fault reaction active" state to power-off.

When a system recovery is detected, the following state transitions are possible:

- Operation enabled (if the restart speed limit has not fallen below yet)
- Power – off active (drive continues deceleration and completes power-off function)

The following state transitions are possible when the power-off function has been terminated:

- Fault (after expiry of the deactivation time)

A change to the state "Switch on disabled" can be made at any time using the command "Disable Voltage".

4.4.22.7 Power off DC link voltage - control structure

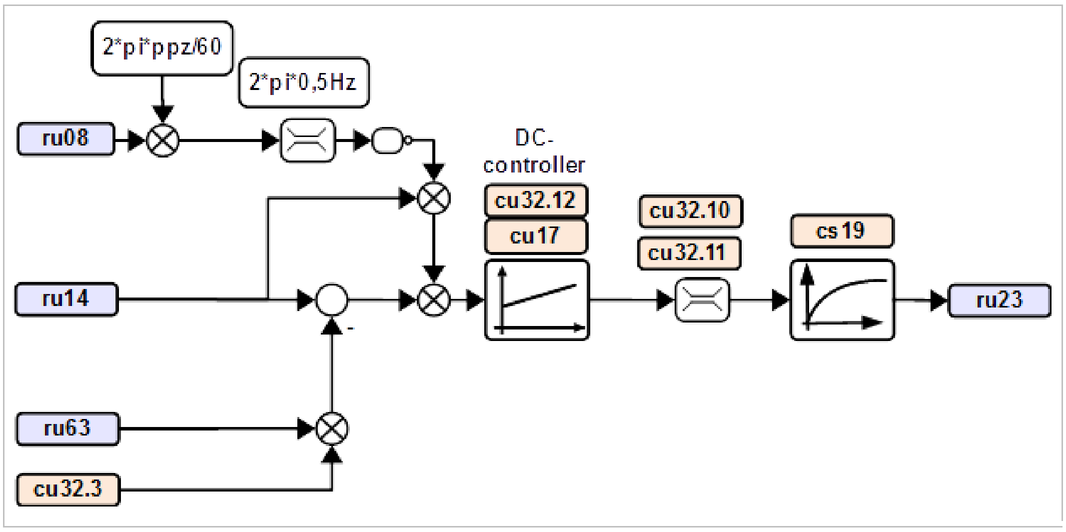


Figure 23: Circuit diagram of the DC control (ppz=number of pole pairs)

4.4.22.7.1 Design of the DC link voltage controller

The DC link voltage controller is designed according to the symmetrical optimum.

Tdelay = 1.125ms , e.g. Td = 4*TpBase (see is22 e.g. TpBase = 62.5us)

Tsum = Tdelay + 2*Td , Cuic = cu17, SymOp = cu32.12

$$Kp = \frac{Cuic}{SymOp * Tsum}$$

$$Tn = SymOp^2 * Tsum$$

4.4.22.7.2 Control to constant DC link voltage

When controlling to constant DC link voltage, the speed controller is replaced by a DC link voltage controller. Like the output of the speed controller, the output of the DC link voltage controller is also used as setpoint for the torque, current control loop.

4.4.22.7.3 Control to constant braking torque

Control to constant braking torque is a special case of control to constant DC link voltage.

- For this purpose, parameter DC voltage ref must be set to a value that cannot be reached (e.g. 200%). Thus, the Uic controller is driven into the regenerative torque limit. A brake transistor, for example, is required to prevent shutdown due to overvoltage.

4.4.23 **Minimum switch-off times**

4.4.23.1 Overview of variable minimum switch-off times

A minimum switch-off time is defined for each power unit, which expires in the default setting before the modulation can be reactivated.

If the bit "Enable operation" in the controlword is set to 1 and the time has not yet expired, the state in st12 is set to "12: Mod off pause active“.

If the minimum switch-off time of the device has expired, no new edge of "Enable operation" is required, the drive changes automatically into state "Start operation active".

This minimum switch-off time reduces the load for the drive and the application. A motor which is still rotating or a rotor flux that has not yet been reduced can generate undefined torques when switching on again.

In other cases, the minimum switch-off time is unnecessary or interferes with the application, e.g. when the drive has come to a defined standstill.

4.4.23.2 Configuration of the minimum switch-off time

Index	Sub Idx	Id-Text	Name	Function
0x2A55	1	pn85	customer time usage	Use of the variable modulation minimum-off time
	2		customer modulation off time	Setting of the variable modulation minimum switch-off time
0x210C	0	st12	state machine display	Display whether minimum switch-off time is active

Parameter pn85 can be used to configure whether and when the user-defined instead of the default minimum switch-off times from the power unit data shall be used.

Additionally the user-defined time can be preset there.

SubIndex 1 can be used to define when the alternative minimum switch-off time shall be used.

pn85[1]	customer time usage	0x2A55 [1]
Bit	Display	Note
0	1: at auto retry	Use the time from pn85[2] if a restart shall occur after auto-retry.
1	2: only at low speed	Use of the time from pn85[2] only if the actual speed at the time of modulation deactivation is < 10% of the rated motor speed. If the user-defined minimum switch-on time is active, it will not be changed again until the next switch-on.
2	4: use always pn85[2]	The time parameterized by the customer is always used as the minimum switch-off time. If this bit is set, the other settings have no function.
3	8: at manual reset	after error reset the time from pn85[2] is used, unless it is an error that requires a protection time (OC, OL2, OP, OP2). Then the protection time is the minimum time that is always observed. If pn85[2] is higher than the protection time, pn85[2] is used.

The desired minimum switch-off time can be parameterized in SubIndex 2:

pn85[2]	customer modulation off time		0x2A55 [2]
Value	Display	Note	
0	PU data value	The value from the power unit data is always used	
1…1000	0.01…10.00 s	Value of the alternative (user-defined) minimum switch-off time	

The default value of the parameter is 0: PU data value.

4.4.23.3 Increased minimum switch-off time in case of errors

For errors that cause stress to the inverter, hardware-related pauses must be observed independent of the parameterized minimum switch-off time.

These errors are: OC, OP, OP2, OL2

Minimum switch-off time after first error (or after 2 minutes without error)
=> 50ms

Minimum switch-off time for the next 4 errors within the monitoring interval of 2 minutes: => The value defined in the power unit data for the minimum switch-off time.

A counter increments with each error. The error counter is reset when this error has not occurred for 2 minutes.

In order to avoid frequent repetition of the same error, the release of the modulation is rejected for a longer time if a counter of category (OC, OP / OP2, OL2) reaches the error level 6. The minimum switch-off time changes then to 2 minutes.

Minimum switch-off time for 6 errors within the monitoring interval of 2 minutes: => 2 Minutes

After 2 minutes without error, the device is regarded again as "unloaded" and the short protection time for the initial error becomes effective again.

4.4.23.4 Display minimum switch-off time / protection time active

The protection times after the occurrence of an error and the "standard" minimum switch-off time have the same effect: they prevent the activation of the modulation.

If it is tried to set the drive into the state "operation enabled" while the minimum switch-off time is still running, the drive is set to "Mod off pause active" instead.

If it is tried to set the drive into the state "operation enabled" while the guard time is running, the drive is set to "protection time active" instead.

st12	state machine display		0x210C
Value	State	Note	
12	mod off pause activ	Minimum switch-off time not triggered by error is running	
14	protection time active	Minimum switch-off time triggered by error is running	
16	endless protection time	by exceeding the permissible number of errors within the monitoring interval of 2 minutes, the activation of the modulation was permanently prevented. Restart is only possible by switching off the 24V supply or the high voltage.	

4.4.24 **Blockade handling**

If the inverter tries to start against a mechanical blockage during start-up, or if the motor is blocked during operation, the inverter should detect this and react automatically without intervention by a control.

4.4.24.1 Blockade detection

By way that the motor blockage detection is activated, the ramp output value ru06 must be above a defined speed threshold.

pn87[2]	detection speed level		**0x2A57 [2]**
Value	Display	Note	
0…81920000	0.0000…10000.0000 rpm	Speed level for blockade detection	

The motor blockage detection compares the ramp output value (ru06) with the actual value (ru08).

If the actual value (ru08) is below and the setpoint ru06 above the value set in pn87[2] detection speed level, pn87[3] detection time is running.

pn87[3]	detection time		**0x2A57 [3]**
Value	Display	Note	
0…10000	0.00…100.00 s	Time between falling below pn87[2] detection speed levels until the blockade state is triggered.	

If the ramp output value ru06 ramp out display is above the detection level and ru08 actual value is below the level, the blockade time counter counts up.

If one of the conditions is no longer met, the counter counts down.

The state blockade is set if the counter reaches the end value defined by detection time.

If a blockade is detected, the content of ru06 changes: the setpoint speed valid for the speed controller is no longer determined by external setpoints or the ramp generator, but is set by the programmed blockade reaction. The speed that would be valid if it were not suppressed by the blockade reaction can be seen in parameter ru86 standard set speed.

The state of the blockade monitoring is displayed in pn87[6]. (See chapter 4.4.24.3 Blockade display).

4.4.24.2 Blockade reaction

When the blockade reaction is finished, it is immediately change back to "standard" operation (without internal ramps or straightening).

If this is not desired, an error can be set at the end of the blockade reaction (parameterization of bit 7...9 "error").

Whether a change of the setpoint speed should have an influence on the blockade reaction can be parameterized in pn87[1] blockage mode.

The internally effective setpoint speed during the blockade and the current / torque limits can also be defined here.

pn87[1]	blockage mode			0x2A87 [1]
Bit	Function	Value	Plaintext	Note
0…3	reaction	0	no reaction	
		1	save actual torque	The behaviour of this setting depends on the selection in bit 11,12 "Blockade reaction speed setting": With the "no speed reduction" setting, the internal setpoint is frozen at the start of the blockade. The current/torque limits are not affected. For all other settings, the torque limit is set equal to the actual set torque at the start of the blockade reaction. The internal setpoint speed is decelerated to zero during pn87[4] blockade reaction time
		2	save actual torque until time	Same behavior as with "save actual torque". But after the pn87[4] blockage reaction time has expired, the change to "blockage reaction finished" occurs.
		3	linear torque ramp	A detected blockage is break down with a linear torque ramp. For this the torque limit is decremented linearly to zero. With Parameter pn87[5] lower limit reduce the reduction of the torque limit can be limited to pn87[5] * dr09 rated torque. The ramp is not affected by this setting, the torque limit is just not lowered further. The drive changes to the state "blockage reaction finished" at the end of pn87[4] blockage reaction time.
		4	linear current ramp	A detected blockage is break down with a defined linear current ramp. For this the total current limit is decremented linearly to zero. With parameter pn87[5] lower limit reduce the reduction of the torque limit can be limited to pn87[5] * dr03 rated current. The ramp is not affected by this setting, the torque limit is just not lowered further. The drive changes to the state "blockage reaction finished" at the end of pn87[4] blockage reaction time.

The speed controller remains active during all blockade reactions.

The model shutdown for encoderless operation (A)SCL occurs as preset in the ds parameters (ds41...ds48 model control). There are no additional parameters for the blockage.

pn87[1]		blockage mode			0x2A87 [1]
4…6	warning	0	no warning	Warning bit is not set	
		16	warning at detection	The warning bit is set as soon as the blockage is detected. (Transition of the status from "blockage detection time running" to "reaction hold" or "reaction time running") The warning is reset when the blockage detection state changes to "blockage detection inactive" or "no blockage detected".	
		32	warning at reaction end	The warning bit is set as soon as the state "blockage reaction finished" is reached. The warning is reset when the blockage detection state changes to "blockage detection inactive" or "no blockage detected".	
7…9	error	0	no error	Error Blockade is not set	
		128	error at detection	The error blockade is set as soon as the blockade is detected. (Transition of the status from "blockage detection time running" to "reaction hold" or "reaction time running") This means that the reaction setting has no function	
		256	error at reaction end	The error blockade is set after the blockade reaction has elapsed. (Transition of the state after "blockage reaction finished")	
10	abort blockade	0	no abort	A blockade reaction once started is always completed; the speed setpoint has no influence.	
		1024	abort blockade at set speed zero	If the speed setpoint ru86 standard set speed is zero or reversal of the direction of rotation, the blockade reaction is aborted	
11..12	Blockade reaction speed setting	0	reaction speed fade out	The internally effective setpoint speed during the blockade is internally decremented to zero during the reaction time (allows linear torque reaction)	
		2048	reaction speed zero	The internally effective setpoint speed is abruptly decremented to zero at the start of the blockade. This also initiates the model shutdown in closed-loop operation without encoder. Thus this setting is suitable to avoid problems due to instability of the speed estimation at low speeds in encoderless operation. The speed controller integral component is loaded in one cycle with the set torque of the previous cycle. Then the speed controller is active again. When the blockage is removed, there is no "jerking" of the drive, the torque is continuously reduced. However, the torque reduction does not take place at the linearly decreasing torque limit, but the interventions of the control are visible.	

pn87[1]		blockage mode		0x2A87 [1]
		4096	reduce speed from detection level	Behaviour like „reaction speed zero“. Exception: The internally effective setpoint speed is abruptly set to pn87[2] detection speed level and from there to zero.
		6144	no speed reduction	only effective with reaction mode save actual torque: internally effective setpoint speed remains constant.

The time in which the blockade reaction selected in pn87[1] is carried out can be specified in the following parameter.

pn87[4]	blockage reaction time	0x2A57 [4]
Value	Display	Note
0…10000	0.00…100.00 s	Time wherein - depending on the mode - the reaction (current/torque linear to zero / torque maintained / DC braking) is carried out. The time for current/torque reduction is always constant, independent of the starting value

Reducing the torque/current limit to zero can cause problems.

Current offset or position misorientation can cause movements that can no longer be compensated by the control.

This parameter can be used to preset the lower limit of the reduction in % rated motor torque or % rated motor current.

The ramp is not affected by this parameter.
Due to the limitation, the value remains constant after reaching the lower limit until the end of the blockage reaction time.

pn87[5]	lower limit reduce	0x2A57 [5]
Value	Display	Note
0…100	0…100%	Factor for limiting the current / torque reduction

4.4.24.3 Blockade display

4.4.24.3.1 Detailed state display

In the structure pn87 there is a parameter that dispays the actual status of the blockade detection:

pn87[6]	blockage detection status	0x2A57 [6]
Value	Plaintext	Note
0	blockage detection inactive	In parameter pn87[1] neither a control reaction, nor setting of the "warning bit" or triggering of an error is activated.
1	no blockage detected	Detection is activated, but the condition setpoint above pn87[2] detection speed level and actual value below pn87[2] is **not** met.
2	blockage detection time running	The condition setpoint above pn87[2] detection speed level and actual value below pn87[2] is met and the timer for pn87[3] detection time is running.

pn87[6]	blockage detection status		0x2A57 [6]
Value	Plaintext	Note	
3	blockage reaction hold	The timer pn87[3] detection time has expired and the torque / current is held	
4	blockage reaction time running	The blockage reaction is running and the torque/current is decayed.	
5	blockage reaction finished	A blockage is detected, the reaction is finished This state is always left by switching off the modulation and, depending on the setting in pn78[1], also at setpoint speed equal to zero or change of the setpoint direction of rotation. The current and the torque are no longer affected by the blockage. The internal setpoint is held at zero.	

4.4.24.3.2 Display in the ru parameters

If a value not equal to zero is parameterized in pn87[1] blockage mode->warning, bit ***blockage warning*** is displayed in ru02 and ru03.

ru03	warning state		0x2C03
Value	Plaintext	Note	
137	blockage warning active	Blockade warning bit is set and no higher priority message is active	
ru02	warning bits		0x2C02
Bit	Plaintext	Note	
18	blockage warning	Blockade warning bit is set	

Whether ***7: warning*** is also set in the statusword st00 or 0x6041 when the blockade warning bit is set can be defined via the object pn28 warning mask.

4.4.25 Monitoring of the load

Parameter ru80 relative load is used to display the load of the entire drive system consisting of inverter, motor and application against torque and thermal limits.

No automatic reaction can be made dependent on the load display.

In the previous software versions, the rated torque was predefined by the drive. Object pn88 now allows you to choose between different options for defining the rated torque.

Configuration of the load display:

pn88	display configuration				0x2515
Bit	Function	Value	Plaintext	Note	
0,1	display mode	0	standard display	Standard display in ru80: ru50 / ru51 > 100% => ru80 = ru24 actual torque ru50 / ru51 ≤ 100% => ru80 = ru24 / ru50 (or ru51)	
		1	extended display	Display is configured by the settings in bit 2..7	
2,3	drive reference	0	no drive limit	Inverter limits are not consisered	
		4	actual torque limit	Reference: 100% = current torque limit ru50 / ru51 (= limiting characteristic + parameterized torque limits in the cs parameters + effective current limits)	
4,5	application reference	0	no application limit	Parameter pn88[2] application torque limit has no influence on the display in ru80	
		16	constant limit	100% = pn88[2] constant torque limit => Application torque limit	
6,7	thermal limit	0	no thermal limit	the thermal load is not considered	
		32	thermal limit	Up to the rated speed, the reference for the actual torque is dr09 rated torque, then the thermal permanently available torque is reduced according to a 1/x function, independent of the motor type . (Thermal load)	

pn88	display configuration				0x2515
Bit	Function	Valu e	Plaintext	Note	
		64	thermal limit with dc voltage	The speed up to which the rated torque dr09 rated torque applies (before it is reduced according to a 1/x function) is shifted depending on the DC link voltage. If the DC link voltage >= dr28 Uic reference voltage, the rated speed applies. If the DC link voltage is lower, the speed for the 1/x curve is reduced proportionally.	

4.4.25.1 Standard display

100% corresponds to the rated motor torque as long as the current torque limit is higher than or equal to the rated torque.
The cause of a lower torque limit (ru50 / ru51 actual torque limit) can be the reduced torque in the field weakening range or the setting of a lower torque limit via the cs parameters.

The formula for ru80 relative torque is:
ru50 / ru51 > 100%
=> ru80 = ru24 actual torque

ru50 / ru51 ≤ 100%
=> ru80 = ru24 / ru50 (or ru51)

4.4.25.2 Extended display

Parameter ru80 relative load is used to display the load of the entire drive system consisting of inverter, motor and application against torque and thermal limits.

4.4.25.2.1 Inverter / motor limits (drive reference)

The torque-dependent drive load is calculated from the current torque, torque limit and rated torque.

The calculation of the torque limit depends on the parameters that define the inverter maximum current and on the parameterization of the limiting characteristic.

Additionally the boundary conditions resulting from the data of the power unit always apply (current, switching frequency limits).

Reference value for a positive torque is always the positive limit, for a negative torque the negative limit.

4.4.25.2.2 Torque limit of the application (application reference)

The maximum permissible torque can also be defined by the application, e.g. if a connected gear can only transmit a certain torque permanently.

The reference of the application load can be defined with the setting of application reference (bit 4,5).

The actual torque used for the load calculation is always the motor torque regardless of any gear factors.

- ► 0: no application limit

The load display is not influenced by an application-dependent torque reference with value 0.

- ► 16: constant limit

The parameterized value in pn88[2] application reference is the reference value for the load calculation.

pn88[2]	application torque limit		0x2a58 [2]
Value	Display	Note	
0…10000	0.0… 1000.0%	Application-dependent reference torque of the load display in %dr09	

Application-dependent load = actual torque ru24 / reference torque pn88[2]

4.4.25.2.3 Thermal limit of the motor (thermal reference)

The setting of thermal reference (bit 6,7) can be used to determine whether the thermal load of the motor shall also be used for the display of ru80.

For the determination of the thermal rated torque it is assumed that the motor can also provide rated torque up to rated speed.

For the range above rated speed, it is assumed that the motor can continue supply rated power permanently without overheating.

The thermal rated torque is therefore equal to the rated torque up to rated speed and is then reduced according to a 1/x function.

It can be parameterized whether the DC link voltage influences the value of the thermal load.

4.4.25.3 Resulting display

The maximum value of the 3 loads (motor/inverter, application, thermal load of the motor) in % with 0.1% resolution is displayed in ru80 relative load.

ru80	relative load		0x2C50
Value	Display	Note	
0…10000	0.0…1000.0%		
10001	invalid calculation result	The actual torque was higher than the reference torque by more than a factor of 10.	

For a better overview of the reference values, the internal limit values are made available as displays in % of the rated torque:

pn88[3]	active torque limit value		2A58[3]
pn88[4]	active thermal limit		2A58[4]
Value	Display	Note	
0… 10000	0,0%… 1000,0 %	Display of the reference values for the load calculation in % of the rated motor torque dr09. Resolution 0.1 %	

4.4.25.4 Restrictions

> **NOTICE**
>
> If modulation is deactivated, value zero is always displayed.
>
> The display of ru80 is only valid in closed-loop operation with activated modulation.
>
> In addition, no special functions such as DC braking, identification, etc. may be active.
>
> The display is only conditionally usable for special motors (IPM and synchronous reluctance). In open-loop operation or other state there is no valid value for ru80.

The load display does not work in v/f mode, since the torque is the basis of all calculations.

If the motor data or the available currents change due to saturation, heating or similar, the torque limit and thus one of the reference points for the load calculation will also shift.

For IPM and synchronous reluctance motors the display can only be used conditionally. Since the torque depends on both current components Id and Iq, which are changed by the control during operation, the reference torque can change permanently.

4.4.26 Quickstop

Quickstop is triggered by setting bit 2 (no Quick Stop) in the control word (co00) to 0. A change into state "Quick Stop active" can only be done from the state "Operation Enabled" (=> also description of the state machine in Chapter 3.1).

> **i** The quickstop function must be activated in co32 (state machine properties). If the quickstop function is deactivated, the quickstop bit in the control word is not evaluated and quickstop is not triggered.

The behavior in the quickstop state can be influenced by the object 0x605A.

	Quickstop option code	0x605A
Value	Function	
0	Disable drive function (direct change into the state "Switched on“)	
-1	Deceleration with the fault reaction ramp (=> Chapter 4.3.1.1)	
-2	Deceleration with the fault reaction ramp and remaining in the "Quickstop“ state	
-3	Deceleration with the standard ramp (co48…co60), transition to "switched on“	
-4	Deceleration with the standard ramp (co48…co60) and remaining in the "Quickstop“ state	
-5	Deceleration with the positioning module ramp (ps48…ps59), transition to "switched on“	
-6	Deceleration with the positioning module ramp (ps48…ps59), remaining in the "Quickstop“ state“	

> **i** If Quickstop is activated in cyclic operating modes, the cyclically preset setpoints are ignored and the motion profile is generated independently by the drive, according to the selected Quickstop option code. If the function is deactivated during the Quickstop deceleration ramp, the preset setpoints apply immediately.

4.4.27 Minimum current monitoring in the safety module

With activation of encoderless monitoring in the safety module type 5, the current is also monitored to a minimum limit. The current level is set on the safety module with parameter "Hysteresis of the electrical current" (2% default, from the current scales of the drives (de80[1])).

Parameter "Allowed time difference frequency to current" is used to set a filter time (200ms default) until an error is output by the safety module when the current falls below the specified value.

The drive complies with this setting by increasing the field-generating current.

For all motor types there is a limitation, either in the max. achievable speed or the minimum current generates additional heating.

Motor types	field-generating axis				Torque generating Axis	Limitation max. achievable speed	Additional heating
	Axis	Mode	Stand-still	unequal ZERO			
SM	Id	ENC	-	-	Iq	No	Yes
SM	Id	SCL	+	-	Iq	No	Yes
IPM	Id	ENC	-	-	Iq	No	Yes
IPM	Id	SCL	+	-	Iq	No	Yes
SynRM	Iq	ENC	+	+	Id	Yes	Yes
SynRM	Iq	SCL	+	+	Id	Yes	Yes

With the SRM there is no sign change, the stabilization is achieved with a positive sign. This current limits the max. achievable speed and the minimum current cannot be maintained above this speed (reason: prioritisation of current controller components).

For SM and IPM without encoder, the sign must be changed depending on the speed level to operate the motor in the field weakening. For this change, parameter "Allowed time difference frequency to current" in the safety module is decisive.

Index	Id-Text	Name	Function
0x3720	fc32	minimal current (SM)	Parameter structure to define the behavior to set a minimum current. Only synchronous machines of the type: SM (SM,IPM,SRM), no asynchronous motors
Sub Idx	**Name**		**Function**
1	min. current mode		Different modes are adjustable
2	min. current [%de80[1]]		Minimum current in % of the current measuring range end value (de80[1] current scale value) Calculation example: de80[1] = 100.0A, fc32[3]= 3% ⇨ $Minimum\ current\ (effective\ value) = \frac{100\ A}{\sqrt{2}} * \frac{3\%}{100\%}$ = 2.21 A
3	ramping time		Ramp time, related to the rated motor current. A ramp can be specified via this parameter in order to compensate the missing current or to change the sign in the stabilizing current. Setting instructions: Mode 1: > 10ms Mode 2: < 10ms

fc32	min. current mode			0x3720 Sub Idx. 1
Bit	Function	Value	Plaintext	Notes
0…2	mode	0	off	Off
		1	stabilisation current	The minimum current is monitored depending on the setpoint in the stabilising current axis.
		2	apparent current	The minimum current is monitored depending on the level of the total current setpoint. I.e. if the total current setpoint is above the minimum current, no additional stabilisation current is supplied. This dependency can cause the system to oscillate if the position is misaligned, but has the advantage that the motor is **not** heated with additional current under load.

The compensation of the minimum current is in the range of -2*Imin...+2*Imin. If, for example, the stabilisation current is adjusted via the Isd offset (ds55), it may not be possible to compensate this via the minimum current function in order to achieve the "set" sign.

Figure 24: Minimum current course

SM/IPM without encoder with ramp time (tr, fc32[3]) and Imin=20% of rated motor current, speed leakage values via stabilisation current (here ds38=100%, ds35=50%, ds36=10%, ds37=20%). The speed hyteresis results from ds37 + (ds37-ds36).

4.5 Braking transistor

4.5.1 Braking transistor handling

Index	Id-Text	Name	Function
0x2A1F	pn31	enable braking trans. source	Defines a digital input to activate the braking transistor
0x2A20	pn32	braking transistor level	Threshold of the DC link voltage to activate the braking transistor. (is internally limited by the input voltage) resolution: 0.1V
0x2C3F	ru63	Uic voltage at Power On	Measured DC link voltage at the end of the pre-charging
0x351E	is30	braking transistor function	Activation of the braking transistor functionality
0x2024	de36	braking transistor default level	Display of the default switch-on threshold of the braking transistor (depending on the power unit)
0x2A21	pn33	braking transistor mode	Braking transistor activation / deactivation options

Parameter de36 indicates if the used inverter contains a braking transistor module.

de36	braking transistor default level	0x2024
Value	Function	
0: no braking transistor	the inverter does not contain a braking transistor	
other values	Default switch-on threshold in 0.1V resolution	

On default set loading the value for pn32 braking transistor level is written to the value of de36. The braking transistor is not activated automatically.

By way that the braking transistor can be used, the braking transistor function must generally be enabled with is30 braking transistor function.

> **i** If parameter is30 braking transistor function is not set to 1: on, the braking transistor is never switched on by the software, regardless of all other parameters.
> Parameter is30 is already activated at the factory for devices with sub-mounted braking resistor.

4.5.1.1 Braking transistor activation / deactivation

4.5.1.1.1 Voltage-dependent activation

The response threshold of the braking transistor is set in parameter pn32 braking transistor level with a resolution of 0.1V.

When connecting the mains the DC link of the inverter is precharged to the max. value of the input voltage ($U_{DC\ link} \approx \sqrt{2} * U_{mains}$). This DC link voltage value at the end of the precharging limits internally the switching level of the braking transistor.

The value can be read in ru63 Uic voltage at Power On. If the value in pn32 < 1.06 * ru63, the switching level of the braking transistor is internally set to 1.06 * ru63.

This threshold ensures that the braking transistor is not responded by the mains input voltage. However, provided that the mains input voltage does not increase upon completion of the precharging of the DC link.

The default values for the braking transistor threshold are depending on the voltage class of the inverter.

Voltage class	OP threshold	Braking transistor-threshold
230 V	400 V	380 V
400 V	840 V	780 V
690 V	1200 V	1140 V

Table 4-3: Switching threshold for braking transistor

The braking transistor is switched on as soon as the DC link voltage exceeds the threshold and switched off as soon as the threshold is below the threshold. The maximum switching frequency is currently 4kHz.

By default, when the braking transistor is activated via DC link voltage, it is only activated when the modulation is enabled.

Also the braking transistor is not switched on if there is an error or the modulation is deactivated by the status machine.

Exception: if in ds04 current mode in bit 3: bandpass filter the setting "8: on“ is selected or if the voltage exceeds OP2 (extreme overvoltage level), the braking transistor is never deactivated.

4.5.1.1.2 Activation via digital input

In addition (corresponds to OR link), the braking transistor can be also be activated by a digital input.

The digital input can be selected in pn31 enable braking trans. source.

Activation via digital input always operates when ru04 supply unit state is 4: run, independent of the modulation release.

4.5.1.1.3 Deactivation options

In parameter pn33 braking transistor mode it can be variably configured which sources can deactivate the braking transistor. The activation sources are OR linked. This means: if the braking transistor is activated due to the DC link voltage, the status of the activation via the digital input has no longer any influence.

The specification that the braking transistor is never deactivated when the bandpass filter is active remains. This exception has priority over the settings in pn33.

The braking transistor can generally only be activated when the precharging is completely finished (ru04 supply unit state = "4: run“).

Exception: If the deactivation of the input thyristors is triggered by OP2, the braking transistor remains active.

pn33	braking transistor mode		0x2A21
Bit	**Name**	**Plaintext**	**Note**
0	voltage error dependency	1: Udc: GTR7 off at error	Braking resistor is also switched off at voltage-dependent activation when an error is present that has switched off the modulation.
1,2	voltage modulation dependency	0: Udc: no GTR7 mod state dependency	The voltage-dependent braking resisstor control is independent of the state of the modulation and the STO inputs.
		2: Udc: GTR7 off at STO missing	Deactivation of the braking transistor if the STO inputs (virtual via the safety module or on-board) are not set in ru18
		4: Udc: GTR7 off at mod off	Deactivation of the braking transistor if the modulation is deactivated
3	input error dependency	8: input: GTR7 off at error	Braking transistor is also switched off when activated by a digital input if an error is present that has switched off the modulation.
4,5	input modulation dependency	0: input: no GTR7 mod state dependency	The digital input-dependent braking transistor control is independent of the state of the modulation and the STO inputs.
		16: input: GTR7 off at STO missing	Deactivation of the braking transistor if the STO inputs (virtual via the safety module or on-board) are not set in ru18
		32: input: GTR7 off at mod off	Deactivation of the braking transistor if the modulation is deactivated
6	inp: off at Udc < ru63	64: input: Udc < ru63	The braking transistor cannot be activated via the digital inputs as long as the DC link voltage (U_{dc}) is < ru63 * 1.06
7	GTR7 off at OH-heatsink and modulation off	128: off at OH heatsink	If the inverter modulation is switched off by OH, the braking transistor should also be deactivated, since it can be destroyed by overtemperature in the same way. If OH is still decelerating at a ramp (error reaction ramp), the braking transistor is also not switched off during this time.
8	GTR7 off at braking res. temp. warning	256: off at brak. res. temp. warning	Deactivation of the braking transistor when the braking resistor warning level is exceeded

Bit 0..2 can be used to prevent deactivation of the voltage-dependent braking transistor control.

The activation of the braking transistor by a digital input can additionally also be made dependent on the modulation with bit 3..5.

4.5.2 Braking transistor protective functions

With some inverters, the braking transistor can be monitored:

The „GTR7 OC“ protection function detects a **short circuit** at the braking resistor terminals. Ground faults are not reliably detected by the internal protective circuit.

The so-called feedback signal (short-circuit / function monitoring of the transistor) can be used to monitor whether the braking transistor is still switching. Whether the inverter in question supports this protective function is listed in the installation manual.

A short circuit at the braking resistor connections leads to error message 116 "ERROR GTR7 OC". This error cannot be deactivated if the inverter has the appropriate monitoring. A reset of this error is only possible after 1 second.

If the braking transistor cannot be switched on, the drive goes to 115 "ERROR GTR7 always OFF". If the braking transistor cannot be switched off, the drive goes to 117 "ERROR GTR7 always ON".

For all inverters that have the monitoring function in hardware, it is activated as soon as the GTR7 functionality is30 = 1 "on“.

If the error "ERROR GTR7 always ON" is detected, the input thyristors of inverters whose DC link is supplied via input thyristors are switched off.

NOTICE

Hazards and risks through ignorance!

- If the error "ERROR GTR7 always ON" occurs, the drive controller must be disconnected from the mains supply within 5 minutes!

Additionally valid: If the DC link voltage exceeds the overvoltage level (OP), the braking transistor remains active.

⚠ WARNING

Load of the braking resistor in case of overvoltage

- The overvoltage level should never be exceeded when using a braking resistor. A motor accelerating uncontrollably due to errors, incorrect parameterisation (e.g. of the EMF) or incorrect adjustment of a filter can lead to extreme overvoltage. If the regeneration by the application is greater than it can be reduced by the braking resistor, the overvoltage level can also be exceeded. This overload case must be considered when selecting / protecting the resistor.
- Activation for too long (especially with input-dependent instead of voltage-dependent control) can lead to overheating and destruction of the braking resistor.

4.5.3 Power and temperature calculation at the braking resistor

Index	Id-Text	Name	Function
0x351F	is31	braking resistor data	Parameter structure for displaying the power at the braking resistor
	Sub Idx	Name	Function
	1	rated resistance at 20°C	Resistance value of the braking resistor
	2	average dissipated power	average absorbed power of the braking resistor ⚠ Notice Change of the time constant: previous softwares: PT1 time = 4.3 min **new time constant: 2 minutes**
	3	current electrical resistance	**Only for sub-mounted braking resistor:** Actual electrical resistance from the temperature model. Display when the power unit is not ready: 4294967295: power unit not ready Without sub-mounted braking resistor identcal with is31[1]
	4	current wire temperature	Actual wire temperature in 0.1 °C resolution Display if no temperature model is available: -1000: no temperature available Display when the power unit is not ready: 32767: power unit not ready
	5	peak wire temperature	For sub-mounted braking resistor: Maximum wire temperature in 0.1 °C resolution Without sub-mounted braking resistor: Display -1000: no temperature available
	6	peak power over braking resistor	Maximum power at the braking resistor (maximum value of is31[9], stored non-volatile)
	7	error resistor data	0: Data for sub-mounted braking resistor OK All other values: invalid sub-mounted braking resistor data
	8	cumulated energy over braking resistor	cumulated energy over braking resistor (resolution: 0.01 kWh) The value can be reset / set to any value by writing to the parameter.
	9	current power over braking resistor	Actual power flowing into the braking resistor. The filter time is calculated from the basic process time (see description is22) Filter time without sub-mounted braking resistor: TFilter = 48 * basic Tp (at Tp = 62.5us TFilter is = 48 * 62.5us = 3ms) Filter time with sub-mounted braking resistor: TFilter = 64 * basic Tp

4.5.4 Sub-mounted braking resistor protection

If an inverter contains a KEB sub-mounted braking resistor, data (e.g. resistance value and temperature limits) are stored for the resistor in de86 build in brake resistor.

A non-zero value in de86[2] means that a braking resistor download is present and activated. In this case, parameter is31[1] braking resistor value contains the value of de86[1] total resistor value and cannot be changed manually.

Additionally, is30 braking transistor function is automatically activated and cannot be switched off.

When using a KEB sub-mounted braking resistor, the temperature of the braking resistor wire is monitored by a calculation via a thermal resistance model.

⚠ WARNING

- The thermal modeling is only sufficiently accurate if all installation settings regarding liquid cooling are observed (see installation manuals of the power units).

Index	Id-Text	Name	Function
0x2A59	pn89	warning brOH stop mode	Programmable reaction of the inverter when the warning level is exceeded
0x2A5A	pn90	brOH warning level	Warning level overtemperature braking resistor Adjustable from 400°C to maximum temperature of the resistor (de86[5] max. temperature error level)
0x2A5B	pn91	brOH error level	Error level overtemperature braking resistor Adjustable from 400°C to maximum temperature of the resistor (de86[5] max. temperature error level)

The braking resistor is protected by switching off the braking transistor when the braking resistor temperature reaches the error threshold (pn91).

The error/warning thresholds are configurable by parameters pn90 brOH warning level and pn91 brOH error level. The upper limit of pn90 and pn91 is set by sub-mounted braking resistor data, found in the de parameters. de86[5] max. temperature error level shows the upper limit for pn90 / pn91.

The reset hysteresis is 80.0°C for the two thresholds.

If the brOH error level is exceeded, an error is triggered which switches off the modulation and the braking resistor.

The reaction to exceeding the brOH warning level can be set in pn89 warning brOH stop mode.

The error/warning response is displayed in parameters ru01 / st01, ru02, ru03.

Additionally, it can be parameterized in pn33 braking transistor options that the braking transistor is deactivated when the warning threshold is exceeded.

If "warning" is set in pn89, it is possible to achieve that the braking transistor is already deactivated without switching off the modulation.

⚠ WARNING

- Exception: the braking resistor is activated again, regardless of its temperature, when the DC link voltage exceeds the OP2 threshold ("extreme overpotential").

NOTICE

Since the drive does not contain a real-time clock, the time when the control board has been switched off is unknown. Thus, the cooling time for the submounted braking resistor is also unknown.

The calculated temperature of the braking resistor is stored every 5 seconds. After switching on again, the display of the resistance starts with the last stored value.

4.6 Fan control

4.6.1 Fan control F6

The F6 has one or more fans depending on the device size and the cooling version (air or water cooling or flat rear). Whether a fan is included and whether it is implemented as an individual fan or a fan group can only be determined from the installation manual for the respective power unit.

A distinction is made between the interior fans, which are controlled by the internal temperatures(ru26 internal temperature PU / ru77 internal temperature CB) and the heat sink fans, which are dependent on the heat sink temperature.

Some devices contain fans that adjust their speed depending on the temperature and the individual fans in a group are sometimes switched on sequentially. Other inverters have only the on/off state of the fans.

The switch-on temperature can be changed by parameters is26 / is27.

is26	cooling fan HS level	0x351A
is27	cooling fan ID level	0x351B
Value	Meaning	
-1: on	The fan / fan group is always running at full speed. The start process (sequential activation or start ramp) is pass through.	
0: LT Value	Fan is activated with default setting (power unit-dependent)	
0.1…°C	Activation threshold in °C. The upper limit depends on the respective power unit.	

For inverters that contain variable-speed fans, the temperature at which the maximum fan speed is reached can also be parameterized:

is28	HS fan full speed temp	0x351C
is29	ID fan full speed temp	0x351D
Value	Meaning	
0: LT Value	Fan reaches maximum speed with default setting (power unit-dependent)	
0.1…°C	Maximum speed level in °C. The upper limit depends on the respective power unit.	

4.6.2 Fan control S6-A / S6-K

The S6 servo controller has only one fan, which is controlled by the interior (ID) or heat sink (HS) temperature.

The fan is activated in the default setting for unit sizes 9, 10 or 11, if the interior temperature or the heatsink temperature exceeds 50°C.

This threshold is dependent on the power unit and can vary for other sizes or special devices.

The switch-off threshold is 5°C below the switch-on threshold and the minimum switch-on time is 5s.

The switch-on temperature can be changed by parameters de116 / de117.

de116	cooling fan HS level	0x2074
de117	cooling fan ID level	0x2075
Value	Meaning	
-1: on	Fan is always on	
0: LT Value	Fan is activated with default setting	
0,1…50,0	Activation threshold in °C, is limited upwards depending on the power unit. (For unit size 9, 10 or 11 the upper limit is equal to the default setting = 50 °C)	

4.7 Terminals short circuit protection

4.7.1 Control type K

The digital outputs Out 1...Out 4 on the terminal blocks X2A and X2B, as well as the voltage outputs 24V OUT and the 24V encoder supply are short-circuit protected.

However, the current is not limited to the maximum permissible value (=> installation manual), but it is a thermal protection.

Thus the inverter is protected against destruction, but the 24V supply can failure due to overload.

If the supply voltage does not failure, the inverter changes to the following errors:

Short circuit of a digital output	100 “ERROR overcurrent out1” 101 “ERROR overcurrent out2” 102 “ERROR overcurrent out3” 103 “ERROR overcurrent out4”
Short circuit of a 24V voltage output	106 “ERROR overcurrent 24V”
Short circuit of the 24V encoder supply	105 “ERROR overcurrent encoder”

4.7.2 Control type A

The digital outputs Out 1 and Out 2 on the terminal block X2A, as well as the voltage outputs 24V OUT and the 24V encoder supply are short circuit protected.

However, the current is not limited to the maximum permissible value (=> installation manual), but it is a thermal protection.

Thus the inverter is protected against destruction, but the 24V supply can failure due to overload.

If the supply voltage does not failure, the inverter changes to the following errors:

Short circuit of a digital output	100 “ERROR overcurrent out1” 101 “ERROR overcurrent out2”
Short circuit of a 24V voltage output	106 “ERROR overcurrent 24V”
Short circuit of the 24V encoder supply	105 “ERROR overcurrent en-coder”

4.7.3 Control type P

Description of the digital outputs see installation manual of the Pro control board

4.8 Operating modes

The operating mode is essential for the context in which an inverter is operated.
The selection occurs via object co01:

Index	Id-Text	Name	Function
0x2501	co01	modes of operation	Selection of the operating mode
0x6060			

The single values of co01 have the following meaning:

co01	modes of operation		0x2501
Value	Name	Note	
-2	jog mode	Manufacturer-specific operating mode: the drive should be able to be moved independently via digital inputs, e.g. in case of failure of a higher-level control.	
0	no mode change	Does not change the mode	
1	profile position mode	Presetting the target position by the control Generation of the motion profile in the drive Position-, speed and torque control in the drive	
2	velocity mode	Presetting the target speed by the control Generation of the speed profile in the drive Speed- and torque control in the drive	
6	homing mode	Used to define the reference position	
8	cyclic sync position mode	Cyclic presetting of the set position by the control Interpolation of the set positions in the drive Position, speed and torque control in the drive	
9	cyclic sync velocity mode	Cyclic presetting of the set speed by the control Position control circuit in the control Interpolation of the set speed in the drive Speed and torque control in the drive	
10	cyclic sync torque mode	Cyclic setting of the set torque by the control Position and speed control circuit in the control Interpolation of the torque and torque control in the drive	
3…5, 7	reserved	Reserved, do not use!	

Generally distinction is made between synchronous and non-synchronous operating modes. For synchronous operating modes (=> Synchronization), all setpoints are transmitted to the drives within a fixed synchronous time grid. The correct function of the drive is only ensured if control grid and setpoint setting are synchronized. This is displayed with bit 8 (synchronous) in the status word.

4.8.1 Operating mode 1: Profile position mode

There are 2 modes for the positioning mode:

- profile position mode with FIFO (=> Chapter 4.8.1.2 Profile positioning mode with FIFO (pp-mode))
- Index positioning (=> chapter 4.8.1.3 Index positioning)

Switching between the two modes is done in parameter ps38 positioning module in bit 0.

ps38	positioning module				0x2E26
Bit	Function	Value	Plaintext	Notes	
0	positioning module	0	pp-mode	profile position mode with FIFO Positions must be preset for each start.	
		1	index selec-tion	index positioning Up to 32 position sets are stored in the unit and they can be passed through according a defined procedure.	

A single position can be approached in positioning mode or position sets can be programmed which shall be reached one after another or which shall be passed through with defined speed.

4.8.1.1 Controlword in profile position mode

co00	controlword	0x2500
Bit	Name	Note
0	Switch on	State machine
1	Enable voltage	
2	no Quick stop	
3	Enable operation	
4	Start Posi	Starts a positioning
5	Change Set Immediately	Changes immediately to a new positioning
6	Absolut / Relativ	0 : Absolute, 1 : Relative positioning
7	Fault reset	Fault reset
8	Halt	Sets setpoint 0, finishes a positioning
9	Change on Setpoint	is not supported
10…14	Operation mode specific	Manufacturer-specific, without function
15	Open brake	Manufacturer-specific, 1 opens the motor brake (depending on co21 brake control mode)

4.8.1.2 Profile positioning mode with FIFO (pp-mode)

Up to 5 position sets can be stored in the FIFO memory. However, these position sets are not stored permanently, but must be preset for each restart.

A position set for the positioning consists of the following objects.

- (CiA 0x607A) co19 target position
- (CiA 0x6081) ps30 profile velocity
- (CiA 0x6082) ps31 end velocity
- Bit 6 in the control word, absolute (Bit = 0) or relative positioning (Bit = 1).

The single position sets are generated when the actual values of parameters co19, ps30, ps31 and the "absolute / relative“ control word bit are written into the FIFO memory with setting of bit "new setpoint“ in the control word.

The start of the positioning occurs with bit 4 (new setpoint) in the control word. Acknowledgement occurs with bit 12 (setpoint acknowledge) in the status word.

An already active positioning can be interrupted with bit 8 "stop" in the control word or by setting a new position set with bit 5 "change set immediately".

If a positioning is completed, also the setpoint via vl20 / vl21 is active.

Thus, a positioning can be started directly from operation with speed setpoint. Conversely, it can be changed directly after positioning with final speed to the speed setpoint.

4.8.1.2.1 Overview profile positioning mode with FIFO

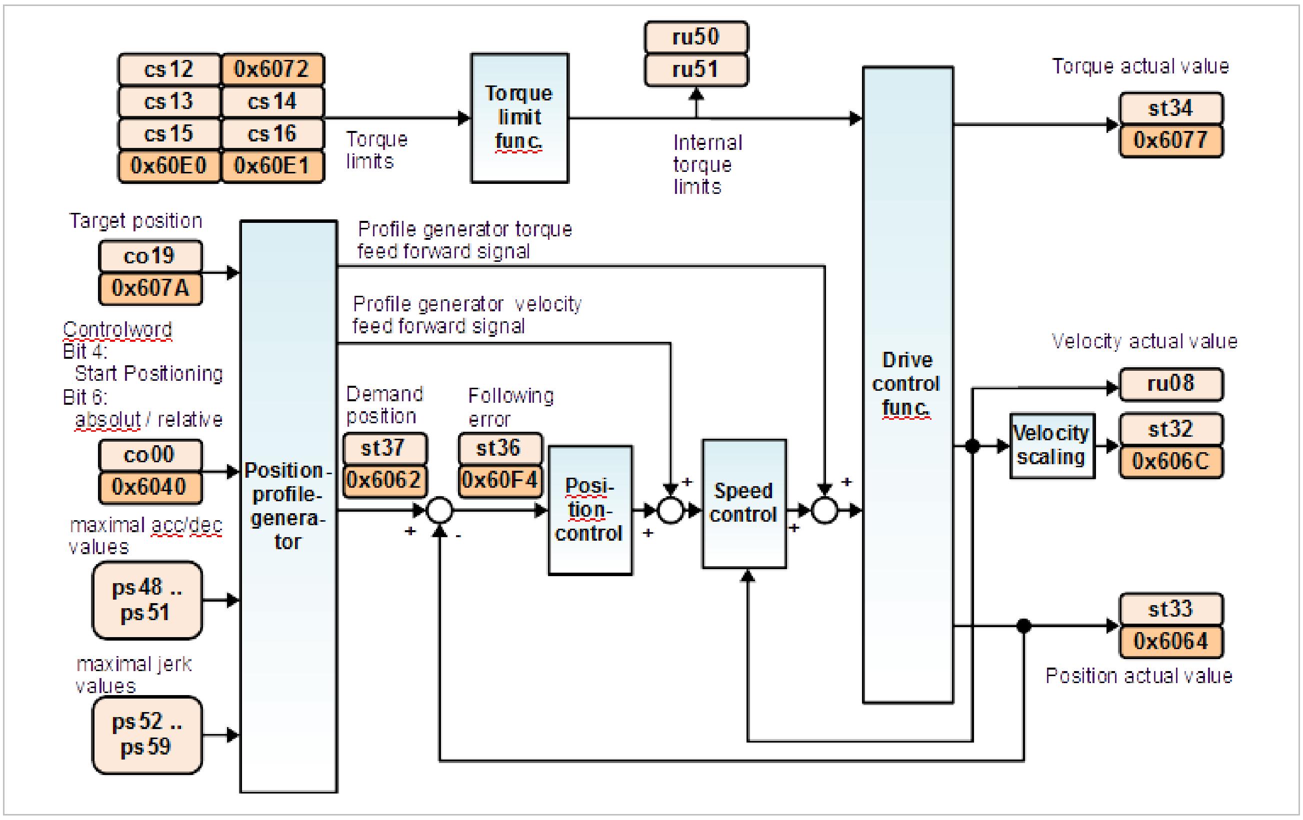


Figure 25: Profile positioning mode (1)

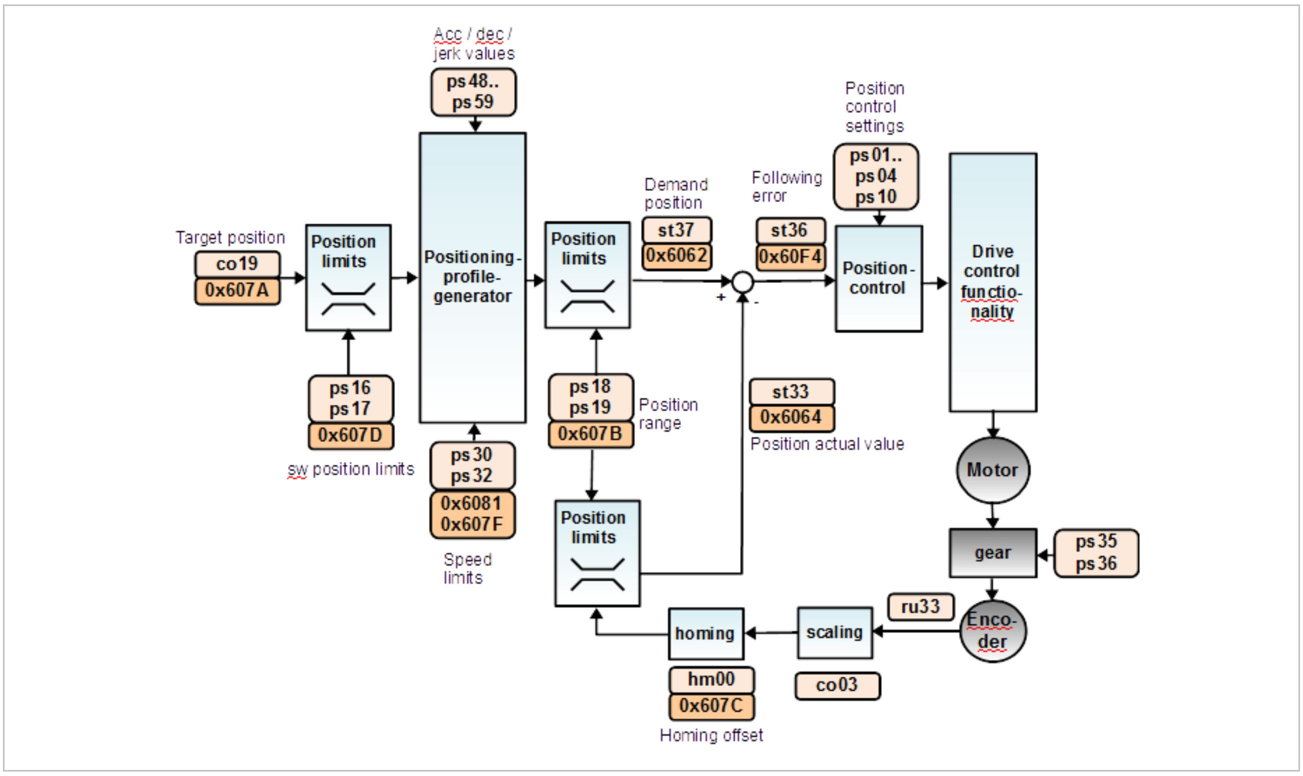


Figure 26: Profile positioning mode (2)

4.8.1.2.2 Single positioning (single set-point)

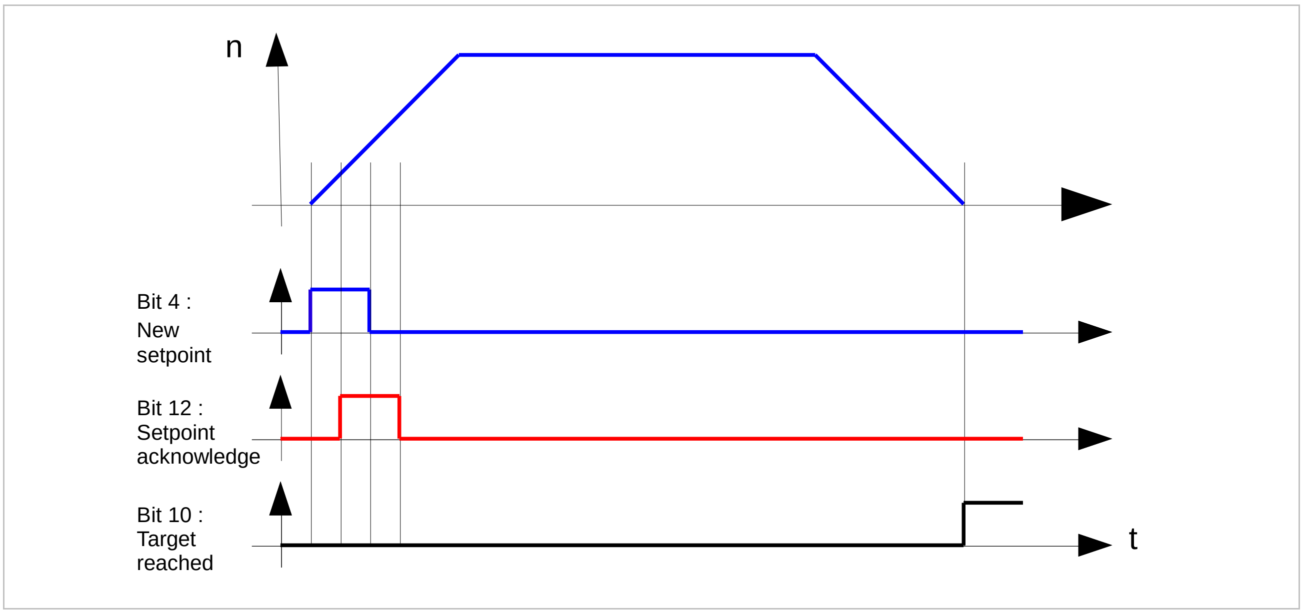


Figure 27: Single positioning

4.8.1.2.3 Multi positioning (Set of set-points)

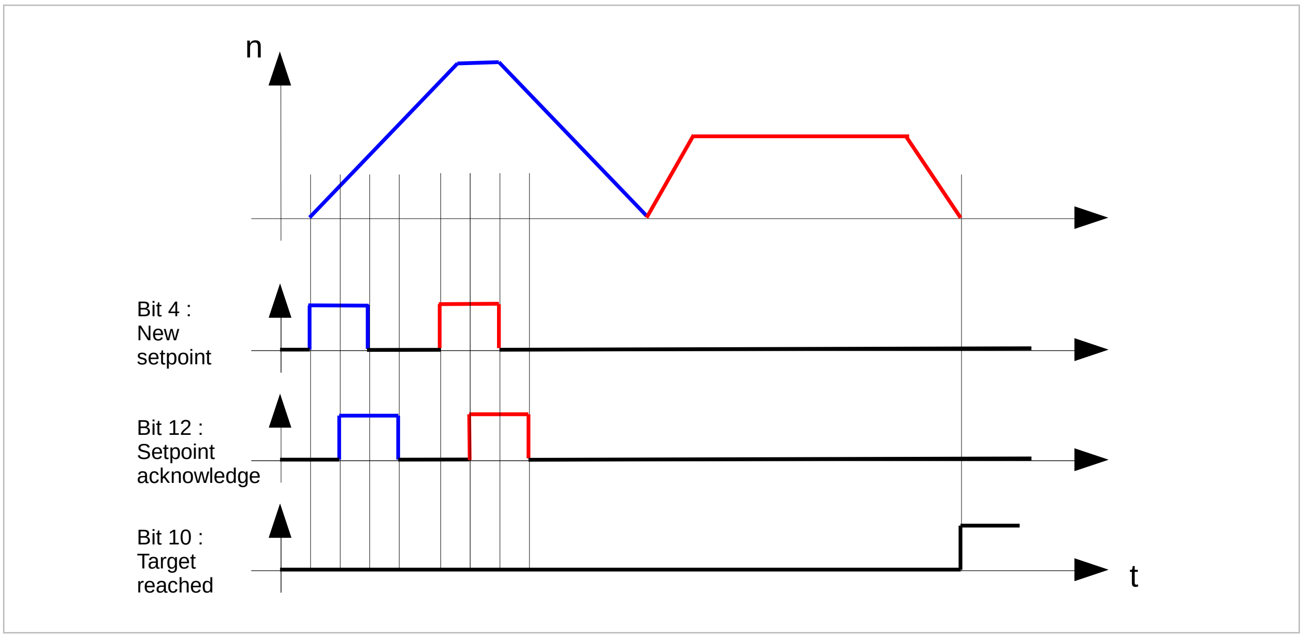


Figure 28: Multi positioning

Here, the second position is only approached after the first positioning has been completed. There is a FIFO memory with 5 entries in order to add further position sets.

If this internal memory is occupied, bit 12 (set-point acknowledge) in the status word remains set until a memory space is available again.

4.8.1.2.4 Restart in a positioning (Change set immediately)

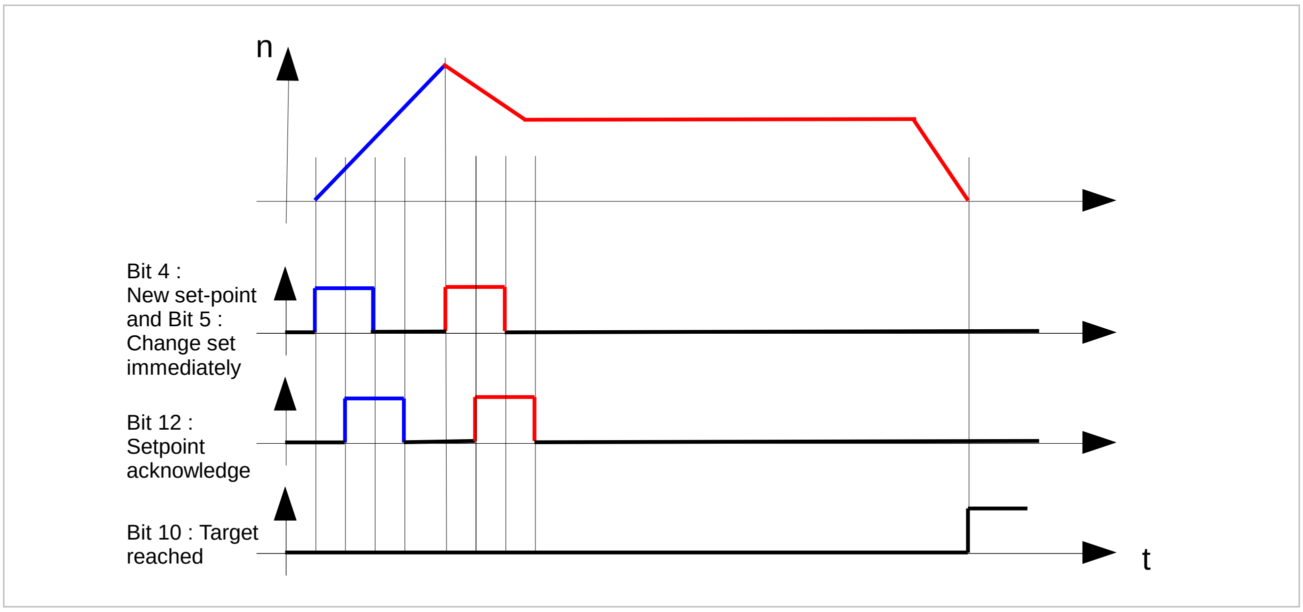


Figure 29: Restart of a positioning

In this case, further positioning is started during single positioning, whereby bit 5 (change set immediately) is set additionally in the control word. Then all existing position sets are deleted and continued with the new position set.

4.8.1.3 Index positioning

Index	Id-Text	Name	Function
0x2E26	ps38	posi operation mode	Changes between pp mode with FIFO and index positioning.
0x2E27	ps39	index position	Array[32] positions selectable via the inputs.
0x2E28	ps40	index speed	Array[32] setpoint speed for this position index
0x2E29	ps41	index end speed	Array[32] speed setpoint for set position
0x2E2A	ps42	next index	Array[32] subsequent index for automatic sequence of positions
0x2E2B	ps43	index mode	Array[32] position mode
0x2E2C	ps44	immediately input	Mask to generate an input to cancel an index positioning
0x2E2D	ps45	immediately index	Index selection for the abort
0x2E2E	ps46	start index	Setting of the starting index. The value -1 allows a setting by digital inputs
0x2E2F	ps47	active index	Display of the currently active index for positioning

A sub-mode is implemented for the pp-mode, by way up to 32 different positions can be selected. The selection can be done e.g. by the index from the digital inputs (defined by di21 / di22 / di25).

Positioning is started with bit 4 (new setpoint) in the control word. This can also be done with a digital input (=> Chapter 7.1.9 Functions of the digital inputs).

An already active positioning can be stopped with bit 8 "stop" in the control word. This function can also be activated with a digital input.

The positions can be linked with ps42, by way a sequence control system is possible.

The speed setpoint is preset to the appropriate ps39 index position with ps41 index end speed. This value must always be lower than the profile speed setpoint during the positioning (ps40 index speed).

The speed setpoint during positioning can always be reduced with ps32 (CiA 0x607F) max profile velocity.

There is no negative acknowledgement for the index positioning. This means, the new position is always accepted. Thereby position setpoints are also possible, which can not be reached with compliance of the current setpoint ramps. The index positions must be corrected by way that the distance to the new set position can also be reached with the valid ramps.

4.8.1.3.1 Single positioning

If value -1 "off" is set in ps42 next index, a position can be selected with ps46 start index, which is then approached with the next start positioning command.

If value -1 "with digital input" is entered in ps46 start index, the index selected via digital inputs (=> Chapter 7.1.9.3 Index setting via digital inputs) is used as start index.

4.8.1.3.2 Sequence control system

There are 2 types of sequence control systems "auto index mode" or "stop after each index". The selection is made via ps38 posi operation mode.

ps38	posi operation mode	
Bit1	index mode	
Value	Name	Note
0	auto index mode	After the "Start Positioning" command, all index positions are moved in succession until an index is reached for which value -1 "off" is programmed in parameter ps42 next index. The first position is defined by ps46 start index. ps46 is not changed automatically.
2	stop after each index	With this index mode, the positioning is completed after each index in case of subsequent positioning (ps42 next index unequal -1). The new index (ps42 next index) is automatically entered in ps46 start index. With the next command "Start positioning" the index entered in ps46 is used. Therefore, a "Start Positioning" command must always be given to move to the individual positions of the programmed sequence. If a positioning sequence is finished (ps42 next index = -1), the value of ps42 next index (-1) is copied in ps46 start index when the last target is reached. The next positioning sequence starts with the index which is selected via digital inputs.

The sequence of the positions is determined via ps42 next index.

ps42	next index	
Value	Name	Note
-1	off	End of sequence control system The positioning is completed as soon as the actual index position is reached.
0 …31	next index	As soon as the position of the current index is reached, the program switches to the next index.

A running index positioning can be interrupted and programmed to alternative sequence with ps44 and ps45.

The condition for this can be assigned (e.g.) to the software outputs OA…OC via the do-objects.

There is no negative acknowledgement for the index positioning. This means, the new position is always accepted.

Thereby position setpoints are also possible, which can not be reached with compliance of the current setpoint ramps. The index positions must be corrected by way that the distance to the new set position can also be reached with the valid ramps.

4.8.1.4 Operating modes of positioning

In Profile positioning mode there are the same positioning modes for positioning with FIFO and positioning in index mode. However, they are adjusted in different objects.

4.8.1.4.1 Positioning modes in profile positioning mode with FIFO

The absolute positioning is selected in co00 0x6040controlword with bit 6 (absolute/relative) = 0.

Optionally, the operating mode which is most appropriate for the application can be selected with ps33 absolute positioning or in the index mode with ps43 index mode.

ps33	absolute positioning	0x2E21
Value	Name	Note
1	shortest path selection	Round table positioning with shortest path. The inverter automatically selects the appropriate direction of rotation
2	forward	Round table positioning, only forward
3	reverse	Round table positioning, only reverse
4	relative to zero	Approach of an absolute position within one motor revolution (tool change)
5	reserved	
6	within single rotation of enc A	Approach of an absolute position within one revolution of encoder A considering the gear factor of ec24 and ec25

4.8.1.4.2 Positioning modes for index positioning

ps43	index mode	0x2E2B
Value	Name	Note
2	shortest path selection	Round table positioning with shortest path. The inverter automatically selects the appropriate direction of rotation
3	forward	Round table positioning, only forward
4	reverse	Round table positioning, only reverse
5	relative to zero	Approach of an absolute position within one motor revolution (tool change)
6	speed reference	Simple setpoint setting with ps40 in this position index
7	within single rotation of enc A	Approach of an absolute position within one revolution of encoder A considering the gear factor of ec24 and ec25

4.8.1.4.3 Absolute / relative positioning

4.8.1.4.3.1 Selection in profile positioning mode with FIFO

Bit 6 "abs/rel" in the controlword determines if the position values shall be absolute or relative positions.

4.8.1.4.3.2 Selection for index positioning

In ps43 index mode can be selected, if the position values shall be absolute or relative positions. Bit 6 "abs/rel" in the controlword has no meaning.

ps43	index mode	
Value	Name	Note
0	relative	Relative positioning
1	absolute	Absolute positioning

4.8.1.4.3.3 Relative positioning

For relative positioning there is a further differentiation:

If the respective relative positioning should be independent how exactly the last target was reached, the new position must be calculated relative to the current actual position.

If, on the other hand, the sum of the relative positionings in relation to a reference point should be as exact as possible, the new position must be calculated relative to the current set position.

ps38	posi operation mode	
Bit 2	relative positioning	
Value	Name	Note
0	set position	Relative positioning always occurs from the internal set position. Even with multiple positioning, no errors can add up.
4	actual position	Relative positioning always occurs relative to the actual position

4.8.1.4.4 Relative to zero

In the position mode "relative to zero“ the motor should stop in a defined position within one motor revolution (e.g. for tool change).

Position value 0 corresponds to the zero signal of the encoder.

The selection of such a defined position index shall be done from a constant motion.

The setpoint speed (profile speed) of this positioning (ps30 (CiA 0x6081) profile velocity or ps40 index speed) must be higher than the setpoint speed at the start of the positioning.

The value range for ps39 index position must be within a positive motor revolution (0…65536).

A final speed is not permitted (ps41 index end speed / or ps31 0x6082end velocity = 0).

4.8.1.4.5 Relative to enc A with gear

Positioning of any constant speed setpoint to the absolute position of encoder A within one revolution.

Encoder A can be installed in front of a gear.

The distance is defined by the ramps (e.g. tool change).

The gear factor in ec24 and ec25 is considered.

The target position is preset exactly as in ru38[3] gearless pos low.

The permissible value range is 0 … 65535.

4.8.1.4.6 Round table positioning

A positioning over 360° is possible for round table positioning or similar. Positions on this cycle can be appraoched from both directions. The referencing can be monitored at a non even-numbered gear factor.

The definition of the value range of the round table occurs according to the general set- / actual position limits and is described in chapter 6.5.1 Position values.

Also the cyclic referencing is possible in all position-controlled modes and is described in chapter 4.8.4 Cyclic referencing.

ps38	posi operation mode	
Bit3	round table mode position	
Value	Name	Note
0	off	The limits of ps18 and ps19 have only effect on the non-linear torque pre-control with linear value range
8	on	The value range for the round table function is defined with ps18 and ps19.

4.8.1.5 Positioning with start speed

Positioning can also be started directly from a setpoint, note that the DRIVE is in a constant movement (no ramps active). Furthermore, the setpoint must be within the limits of ps30 or ps40. If you do not follow these instructions, errors may occur in the profile calculation and the drive may not reach the desired position directly. After stopping, the required position is then automatically approached in a second positioning.

4.8.1.6 Position controller

In "Profile position mode“ the position controller is always active by default. The position controller is always active with ps00 position control mode = 1 "auto (Default)“ or 2 "on“.

Also in operating mode 1, both setpoint speed and set position values can be preset to the drive.

If setpoint speeds are preset in operating mode "1: profile positioning mode" when the position controller is activated, they are integrated and a target position is calculated (st37 demand position). If the drive cannot follow the setpoints exactly, the actual position is adjusted via the position controller.

If this permanent activity of the position controller is not desired, it can be switched "off" with ps00 position control mode = 0.
st37 demand position and st36 following error are set to zero.

4.8.1.7 Ramps in profile position mode

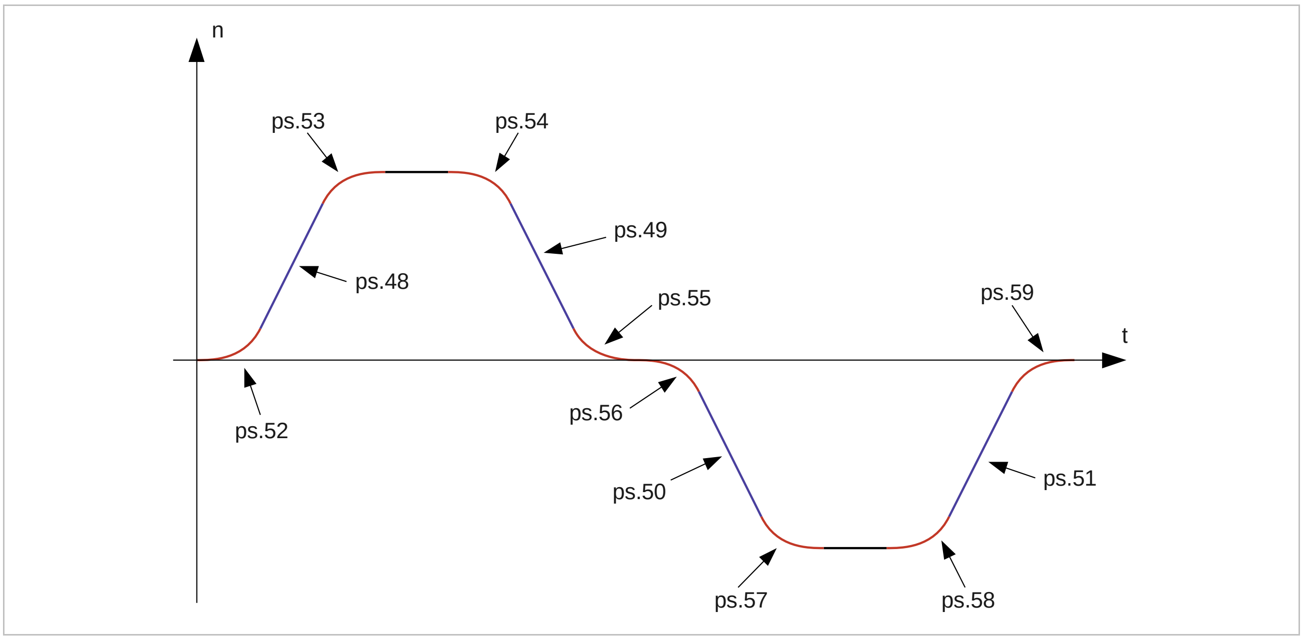


Figure 30: Ramps in profile position mode

The behaviour of the ramp generator can be adapted to the requirements of the application via object ps60 ramp mode.

Index	Id-Text	Name	Function
0x2E3C	ps60	ramp mode	Operational performance of the ramp generator

The bits in ps60 have the following functions:

<table>
<tr><td>ps60</td><td colspan="3">ramp mode</td><td>0x2E3C</td></tr>
<tr><td>Bit</td><td>Function</td><td>Value</td><td colspan="2">Function</td></tr>
<tr><td rowspan="2">0</td><td rowspan="2">ramp type</td><td>0: S-curve</td><td colspan="2">S-curves</td></tr>
<tr><td>1: lin</td><td colspan="2">Linear ramps</td></tr>
<tr><td rowspan="2">1</td><td rowspan="2">linear ramp acc/dec</td><td>0: sep. para</td><td colspan="2">ps48…ps51</td></tr>
<tr><td>2: acc for para</td><td colspan="2">ps48 is acceleration/deceleration setting for all directions of rotation (only effective if linear ramps are selected, otherwise ps48…ps51) always apply</td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">s-curve type</td><td>0: continuous s-curve</td><td colspan="2" rowspan="2">Only effective if no positioning is active.
See also graphic under co60</td></tr>
<tr><td>4: abort in s-curve</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">pass zero type</td><td>0: not zero</td><td colspan="2" rowspan="2">Only effective if no positioning is active.
See also graphic under co60</td></tr>
<tr><td>8: zero</td></tr>
<tr><td rowspan="4">4,5</td><td rowspan="4">same acc dec</td><td>0: single para setting</td><td colspan="2">The acceleration and deceleration for each direction of rotation is defined separately in the corresponding parameters.</td></tr>
<tr><td>16: all</td><td colspan="2">The value in ps48 defines the acceleration as well as the deceleration for both directions of rotation</td></tr>
<tr><td>32: dec = acc</td><td colspan="2">The values in ps48 and ps50 also define the deceleration for the respective direction of rotation.
ps49 and ps51 have no function</td></tr>
<tr><td>48: rev = for</td><td colspan="2">The values in ps48 and ps49 also define the acceleration or deceleration for the reverse direction of rotation.ps50 and ps51 have no function</td></tr>
<tr><td rowspan="3">6…7</td><td rowspan="3">same jerk</td><td>64: all</td><td colspan="2">The value in ps52 determines all jerk values. Parameters ps53..ps59 have no function</td></tr>
<tr><td>128: acc and dec</td><td colspan="2">ps52 for acc jerk ls [s-3] defines all acceleration jerk values, ps54 for dec jerk hs [s-3] defines all deceleration jerk values.
ps53 and ps55..ps59 have no function.</td></tr>
<tr><td>192: rev = for</td><td colspan="2">The four jerk values for the reverse direction of rotation are taken over from the forward direction of rotation. ps56..ps59 have no function</td></tr>
</table>

In addition to the ramps in the Ps parameters, fault reaction, shutdown or standard ramps can also become effective. Observe setting of co32.

The ramp generator is described in more detail in chapter 4.8.2.4 Ramp generator Velocity mode.

4.8.1.8 Speed limits

The maximum speed is limited in the operating mode profile positioning mode via ps32 (CiA 0x607F) max profile velocity. A change is also possible with active positioning.

This value limits all setpoint speeds (target velocity vl20 / vl21, ps40 index speed, setpoint speed from the profile generator), with the exception of the position controller output.

The position controller output value can still be added to the (CiA 0x607F) max profile velocity ps32.

4.8.1.9 Position limits

The position setpoint and position actual value limits are described in chapter 6.5.1 Position values.

4.8.1.10 Speed settings

Speed setpoints can also be specified in the "Profile positioning mode" instead of position setpoints.

There are 2 different modes:

- Speed setpoint setting via the vl parameters
- Index speed setting

If no positioning and no index speed is active, the speed setpoint setting is set via the vl parameters (=> Chapter 4.8.2.1 Set speed setting). The speed setting via the vl_parameters is always limited additionally to the limit of ps32 by the vl velocity min / max amount parameter (vl04…vl07).

In the "Index positioning" mode, a simple fixed speed setting (index speed setting) of up to 32 different speeds can also be realized instead of a positioning sequence in the following way:

- According to the number of required speed setpoints, a number of digital inputs must be defined, which are used for index selection (=> Chapter 7.1.9.3 Index setting via digital inputs).
- For the used array indices, value 6 "speed reference" must be entered in ps43 index mode].
- The setpoint speeds must be entered in the used array indices of ps40 index speed.

Example:

It should be possible to specify 5 fixed speeds with digital inputs:

-1000, -500, 0 , 500 und 1000 rpm

Three inputs are required in order to display the 5 numbers (0, 1, 2, 3, 4) digitally binary (000_b,001_b,010_b,011_b,100_b). The inputs I1, I2, I3 are selected

- di21 index input = 7: I1 + I2 + I3

Operating mode 1 must be selected

- co01 = 1

value 6 "speed reference" must be entered in ps43 index mode [ ]

- ps43 index mode [1] = 6
- ps43 index mode [2] = 6
- ps43 index mode [3] = 6
- ps43 index mode [4] = 6
- ps43 index mode [5] = 6

The setpoint speed must be entered in ps40 index speed [ ]

- ps40 index speed [1] = -1000
- ps40 index speed [2] = -500
- ps40 index speed [3] = 0
- ps40 index speed [4] = 500
- ps40 index speed [5] = 1000

If, for example, input I2 is now set ru58 actual Index will have the value 2. The array index is always actual index +1, = 3
Thus the setpoint speed ps40 index speed [3] = 0 is selected.

If no input is set, ru58 actual Index has the value 0. The array index is then 1, thus the setpoint speed ps40 index speed [1] = -1000 is selected.

4.8.1.11 Following error

The following error (st36 following error) can be monitored in all operating modes with active position controller. The description of the following error monitoring is described in chapter 6.5.4 Following error.

4.8.1.12 Target reached

Bit 10 in the status word "target reached" is only managed in the profile positioning mode. The "target reached" bit is only set when an (intermediate) target is reached if:

- in profile positioning mode with FIFO there is no further position set in the FIFO (i.e. a subsequent positioning is not started immediately)
- in auto-index mode (ps38 positioning module Bit 1 index mode = 0 "auto index mode“) the last position is reached (ps42 next index [ ] = -1 "off“). If a loop is programmed (last index points to start index), bit 10 target reached is never set.
- in stop-after-each-index-mode the current target position has been reached.

The behaviour depends on the setting in ps31 (CiA 0x6082) end velocity or ps41 index end speed. The bit "target reached" (TR) is set immediately after completion of the pre-control profile if the target speed (ps31 or ps41) is not equal to 0. Otherwise the target window (ps14 (CiA 0x6067) positioning window and ps15 positioning window time) is considered.

ps31 or ps41 ≠ 0	ps31 or ps41 = 0
the pre-control profile at the target has expired	the pre-control profile at the target has expired ➢ ps14 (CiA 0x6067) positioning window defines a position window symmetrically to the target position (position window = target position +/- ps14). ➢ ps15 (CiA 0x6068) positioning window time defines the time the drive must be in this target window. ➢ The drive is in the target window for the time ps15 (target position +/- ps14).

Attention, when reaching the target position, bit 4 in the co00 (CiA 0x6040) controlword must no longer be set in order to trigger bit 10 target reached in the st00 (CiA 0x6041) statusword.

To start a new positioning, the positioning must be completed. A completed positioning means:

- the bit target reached is set for single positioning
- the drive is in the target window in the following positioning

If a new positioning shall be started without finishing the previous one, this is only possible via the bit change set immediately or by removing the modulation release.

4.8.1.13 Examples for rotary table positioning

4.8.1.13.1 Motor encoder with initiator at rotary table

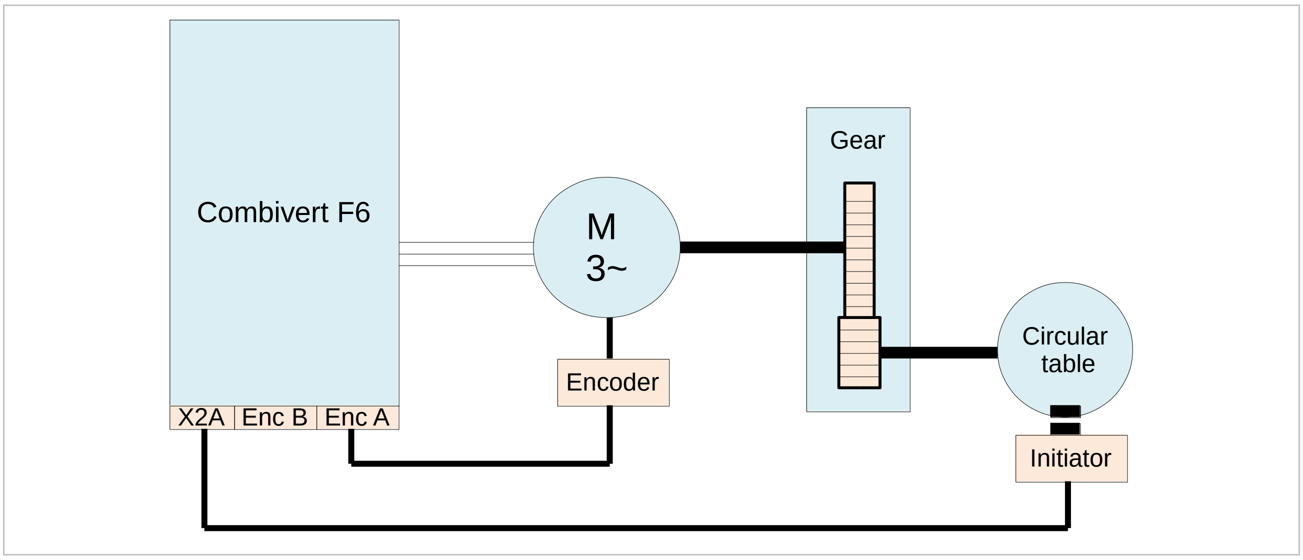


Figure 31: Motor encoder with initiator at rotary table

In this example the value range of the rotary table is monitored only by an initiator. A non-integer gear factor can be compensated.

A possibly existing backlash should be considered that the positions can be approached only with a fixed direction of rotation (ps33 = 2 or 3).

4.8.1.13.2 Motor encoder with encoder and initiator at rotary table

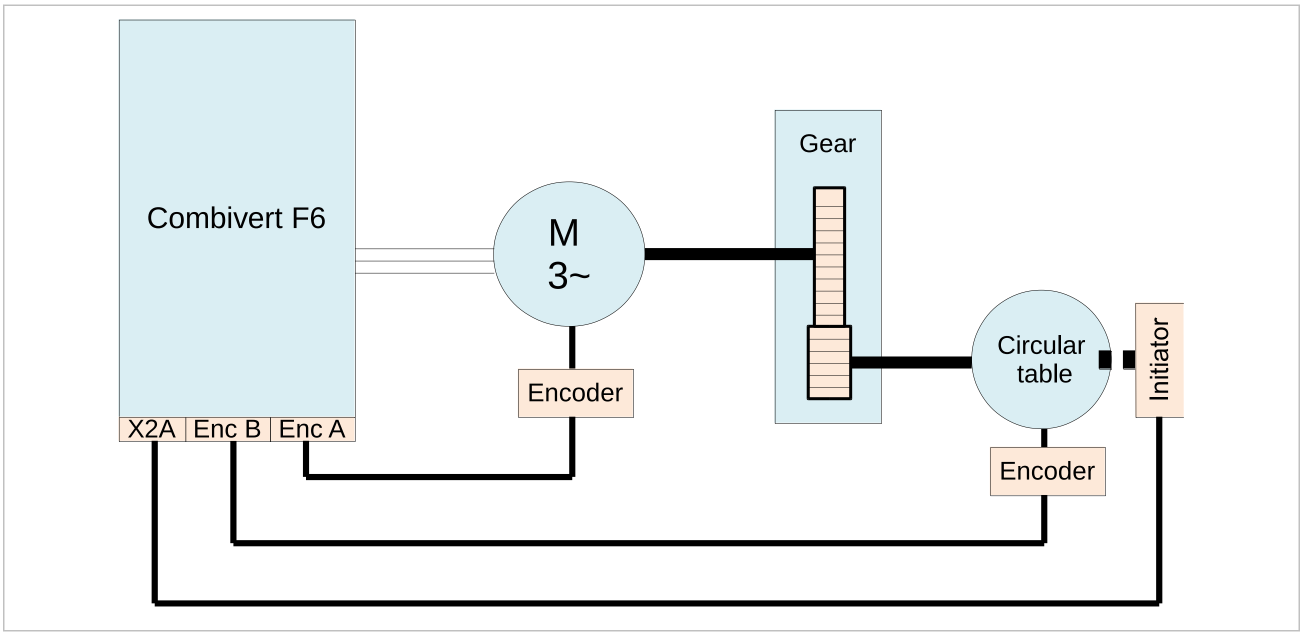


Figure 32: Motor encoder with encoder and initiator at rotary table

This is the most complex configuration. There are all possibilities. Backlash can be compensated.

4.8.1.13.3 Operation with motor model and encoder with initiator at rotary table

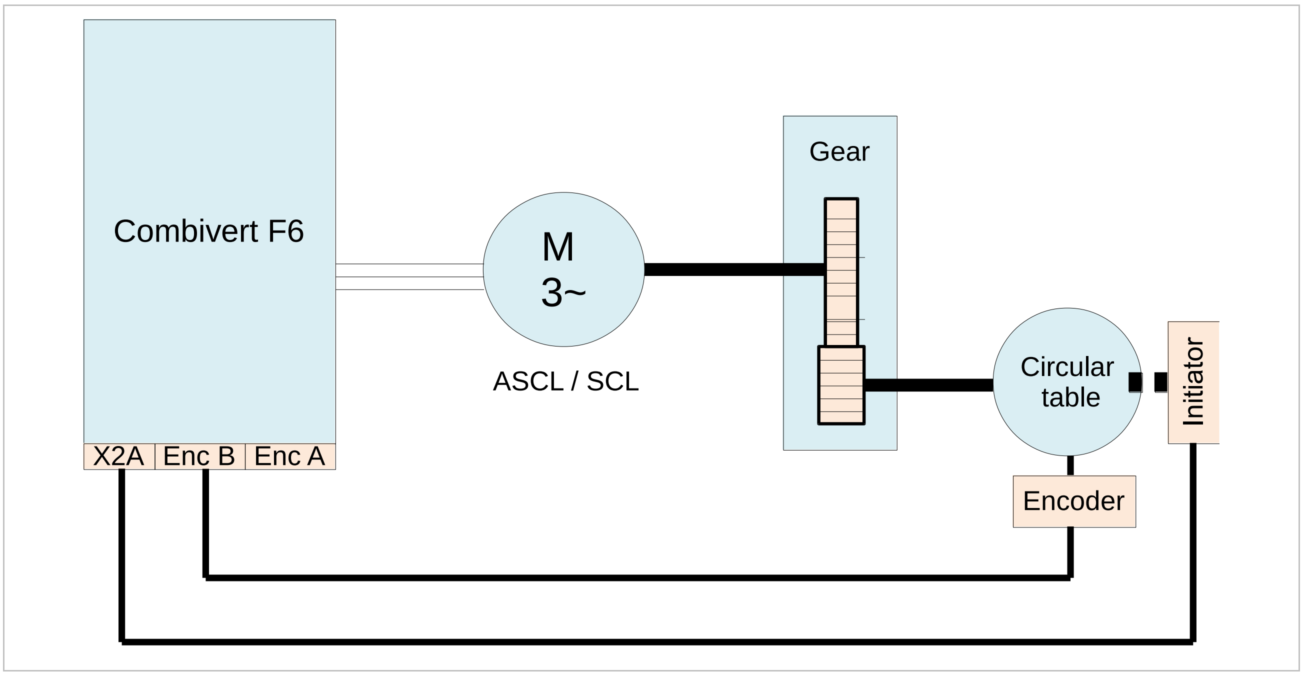


Figure 33: Operation with motor model and encoder with initiator at rotary table

In this example for operation with motor model there is no encoder required at the motor, nevertheless the possibility to compensate backlash is also given here.

4.8.2 Operating mode 2: Velocity mode

The target speed is preset by the superior control in operating mode "Velocity mode". Generation of the speed profile and the speed control circuit are located in the drive. The following figure shows the principle function.

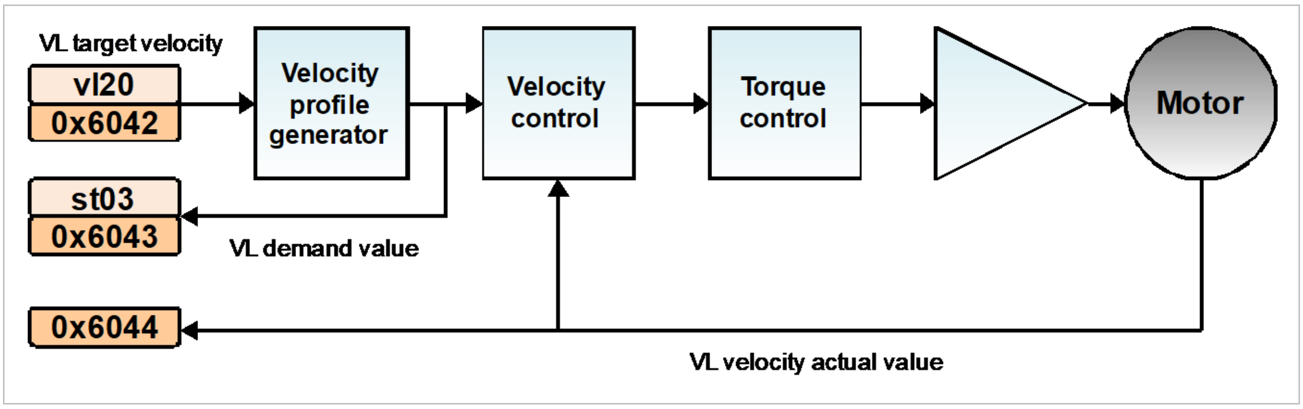


Figure 34: Velocity mode - overview

The yellow elements indicate the KEB specific objects, the orange-colored objects indicate the appropriate objects of the CiA402 profile.

The function of the individual objects can be influenced by different other function blocks. The following figure shows a detailed description of the operating mode.

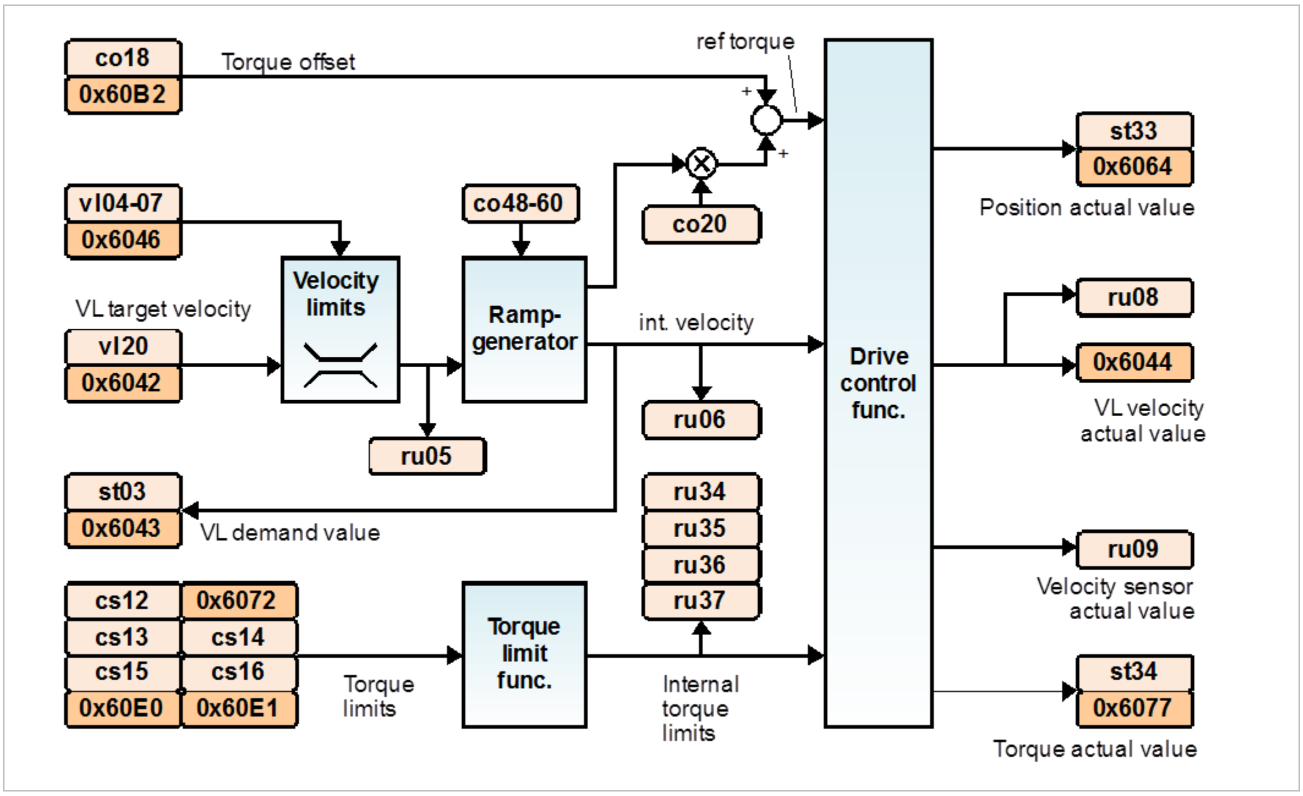


Figure 35: Velocity mode

4.8.2.1 Set speed setting

The target speed is preset via vl20 vl target velocity. The resolution is 1 rpm .

Index	Id-Text	Name	Function
0x2314	vl20	vl target velocity	Setting the target speed Resolution 1 rpm
0x6042			

The target speed can be preset with higher resolution with vl21. This object is not defined according to CiA402

Index	Id-Text	Name	Function
0x2315	vl21	target velocity high res	Setting the target speed Resolution: 1/8192 rpm = 0.000122 rpm

Parameters vl20 and vl21 are added to a common target speed.

4.8.2.2 Target speed limitation

The target speed is limited in the function block Velocity limits. The settings are made via the following objects.

Index	Id-Text	Name	Function
0x2304	vl04	vl velocity min amount for	Minimum speed in FOR direction of rotation (pos. speeds)
0x2305	vl05	vl velocity max amount for	Maximum speed in FOR direction of rotation (pos. speeds)
0x2306	vl06	vl velocity min amount rev	Minimum speed in REV direction of rotation (neg. speeds)
0x2307	vl07	vl velocity max amount rev	Maximum speed in REV direction of rotation (neg. speeds)

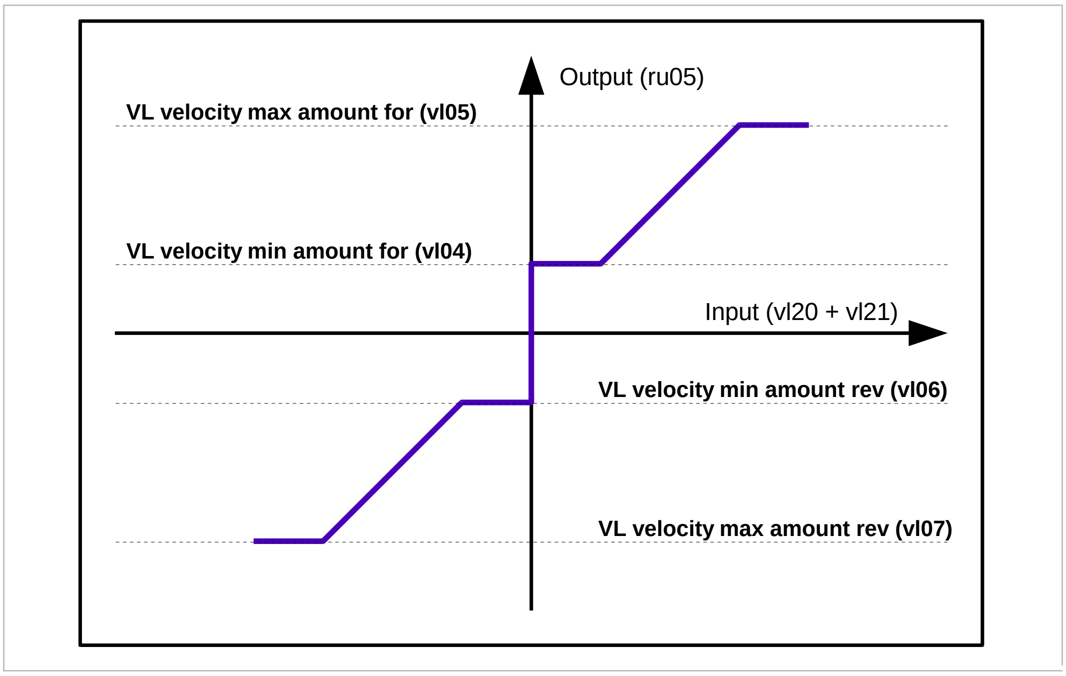


Figure 36: Target speed limitation

4.8.2.3 Controlword in the velocity mode

The properties of some controlword bits depend on the OperationMode. In velocity mode they are defined as follows:

co00	(CiA 0x6040) controlword		0x2500
Bit	Name	Note	
4	enable ramp	0: Ramp output is always 0 1: Ramp generator is active	
5	unlock ramp	0: Ramp output is "frozen" 1: Ramp generator is active	
6	reference ramp	0: Ramp input is always zero 1: Setpoint is valid	
8	Halt	0: Setpoint is valid 1: Ramp input is always zero	

Bits 4...6 and 8 are not supported in the controlword in software version 2.1.

They can be used from version 2.2. Since this causes significant function changes in the vl mode, this bits must be activated for compatibility reasons with bit 8 "enable vl ramp options“ in co32 state machine properties.

4.8.2.4 Ramp generator

The ramp generator supports linear ramps and those with linearly increasing acceleration (s-curves). Furthermore the behaviour can be parameterized flexible when changing the direction of rotation.

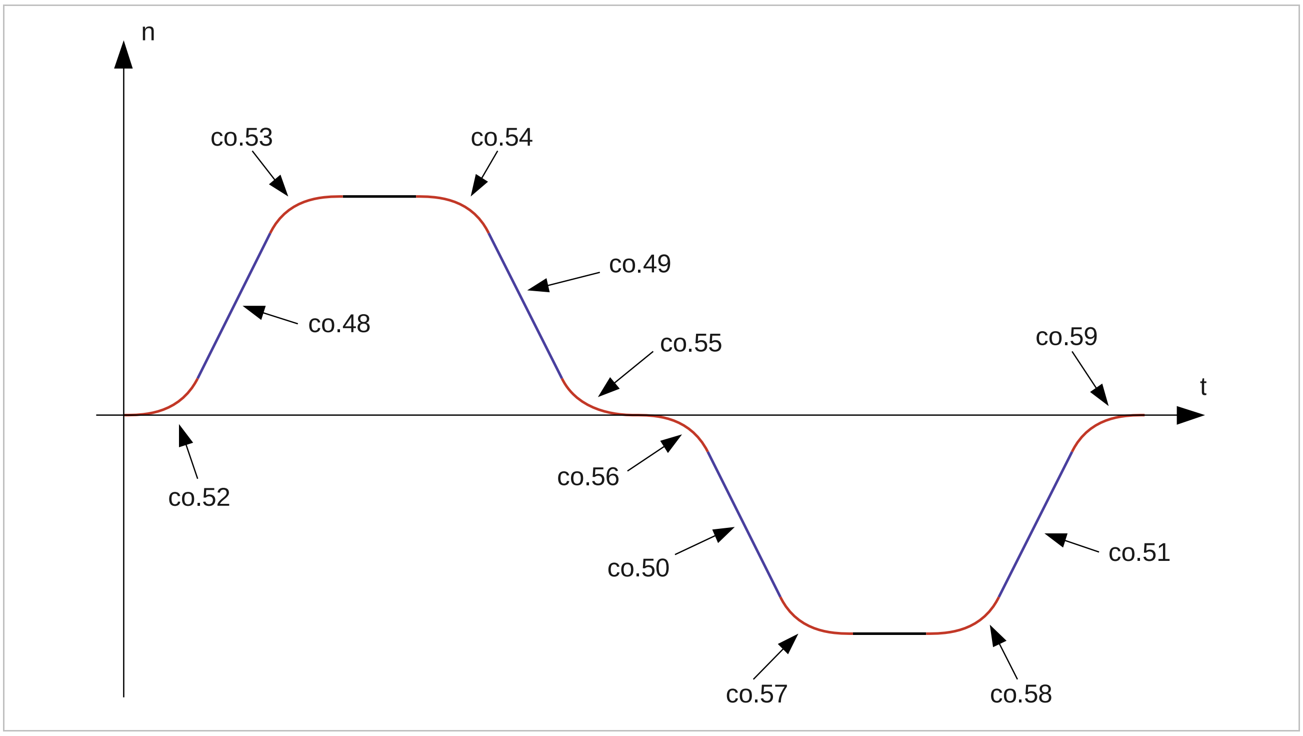


Figure 37: Ramp generator

4.8.2.4.1 Maximum acceleration / deceleration

The maximum acceleration or deceleration is parameterized via the following objects. The resolution of the values is 1/100 s^{-2} = 0.01 s^{-2}.

Index	Id-Text	Name	Function
0x2530	co48	acceleration for [s-2]	Maximum acceleration at FOR direction of rotation (pos. speeds)
0x2531	co49	deceleration for [s-2]	Maximum deceleration at FOR direction of rotation (pos. speeds)
0x2532	co50	acceleration rev [s-2]	Maximum acceleration at REV direction of rotation (neg. speeds)
0x2533	co51	deceleration rev [s-2]	Maximum deceleration at REV direction of rotation (neg. speeds)

Example:

Which acceleration is present, when a drive accelerates in 1s from 0 to 1000 rpm?

$a = \Delta n/\Delta t = 1000 / 60\ s^{-1} / 1\ s^{-1} = 16.67\ s^{-2}$

The co48 is also mapped via 0x6083 profile acceleration [inc s-2]. The increments per revolution result from the co03 position rot scale. If required, 0x6083 can be set to the acceleration and deceleration values of all ramps with the options from co32 and xx60.

4.8.2.4.2 Jerk limiting

The maximum acceleration change (jerk) is parameterized via the following objects. The resolution of the values is 1/100 s^{-3} = 0.01 s^{-3}.

Index	Id-Text	Name	Function
0x2534	co52	for acc jerk ls [s-3]	Maximum jerk at acceleration in FOR direction of rotation (low speed)
0x2535	co53	for acc jerk hs [s-3]	Maximum jerk at acceleration in FOR direction of rotation (high speed)
0x2536	co54	for dec jerk hs [s-3]	Maximum jerk at deceleration in FOR direction of rotation (high speed)
0x2537	co55	for dec jerk ls [s-3]	Maximum jerk at deceleration in FOR direction of rotation (low speed)
0x2538	co56	rev acc jerk ls [s-3]	Maximum jerk at acceleration in REV direction of rotation (low speed)
0x2539	co57	rev acc jerk hs [s-3]	Maximum jerk at acceleration in REV direction of rotation (high speed)
0x253A	co58	rev dec jerk hs [s-3]	Maximum jerk at deceleration in REV direction of rotation (high speed)
0x253B	co59	rev dec jerk ls [s-3]	Maximum jerk at deceleration in REV direction of rotation (low speed)

Example:

The acceleration in the previous example should be reached after one second.

$r = \Delta a/\Delta t$

In our case with constant jerk it is:

$r = a / t = 16.67 s^{-2} / 1 s = 16.67\ s^{-3}$

4.8.2.4.3 Operating modes of the ramp generator

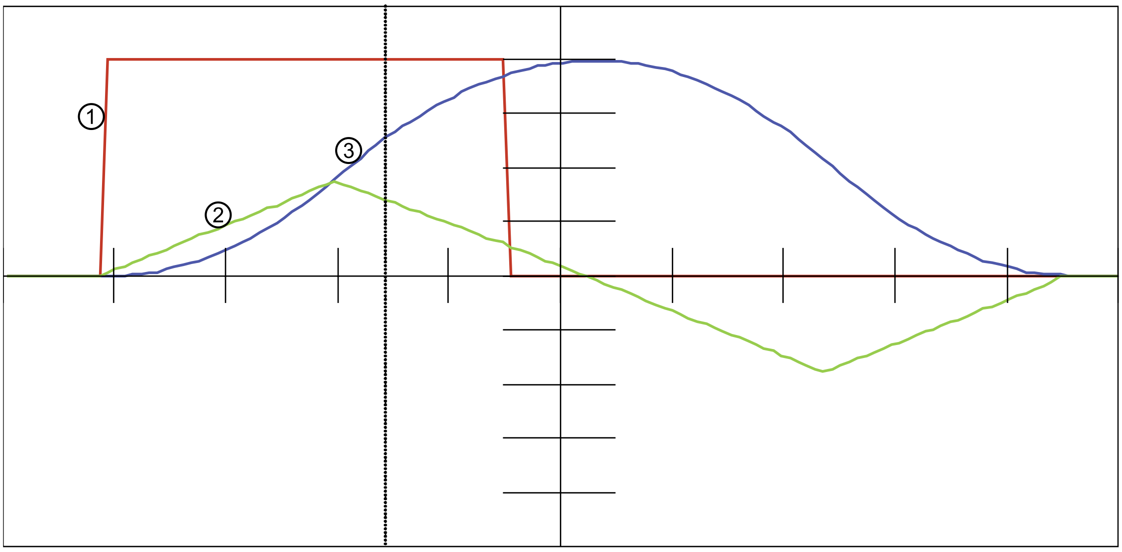
The behaviour of the ramp generator can be adapted to the requirements of the application via object co60 ramp mode.

Index	Id-Text	Name	Function
0x253C	co60	ramp mode	Operational performance of the ramp generator

The bits in co60 have the following functions:

co60	ramp mode		0x253C
Bit	Function	Value	Function
0	ramp type	0: S-curve	S-curves
		1: lin	Linear ramps
1	linear ramp acc/dec	0: sep. para	co48…co51
		2: acc for para	co48 is acceleration/deceleration setting for all directions of rotation (only effective if linear ramps are selected, otherwise co48…co51) always apply
2	s-curve type	0: continuous s-curve	Function => see graphic
		4: abort in s-curve	
3	pass zero type	0: not zero	Function => see graphic
		8: zero	
4,5	same acc dec	0: single para setting	The acceleration and deceleration for each direction of rotation is defined separately in the corresponding parameters.
		16: all	The value in co48 defines the acceleration as well as the deceleration for both directions of rotation
		32: dec = acc	The values in co48 and co50 also define the deceleration for the respective direction of rotation. co49 and co51 have no function
		48: rev = for	The values in co48 and co49 also define the acceleration or deceleration for the reverse direction of rotation.co50 and co51 have no function
6…7	same jerk	64: all	The value in co52 determines all jerk values. Parameters co53..co59 have no function
		128: acc and dec	co52 for acc jerk ls [s-3] defines all acceleration jerk values, co54 for dec jerk hs [s-3] defines all deceleration jerk values. co53 and co55..co59 have no function.
		192: rev = for	The four jerk values for the reverse direction of rotation are taken over from the forward direction of rotation. co56..co59 have no function

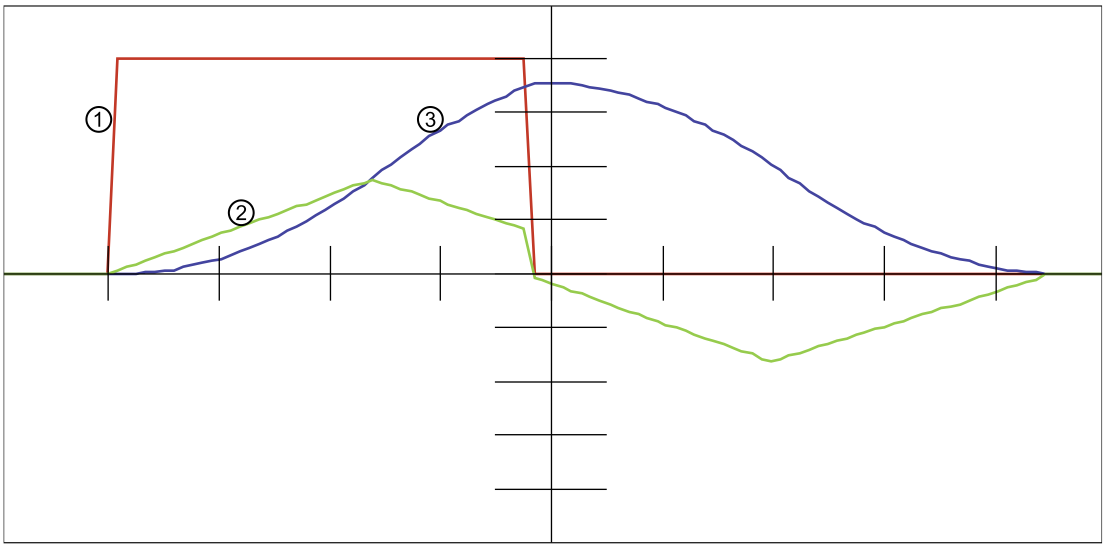
continuous S-curve: Actual acceleration is changed with actual jerk to the new setpoint. There is no jump in the acceleration.



1 Setpoint (vl20 vl target velocity)
2 Acceleration (defined by co48…co59)
3 Ramp output value (ru06 ramp out display)

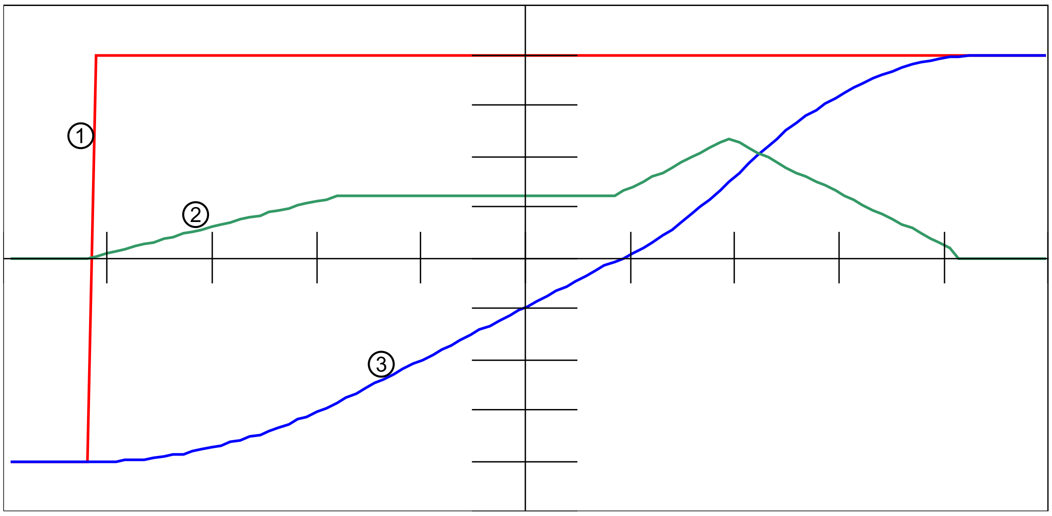
Figure 38: s-curve type = 0: continuous s-curve

abort in S-curve: The actual acceleration is immediately limited to 0 if the setpoint is lower than the actual value. In acceleration there is a jump to 0 at this point.



1 Setpoint (vl20 vl target velocity)
2 Acceleration (defined by co48…co59)
3 Ramp output value (ru06 ramp out display)

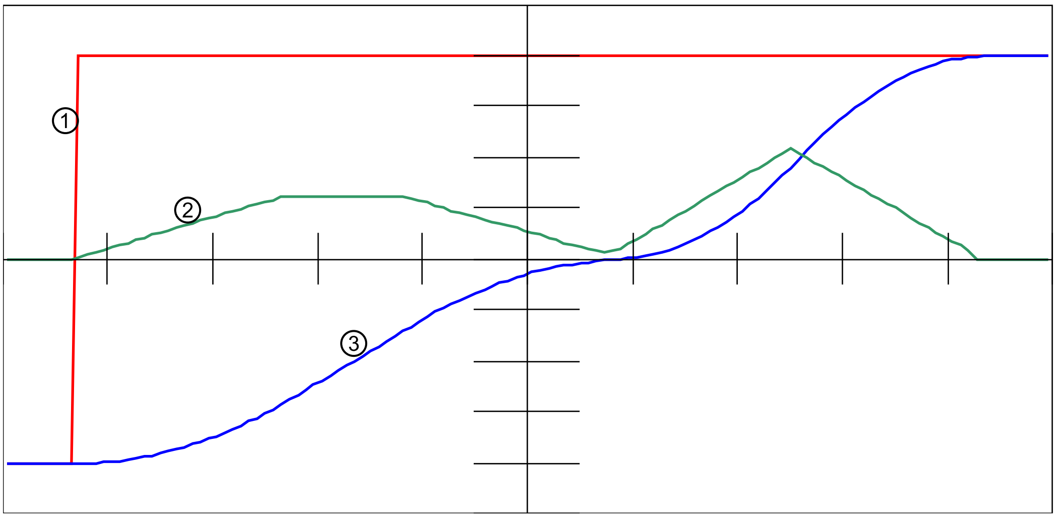
Figure 39: s-curve type = 4: abort in s-curve



1 Setpoint (vl20 vl target velocity)
2 Acceleration (defined by co48…co59)
3 Ramp output value (ru06 ramp out display)

Figure 40: pass zero type = 0: not zero

The acceleration remains on the actual value, if the ramp output changes the sign. If the acceleration, as in this example, has a different value in the other direction, the acceleration changes with the actual jerk to the new value.



1 Setpoint (vl20 vl target velocity)
2 Acceleration (defined by co48…co59)
3 Ramp output value (ru06 ramp out display)

Figure 41: pass zero type = 8: zero

The acceleration is reduced to 0 when the ramp output changes the sign.

Calculation example with timing

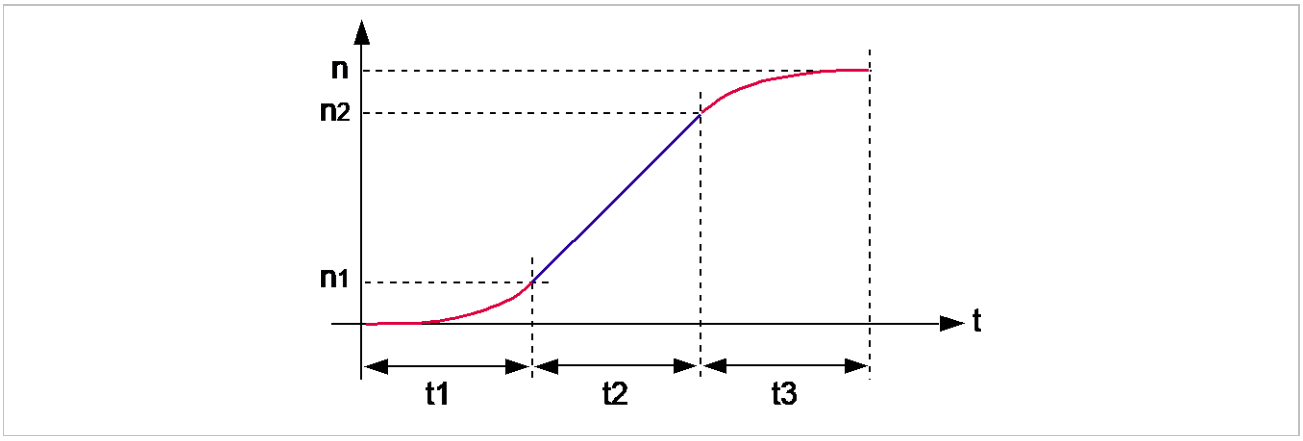


Figure 42: Calculation example

Setting of an acceleration profile according to Figure 42. The setpoint speed n is known as well as the three periods t_1, t_2 and t_3.

n = 1000rpm = 16.67 s^{-1}, t_1 = 1 s, t_2 = 2 s, t_3 = 3 s

Calculate the constant acceleration a in the second period t_2:

$$a = \frac{n}{\frac{t1}{2} + t2 + \frac{t3}{2}} \qquad a = \frac{16.67s^{-1}}{\frac{1s}{2} + 2s + \frac{3s}{2}} = 4.17s^{-2}$$

The resulting value for the acceleration is entered in co48.

Calculation of the jerk r_1 in the first period t_1:

$$r1 = \frac{a}{t1} \qquad r1 = \frac{4.17s^{-2}}{1s} = 4.17s^{-3}$$

The calculated value for the jerk r1 can be adjusted in co52.

Calculation of the jerk r_3 in the third period t_3:

$$r3 = \frac{a}{t3} \qquad r1 = \frac{4.17s^{-2}}{3s} = 1.39s^{-3}$$

The calculated value for the jerk r3 can be adjusted in co53. For the sake of completeness, when you want, calculate the speeds n_1 and n_2 at the changes:

$$n1 = \frac{a*t1}{2} \qquad n1 = \frac{4.17s^{-2} * 1s}{2} = 2.08s^{-1}$$

$$n2 = n1 + a * t2$$

$$n2 = 2.08s - 1 + 4.17s - 2 * 2s = 10.42s - 1$$

The formulas are also valid for the case if there is no constant acceleration. Then there is no smooth transition of the s-curves. In this case t_2 is 0.

4.8.3 Operating mode 6: Homing mode

The homing mode is completely implemented according to IEC 61800-7-200 (document 22G/184/FDIS, chapter 11).

In principle, a distinction is made between master-based and slave-based homing.

With master-based homing, the drive is moved to the required position in any operating mode. Then the actual position is overwritten with the value of hm00 (CiA 0x607C) home offset. Thereby e.g. through the Touch probe function, the actual function can be scanned by a digital input or at a zero signal of the encoder. The master can read out and evaluate this information via hm12 and hm13.

In slave-based homing, the inverter searches independently for the home position.

The required homing method is first selected under hm01 (CiA 0x6098) homing method. Method 37 "on current position" is preset, which overwrites only the actual position with the position in hm00. Only this method can be used for master-based homing. All other methods are slave-based homing.

The inverter must be in operating mode 6 "Homing" to start the homing mode.

The homing mode is started by the positive edge with setting bit 4 in the control word. (Op. Mode spec. 1 / homing operation start).

In the example with method 37, the actual position is now directly overwritten with the homing offset. Then the homing mode is completed by resetting bit 4 in the control word.

Bit13	Bit12	Bit10	Definition
0	0	0	Homing procedure is in process
0	0	1	Homing procedure is interrupted or not started
0	1	0	Homing is attained, but target is not reached
0	1	1	Homing procedure is completed successfully
1	0	0	Homing error occurred, velocity is not 0
1	0	1	Homing error occurred, velocity is 0
1	1	x	reserved

Bits 10 (target reached), 12 (homing attained) und 13 (homing error) are set in the status word by the homing mode.

Error-free homing is stored internally and can be monitored via the switching condition 54 "Homing done" (e.g. via a digital output).

4.8.3.1 Controlword in the homing mode

co00	(CiA 0x6040) controlword	0x2500
Bit	Name	Note
0	Switch on	State machine
1	Enable voltage	
2	no Quick stop	
3	Enable operation	
4	Start Homing	Starts the zero search
5…6	reserved	
7	Fault reset	Fault reset
8	Halt	Sets setpoint 0, finishes a zero search
9…14	Operation mode specific	Manufacturer-specific, without function
15	Open brake	Manufacturer-specific, 1 opens the motor brake (depending on co21 brake control mode)

4.8.3.2 Homing Offset

A position offset is internally calculated immediately with exiting the homing mode, thus the same value which is preset in the homing offset also is set in the actual position (st33 position actual value).

This once calculated value is stored non-volatile in hm09 position offset.

Thus the absolute position (multiturn) can be reset also at power-on along with an absolute value encoder (singleturn), provided the drive will not be moved in switched off state.

hm09 position offset can also be written. Thus referencing in other operating modes is also possible, respectively it is not necessary to change into operating mode homing. The value in hm09 is also modified by internal functions such as (e.g.) ps18 and ps19.

4.8.3.3 Digital inputs

The digital inputs can be assigned in any order to the homing functions:

Index	Id-Text	Name	Function
0x3105	hm05	digital inputs	Overview of the function selected by digital inputs
0x3106	hm06	negative limit switch source	Input selection for the negative limit switch
0x3107	hm07	positive limit switch source	Input selection for the positive limit switch
0x3108	hm08	home switch source	Input selection for the homing switch
0x310E	hm14	homing mode source	Input selection for direct activation of the homing mode with digital input.

The inputs for the limit switches are 0-active, i.e. value 0 for a limit switch input means that the drive is located on the limit switch. The homing switch is 1-active.

4.8.3.4 Setpoint speeds and ramps

The setpoint speed to start the homing function is preset with hm02 (CiA 0x6099 [1]) speed during search for switch.

The setpoint speed on driving free of the home switch is set in hm03 (CiA 0x6099 [2]) speed during search for zero.

Index	Sub-Idx	Id-Text	Name	Function
0x3102 0x6099	0 1	hm02 ---	(CiA 0x6099 [1]) speed during search for switch homing speeds [1]	Homing function starts with set-point speed
0x3103 0x6099	0 2	hm03 ---	(CiA 0x6099 [2]) speed during search for zero homing speeds [2]	Setpoint speed on driving free of the home switch
0x3104 0x609A		hm04	(CiA 0x609A) homing acceleration homing acceleration [s-2]	Adjustment of the ramps in the homing mode

4.8.3.5 Homing methods

Index	Id-Text	Name	Function
0x3101	hm01	(CiA 0x6098) homing method	Selection of the zero point search

With slave-based homing, the limit switches are always active. A setpoint is only enabled if the corresponding limit switch is also set.

The logic of the digital inputs can be adjusted with di00 thereby a test operation of the homing functions is also possible.

4.8.3.5.1 Method 1 (17) Homing to the negative limit switch and zero track

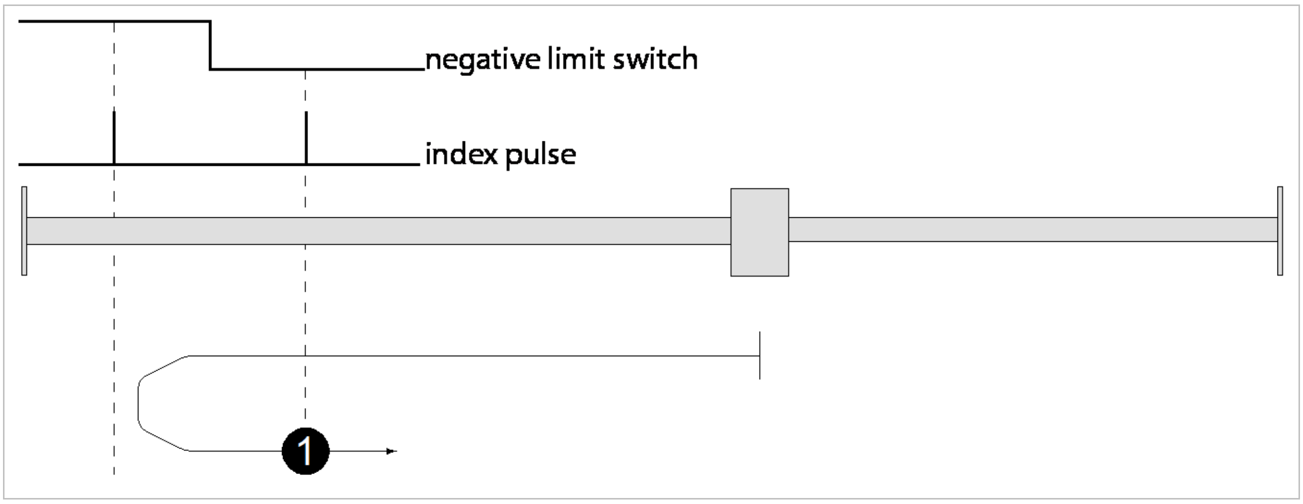


Figure 43: Homing – Method 1

Method 1 is started first with negative direction of rotation with the adjusted setpoint in hm02 (as shown in the figure above).

When approaching the negative limit switch, the drive reverses and removes the limit switch with the setpoint set under hm03.

Then the drive moves to the next zero signal of the encoder.

At this point the drive stops and the homing offset is transferred to the actual position.

Method 17 corresponds to method 1, but without zero signal search.

4.8.3.5.2 Method 2 (18) Homing to the positive limit switch and zero track

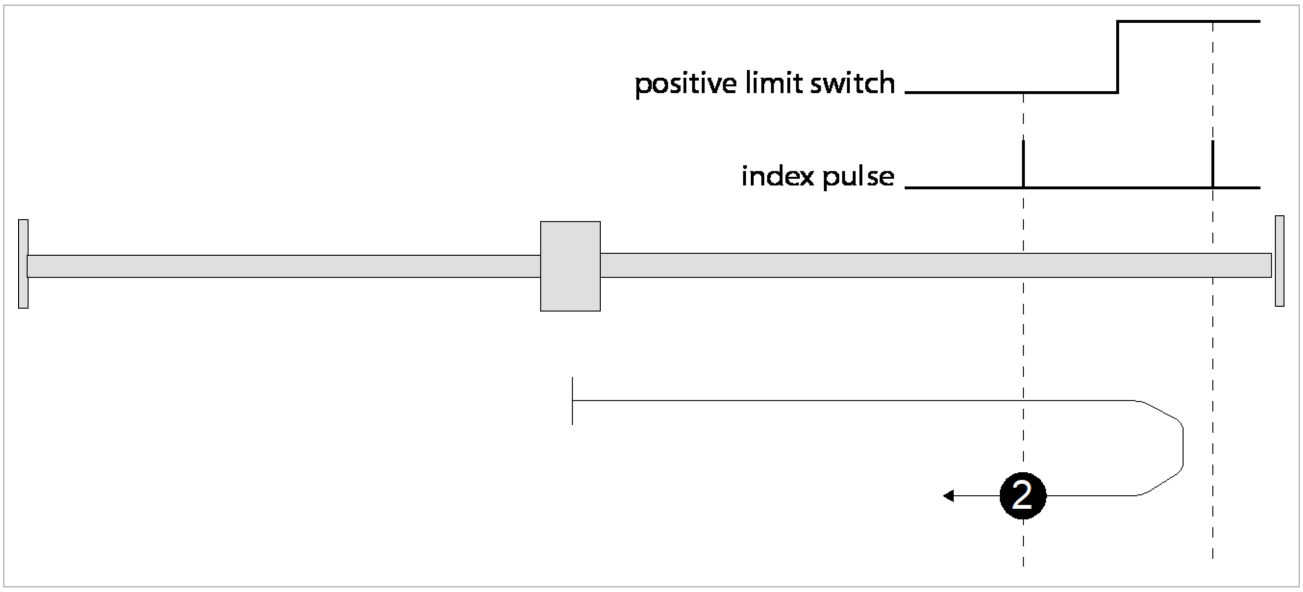


Figure 44: Homing – Method 2

4.8.3.5.3 Method 3 and 4 (19,20) Homing to the positive home switch and zero track

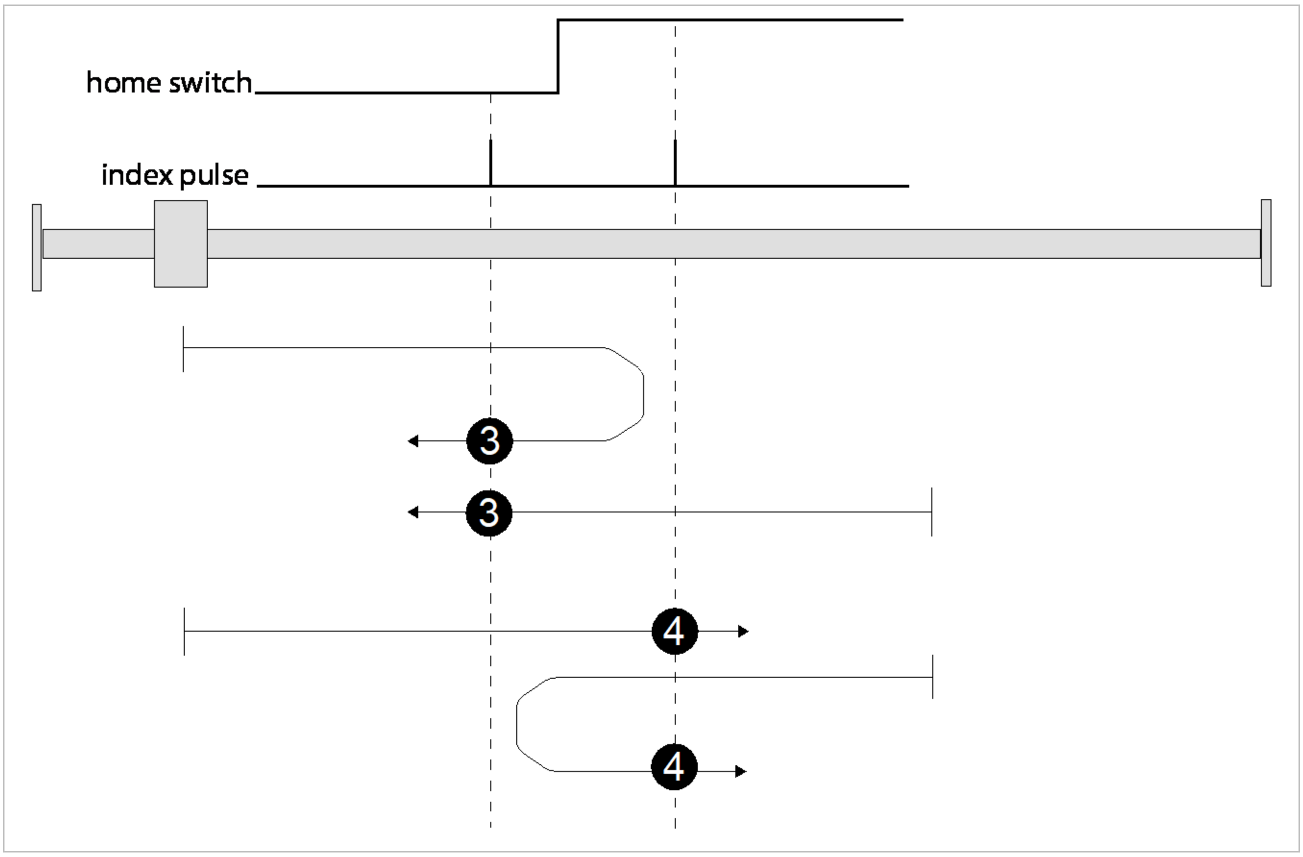


Figure 45: Homing – Method 3 and 4

4.8.3.5.4 Method 5 and 6 (21, 22) Homing to the negative home switch and zero track

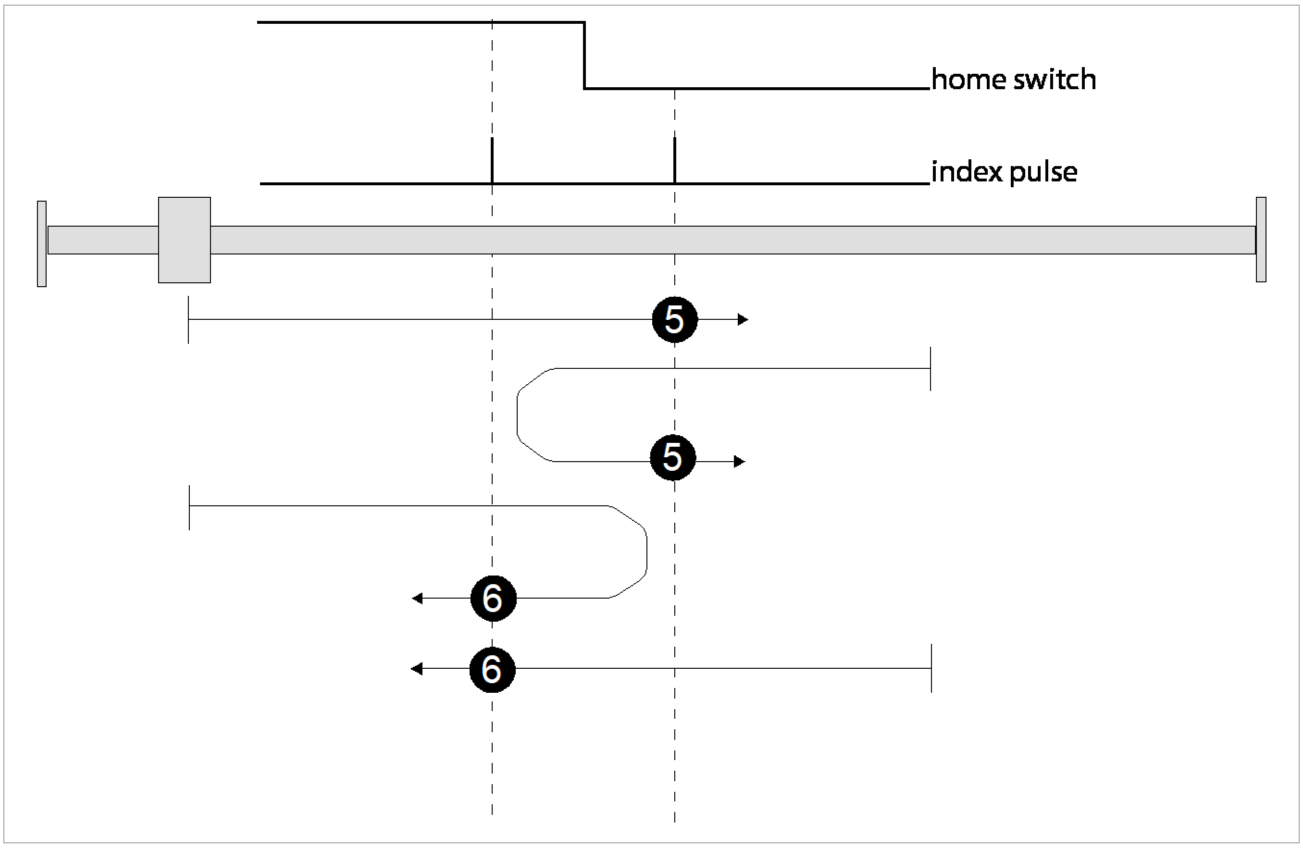


Figure 46: Homing – Method 5 and 6

4.8.3.5.5 Method 7 up to 14 (23…26) Homing to the home switch and zero track

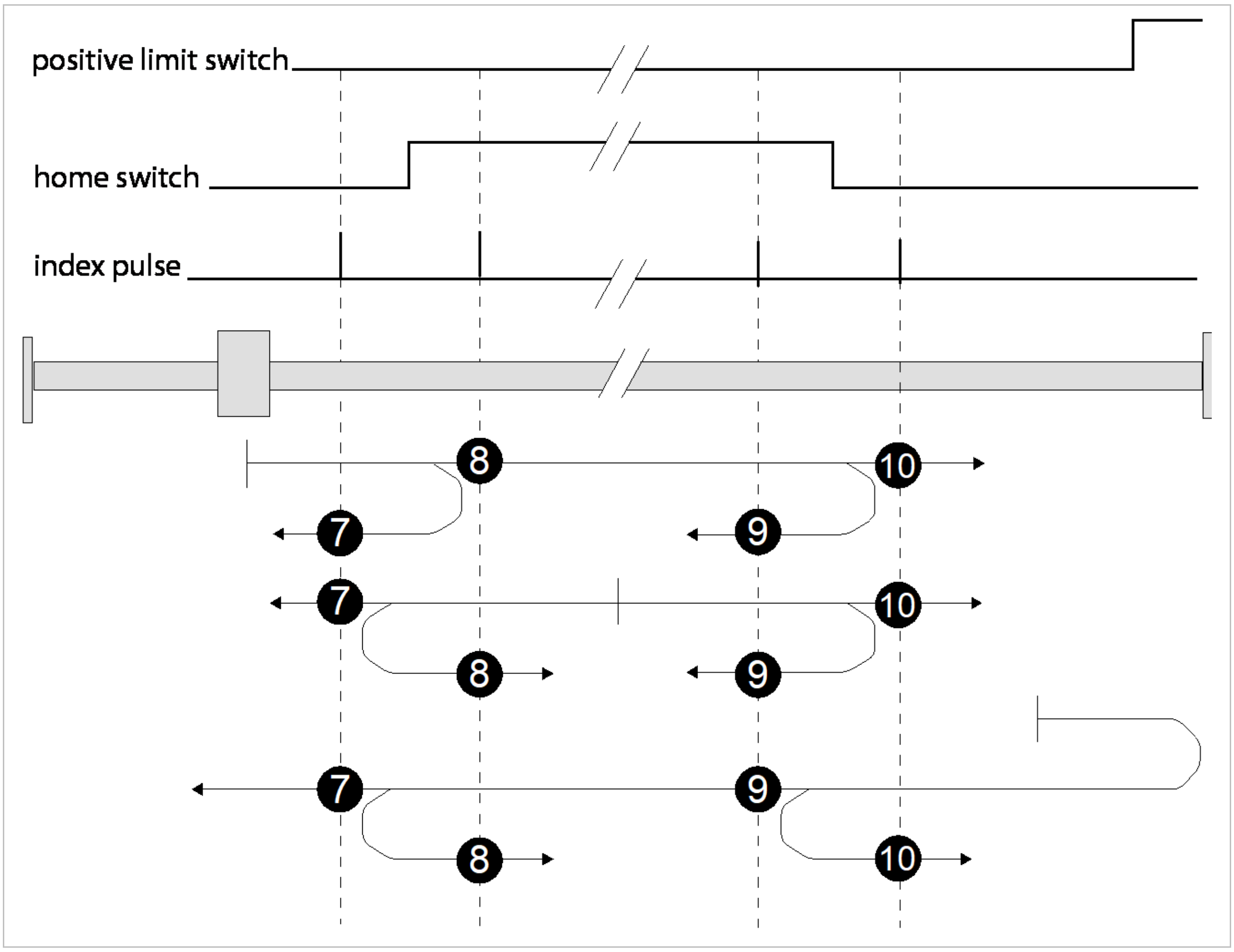


Figure 47: Homing – Method 7 to 14 (23 to 26)

4.8.3.5.6 Method 17 up to 30 Homing without zero track

These methods behave exactly like methods 1 to 14, except that the zero signal of the encoder is not considered.

4.8.3.5.7 Method 33 and 34 Homing to the zero track

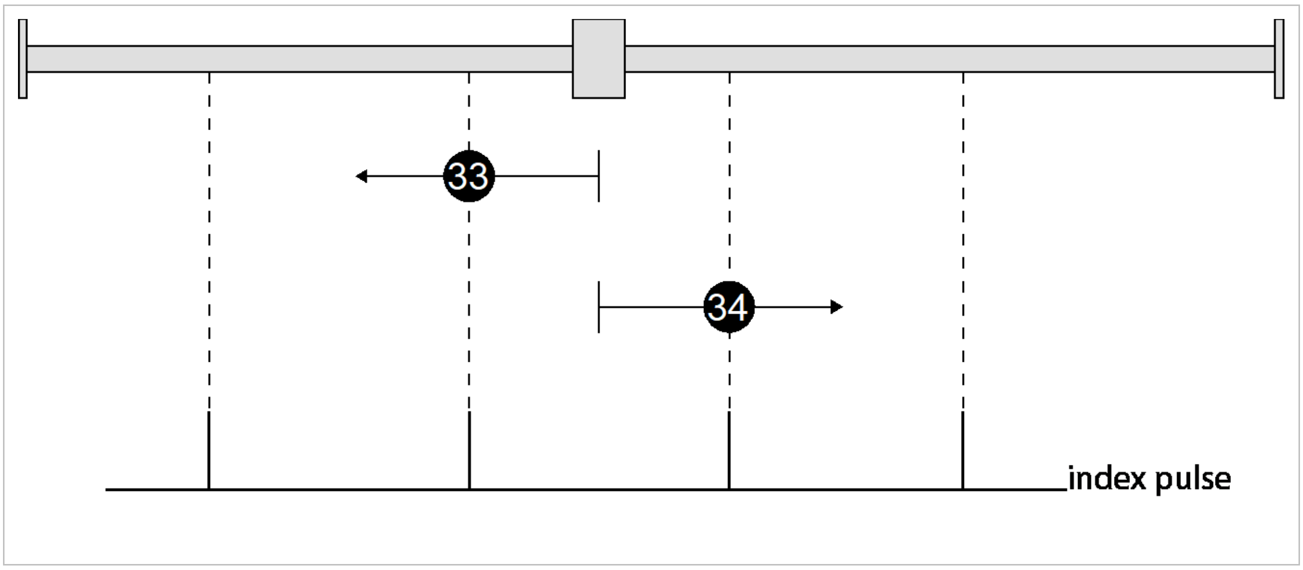


Figure 48: Homing – Method 33 and 34

4.8.3.5.8 Method 37 (35) Homing at current position

With this method, the drive does not move. The actual position is only overwritten by the position value in hm00.

4.8.3.6 Zero signal offset

Index	Id-Text	Name	Function
0x3115	hm21	zero point distance	Distance needed for the last zero point search. The optimum is always a half revolution (32768 increments). The sign indicates the direction of rotation.
0x3116	hm22	zero point offset	The next zero point search is corrected with this offset. +/- half a revolution can be corrected. With the value "-32768: auto" the optimal value for hm22 is automatically calculated from the measured value in hm21.
0x3117	hm23	homing options	Options for homing.

The additional referencing to the zero signal of the encoder increases the reproducibility of the reference position after homing (homing methods 1...16). This requires that the encoder is mechanically aligned to the reference limit switch so that the zero signal is about half a revolution next to the edge of the reference limit switch.

In addition to mechanical alignment, this adjustment can also be carried out by software. For this purpose, the distance between the edge of the reference limit switch and the edge of the zero signal is measured first. This distance is displayed in hm21 zero point distance.

A value can now be preset via hm22 zero point offset in order to correct the zero signal.

With the setting "-32768: auto“ the optimal value for the shifting of the virtual zero pulse is automatically calculated from the position distance in hm21.

Bit 0 check zero point offset in hm23 homing options has the following function:

hm23	homing options		0x3117
Bit	Function	Value	Function
0	check zero point offset	0 : off	Check the zero signal position to the reference limit switch. Min. 1/3 revolution, max. 2/3 revolution. Homing is not acknowledged positively if the condition is not met.
		1 : on	

4.8.3.7 Homing done

Error-free homing is stored internally and can be evaluated via the switching condition 54 „Homing done".

If the value of a parameter relevant for homing is changed (co03, co04, co08), Homing done is deleted.

An encoder error of the encoder selected by co04 also deletes Homing done.

After power-on, homing done is always 0.

4.8.3.8 Touch probe

The Touch probe is available in all operating modes. The function and the digital inputs are sampled with the time adjusted by is22. With a digital input or when passing the zero signal from the current position encoder, the actual position can be stored edge-dependent in hm12 or hm13.

The digital inputs I1...I4 are selectable for the touch probe.

The status of the function is displayed in hm11:

The respective operating mode is adjusted via hm10.

hm10	(CiA 0x60B8) touch probe function			0x310A 0x60B8
Bit	Function	Value	Plaintext	Notes
0	touch probe 1	0	off	Switching off the touch probe function
		1	enable	Activation of the touch probe function
1	trigger	0	first event	Unique storing of the position with an edge of the touch probe signal in hm12 or hm13. Automatic deactivation of the function after the edge.
		2	continous	The actual position is stored in hm12 or hm13 with each edge of the touch probe signal
2,3	source	0	touch probe 1	Digital input I1 serves as touch probe signal. The position of a positive edge is stored in hm12, the position of a negative edge is stored in hm13.
		4	zero signal of position encoder	Zero signal of position encoder serves as touch probe signal. The position for forward direction is stored in hm12, the reverse direction position is stored in hm13.
		8	source 0x60D0	The source for the touch probe can be selected via the object 0x60D0.

hm10	(CiA 0x60B8) touch probe function			0x310A 0x60B8
Bit	Function	Valu e	Plaintext	Notes
4	positive edge	0	switch off sampling	Sampling deactivated, no new values are taken over in hm12.
		16	enable sampling	Sampling activated, with positive edges values are taken over in hm12.
5	negative edge	0	switch off sampling	Sampling deactivated, no new values are taken over in hm13.
		32	enable sampling	Sampling activated, with negative edges values are taken over in hm13.

	touch probe source	0x60D0[1]
Value	Plaintext	Notes
1	I1	Digital input I1 is used for touch probe 1.
2	I2	Digital input I2 is used for touch probe 1.
3	I3	Digital input I3 is used for touch probe 1.
4	I4	Digital input I4 is used for touch probe 1.
5	zero signal of position encoder	The zero signal of the current position encoder is used for the touch probe.

hm11	(CiA 0x60B9) touch probe status			0x310B 0x60B9
Bit	Function	Value	Plaintext	Notes
0	state	0	switched off	Function deactivated
		1	enabled	Function waits for edge from touch probe signal
1	positive edge	2	positive edge stored	Positive edge at the digital input or zero impulse at forward direction of rotation was recognized and position stored in hm12
2	negative edge	4	negative edge stored	Negative edge at the digital input or zero impulse at reverse direction of rotation was recognized and position stored in hm13

4.8.4 Cyclic referencing

4.8.4.1 Cyclic referencing with digital input

The value range of the rotary table can be referenced when passing the defined home switch by hm08 home switch source. Thereby the positive edge of the initiator is selected at positive direction and the negative edge at negative direction.

This function is activated by presetting a value unequal zero in ps20 range ref window.

The referencing is only executed if the edge is in the defined window by ps20. At valid edge the internal position offset hm09 is modified by way that the actual position st33 position actual value is assigned to the preset reference value set with hm00 (CiA 0x607C) home offset at triggering edge.

Contrary an error counter is increased in ps21 if the window defined in ps20 range ref window is passed without recognizing an initiator. The error counter is reset again with valid initiator.

The homing mode with method 18 is reasonable for the first referencing to reach the same mechanical position which is used also for the cyclic referencing.

4.8.4.2 Automatic cyclic referencing

If a systematic error occurs due to an odd gear factor, it can be corrected automatically. The following two objects are installed for this purpose.

Index	Id-Text	Name	Function
0x2E17	ps23	position range periods	Number of periods of the rotary table value range which must be passed through to carry out the adjusted correction in ps24.
0x2E18	ps24	range correction	Correction in increments to be performed.

Example:

A drive shall operate a rotary table via a 7/9 gearbox and a toothed belt with gear ratio 1/13. For 7 rotations of the rotary table, the motor must rotate 9 * 13 = 117 times.

The encoder is mounted on the motor, so the position is specified as motor position.

The total gear ratio results to: $\frac{7}{9*13} = \frac{7}{117}$

One revolution of the rotary table = 117 / 7 = 16.714 motor revilutions.

If the position scaling is set to 1 revolution = 16 Bit = 65536 (co03 = 16), the rotary table range (ps19 (CiA 0x607B [2]) max position range limit – ps18 (CiA 0x607B [1]) min position range limit) is calculated to:

$$\frac{65536 * 117}{7} = 1.095.387,429$$

The decimal places must be omitted, since the rotary table value range can only be entered in whole numbers. The rotary table range ps19 … ps18 is therefore 1,095,387.

Due to this inaccuracy, an error adds up if the drive runs endlessly in one direction.

After 117 motor revolutions the real position difference is 117 * 65536 = 7667712

According to the definition of the rotary table area (by the rounding) the position difference after 7 revolutions should be = 7 * 1,095,387 = 7667709.

The difference between the real rotary table position after 7 rotary table rotations is: 7667712 - 7667709 = 3 increments.

A correction with 3 increments must be done after 7 revolutions at the rotary table.

This results in the setting ps23 = 7 and ps24 = 3

The higher the position resolution (co03) is selected, the lower the error and thus the correction value. Therefore at least co03 = 16 => 1 revolution corresponds to 65536 should be used.

4.8.5 Operating mode 8: Cyclic synchronous position mode

In operating mode "cyclic synchronous position mode", position setpoints are cyclically preset by the superior control. The superior control calculates the position profile, the position control circuit is at the motor.

The following figure shows the principle function.

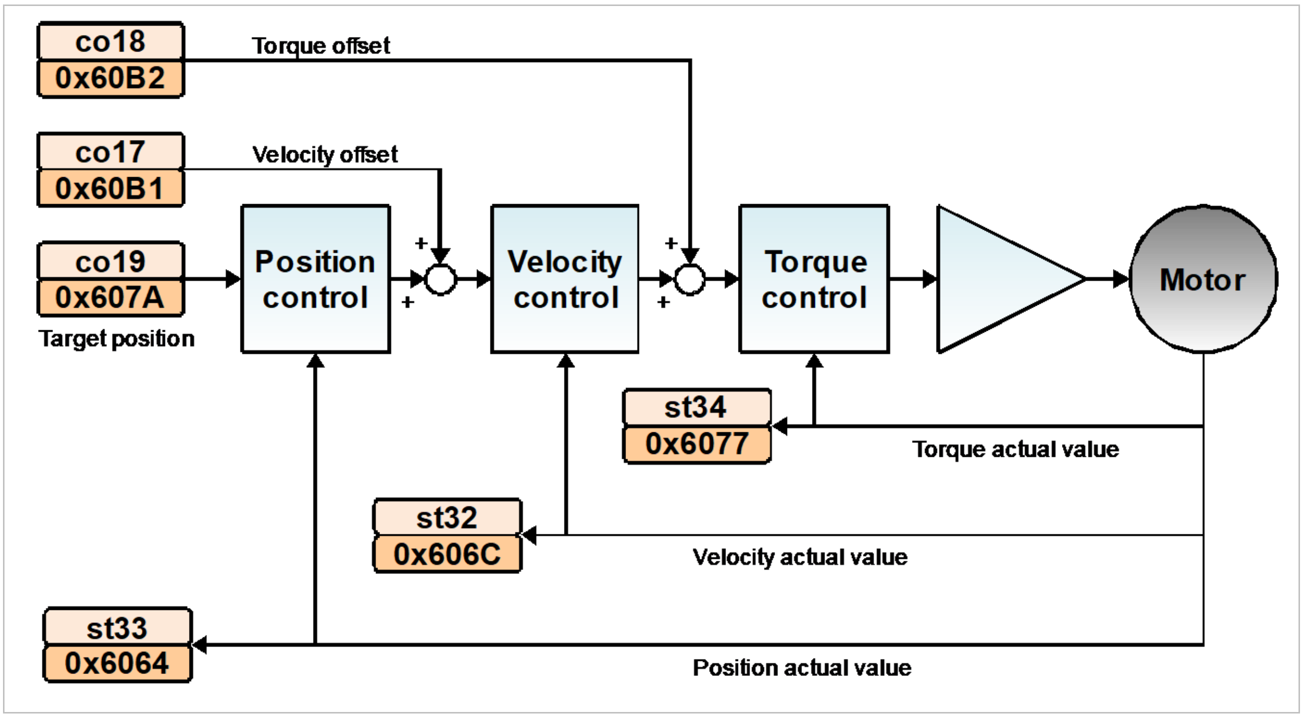


Figure 49: Cyclic synchronous position mode - overview

The yellow elements indicate the KEB specific objects, the orange-colored objects indicate the appropriate objects of the CiA402 profile.

The function of the individual objects can be influenced by different other function blocks. The following figure shows a detailed description of the operating mode.

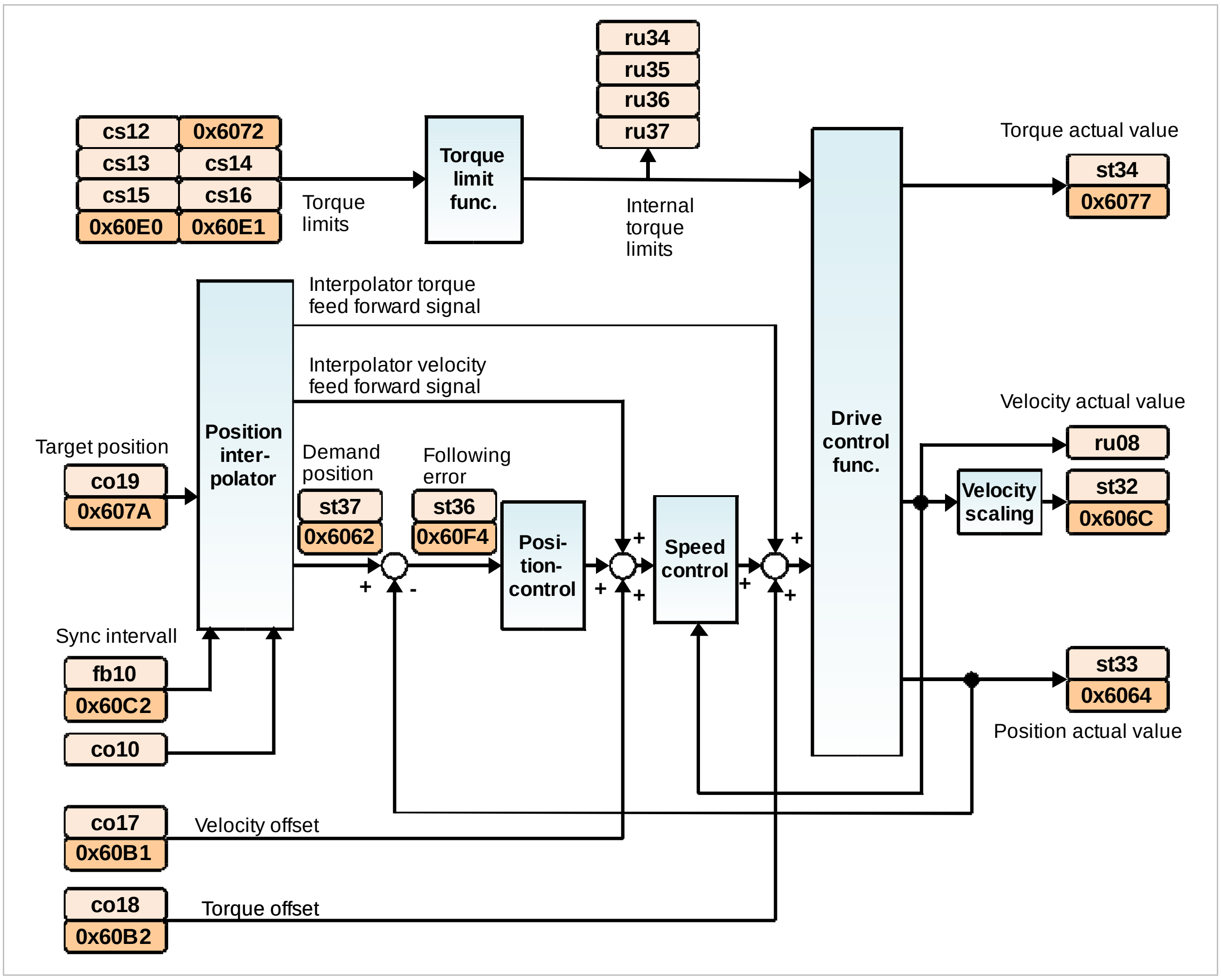


Figure 50: Cyclic synchronous position mode

The position setpoints are preset via the object co19.

Index	Id-Text	Name	Function
0x2513	co19	(CiA 0x607A) target position	Presetting the set position
0x607A		target position	

Then the position setpoints are interpolated to the cycle time of the internal control grid. The used method can be selected via the object co10.

Index	Id-Text	Name	Function
0x250A	co10	position interpolator	Determines the used interpolation method

The values of co10 have the following meaning:

<table>
<tr><td>co10</td><td colspan="3">position interpolator</td><td>0x250A</td></tr>
<tr><td>Bit</td><td>Function</td><td>Value</td><td>Plaintext</td><td>Notes</td></tr>
<tr><td rowspan="3">0…3</td><td rowspan="3">interpolator mode</td><td>0</td><td>Linear 2 points external pre control</td><td>Linear interpolation of the position, no internal pre-control of speed and torque. The pre-control can be done externally via co17 and co18.</td></tr>
<tr><td>1…3</td><td></td><td>reserved</td></tr>
<tr><td>4…15</td><td>B-Spline (n points)</td><td>B-spline interpolation via the last n points</td></tr>
<tr><td rowspan="2">4</td><td rowspan="2">init</td><td>0</td><td>init actual value</td><td>Initialization with actual values</td></tr>
<tr><td>16</td><td>init target value</td><td>Initialization with setpoints</td></tr>
</table>

⚠ CAUTION

Do not set the setting of the function **interpolation mode** to value "0: linear 2 points“ during axis operation.

- The speed pre-control value calculated before the changeover is no longer updated and also not deleted, but remains.
- In general, jumps / jerks are to be expected when adjusting during active positioning.

The interpolation results in a signal delay, which is calculated as follows:

Deceleration = cycle time (fb10) * (number of calculation points (co10) – 1)

Formula 1: Signal delay by interpolation

Example:

With a cycle time of 1ms and B-spline interpolation of 4 points, there is a delay of 1ms * (4-1) = 3ms.

The setpoint speed and the required set torque are directly derived from the set positions. The values are directly interpolated to the 250us grid of position and speed controller.

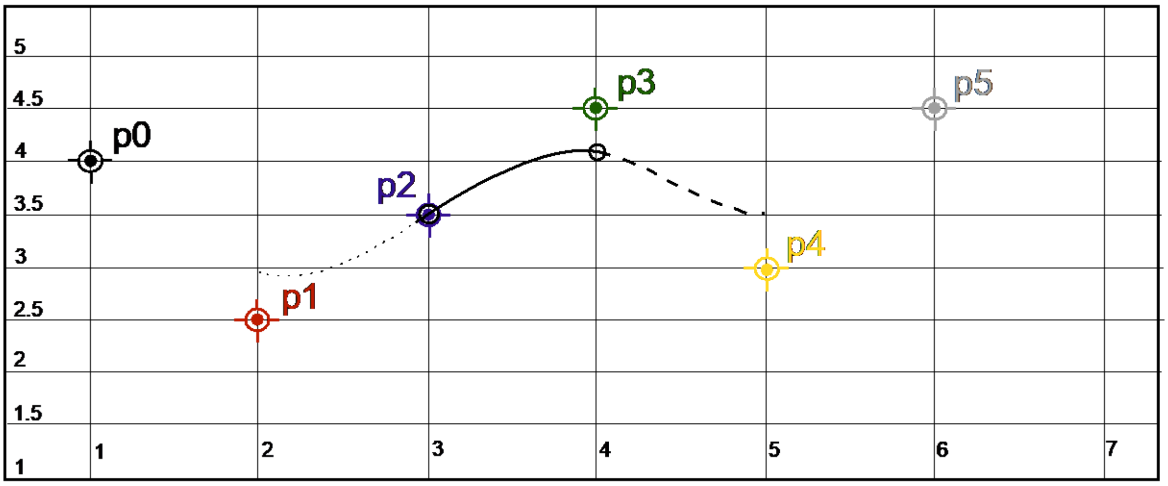


Figure 51: Example interpolation

If the number of grid points is increased withco10, possible errors in the set profile will be compensated better, but the set profile is also slightly straightened thereby.

Due to the minimum required 4 points, the position setpoint is delayed by the triple cycle time in fb10. The cycle time is three times between the 4 points. Each additional point corresponds to a delay of another cycle time in fb10.

However, the three control loops for position, speed and current are closed behind the interpolation. Thus the parameterization of co10 does not have any effects on the three control circuits.

At least four points are necessary since the precontrol values for speed and acceleration are calculated from the position setpoints by two-fold differentiation.

The type of initialization of the interpolator is selected with bit 4 in co10.

The setting "actual value" is favourable, if the mode change shall be made at standstill.

Value 16 "target value" should be selected if the operating mode shall be changed during operation.

For initialization with setpoints, new setpoints must be preset via co19 even before mode changeover. The number of setpoints, which must be preset at least before, is depending on co10: Number of setpoints = number of points -1.

This means: if co10 = 5 "B-Spline, 5 points average“, the setpoint must be written 4-times to co19 before mode changeover.

The function blocks torque limiting and selection of the torque offset are described in chapter 4.8.8

4.8.5.1 Position precontrol

In the Cyclic Sync Position Mode, the spline interpolator causes a temporal shift between the position setting by the higher-level control co19 (CiA 0x607A) target position and the actual set position for the motor ((CiA 0x6062) st37 demand position).

The time is made up from the process data communication and the setting of fb10 and co10.

This is a known time and it can be set for all axes. Then the track profiles are processed exactly synchronously on all axes with this constant deceleration.

If desired, the position offset between co19 and st37 can be corrected. Thus the driving profile has been slightly modified.

Index	Id-Text	Name	Function
0x250D	co13	pos. pre control	Position precontrol [us]

The value for co13 can be determined as follow.

The points of the interpolator in co10 are halved multiplied with fb10. Approx. one clock of fb10 must be considered as deceleration for the process data communication.

Example: co10 = 4: B-Spline, 4points avg + actual value
fb10 = 1ms
=> co13 ≈ 0.5 * 4ms + 1ms ≈ 2500µs…3000µs

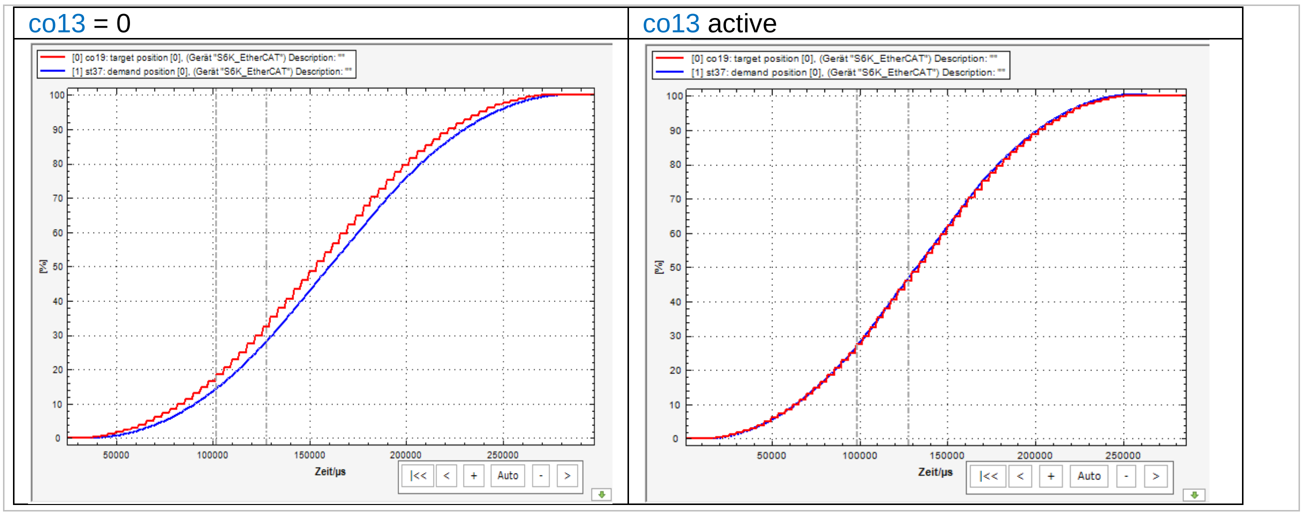


Figure 52: Position precontrol

4.8.5.2 Status displays

In cyclic synchronous position mode, bit 11 and 12 are set op mode-dependent in the statusword (0X2100 st00 / 0x6040).

st00	(CiA 0x6041) statusword	0x2100
Bit	Name	Note
11	internal limit active	This can be caused either by reaching of a torque or current limit (parameterized or hardware-dependent).
12	drive follows command value	Value 0: The drive does ***not*** follow the specification of target position. Value 1: The drive follows the setpoint setting of target position.

4.8.6 **Operating mode 9: Cyclic synchronous velocity mode**

4.8.6.1 General description

In operating mode „cyclic synchronous position mode", speed setpoints are cyclically preset by the superior control.

The position control is in the superior control and calculates the speed settings from the target position and the actual position, which is read by the drive.

The following figure shows the principle function.

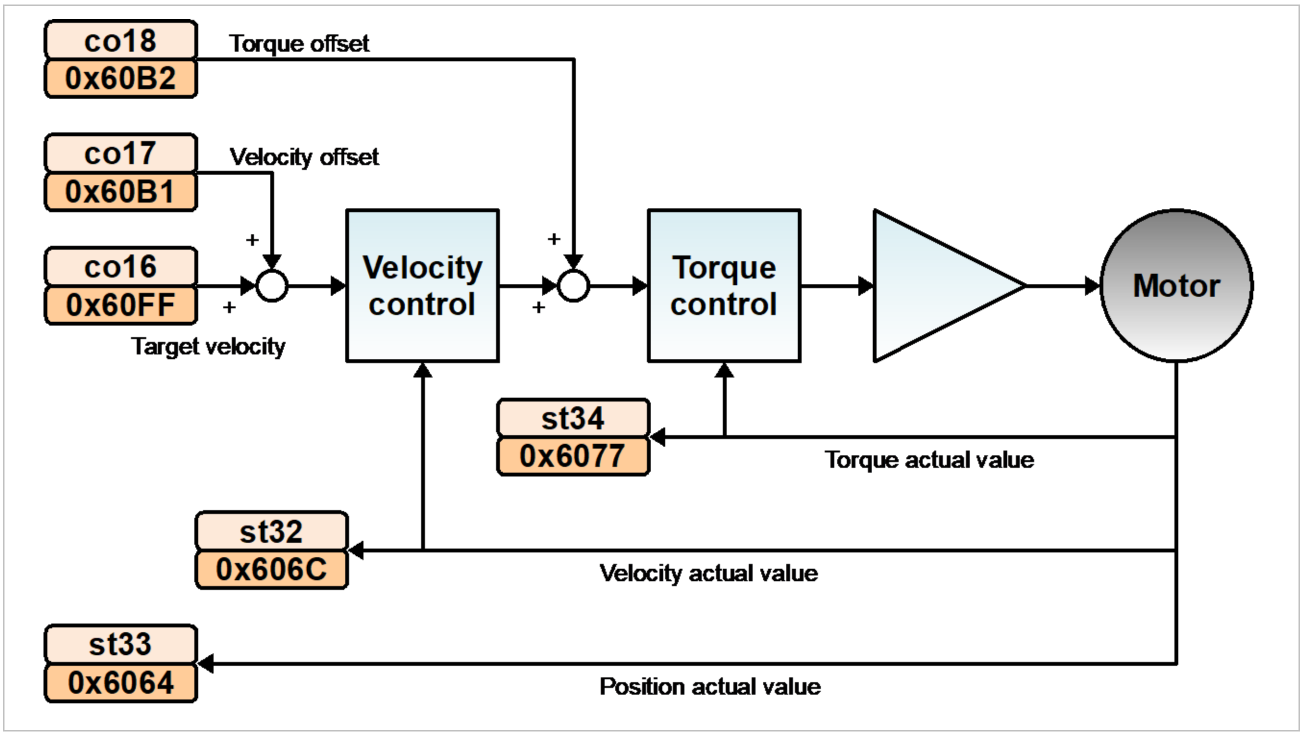


Figure 53: Cyclic synchronous velocity mode - principle

The yellow elements indicate the KEB specific objects, the orange-colored objects indicate the appropriate objects of the CiA402 profile.

The function of the individual objects can be influenced by different other function blocks. The following figure shows a detailed description of the operating mode.

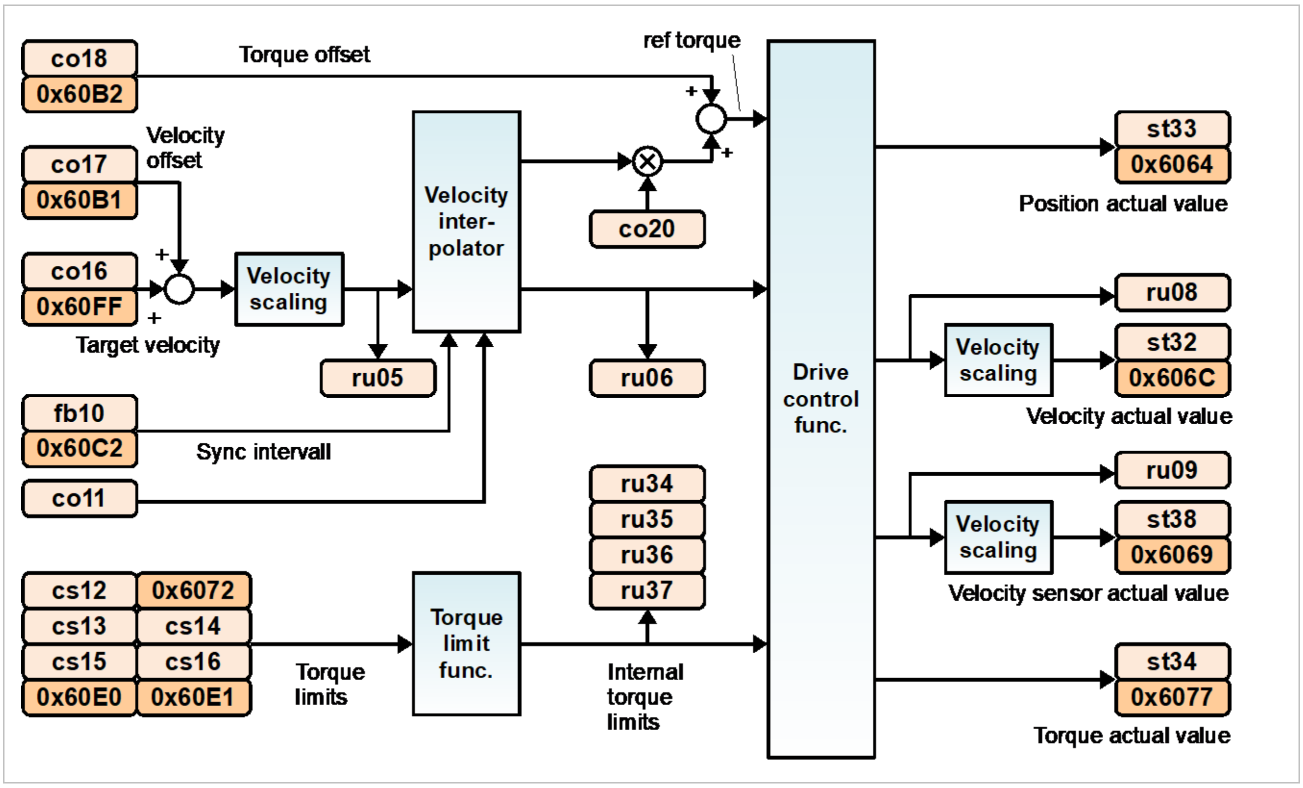


Figure 54: Cyclic synchronous velocity mode

4.8.6.2 Speed settings

The speed setpoints are preset via the objects co16 and co17.

Index	Id-Text	Name	Function
0x2510	co16	(CiA 0x60FF) target velocity	Setting the setpoint speed
0x60FF		target velocity	
0x2511	co17	(CiA 0x60B1) velocity offset	Is added to target velocity
0x60B1		velocity offset	

The resolution of these objects is depending on the adjusted speed scaling. This is adjusted via co02 velocity shift factor.

Index	Id-Text	Name	Function
0x2502	co02	velocity shift factor	Determination of the speed resolution for setpoints and actual values in co, st and pr parameters in the cyclic operating modes.

The values of co02 have the following meaning:

co02	velocity shift factor					0x2502
Value	Name	Function	Value	Name	Function	
0	13 bit	Resolution 13 Bit = 1/8192 rpm	7	6 bit	Resolution 6 Bit = 1/64 rpm	
1	12 bit	Resolution 12 Bit = 1/4096 rpm	8	5 bit	Resolution 5 Bit = 1/32 rpm	
2	11 bit	Resolution 11 Bit = 1/2048 rpm	9	4 bit	Resolution 4 Bit = 1/16 rpm	
3	10 bit	Resolution 10 Bit = 1/1024 rpm	10	3 bit	Resolution 3 Bit = 1/8 rpm	
4	9 bit	Resolution 9 Bit = 1/512 rpm	11	2 bit	Resolution 2 Bit = 1/4 rpm	
5	8 bit	Resolution 8 Bit = 1/256 rpm	12	1 bit	Resolution 1 Bit = 1/2 rpm	
6	7 bit	Resolution 7 Bit = 1/128 rpm	13	0 bit	Resolution 0 Bit = 1 rpm	

Internally all speed values with a resolution of 1/8192 rpm are displayed.

The following objects of the defined resolution in co02 are adapted in all operating modes. 0x606B velocity demand und 0x2120, 0x606c st32 velocity actual value.

4.8.6.3 Interpolator

Then the speed setpoints are interpolated to the cycle time of the internal control grid. The used method can be selected via the object co11.

Index	Id-Text	Name	Function
0x250B	co11	velocity interpolator	

The values of co11 have the following meaning:

co11	velocity interpolator			0x250B
Bit	Function	Value	Plaintext	Notes
0…3	interpola-tor mode	0	linear, 2 points avg	Linear interpolation between the last two values
		1	no interpolation	Direct acceptance of the setpoint
		2	reserved	
		3…15	B-spline, n points avg	B-spline interpolation via the last n points
4	init	0	actual value	Initialization with actual values
		16	target value	Initialization with setpoints

The interpolation results in a signal delay, which is calculated as follows:

Deceleration = cycle time (fb10) * (number of calculation points (co11) – 1)

Example:

With a cycle time of 2ms and B-spline interpolation of 4 points, there is a delay of 2ms * (4-1) = 6ms.

Additionally to the interpolated speed setpoint, the speed interpolator also generates the corresponding torque profile.

4.8.6.4 Torque limiting and precontrol

The function blocks **torque limiting** and **torque precontrol** are described in chapter 4.8.9 Operating mode-independent functions

4.8.6.5 Status displays

In cyclic synchronous mode, bit 11 and 12 are set op mode-dependent in the statusword (0X2100 st00 / 0x6040).

st00	(CiA 0x6041) statusword	0x2100
Bit	Name	Note
11	internal limit active	This can be caused either by reaching of a torque or current limit (parameterized or hardware-dependent).
12	drive follows command value	Value 0: The drive does ***not*** follow the setting of target velocity and velocity offset. Value 1: The drive follows the setpoint setting of target velocity and velocity offset.

4.8.7 Operating mode 10: Cyclic synchronous torque mode

4.8.7.1 General description

In cyclic sync torque mode, new set torque settings are transferred to the drive controller by a higher-level control with each bus cycle. The Drive Controller does not calculate any acceleration or deceleration ramps, it only follows the torque settings from the control. The target torque is transmitted via the process data channel (PDO).

Torque control is not possible in v/f operation.

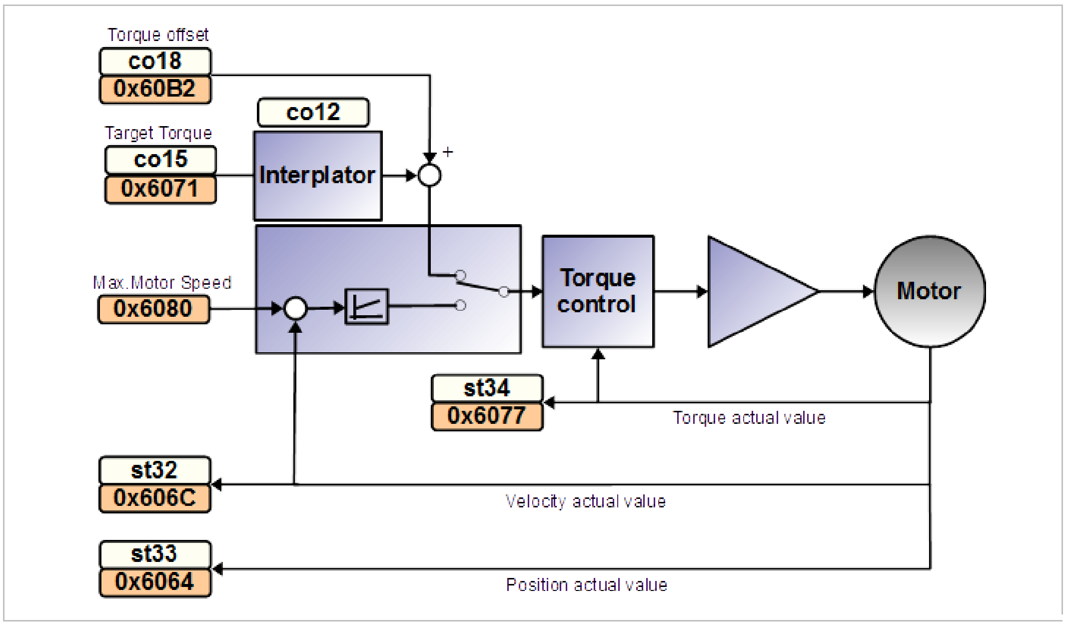


Figure 55: Cyclic synchronous torque mode - Overview

4.8.7.2 Interpolator

The setpoint is interpolated to the cycle time of the internal control grid. The used method can be selected via the object co12.

Index	Id-Text	Name	Function
0x250C	co12	torque interpolator	Interpolation of the torque setpoint

co12	torque interpolator		0x250C
Value	Name	Note	
0	linear, 2 points avg	Linear interpolation between two values (average value)	
1	no interpolation	Direct acceptance of the torque setpoint	
2	B-spline, 2 points avg	B-spline, from 2 values	
3	B-spline, 3 points avg	B-spline, from 3 values	
...			
15	B-spline, 15 points avg	B-spline, from 15 values	

With co12 = "1: no interpolation“, the torque setpoints are directly taken over.

This setting is ideal for the "cyclic synchronous torque mode", because no controller precontrols must be calculated in this mode and only the fastest possible reaction of the drive to the setpoint is important.

4.8.7.3 Setpoint setting

The torque setpoints are specified via object co15.

Index	Id-Text	Name	Function
0x250F	co15	(CiA 0x6071) target torque	Setting of the setpoint torque to the spline interpolator
0x6071		target torque	

This parameter can be used to specify a torque offset value. This value is added directly to the interpolator output value.

Index	Id-Text	Name	Function
0x2512	co18	(CiA 0x60B2) torque offset	Setting of the torque offset
0x60B2		torque offset	

The resolution of co15 and co18 is defined via co84 torque resolution. (Description which parameters are affected by this parameter, see chapter 4.8.7.4 Torque resolution)

The value calculated from target torque and torque offset passes through subsequently the torque limiting block (see chapter 4.8.7.5 Limitation of the torque setting).

The resulting torque setpoint can be smoothed with a PT1 filter. (See chapter 6.3.7 Speed controller PT1 output filter)

Index	Id-Text	Name	Function
0x2714	cs20	torque ref. Pt1-time	Pt1 time torque reference

The active setpoint for torque control is displayed in ru23

Index	Id-Text	Name	Function
0x2C17	ru23	reference torque	Control set torque (resolution constant 0.1% rated torque dr09)

4.8.7.4 Torque resolution

Index	Id-Text	Name	Function
0x2554	co84	torque resolution	Setting of the resolution of the torque reference / display

co84	torque resolution		0x2554
Value	Plaintext	Resolution	Meaning
0	0,1	1/10 dr09	In order to achieve a higher resolution of 1 per mil of the rated torque dr09, the resolution of some parameters can be parameterized via co84
1	0,05	1/20 dr09	
2	0,025	1/40 dr09	
3	0.0125	1/80 dr09	
4	0,01	1/100 dr09	

All co / st parameters and some parameters of the pr group are influenced by the variable resolution.

The resolution of the torque limits, in the cs parameters and in the pr parameters, is always constant 0.1% dr09 rated torque.

The resolution of the set torque setting via target torque (0x 250F co15 / 0x6071) and torque offset (0x2512 co18 / 0x60B2) is variable.

The resolution of the precontrol torque for brake handling co26[3] is variable.

The resolution of the display of control set torque and actual torque in the ru parameters (ru23 reference torque and ru24 actual torque) is constant 0.1% dr09 rated torque.

The resolution of the display of the actual torque in 0x2122 st34 / 0x6077 torque actual value is variable.

The following parameters are influenced by co84 torque resolution:

0x250F	0x6071	target torque
0x2512	0x60B2	torque offset
0x251A	SubIdx 3	brake ctrl => pre torque setting
0x2122	0x6077	torque actual value

4.8.7.5 Limitation of the torque setting

The set torque in the cyclic synchronous torque mode is also limited like the output signal of the speed controller in the other modes.

The following still apply

- application-specific limitations (cs12..cs16 bzw. 0x6072, 0x60E0, 0x60E1)
- physical limiting characteristic of the motor (motor data, ds11)
- torque limits resulting from maximum currents (motor data, is parameters, inverter limit values)

4.8.7.6 Actual torque display

The display in the ru parameter group occurs with constant resolution, the resolution in the st and pr parameter group is determined by co84.

Index	Id-Text	Name	Function
0x2C18	ru24	actual torque	Actual torque Resolution constant 0.1% rated torque dr09

Index	Id-Text	Name	Function
0x2122	st34	torque actual value	Actuial torque Resolution defined by co84
0x6077			

4.8.7.7 Status displays

In cyclic synchronous mode, bit 11 and 12 are set op mode-dependent in the statusword (0X2100 st00 / 0x6040).

st00	(CiA 0x6041) statusword		0x2100
Bit	Name	Note	
11	internal limit active	The flag is set if the torque setpoint from co15 (after interpolator) and co18 cannot be reached. This can be caused either by reaching of a torque or current limit (parameterized or hardware-dependent) or by leaving the torque control when an overspeed is detected (see chapter 4.8.7.8 Interception of overspeeds)	
12	drive follows command value	Value 0: The drive does ***not*** follow the setting of target torque and torque offset. Value 1: The drive follows the torque setpoint setting of target torque and torque offset.	

4.8.7.8 Interception of overspeeds

Parameter 0x6080 max. motor speed forms a superimposed setpoint speed limitation which intervenes directly before the speed controller.

If the counter torque (load torque) is omitted in torque-controlled operation, the drive must not accelerate to any speed.

Therefore, when reaching the parameterized maximum speed 0x6080 max.motor speed it is switched into the speed-controlled mode.

Index	Id-Text	Name	Function
0x6080		max motor speed	Resolution defined by co02 velocity shift factor

The changeover is indicated in statusword bit12 (0: The drive does ***not*** follow the setting of target torque and torque offset).

The sign of the maximum speed is taken from the sign of the torque setpoint. The signed maximum speed is displayed in parameter ru06 ramp out display.

A changeover of the internal mode from torque-controlled to speed-controlled occurs when the amount of the actual speed is higher than the amount of the maximum speed.

The return from the speed-controlled mode to the selected torque-controlled mode occurs when the actual speed is lower than the setpoint speed (maximum speed).

Furthermore, in the case of a positive set torque (sum of the target torque and torque offset) the torque required to maintain the maximum speed must be higher than the specified set torque. Only if the torque setpoint is lower than the torque required to adjust the speed at the moment, it will be avoided that the drive immediately accelerates beyond the speed limit of max. motor speed. The same applies to reverse direction of rotation.

In torque-controlled mode, the integral part of the Pi speed controller is precharged with *ZERO* if the actual speed and the preset set torque have the same sign.

4.8.7.9 Structure overview

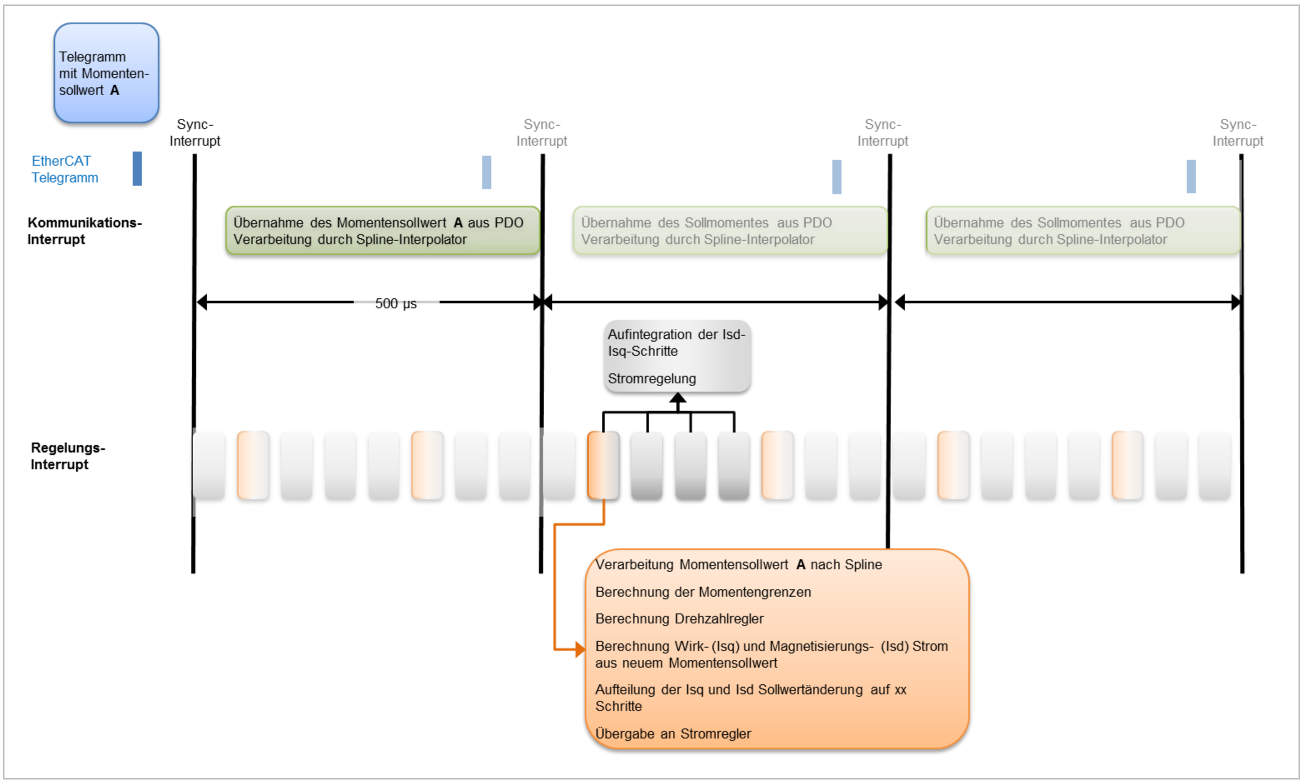


Figure 56: Transfer torque setpoint telegram -> current controller

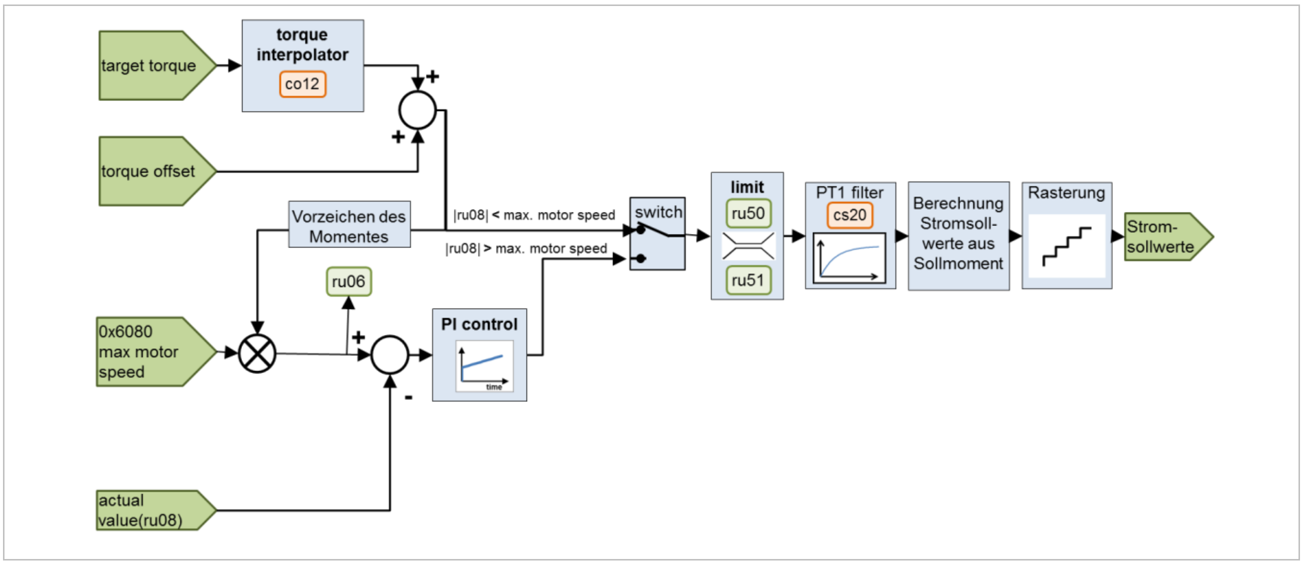


Figure 57: Torque control and overspeed interception

4.8.8 Operating mode -2: jog mode in the cm customer modes group

The drive should be able to be moved at any time, independent of the traversal manner set in automatic mode. For this purpose, an operating mode has been introduced which allows this with appropriate adapted conditions.

⚠ CAUTION

All reactions to configurable errors that do not trigger an error, but only a quick stop (e.g. Disable Operation) are suppressed when the Jog Mode is active!

➢ If an error reaction shall be triggered even when Jog mode is active, settings must be used in the corresponding stop mode parameter ("0: fault“ or "1: dec to stop“) that also trigger an error

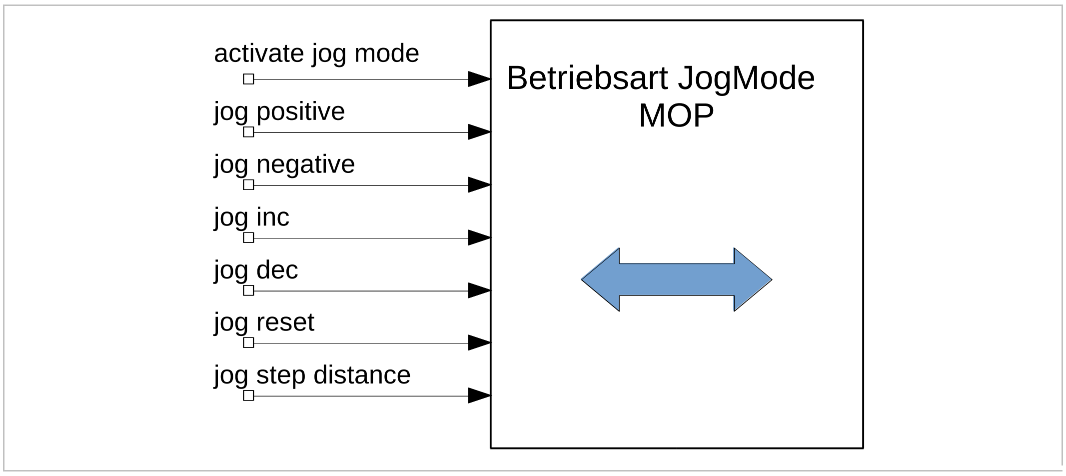


Figure 58: Operating mode jog mode

4.8.8.1 Digital inputs

Definition of digital inputs in jog mode:

Index	Id-Text	Name	Function
0x3B1F	cm31	inc motor poti input	Incrementing the motor poti (MOP) setpoint for the jog mode
0x3B20	cm32	dec motor poti input	Incrementing the motor poti (MOP) setpoint for the jog mode (priority over jog inc MOP input)
0x3B21	cm33	reset motor poti input	Reset the motor poti setpoint to the reset value preset by cm28. (priority over jog inc/dec MOP inputs)
0x3B22	cm34	activate jog mode	Activation of jog mode. Alternatively, this can also be done via the 01 co.modes of operation object. (-2 : jog mode)
0x3B23	cm35	jog positive	jog mode in positive direction
0x3B24	cm36	jog negative	jog mode in negative direction
0x3B25	cm37	activate jog speed 2	Selection of the second speed

Index	Id-Text	Name	Function
0x3B26	cm38	jog step mode	Selection of the step size limitation in jog mode. The setpoint is enabled as long as the preset step distance has not been exceeded.

4.8.8.1.1 Error handling in jog mode

By activating the jog mode via the digital input specified in cm34, any errors that may have occurred are automatically reset once. The two fieldbus errors from pn22 E.fb watchdog and pn23 E.fb heartbeat are not active in jog mode. Hardware limit switches and software limit positions are observed in jog mode, errors which are selectable by pn20 E.SW-switch stop mode, pn78 limit swich forware stop mode and pn79 limit switch reverse stop mode are suppressed.

4.8.8.1.2 Status machine in jog mode

If the jog mode is activated via co01 modes of operation, the status machine is not affected. This must be started via the co00 (CiA 0x6040) controlword.
If the input function is used with cm34, the status machine is first briefly reset, then after an error reset the status machine is automatically started up to Operation Enabled. For this the co00 (CiA 0x6040) controlword is internally switched off. If the input of cm34 is deactivated again, the status machine is shut down again. The drive cannot start unintentionally when leaving the jog mode.

4.8.8.1.3 Setpoints

Definition of setpoints in jog mode:

Index	Id-Text	Name	Function
0x3B17	cm23	min limit for motor poti	0,00% … 100,00% Limitation of the MOP setpoint separately for both directions of rotation.
0x3B18	cm24	max limit for motor poti	
0x3B19	cm25	min limit rev motor poti	
0x3B1A	cm26	max limit rev motor poti	
0x3B1B	cm27	motor poti ref value	Reference speed to which the 100% value of the MOP function refers. 0 …128000 rpm
0x3B1C	cm28	motor poti reset value	Reset value of the MOP function in % -100.00% … 100.00%
0x3B1D	cm29	motorpoti inc gain [%/s]	Increase of the MOP setpoint when the jog inc MOP input is active in %/s
0x3B1E	cm30	motor poti dec gain [%/s]	Increase of the MOP setpoint when the jog dec MOP input is active in %/s
0x3B29	cm41	jog speed 1 positive	Speed 1 in positive direction of rotation
0x3B2A	cm42	jog speed 1 negative	Speed 1 in negative direction of rotation
0x3B2B	cm43	jog speed 2 positive	Speed 2 in positive direction of rotation
0x3B2C	cm44	jog speed 2 negative	Speed 2 in negative direction of rotation
0x3B2D	cm45	jog step distance	Maximum step distance in jog mode when step size limitation is active.

4.8.8.1.4 Options of the jog mode

Index	Id-Text	Name	Function
0x3B2E	cm46	jog mode options	Options for the jog mode.

The bits in cm46 have the following functions:

cm46	jog mode options		0x3B2E
Bit	Function	Value	Function
0	limit swich	0 : off	Hardware limit switches in hm06 or hm07 are ignored.
		1 : on	Hardware limit switch active.
1	sw limit switch	0 : off	Software end positions in pn18 and pn19 are not active.
		2 : on	Software end positions active.
2,3	jog mode	0 : standard	Setpoints are preset by cm41 ... cm44
		4 : jog pos/neg	Setpoints are generated by MOP. cm23 ... cm30 Only positive setpoints are possible between cm23 and cm24. The direction of rotation determines the jog positive or jog negative inputs.
		8 : sign of ref	The direction of rotation results from the sign of the MOP setpoint. The jog positive or jog negative inputs are not evaluated.
4,5	MOP re-set	0 : start with 0	Motorpoti function always starts with setpoint 0
		16 : reset value	Start with cm28 motor poti reset value
		32 : last ref value	After the start the last motor poti setpoint is active.

4.8.8.2 Ramp generator in jog mode

4.8.8.2.1 Maximum acceleration / deceleration

The maximum acceleration or deceleration is parameterized via the following objects. The resolution of the values is 1/100 s^{-2} = 0.01 s^{-2}.

Index	Id-Text	Name	Function
0x3B30	cm48	jog acceleration for [s-2]	Maximum acceleration at FOR direction of rotation (pos. speeds)
0x3B31	cm49	jog deceleration for [s-2]	Maximum deceleration at FOR direction of rotation (pos. speeds)
0x3B32	cm50	jog acceleration rev [s-2]	Maximum acceleration at REV direction of rotation (neg. speeds)
0x3B33	cm51	jog deceleration rev [s-2]	Maximum deceleration at REV direction of rotation (neg. speeds)

4.8.8.2.2 Jerk limiting

The maximum acceleration change (jerk) is parameterized via the following objects. The resolution of the values is 1/100 s^{-3} = 0.01 s^{-3}.

Index	Id-Text	Name	Function
0x3B34	cm52	jog for acc jerk ls [s-3]	Maximum jerk at acceleration in FOR direction of rotation (low speed)
0x3B35	cm53	jog for acc jerk hs [s-3]	Maximum jerk at acceleration in FOR direction of rotation (high speed)
0x3B36	cm54	jog for dec jerk hs [s-3]	Maximum jerk at deceleration in FOR direction of rotation (high speed)
0x3B37	cm55	jog for dec jerk ls [s-3]	Maximum jerk at deceleration in FOR direction of rotation (low speed)
0x3B38	cm56	jog rev acc jerk ls [s-3]	Maximum jerk at acceleration in REV direction of rotation (low speed)
0x3B39	cm57	jog rev acc jerk hs [s-3]	Maximum jerk at acceleration in REV direction of rotation (high speed)
0x3B3A	cm58	jog rev dec jerk hs [s-3]	Maximum jerk at deceleration in REV direction of rotation (high speed)
0x3B3B	cm59	jog rev dec jerk ls [s-3]	Maximum jerk at deceleration in REV direction of rotation (low speed)

4.8.8.2.3 Operating modes of the ramp generator

The behaviour of the ramp generator can be adapted to the requirements of the application via object cm60 jog ramp mode.

Index	Id-Text	Name	Function
0x3B3C	cm60	jog ramp mode	Operational performance of the ramp generator

The bits in cm60 have the following functions:

cm60	jog ramp mode		0x3B3C
Bit	Function	Value	Function
0	ramp type	0: S-curve	S-curves
		1: lin	Linear ramps
1	linear ramp acc/dec	0: sep. para	cm48-cm51
		2: acc for para	cm48 is acceleration/deceleration setting for all directions of rotation (only effective if linear ramps are selected, otherwise cm48-cm51 always apply)
2	s-curve type	0: continous s-curve	Function => Graphics in co mode
		4: abort in s-curve	
3	pass zero type	0: not zero	Function => Graphics in co mode
		8: zero	

Bit 4 … 7 see co60

Drive profiles

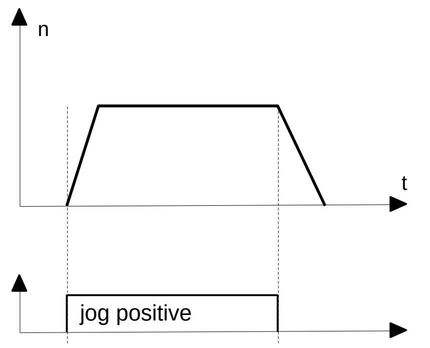
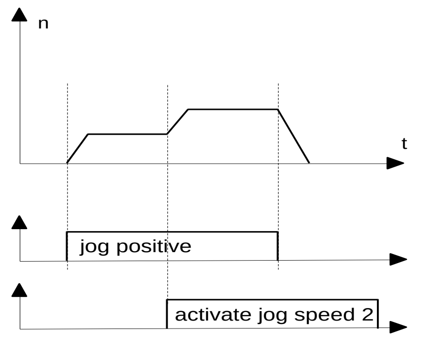
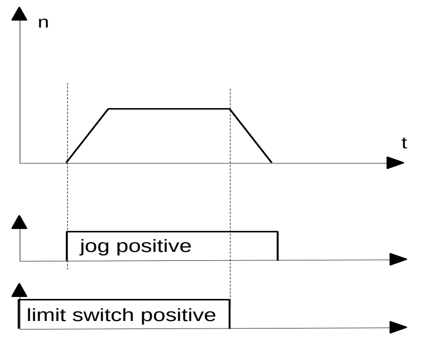
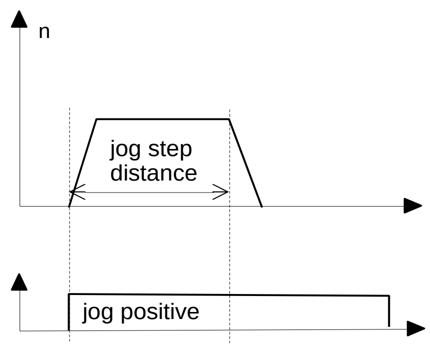
	Jog mode when activating jog positive.
	Speed 2 is activated by activate jog speed 2. After removal of jog positive it is decelerated with the set ramp.
	Jog mode on hardware limit switch. The drive decelerates with the set ramps to 0. Driving free in the opposite direction is possible. The same behavior also occurs when the software end positions will be passed (pn18, pn19).
	Jog mode with step size limitation. With the input jog step mode you can choose permanently if the step limitation shall be used. With each pos. edge at jog positive or jog negative the step limitation is restarted, or with each setting of the jog input, the setpoint is activated until jog step distance has been passed. For the special case that the jog step mode is activated while jog is already active, the edge at this input also initializes the step limitation.

Figure 59: Drive profiles in jog mode

4.8.8.3 State of the jog mode

The state of the jog mode is displayed via the object cm61 jog mode state.

Index	Id-Text	Name	Function
0x3B3D	cm61	jog mode state	Status displays of the jog mode.

The bits in cm61 have the following functions:

cm61	jog mode state		0x3B3D
Bit	Function	Value	Function
0…1	jog mode positive	0 : off	jog mode not activated
		1 : pos	jog mode active in the positive direction
		3 : pos v2	jog mode active in positive direction with second speed
2…3	jog mode negative	0 : off	jog mode not activated.
		4 : neg	jog mode active in negative direction
		12 : neg v2	jog mode active in negative direction with second speed
4	step dis-tance	0 : off	no limitation of the setpoint
		16 : distance	The step size limitation has responded the setpoint in jog mode has been limited.
5	limit switch	0 : off	no limitation of the setpoint
		32 : lim switch	A hardware limit switch (hm06, hm07) has responded, the set-point has been limited.
6	sw limit switch	0 : off	no limitation of the setpoint
		64 : sw limit	A software end position (pn18, pn19) has responded, the setpoint has been limited.

4.8.8.4 Current motorpoti setpoint

Index	Id-Text	Name	Function
0x3B3E	cm62	motor poti actual value	Setpoint currently selected by the motor poti function. -100,00% … 100,00%

4.8.9 Operating mode-independent functions

4.8.9.1 System inversion

According to the definition, the motors rotate with positive setpoints in clockwise rotation when looking at the motor shaft. If this is not required, the real motor direction can be changed by this parameter. After activating the system inversion with co06 = 2, nothing changes except the physical direction of rotation of the motor: an adjusted positive speed setpoint causes a positive speed actual value display and a positive torque display with positive speed display indicates motorized operation. Ramps, limits and similar are not affected. All settings and displays therefore remain consistent. The display of ***both*** encoder channels is inverted to the physical direction of rotation.

Index	Id-Text	Name	Function
0x2506	co06	system inversion	System inversion

co06	system invertion			0x200F
Bit	Function	Value	Plaintext	Notes
0…1	on	0	off	Function off
		1	reserved	The old type of system inversion is still supported for reasons of compatibility. The parameter displays are only partially consistent, since some parameters still display the real value and not the inverted value. Therefore, always use value 2 for the system conversion in new applications.
		2	on, plus encoder inversion ChA + ChB	The system inversion is realized by the internal change in the control of two motor phases (U⇔W). Additionally ***both*** encoder channels (A and B) are inverted. This only changes the real, physical direction of rotation of the motor.

4.8.9.2 Torque precontrol from spline-interpolator / ramp generator

A set torque is calculated from the internal speed difference of the ramp generator or the interpolator in the cyclic operating modes, depending on the mass moment of inertia (cs17 + dr32). This torque precontrol can be fine adjusted with factor co20.

Index	Id-Text	Name	Function
0x2514	co20	internal pretorque fact	Evaluation of torque pre-control from interpolator or ramp generator

Contrary to older firmware versions, a precontrol value is currently calculated from the spline-interpolator also at value 0 (linear interpolation) and value 3 "B-spline 3 points average“.

Adjustment 2 "reference torque“ can always be used in cs21 pretorque mode. (Description of the torque precontrol => Chapter 6.3.8 Torque precontrol)

The speed or position interpolator calculates the torque for precontrol, based on the acceleration profile and the mass moment of inertia of motor and load. Therefore, the correct setting of dr32 and cs17 must be ensured.

4.8.9.3 Application-specific torque limitation

The torque limitation is parameterized via the following objects.

The torque limits are indicated in % referring to the rated motor torque. The resolution is 0.1%.

Index	Id-Text	Name	Function
0x270C 0x6072	cs12 ---	absolute torque max torque	Max. torque (applies in all quadrants)
0x270D 0x60E0	cs13 ---	torque limit mot for positive torque limit value	Torque limit mot., positive speed
0x270E 0x60E1	cs14 ---	torque limit mot rev negative torque limit value	Torque limit mot., negative speed -1: Value is accepted from cs13
0x270F	cs15	torque limit gen for	Torque limit gen., positive speed -1: Value is accepted from cs13 -2: Value is accepted from cs14
0x2710	cs16	torque limit gen rev	Torque limit gen., negative speed -1: Value is accepted from cs15 -2: Value is accepted from cs13

The following behavior is described in the CiA402 profile: **positive torque limit value** is valid for mot. for and gen. rev
negative torque limit value is valid for mot. rev and gen. for
To achieve this behavior, the following setting must be made: cs16 = -2 (cs16 = cs13) ; cs15 = -2 (cs15 = cs14)

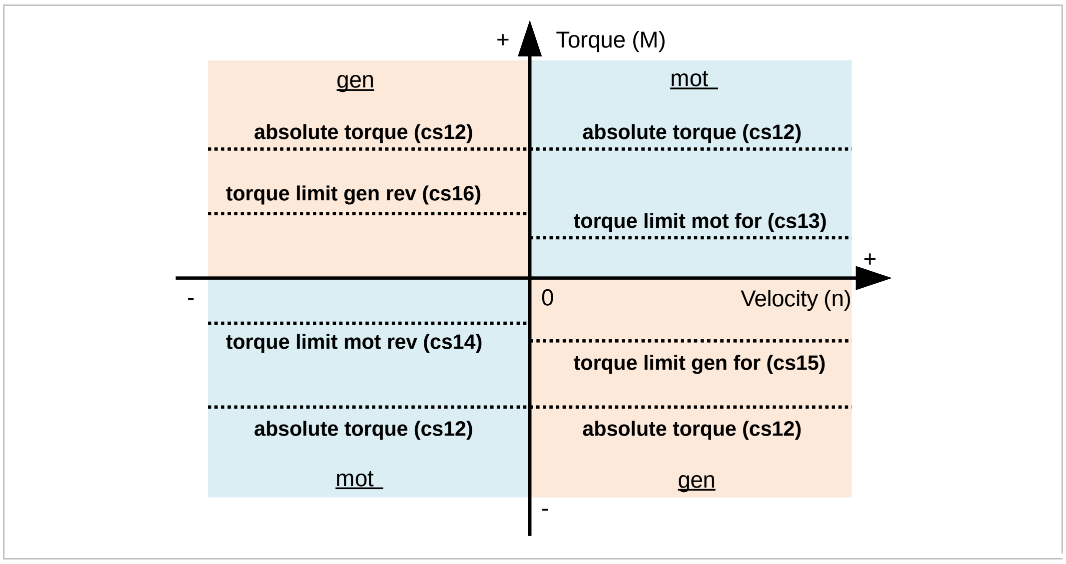


Figure 60: Torque limit in all quadrants

The smallest limit is activated in each quadrant. The effective torque limits can be read out via the following objects:

Index	Id-Text	Name	Function
0x2C22	ru34	act. torque lim mot for	Torque limit mot., positive speed
0x2C23	ru35	act. torque lim mot rev	Torque limit mot., negative speed
0x2C24	ru36	act. torque lim gen for	Torque limit gen., positive speed
0x2C25	ru37	act. torque lim gen rev	Torque limit gen., negative speed

The displayed limits here do not correspond to the available torque. They can be reduced by further limits (e.g. motor limit characteristic).

The final limit values can be read out via ru50 / ru51 act. torque lim. pos. / neg.. Since they depend, among other things, on the magnetization state of the motor, they can be displayed only after modulation release.

4.8.9.4 Operating mode switchover

Basically an operating mode change can also be carried out during operation.

The ramp generators are preloaded with the actual setpoints.

When changing into the cyclic operating modes, it must be selected with bit 4 in parameters co10…co12 whether the spline-interpolators are to be initialized with setpoints or actual values.

4.8.9.4.1 Initialization of the interpolator with actual values

Default value is the initialization with actual values. Thereby the non-active interpolators of operating modes 8…10 are constantly preloaded with actual values. After a change a setpoint can be preset directly via co15, co16, co19. A change into operating mode 8 should be done only at standstill.

4.8.9.4.2 Initialization of the interpolator with setpoints

Especially for operating mode switchover according to 8: "cyclic sync position mode" during operation, it is preferable when the initialisation of the interpolator takes place in the control.

Thereby the actual position must be read out from the inverter and setpoints must be determined by precalculation with which the complete interpolator must be filled via co19 before change-over.

Example:

at co10 = 20 “B-Spline, 4 Points + target value” applies:

three setpoints must be preset before the changeover via co19. The fourth setpoint is set simultaneously with the changeover to operating mode 8.

4.9 Synchronisation

4.9.1 Synchronous time

Ethernet-based fieldbus types such as EtherCAT support the synchronous (cyclic synchronous) operating modes.

This means, each inverter has a PLL which automatically synchronizes with the fieldbus master. As soon as the sync interval is set by the master, all control algorithms synchronize to the sync signal via the PLL.

As soon as the sync interval of the master is adjusted in fb10 after power-on, all controller algorithms also synchronize to this PLL.

If the synchronization has been carried out, bit 8 (synchronous) is set in the status word (after power-on the synchronous operating mode is initially deactivated).

All inverters on an EtherCAT master can be operated synchronously at about +/- 100ns.

Alternatively, it is also possible to parameterize the sync interval in object 0x60C2 Interpolation time period.

If it is written subsequently via bus to 0x2B0A fb10 or 0x60C2 Interpolation time period, the value must be suitable to the value of the EtherCAT register. Otherwise the drive will not be synchronous.

Index	Id-Text	Name	Function
0x2B0A	fb10	sync interval	Activation of the synchronous operating modes
0x2B0B	fb11	set sync level	Definition of the level for the synchronous bit
0x2B0C	fb12	KP sync PLLI	Kp for the internal Pll
0x2B13	fb19	measured sync interval	Measured value of actual syncs

The default values for fb11 and fb12 are optimized for EtherCAT. The internal behaviour of the PLL can be adapted to other fielbus master with fb11 and fb12.

If bit 8 (synchronous) should not be set, the sync level or the Kp can be increased to achieve the synchronization.

The changed value of fb12 has only an effect when fb10 is written again.

Independent on the adjustments of fb10 – fb12, the distance between two syncs signals is measured and displayed in fb19. With the first valid measured value after power-on, fb10 is automatically parameterized.

Depending on is22, fb10 is set to the valid value which is nearest to the measured value fb19. => Table for is22.

The minimum (one "mid irq") and maximum (absolute upper limit 16ms) cycle time depends on is22.

- ➢ The resolution of fb19 is different for the different control card types. Observe scaling factor.
- ➢ The behavior of the synchronization differs depending on the active fieldbus system. Detailed information can be found in the Programming Manual | Fieldbus Systems.
- ➢ The Programming manual | Fieldbus systems can be downloaded from the KEB website. Registration is required.

4.9.2 Optimizing the PLL

As soon as a SYNC signal is given cyclically, the measured value is visible under fb19 measured sync interval. If an offline recording of this value is taken with the scope of COMBIVIS 6, it can be determined how exactly the respective master can preset the SYNCS. With this calculated deviation you can determine the setting for fb11 set sync level. (largest value of fb19 – smallest value of fb19). The value for fb11 should always be greater than the deviation of the measured values determined from the scope recording.

The gain of the PLL can be influenced with fb12 KP sync PLL and by way the speed which reacts to changes of the SYNC. For this you can make an offline recording with aa85, st00 and fb10. The offline measurement is started by setting a value to fb10, thus the transient response of the PLL can be seen. At the point where fb10 is preset, aa85 will change to a maximum value until the SYNC bit is set in st00. This behavior can now be changed with fb12 until a required characteristic occurs.

The changed values of fb11 and fb12 have only an effect when fb10 is written again.

5 Display Parameters

5.1 Overview of the ru parameters

The ru- (run) parameter group represents the multimeter of the inverter. Speeds, voltages, currents etc. are displayed here, with which a statement about the current operating status of the inverter can be made.

These parameters are required especially during start-up or troubleshooting of a system.

The following parameters are available:

<table>
<tr><th>Index</th><th>Id-Text</th><th>Name</th><th colspan="2">Function</th></tr>
<tr><td>0x2C01</td><td>ru01</td><td>exception state</td><td colspan="2">Display of the current error
(=> Chapter 4.3.1 Errors)</td></tr>
<tr><td>0x2C02</td><td>ru02</td><td>warning bits</td><td>Display of the warnings bit-coded</td><td rowspan="2">(=> 4.3.3 Warnings)</td></tr>
<tr><td>0x2C03</td><td>ru03</td><td>warning state</td><td>Displays the warning message with the highest priority</td></tr>
<tr><td>0x2C04</td><td>ru04</td><td>supply unit state</td><td colspan="2">Status display of the DC link</td></tr>
<tr><td>0x2C05</td><td>ru05</td><td>set value display</td><td colspan="2">Set value display (before ramp generator) in velocity mode</td></tr>
<tr><td>0x2C06</td><td>ru06</td><td>ramp out display</td><td colspan="2">Setpoint speed for speed controller
(after ramp and PT1 filter)</td></tr>
<tr><td>0x2C07</td><td>ru07</td><td>act. frequency</td><td colspan="2">Actual output frequency (resolution 1/8192 Hz)</td></tr>
<tr><td>0x2C08</td><td>ru08</td><td>act. value</td><td colspan="2">Actual speed for speed controller (measured or estimated)</td></tr>
<tr><td>0x2C09</td><td>ru09</td><td>act. encoder speed</td><td colspan="2">actual measured speed</td></tr>
<tr><td>0x2C0A</td><td>ru10</td><td>act. apparent current</td><td colspan="2">Motor apparent current</td></tr>
<tr><td>0x2C0B</td><td>ru11</td><td>act active current</td><td colspan="2">Motor active current (undefined in v/f operation)</td></tr>
<tr><td>0x2C0C</td><td>ru12</td><td>act. reactive current</td><td colspan="2">Motor magnetizing current (undefined in v/f operation)</td></tr>
<tr><td>0x2C0D</td><td>ru13</td><td>peak apparent current</td><td colspan="2">peak apparent current</td></tr>
<tr><td>0x2C0E</td><td>ru14</td><td>act. Uic voltage</td><td colspan="2">DC link voltage</td></tr>
<tr><td>0x2C0F</td><td>ru15</td><td>peak Uic voltage</td><td colspan="2">Peak value of the DC link voltage</td></tr>
<tr><td>0x2C10</td><td>ru16</td><td>act. output voltage</td><td colspan="2">Output voltage</td></tr>
<tr><td>0x2C11</td><td>ru17</td><td>modulation grade</td><td colspan="2">Modulation grade</td></tr>
<tr><td>0x2C12</td><td>ru18</td><td>dig. input state</td><td colspan="2">Internal image of the digital inputs (after processing) (=> 7.1 Digital Inputs)</td></tr>
</table>

<table>
<tr><th>Index</th><th>Id-Text</th><th>Name</th><th colspan="2">Function</th></tr>
<tr><td>0x2C13</td><td>ru19</td><td>internal output state</td><td>State of the internal digital outputs</td><td rowspan="3">(=> Chapter 7.2 Digital outputs)</td></tr>
<tr><td>0x2C14</td><td>ru20</td><td>dig. output state</td><td>State of the outputs
(at the end of the processing blocks)</td></tr>
<tr><td>0x2C15</td><td>ru21</td><td>dig. output flags</td><td>State of the flags</td></tr>
<tr><td>0x2C17</td><td>ru23</td><td>reference torque</td><td colspan="2">Reference torque (output of the speed controller)</td></tr>
<tr><td>0x2C18</td><td>ru24</td><td>actual torque</td><td colspan="2">Actual torque</td></tr>
<tr><td rowspan="4">0x2C19</td><td rowspan="4">ru25</td><td>heatsink temperature values</td><td colspan="2">Structure of heatsink temperature values</td></tr>
<tr><td>heatsink temperature 1</td><td colspan="2">Heatsink temperature display</td></tr>
<tr><td>heatsink temperature 2</td><td colspan="2" rowspan="2">From housing size 7, several heatsink temperatures are measured, displayed and evaluated for overtemperature protection</td></tr>
<tr><td>heatsink temperature 3</td></tr>
<tr><td rowspan="4">0x2C1A</td><td rowspan="4">ru26</td><td>internal temperature PU values</td><td colspan="2">Structure of heatsink temperature values</td></tr>
<tr><td>internal temperature PU 1</td><td colspan="2">Internal temperature power unit</td></tr>
<tr><td>internal temperature PU 2</td><td colspan="2" rowspan="2">From housing size 7, several internal temperatures are measured, displayed and evaluated for overtemperature protection</td></tr>
<tr><td>internal temperature PU 3</td></tr>
<tr><td>0x2C1B</td><td>ru27</td><td>OL2 counter</td><td colspan="2">Short-term overload level</td></tr>
<tr><td>0x2C1C</td><td>ru28</td><td>motor temperature</td><td colspan="2">Motor temperature (respectively state of the PTC)</td></tr>
<tr><td>0x2C1D</td><td>ru29</td><td>OL counter</td><td colspan="2">Continuous overload counter</td></tr>
<tr><td>0x2C1E</td><td>ru30</td><td>SACB comm state</td><td colspan="2">State of the internal communication bus (SACB bus)</td></tr>
<tr><td>0x2C20</td><td>ru32</td><td>motor prot. counter</td><td colspan="2">Level of the electronic motor protection relay</td></tr>
<tr><td>0x2C21</td><td>ru33</td><td>position actual value</td><td colspan="2">Position value of the encoder after the gear factor ec24/ec25</td></tr>
<tr><td>0x2C22</td><td>ru34</td><td>act. torque lim. mot for</td><td colspan="2" rowspan="4">Torque limits, which result from the settings in cs12 … cs16 or in the profile parameters 0x60E0 / 0x60E1.
The final limits can be different due to the influence of the limiting characteristic.</td></tr>
<tr><td>0x2C23</td><td>ru35</td><td>act. torque lim. mot rev</td></tr>
<tr><td>0x2C24</td><td>ru36</td><td>act. torque lim. gen for</td></tr>
<tr><td>0x2C25</td><td>ru37</td><td>act. torque lim. gen rev</td></tr>
<tr><td rowspan="4">0x2C26</td><td rowspan="4">ru38</td><td>encoder positions</td><td colspan="2">Structure of position values of encoder 1</td></tr>
<tr><td>gearless pos [1]</td><td colspan="2">Direct position value of the encoder 32bit without sign</td></tr>
<tr><td>gearless pos high [2]</td><td colspan="2">Upper 16bit of the direct position value</td></tr>
<tr><td>gearless pos low [3]</td><td colspan="2">Lower 16bit of the direct position value</td></tr>
<tr><td>0x2C29</td><td>ru41</td><td>dig. input terminal state</td><td colspan="2">State of the digital inputs (before processing)
(=> 7.1 Digital Inputs)</td></tr>
</table>

<table>
<tr><th>Index</th><th>Id-Text</th><th>Name</th><th colspan="2">Function</th></tr>
<tr><td>0x2C2A</td><td>ru42</td><td>AN1 value display</td><td colspan="2">Analog input value of AnalogIn 1</td></tr>
<tr><td>0x2C2B</td><td>ru43</td><td>AN1 after gain display</td><td colspan="2">Analog input value of AnalogIn 1</td></tr>
<tr><td>0x2C2A</td><td>ru44</td><td>AN2 value display</td><td colspan="2">Analog input value of AnalogIn 2</td></tr>
<tr><td>0x2C2B</td><td>ru45</td><td>AN2 after gain display</td><td colspan="2">Analog input value of AnalogIn 2</td></tr>
<tr><td>0x2C30</td><td>ru48</td><td>analog REF display</td><td colspan="2">=> Chapter 7.3.4 Calculation of REF and AUX</td></tr>
<tr><td>0x2C31</td><td>ru49</td><td>analog AUX display</td><td colspan="2">=> Chapter 7.3.4 Calculation of REF and AUX</td></tr>
<tr><td>0x2C32</td><td>ru50</td><td>act. torque lim. pos.</td><td colspan="2" rowspan="2">Actual torque limit (after consideration of limiting character-istic, current limits, etc.)</td></tr>
<tr><td>0x2C33</td><td>ru51</td><td>act. torque lim. neg.</td></tr>
<tr><td>0x2C34</td><td>ru52</td><td>system date</td><td>Date: 32 bit counter with 1s resolution from 1th January 1970 00:00.</td><td rowspan="2">(=> 5.9.1 Real time clock)</td></tr>
<tr><td>0x2C35</td><td>ru53</td><td>system time</td><td>Time: 32 bit counter with 1ms resolution from 00:00.</td></tr>
<tr><td>0x2C39</td><td>ru57</td><td>eff. motor load</td><td colspan="2">mean effective motor utilization</td></tr>
<tr><td>0x2C3A</td><td>ru58</td><td>actual index</td><td colspan="2">Actual index. Results from the state of the inputs, which are selected with di21 index input for the index setting.</td></tr>
<tr><td>0x2C63</td><td>ru63</td><td>Uic voltage at Power On</td><td colspan="2">Measured DC link voltage at the end of the precharging</td></tr>
<tr><td>0x2C48</td><td>ru72</td><td>act. switch. freq</td><td colspan="2">Actual switching frequency</td></tr>
<tr><td>0x2C49</td><td>ru73</td><td>Imot/ImaxOL2</td><td colspan="2">Ratio of the actual motor current to short time current limit</td></tr>
<tr><td>0x2C4A</td><td>ru74</td><td>unfiltered flags state</td><td colspan="2">State of the unfiltered flags
(=> Chapter 7.2 Digital outputs)</td></tr>
<tr><td>0x2C4B</td><td>ru75</td><td>global drive state</td><td colspan="2">Global status display</td></tr>
<tr><td>0x2C4C</td><td>ru76</td><td>drive state</td><td colspan="2">Global overview over the drive state</td></tr>
<tr><td>0x2C4D</td><td>ru77</td><td>internal temperature CB</td><td colspan="2">Internal temperature control board</td></tr>
<tr><td>0x2C4E</td><td>ru78</td><td>analog out display</td><td colspan="2">Value of the analog output in % (100% = 10V)</td></tr>
<tr><td>0x2C50</td><td>ru80</td><td>relative torque</td><td colspan="2">Current torque referred to a limit value
(Description => Chapter 5.6 Torque displays)</td></tr>
<tr><td>0x2C51</td><td>ru81</td><td>act torque</td><td colspan="2">Actual torque (identical ru24) in Nm</td></tr>
</table>

Index	Id-Text	Name	Function
0x2C52	ru82	actual power	Structure of power displays
		mechanical power [1]	Mechanical shaft power
		electrical output power [2]	Electrical output power of the converter
		electrical power loss [3]	Power loss (= emitted active power by the inverter - emitted shaft power)
		out. energy mot.[4]	Motor energy (integrated value of the positive (motor) electrical output power[2])
		out. energy mot. volatile[5]	Motor energy during a power-on cycle (Value is deleted when the 24V supply is switched off)
		out. energy gen.[6]	regenerative energy (integrated value of the negative (regenerative) electrical output power[2])
		out. energy gen. volatile[7]	regenerative energy during a power-on cycle (Value is deleted when the 24V supply is switched off)
0x2C53	ru83	diff. speed	Structure of differential speed displays (is also calculated when the modulation is switched off)
		diff. speed [1]	Difference between speed setpoint (ru84) and actual speed value (ru08)
		diff. speed [2]	Difference of not smoothed ramp output value (see **A** in Figure 60) and actual speed value (ru08)
		diff. speed [3]	Difference of smoothed ramp output value (smoothing after cs19; see **B** in Figure 60) and actual speed value (ru08)
		diff. speed [4]	Difference (see **C** in Figure 60) of smoothed ramp output value with position controller influence (ru06) and actual speed value (ru08)
0x2C54	ru84	ref. value display	preset setpoint speed (in each operating mode)
0x2C55	ru85	actual speed PT1	filtered actual speed (ru08 to PT1 filter / filter time constant = is39)
0x2C56	ru86	standard set speed	actual setpoint speed, but this can be overwritten by the blockade function. ru86 displays the setpoint that would be active if the blockade function did not determine the setpoint speed
0x2C57	ru87	ramp out value	smoothed ramp output value (smoothing according to cs19; see point **B** in Figure 60)

5.2 Speed displays

Set value displays:

Index	Id-Text	Name	Function	Resolution
0x2C05	ru05	set value display	Setpoint speed display before ramp generator in state OPERATION ENABLED at mode of operation = 2 „velocity mode“	1/8192 rpm
0x2C06	ru06	ramp out display	Set speed for speed controller after ramp generator and the PT1 filter of the set speed (cs19 ref speed PT1-time)	1/8192 rpm
0x2103	st03	vl velocity demand	Set speed at the ramp generator output	1 rpm
0x2C54	ru84	ref. value display	Setpoint speed display before ramp generator (operating mode independent)	1/8192 rpm
0x2C55	ru85	actual speed PT1	filtered actual speed (ru08 to PT1 filter / filter time constant = is39)	1/8192 rpm
0x2C56	ru86	standard set speed	ru86 displays the setpoint that would be active if the blockade function did not determine the setpoint speed	1/8192 rpm
0x2C57	ru87	ramp out value	smoothed ramp output value (smoothing according to cs19; see point **B** in Figure 60)	1/8192 rpm

Actual speed / frequency displays:

Index	Id-Text	Name	Function	Resolution
0x2C07	ru07	act. frequency	Actual output frequency	1/8192 Hz
0x2C08	ru08	act. value	Actual speed: - measured speed at control mode with encoder - estimated speed at ASCL / SCL - ramp output speed at v/f control	1/8192 rpm
0x2C09	ru09	act. encoder speed	Actual speed measured with encoder	1/8192 rpm
0x2120	st32	velocity actual value	Current actual speed as ru08 normalized by the velocity shift factor co02	defined by co02
0x2C55	ru85	actual speed PT1	filtered actual speed (ru08 after PT1 filter with the time constant is39 / 0 = filter switched off)	1/8192 rpm

Difference speed displays:

Index	Id-Text	Name	Function
0x2C53	ru83	diff. speed [1]..[4]	Difference between setpoint speed and actual speed Description see previous chapter: 5.1 Overview of the ru parameters and Figure 60

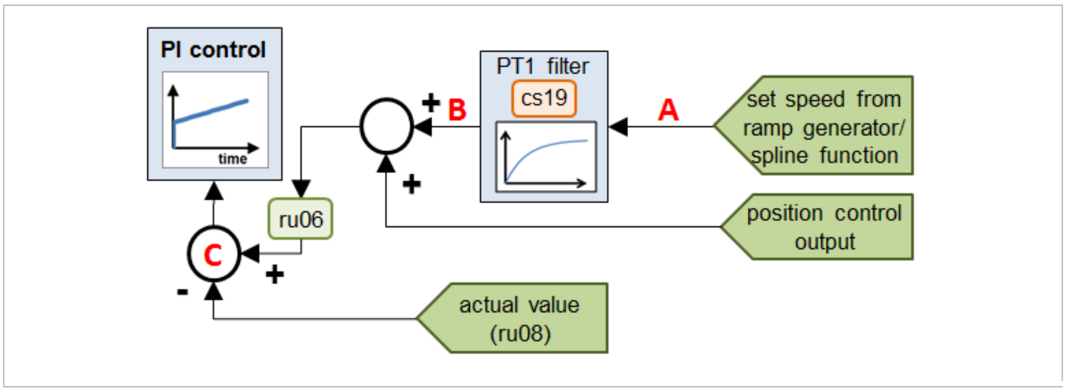


Figure 61: Auxiliary representation for the calculation of ru83[]

5.3 Position displays

Index	Id-Text	Name	Function
0x2C21	ru33	position actual value	Position value of the encoder (without influencing homing, position scaling or system inversion) after the gear factor ec24/ec25.
0x2C26	ru38	encoder positions	Structure of position values of encoder 1
		gearless pos [1]	Direct position value of the encoder 32bit without sign
		gearless pos high [2]	Upper 16bit of the direct position value
		gearless pos low [3]	Lower 16bit of the direct position value
0x2125	st37	demand position	Internal set position ***profil positioning mode:*** Output of the profile generator ***cyclic sync position mode:*** Output of the spline interpolator Resolution defined by co03
0x2121	st33	position actual value	Actual position / resolution defined by co03
0x2124	st36	following error	Actual following error / resolution defined by co03
0x2130	st48	rho actual value	Electrical position / 65536 = 1 electr. period = 360° electr.

5.4 DC link displays

Index	Id-Text	Name	Function
0x2C04	ru04	supply unit state	Charging status of the DC link: - 5: phase failure => DC voltage lower than required for oper-ation - 2: charging => Load-shunt-delay time is running - 4: run => Operation (modulation release) possi-ble
0x2C0E	ru14	act. Uic voltage	Voltage in DC link [0.1V]
0x2C0F	ru15	peak Uic voltage	Peak value of the DC voltage is deleted by Power-On or overwritten with the value 0

5.5 Current displays

Index	Id-Text	Name	Function
0x2C0A	ru10	act apparent current	Motor apparent current [0.01A]
0x350C	is12	display apparent current PT1	Smoothing time for the motor current display in ru10
0x2C0D	ru13	peak apparent current	Peak value of unsmoothed motor apparent current Deletion by Power-On or overwriting with 0
0x2C0B	ru11	act active current	Active current [0.01A]
0x2C0C	ru12	act reactive current	Reactive current [0.01A]
0x2C49	ru73	Imot/Imax OL2	Ratio of the actual motor current to short time current limit [0.1%]
0x2C39	ru57	eff. motor load	Mean effective motor load [0.1%]

5.6 Torque displays

Index	Id-Text	Name	Function	Resolution
0x2C17	ru23	reference torque	Reference torque (output of the speed controller)	1000 = 100% dr09 rated torque
0x2C18	ru24	actual torque	Actual torque (COMBIVIS display in %)	
0x2122	st34	torque actual value	Actual torque (COMBIVIS display unnormalized)	
0x350D	is13	display torque PT1	Smoothing time for the torque display in ru23 / ru24 / ru81	1000 = 1ms
0x2C19	ru34	act torque lim mot for	Torque limits, which result from the settings in cs12 … cs16 or in the profile parameters 0x60E0 / 0x60E1. The final limits can be different due to the influence of the limiting characteristic or the operation mode (e.g. fault reaction ramp).	1000 = 100% dr09 rated torque
0x2C1A	ru35	act torque lim mot rev		
0x2C24	ru36	act torque lim gen for		
0x2C25	ru37	act torque lim gen rev		

Index	Id-Text	Name	Function	Resolution
0x2C32	ru50	act torque lim pos	Actual valid torque limit with consideration of the operating condition: speed, limiting characteristic, current limits, motor flux, etc. Since there is no current flow when the modulation has been switched off, the actual torque limit is 0.	
0x2C33	ru51	act torque lim neg		
0x2C50	ru80	relative torque	ru80 indicates the machine load with regard to torque. The display can be adjusted with parameter pn88 [1] display configuration. (Description see chapter 4.4.25 Monitoring of the load)	0,1%
0x2C51	ru81	act torque	Actual torque (identical ru24) in Nm	0.001 Nm

5.7 Power/Energy Displays

Index	Id-Text	Name	Function	Resolution
0x2C52	ru82	mechanical power [1]	Shaft power output	0.001 kW
0x2C52	ru82	electrical output power [2]	Active power absorbed by the motor	
0x2C52	ru82	electrical power loss [3]	Power losses = emitted active power by the inverter - emitted shaft power	
0x2C52	ru82	out. energy mot.[4]	Motor-integrated “electrical output power[2]”, energy	0.1 kWh
0x2C52	ru82	out. energy mot. volatile[5]	The motor integrated “electrical output power[2]”, energy (volatile, ZERO again after power on)	0.001 kWh
0x2C52	ru82	out. energy gen.[6]	The generator-integrated “electrical output power[2]”, energy	0.1 kWh
0x2C52	ru82	out. energy gen. volatile[7]	The generator-integrated “electrical output power[2]”, energy (volatile, ZERO again after power on)	0.001 kWh

The power display can be filtered via "display power PT1“ is34

NOTICE

➢ The display of ru82[1] and ru82[3] is only valid in closed-loop operation in the state "*operation enabled*“! In open-loop operation or other states any values can be displayed.

5.8 Status displays

5.8.1 ru75 global drive state

A global overview of the drive state can be obtained with this 32 bit object. The different bit groups contain information about the operating state, the actual state of the state machine, the ramp generator and the posi module.

ru75	global drive state		0x2C4B
Bit	Name	Note	
0 … 3	ready for modulation	Reasons that prevent a modulation release	
4 …7	state machine display	st12	
8 …15	exception state	ru01	
16…19	ramp state	State of the ramp generator	
20…23	posi state	State of the positioning module (pp-modes)	
24…25	pos./neg. limit switch active	(internal) state of the positive/negative limit switch	
26	error bit suppression active	Indication that the modulation is switched off due to an error, but the error bit in the statusword and the error display in ru01 are not set.	
27…31	reserved	not used	

The value of the parameter consists of the sum of the single bits or bit groups. The value and the multiplier with which the parameter value is created are entered in the following tables.

Example:

- DC link precharging not yet executed (Bit 1 Uic error is set)
- STO is not set (Bit 2 STO missing is set)
- Display of the state machine is value 2 (Switch on disable)
- Error display is value 0 (no error)
- State of the ramp generator is value 6 (ramp output corresponds to input)
- State of the positioning module is value 0 (no active positioning)

=> this results in the following total value for ru75:

1 * 2 + 1 * 4 + 16 * 2 + 256 * 0 + 6 * 65536 + 0 * 1048576 = 393254dez. = 00060026hex.

5.8.1.1 State for modulation release (4 bits)

With these 4 bits it can be determined what is currently missing for modulation release.

ru75	global drive state			Bit 0…3	ready for modulation state
Bit	Value	Mult.	Plaintext	Notes	
0…3	0	0	RFM	Modulation release can be made directly with setting the enable modulation bit in the controlword	
0	1	1	E,ru01	There is an error. => ru01	
1	1	2	E.uic	The DC link in the power unit has not been charged. The voltage is below the UP level. ru04 is unequal to 4 "run“	
2	1	4	E.STO	At least one STO input is not set. => ru18	
3		8		Reserved	

5.8.1.2 Display of the state machine (4 Bits)

This 4 bits displays the actual state of the state machine.

ru75		global drive state		Bit 4…7	state machine display
Bit	Value	Mult.	Plaintext		
4…7	0	16	initialization	The meaning and the values are identical with the description of st12. The detailed description of the single states of the state machine and the changes can be found in chapter 4.1 State machine	
	1		not ready to switch on		
	2		switch on disable		
	3		ready to switch on		
	4		switched on		
	5		operation enabled		
	6		quick stop active		
	7		fault reaction active		
	8		fault		
	9		shutdown active		
	10		disable operation active		
	11		start operation active		
	12		mod off pause active		
	13		power off active		

5.8.1.3 exception State (8 Bit)

The actual ru01 error message is displayed in these 8 bits. The value is identical to ru01, but it is multiplied with 256 to be displayed in bits 8...15 of ru75.

ru75		global drive state		Bit 8…15	exception state display
Bit	Value	Mult.	Plaintext	Meaning	
8…15	0	256	no exception	The adjacent lines are illustrative only (examples) of the values. The meaning of the values is identical with ru01. The complete list of all values and the description of the error messages can be found in the chapter 4.3.1 Errors	
	3		ERROR overcurrent PU		
	4		ERROR overcurrent analog		
	…		…		
	116		ERROR GTR7 OC		
	117		ERROR GTR7 always ON		

5.8.1.4 State of the ramp generator (4 Bit)

ru75		global drive state		Bit 16…19	ramp state display
Bit	Value	Mult.	Plaintext	Meaning	
16…19	0	65536	pos acc inc	Positive output value, positive acceleration is increased	
	1		pos acc	Positive output value with constant positive acceleration	
	2		pos acc dec	Positive output value, positive acceleration is decreased	
	3		neg acc inc	Negative output value, negative acceleration is increased	
	4		neg acc	Negative output value with constant negative acceleration	
	5		neg acc dec	Negative output value, negative acceleration is decreased	
	6		ref eq out	Ramp output equal to ramp input	
	7		pos dec inc	Positive output value, negative acceleration is increased	
	8		pos dec	Positive output value with constant negative acceleration	
	9		pos dec dec	Positive output value, negative acceleration is decreased	
	10		neg dec inc	Negative output value, positive acceleration is increased	
	11		neg dec	Negative output value with constant positive acceleration	
	12		neg dec dec	Negative output value, positive acceleration is decreased	

positive or negative acceleration describes the sign of the acceleration or deceleration torque:

positive acceleration = forward acceleration or reverse deceleration

negative acceleration = reverse acceleration or forward deceleration

5.8.1.5 State of the posi module (4 Bit)

ru75		global drive state		Bit 20…23	ramp state display
Bit	Value	Mult.	Plaintext	Meaning	
20…23	0	1048576	ready for posi	Positioning is not active	
	1		init posi	Initialization of the posi module	
	2		posi pos	Positioning in positive direction	
	3		posi neg	Positioning in negative direction	
	4		target approach	Approach into target position	
	5		V3P active	Intermediate speed positive	
	6		V3N active	Intermediate speed negative	
	7		target reached	Target reached	

5.8.1.6 State of the pos./neg. limit switch

ru75		global drive state		Bit 24…25	pos./neg. limit switch active
Bit	Value	Mult.	Plaintext	Meaning	
24	1	16777216	pos. limit switch active	positive limit switch internally active	
25	1	33554432	neg. limit switch active	negative limit switch internally active	

5.8.1.7 Suppressed error bit

ru75		global drive state		Bit 26	error bit suppression active
Bit	Value	Mult.	Plaintext	Meaning	
26	1	67108864	error bit suppression active	Indication that the modulation is switched off due to an error, but the error bit in the statusword and the error display in ru01 are not set.	

5.8.2 ru76 drive state

A global overview of the different drive state displays can be obtained with this 32 bit object.

The value of the parameter consists of the sum of the single bits or bit groups (like ru75).

The value and the multiplier with which the parameter value is created are entered in the following tables.

ru76	drive state	0x2C4C
Bit	Name	Note
0	modulation state	Modulation active
1 … 4		Reasons that prevent a modulation release
5 … 8	modes of operation	Display of the operating mode (st02)
9 … 11	act. Motor	Display of the motor type (dr00)
12 … 14	control Mode	Actual control mode (cs00)
15 … 17	Ramp state	State of the ramp generator
18 … 20	other	State of special functions
21 … 31	reserved	not used

5.8.2.1 State of modulation release (5 Bit)

ru76	drive state			Bit 0…4	modulation state
Bit	Value	Mult.	Plaintext	Notes	
0	1	1	MON	Modulation is active	
1…4	0	1	RFM	Modulation release can be made directly with setting the enable modulation bit in the control word	
1	1	2	E,ru01	There is an error. => ru01	
2	1	4	E.uic	The DC link in the power unit has not been charged. The voltage is below the UP level. ru04 is unequal to 4 "run“	
3	1	8	E.STO	At least one STO input is not set. => ru18	
4		16		Reserved	

5.8.2.2 Modes of Operation display st02 (4 Bit)

ru76	drive state			Bit 5…8	modes of Operation
Bit	Value	Mult.	Plaintext	Notes	
5…8	1	32	PP	Profile positioning mode	
	2		VL	Velocity mode	
	6		HM	Homing mode	
	8		CSP	Cyclic synchronous positioning mode	
	9		CSV	Cyclic synchronous velocity mode	
	0, 3…5, 7,10…15		reserved		

5.8.2.3 Actual motor dr00 (3 Bit)

ru76	drive state			Bit 9…11	actual motor
Bit	Value	Mult.	Plaintext	Notes	
9…11	0	512	ASM	Asynchronous motor	
	1		SM	Synchronous motor	
	2		reserved		
	3		reserved		
	4		SynRM	Synchronous reluctance motor	
	5…7		reserved		

5.8.2.4 Actual control mode cs00 (3 Bit)

ru76	drive state			Bit 12…14	actual control
Bit	Value	Mult.	Plaintext	Notes	
12…14	0	4096	v/f	Voltage-/frequency characteristic	
	1		Enc	Operation with encoder without motor model	
	2		Enc+Model	Operation with encoder and motor model	
	3		Model	Operation without encoder with motor model (SCL / ASCL)	
	4…7			reserved	

5.8.2.5 State ramp generator (3 Bit)

ru76	drive state			Bit 15…17	ramp state
Bit	Value	Mult.	Plaintext	Notes	
15…17	0	32768	zero speed	Set speed 0	
	1		forward acc	Forward acceleration	
	2		forward dec	Forward deceleration	
	3		forward const	Forward constant run	
	4		reverse acc	Reverse acceleration	
	5		reverse dec	Reverse deceleration	
	6		reverse const	Reverse constant run	
	7			reserved	

5.8.2.6 Others (3 Bit)

ru76	drive state			Bit 18…20	others
Bit	Valu e	Mult.	Plaintext	Notes	
18…20	0	262144		No special function active	
	1		ssf	Speed search function active	
	2		ident	Motor identification active	
	3		flux	Flux formation active (ASM)	
	4		brake	one of the brake downtimes is running	
	6		fault reaction	Fault reaction ramp is active	
	5, 7			reserved	

5.8.2.7 Example

If the drive is in the following state:

ru76	drive state			
State	Bit group	Valu e	Mult.	Meaning
modulation state	0…4	1	1	Modulation active
modes of Operation	5…8	2	32	Velocity mode is active
actual motor	9…11	1	512	Motor type is synchronous motor
actual control	12…14	2	4096	Operation with encoder and motor model
ramp state	15…17	3	32768	actual ramp state = forward constant run
others	18…20	0	262144	No special function active

the following parameter value results for ru76

1 * 1 + 2 * 32 + 1 * 512 + 2 * 4096 + 3 * 32768 + 0 * 262144 = 107073dec. = 0001A241hex.

Display:

MON + VL + SM + Enc+Model + forward const

5.8.3 **de115 global drive state mask**

Index	Id-Text	Name	Function
0x2073	de115	global drive state mask	Masking of single bits of ru75

Single bits of ru75 and ru76 can be switched off with this object.

Example: de115 = 0x0F0000. Only the ramp state is visible in ru75 with this setting. All other bits are suppressed.

5.8.4 ru30 SACB comm state

This 16 bit object displays the state of the communication of the control board with the safety module (only F6-A and S6-A) with the power unit (from housing size 6 at F6) and with the encoder interface.

This object can be used to evaluate errors ru01 = 41 "ERROR safety module SACB comm.“, ru01 = 42 "ERROR power unit SACB comm.“ and ru01 = 43 "ER-ROR enc.intf. SACB comm.”.

There are two special cases for the communication with the power unit: - For de-vices up to housing size 5 there is no communication with the power unit, but the plain texts for bits 8 ... 11 = 0 and bits 16 ... 19 = 0 are displayed. - For devices of housing size 6, there is no communication with the power unit CPU2, but the plain texts for bits 16… 19 = 0 are displayed.

In both cases the bits are not considered in the error evaluation, error ru01 = 42 "ERROR power unit SACB comm." is not triggered by this.

The meaning of the individual bits is defined as follows:

ru30	SACB comm state		0x2C1E
Bit	Value	Function	
0 … 7	Status SACB communication with the safety module (only F6-A / S6-A)		
0	1	Safety module found	All bits are set (value 15): Communication OK
1	2	Communication active	
2	4	Communication initialized	
3	8	Communication is running	
4	16	Error initialization safety module	
5 … 7		reserved	
8 … 15	Status SACB communication with power unit (F6 from housing size 6)		
8	256	Power unit found	All bits are set (value 240): Communication OK
9	512	Communication active	
10	1024	Communication initialized	
11	2048	Communication is running	
12	4096	Error initialization power unit	
13 … 15		reserved	
16 … 23	Status SACB communication with power unit CPU2 (F6 from housing size 7)		
16	65536	Power unit CPU2 found	All bits are set (value 983040): Communication OK
17	131072	Communication active	
18	262144	Communication initialized	
19	524288	Communication is running	
20	1048576	Error initialization power unit CPU2	
21 … 22		reserved	
23	8388608	Communication with power unit CPU2 deactivated (power unit not switched on)	
24 … 31	Status SACB communication with the encoder interface		

<table>
<tr><td>ru30</td><td colspan="3">SACB comm state</td><td>0x2C1E</td></tr>
<tr><td>Bit</td><td>Value</td><td colspan="3">Function</td></tr>
<tr><td>24</td><td>16777216</td><td>Encoder interface found</td><td colspan="2" rowspan="4">All bits are set (value 25658240):
Communication OK</td></tr>
<tr><td>25</td><td>33554432</td><td>Communication active</td></tr>
<tr><td>26</td><td>67108864</td><td>Communication initialized</td></tr>
<tr><td>27</td><td>134217728</td><td>Communication is running</td></tr>
<tr><td>28</td><td>268435456</td><td colspan="3">Error initialization encoder interface</td></tr>
<tr><td>29 …
31</td><td></td><td colspan="3">reserved</td></tr>
</table>

5.9 Operating hours counter

5.9.1 Real time clock

The device has parameters for a real time clock. Time and date must be adapted by the control with each power-on. The time formats TIME and DATE which are known from CODESYS are used.

Index	Id-Text	Name	Function
0x2c34	ru52	system date	Datum [DATE_AND_TIME]
0x2c35	ru53	system time	Time [TIME_OF_DAY]

DATE_AND_TIME : 32 bit counter with 1s resolution from 1th January 1970 00:00.

TIME_OF_DAY : 32 bit counter with 1ms resolution from 00:00.

Only ru52 is writable. Internally, ru53 is directly synchronized with ru52.

5.9.2 Operating hours counter

Index	Id-Text	Name	Function
0x2064	de100	hour counter	Operating time in hours
0x2065	de101	mod hour counter	Operating time in hours when modulation is switched on

5.9.3 System counter

Index	Id-Text	Name	Function
0x2123	st35	system counter	Continuous 250us counter

5.10 Error displays and counter

5.10.1 Error / warning displays

Index	Id-Text	Name	Function	
0x2C01	ru01	exception state	Display of the current error (=> Chapter 4.3.1 Errors)	
0x2C02	ru02	warning bits	Display of the warnings bit-coded	(=> 4.3.3 Warnings)
0x2C03	ru03	warning state	Displays the warning message with the highest priority	

5.10.2 Error counter

The occurrence of specific errors is counted internally.

Index	Id-Text	Name	Function
0x2066	de102	OC error count	Number of errors (is stored non-volatile, if storage is not de-activated)
0x2067	de103	OL error count	
0x2068	de104	OP error count	
0x2069	de105	OH error count	
0x206a	de106	OHI error count	

5.10.3 Error memory

The occurrence of exceptions is stored with date and time. To this end there is a FIFO memory with 16 entries. Beside the three fixed defined values, 4 additional objects can be recorded in the error memory.

Index	Id-Text	Name	Function
0x300A	ud10	exception history date	Value list of ru52 system date when the error occurred
0x300B	ud11	exception history time	Value list of ru53 system time when the error occurred
0x300C	ud12	history exception state	Error list of ru01 exception state
0x300D	ud13	history data 1	List of the defined data in ud17
0x300E	ud14	history data 2	List of the defined data in ud18
0x300F	ud15	history data 3	List of the defined data in ud19
0x3010	ud16	history data 4	List of the defined data in ud20
0x3011	ud17	history data 1 selector	Selection of the data for ud13
0x3012	ud18	history data 2 selector	Selection of the data for ud14
0x3013	ud19	history data 3 selector	Selection of the data for ud15
0x3014	ud20	history data 4 selector	Selection of the data for ud16

	history data selector	ud17 … ud20	
Value	selected parameter	Id-Text	Resolution
0	no	0000h: off	
0x2C0A	Apparent current	ru10	0.01 [A]
0x2C0E	DC link voltage	ru14	0.1 [V]
0x2C09	Actual speed	ru09	8192^{-1} [rpm]
0x2C19	Temperature	ru25 [1]	0.1 [°C]
0x2064	Operating hours counter	de100	0.1 [h]
0x2065	Operating hours counter modulation on	de101	0.1 [h]
0x2C10	Output voltage	ru16	0.1 [V]
0x2C11	Modulation grade	ru17	0,1 [%]
0x2C21	Actual position	ru33	1/65536 revolution

The above table contains only the parameters whose recording appears to be most useful in most cases. In principle, the address of each parameter can be entered in ud17...ud20.

When a value is entered in the history data selector, the corresponding error memory is overwritten with 0. The latest entry is always stored in index 1, the oldest entry is stored in index 16 which is deleted with the next error.

The standardisation of the corresponding parameter must be observed for the interpretation of the values in ud13 … ud14

5.11 Inverter data

The most important inverter characteristics are displayed in the inverter data.

The limits dependent on the power unit are displayed for some parameters (de32 tripping threshold undervoltage , de29 inverter maximum current).

The actual limit can be changed by parameter settings.

Not all parameters are available for all control types (A or K).

Index	Id-Text	Name	Function
0x2000	de00	device serial number	Serial number of the inverter
0x2002	de02	device production info	only for internal use
0x2003	de03	device type	
0x2004	de04	AB number	
0x2006	de06	customer number	
0x2008	de08	device configuration ID	Configurations ID (number of the parameter description for COMBIVIS)
0x200B	de11	VARAN licence number	VARAN licence number
0x200D	de13	ctrl hw type	Control card type (Fieldbus type, hardware version)
0x200E	de14	ctrl production info	only for internal use
0x200F	de15	ctrl type	Control card type
0x2010	de16	ctrl software version	Software version
0x2011	de17	ctrl software date	Software date
0x2012	de18	fpga core version	FPGA software version
0x2013	de19	fpga core date	FPGA software date
0x2016	de22	power production info	only for internal use
0x2018	de24	power software version	Power unit software version
0x2019	de25	power software date	power unit software date
0x201A	de26	saved inverter data ID	Saved power unit identifier
0x201B	de27	inverter data ID	Actual power unit identifier
0x201C	de28	inverter rated current	Inverter rated current
0x201D	de29	inverter maximum current	Inverter software current limit
0x201E	de30	inverter rated voltage	Inverter rated voltage
0x201F	de31	inverter maximum DC voltage	Tripping threshold overvoltage error
0x2020	de32	inverter minimum DC voltage	Tripping threshold undervoltage error
0x2021	de33	inverter rated switching frequency	Rated switching frequency
0x2022	de34	inverter maximum switching frequency	Maximum switching frequency
0x2023	de35	inverter intermed.circuit capacity [uF]	DC link capacity
0x2024	de36	braking transistor default level	Default level for braking transistor activation
0x2026	de38	safety serial number	Unique identification number of the safety functionality Part 1
0x2027	de39	saved safety type	Saved type of the safety module
0x2028	de40	safety production info	Unique identification number of the safety functionality Part 2

Index	Id-Text	Name	Function
0x2029	de41	safety type	Current type of the safety module
0x2030	de42	safety software version	Software version of the safety module
0x2031	de43	safety software date	Software date of the safety module
0x202C	de44	KTY software version	Motor temperature measuring software version
0x202D	de45	KTY software date	Motor temperature measuring software date
0x2032	de50	fieldbus stack version	Version of the fieldbus stack
0x2033	de51	fieldbus stack date	Date of the fieldbus stack
0x2034	de52	enc interf software version	Software version of the encoder interface software (control type A and P only)
0x2035	de53	enc interf software date	Software date of the encoder interface software (control type A and P only)
0x2050	de80[1]	current scale value	Full scale current
	de80[2]	power unit data format	Power unit data format
0x2078	de120	max output frequency	Maximum output frequency

5.11.1 Product code

The product code identifies the inverter in the bus so that the control can recognize the device type.

The range 0x00800000 to 0x0080FFFF is reserved for device type F6 (1…9).

de09	product code	0x2009
Value	Device type	
0x00800000	Device type F6 (1…9) control type K	
0x00800001	Device type F6 (1…9) control type A	
0x00800002	Device type F6 (1…9) control type P without encoder interface	
0x00800003	Device type F6 (1…9) control type P with encoder interface	

The range 0x00700000 to 0x0070FFFF is reserved for device type S6.

de09	product code	0x2009
Value	Device type	
0x00700000	S6 control type K	
0x00700001	S6 control type A	

5.11.2 Device type, software version and date

The hardware version of the control board can be differentiated with de13.

de13	ctrl type			0x200D
Bit	Function	Value	Plaintext	Notes
for control type F6-K				
0…1	bus-type	0	EtherCAT/Can	Fieldbus type supported by the hardware
		1	VARAN/Can	
2…5	Hw-version	4	3	only external 24V supply
for control type S6-K				
0…1	bus-type	0	EtherCAT/Can	Fieldbus type supported by the hardware
		1	VARAN/Can	
for control type F6-A				
0	Hw-version	1	1	not PCB version 1A
for control type x6-P				
0..7	Hw-version	4	enc. intf. + relay + 485	
		5	no enc. intf. + safety relay	
		6	enc. intf. + safety relay	
15..8	hardware type	256	F6	
		512	S6	
23..16	safety type	327680	sm type 5	

The device type can be differentiated within a device series (F6/S6) with de15.

de15	ctrl type			0x200F
Bit	Function	Value	Plaintext	Notes
0…7	modul type	32	module: SAM	Definition of the software type (single axis module)
8…15	hardware type	8192	Control K / EtherCAT	Determination of the control and/or fieldbus type CAN is additionally included with all types. (Exception: a hardware revision for control type P) With control type A or P the fieldbus type is independent of the hardware
		8448	Control K / VARAN	
		12288	Control A	
		16384	Control P	

The software version of the single modules can be read with the following objects. The display is a hexadecimal value.

de16	ctrl software version		0x2010
de18	fpga core version		0x2012
de24	power software version		0x2018
de42	safety software version		0x202A
de44	KTY software version		0x202C
de52	enc interf software version		0x2034
Bit	Function	Value	Notes
0…7	Number of date codes	0…FF	Is increased in case of minor modifications which require no new parameters or error correction.
8…15	Customer version	0…FF	Is used to identifier customer / special versions
16…23	Minor version	0…FF	Is increased when introducing new parameters or functions
24…31	Major version	0…FF	Increased only at general changes

Example: Software version 0201000Ch (hexadecimal) = 33619980 (decimal)

Main version: 2

Sub-version: 1 standard version date code: 12dec (= 0C hex)

de50	fieldbus stack version	0x2032
	Note	
	Shows the stack version of the RTE module of the adjusted fieldbus	

The software date can be read with the following objects:

de17	ctrl software date		0x2011
de19	fpga core date		0x2013
de25	power software date		0x2019
de43	safety software date		0x202B
de45	KTY software date		0x202D
de51	fieldbus stack date		0x2033
de53	encoder interf software date		0x2035
Date format	Value	Display	
YYYY.MM.DD (year, month, day)	= YYYY*10000 + MM * 100 + DD	The decimal value representing the date is displayed directly without separators	

Example: Software date 20.01.2016 => display: 20160120

5.11.3 Power unit identification

The power unit is identified with de27 inverter data ID. The value is displayed decimal, separated by dots.

<table>
<tr><td>de26</td><td colspan="3">saved inverter data ID</td><td>0x201A</td></tr>
<tr><td>de27</td><td colspan="3">inverter data ID</td><td>0x201B</td></tr>
<tr><th>Bit</th><th>Function</th><th>Value</th><th colspan="2">Notes</th></tr>
<tr><td>0…7</td><td>Power unit code</td><td rowspan="4">0…255</td><td colspan="2">Identification number of the various power units within a device size class</td></tr>
<tr><td>8…15</td><td>Version number</td><td colspan="2">Version number of the power unit data</td></tr>
<tr><td>16…23</td><td>Housing identification</td><td colspan="2">e.g. 02, 04, 06, …</td></tr>
<tr><td>24…31</td><td>Device size</td><td colspan="2">Identification for inverter rated power
(=> Operating instructions with technical data)</td></tr>
</table>

Example: the first released version of an 11F6 kW F6 inverter in housing size 2 with power unit code 53 would display the following value:

de27 = 15.2.1.53

If the "saved" value is different to the actual value, the control card has been set to a power unit with different ID.

This causes the inverter changes to error 64 "ERROR power unit type changed".

By writing on parameter de27, the actual "inverter data ID" is adopted as "saved inverter data ID" and the error can be reset.

The following data can be read by way that the most important inverter identification data are also available if no manual is currently available:

Id	Function	
de28	inverter rated current	Inverter rated current [in 0.01A]
de29	inverter maximum current	Inverter software current limit [in 0.01A] for closed-loop operation (depending on the inverter type and the setting of is35 set current limit). The limit for the control can be decreased by other parameters (dr12, is11)
de30	inverter rated voltage	Inverter rated voltage [in 0.1V]
de31	inverter maximum DC voltage	Tripping threshold overvoltage error [in 0.1V]
de32	inverter minimum DC voltage	Tripping threshold undervoltage error [in 0.1V]
de33	inverter rated switching frequency	Rated switching frequency [in 0.01 kHz]
de34	inverter maximum switching frequency	Maximum available switching frequency (at reduced current)
de35	inverter intermed.circuit capacity [uF]	Capacity of the capacitors in the DC link
de36	braking transistor default level	Value at which the braking transistor is activated voltage-dependent in the default setting. Value "zero" means that the device does not contain a braking transistor.

Id	Function	
de120	max output frequency	Maximum output frequency if the output frequency exceeds this value, error 107 "ERROR over frequency" is triggered

Index	Id-Text	Sub-Idx	Name	Function
0x2050	de80	1	current scale value	Full scale of the drive controller (DC current)
		2	power unit data format	0: basic version 1: additional ol2 data supported Value 1 means that temperature-dependent OL2 data are available to support is17.
				0: no extended OI values 2: extended OI values available
				0: IGBT model was not identified in the factory 8: IGBT model was identified by the factory

5.11.4 Serial numbers

de00 device serial number contains the serial number of the inverter.

de38 safety serial number and de40 safety production info provide the unique identification number for the FS related hardware.

Unwritten parameters are for internal use only.

6 Motor Control

6.1 Interface to the encoder

The parameters for setting the speed measurement via channel A and B and status parameters are contained in the two ec groups.

The parameters are identical except for the change-over of the operating voltage ec14 and the parameters for data storing in the encoder ec46 / ec47. These are only available for channel A.

The addresses for channel B have an offset of 0x2000 compared to channel A.

The names of parameters for channel B are the same and end extra with "B".

Example:

0x2810 encoder type → Adjustment of the used encoder on channel A

0x4810 encoder type B → Adjustment of the used encoder on channel B

6.1.1 Terms and definitions used here

Since some terms in connection with encoders are often misleading, here there is a description of some terms used in this manual:

TTL signals	Rectangular difference signals according to RS422/RS485 specification
Sine/cosine, 1Vpp, 1Vss	Sinusoidal difference signals with $1V_{ss}$ amplitude
Increments per revolution	Number of signal periods per revolution
Unit "increments" and position in increments	The resolution per signal period is 4 for encoders with incremental signals. That means, the resolution per revolution is the number of signal periods x 4. ¼ signal period is called here "increments". If, for example, a TTL encoder with 2500 signal periods per revolution is rotated by one revolution, the position in increments changes by 10000 increments. This increment value is not used in the actual position display in ru33 or the st parameters. Standardisation ru33: 65536 always corresponds to 1 revolution
High-resolution	The position within one signal period is also determined in case of sinusoidal incremental signals. This resolution is always 13 bit and is added to the position in increments. The accuracy is dependent on the encoder, lines, evaluation circuit, signal frequencies, component tolerances and is significantly lower than 13 bit.
Zero signal or reference mark	With rotary encoders, one speaks of zero signals, with linear encoders of reference marks. But it is physically the same and is a digital signal, which is 1-active only at a certain signal period and 0-active otherwise. Thus it forms reference points at non-absolute encoders, which must first be passed in order to be able to evaluate them.

	With rotary encoders, a zero signal occurs once per revolution at always the same angle of rotation. Linear encoders can have one reference mark on the travel path or several. Several reference marks can either have the same distance of signal periods to each other (periodic reference marks), or the distances are so different from reference mark to reference mark that an absolute reference point can be calculated from them (distance-coded reference marks).

6.1.2 **Encoder types**

Since the encoder evaluation can evaluate different encoder types and many parameters are only necessary for certain encoders, the differences are shortly described here:

Generally absolute and non-absolute encoders can be differentiated first.

6.1.2.1 Absolute encoder

Absolute encoders supply after switching on directly the "right" position value, i.e., the reference of position and rotor is always maintained.
Singleturn encoders can only restore the position within one revolution after switching on. Multiturn encoders temporary store a certain number of whole revolutions depending on the encoder type.

Absolute encoders are different in:

- **Resolver**

Resolver are always singleturn encoders

- **Digital encoder (EnDat digital, BiSS, SSI)**

The position value is determined by the encoder itself and transmitted via a fast serial communication in each control cycle for encoder evaluation.

- **Absolute encoders with incremental signals (Endat+1Vss, SinCos-SSI, Hiperface, SinCos with absolute track)**

After switching on the device, the absolute position is determined once from the encoder. Since the detection of this position is either too slow (e.g. slow serial communication at Hiperface) or too inaccurate (sine-cosine), it is used only as starting value. Only the incremental signals, which can be counted and evaluated in real-time are used from this starting value.

Then the absolute position is only read in order to compare it with the incremental counted position for diagnosis purposes (monitoring) (every 8 ms or depending on the encoder typ).

If more incremental signals are counted e.g. by EMC than actually overrun, there is a deviation between incremental and absolute position.
This position deviation is corrected, i.e., the incremental counted position is shifted again to the absolute position. An error message is triggered if these position deviations appear so often that they can not be corrected any more.

The position correction function can be parameterized under 6.1.6.5 "Position monitoring and correction", page 244.

6.1.2.2 Non-absolute encoders

HTL, TTL, SinCos without absolute track

These encoders always have incremental signals, either square-wave or sinusoidal.

The position after switching on is always 0, i.e., without reference to the rotor.

If the encoders have a zero signal, the reference to the zero position (ec31) can be done over this, as soon as the signal has been passed.

The zero signal is also used to check and correct wrong counted incremental signals (e.g., due to EMC).
The position correction function can be parameterized under 6.1.6.5 "Position monitoring and correction", page 244.

6.1.2.3 Supported encoders

Which encoders are generally supported and which physical limitations apply (e.g. maximum signal frequencies, lines to be used, signal forms etc.) can be found in the installation manual associated to the device.
This chapter describes only the software restrictions for certain encoder types.

All standard SinCos, TTL and HTL encoders are supported within the following parameters described below.

- **EnDat**

Variants of the EnDat interface and the different "EnDat" terms:

The EnDat interface is a digital connection to read or write the position and a wide variety of other data of the encoder.

The commands required for this are summarised in the command set. The newer command set *"EnDat 2.2"* has more commands than its previous version *"EnDat 2.1"* and is downward compatible to it.

Many EnDat encoders have incremental signals in addition to this digital interface, e.g. to obtain a higher-resolution position. These signals can be 1Vpp, HTL or TTL signals.

The incremental signals and the encoder set is indicated with the order designation, which is also on the nameplate of the encoder.

The order designation *"EnDat22"* must not be confused with the command set *"EnDat 2.2"*.

Currently there are e.g. the following order designations:

Bestellbezeichnung	Befehlssatz	Inkrementalsignale
EnDat01 EnDatH EnDatT	EnDat 2.1 oder EnDat 2.2	1 Vss HTL TTL
EnDat21		–
EnDat02	EnDat 2.2	1 Vss
EnDat22	EnDat 2.2	–

Versionen der EnDat-Schnittstelle

Figure 62: Order designation

Supported EnDat encoder

The encoder evaluation recognises whether the encoder has the *"EnDat 2.1"* or *"EnDat 2.2"* command set and can evaluate both variants.

The evaluation only distinguishes whether the 1Vpp signals are to be evaluated (ec16 = "EnDat+1Vpp") or not (ec16 = "EnDat digital").

Also encoders with 1Vss signals can be evaluated purely digital. This can be useful for diagnostic purposes, for example, or if the digital position has a higher resolution than can be achieved with the 1Vpp signals.

It follows that, with regard to the interface, first of all all encoders with all "EnDat.." order designations with ec16 = "EnDat digital" can be evaluated. If the encoder still has 1Vpp signals,ec16 = "EnDat+1Vpp" is also possible. TTL and HTL signals are not evaluated.

In addition, there are the following restrictions:

The EnDat encoder type can be read out from the encoder (word 14 of the manufacturer parameters). Only the following identifiers are supported:

0xC0: Singleturn rotary encoder and angle encoders

0xE0: Multiturn rotary encoder with gear

0xD0: Multiturn rotary encoder with battery buffering (see also 6.1.9, „Operation of EnDat multiturn encoders with battery buffering“, page 255)

0x40: Absolute length measuring device (with or without 1Vpp signals)

The new, always purely digital EnDat 3 interface is physically different and is not supported here.

- **Hiperface**

Hiperface encoders are only supported by the evaluation if they are either known to it or if newer encoders have the so-called "extended nameplate 0xFF". This contains additional information about the encoder, such as increments per revolution, maximum temperatures, encoder designation, and also allows an evaluation if the concwened encoder type is not explicitly stored in the encoder evaluation.

Which Hiperface encoders are currently supported, is described in chapter 6.1.2.6, "Display detected encoder type", page 226.

Hiperface encoders must ALWAYS be supplied with 8V.

- **BiSS**

There are different variants from this (copyrighted) open interface, which are also partly changed by the different encoder manufacturers. Although there are possibilities for standardization (profiles), each encoder which is not explicitly tested and released can not be supported once. These two BiSS variants are differentiated in this manual:
BiSS with electronic type plate (EDS) and BiSS-C-unidirectional or without EDS

Clock frequency is 3.125 MHz

BiSS with EDS:

BiSS encoders with electronic name plate have a non-volatile memory, from which all parameters which are required for the evaluation of the encoder can be read out.
Additionally, motor data can be stored and read out again in the encoder. That means, only encoder type ec16 must be set to "BiSS" to evaluate these encoders.

All BiSS Acuro encoders from the Hengstler company belong to this category and are fully supported.

From firmware version 2.4, encoders are also supported if the stored data correspond to the BiSS profiles BP1 ("Standard Rotary Encoder") or BP3 ("Standard Encoder Profile").

BiSS-C-unidirectional:

These BiSS encoders do not allow memory access or have no memory. As a result, all required values for communication must be adjusted via parameters (parameter: 6.1.6.6, "The digital data word", Page 245)

Additionally, the data word must be structured as follows:

Figure 63: Structure data word BiSS

Start:	Start bit is always 1
0:	The bit following the start bit is always "0"
MT:	Multiturn resolution ec41
ST:	Singleturn resolution ec40
ERR:	Error bit 0-active
WARN:	Warning bit 0-active
CRC polynomial:	6 bit: $x^6+x^1+1 \rightarrow$ 0x43

These include e.g.encoders of the company Renishaw or Kübler

other BiSS encoders:

many other tested encoders contain only parts of the functionality of BiSS with EDS, for example:

they only allow read access, but no write access

they contain no / usable data

they generally correspond to the specifications of the BiSS profile BP3 for encoders, but differ in one point from them

the functionality / the memory content change with the date of the firmware of the encoder

These encoders can often be evaluated although as BISS-C-unidirectional encoder, if the data word is configured accordingly.

Initialization of BiSS encoders:

If the stored manufacturer ID in the encoder is unknown to the encoder evaluation, it attempts to establish communication with the encoder based on the stored data in the encoder. If this fails, an error message is output and possibly the encoder can be evaluated as BiSS-C unidirectional.

Even if the communication can be established error-free, it is possible that position values or speeds are wrong because the data stored in the encoder do not correspond to the profile or manufacturer specifications, which sometimes occurs in practice.

Based on the detected encoder type in ec17 it is possible to evaluate to what extent the connected encoder has been detected.

If the COMBIVIS plaintext for ec17 contains the manufacturer name and the encoder type (e.g. 65 "BiSS Hengstler Acuro AC36 Singleturn"), there is an encoder connected which is stored in the encoder evaluation and which is completely known.

If ec17 only contains the manufacturer name (e.g. 76 "BISS Mode Hengstler, Singleturn" or 77 "BISS Mode Hengstler, Multiturn"), the encoder evaluation could read a manufacturer ID from the encoder without knowing the exact encoder type.

The values of 74 and 75 "BiSS Mode C, singleturn or multiturn, + EDS type label" indicate that the manufacturer identification is unknown, but the encoder contains an el. nameplate, which corresponds to the BiSS profile BP3.

Values 61 and 62 "BiSS Mode C, singleturn or multiturn" (i.e. without el. nameplate) mean that the encoder does not allow memory access or it is a BiSS-C unidirectional variant.

If value 84 "BiSS Mode C, EDS containing inconsistent data" is displayed, the encoder has an electrical nameplate, but the data does not correspond to the profile definition or they are inconsistent.

In this case, the values must be set as for BiSS-C unidirectional encoders, because it cannot be ensured that the values from the encoder are correct.

The display of the manufacturer name in ec17 means, encoders of this manufacturer have already been tested. However, it is recommended to test actual encoders again.

BiSS linear encoders:

Only linear encoders with BiSS-C unidirectional are supported.

➢ **Linear measuring devices**

Different linear encoders are supported:

- EnDat: absolute linear encoders

- BiSS-C, but only unidirectional, i.e. without electronic nameplate

- SSI

- Incremental linear encoders with 1Vpp or square-wave signals, with periodic, distance-coded or without reference marks.

For more information on linear encoders, see 6.1.7, "Operation of absolute linear encoders“, page 251 and 6.1.8 "Operation of non-absolute linear encoders (with and without reference marks))“, page 254)

6.1.2.4 List with tested encoders

The following list contains a selection of tested absolute encoders with different protocols and interfaces. "Standard" incremental encoders with SinCos, TTL or HTL signals are not listed:

Manufacturer	Type designation	Type
Heidenhain	EQI1317, ECN1313, EQI1329, EQI1331, EQI1337, EQN1337, EQN1325, ROQ425	EnDat Single and Multiturn rotary encoder
	ERN1188, ERN1387	SinCos with absolute track
	ECN1313	SinCos with SSI
	EBI135	EnDat Multiturn with battery buffering

Manufacturer	Type designation	Type
	LC185, LC281	absolute EnDat linear encoder
	LS187C	Incremental linear encoder with distance-coded reference marks
Hengstler	AD34, AD35, AD36, AC58	BiSS Single and Multiturn
Kübler	IK.IT.02C-CA00	BiSS Multiturn
Kübler	8.F5863.1222.G221	BiSS Multiturn
Posital Fraba	KCD-BC00B-1617-C10C-2RW	BiSS Multiturn
Pepperl+Fuchs	AVM58N-086AARHGN-1212	SSI Multiturn
Renishaw	RA18BAA209 B30A, RA26BAA104B30A	BiSS Singleturn
	RL26BAT050B05A	BiSS linear encoder
Sick-Stegmann	SEL37, SEK90, SEK160, SKM36, SRS50, SRM50	Hiperface Single and Multiturn rotary encoder
	TTK70	Hiperface linear encoder
Sick	DL 100 SSI	Laser linear encoder
TWK	AFM60	SSI Multiturn
	CRE65	SSI Multiturn

Table 6-1: Selection of tested encoders

6.1.2.5 Setting encoder type

Which encoder or which signals shall be evaluated is adjusted in ec16 encoder type.

Index	Id-Text	Name	Function
0x2810 0x4810	ec16	encoder type	Adjustment of the encoder signals to be evaluated

The identification and initialisation of the connected encoder is triggered by the write access. This process can take upto several seconds.

If Endat encoders shall be evaluated at both channels, only Endat digital is possible at both channels.

If an error is displayed in ec00 status encoder interface it can be helpful for diagnostic purposes to set a different encoder type first, in order to check individual signals.
For example at a Hiperface encoder, only the evaluation of the 1Vss signals can be activated with ec16 = 3 "sine/cosine without absolute track without zero signal".
By way it can be checked whether these signals are correctly connected and whether the sense of rotation and the number of signal periods are correct.

Endat encoders with 1Vss signals can only be evaluated digitally. The serial communication can be checked with it.

When switching between digital evaluation and evaluation with 1Vpp signals, the position in the ru parameters changes slightly. There is a difference of half a signal period because the digital position value is adapted to the 1Vpp signals.

The selection of an encoder type with or without zero signal means that the zero signal is evaluated or not evaluated, independent whether the encoder actually provides a zero signal.

NOTICE

➢ If another encoder shall be connected, ec16 must first be set to 0 before the connected encoder is disconnected and the new encoder is plugged in.

The following encoder types at channel A are possible in ec16:

ec16	encoder type	0x2810
Value	Encoder type	
0	no encoder evaluation	
1	TTL without zero signal	
2	TTL with zero signal	
3	Sine/cosine without absolute track without zero signal	
4	Sine/cosine without absolute track with zero signal	
5	Sine/cosine with absolute track without zero signal	
6	Sine/cosine with absolute track with zero signal	
7	Sine/cosine with SSI	
8	SSI	
9	Resolver	
10	Endat + 1Vpp	
11	EnDat digital	
13	Hiperface	
14	Linear BiSS-C unidirectional	
15	BiSS	
17	Linear encoder with SinCos signals and without reference marks	
18	Linear encoder with TTL signals and without reference marks	
19	Linear encoder with SinCos signals and periodic reference marks	
20	Linear encoder with TTL signals and periodic reference marks	
21	Linear encoder with SinCos signals and distance-coded reference marks	
22	Linear encoders with TTL signals and distance-coded reference marks	

NOTICE

➢ The supply voltage of the encoder must always be set to 8V for Hiperface encoders (ec14).

The following encoder types at channel B are possible in ec16:

ec16	encoder type B	0x4810
Value	Encoder type	
0	no encoder evaluation	
1	TTL / HTL without zero signal	
2	TTL / HTL with zero signal	
8	SSI	
11	EnDat digital	
14	Linear BiSS-C unidirectional	
15	BiSS	
16	Incremental encoder emulation	
18	Linear encoder with TTL signals and without reference marks	
20	Linear encoder with TTL / HTL signals and periodic reference marks	
22	Linear encoder with TTL / HTL signals and distance-coded reference marks	
23	Inductive sensors (only for F6P and S6P devices)	

6.1.2.6 Display detected encoder type

The detected encoder type by the encoder interface is displayed in ec17 detected encoder type:

Index	Id-Text	Name	Function
0x2811 0x4811	ec17	detected encoder type	Display the detected encoder type

By writing on any parameters (e.g. ec14, ec16, ec28, ec29, ec32, ec35), parts of the initialization and encoder detection are executed once again, depending on the encoder to be evaluated.
The actual position is then set to the same value as after switching on, e.g. for non-absolute encoders (TTL, HTL or sine/cosine) to 0.

For encoders that have or could have a zero signal or reference marks, the recognised encoder type goes to 1 "encoder identification running" after switching on. Here the differences:

➢ **Encoder type with zero signal (ec16)**

If an encoder type with zero signal is set, the encoder identification is active until the encoder has passed at least one complete revolution with two zero signals. In this case, the passed zero signals and the covered periods per revolutions are monitored and checked with the setting in ec29.

Then the encoder identification is completed and either the recognized encoder type is displayed or an error message is triggered if one of the checks has failed. Now the position of the zero signal is also available in ec31.

As long as no second zero signal is passed or always only the same one, the recognised encoder type ec17 remains at 1 "encoder identification running". But apart from this display, this has no further effects. All monitoring is already running.

An error is triggered if no zero signal has been passed after three revolutions. How many increments are regarded as revolution is depending on the setting in ec29 periods per revolution.

Example:
If the increments per revolution of an encoder is 1024, but 2048 pulses per revolution are adjusted in ec29, the error is triggered after 3 * 2048 pulses = 6 revolutions (3 * 2048 / 1024).

➢ **Encoder type without zero signal (ec16)**

If a zero signal is detected, an encoder with a zero signal is displayed in the detected encoder type, but there is no further evaluation.

The detection of a zero signal here only means that the zero signal input of the encoder evaluation is in any manner connected
If, for example, "TTL without zero signal" is adjusted as encoder type in ec16 and a SSI data signal is connected to the zero signal input, an encoder with zero signal is displayed in ec17 detected encoder type.
Whether the detected signal is actually a zero signal can be checked by activating an encoder type with zero signal.
During the encoder identification, the described checks (in the previous item) of the zero signal are executed then.

The following encoder types are defined in ec17:

ec17	detected encoder type	0x2811 / 0x4811
Value	detected encoder type	Value ec16
0	No encoder detected	0
1	Detection is running Only for encoders that (could) have a zero signal. The value changes to the detected encoder type, if the encoder has been moved one complete revolution with two zero signals. In this case, the traversed zero signals and the covered periods per revolutions are monitored and checked with the setting in ec29.	1 - 6
2	Detected encoder is not supported	---
3	TTL / HTL without zero signal	1, 2
4	TTL / HTL with zero signal	1, 2
5	Sine/cosine without absolute track without zero signal	3 - 6, 13
6	Sine/cosine without absolute track with zero signal	3 - 6
7	Sine/cosine with absolute track without zero signal	3 - 6
8	Sine/cosine with absolute track with zero signal	3 - 6
9	Sine/cosine with SSI	7, 8
10	SSI	7, 8
11	Resolver	9
20	Endat not supported type	10, 11
21	only 1Vpp signals were detected, but digital communication is not possible	10, 11
22	Endat 2.1 without 1Vpp, singleturn	10, 11
23	Endat 2.1 with 1Vpp, singleturn	10, 11
24	Endat 2.1 without 1Vpp, multiturn	10, 11
25	Endat 2.1 with 1Vpp, multiturn	10, 11
26	Endat 2.1 ohne 1Vpp, linear	10, 11
27	Endat 2.1 mit 1Vpp, linear	10, 11
28	Endat 2.2 without 1Vpp, singleturn	10, 11
29	Endat 2.2 with 1Vpp, singleturn	10, 11
30	Endat 2.2 without 1Vpp, multiturn	10, 11
31	Endat 2.2 with 1Vpp, multiturn	10, 11
32	Endat 2.2 without 1Vpp, linear	10, 11
33	Endat 2.2 with 1Vpp, linear	10, 11
34	EnDat 2.2 without 1Vpp, battery-buffered multiturn	10, 11
35	EnDat 2.2 with 1Vpp, battery-buffered multiturn	10, 11
40	Hiperface not supported type	13
41	Hiperface SCS 50/60 singleturn	13
42	Hiperface SCM 50/60 multiturn	13
43	Hiperface SRS 50/60 singleturn	13
44	Hiperface SRM 50/60 multiturn	13
45	Hiperface SKS 36 singleturn	13
46	Hiperface SKM 36 multiturn	13
47	Hiperface SEK 37/52 singleturn	13
48	Hiperface encoder with extended nameplate 0xFF	13
49	Hiperface without 1Vpp signals	13
50	Hiperface TTK70	13
51	Hiperface TTK70 (must be calibrated)	13
52	Hiperface SEL 37/52 multiturn	13
53	Hiperface TTK50	13
60	BiSS not supported type	15
61	BiSS mode C singleturn unidirectional without el. nameplate	15
62	BiSS mode C multiturn unidirectional without el. nameplate	15

ec17	detected encoder type	0x2811 / 0x4811
Value	detected encoder type	Value ec16
63	BiSS Hengstler Acuro singleturn	15
64	BiSS Hengstler Acuro multiturn	15
65	BiSS Hengstler Acuro AC36 singleturn	15
66	BiSS Hengstler Acuro AC36 multiturn	15
67	BiSS Hengstler Acuro AD36 singleturn	15
68	BiSS Hengstler Acuro AD36 multiturn	15
69	BiSS Hengstler Acuro AC58 singleturn	15
70	BiSS Hengstler Acuro AC58 multiturn	15
71	BISS mode B Baumer Thalheim singleturn	15
72	BISS mode B Baumer Thalheim programmable multiturn	15
73	BISS mode B Baumer Thalheim not programmable multiturn	15
74	BISS mode C, singleturn, with el. nameplate	15
75	BISS mode C, multiturn, with el. nameplate	15
76	BISS mode C Hengstler, singleturn	15
77	BISS mode C Hengstler, multiturn	15
78	BISS mode C Kübler, singleturn	15
79	BISS mode C Kübler, multiturn	15
80	BISS mode C AMO Absys, singleturn	15
81	BISS mode C AMO Absys, multiturn	15
82	BISS mode C AMO Absys, linear	15
83	BISS mode C AMO, no EDS nameplate	15
84	BiSS mode C, EDS contains inconsistent data	15
85	BiSS mode C Posital-Fraba, singleturn	15
86	BiSS mode C Posital-Fraba, multiturn	15
87	BiSS mode C linear encoder	14
120	TTL/HTL, track A has 1-level, track B has 0-level	21 (1)
121	TTL/HTL, track A has 0-level, track B has 1-level	21 (1)
122	TTL/HTL, track A has 0-level, track B has 0-level	21 (1)
123	TTL/HTL, track A has 1-level, track B has 1-level	21 (1)

(1) Details on this at ec35

6.1.3 Position resolution of different encoder types

The resolution of the position within one revolution, which is determined by the encoder evaluation is depending on the adjusted encoder type and the connected encoder.

This position is converted to a fixed format for the display in ru33, 65536 (16 bit) corresponds to one revolution.
That means, the lower 16 bit of ru33 are the position within one revolution and the upper 16 bit the whole revolutions.

If the determined position of the encoder has a worse resolution (e.g., 13 bit with resolver) the least significant bits in ru33 are always zero.
If the determined position has a better resolution than 16 bit per revolution, the resolution for the display is reduced in ru33, that means: the lower bits of the determined encoder position are omitted.

The different internal functions (e.g. speed calculation, current control) use the full value range of the position detection to a maximum of 32 bit per revolution.

6.1.3.1 Resolver

The position determined by the encoder is resolved with 13 bit, one revolution corresponds to:

- 1 revolution = 2^{13} = 8192

6.1.3.2 Encoder with rectangular incremental signals (TTL and HTL)

A signal period contains 4 edges, which are counted.

The resolution corresponds to 4-fold of the number of pulses per revolution

- 1 revolution = ec29 · 4

6.1.3.3 Encoder with sine-wave 1Vss signals (Endat+1Vss, SinCos-SSI, Hiperface, Sin-Cos)

The position is always determined from the 1Vss signals for these encoders. Additionally to the counting of the traversed sine periods, also the position within one sine period is evaluated.
Since this high resolution is 13 bit, one revolution corresponds to:

- 1 revolution = ec29 · 2^{13} = ec29 · 8192

If these encoders have additional absolute information (digital or analog), this is only used to monitor the incrementally counted position (=> see 6.1.2.1 Absolute encoder).

The resolution of this absolute information is independent of the resolution of the position from the 1Vss signals. Typically, it is also significantly lower.

Example:

The key data of an Endat encoder are specified in the catalogue with:

- "increments per revolution = 512"

- "Positions/U = 2048 (11 bit)"

If this encoder is evaluated with ec16 = 10 " Endat + 1Vpp", corresponds to one revolution:

- 1 revolution = ec29 · 2^{13} = 512 · 8192 = 2^9 · 2^{13} = 2^{22} = 4194304

The position here is resolved with 22 bit, although the resolution of the absolute position, which is read out via the serial Endat communication is only 11 bit ("positions/U").

6.1.3.4 Digital encoder (EnDat digital, BiSS, SSI)

Since the position value is directly read out for digital encoders, the resolution of the detected position is also equal to the resolution of this serial position value.

For encoders with electronic type plate (Endat and partly also BiSS), the serial position is automatically read out without additional parameter settings. Therefore the resolution is indicated in the data sheets of the encoder manufacturer.

For evaluation of the Endat encoder from the previous example, the position within one revolution has a resolution of 11 bit at ec16 = 10 "Endat digital".

- 1 revolution = 2^{11} = 2048

If the encoder does not have an electronic nameplate (SSI and partly also BiSS), ec40 singleturn res. must be adjusted according to the data sheet specifications (=> see 6.1.6.6, "The digital data word“).

The resolution is 2^{ec40}, one revolution corresponds to:

- 1 revolution = 2^{ec40}
-

Example:

ec40 = 12

- 1 revolution = 2^{12} = 4096

6.1.3.5 For all encoders

In addition to the resolution, the control characteristics of a drive are significantly influenced by the accuracy of the position.
The accuracy is reduced compared to the position resolution by errors in the encoder, in the signals, the encoder mounting on the motor, the signal transmission, the input circuit, the encoder evaluation, the signal detection, etc.

Example:

A "system accuracy" of ± 60 angular seconds and a resolution of "positions/U = 2048 (11 bit)" is specified for an Endat encoder in the catalogue.

The resolution of the digital position is calculated by the 11 bit specification:

360° / 2^{11} = 0.176° per bit = 0.176 · 3600 angular seconds = 632 angular seconds per bit

If the 1Vss signals are evaluated, the position value has a resolution of 22 bit. This corresponds to a position resolution of

360° / 2^{22} = 0.000086° per bit = 0.000086 · 3600 angular seconds = 0.31 angular seconds per bit

In this case, the error of the position, which already results from the encoder (± 60 angular seconds) is many times greater than the resolution (0.31 angle seconds).

6.1.4 Scan time snd speed fluctuations

The speed is calculated from position differences. Therefore, the non-infinite resolution of the position mathematically always leads to a fluctuation of the speed. The finer the resolution of the position, the lower the speed fluctuations.

The scan time is the second influencing variable on the speed fluctuation, i.e. the time between the two position values from whose difference the speed is calculated. The greater the scan time, the lower the speed fluctuation.

From these two mathematical correlations there is a minimal fluctuation of the speed, which always occurs at fluctuation of the position by 1 increment and it can be calculated as follows:

$$\Delta n\,[rpm] = \frac{\Delta position}{scan\ time\ [min]} = \frac{resolution \cdot 1000 \cdot 60}{scan\ time\ ec26\ [ms]} = \frac{resolution \cdot 60000}{scan\ time\ ec26 [ms]}$$

6.1.4.1 Theoretical fluctuation of the speed due to the position resolution

Minimum speed fluctuation for resolver and default setting of ec26 by the position resolution:

Default setting ec26: 2 ms
position resolution for resolver: 1 revolution = 8192 => resolution = 1 / 8192 = 0.0001221

$$\Delta n\,[rpm] = \frac{0.000121 \cdot 60000}{2} = 3.66\ rpm$$

6.1.4.2 Real fluctuation of the speed

Additional to this minimal fluctuation at the real drive there are errors in the signals, the encoder mounting at the motor, the transmission path, the input circuit, the signal detection, etc. These factors cause additional fluctuations of the speed and thus influence the control.

Example for a resolver:
Due to the errors described above, the reliable position resolution is reduced to 10 bit (1 revolution = 1024 = > real resolution of the resolver = 1/1024 = 0.000977). When the scan time is set to 250 µs (0.25 ms), there is a speed fluctuation of:

$$\Delta n\,[rpm] = \frac{0.000977 \cdot 60000}{0.25} = 234.4\ rpm$$

Example for a SinCos encoder

An encoder with a high real resolution must be selected if the dynamics of the application require a short speed scan time. For a SinCos encoder with optical scanning with 2048 increments, the following real resolution is obtained:

Number of signal periods:	2048 increments (corresponds to 11 bit)
High resolution	real 8 bit high resolution (instead of the ideal 13 bit)
real resolution:	1 revolution corresponds to 2^{19} = 524288 resolution = 1 / 524288 = 0.00000191

$$\Delta n\,[rpm] = \frac{0.00000191 \cdot 60000}{0.25} = 0.46\ rpm$$

6.1.4.3 Effects of the scan time

As shown in the previous chapters, a short scan time causes a very high noise at the speed actual value when using encoders with low position resolution or position accuracy.

The speed fluctuations can be reduced by increasing the scan time.

This also reduces the achievable dynamic of the speed control circuit and thus of the drive.

However, a hard setting of the speed controller can prevent the noise of the speed. The evaluation which scan time is optimally can be done only in the application.

6.1.5 Status parameters of the encoder interface and encoder

The state of the encoder interface is displayed in ec00:

Index	Id-Text	Name	Function
0x2800 0x4800	ec00	status encoder interface	Displays the actual status of the encoder interface

ec00	status encoder interface		0x2800 / 0x4800	
Value	Name	Function	Position / speed	Parameter
0	undefined state	undefined, defect or no communication between encoder evaluation and control	invalid	-
1	interface init active	Initialize the encoder interface	invalid	-
2	wait for encoder type	Wait for encoder type setting in ec16	invalid	-
3	encoder depend init	Encoder dependent initialization	invalid	-
4	enc self initialisation	Encoder initializes itself	invalid	-
5	enc initialisation	Encoder initialisation, e.g. read data, delete error bits in the encoder, etc.)**1)**	invalid	-
6	busy position value ok	Request will be processed, e.g. save data in the encoder or error reset	valid	-
7	initialisation finished	Initialisation finished	invalid	-
8	wait for end of init	Initialization of speed calculation	invalid	-
9	position value ok	Operation	valid	-
10	interface warning	Encoder interface warning	valid	ec02
11	warning encoder	Warning encoder	valid	ec19
12	busy position value wrong	Request will be processed, e.g. save data in the encoder or error reset	invalid	-
13	error encoder interface	Error encoder interface	invalid	ec01
14	error encoder	Error encoder	invalid	ec18

1) If the state of ec00 remains at value 5: "enc initialisation" after switching on, the encoder interface waits for missing settings which are required for the encoder evaluation.

- TTL-, SinCos- and SinCos-SSI encoders: ec29 (signal periods per revolution) is still 0.
- SSI-, SinCos-SSI-, and BiSS encoders (only BiSS encoders without el. nameplate): SSI singleturn resolution in ec40 is still 0.
- Encoder emulation on channel B: After switching on, the position of channel A is not valid because e.g. no encoder is connected.

ec00 = 5 "enc initialisation" for BiSS means, that no electronic nameplate has been recognized and the interface tries to connect the encoder with the SSI parameters. 6.1.6.6 As soon as a correct response has been recognized by the encoder, the status ec00 changes to 9 "position value ok" (=> see "The digital data word", Page 245).

This means: if an encoder supported by the software is connected with el. nameplate and the state ec00 nevertheless remains at 5 "enc initialisation", there is a problem in the encoder connection.

If a BiSS encoder *without* el. nameplate is connected on a channel, which is waiting at state 5 and a BiSS encoder *with* el. nameplate is connected on the other channel, the state remains in value 7 "initialisation finished". The position can only be read cyclically from the encoders when both channels have either completed the initialization or are set to error.

Position and speed values are still valid when the warning function is activated, but in error case they are not valid.

The error state of the encoder interface is displayed in ec01 error encoder interface. The value is 0 if there is no error and unequal 0 if ec00 status encoder interface contains the value 13 "error encoder interface".

The warning state of the encoder interface is displayed in ec02 warning encoder interface. The value is 0 if there is no warning and unequal 0 if ec00 is in status 10 "interface warning".

Warnings and errors from the encoder are determined by the encoder itself and then actively sent by the encoder. The encoder evaluation only transmits the error messages and displays them directly.

The error state of the encoder is displayed in ec18 error encoder. The value is 0 if there is no error and unequal 0 if ec00 is in status 14 "error encoder".

The warning state of the encoder is displayed in ec19 warning encoder. The value is 0 if there is no warning and unequal 0 if ec00 is in status 11 "warning encoder".

More information about warnings and errors 6.1.10, "Error and warning messages" page 256.

6.1.6 Parameters for the encoder adjustment

6.1.6.1 Belonging of parameters to encoder type

Only certain parameters are necessary for the respective adjusted encoder type. The status parameters ec00 to ec19 are always valid for all encoder types.

Parameter		1: TTL / HTL without zero signal	2: TTL / HTL with zero signal	3: SinCos without abs.-track without	4: SinCos without abs.-track with zero	5: SinCos with abs.-track without zero	6: SinCos with abs.-track with zero	7: SinCos with SSI	8: SSI	9: Resolver	10: Endat + 1Vss	11: EnDat digital	13: Hiperface	14: Linear BiSS-C unidirectional	15: BiSS
ec14	encoder interf. gen. settings	×	×	×	×	×	×	×	×	×	×	×	✓	×	×
ec23	system offset (SM)	only for synchronous machines, independent of ec16													
ec24	gear numerator	×	×	×	×	×	×	×	×	×	×	×	×	×	×
ec25	gear denumerator	×	×	×	×	×	×	×	×	×	×	×	×	×	×
ec26	speed scan time	×	×	×	×	×	×	×	×	×	×	×	×	×	×
ec27	speed PT1-time	×	×	×	×	×	×	×	×	×	×	×	×	×	×
ec28	revolution range	-	-	-	-	×	×	×	×	×	×	×	×	×	×
ec29	periods per revolution	✓	✓	✓	✓	✓	✓	✓	-	-	-	-	-	-	-
ec30	Resolver pole pairs	-	-	-	-	-	-	-	-	×	-	-	-	-	-
ec31	zero pulse pos.	-	×	-	×	-	×	-	-	-	-	-	-	-	-
ec32	max. pos. error	-	×	-	×	×	×	×	-	-	×	-	×	-	-
ec33	abs. pos. accuracy	-	-	-	-	×	×	×	-	-	×	-	×	-	-
ec35	pos. calc. mode	×	×	×	×	×	×	×	×	×	×	×	×	×	×
ec36	several encoder functions	-	-	-	-	-	-	-	-	-	×	×	×	-	-
ec40	singleturn res.	-	-	-	-	-	-	✓	✓	-	-	-	-	**1)**	**1)**
ec41	multiturn res.	-	-	-	-	-	-	✓	✓	-	-	-	-	**1)**	**1)**
ec42	SSI data format	-	-	-	-	-	-	✓	✓	-	-	-	-	-	-
ec43	SSI clock freq.	-	-	-	-	-	-	✓	✓	-	-	-	-	-	-
ec44	SSI abs. allocation	-	-	-	-	-	-	✓	✓	-	-	-	-	-	-
ec46	encoder read/write	-	-	-	-	-	-	-	-	-	×	×	×	-	×
ec47	status encoder r/w	-	-	-	-	-	-	-	-	-	×	×	×	-	×
ec50	virtual rounds for linear enc.	-	-	-	-	-	-	-	-	-	×	×	×	×	-

Parameter		16: Incremental encoder emulation	17: Lin. SinCos, without refmarks	18: Lin. TTL, without refmarks	19: Lin. SinCos, period. Refmark.	20: Lin. TTL, period. refmark.	21: Lin. SinCos, abs.-cod. refmark.	22: Lin. TTL, abst.-cod. refmark.					
ec14	encoder interf. gen. settings	×	×	×	×	×	×	×					
ec24	gear numerator	-	×	×	×	×	×	×					
ec25	gear denumerator	-	×	×	×	×	×	×					
ec26	speed scan time	-	×	×	×	×	×	×					
ec27	speed PT1-time	-	×	×	×	×	×	×					
ec28	revolution range	-	-	-	-	-	-	-					
ec29	periods per revolution	✓	✓	✓	✓	✓	✓	✓					
ec30	Resolver pole pairs	-	-	-	-	-	-	-					
ec31	zero pulse pos.	-	-	-	×	×	×	×					
ec32	max. pos. error	-	-	-	×	×	×	×					
ec33	abs. pos. accuracy	-	-	-	-	-	-	-					
ec35	pos. calc. mode	-	×	×	×	×	×	×					
ec36	several encoder functions	-	-	-	-	-	-	-					
ec40	singleturn res.	-	-	-	-	-	-	-					
ec41	multiturn res.	-	-	-	-	-	-	-					
ec42	SSI data format	-	-	-	-	-	-	-					
ec43	SSI clock freq.	-	-	-	-	-	-	-					
ec44	SSI abs. allocation	-	-	-	-	-	-	-					
ec46	encoder read/write	-	-	-	-	-	-	-					
ec47	status encoder r/w	-	-	-	-	-	-	-					
ec50	virtual rounds for linear enc.	-	×	×	×	×	×	×					

Explanations

- \- has no influence to this encoder type.
- × must be adjusted depending on the application. However, the encoder evaluation is also possible.
- ✓ must be adjusted for this type, otherwise evaluation is not possible.
- 1) must only be adjusted for BiSS unidirectional or BiSS encoders without electronic nameplate. This parameter has no influence for BiSS encoders with electronic nameplate.

From this table it can been seen, that operation of Resolver, Endat and BiSS (with el. nameplate) directly after default set loading it is only possible with the setting of ec16.

6.1.6.2 Encoder signals

Value range for whole revolutions **ec28** revolution range

Index	Id-Text	Name	Function
0x281C 0x481C	ec28	revolution range	Defines the value range for whole revolutions

Max. 65536 revolutions are always counted at singleturn encoders. The counting method of the revolutions can be adjusted here for multiturn encoders.

This parameter is bit-coded:

ec28	revolution range		
Bit	Name	Value	Function
0..1	counting revolutions	0	If the multiturn range of the encoder is left, the revolutions change to 0 (overflow) respectively to max. revolution value of the encoder (underflow). Position remains the same even after switching on/off.
		1	If the multiturn range of the encoder is left, the revolutions are still incremented and overflow occurs after 65535 revolutions. After switching off/on, the revolutions that exceeded the multiturn range are set to 0, so that the position can be different after switching off/on.
		2	**Multiturn encoder:** If the multiturn range of the encoder is left, the revolutions are still incremented and overflow occurs after 65535 revolutions. The revolutions counted beyond the multiturn range are stored non-volatile, and after switching off/on they are calculated with the position of the encoder by way that the position remains the same. If this function is activated, eventually previously counted overflows are deleted. Precondition: - When the unit is switched off the encoder shall not be turned more than half of its multiturn range. - The non-volatile storing must be completed before the unit is switched off. **Singleturn encoder:** Accordingly, the counted revolutions can also be stored non-volatile for absolute singleturn encoders (e.g., resolver, SinCos with absolute track etc.). Precondition: - When the unit is switched off the encoder shall not be turned more than a quarter revolution. **Non-absolute encoders:** The setting of this value is not possible ("data invalid") for non-absolute encoders (e.g., TTL and SinCos without absolute track).

ec28	revolution range		
Bit	Name	Value	Function
2	auto adjust counting	0	no automatic setting
		4	(not available for compact cards) If an absolute encoder is set in ec16, e.g. Resolver, Endat etc, the bits "counting revolutions" are automatically set to 2 and by way the non-volatile storage of the revolutions is activated. If a non-absolute encoder is set, e.g. TTL or SinCos without absolute track, the bits "counting revolutions" are automatically set to 0.

NOTICE

- Parameter ec28 must be set to 1 or 2, if the value range shall be passed at a multiturn encoder. Otherwise, there is a jump in the position measurement when passing the multiturn range.

Signal periods per revolution ec29 periods per revolution

ec29	periods per revolution	0x281D / 0x481D
Value	Meaning	
0…500.000.000	Number of signal periods per revolution	

If the encoder has incremental signals, this parameter displays the number of signal periods per revolution (= increments per revolution). The number of periods of the encoder must be set here for TTL and sine-cosine encoders (ec16 = 1…7). If the encoder interface can read out this value from the encoder (e.g., at Endat, Hiperface, BiSS with el. nameplate), it is displayed here and it can not be changed. With activated incremental encoder evaluation at channel B, the number of signal periods per revolution are adjusted. The maximum possible value is 16384.

For linear encoders with reference marks, the number of signal periods between the reference marks is set here, or for distance-coded reference marks, the so-called base distance.

See also 6.1.8 "Operation of non-absolute linear encoders (with and without reference marks))"

Virtual revolutions for linear encoders ec50 virtual rounds for linear encoder

ec50	virtual rounds for linear encoder	0x2832 / 0x4832
Value	Meaning	
0…500.000.000	"Virtual revolution", means the changing of numbers of the encoder position according to the whole number of motor pole pairs are passing.	

Only for evaluation of linear encoders.

For digital encoders (EnDat digital), the amount by which the digital position word changes is set here.

For encoders with incremental signals (EnDat+1Vss, Hiperface, SinCos, TTL), the number of signal periods is set here.

This value also determines how the linear positions and speeds are converted into rotative positions and speeds and displayed in e.g. ru33 and ru09.

Further information: 6.1.7, „Operation of absolute linear encoders“, page 251

Number of resolver pole pairs ec30 Resolver pole pairs

ec30	abs periods number	0x281E
Value	Meaning	
0…10	Resolver: Number of pole pairs	

Resolvers with pole pair number 1 (i.e. 2-pole) can be used for motors with any pole pair number.

If the number of pole pairs is greater than 1, the number of pole pairs of the motor and resolver always match. Here the resolution is higher than for resolvers with pole pair number 1.

Operation is also possible if the number of pole pairs of the motor is an integer multiple of the number of pole pairs of the resolver. Whereby: The larger the factor PPZ motor / PPZ resolver factor, the lower the resolution of the position.

Position of the zero signal ec31 zero pulse pos.

ec31	zero pulse pos.	0x281F / 0x481F
Value	Meaning	
$-2^{31}-1 \ldots 2^{31}-1$	Display of the position of the zero signal in increments (read-only)	

The encoder detection is active after the initialization of encoders which (could) have a zero signal. This is displayed in ec17 detected encoder type with "1: encoder identification running".

After the first zero signal has been passed, the position of the zero signal is calculated and then displayed in ec31 when the encoder detection has been completed, i.e. ec17 displays the detected encoder type.

The position of the zero signal is defined as the distance between the position when switching on (i.e. where ru33 = 0) and the "zero point" of the encoder, e.g. the zero signal or the first reference mark.

It is calculated from the zero signal that is first passed after switching on (or error reset).

The resolution of this value is in increments (= number of signal periods x 4), i.e. different from ru33!

➢ **Rotary encoder**

Here the reference point is the zero signal. The position of the zero signal is always indicated in positive direction of rotation, i.e. it is always positive.

<u>Example:</u>

The device is switched on with a TTL encoder with 1000 signal periods per revolution. The position value after switching on for non-absolute encoders is always 0. The encoder is at an angle of rotation of 300°, so the zero signal is 60° in positive direction of rotation.

When the encoder detection is finished after the drive has started, the value of ec31 (the position of the zero signal in encoder increments) is 667, i.e.:

$$\text{ec31} = \text{ec29} \cdot 4 \cdot \frac{60°}{360°} = 1000 \cdot 4 \cdot \frac{60°}{360°} = 667$$

ru33 has the position value at this position of the zero signal (because it is normalised in 16 bits = 65536 = 1 revolution):

$$ru33 = \frac{667}{ec29 \cdot 4} \cdot 65536 = \frac{667}{1000 \cdot 4} \cdot 65536 = 10928$$

This formula is only valid if the gear factor in ec24 / ec25 is 1.

- **Linear encoders with periodic reference marks**

For linear encoders, the value of ec31 is positive if the first passed reference mark is in the direction of ascending position values (from the switch-on position). If it is in the direction of descending position values, it is negative.

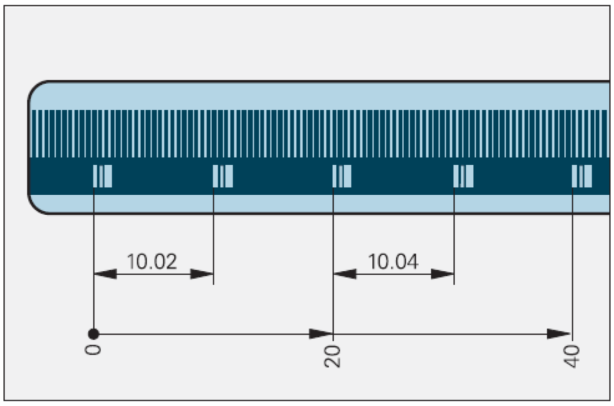
When converting to position parameters such as ru33, it should be noted that for linear encoders these refer to one virtual revolution in ec50, i.e.:

$$ru33 = \frac{ec31}{ec50 \cdot 4} \cdot 65536$$

- **Linear encoders with distance-coded reference marks (distance-coded reference marks)**

This variant of the reference mark track, mainly used by Heidenhain, consists of many reference marks which all have a different distance to each other. From these distances, the absolute reference can be calculated if two adjacent reference marks have been passed.

At the beginning of the scale is the first reference mark (here is an excerpt from the Heidenhain documentation):



Schematic representation of an incremental graduation with distance-coded reference marks (LS as example)

	Signal period	Nominal increment *N* in signal periods	Maximum traverse
LF	4 µm	5000	20 mm
LS	20 µm	1000	20 mm
LB	40 µm	2000	80 mm

Figure 64: distance-coded reference marks at Heidenhain

They are structured like this:

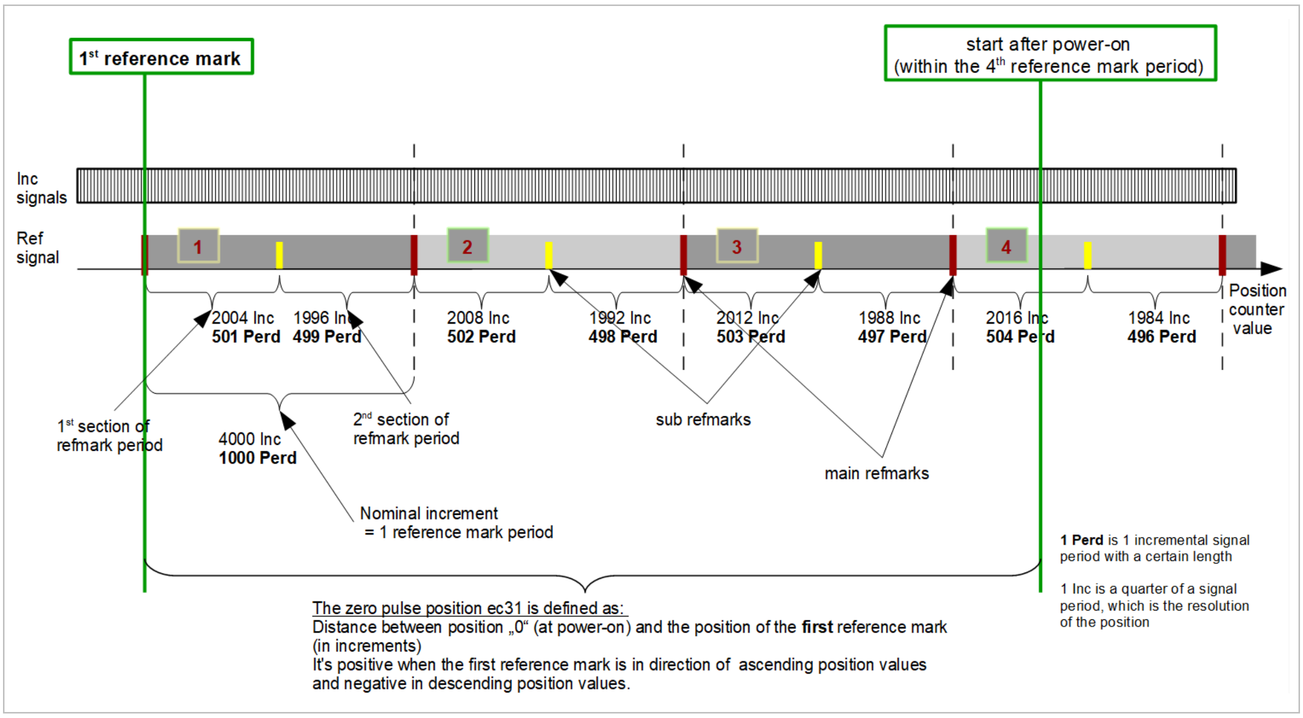


Figure 65: distance-coded reference marks

First there are the main reference marks, which have all the same distance to each other, between them is always the same number of signal periods. This is the basic distance (nominal increment) that must be entered in ec50.

Between the main reference marks are the sub reference marks (sub refmarks), which all have a different distance to each other and also to the main reference marks.

If at least two adjacent reference marks are passed (i.e. main and sub reference mark), the absolute reference can be determined from the number of signal periods between them, i.e. exactly where the drive is on the scale.

The distance between two reference marks is max. the base distance and min. half of it. If the base distance is e.g. 1000 periods and one signal period is 20 µm long, this is 20 mm.

Only when two reference marks have been passed, ec17 changes from 1 "encoder identification running" to the recognized encoder type and the calculated position of the zero signal is displayed in ec31.

The zero signal position in ec31 is also the absolute reference, which is defined here as distance between the first reference mark (which is at the beginning of the linear measuring system) and the position when the device is switched on.

If the 1st reference mark is in the direction of ascending position values from the switch-on position, the zero signal position is positive. If it is in the direction of descending position values, it is negative, which is usually the case.

Mode position calculation ec35 pos. calc. mode

Index	Id-Text	Name	Function
0x2823 0x4823	ec35	pos. calc. mode	Defines different settings for position calculation.

This parameter is bit-coded:

ec35	pos. calc mode		
Bit	Function	Value	Function
0	Evaluation high-resolution (at 1Vss signals)	0	High-resolution is evaluated.
		1	High-resolution is not evaluated.
1	Rotation of the position and speed	0	not inverted
		2	inverted
2	Resolver evaluation compatibility mode	0	Improved resolver evaluation (from V2.6)
		4	Previous resolver evaluation (up to V2.5)
3..4	Only for F6P and S6P devices and only for ec16 = 21: "Inductive Sensors": Evaluation signal tracks	0	Tracks A and B are evaluated
		8	Only track A is evaluated
		16	Only track B is evaluated
5	Only for F6P and S6P devices and only for ec16 = 21: "Inductive Sensors": Display of signal levels	0	off
		32	on

Encoder breakage recognition

The encoder signals, which shall be evaluated via ec16 are tested after switched on and cyclically in operation, whether they correspond to the specifications (e.g., RS485 or 1Vss).

A warning is triggered, if deviations from the specifications are detected. An error message is triggered in ec00, if these deviations occur too often.

Whether the axis module changes into error state through this error message of the encoder interface depends on the programming of the pn parameters and the used control mode (cs00).

Pure digital encoder evaluations (ec16 = Endat digital, BiSS and SSI) recognize an interrupted signal line of 10 ms and lower.

The disconnecting time is depending on the adjusted encoder type, the signal levels, signal frequency and position for the evaluation of analog signals.

In an extreme case (e.g.) if a COS line is interrupted at a position where the signal would have a signal difference of 0V, no encoder breakage can be recognized at all!

6.1.6.3 Speed smoothing

The total speed deceleration is calculated by:

ec26 speed scan time / 2 + ec27 speed PT1-time

Speed scan time ec26 speed scan time

This parameter determines the time between the measured positions wherefrom the speed is generated.

Index	Id-Text	Name	Function
0x281A 0x481A	ec26	speed scan time	Scan time for speed

ec26	speed scan time	0x281A / 0x481A
Value	Speed scan time	
2	250 µs	
3	500 µs	
4	1 ms	
5	2 ms	
6	4 ms	
7	8 ms	

The minimum possible sampling time is always 250 µs.

This time can be extended for SSI encoders, e.g. with long telegram lengths and low clock frequencies. (Chapter 6.1.6.6 The digital data word)

For more information about scan time, see chapter6.1.4 Scan time snd speed fluctuations

Speed filter ec27 speed PT1-time

The filter time of the PT1 filter for the speed calculation is adjusted with this parameter.

ec27	abs periods number	0x281B / 0x481B
Value	Meaning	
0…256.000ms	PT1 – filter time resolution 0.001ms	

The PT1 filter time should not be higher than the half scan time. If ec26 = 5 "2ms“ is selected, then ec27 should be set to 1ms.

6.1.6.4 Gear factor

A gear factor can be adjusted with ec24 and ec25, which takes effect on all position and speed calculations of the encoder interface before the position and speed are internally transmitted to the control.

The position before the gear factor is displayed in ru38.

The displayed values in the speed parameters (e.g. ru08 / ru09) or position parameters (e.g. ru33) include already the gear conversion factor, except for ec31 and ec33.

If the number of motor revolutions is adjusted in ec24 gear numerator and the number of speed encoder revolutions in ec25 gear denominator, then the position and speed related to the motor shaft is displayed in the inverter parameters.

Gear factor numerator ec24 gear numerator

Position and speed are multiplied with this value.

ec24	gear numerator	0x2818 / 0x4818
Value	Meaning	
0…65535	Multiplier for position and speed	

Gear factor denominator ec25 gear denominator

Position and speed are divided by this value.

ec25	gear denominator	0x2819 / 0x4819
Value	Meaning	
0…65535	Divisor for position and speed	

6.1.6.5 Position monitoring and correction

Maximum position error (position monitoring function) ec32 **max. pos. error**

ec32	max. pos. error	0x2820 / 0x4820
Value	Meaning	
0…180° el.	Position monitoring function: Maximum permitted deviation between incremental counted position and absolute position. 180° el: position monitoring is switched off, neither warning nor error will be triggered.	

For absolute encoders with incremental signals

A warning is triggered in ec02 warning encoder interface if the cyclically determined deviation between incremental and absolute position is higher than the adjusted value in ec32. An error is triggered, if the deviation is repeated several times in succession.

ec32 max pos error is expressed in (electrical) degrees, since a deviation of just a few encoder signal periods in combination with high poled synchronous machines may have been dramatic effects for encoders with low resolution.

The position error in increments is calculated as:

max. position error [inc] = ec29 * 4 [inc] * ec32 [°] / 360° / motor pole pair number

Example: If a max. position error of 20° is electrically adjusted in ec32, the following consequences occur for a motor with 3 pole pairs and an encoder with 1024 periods per revolution: The position monitoring triggers a warning message, if the incremental position has moved from the absolute position by 76 increments or 19 signal periods.

For non-absolute encoders with zero signal

The only difference to position monitoring for absolute encoders is that the incremental position is compared with the zero signal (instead with the absolute position).

The first passed zero signal is taken as start value and all subsequently detected zero signals are compared with it. Even if the same zero signal is always passed when turning back and forth by just a few degrees.

Special case SinCos encoder with absolute track without zero signal

Here the incremental position is compared with the absolute position. The maximum deviation is fixed (mechanically) adjusted to 16° and can not be changed.

Accuracy of the absolute position (position correction function) ec33

ec33	abs. pos. accuracy	0x2821 / 0x4821
Value	Meaning	
4…65535 Inc.	Deviation between incrementally counted encoder increments and absolute position of the encoder, from which the incremental position is set back to the absolute position. 65535 Inc: Position correction is switched off	

For absolute encoders with incremental signals

If the determined deviation between incremental and absolute position is higher than the value in ec33 (standardisation encoder increments), the incremental position is set back to the absolute position via ramp and with filter. If value 4 is set, a deviation is corrected by a signal period.

This can prevent position deviations, which could be caused by interference pulses during continuous operation.

Some encoders have speed-dependent a systematic error between absolute position and incremental position. Then the position correction function would adjust the actual (correct) incremental position to the wrong (delayed) absolute value. This (error) correction would be reversed at low speed, whereby a permanent intervention of the correction function occurs.

This behavior can lead to disturbing influences on the drive and can be prevented by increasing the minimum position difference from which the position correction function starts with the correction.

SinCos encoders have a relatively inaccurate analog absolute position. The start value for the correction must be adjusted correspondingly high (e.g. ec33 = 80).

6.1.6.6 The digital data word

The following parameters are for encoders where the position can be read digitally, i.e. EnDat, Hiperface, BiSS, SSI, SSI with SinCos. They describe the digital data word, which contains the position value and possibly also error bits.

The function depends on the encoder type, e.g. whether the encoder has an electronic nameplate or not.

Resolution of the digital position value ec40 **/** ec41 **singleturn / multiturn res.**

Index	Id-Text	Name	Function
0x2828 0x4828	ec40	singleturn res.	Adjusts the singleturn resolution in bit
0x2829 0x4829	ec41	multiturn res.	Adjusts the multiturn resolution in bit

<u>Encoders without electronic nameplate, i.e. SSI, BiSS-unidirectional and some other BiSS variants:</u>

The single and multiturn resolution from the encoder data sheet must be set here because they cannot be read out.

Only the number of bits that also belong to the position is set here, i.e. no error bits. The total length of the position value is then ec40 SSI singleturn res. + ec41 SSI multiturn res. .

Some encoders have data bits that must be clocked out but have no function or do not belong to the position value. For example, 32 bits must always be read, but the first 8 bits are always 0 and only the last 24 bits contain the position value.

In this case there is a large speed jump when the overflow position is passed (i.e. after 24 bits) because the encoder evaluation expects the overflow at 32 bits.

This means, such encoders can only be used when the overflow point is not passed!

Special features for SSI:

If a power fail bit is still set in ec42 (error bit), ec40 or ec41 do not increase.

The total data word length, i.e.ec40 + ec41 + PFB must be between 8 bits and 48 bits.

Encoders with electronic nameplate, i.e. EnDat, Hiperface and some BiSS variants:

The encoder interface reads the single and multi-turn resolution from the encoder and displays these values in these parameters, which cannot be changed. (Not available for compact cards, where these parameters have no function in this case)

Special feature at Hiperface:

Here the digital position is always devided in 5 bits of one signal period, i.e. with 5 bits of the high resolution.

If, for example, the encoder has 128 signal periods, which corresponds to 7 bits, ec40 = 12 is displayed, i.e. 7 bits for the signal periods + 5 bits for the high resolution.

Special feature for EnDat encoders that also have 1Vpp signals:

Here the digital position is always devided in 2 bits of one signal period, thus with 2 bits of the high resolution.

For example, if the encoder has 2048 signal periods, which corresponds to 11 bits, ec40 = 13 is displayed, i.e. 11 bits for the signal periods + 2 bits for the high-resolution.

Which BiSS encoders have an el. nameplate or not, is described here in more detail: => 6.1.2.3 "Supported encoders", page 219

SSI data format ec42 SSI data format

Index	Id-Text	Name	Function
0x282A 0x482A	ec42	SSI data format	Selection of the SSI data format

These are the setting possibilities according to the SSI specification:

ec42	SSI data format / SSI data format B			0x282A / 0x482A
Bit	Function	Value	Plaintext	Function
0…1	SSI PFB mode	0	PFB off	no Power Fail Bit
		1	PFB at start of da-taword	Power Fail Bit at the beginning of the posi-tion value (before MSB)
		2	PFB at end of da-taword	Power Fail Bit at the end of the position value (after LSB)
		3	reserved	Reserved
2	even parity check	0	no parity check	No parity check
		4	even parity check	Even parity check
3	Data format	0	fir tree	Fir tree
		8	serial right aligned	Serial right-justified
4	SSI data code	0	binary	Binary code
		16	gray	Gray code

Some encoders send in addition to the position values ec40 and ec41 an error bit (often called Power Fail Bit PFB) which is 0 in normal operation and becomes 1 when the encoder detects an error status, e.g. operating voltage too low.

When a PFB is set, an additional clock is automatically output to read this bit. I.e. ec40 and ec41 remain unaffected.

If the encoder has a PFB and the data word is gray coded, the PFB must also be gray coded. In contrast, this variant is not supported: Only the position value is gray coded and then the PFB is attached.

The fir tree data format is rarely found today. Most encoders have the serial-right data format, so this should be set first.

SSI clock frequency ec43 SSI clock freq.

Index	Id-Text	Name	Function
0x282B 0x482B	ec43	SSI clock freq.	Selection of the SSI transmission clock frequency

The following frequencies can be selected:

ec43	SSI clock freq.	0x282B / 0x482B
Value	Clock frequency	
0	100 kHz (156 kHz)	
1	500 kHz	
2	1 MHz (833 kHz)	

The values in brackets apply if Endat is adjusted on the other encoder channel.

Since the position for SinCos-SSI encoders is mainly determined from the 1Vss signals and the SSI position serves only for monitoring (=> see "Absolute encoder", 6.1.2.1, page 218), it is recommended to maintain the clock frequency at 100 kHz.

For SSI encoders, the position is cyclically clocked synchronously to the control grid. Depending on the clock frequency and data word length, reading out can take more time than the control grid length. Then the position value is not longer read out in each control grid cycle, but so many cycles are omitted until the read out is completed.

The SSI telegram length in µs is calculated as:

(ec40 + ec41) / clock frequency [MHz] + 20 µs processing time

One channel active	
Telegram length	Time pattern SSI position
upto 62 µs	125 µs
62 … 187 µs	250 µs
187 … 312 µs	375 µs
312 … 437 µs	500 µs
more than 437 µs	625 µs

Both channels active	
Telegram length	Time pattern SSI position
upto 62 µs	250 µs
62 … 312 µs	500 µs
more than 312 µs	750 µs

The missing position values can have a negative effect on the control characteristics of the drive if an SSI encoder is used as motor feedback. The influence for the position control is lower.

The telegram length can be decreased with higher clock frequency, but the encoder, line lengths, line capacities and running times limit the max. possible clock frequency.

The monoflop time of the encoder (i.e. the pulse off time which must be maintained after reading out of a position value, in order that the encoder determines a new position value) must not be higher than 60 µs for a switched on channel and not higher than 180 µs for both switched channels.
With standard SSI encoders it is in the range of 10 to 20 µs.

Allocation of the SSI position to the 1Vss signals ec44 SSI allocation absolute / incremental position

Only for SinCos-SSI encoder:

ec44	SSI allocation absolute / incremental position	0x282C / 0x482C
Value	Plaintext	Function
0	0: 0° - 90°	Allocation of the SSI position to the 1Vss signals. The angle is adjusted within a signal period where the absolute SSI position is 0. The data must be taken from the encoder data sheet.
1	1: 90° - 180°	
2	2: 180° - 270°	
3	3: 270° - 360°	

At the position where the absolute SSI position is 0, the high resolution (i.e. the position within an incremental signal period) also has a position angle, which can be entered in this parameter.
Without this setting, position deviations of one signal period (4 increments) can occur at higher signal frequencies, which can be toggled by the position correction function.

6.1.6.7 Special Functions

6.1.6.7.1 General settings for encoder evaluation ec14 encoder interf. gen. settings

Index	Id-Text	Name	Function
0x280E	ec14	encoder interf. gen. settings	Adjustment of the encoder supply voltage

Different encoders operate with different supply voltages. These supply voltages are provided at the encoder interface at different contacts:

Pin 8 / 9 supply voltage for 5V encoder

Pin 25 / 26 supply voltage for 8V encoder

Pin 18 supply voltage for 24V encoder

Pin 14 / 15 resolver modulation for encoder channel A

Notes for pin 25 / 26

The supply voltage of DC 8 V is only output if
a) Parameter ec14 Bit 1 = "manual“ and ec14 Bit 0 = "1: 8V“ is adjusted.
b) Parameter ec14 Bit 1 = "automatic“ and ec16 = "Hiperface“ is adjusted.

All other voltages at these contacts are not defined and may not be used to supply encoders.

The settings affect both encoder channels A and B (at X3A and X3B):

ec14	encoder interf. gen. settings			0x280E
Bit	Function	Value	Plaintext	Function
0	Supply voltage of the encoder	0	5V	Must be selected if two 5V encoders are connected, otherwise the maximum output current of 250mA per channel is not available. (8V supply voltage at Pin 25 / 26 is not available)
		1	8V	one 8V encoder is used
1	Adjustment of the supply voltage	0	manual	The supply voltage must be set with bit 0.
		2	automatic	When ec16 is set to Hiperface, the supply voltage at Pin 25 / 26 is automatically set to 8V.

Hiperface encoders must always be supplied with 8V.

6.1.6.7.2 Several encoder functions ec36 several encoder functions

Index	Id-Text	Name	Function
0x2824 0x4824	ec36	several encoder functions	Several encoder functions

After setting a bit, the respective function is triggered and the bit is deleted after this function is terminated.

NOTICE

➢ By the function "set zero pos." also the system offset changes. Therefore subsequently the changed system offset must be absolutely determined for synchronous motors.

ec36	several encoder functions			0x2824 / 0x4824
Bit	**Function**	**Value**	**Plaintext**	**Function**
0	Set zero position	1	set zero position	With EnDat and Hiperface encoders, the absolute position ***in the encoder*** can be set to zero. If the position correction function is active, the error ec01 = 91 "dig. pos. corr. diff. err" may occur after setting the zero point because the position of the encoder suddenly changes. The new position is valid after the error is reset. For encoders with 1Vpp signals, the position cannot be set exactly to zero. The lowest bits, which correspond to the position within a signal period, are retained. With singleturn encoders, the counted revolutions are also deleted after zeroing. With multiturn encoders, the multiturn revolutions in the encoder are also set to zero. **Special features of linear encoders** Here, the position is set to 10 mm in order to avoid permanent overflows and underflows due to fluctuations of the position value after zero setting. If ec50 is used and if after zero setting the drive is moved in the direction of lower position values over the lower limit of the position, there is a jump in position and speed due to the conversion into virtual revolutions. The zero point should be set by way that it is not possible to drive over the lower limit.
1	Reset error for battery-buffered EnDat multiturn encoders	2	reset error for battery-buffered EnDat encoder	If battery-specific errors are to be reset, this bit must be set before the error reset. This is to prevent accidental resetting. (see also 6.1.9.1, „Battery-specific error and warning messages“, page 255)
2	Zero setting of the revolution counter in the encoder	4	clear multiturn rounds for battery-buffered EnDat encoder	For encoders with battery buffering, the counted revolutions in the encoder are set to 0. (see also 6.1.9.3 „Zero setting of the revolution counter in the encoder“, page 255)

6.1.6.7.3 Define system position system offset (SM) ec23

The reference between rotor position and zero position of the attached encoder system is created by the system position.

This system position is preset in the factory setting for standard KEB motors.

In order to operate a "unknown" motor with encoder system, it is necessary to carry out an adjustment in order to detect the system position.

This parameter is described in chapter **6.2.3.5 System** offset.

6.1.6.8 Incremental encoder emulation

An incremental encoder emulation can be activated for channel B if the encoder type for channel B ec16 is set to 16 "TTL output".

In this case, a position difference, which occurs at channel A from one control grid cycle to the next, is converted into two rectangular incremental signals which are shifted by 90° and output at channel B during the following control cycle. Due to this non-continuous output, the position may fluctuate more than the reference position of channel A, especially at low speeds and with few signal periods.

How many signal periods per revolution shall be output is set in ec29 "signal periods per revolution B" in encoder parameter B group. The maximum is 16384.

If the position of channel A has the value zero within one revolution, a zero signal is additionally output at channel B.

It is irrelevant which encoder type is evaluated at channel A. Also positions of the resolver are converted into incremental signals.

Signals are only output if the position value on channel A is also valid, which is displayed in ec00. If channel A changes directly to error after switching on, e.g. because no encoder is connected, ec00 remains at 5 "enc. initialisation". If channel A has a valid position after switching on and later changes to error, the encoder emulation also changes to error.

An error is triggered if the maximum possible signal frequency of 500 kHz is exceeded.

6.1.7 Operation of absolute linear encoders

With these encoder types in ec16, linear motors can be operated current and speed-controlled (provided the connected encoder is supported):

EnDat + 1Vpp, EnDat digital, Hiperface, BiSS Linear

With these encoder types, linear encoders can only be evaluated as position feedback:

SSI, TTL zero sig, Sin/Cos abs zero sig,

With these encoder types, linear motors can be operated current and speed-controlled if the system position is measured each time after switching on. Otherwise they can only be evaluated as position feedback:

Linear Sin/Cos with perodic zero sig, Linear Sin/Cos with distance-coded zero sig, Linear TTL with perodic zero sig, Linear TTL with distance-coded zero sig,

All other encoder types in ec16 cannot be used for linear encoders.

As far as possible, the setting and use of linear encoders is kept the same as that of rotary encoders. The few differences are described for the relevant parameters.

This means, for example, zero setting of the position in the encoder with ec36 or saving and reading of motor data with ec46 in the encoder will work in the same way if the encoder supports them.

In general, the position with ec36 should be set at a defined position for linear encoders in order to prevent overflow or underflow. Otherwise jumps in position and speed may occur or error ec01 = 91: "position difference too high" is triggered.

If the connected linear encoder shall be used only for a higher-level position control or as a position display for a control, the corresponding encoder type must be set in ec16 for EnDat or Hiperface for this purpose. As for rotary encoders, the encoder evaluation reads all required values from the electronic nameplate of the encoder.

For incremental encoders, the increments per revolution or the basic distance must be set in ec29.

For BiSS and SSI, the entire digital resolution must be set in ec40. i.e. ec41 remains 0.

However, if a linear motor shall be operated with current and speed control, special settings are required, which are described below.

The control on the control board does not differentiate between rotary and linear drives.

I.e. a linear motor must be "simulated" in such a way that a suitable rotary drive results for it. For this, parameters ec50 virtual round for linear encoder, dr06 rated frequency and dr04 rated speed are set.

To do this, a piece of a certain length is ***mentally*** cut out of the linear drive, bent into a circle and the two ends joined together to form a virtual, rotary drive.

The length of this piece must have be an integer number of position information (or sine periods) AND an integer number of motor pole pairs. Otherwise, there would be either a discontinuity (jump) in the position or an asymmetry in the motor structure at the point where the two ends are mentally joined together.

6.1.7.1 dr06 rated frequency and dr04 rated speed

This adapts **the motor** to the imaginary (virtual) rotatory drive.

6.1.7.2 ec50 virtual round for linear encoder and the difference to ec29

This adapts the **encoder** to the imaginary (virtual) rotary drive.

In parameter ec50, which is only necessary for linear encoders, it is entered how much of the position information from the encoder covers a multiple number of motor pole pairs.

- ec50 determines how long the encoder has passed a virtual revolution. This also defines the value of the position parameters, e.g. ru33 for one revolution or the result of the speed in ru09.

ec50 is dependent on the used ***motor***.

- As before ec29 is iincrements per revolution. Just as for rotary encoders, the number of signal periods between the zero signals (or also reference marks) is set here. In the case of distance-coded reference marks, the base distance is set here. (More about the reference signals, see 6.1.8 „Operation of non-absolute linear encoders (with and without reference marks)“, page 254)

ec29 is dependent on the used ***encoder***.

Evaluation with incremental signals (sinusoidal or rectangular)

If the incremental signals of the encoder are evaluated (e.g. for ec16 = "10: EnDat, + 1Vpp" or ec16 = "13: Hiperface"), the number of signal periods covering a whole number of motor pole pairs is entered in ec50.

Evaluation of digital encoders

If the connected measuring system is evaluated digitally (e.g. at ec16 = " 11: EnDat digital“ or ec16 = " 14: BiSS Linear“) the value range of the digital position is entered in ec50, which covers a multiple number of motor pole pairs, i.e. by how much the digital position word from the encoder changes when a multiple number of motor pole pairs is passed.

6.1.7.3 Example for evaluation of incremental signals

Assuming the linear motor has a distance from one north pole to the next of 70 mm (length of a motor pole pair) and a signal period is 22.5 mm. This ratio of 70 / 22.5 is converted by way that the numerator and denominator become the smallest possible integer values, i.e. in this case: 28 / 9.

The reciprocal of this ratio is 9/28. If you multiply the reciprocal by the ratio, you have the distance where the integer number of motor pole pairs matches to a integer number of sine periods.

70mm / 22.5mm x 9 / 28 = 630mm / 630mm.

Thus this virtual rotary drive, divided over its 630 mm circumference, has 9 integer motor pole pairs and 28 integer signal periods.

These 28 signal periods are set in ec50.

Next, the linear rated speed is converted into the rotatory nominal frequency. The rated frequency is the number of motor pole pairs that are passed per second at rated speed.

Rated frequency = rated speed / length of a motor pole pair.

For an assumed rated speed of 4.5 m/s, the following results:

Rated frequency = 4.5 m/s / (70 mm / 1000) = 4.5 m/s / 0.07 m = 64.286 Hz.

For convenience only, 65 Hz is chosen.

At last the number of motor pole pairs is set to 9 with the rated speed, i.e.:

Rated speed = rated frequency / motor pole pairs = 65 Hz / 9 * 60 = 433.333 rpm

To get integer values for rated speed and frequency, both values are multiplied by 3, which results a total of:

rated speed dr04 = 433.33 rpm * 3 = 1300 rpm

rated frequency dr06 = 65 Hz * 3 = 195 Hz

6.1.7.4 Example for evaluation of purely digital linear encoders

With digital encoders, instead of the length of one sine period, the resolution of the digital position (also called measuring step) must be used, i.e. how far the measuring value must be turned that the position increases by 1.

The length of the motor pole pair from the previous example is 70 mm and the measuring step is 20 µm. I.e. if a whole motor pole pair is passed through, the position changes by the value 70 mm / 0.02 mm = 3500.

3500 is entered in parameter ec50.

Since the ratio 70 mm / 0.02 mm is already an integer, this already results in a minimum possible number of pole pairs of 1.

6.1.8 Operation of non-absolute linear encoders (with and without reference marks))

In principle, the evaluation of non-absolute linear encoders with incremental signals is largely the same as that of non-absolute rotary encoders. The main difference is the calculation of the position of the zero signal in ec31.

Devices with sinusoidal 1Vpp and square-wave incremental signals are also evaluated in the same way.

The detection of the encoder type and the calculation of the position of the zero signal of the first procedure is the same as for rotary incremental encoders with reference marks/zero signals. The values for the detected encoder type in ec17 and the possible error messages in ec01 are correspondingly the same.

6.1.8.1 With periodic reference marks

Here the linear encoder has several reference marks with the same distance to each other. How many periods of the incremental signals are between the reference marks is set in ec29 "signal periods per revolution".

A special case of this is when there is only one reference mark on the travel path. Then min. one higher value of signal periods is set in ec29 than half of the signal periods which are on the distance.

Example:

A linear encoder is 540 mm long and a signal period is 20 µm. Then there are 540 mm / 0.02 mm = 27000 periods over the entire travel path, i.e. at least 13500 must be set in ec29.

As long as a second zero signal is not passed or only the same one is passed, the detected encoder type ec17 remains at 1 "encoder identification running", i.e. even if there is only one zero signal on the travel path. Apart from this display, this has no further effects. All monitorings are already running.

If no zero signal has passed by three revolutions (3 x ec29) after switching on, error ec01 = 113 "Sin/Cos: no reference detected", or 125 "TTL: no reference mark detected“ is triggered.

6.1.8.2 With distance-coded reference marks

For distance-coded reference marks, the reference mark track consists of many reference marks that all have a different distance from each other. From these distances, the absolute reference can be calculated if two adjacent reference marks have been passed.

This absolute reference is also calculated here and is displayed as position of the zero signal in ec31.

6.1.9 Operation of EnDat multiturn encoders with battery buffering

For some designs, such as larger hollow shaft encoders or scale rings with scanning heads, no gearbox can be installed. The multiturn function is then implemented here with a buffer battery which is connected to the encoder. This only supplies the part in the encoder that is responsible for counting the revolutions, even if the "normal" main voltage supply to the encoder is switched off.

As long as either the battery voltage or the main voltage supply is above its maximum value, the counted revolutions are reliable.

If the voltage of the buffer battery (rated voltage 3.6V) is below certain threshold values, the encoder reports warning and/or error messages.

The multiturn range is dependent on the encoder and min. 65536 revolutions, whereby the encoder evaluation can only process max. 65536 revolutions from the encoder.

Only the software-related functions that result from the EnDat protocol for the operation of these encoders are described here. All hardware-related information (e.g. battery types, connection, etc.) can be found in the Heidenhain documentation.

6.1.9.1 Battery-specific error and warning messages

The errors for battery-buffered encoders are fundamentally important for the function of the encoder and the reliability of the position value. Therefore, for resetting, e.g. with co00 = 128, bit 1 "reset error for battery-buffered EnDat encoder" in ec36 several encoder functions must be set beforehand.

This is to prevent these messages from being accidentally reset and thus overlooked by an automated error reset (e.g. after each switch-on).

The following battery-specific error and warning messages are described in the respective chapters for error and warning messages, in detail:

- Error message of the encoder evaluation: ec01 = 62 „EnDat: encoder send battery warning“

- Warning from the encoder: ec19, Bit 3: "Battery charge“

- different alarm bits and operating status error sources from the encoder in ec18.

6.1.9.2 Changing the buffer battery

When changing the buffer battery, the encoder must be connected to the main power supply. Otherwise, the counted revolutions are lost, which is displayed with the operating status error source "M Voltage interruption" in ec18.

The battery charge warning can be cleared by switching the encoder type ec16 off and on again.

6.1.9.3 Zero setting of the revolution counter in the encoder

With bit 2 "clear multiturn rounds for battery-buffered EnDat encoder" of ec36, the revolution counter in the encoder can be set to zero, i.e. subsequently the counted revolutions are 0. By way the revolutions can be set to a defined value if they are no longer reliable.

The revolutions can only be deleted if there are no encoder errors for battery-buffered encoders.

Only the revolutions are set to 0 with bit 2, i.e. if the entire position shall be set to 0, then bit 0 "set zero position" of ec36 must be set.

6.1.10 Error and warning messages

6.1.10.1 Error messages of the encoder interface

Index	Id-Text	Name	Function
0x2801 0x4801	ec01	error encoder interface	Error message of the encoder interface

<table>
<tr><th>ec01</th><th colspan="2">error encoder interface</th></tr>
<tr><th>Value</th><th>Name</th><th>Note</th></tr>
<tr><td colspan="3">general errors</td></tr>
<tr><td>0</td><td>no error</td><td></td></tr>
<tr><td>25</td><td>enc. supply during init</td><td>Error during switching on the power supply, e.g. current is too high or short circuit</td></tr>
<tr><td>29</td><td>wrong enc type combination</td><td>EnDat digital is set on one channel and EnDat+1Vss on the other channel, which cannot be evaluated together.</td></tr>
<tr><td>30</td><td>read motor temp. via encoder</td><td>A serial communication error has occurred while reading the motor temperature via the encoder. (Motor temperature sensor is connected to the encoder and is evaluated by it)</td></tr>
<tr><td>41</td><td>int. comm: Tx still active</td><td rowspan="7">Internal communication between main CPU and encoder evaluation</td></tr>
<tr><td>42</td><td>int. comm: Rx still active</td></tr>
<tr><td>43</td><td>int. comm: CRC error</td></tr>
<tr><td>44</td><td>int. comm: CRC payload</td></tr>
<tr><td>45</td><td>int. comm: no. of received data</td></tr>
<tr><td>46</td><td>int. comm: faulty stop bit</td></tr>
<tr><td>47</td><td>int. slow comm: BCC error</td></tr>
<tr><td colspan="3">Endat encoder</td></tr>
<tr><td>51</td><td>EnDat: no comm.</td><td>Communication to the encoder could not be established already during the initialization, e.g. wrong encoder, missing supply voltage or problem of the encoder cable. Are 1Vss signals possibly detected in ec17?</td></tr>
<tr><td>52</td><td>EnDat: 1Vpp missing</td><td>Already during the initialization no 1Vss signals could be detected. But Endat with 1Vss is adjusted as encoder type. Is the communication ok?</td></tr>
<tr><td>55</td><td>EnDat: unsupported type</td><td>The encoder identifier (from word 14 of the manufacturer parameters) is not supported.</td></tr>
<tr><td>57</td><td>EnDat: unsupp. version</td><td>EnDat version is neither 2.1 nor 2.2 and is not supported.</td></tr>
</table>

ec01	error encoder interface	
Value	Name	Note
62	EnDat: encoder sent battery warning	If the battery is disconnected and the device is switched off and on again, the encoder only sends a warning in ec19, bit 3. However, the position may be wrong, i.e. the revolutions are set to another value. In order to prevent starting with the wrong position, this error is triggered when the encoder sends a battery warning during initialisation. If the battery voltage falls below the limit value during operation (i.e. with the main voltage switched on), the encoder only sends a warning, which is also displayed as warning by the encoder. The whole revolutions are retained, i.e. the position value is correct.
68	EnDat: write data error	The read back data does not match the previously stored data. Encoder defective.
74	EnDat: timeout at reading additional information	While reading the additional information, the communication is interrupted, e.g. due to a break of the core in the encoder cable.
83	EnDat: CRC error position	Error in Endat communication during operation. But it was already ok. Possible causes are EMC disturbances or defect of encoder cable, encoder evaluation or encoder.
84	EnDat: CRC error add.info 1	
85	EnDat: CRC error add.info 2	
86	EnDat: encoder error type 1	
87	EnDat: watchdog error	
88	EnDat: communication not started	
89	EnDat: comm. not finished	
Position correction function		
91	position difference too high	Position difference between incremental and absolute (digital) position too large.
92	difference in rounds occured	Difference between counted revolutions and revolutions of the (multiturn) encoder has occurred.
96	Sin/Cos: position difference to absolute position too high	Position difference between incremental and absolute (analog) position too high for SinCos encoder.
Monitoring of the 1Vss signals		
101	1Vpp incremental signals: signal error	Error 1Vpp incremental signals (one or both signals)
103	1Vpp absolute signals: signal error	Error 1Vpp absolute signals with SinCos encoder (one or both signals)
Sine-cosine-SSI encoder		
105	Sin/Cos+SSI: no signals detected in init	Already during the initialization, not all encoder signals have been recognized (recognized encoder types are displayed in ec17).
Sine-cosine encoder		
113	Sin/Cos: no reference mark detected	Reference signal not recognized (inc per revolution could be wrong too).
114	Sin/Cos: adjusted signal periods too small	The adjusted increments per revolution are too small (compared to the distance between two detected reference signals).
115	Sin/Cos: adjusted signal periods too high	The adjusted increments per revolution are too high (compared to the distance between two detected reference signals).
116	Sin/Cos: init error	Already during the initialization, not all encoder signals have been recognized (recognized encoder types are displayed in ec17).
117	Sin/Cos: reference signal not recognised anymore	Reference signal is not recognized since some revolutions, but it was already valid.
TTL-/HTL encoder		

ec01	error encoder interface	
Value	Name	Note
121	TTL: track A/Cos error	Trace A defective or missing
122	TTL: track B/Sin error	Trace B defective or missing
123	TTL: track A or B error	Trace A and B defective or missing
125	TTL: no reference mark detected	Reference signal not recognized (inc per revolution could be wrong too).
126	TTL: adjusted signal periods too small	Adjusted increments per revolution are too small (compared with distance between two reference signals).
127	TTL: adjusted signal periods too high	Adjusted increments per revolution are too high (compared with distance between two reference signals).
128	TTL: init error	Already during the initialization, not all encoder signals have been recognized (recognized encoder types are displayed in ec17).
129	TTL: reference signal not recognised anymore	Reference signal is not recognized since some revolutions, but it was already valid.
BiSS encoder		
131	BISS: no reaction from encoder in init	No encoder connected because the encoder does not react when communication is first established.
132	BISS: invalid data signal level in init	No encoder connected because the signal level at the data input is invalid.
133	BISS: unsupp. protocol	Communication is possible, but the detected protocol is not supported. An unknown BiSS encoder is connected.
134	BISS: enc comm init err	Encoder is connected but the communication could not be established without errors during initialization. The settings in ec40, ec41, ec42 are wrong. If ec17 = 0: "no encoder detected" and ec02 = 20: "BISS: encoder communication": A BiSS-C unidirectional (without el. nameplate) has been detected. If ec17 = 84: "BiSS Mode C, EDS containing in-consistent data" and ec02 = 31: "BISS Mode C: EDS data invalid": A BiSS-C-encoder with el. nameplate has been detected, but it could not be initialized with it. Then an attempt was made to initialize the encoder as BiSS-C unidirectional encoder, which also failed.
137	BISS: unsupp. enc ID	The detected encoder type is not supported
138	BISS: read para timeout	BiSS communication faulty in operation. But it was already ok. Possible causes are EMC disturbances or defect of encoder cable, encoder evaluation or encoder.
139	BISS: read pos. timeout	
140	BISS: enc comm err	
141	BISS: comm watchdog err	
142	BISS comm: pos. CRC err	
143	BISS comm: para CRC err	
144	BISS: pos. read err	
145	BISS: pos. invalid	
146	BISS: enc err bit	
147	BISS: CPU watchdog err	
Resolver		
151	Resolver: signal err	One or both signals are invalid.
Hiperface		

ec01	error encoder interface	
Value	Name	Note
161	Hiperface: init error	Already during the initialization, not all encoder signals have been recognized (recognized encoder types are displayed in ec17).
163	Hiperface: name plate access err	Error in case of access to the extended nameplate 0xFF in the encoder.
168	Hiperface: enc comm BCC err	Communication to the encoder is faulty during operation. But it was already ok. Possible causes are EMC disturbances or defect of encoder cable, encoder evaluation or encoder.
171	Hiperface: enc comm parity err	
172	Hiperface: enc comm overrun err	
173	Hiperface: enc comm overrun + parity err	
174	Hiperface: enc comm frame err	
175	Hiperface: enc comm frame + parity err	
176	Hiperface: enc comm frame + overrun err	
177	Hiperface: enc comm frm + ovrrn + prty err	
178	Hiperface: enc comm trm time out	
179	Hiperface: enc comm time out	
181	Hiperface: enc reset error	Encoder cannot be reset: After command "encoder reset" the encoder responds, but this is inadmissible.
SSI and sine-cosine-SSI encoder		
191	SSI: no SSI in init	No SSI communication in initialization. Are 1Vss signals possibly detected in ec17?
192	SSI: invalid data signal level in init	No encoder connected because the signal level at the data input is invalid.
193	SSI: no reaction or position from encoder	Error SSI communication: No reaction or no position value from encoder. Can also occur if the adjusted data word length is less than the actual one of the encoder.
194	SSI: parity error	Parity bit is wrong, if parity check is activated.
195	SSI: error bit sent by encoder	Encoder has sent error bit
Incremental encoder emulation		
202	TTL output: frequency too high	Maximum frequency of the output signals is exceeded (500 kHz).
203	TTL output: Channel A position invalid	The position of channel A, which shall be output at channel B is invalid, e.g. because an error has been triggered.

6.1.10.2 Warning messages of the encoder interface

Index	Id-Text	Name	Function
0x2802 0x4802	ec02	warning encoder interf.	Warning message of the encoder interface

ec02	warning encoder interface	
Value	Name	Note
0	no warning	No warning
1	fast communication	Process data communication
2	SACB communication	SACB communication
6	enc supply out of specification	Encoder supply voltage temporary out of specification during switching on
10	EnDat: communication	Endat communication
11	EnDat: comm add. info	Endat communication (embedded additional communication)
12	pos diff occurred	Position deviation occurred
13	pos diff corrected	Position deviation occurred and corrected
14	1Vpp incremental signals: signal error	1Vpp incremental signals invalid
15	1Vpp absolute signals: signal error	1Vpp absolute signals invalid
16	TTL: track A/Cos error	TTL track A invalid
17	TTL: track B/Sin error	TTL track B invalid
18	position difference too high	Position deviation to 1Vpp absolute track occurred.
19	position difference corrected	Position deviation to 1Vpp absolute track corrected.
20	BISS: encoder communication	BiSS communication
21	encoder error	Encoder has sent error message, but error tripping is deactivated
22	SSI communication error	SSI communication error
23	BISS Mode C: enc mem access	BISS Mode C: encoder memory access
24	encoder data reading error	Data reading from encoder incorrect
25	encoder data writing error	Data writing in encoder incorrect
26	internal encoder EEPROM error	Encoder has detected internal EEPROM error
27	no reference signal detected by encoder	Reference signal not detected by the encoder
28	Hiperface: communication	Hiperface communication
29	Invalid data in encoder memory	Memory in encoder contains no usable data
30	TTL output: sync warning	Encoder emulation: Not all signals could be output at the last cycle and will be output in the next cycle.
32	EnDat: incremental track has reached the functional limit	This part has reached the functional limit and the encoder should be replaced.
33	EnDat: absolute track has reached the functional limit	
34	EnDat: pos. calculation has reached the functional limit	
35	enc. sync. comm. is longer than sync cycle	Communication to the encoder is too long and cannot be completed in the control grid. This encoder cannot be safely evaluated because no current position can be calculated in the faulty cycles.

6.1.10.3 Error messages from the encoder

Index	Id-Text	Name	Function
0x2812 0x4812	ec18	error encoder	Error message from the encoder

Warnings and errors from the encoder are determined by the encoder itself and then actively sent by the encoder. The encoder evaluation only transmits the error messages and displays them directly. Consequently, the values are depending on the used encoder and the meaning can be taken from the corresponding data sheets.

If ec18 displays the value 0xFFFF FFFF = 4294967295, the encoder has sent an error bit but the actual error message could not be read out.

The following are examples of some error messages of common, supported encoder types

ec18	error encoder
Value/Bit	Error encoder
0	No error
EnDat: 16 bit value "Alarms“ to address 0 in memory area "Operating condition“ of the encoder	
Bit0	Lighting failed
Bit1	Signal amplitude invalid
Bit 2	Position value invalid
Bit3	Overvoltage
Bit4	Undervoltage
Bit5	Overcurrent
Bit6	Battery change required (if available)
Bit 7-15	Not yet defined
EnDat: 16-bit value "Operating state error sources“	
Bit 16	Lighting (EQUAL)
Bit 17	Signal amplitude (EQUAL)
Bit 18	S Position 1 (POS)
Bit 19	Overvoltage (EQUAL)
Bit 20	Undervoltage (EQUAL)
Bit 21	Overcurrent (EQUAL)
Bit 22	Temperature exceeding
Bit 23	S Position 2 (POS)
Bit 24	S System (POS), (BATT) Error in singleturn calculation during initialisation. If the error still occurs after switching off and on again, there is a hardware problem with the encoder.
Bit 25	S Voltage interruption (BATT)
Bit 26	M Position 1 (POS), (BATT) Error in multiturn calculation or sampling. The encoder must be referenced again if it cannot be ensured that the whole revolutions are still correct.
Bit 27	M Position 2 (POS)
Bit 28	M System (POS), (BATT) Error in multiturn calculation during initialisation. If the error still occurs after switching off and on again, there is a hardware problem with the encoder. The encoder must be referenced again if it cannot be ensured that the whole revolutions are still correct.

ec18	error encoder
Value/Bit	Error encoder
Bit 29	M Voltage interruption (POS), (BATT) The battery voltage **and** the main supply voltage have been fallen below the limit values. As long as this error is active, no revolutions are counted. The battery must be replaced and the encoder must be referenced if it cannot be ensured that the whole revolutions are still correct. The possibly accompanying error sources M Position 1, M System and Overflow/Underflow are to be ignored.
Bit 30	Overflow / Underflow (POS), (BATT) The specified multiturn counting range is exceeded. The error can only be reset when the encoder has been moved back into the specified counting range. This error source is only supported by special encoder versions, which do not support resetting the multiturn counter.
Bit 31	M battery (BATT)
BiSS Hengstler Acuro : Error register to address 0x68	
Bit0	LED current outside specification
Bit1	Multiturn error
Bit 2	Position error
Bit7	Temperature outside specification
Hiperface: Values encoder status	
1	Analog signals out of specification or faulty compensating data
2-6	Initialization of the encoder, e.g. internal values faulty
9-13	Communication disturbed
14-18	Access to encoder memory
28	Analog signals invalid
29	LED current outside specification
30	Critical encoder temperature
31	Speed too high
32-35	Position incorrect or with linear encoders: Sensor is not calibrated or distance magnetic tape/sensor too large
SSI:	
1	Power Fail Bit is active

For EnDat operating state error sources
S = Singleturn, M = Multiturn
1 = position value 1, 2 = position value 2
(EQUAL) = Operating state error source is equal to the alarm bit in the lower 16 bits of ec18
(POS) = Operating state error source is an extension of the alarm bit "Position value faulty" (bit 2) and is the same in description and remedy
(BATT) = for battery-buffered measuring devices

Special features of the EnDat error messages

The EnDat interface distinguishes between alarms and so-called "operating state error sources"

When the encoder detects an internal error, it sends an alarm bit, which is indicated in the lower 16 bits of ec18.

The so-called "operating state error sources" allow further information on these alarm bits. If the encoder also supports operating state error sources, these are now read out and displayed in the upper 16 bits of ec18.

Some error sources are the same as the alarm bits in the lower 16 bits of ec18, i.e. they are set simultaneously and also mean the same.

Some error sources belong to the alarm bit "position value faulty" (bit 2), i.e. they are an extension of this alarm bit and provide a more precise error cause.

Some error sources belong to battery-buffered devices and sometimes require a certain action from the user so that the position value remains reliable.

(also see 6.1.9 „Operation of EnDat multiturn encoders with battery buffering“, page 255)

6.1.10.4 Encoder warning messages

Index	Id-Text	Name	Function
0x2813 0x4813	ec19	warning encoder	Encoder warning message

Some encoders send warning messages, which are only displayed by the encoder evaluation (just the same as error messages). The position value is (still) reliable for warnings. The following are examples of some error messages of common, supported encoder types

ec19	warning encoder
Value/Bit	Error encoder
0	No warning
Endat: 16 bit value "warnings“ to address 1 in memory area "operating condition“ of the encoder	
Bit0	Frequency collision
Bit1	Temperature exceeding
Bit 2	Control reserve LED reached
Bit3	Battery charge too low No battery is connected or the battery voltage has dropped below the limit value (e.g. 2.8V +/- 0.2V, see encoder data sheet) while the encoder is being supplied with the main voltage. As long as the encoder is supplied by the main voltage, the encoder remains fully functional and the position value remains reliable. After changing or connecting the buffer battery, the warning can be reset by switching the encoder type in ec16 off and on again.
Bit4	Reference point reached
Bit 5-15	Not yet defined
BiSS Hengstler Acuro : Error bit in position data word	
1	OptoAsic temperature exceeded or fall below

6.1.11 Store data in the encoder

Motor data can be read from an encoder with electronic type plate or written into the encoder.

The values are stored in the encoder which were previously taken over with dr99 motordata control.

After reading or writing data, the ec status parameters should also be checked to see if the encoder evaluation has still triggered errors or warnings.

Index	Id-Text	Name	Function
0x282E	ec46	encoder read/write	Write or read data to the encoder.
0x282F	ec47	status encoder r/w	State of the function of ec46.

ec46 and ec47 are only supported on encoder interface channel A.

ec46	encoder read/write			
Bit	Function	Value	Plaintext	Function
0	read data	0	off	
		1	enable	Motor data are transferred from the encoder to the inverter.
1	store data	0	off	
		2	enable	Motor data are stored in the encoder.

ec47	status encoder r/w	
Value	Name	Note
0	idle	no communication
1	busy	Data are written to the encoder or read by the encoder.
2	data invalid	The read data are not conform with a valid format for KEB. No data will be transferred.
3	basic data loaded	Data from the KEB-F5 Definition are found and transferred in the encoder.
4	enhanced data loaded	Data for the enhanced format for H6 are found and transferred in the encoder.
5	data stored	
6	comm error	No communication to the encoder possible. (No encoder connected or interface not activated with ec16).

6.1.11.1 Format for the data in the encoder

The data in the following table are stored in the encoder depending on the motor type. There are 2 different formats supported: "basic" = F5 format and "enhanced" = for device generation 6 extended format

The extended (enhanced) format is always used when writing the data to the encoder. This is defined by way that the data of the F5 format (basic) remain accessible. An encoder written in the "enhanced" format can be read out with F5 devices.

NOTICE

➢ The rated motor voltage (dr05 rated voltage) is **not** stored in the encoder for synchronous motors. If the value is unequal to the default value of the inverter, dr05 must also be written, since the limiting characteristic of the synchronous motor is also dependent on the rated motor voltage of dr13 breakdown torque and dr25 breakdown speed.

Id-Text	Name	DSM		DASM	
		basic	enhanced	basic	enhanced
dr00	motor type	x	x	x	x
dr01	motor part number		x		x
dr03	rated current	x	x	x	x
dr04	rated speed	x	x	x	x
dr05	rated voltage			x	x
dr06	rated frequency	x	x	x	x
dr09	rated torque	x	x	x	x
dr11	max torque %	x	x		x
dr12	max current %	x	x		x
dr13	breakdown torque %		x		x
dr14	SM EMF [Vpk/1000min.1]	x	x		
dr15	SM inductance q-axis UV	x	x		
dr16	SM inductance d-axis %	x(1)	x		
dr17	stator resistance UV	x	x	x	x
dr18	ASM rotor resistance UV %			x	x
dr19	ASM head inductance UV			x	x
dr21	ASM sigma stator inductance UV			x	x
dr22	ASM sigma rotor inductance %			x	x
dr25	breakdown speed %		x		x
dr28	Uic reference voltage		x		x
dr32	inertia motor [kg*cm^2]		x		x
dr33	motor temp sensor type		x		x
dr34	motorprotection current %		x		x
dr35	SM prot. time. Min. Is/Id		x		
dr36	SM prot. time Imax		x		
dr37	SM prot. recovery time		x		
dr38	SM prot. min. Is/Id		x		
dr39	ASM prot. Mode				x
ec23	system offset	x	x		
ec26	speed scan time	x	x	x	x
ec27	speed PT1 time	x(1)	x(1)	x(1)	x(1)
cs12	absolute torque	x	x	x	x

(1) This value is not directly stored, but calculated from other objects.

The extended (enhanced) format is always used when writing the data to the encoder. This is defined by way that the data of the F5 format (basic) remain accessible. An encoder written in the "enhanced" format can be read out with F5 devices.

6.1.12 Encoder serial number

Index	Id-Text	Name	Function
0x2830	ec48	saved encoder serial number	Saved encoder serial number
0x2831	ec49	encoder serial number	Serial number read out by the encoder

The encoder serial number is read out from the encoder with each power-on reset and each change of the encoder type. ec49 is deleted for encoders without serial number.

Since the serial number for different encoder types is defined differently, the read value is converted in an ASCII string and is displayed byte-by-byte for display standardization.

Example 1: BiSS encoder Hengstler Acuro AC58 / serial number = 255229

ec49	Encoder serial number											
Subindex	1	2	3	4	5	6	7	8	9	10	11	12
ASCII	0x30	0x30	0x32	0x35	0x35	0x32	0x32	0x39	0x00	0x00	0x00	0x00
Character	0	0	2	5	5	2	2	9	not used			

Example 2: Hiperface encoder SKM 36 / serial number = GB0450179

ec49	Encoder serial number											
Subindex	1	2	3	4	5	6	7	8	9	10	11	12
ASCII	0x47	0x42	0x30	0x34	0x35	0x30	0x31	0x37	0x39	0x00	0x00	0x00
Character	G	B	0	4	5	0	1	7	9	not used		

6.1.12.1 Save the encoder serial number

By writing on ec49 the read serial number from the encoder is copied to ec48 and is stored non-volatile.

6.1.12.2 Testing on exchange of the encoder

By means of the encoder serial number it can be checked whether the encoder has been replaced.

If pn73 E.enc A changed stop mode is activated for encoder A or pn74 E.enc B changed stop mode for encoder B, the adjusted response is triggered, as soon as ec48 und ec49 are different.

6.1.13 Assignment of the encoder channels

Index	Id-Text	Name	Function
0x2504	co04	position source	0 : channel A 1 : channel B 2 : estimated position
0x2505	co05	speed control source	0 : channel A 1 : channel B

If a control mode with encoder is selected in cs00 control mode, the source for the speed can be selected with this parameter. Channel A is always used as default setting for speed control.

The source for a position control can be selected with co04 position source.

6.2 Motor parameterization

6.2.1 General

An assistent for start-up-support is integrated in Combivis 6.

Each parameter input in the dr group is only stored if parameter dr99 "motordata control“ is written.

<table>
<tr><td>dr99</td><td colspan="4">motordata control</td></tr>
<tr><td>Bit</td><td>Function</td><td>Value</td><td>Plaintext</td><td>Function</td></tr>
<tr><td rowspan="3">0…1</td><td rowspan="3">motor-data control</td><td>0</td><td>store motor-data, init reg.</td><td>The new motor data are transferred and initialization of all standardizations</td></tr>
<tr><td>1</td><td>store motor-data, no reg.</td><td>The new motor data are transferred, but the following parameters are not recalculated:
current controller (ds00…ds03) / flux controller (fc18, fc19) /
filter time for the stabilization (ds33)</td></tr>
<tr><td>2</td><td>store motor-data, calc e.c.d. (ASM)</td><td>The equivalent circuit data for the asynchronous machine (ASM) are determined from the nameplate data. dr99 is set to ZERO after calculation.
The following parameters are calculated:
⇒ Main inductance (Lh)
⇒ Stator leakage inductance (sLs)
⇒ Rotor leakage inductance (sLr)
⇒ Stator resistance (Rs)
⇒ Rotor resistance (Rr)
⇒ Boost (Uboost)</td></tr>
</table>

If a parameter is changed manually, which is only calculated automatically at motordata control = 0 (e.g., current controller gain), dr99 is set automatically to value 1.

The status can be read in parameter dr02 motordata state.

Modulation release is not possible in status "fill motordata“ and "storing motordata“. If the drive is set to state "operation enabled" nevertheless, it changes to "ERROR motordata not stored“ (ru01 = 21).

This error can only be reset when the data are transferred with dr99. dr-parameters can be changed and activated by writing on dr99 while the drive is in state "operation enabled".

dr02	motordata state			
Bit	Function	Value	Plaintext	Function
0-1	motor-data state	0	fill motor-data	New data are written, but not transferred yet
		1	storing motordata	Initialization of standardizations
		2	motordata stored	The data are transferred for the control, but the storage in the EEPROM is not completed yet
		3	error norm motordata	Error occurred in standardization routine: • Control parameters could not be calculated (motor / inverter size not suitable, motor data not associated) • Rated switching frequency too low

It can be selected between asynchronous and synchronous motor via dr00 motor type.

dr00	motor type	
Value	Name	Note
0	asynchron. motor (ASM)	an asynchronous motor should be parameterized
1	synchronous motor (SM)	an asynchronous motor should be parameterized
4	synchronous reluctance motor (SynRM)	The start-up of this motor type is currently only possible in cooperation with KEB. Information can be obtained from the sales representative responsible for you.

The equivalent circuit data (resistance, inductance) must be preset as phase-phase values.

If only phase values are specified in the data sheet these values must be converted in phase-phase values (depending on the circuit mode) for inverter parameters.

Switching type	Inverter value
Star (Y)	Phase value * 2
Delta (Δ)	Phase value * 2/3

The dr parameters differ in nameplate data, equivalent circuit data (determined of data sheet or auto-ID) and application-specific data.

6.2.2 Asynchronous motor

6.2.2.1 Nameplate data

Index	Id-Text	Name	Function
0x2203	dr03	rated current	rated current
0x2204	dr04	rated speed	rated speed
0x2205	dr05	rated voltage	Rated voltage
0x2206	dr06	rated frequency	Rated frequency
0x2207	dr07	ASM rated cos(phi)	cos phi
0x2209	dr09	rated torque	Rated torque (calculated from nameplate data)
0x2220	dr32	inertia motor (kg*cm^2)	Mass moment of inertia of the motor

For an asynchronous motor typically not the rated torque but the rated power is specified.

The rated torque can be determined from the power and rated speed according to the following formula:

$$\text{dr09 rated torque} = \frac{\text{rated power [kW]} * 9550}{\text{rated speed } [\frac{\text{rpm}}{}]}$$

Formula 2: Calculation rated torque

If the motor inertia can be taken from the data sheet, this value should be entered in dr32.

If the motor inertia is unknown, cs17 can be set to 0 and instead the total inertia of the motor plus all rigidly coupled inertia can be entered in parameter dr32 (=> also 6.3.6 Determination of the mass moment of inertia).

NOTICE

- If cs99 optimisation factor is not set to 19 "off", the total inertia torque shall not be 0, otherwise the error drive data is triggered when operating dr99.
- If the total inertia of the motor is entered in cs17 instead of dr32 and dr32 is set to zero, this can cause problems during parameter saving. cs17 is set to zero in the default state. If the value dr32 (which is written before cs17) is now set to zero by parameter backup, there are many error messages.

6.2.2.2 Equivalent circuit data

Index	Id-Text	Name	Function
0x2211	dr17	stator resistance UV	Stator resistance Rs in Ohm
0x2212	dr18	ASM rotor resist. UV %	Rotor resistance Rr in % of the stator resistance
0x2213	dr19	ASM head inductance UV	Head inductance Lh in mH
0x2215	dr21	ASM sigma stator ind. UV	Stator leakage inductance in mH
0x2216	dr22	ASM sigma rotor ind. %	Rotor leakage inductance in % of the stator leakage
0x222C	dr44	speed (Lh/EMK ident.) %	Speed when main inductance is identified (automatically preset) in% of rated speed
0x2236	dr54	ident	Starts the identification
0x2237	dr55	ident state	Displays current measurement or status message (e.g. "stator resistance“ "ready“ or "error“)

Parameters dr17, dr18, dr19, dr21 and dr22 can be taken from a data sheet or automatically determined by the identification.

Especially the main inductance should be always identified, since it is dependent on the magnetising current and the data sheet value is possibly valid for another current. For identification of main inductance the motor must be able to turn freely without load.

The speed for identification is determined by dr44. This value must be changed only if the application (e.g.) requires a lower speed limit.

During the identification steps at standstill the motor may be moved slightly by the test signals.

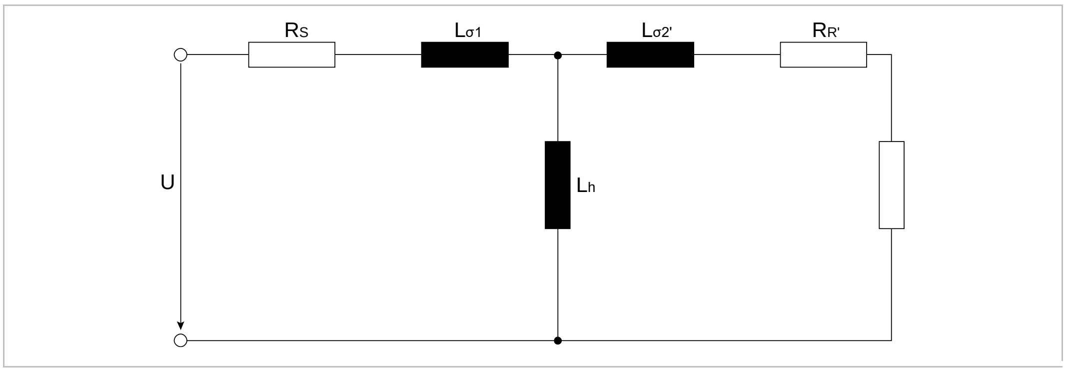


Figure 66: Equivalent circuit diagram motor

6.2.2.3 Application-specific data

Index	Id-Text	Name	Function
0x2208	dr08	magnetising current %	Magnetising current in % of the rated motor current
0x220B	dr11	max. torque %	Max. torque in % rated torque
0x220C	dr12	max. current %	Max. current in % rated motor current
0x220D	dr13	breakdown torque %	Maximum torque at start of field weakening
0x2219	dr25	breakdown speed %	Field weakening speed in % of the rated field weakening speed
0x221C	dr28	Uic reference voltage	DC reference voltage in V
0x222D	dr45	ASM u/f boost	Boost

The magnetising current can be preset manually in order to reduce motor losses (=> Chapter 6.2.5 Magnetizing current)

dr08	magnetising current %		0x2208
Value	Name	Note	
0	off	automatic calculation of the magnetising current from cos phi	
0.1…100%		Manual setting of a magnetising current	

In order to protect the mechanism against excessive torques, the torque can be limited with dr11.

dr11	max torque %	0x220B
Value	Note	
0…6000 %	Maximum permissible torque in% of rated torque	

If a motor is energized with multiple of the maximum permissible value, it can not be protected against destruction either by the motor protection function nor by the temperature sensors. Therefore the maximum current can be limited.

dr12	max current %	0x220C
Value	Note	
0…6000 %	Maximum permissible motor current in% of the rated motor current	

The application point of the field weakening operation and the limiting characteristic of the motor is defined with dr13 and dr25 (=> Chapter 6.2.10 Field weakening).

The default values are generally sufficient for an initial start-up.

dr13	breakdown torque %	0x220D
Value	Note	
0…6000.0 %	Maximum torque at start of field weakening	

dr25	breakdown speed %	0x2219
Value	Note	
0.1…1000.0 %	Speed for using the field weakening in % of the rated field weakening speed (rated value calculated from rated motor voltage, DC link voltage and rated frequency)	

The DC link voltage is defined with dr28, designed for the limiting characteristic and the field-weakening range.

The expected DC link voltage, which is dependent on the mains voltage (√2 * U_{mains}) or the AFE voltage should be entered in this object (see Chapter 6.2.10 Field weakening).

dr28	uic reference voltage	0x221C
Value	Note	
200…830V	DC reference voltage in V	

6.2.2.4 Motor protection

Index	Id-Text	Name	Function
0x2221	dr33	motor temp sensor type	0 = KTY 84-130, 1 = PTC, 2 = via encoder, 3 = KTY 83 110, 4 = PT1000
0x2222	dr34	motorprotection curr. %	Rated current for software motor protection function in % rated motor current
0x2227	dr39	ASM prot. mode	Cooling type (self or separately cooled)

The overtemperature motor protection is parameterized with this objects (=> Chapter 4.4.5 Overtemperature motor (dOH) and chapter 4.4.6 Motor protection switch OH2).

6.2.2.5 Quick start-up of an asynchronous motor

The start-up should always be done with co01 modes of operation = 2 "velocity mode“, also if another operating mode shall be used later.

Drive must not be in operation

co00 (CiA 0x6040) controlword = 0 or hardware modulation lock

Load default data

Default data are automatically loaded in all parameters with co08 = 2 and then co09 = 1.

Select operating mode

The operating mode is selected in cs00 bit 0…3 (0 = v/f characteristic operation / 1 = with encoder, without model / 2 = with encoder, with model /3 = without encoder, with model = ASCL)

Preset motor data

With the input of the first motor data the state of dr02 changes to 0 "fill motordata“. Only the following data are required for v/f characteristic operation:

dr00 motor type:	0 “asynchronous motor”
dr03 rated current:	rated motor current (for the electronic motor protection function)
dr04 rated speed / dr06 rated frequency:	Pole-pair number
dr04 rated speed / dr05 rated voltage:	Rated point (voltage for rated speed)
dr45 ASM v/f boost:	Voltage for frequency = 0Hz
dr33 motor temp sensor type:	Selection motor sensor (PTC or KTY) If no motor temperature sensor is available, the monitoring must be deactivated with pn12 = 7.

The following data are ***additionally*** required for closed-loop operation with or without encoder:

dr09 rated torque	torque reference value
dr32 inertia motor (kg*cm^2)	for automatic parameterization of the speed controller (together with cs17 inertia load).
dr07 rated cos(Phi)	Determination of the magnetizing current (if it is not known, the default value of dr07 can be used).

Adjust equivalent circuit data dr17, dr18, dr19, dr21

There are 2 possibilities:

The equivalent circuit data are taken from one data sheet. Additionally the main inductance should be determined by identification, because the data sheet value is usually suitable only for a specific magnetizing current (dr54 = 8).

The equivalent circuit data are automatically determined completely through identification by the drive (dr54 = 1).

Values within the correct order of magnitude must be preset for the equivalent circuit data in order that the inverter reaches the status dr02 = 2 „motordata stored“. Otherwise the drive remains in dr02 = 3 "error norm motordata“ and the identification cannot be carried out.

To use the identification, an operating mode with motor model must be selected in cs00 control mode (cs00 bit 0...3 = 2 or 3) and the inverter may not be in error state, otherwise the input is rejected by dr54.

The determination of the resistance and inductance occurs in standstill (slight rotation of the motor is possible by test signals). For the determination of the main inductance, the drive must be in standstill or must be able to rotate only with small load. The speed is determined by dr44 in % rated speed. The default value is optimal for identification, but the value must be changed if the application requires another speed. Forward direction of rotation.

The motor data and the parameterization of the identification are stored with dr99 = 0. Value 2 "motordata stored" must be displayed in dr02.

Parameterize encoder

If a mode with encoder has been selected, the encoder parameters must be set in the ec group (encoder type, smoothing, etc.)
For more information on encoder parameter setting, see chapter 6.1 Interface to the encoder.
At the end of a successful parameter setting, the value of ec00 status encoder interface = 9 "position value“ must be ok.

Identify

The drive must be ready for operation in order to identify:

- The DC link must be loaded.
- ru01 exception state must be equal to 0 "no exception“ (if an error message is present, the cause must be removed and a reset must be executed with co00 = 128).
- The corresponding inputs must be set if the drive has safety functionality.
- The ramps (co48…co60) must be parameterized by way that no excessive acceleration forces occur.
- The speed controller has been adjusted already automatically if the inertia in dr32 nd cs17 has been correctly parameterized. Otherwise, the inertia must be preset in terms of magnitude and the automatic adjustment must be carried out by writing on cs99.□ Alternatively cs99 can be set to 19 "off“ and the speed controller can be adapted manually.
- The torque and current limits are set to 100% (default).

- The modulation is released (in default setting) with co00 = 3 and then co00 = 11 and the drive starts the identification. The progress of the identification can be tracked in dr55 ident state. Some steps may take a few minutes. The final state should be dr55 = 14 "ready“. The type of error can be found in dr57 ident error info if the identification ends in 12 "error“ (=> Description of dr57 in Chapter 6.2.18 Identification).
- Lock the modulation again (co00 = 0).
- Deactivate the identification with dr54 = 0 and store the identified data with dr99 = 0. By way the controller are parameterized.

Application-specific data

The following items are not complete, but these values must be checked at least. base is operating mode velocity mode.

Speed limits

Speed limits can be parameterized in the vl parameters for the velocity mode

Torque limits	
dr11 max torque	Torque limit of the motor
cs12 absolute torque	Torque limit of the application (is valid in all quadrants)
cs13…cs16	Torque limits for the single quadrants
dr13 breakdown torque	Torque for the definition of the speed-dependent limiting characteristic. This value must be increased, if the torque reduction according to a 1/x^2 characteristic starts to early.
Current limits	
de29 inverter maximum current	only display / maximum current for control
dr12 max current	Maximum current of the motor
is11 max current	The maximum current of the inverter can be decreased here (e.g., if the limit for the control should be lowered at motors with high current ripple in order to avoid overcurrent errors)
is35 set current limit	Setting of the maximum current for control (defines the safety distance to the overcurrent switch-off threshold)
Ramps	
co48…co51	Values for acceleration / deceleration
co52…co59	Values for the jerk in different ramp phases
co60	General parameterization of the ramp generator

Protection functions

The different warning level can be set in the pn parameters. In addition, protection functions can be activated / deactivated (e.g. speed monitoring, motor temperature sensor, etc.). Also the quick stop ramp is parameterized here. When the quick stop ramp becomes active (only in case of an error or shut down and disable operation) is defined in co32 state machine properties.

Controller

The adjustment of the current controller occurs automatically. The controller gain can be adjusted with ds14 current cntrl factor in order to adjust special motors or applications. The value becomes only active if dr99 = 0 is written again afterwards. The speed controller can be optimized manually or via cs99 optimisation factor. When using the optimisation factor, the adjustment of the controller automatically adjusts to the changed speed smoothing times. Longer smoothing times (ec26 / ec27) at constant cs99 result in weaker controller setting. A longer smoothing and by way better high-frequency suppression can offer a smaller value for cs99 and thus more dynamic control. If the field weakening range shall be used, eventually the maximum voltage controller must be adapted to the dynamics of the application (=> Chapter 6.2.10.3.2 Maximum voltage controller).

Deadtime compensation

The deadtime compensation should be switched on for operating modes with motor model.

Switching conditions

The output management (determination of the switching conditions, assignment, filtering, etc.) is carried out in the do parameters.

6.2.3 Synchronous motor

6.2.3.1 Nameplate data

Index	Id-Text	Name	Function
0x2203	dr03	rated current	Rated current
0x2204	dr04	rated speed	Rated speed
0x2205	dr05	rated voltage	Rated voltage
0x2206	dr06	rated frequency	Rated frequency
0x2209	dr09	rated torque	Rated torque
0x2220	dr32	inertia motor (kg*cm^2)	Motor inertia

The rated motor data are entered in this objects.

If motor inertia can be taken from the data sheet this value should be entered in dr32.

If the motor inertia is unknown, cs17 can be set to 0 and instead the total inertia of the motor plus all rigidly coupled inertia can be entered in parameter dr32 (=> also 6.3.6 Determination of the mass moment of inertia).

6.2.3.2 Equivalent circuit data

Index	Id-Text	Name	Function
0x220E	dr14	SM EMK [Vpk*1000rpm]	EMC (peak value of the phase-to-phase voltage) at 1000 rpm in V
0x220F	dr15	SM inductance q-axis UV	Cross inductance (inductance q-axis) in mH
0x2210	dr16	SM inductance d-axis %	Series inductance (inductance d-axis) in % of dr15.
0x2211	dr17	stator resistance UV	Stator resistance in Ohm
0x222C	dr44	speed (Lh/EMK ident.) %	Speed when EMC is identified (automatically preset) in % of rated speed
0x2236	dr54	ident	Starts the identification
0x2237	dr55	ident state	Displays current measurement or status message (e.g. "stator resistance“ "ready“ or "error“)

Parameters dr14, dr15, dr16, dr17 can be taken from a data sheet or automatically determined by the identification.

Mostly only one incuctance is given in the data sheet. This means, series and cross inductance are identical. Then the inductance value must be entered in dr15 and dr16 must be set to 100%.

For identification of the EMC the motor must be able to turn freely without load.

The speed for identification is determined by dr44. This value must only be adjusted if the application only allows low speed (e.g.). With the identification steps at standstill the motor can be moved easily by the test signals.

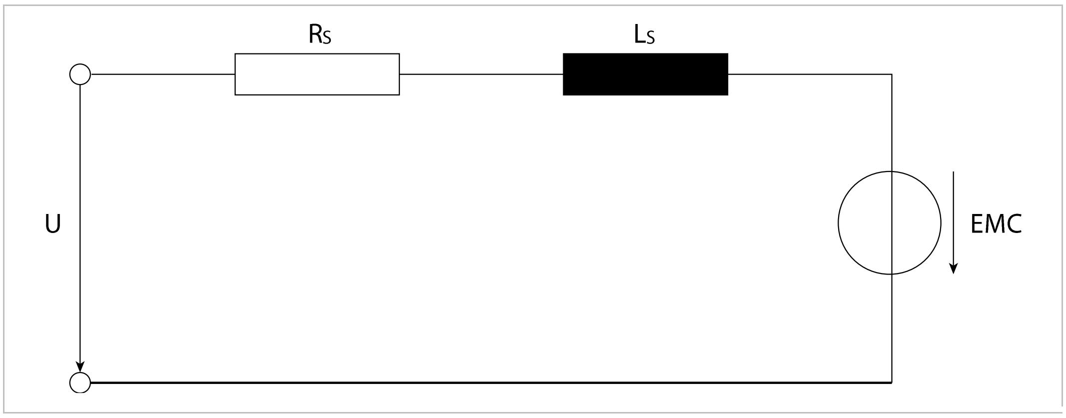


Figure 67: Equivalent circuit diagram synchronous motor

6.2.3.3 Application-specific data

Index	Id-Text	Name	Function
0x2208	dr08	magnetising current %	Magnetising current in % of the rated motor current
0x220B	dr11	max. torque %	Max. torque in % rated torque
0x220C	dr12	max. current %	Max. current in % rated motor current
0x220D	dr13	breakdown torque %	Definition of the limiting characteristic by 1 point (torque at speed) on the 1/x curve
0x2219	dr25	breakdown speed %	
0x221C	dr28	Uic reference voltage	DC reference voltage in V
0x221D	dr29	max. id current fact	Maximum current in the d-axis based on the maximum current (dr12).

For a synchronous motor dr08 should always be set to "off" (=> Chapter 6.2.5 Magnetizing current).

dr08	magnetising current %		0x2208
Value	Name	Note	
0	off	Magnetising current = 0	
0.1…100%		Manual setting of a magnetising current	

The torque can be limited with dr11 in order to protect the mechanics against excessive torques.

This parameter is used together with dr12 to define the saturation characteristic, if the influence of saturation should be considered (=> Chapter 6.2.13 Saturation characteristic (SM)).

dr11	max torque %	0x220B
Value	Note	
0…6000 %	Maximum permissible torque in% of rated torque	

If a motor is energized with multiple of the maximum permissible value, it can not be protected against destruction either by the motor protection function nor by the temperature sensors. Also too high current can lead to demagnetization of the motor. Therefore the maximum current can be limited.

Thus the current limit also limits the torque.

dr12	max current %	0x220C
Value	Note	
0…6000 %	Maximum permissible motor current in% of the rated motor current	

The limiting characteristic of a synchronous motor is approximately one 1/x characteristic (at activated and correctly parameterized maximum voltage controller) neglecting saturation and similar effects.

This characteristic is defined by dr25 (speed) and dr13 (maximum torque at dr25) (=> Chapter 6.2.10 Field weakening).

The default value for both parameter is 100%. That means, one assumes that the motor at rated speed requires also rated voltage for rated torque.

dr13	breakdown torque %	0x220D
Value	Note	
0…6000,0 %	Torque for the definition of the1/x characteristic	

dr25	breakdown speed %	0x2219
Value	Note	
0.1…1000.0 %	Speed for the definition of the 1/x function in % of the rated limiting characteristic speed (rated value calculated from rated motor voltage, DC link voltage and rated frequency)	

NOTICE

- The 1/x limiting characteristic is obtained by a negative magnetizing current (Id), that counteracts the pulse wheel voltage, is preset by the maximum voltage controller.
- If a motor is not suitable for field weakening operation, this Id current must be theoretically higher than the maximum permissible or max. available current.
- Thus, the achievable torque rapidly decreases (=> 6.2.10.3.2.1 Limit value at synchronous motors).

The DC link voltage is defined with dr28, designed for the limiting characteristic.

The expected DC link voltage, which is dependent on the mains voltage ($\sqrt{2} * U_{mains}$) or the AFE voltage should be entered in this object (=> Chapter 6.2.10.4.2 DC link voltage dependence).

dr28	uic reference voltage	0x221C
Value	Note	
200…830V	DC reference voltage in V	

6.2.3.4 Motor protection

Index	Id-Text	Name	Function
0x2221	dr33	motor temp sensor type	0 = KTY 84-130, 1 = PTC, 2 = via encoder, 3 = KTY 83 110, 4 = PT1000
0x2222	dr34	motor protection curr. %	Standstill current (permanent permissible current at standstill) in % of rated motor current
0x2203	dr03	rated current	Rated current = permanent permissible current at rated speed
0x2226	dr38	SM prot min. Is/Id	Application point of the motor protection function in % of the permanent permissible current
0x220C	dr12	max. current %	Max. current in % rated motor current
0x2223	dr35	SM prot time min. Is/Id	Time, after the protection function is triggered at min. current flow (defined dr38)
0x2224	dr36	SM prot. time Imax	Time, after the protection function is triggered at max. current flow (defined dr12)
0x2225	dr37	SM prot. recovery time	The prot. recovery time is the time, which the protection function counter needs to count from 100% to 0%.

The overtemperature motor protection is parameterized with this objects (=> Chapter 4.4.5 Overtemperature motor (dOH) and chapter 4.4.6 Motor protection switch OH2).

6.2.3.5 System offset

6.2.3.5.1 General

The knowledge of the system position is mandatory necessary for the operation of a synchronous motor (also called systemoffset). The system position detects the mechanical difference between rotor position and position information of the installed encoder system.

NOTICE

- If the system offset is incorrectly measured or preset, the synchronous motor can overspeed uncontrollable.

The following cases must be differentiated:

Operation	Explanation
Operation with an encoder which provides an absolute position information per mechanical or electrical revolution	System position must be determined only once System position measurement is started/controlled by dd00
Operation with an encoder without absolute information	The system position must be redetermined at least after power on or with each modulation release. System position measurement is started/controlled by dd00
Operation without encoder (SCL)	System position must be redetermined at each modulation release. System position measurement is started/controlled by dd01

The determination mode of the system offset is adjusted in parameters dd00 (operation with encoder) or dd01(SCL). Not all modes are available in both operating modes.

dd00	rotor detection			0x3600
dd01	SCL rotor detection			0x3601
Bit	Function	Value	Function with encoder	Function SCL
0…2	mode	0, 6, 7	off	off
		1	cvv with check	reserved
		2	cvv only	reserved
		3	reserved	cvv only (SCL)
		4	five step	five step
		5	hf detection	hf detection
3	start after process	0	No	No
		8	yes	yes
4…5	cvv finished	0	hold rotor current	hold rotor current
		16	current to zero	current to zero
		32	reserved	to standstill current
		48	reserved	reserved
6…7	system offset (ec-group)	0	Function not available	overwrite
		64		no overwrite
		128		reserved

dd00	rotor detection			0x3600
dd01	SCL rotor detection			0x3601
Bit	Function	Value	Function with encoder	Function SCL
8	180° off-set(hf det./five step)	0	off	off
		256	on	on

Bit 3 determines after completion of the position identification if it is immediately started with the actual setpoint (standard at SCL), or if the drive remains in "start operation activ" (standard at operation with encoder).

Option "start after process" = no is only useful for SCL operation for tests during start-up (e.g. test of the five-step process).

dd00	rotor detection		0x3600
dd01	SCL rotor detection		0x3601
Bit	Function	Value	Function
3	start after pro-cess	0	No
		8	yes

Bit 4 and 5 determines if the alignment current remains active after completion of the system position identification, or if the current is set to zero or to standstill cur-rent.

This adjustment is only effective with "start after process = no".

dd00	rotor detection			0x3600
dd01	SCL rotor detection			0x3601
Bit	Function	Valu e	Function	Note
4…5	cvv fin-ished	0	hold rotor current	Threading current remains active
		16	current to zero	The current is set to zero at the end of the threading process
		32	to standstill cur-rent	The current of ds38 is output after the end of the threading process (only available at SCL)
		48	reserved	

Bit 6 and 7 determine if the system position (ec23) shall be overwritten with the identified position.

This selection is only possible at SCL operation in the modes "five step“ or "hf de-tection“. With encoder, ec23 is always overwritten with the new identified position.

ec23 is never overwritten at SCL identification mode 3 "cvv without turning".

dd01	SCL rotor detection		0x3601
Bit	Function	Value	Function
6…7	system offset (ec-group)	0	overwrite
		64	no overwrite
		128	reserved
		192	reserved

dd00	rotor detection				0x3600
dd01	SCL rotor detection				0x3601
Bit	Function	Value	Function	Note	
8	180° offset (hf det./five step)	0	off	Depending on the geometry (e.g. slot width) of the motor, the saturation behaviour can be inverted depending on the sign of the current Id. The offset must be activated in this case.	
		256	on		

If the identification is running or completed can be read in dr55.

dr55	ident state		0x2237
Value	Note	Meaning	
12	error	Abort of the system position identification with error	
14	ready	System position identification successfully completed	
17	rotor detection (cvv)	Position identification with "constant voltage vector" mode is running	
18	rotor detection (hf detection)	Position identification with "hf detection“ is running	
19	rotor detection (five step)	Position identification with "five step“ is running	

6.2.3.5.2 Rotor position detection mode cvv only

A voltage vector with constant electrical position is output in this mode. The amount of the current final value is adjusted dd02, the ramp time for current build-up is adjusted with dd03.

If the rotor can freely rotate, it will rotate to a fixed electrical position. The "rotor detection current" flow time is defined with dd04 before the position is considered to be valid. The required waiting period depends mainly on the vibration of the rotor after position change.

This procedure is not suitable for IPM motors or when using a holding brake!

Index	Id-Text	Name	Function
0x3602	dd02	rotor detection current	Alignment current in % of the rated motor current
0x3603	dd03	cvv current ramping time	Time for the current build-up in ms
0x3604	dd04	cvv waiting time	Time, when the alignment current is active (= motor alignment time + decay time of the vibration caused by the alignment)

Possible errors:

dr57	ident error info		0x2239
Value	Note	Meaning	
122	rotor det. cvv curr.	Current stiff could not be executed	

6.2.3.5.3 Rotor position detection mode cvv with check

This mode is an extension of the previous mode, which can be used only at operation with encoder.

dd02 to dd04 have the same function as described above.

In order to check the counting direction of the encoder system, the voltage vector is electrical turned about 60° in both directions. The rotor must return min. one rotation about 12° via the encoder system. Otherwise an error is triggered.

At high cogging torque the rotor often goes into the desired position with a residual error. This error is partly corrected in this mode.

Possible errors:

dr57	ident error info		0x2239
Value	Note	Meaning	
122	rotor det. cvv curr.	Current stiff could not be executed	
123	rotor det. cvv pos.	Encoder position has not turned electrical about min. 12° in the preset direction.	

This procedure is not suitable for IPM motors or when using a holding brake!

6.2.3.5.4 Rotor position detection mode five step

Index	Id-Text	Name	Function
0x3602	dd02	rotor detection current	Test signal-current level in % of the rated motor current
0x3607	dd07	rotor det. 1.order level	Error threshold for test signal
0x3608	dd08	rot. det. inf. (1.order)	Information content of the test signal

The "five step“ method uses the saturation of the motor for detection of the rotor position at standstill.

Five different voltage vectors are applied to the motor within a few ms. The current level to be reached can be preset via parameter dd02. The position of the rotor can be deducted by means on the current rise times.

dd02 should be set to the maximum permissible motor current, since higher current causes higher saturation and thus more precise identification.

If this method can be used for the motor, cannot be calculated previously with the motor data (Ld,Lq).

dd08 indicates the quality of the information content.

Parameter (dd07) defines the level when an error shall be triggered, because the information content is not sufficient (a level of 5% should be selected as starting value).

The information content can be different at different rotor positions. Therefore several different electrical positions should be tested at start-up.

6.2.3.5.5 Rotor position detection mode hf detection

Index	Id-Text	Name	Function
0x3602	dd02	rotor detection current	Current level of the 2nd test signal in % rated motor current
0x3607	dd07	rotor det. 1.order level	Error threshold for 2nd test signal
0x3608	dd08	rot. det. inf. (1.order)	Information content of the 2nd test signal
0x3609	dd09	rotor det. 2.order level	Error threshold for the first test signal
0x360A	dd10	rot. det. inf. (2.order)	Information content from parameters (dr15/dr16): |Ld-Lq| / Lq * 100%
0x3616	dd22	hf inj. frequency	Frequency of the first test signal
0x3617	dd23	hf inj. optimization factor	Hardness of the adjustment of the test signal controller
0x3618	dd24	hf inject. ampl factor	A voltage amplitude is calculated from the motor data, which shall offer a current of 10% of the rated current. The automatically calculated amplitude can be changed via this factor.

The "hf detection" mode consists of two identification steps.

The difference between Ld and Lq is used in the first test step for rotor position detection.

The frequency of the test signal is determined with dd22.

dd10 displays the information content of the first test signal. Parameter dd09 defines the level when an error shall be triggered if the information content is not sufficient. 20% should be selected as starting value.

Generally, the frequency of the test signal should not exceed 1/8 of the switching frequency. Maximum 500Hz can be selected in dd22 at 4kHz switching frequency (is10). This frequency is sufficient in many cases and minimizes the noise development in the motor.

Subsequently, the polarity of the system position is determined with a second test signal (the "five step" signal => previous chapter).

The level for the information content of the second test signal (which triggers an error) can be adjusted in parameter dd07. Since only the polarity must be detected here, dd07 can be selected smaller than in the real "five step" mode (e.g. 3%).

Several different electrical positions should be tested for the reliability of the rotor position detection at start-up.

NOTICE

- An operation with sine-wave filter is not possible parallel to this function.

6.2.3.5.6 Example

Example of the single measurement of the system offset at an encoder system with absolute position information.

Proce-dure	Description
1	The motor must be able to rotate freely, the control mode "2: encoder, with model“ must be selected in control mode in cs00.
2	dd00 = 1 = cvv with check, no start after prozess, hold rotor current
3	dd02 = 100% (=> rated motor current)
4	Release modulation via the controlword => the measurement starts
5	Measurement completed when dr55 = 14 = ready (=> Description Identification)
6	If the encoder shall be mechanically adjusted to a preset system position, the adjustment can now be executed while st12 state machine display is still set at value 11 "start operation active“ and dr55 ident state is set to 14 "ready“. A DC current from U to V is impressed in this step. The electrical position of the encoder must be parameterized in ec23 to this alignment position for normal operation. The electrical position of the encoder is displayed in ec22 rho encoder value. If, by rotating the encoder, the value of ec22 is set to zero (e.g.), then ec23 system offset (SM) must also be set to zero. The value of ec23 can only be preset if dr55 ident state is = 0 "off“ (after switching off the modulation). The correct value of ec23 should be checked by a restart of the system position calibration.
7	co00 = 0 => Switching off the modulation, the measured system offset under consideration of friction is displayed.
8	dd00 = 0 => rotor detection mode = off

6.2.3.6 Rotor position detection in operation at SCL (hf injection)

Index	Id-Text	Name	Function
0x3615	dd21	hf injection mode	Off/on of rotor position detection by HF injection
0x3616	dd22	hf inj. frequency	Frequency of the test signal. The switching frequency should be at least 8 times higher than the test signal frequency. For noise reasons, other test signal frequencies are also possible.
0x3617	dd23	hf inj. optimization factor	Hardness of the PI controller
0x3618	dd24	hf inject. ampl. factor	A voltage amplitude is calculated from the motor data, which shall offer a current of 10% of the rated current. The amplitude can be lowered or increased via this factor.
0x3619	dd25	hf inj. speed ctrl. red. factor	Defines the reduction of the speed controller parameters (kp, ki) as long as the HF injection is active
0x361A	dd26	hf inj. scan time	Pt1 filter time The filter time is automatically calculated at dd26 = -1
0x361B	dd27	hf inj. angle precontrol mode	Off/on of the angular advance under load
0x361C	dd28	hf inj. angle prec. factor [°@ InMot]	Describes how many degrees the angle advances at active current = rated current
0x361D	dd29	hf inj. dev. time	Pt1 time for tracking of the hf speed
0x361E	dd30	hf inj. diff rho current res.[°]	Error angle, due to the current resolution of the used inverter. The value corresponds to the error angle, which is caused by noise with the amplitude of one bit. It should be below 2°.

The HF injection allows the detection of the rotor position during running operation at low output frequencies in SCL operation.

A voltage with high frequency (dd22) is modulated for this. A difference between the inductance in the q and d-axis (Lq> Ld) of the motor is necessary in order to detect the rotor position. The difference is depending on the construction of the motor.

NOTICE

- Important: the information content may not be lost under load (e.g. by saturation). **An operation with sine-wave filter is not possible parallel to this function.**

The speed range wherein the function is active, is defined by parameters ds36/ds37 (min/max speed for stab current). The RF signal is switched off above this range and system position and speed are estimated by the motor model. The speed estimated by the HF controller is usually very noisy and must be additionally filtered by a PT1 element (dd29).

With pronounced IPM characteristics of the motor (Lq>>Ld) it is reasonable to switch off the stabilisation current and the stabilisation term (ds30).

The stator resistance adaptation is internally deactivated with activation of the HF injection.

6.2.3.7 Quick start-up of a synchronous motor

The start-up should always be done with co01 modes of operation = 2 "velocity mode", also if another operating mode shall be used later.

Drive must not be in operation

co00 (CiA 0x6040) controlword = 0 or hardware modulation lock

Load default data

Default data are automatically loaded in all parameters with co08 = 2 and then co09 = 1.

Select operating mode

The operating mode is selected in cs00 bit 0…3 (0 = v/f characteristic operation / 1 = with encoder, without model / 2 = with encoder, with model / 3 = without encoder, with model = SCL).

Preset motor data

With the input of the first motor data the state of dr02 changes to 0 "fill motordata".

The following data are additionally required for closed-loop operation with or without encoder:

dr00 motor type:	1: Synchronous motor
dr03 rated current:	rated motor current (for the electronic motor protection function)
dr04 rated speed / dr06 rated frequency:	Pole-pair number
dr04 rated speed / dr05 rated voltage:	Rated point (voltage for rated speed)
dr33 motor temp sensor type:	Selection motor sensor (PTC or KTY). If no motor temperature sensor is available, monitoring must be deactivated with pn12 = 7.
dr09 rated torque:	torque reference value
dr32 inertia motor (kg*cm^2):	for automatic parameterization of the speed controller (together with cs17 inertia load).

Equivalent circuit data dr14, dr15, dr16, dr17

There are 2 possibilities for the parameterization of the equivalent circuit data.

Either the equivalent circuit data are taken from one data sheet.

Or the equivalent circuit data are automatically determined completely through identification by the converter (dr54 = 1).

Values within the correct order of magnitude must be preset for the equivalent circuit data in order that the inverter reaches the status dr02 = 2 "motordata stored".

Otherwise the drive remains in dr02 = 3 "error norm motordata" and the identification cannot be carried out.

To use the identification, an operating mode with motor model must be selected in cs00 control mode (cs00 bit 0...3 = 2 or 3) and the inverter may not be in error state, otherwise the input is rejected by dr54.

The determination of the resistance and inductance occurs in standstill (slight rotation of the motor is possible by test signals).

For the determination of dr14 SM EMF, the drive must be in standstill or must be able to rotate only with small load.

The speed is determined by dr44 in % rated speed. The value must be changed if the application requires another (lower) speed. Forward direction of rotation.

The motor data and the parameterization of the identification are stored with dr99 = 0. Value 2 "motordata stored" must be displayed in dr02.

Parameterize encoder

If an operating mode with encoder is selected, the encoder parameters must be adjusted in the ec group (encoder type, smoothing, etc.). More information about encoder parameterization can be found in chapter 6.1 Interface to the encoder.
At the end of a successful parameterization the value of ec00 status encoder interface must be = 9 "position value ok".

Prepare system position-identification

The knowledge of the system position is mandatory necessary for the operation of a synchronous motor (also called systemoffset). The following cases must be differentiated: Operation with encoder => system position measurement is checked by dd00 Operation without encoder (SCL) => system position measurement is checked by dd01
For SCL operation, dd01 is set to the correct value after default loading (point 2).
dd00 must be set to value 1 for the operation with encoder, by way that the system position adjustment is executed with the following identification.

Identify

The drive must be ready for operation in order to identify:

- The DC link must be loaded.
- ru01 exception state must be equal to 0 "no exception" (if an error message is present, the cause must be removed and a reset must be executed with co00 = 128).
- The corresponding inputs must be set if the drive has safety functionality.
- The ramps (co48…co60) must be parameterized by way that no excessive acceleration forces occur.
- The speed controller has been adjusted already automatically if the inertia in dr32 nd cs17 has been correctly parameterized. Otherwise, the inertia must be preset in terms of magnitude and the automatic adjustment must be carried out by writing on cs99. Alternatively cs99 can be set to 19 "off" and the speed controller can be adapted manually.
- The torque and current limits are set to 100% (default).

- The modulation is released (in default setting) with co00 = 3 and then co00 = 11 and the drive starts the identification. The progress of the identification can be tracked in dr55 ident state. Some steps may take a few minutes. The final state should be dr55 = 14 "ready“. The type of error can be found in dr57 ident error info if the identification ends in 12 "error“ (=> Description of dr57 in Chapter 6.2.18).
- Lock the modulation again (co00 = 0).
- Deactivate the identification (of the equivalent circuit data and the system position) with dr54 = 0 and dd00 = 0. The adjustment of dd00 is different if an encoder without absolute position is used (see chapter 6.2.3.5 System offset). Accept the identified data with dr99 = 0 and parameterize the controllers.

Application-specific data

The following items are not complete, but these values must be checked at least. base is operating mode velocity mode.

Speed limits

Speed limits can be parameterized in the vl parameters for the velocity mode

Torque limits	
dr11 max torque	Torque limit of the motor
cs12 absolute torque	Torque limit of the application (is valid in all quadrants)
cs13…cs16	Torque limits for the single quadrants
dr13 breakdown torque	Torque for the definition of the speed-dependent limiting characteristic. This value must be increased, if the torque reduction according to a 1/x^2 characteristic starts to early.
Current limits	
de29 inverter maximum current	only display / maximum current for control
dr12 max current	Maximum current of the motor
is11 max current	The maximum current of the inverter can be decreased here (e.g., if the limit for the control should be lowered at motors with high current ripple in order to avoid overcurrent errors)
is35 set current limit	Setting of the maximum current for control (defines the safety distance to the overcurrent switch-off threshold)
Ramps	
co48…co51	Values for acceleration / deceleration
co52…co59	Values for the jerk in different ramp phases
co60	General parameterization of the ramp generator

Protection functions

The different warning level can be set in the pn parameters. In addition, protection functions can be activated / deactivated (e.g. speed monitoring, motor temperature sensor, etc.)
Also the quick stop ramp is parameterized here. When the quick stop ramp becomes active (only in case of an error or shut down and disable operation) is defined in co32 state machine properties.

Controller

The adjustment of the current controller occurs automatically. The controller gain can be adjusted with ds14 current cntrl factor in order to adjust special motors or applications. The value becomes only active if dr99 = 0 is written again afterwards. The speed controller can be optimized manually or via cs99 optimisation factor. When using the optimisation factor, the adjustment of the controller automatically adjusts to the changed speed smoothing times. Although longer smoothing times (ec26 / ec27) at constant cs99 result in weaker controller setting, a longer speed smoothing through better high-frequency suppression can offer a smaller value for cs99 and thus more dynamic control. If the field weakening range shall be used, eventually the maximum voltage controller must be adapted to the dynamics of the application (=> Chapter 6.2.10.3.2 Maximum voltage controller).

Deadtime compensation

The deadtime compensation should be switched on for operating modes with motor model.

Switching conditions

The output management (determination of the switching conditions, assignment, filtering, etc.) is carried out in the do parameters.

6.2.4 Structure overview

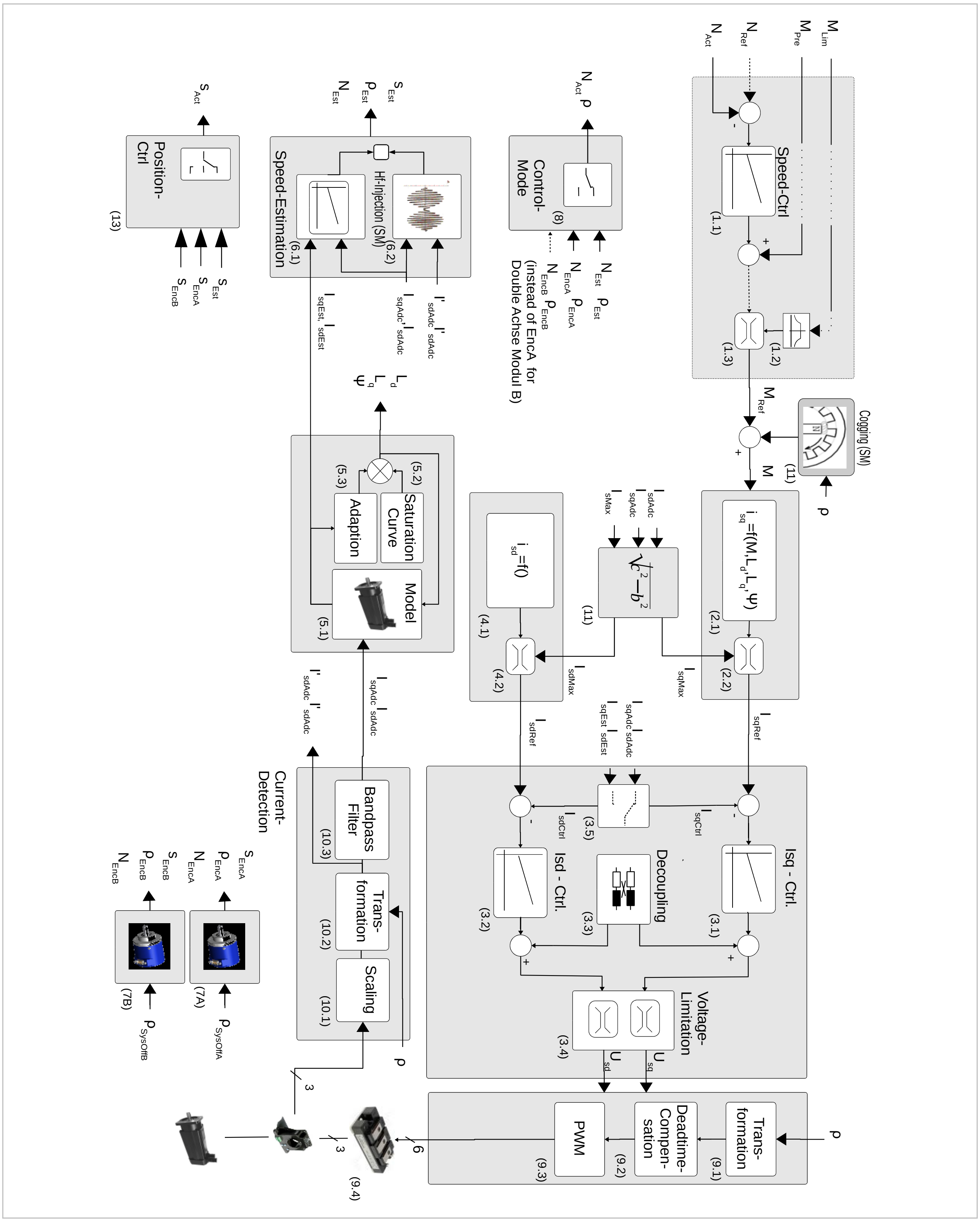


Figure 68: Structure overview motor model

1	Calculate the reference torque
1.1	Speed controller (Chapter 6.3) The PI speed controller gives the torque to regulate the speed difference between set and actual speed. • Variable proportional factor (Chapter 6.3.3) • Variable proportional/integral factor (speed) (Chapter 6.3.4) • Determination of the mass moment of inertia (Chapter 6.3.6) • Speed controller PT1 output filter (Chapter 6.3.7) • Torque precontrol (Chapter 6.3.8)
1.2	The maximum possible torque is reduced in the field weakening. A limitation of the set torque is required in order to bring the drive not into voltage limit. • Torque limiting characteristic (Chapter 6.2.10.4)
1.3	Calculation of the max. torque limit in consideration of maximum currents and detected motor data (Ld, Lq, Ψ) • Adaption (Chapter 6.2.12) • Torque limiting characteristic (Chapter 6.2.10.4) • Current (Chapter 6.2.8) • Torque limits (Chapter 6.4)

2	Calculate the reference active current from torque
2.1	With adapted and/or detected motor data of the saturation characteristic (Ld,Lq,Ψ) $isq = {}^{M}/_{3} \cdot ppz \cdot \Psi + isd \cdot (Lsd - Lsq)$ • Adaption (Chapter 6.2.12) • Saturation characteristic (SM) (Chapter 6.2.13)
2.2	Limitation to the max. active current • Currentlimitations (Chapter 6.2.8)

3	Converting the set currents into output voltage
3.1 3.2	Pi-current controller in d/q system • Current control (Chapter 6.2.6)
3.3	Precontrol of the current controller • Current control (Chapter 6.2.6)
3.4	Voltage limitation • Maximum voltage (Chapter 6.2.10.3)
3.5	Actual values current controller • Measurement / model currents (Chapter 6.2.7)

4	Calculation of the reference idle current
4.1	• Magnetizing current (Chapter 6.2.5) • Maximum voltage (Chapter 6.2.10.3) • Synchronous motor with reluctance torque (Chapter 6.2.5.2.3) • Model stabilization • Stabilisation current / standstill current (only SCL) (Chapter 6.2.16.3) • Sine-wave filter and capacitor current compensation (Chapter 6.2.23 Sinus filter)
4.2	Limitation to the max. reactive current • Current (Chapter 6.2.8)

5	Adaptation and saturation characteristic of the motor equivalent circuit diagram data
5.1	Motor model • Rotor position detection in operation at SCL (hf injection) (Chapter 6.2.3.6) • Model control (ASM and SM) (Chapter 6.2.16) • Model stabilization • Stabilisation current / standstill current (only SCL) (Chapter 6.2.16.3) • Adaption (Chapter 6.2.12)
5.2	Saturation characteristic • Saturation characteristic (SM) (Chapter 6.2.13)
5.3	Adaption (only with motor model) • Adaption (Chapter 6.2.12) • Control mode (with encoder / encoderless) (Chapter 6.2.15)

6	Motor model with estimated rotor position (only for SM)
6.1	Speed estimation • Model control (ASM and SM) (Chapter 6.2.16) • Model stabilization • Stabilisation current / standstill current (only SCL) (Chapter 6.2.16.3)
6.2	Rotor position detection (SM) • Rotor position detection in operation at SCL (hf injection) (Chapter 6.2.3.6) • System offset (Chapter 6.2.3.5)

7	Encoder evaluation
	• Parameterization of the encoder system (Chapter Interface to the encoder 6.1) • System offset (Chapter 6.2.3.5)

8	Control mode
	• Control mode (with encoder / encoderless) (Chapter 6.2.15)

9	Conversion of the voltage in the d/q system into control pulses for the power components (IGBTs)
9.1	Transformation of the voltage of d/q → a/b → uvw with angle (ρ)
9.2	Dead time compensation based on phase currents • Deadtime compensation (Chapter 6.2.19)
9.3	Pulse width modulation (PWM) with adjusted switching frequency • Switching frequency adjustment and derating (Chapter 6.2.20)
9.4	Driver control of the IGBT'S

10	Current measurement
10.1	Phase current detection
10.2	Transformation of the phase currents with angle (ρ) uvw → from → d/q system
10.3	• Band-pass filter (=> Chapter 6.2.23 Sinus filter) • Rotor position detection mode hf detection (Chapter 6.2.3.5.5) • Rotor position detection in operation at SCL (hf injection) (Chapter 6.2.3.6)

11	Maximum set current setting
	• Currentlimitations (Chapter 6.2.8)

12	Cogging (SM)
	• Cogging torque compensation (SM) Current (Chapter 6.2.14)

13	Position control
	• Source selection for the position control (Position controller source Chapter 6.5.3.3)

6.2.5 **Magnetizing current**

6.2.5.1 Magnetizing current asynchronous motor

The rated magnetizing current of an asynchronous motor can be calculated via the cos(phi) and the rated current or specified directly via parameter dr08.

With the automatic calculation of cos (phi) at major motors (> 30kW) one obtain often too high magnetizing current. This high current causes additional stator losses and the drive reaches the voltage limit faster at higher speeds. Since the increased current must be reduced again via the maximum voltage controller causes negative effects in the dynamic operation.

The actual calculation is based on the accuracy of the type plate data, especially of the rated current.

dr08	magnetizing current %	0X2208
Value	Meaning	
off	Current is calculated automatically	
0.1…100%	Magnetizing current in % of the rated motor current	

6.2.5.1.1 Generation of the magnetizing current (overview)

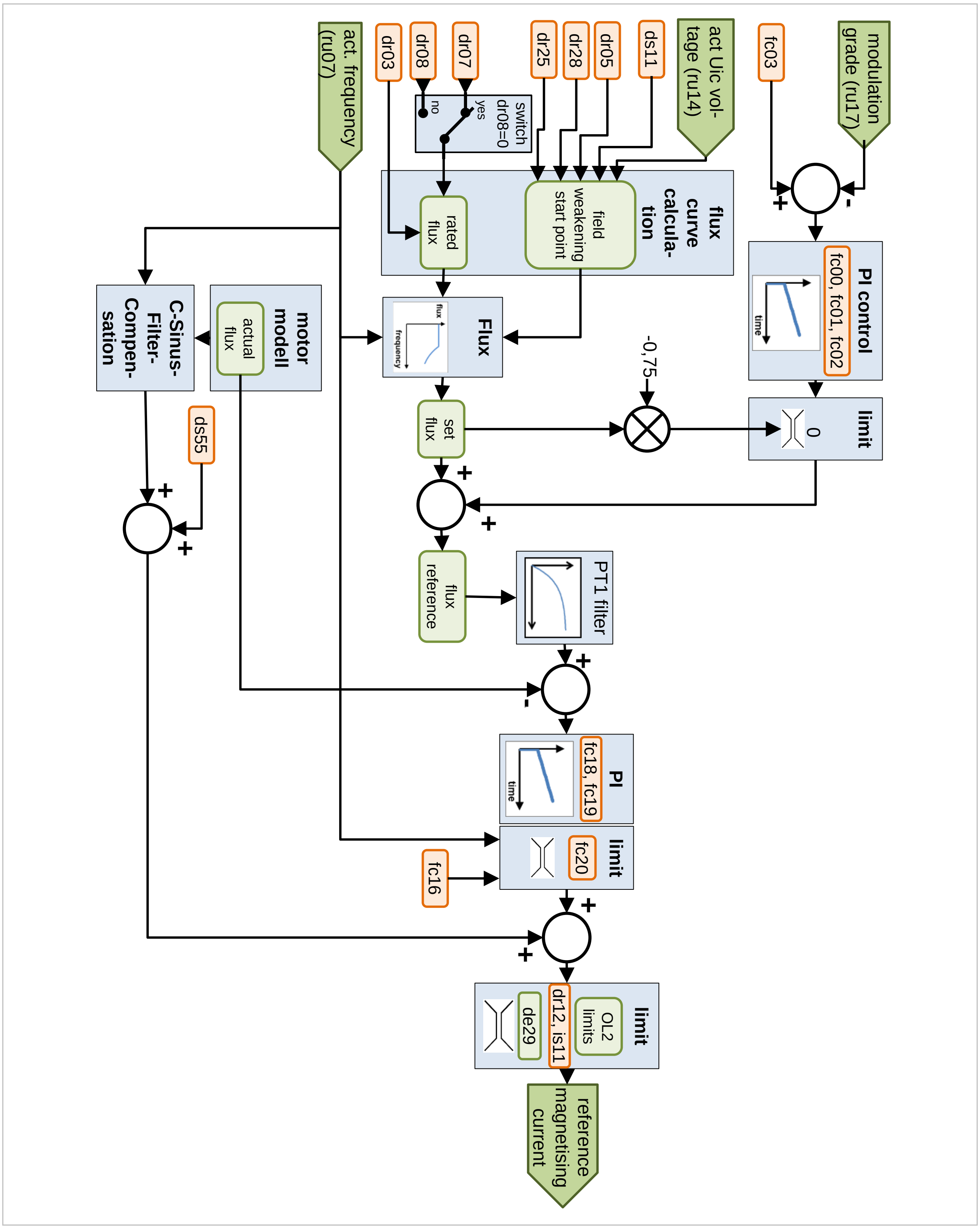


Figure 69: Generation of the magnetizing current

6.2.5.2 d-current cmponent synchronous motor

6.2.5.2.1 Generation of the d-component (overview)

The following picture indicates the composition of the setpoint for the magnetizing current (IdRef) during operation.

Further current components can be active during standstill, identification or measurement of the system position.

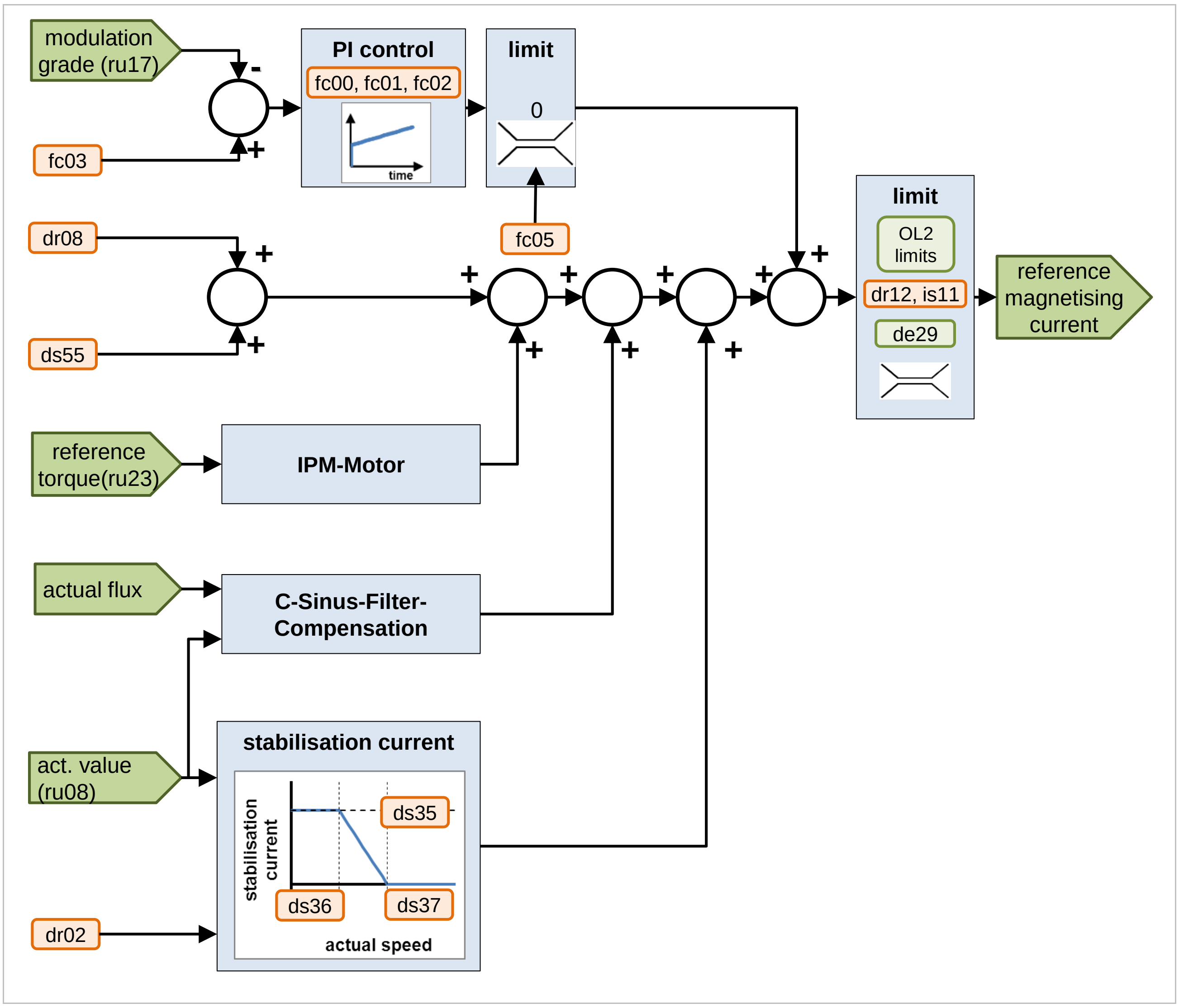


Figure 70: Generation of the d-component

6.2.5.2.2 Standard synchronous motor

A magnetizing current can be preset in 2 identically working objects at synchronous motor: dr08 (only positive values) and ds55. The settings are added.

dr08	magnetizing current %	0x2208
Value	Meaning	
off	Current is calculated automatically	
0.1…100.0%	Magnetizing current in % of the rated motor current	

ds55	Isd offset	0x2437
Value	Meaning	
-800.0%…800.0%	Magnetizing current in % of the rated motor current	

A positive magnetizing current has no influence for the torque buildup at synchronous motors if the inductance of the d and q axis is equal.

As standard, no settings need to be made here.

Possible exceptions:

- Increase of the motor losses at operation without braking resistor.
- Checking of the system position (the motor may not offer torque through current injection in the d-axis).

A negative magnetizing current is required in the field weakening. This current is automatically given via the maximum voltage controller (=> Chapter 6.2.10 Field weakening).

6.2.5.2.3 Synchronous motor with reluctance torque

If the inductances Ld and Lq are different, a reluctance torque can be generated by setting a d-current component (magnetizing current) which amplifies the torque generated by the magnets.

This effect is particularly pronounced at IPM motors.

Operation with encoder feedback:

The Id-current must be preset depending on the actual set torque of the speed controller for optimal operation (preferably low motor current).

In this way losses and possible inverter size can be reduced.

mo03	Fill table sel. (mo04…mo10)			0x3803
Bit	Function	Value	Plaintext	Notes
0	sel.	0	ctrl card	The tables are filled by writing on mo00, mo03 and dr99, ds04. Here, Id is set to 0A and depending on the saturation coefficients, the current for Iq = f(M) is calculated. mo09 from dr12 mo10 from dr11
		1	external	The tables must be filled externally.

Index	Id-Text	Name	Function
0x3804	mo04	Isq opt. Array(Iq=f(M))	ARRAY (16, float32, [A])
0x3805	mo05	Isd opt. Array(Id=f(M)	ARRAY (16 ,float32, [A])
0x3806	mo06	MLim array (M=f(Imax))	ARRAY (16 ,float32, [Nm]), this table is the result of mo04, mo05, if mo03 selection = 0 "ctrl card“ is selected
0x3809	mo09	Current Tab. x-axis	Reference value for the x-axis (float32 [A]]
0x380A	mo10	Torque Tab. x-axis	Reference value for the x-axis (float32 [Nm]]

Operation without encoder feedback:

At operation without encoder feedback (SCL), the table mo05 must be filled with zeros when the high-speed model (ds30) is selected. The optimum apparent current is given automatically.

6.2.6 Current control

➢ This description is not valid for v/f characteristic operation!

The current controller (ds00...ds03) are automatically precharged by writing on dr99= 0 based on the equivalent circuit data.

Therefore it must be ensured that the equivalent circuit data are correct for the connected motor (e.g. by identification).

Index	Id-Text	Name	Function
0x2400	ds00	KP current q-axis (V/A)	Current controller gain, effects proportional and integral part
0x2432	ds02	KP current d-axis (V/A)	
0x2401	ds01	Tn current q-axis	Current controller reset time, effects the integral part (Ki = Kp / Tn)
0x2403	ds03	Tn current d-axis	

If the current controller are adjusted manually, dr99 motordata control must be set to 1 "store motordata, no reg“, otherwise the controller are automatically set to the calculated values with each power on of the inverter.

The inductance changes at some motors (e.g. by saturation). With the default current controller setting an overshoot can occur at current setpoint change which can trigger an overcurrent error.

The current controller can be too hard at standard design also at very dynamic changes, high current ripple or other special applications.

The total current controller gain (Kp and Ki of both controllers) can be reduced or increased with ds14 current control factor.

Index	Id-Text	Name	Function
0x240E	ds14	current ctrl. factor	Percentage factor for the proportional and integral gain of both current controllers (q-axis and d-axis) (Value range 0.1…800.0%)

The adjustment of ds14 becomes only effective if a recalculation of the current controller is started via dr99 = 0 or after restarting the inverter, if dr99 is set to 0 "store motordata,init reg".

Additionally at synchronous motors the current controller can be adjusted depending on the saturation.

For motors that are driven much above saturation, not only the EMF, also the inductance changes. Thus the current controller for the saturation is parameterized too hard. An automatic adjustment of the current controller gain can be reached with this functions in parameter ds04 current mode.

ds04	current mode			0x2404
Bit	Function	Value	Function	Notes (only for synchronous motors)
9-10	sat. Lsq on Isq ctrl.	0	off	no saturation-dependent current controller adjustment
		512	kp,ki	Proportional and integral gain of the Iq-controller are adjusted
		1024	kp	Only proportional gain of Iq-controller is adjusted
		1536	reserved	
12-13	sat. Lsd on Isd ctrl.	0	off	No saturation-dependent current controller adjustment
		4096	kp,ki	Proportional and integral gain of the Id-controller are adjusted
		8192	kp	Only proportional gain of Id-controller is adjusted
		12288	reserved	

The saturation characteristic in dr and mo parameters must be parameterized accordingly to activate this function (=> Chapter 6.2.13 Saturation characteristic (SM)).

This parameter is adjusted automatically depending on the motor type.

Only in very special applications it may be useful to change this value

ds04	current mode			0x2404
Bit	Function	Value	Function	Notes (only for synchronous motors)
4-5	priority	0	d-axis (SM)	Current controller for the d-axis has always priority. Initial setting for SM
		16	reserved	
		32	compression + dyn. decoupling	The priority also changes the type of decoupling. This entails advantages when operating in the voltage limit. The maximum voltage controller is to be considered only as supportive. The advantage for IPM motors is an optimal operating point for the maximum torque. In addition, this current control mode is more tolerant against parameter errors (inductance). This is utilized, e.g. for motors with high saturation. **In this mode it is imperative to set the maximum Id current in parameter dr29.**
		48	auto select (ASM)	The current controller priority is changed depending on the operating point. Initial setting for ASM

Index	Id-Text	Name	Function
0x240F	ds15	dyn dec ctrl. factor	Adjustment of the dynamic proportion of the decoupling: 100% - ds15 forms the proportion of static decoupling. (Parameter is only effective if value 32 "compression + dynamic decoupling" is selected in ds14 for priority).
0x2410	ds16	anti windup speed level	Activation level of the anti windup limitation of the current controllers. Raising the AW level can increase the dynamic range. (Parameter is only effective if value 32 "compression + dynamic decoupling" is selected in ds04 for priority).

6.2.7 Measurement / model currents

6.2.7.1 Control to model currents

At operation with model (cs00 bit 0...3 = 2 or 3) a motor model calculates the model currents from the voltages and motor parameters.

It is adjusted with bit 6 of ds04current mode that the current controller uses the estimated (instead measured) model currents as controller feedback.

This is useful e.g. at HF spindles, where the current measurement is falsified by high current ripple of the motor current, or due to saturation effects high-frequency harmonics are contained in the current which can activate the controller.

ds04	current mode				0x2404
Bit	Function	Value	Function	Notes	
6	current control	0	off	Control to measuring currents	
		64	on	Control to model currents	

This model currents are adjusted for the current controller via timing relay ds08deviation control time to the measured current in order to prevent a long-term divergence of measuring and model current.

Index	Id-Text	Name	Function
0x2408	ds08	deviation control time	Pt1-time for tracking the model current

This time can usually remain unchanged.

6.2.7.2 Observer

An observer can be activated with bit 7 of ds04 current mode. This can improve the model accuracy at high output frequencies.

ds04	current mode				0x2404
Bit	Function	Value	Function	Notes	
7	observer	0	off	Observer for model currents on / off	
		128	on		

Index	Id-Text	Name	Function
0x2407	ds07	observer factor	Defines the influence of the observer

The default value must only be changed in exceptional cases.

6.2.7.3 Software filter

Averaging over two measured values can be activated for interference suppression with bit 11 of ds04 current mode. This function can be reasonable especially at 4 kHz switching frequency, if the motor has a high current ripple due to its low inductance.

ds04	current mode			0x2404
Bit	Function	Value	Function	Notes
11	current sw. filter	0	off	Averaging over two measured values on / off
		2048	on	

The software filter is always activated internally at switching frequencies higher than 4 kHz. ds04 bit 11 has only influence at lower switching frequencies.

6.2.7.4 Decoupling

The decoupling is important for dynamic behaviour of the current control at fast speed or current changes.

For good results it must be ensured that the equivalent circuit data are correct for the connected motor (e.g. by identification).

Normally it can be calculated with the default value "1 decoupling on“ in ds04 current mode.

ds04	current mode			0x2404
Bit	Function	Value	Function	Notes
0…2	current decoupling	0	off	Decoupling off
		1	on	Decoupling on
		2	only q-axis	Only for special applications
		3	only d-axis	
		4	only decoup (d and q)	Only current decoupling, no speed-dependent pre-control of the voltage
		5	only w1 precontrol	Only speed-dependent precontrol of the voltage
		6	only Rs precontrol	Only for special applications
		7	decoup and compl precontrol	Decoupling on additionally a speed and current-dependent torque limit is calculated, which is effective as absolute upper limit

Especially for operation without encoder, the (estimated) speed can be noisy, so the decoupling provides too many disturbances.

In this case, the frequency/speed can also be smoothed.

Index	Id-Text	Name	Function
0x2405	ds05	omega mech precontrol time	Filter time for the precontrol. The default value for this function is 2 ms. For high dynamic processes, when the speed must be changed in a ms range, this value can be too high. In these applications it is recommended to set the time to zero.
0x2406	ds06	omega decoupling time	Filter time for the decoupling.

6.2.8 Currentlimitations

The maximum permissible or possible current for the motor is limited by several parameters (=> also chapter 4.4.8 Maximum current).

Index	Id-Text	Name	Function
0x201D	de29	inverter maximal current	Maximal current of the inverter at rated switching frequency
Specification in instruction manual		Short-time current limit at 0 Hz	Error OL2 is triggered if the current is exceeded
0x220C	dr12	max current %	Permissible max. current in % of the rated motor current
0x350B	is11	max current [de28 %]	Permissible max. current in % of the inverter rated current
0x350E	is14	overload protection mode	Current limitation on short-time current
0x3523	is35	set current limit	Safety distance to the overcurrent (OC)

The current limit defined by the inverter and is35 set current limit is displayed in de29 inverter maximal current.
is35 defines the safety distance between the control limit and the overcurrent switch-off threshold. If this is too small, e.g. due to a very high current ripple, the permissible maximum current can be reduced with is35 is 35 is a "PowerOn“ parameter. is 35.

The maximum permissible current for the motor is entered in dr12max current %. Exceeding of this current could e.g. demagnetize a synchronous motor or the motor winding can be overloaded.

An inverter-dependent current limit can be preset in is11 max current [de28 %] in is11 max current [de28 %] (e.g. to reduce heating).

A further inverter dependent current limit is given by the short-time current limit. This is depending on the output frequency and the switching frequency. The short-time current limit at 0 Hz can be taken from the instruction manual.

At rated switching frequency the short time current limit increases in the range of 0 to 10 Hz from the 0Hz value to de29 inverter maximal current.

is14 overload protection mode is available to prevent OL2 errors. The permissible current is limited depending on OL2 by this function (=> Chapter 4.4.2 Overload power components (OL2)).

The listed limits above limit the total current. The d-current component has priority, the active current component is limited by the total limit and the d-component.

NOTICE

➢ The activation of the overload protection mode causes a dynamic current limitation and thus also a torque limitation. For applications in the field of lifting and lowering, this can lead to any sag of the loads!

The d-current and the currents which identify the motor parameters are always limited by the switching frequency-dependent short-time current limit at 0Hz (independent on the adjustment of is14) (=> Chapter 4.4.2 Overload power components (OL2)).

6.2.9 Torque adjustment

By default, the torque display does not show the value 0 during encoderless operation in no-load operation. The reason for this is, among other things, switching frequency-dependent losses in the motor and no-load and friction losses caused by the application.

In application, however, only the torque at the load is interesting. The mechanical and system losses should not be included in the display.

If the torque display is to be corrected by this offset, the offset for the selected control mode (with encoder or encoderless) must first be calibrated for all used switching frequencies. If a control mode or switching frequency is used for which the characteristic has not been identified, no compensation is carried out.

Basic procedure of compensation: The drive accelerates step by step within the speed range parameterized with mo38 torque offset ident config. For the individual speed values, the torque is measured in static operation and stored as torque offset.

For correction, linear interpolation is performed between the identified offset values. Below the first speed (mo38[1] start speed) the compensation value is linearly reduced to 0. Above the last speed (mo38[2] end speed) the compensation value is kept constant.

The identification of the offset characteristic can only be performed in clockwise direction of rotation. An identical offset is assumed for the left direction of rotation.

Offset compensation is effective in motor and regenerative operation.

Activating the offset compensation causes that the torque limits apply to the load and not to the internal motor torque. In the same way, the actual torque display applies to the torque on the load and not on the motor.

Therefore, torque limits are increased by the identified offset value and actual torques are reduced accordingly.

The physical torque limits (e.g. maximum current of inverter and motor, maximum possible / permissible torque of the motor) remain unaffected by the compensation characteristic.

The settings of the Velocity Mode (e.g. ramp generator, predefined torque limits) apply to the measurement routine.

NOTICE	
	➢ The maximum speed vl05 vl velocity max amount for can be exceeded by the identification. ➢ To ensure stable running during identification, the drive or the control settings should be optimized before starting the measurement routine.

If the drive cannot follow the settings or fluctuates strongly, no identification of the offset characteristic can be made.

6.2.9.1 Configuration of the torque offset identification

The parameter structure mo38 torque offset ident config defines the speed range for which the torque offset identification is performed (subindex 1 and 2).

It is also defined whether the offset values are determined on the basis of the momentary values or of smoothed values (PT1 filter). (Subindex 3 and 4)

The measurement of the torque offset must be carried out at no-load operation in static operation in order to avoid measurement errors due to acceleration torques. Subindices 5...9 determine how static operation is to be defined and monitored.

Index	Idx text	Name	Function
0x3826	mo38	torque offset ident config	Configuration of the torque offset identification
	Su-bidx	Name	Function
	1	start speed [1]	Speed point 1 (start speed of the torque offset characteristic) in % dr04 rated speed
	2	end speed [2]	Speed point 16 (end speed of the torque offset characteristic) in % dr04 rated speed **Notice:** the maximum speed vl05 vl velocity max amount for can be exceeded during the identification, only the end speed is valid as limitation.
	3	ident torque source [3]	Selection of the torque value for the offset identification: 0: raw => non-smoothed torque value 1: PT1 filtered => value smoothed with PT1 filter (ru81)
	4	ident speed source [4]	Selection of the speed source for the offset identification: 0: raw - not smoothed (ru08) 1: PT1 filtered - PT1 smoothed value (ru85)
	5	ident max torque deviation [5]	Permitted deviation of the minimum / maximum torque values from the average value of the measurement in % dr09 rated torque (Description Stability monitoring see chapter 6.2.9.2 Execution of the torque offset identification)
	6	ident max speed deviation [6]	Permitted speed deviation from the setpoint speed of the identification in % dr04 rated speed (Description Stability monitoring see chapter 6.2.9.2 Execution of the torque offset identification)
	7	ident torque number of samples [7]	Number of values whose average value is taken as torque offset (Description of the measurement see chapter 6.2.9.2 Execution of the torque offset identification)
	8	ident speed stability check duration [8]	Time in ms wherein the speed must remain within the limits of mo38[6] by way that the speed is considered stable and the offset measurement can be started (Description of the measurement see chapter 6.2.9.2 Execution of the torque offset identification)
	9	ident speed max settle duration [9]	Maximum allowed time for speed stabilization (Description of the measurement see chapter 6.2.9.2 Execution of the torque offset identification)

The default values of mo38 should allow problem-free identification in most applications:

- start speed [1] = 5 % dr04
- end speed [2] = 130 % dr04
- ident torque source [3] = 1: PT1 filtered
- ident speed source [4] = 0 : raw

- ident max torque deviation [5] = 3 % dr09
- ident max speed deviation [6] = 3 % dr04
- ident torque number of samples [7] = 1000
- ident speed stability check duration [8] = 30 ms
- ident speed max settle duration [9] = 500 ms

6.2.9.2 Execution of the torque offset identification

The identification is related to a specific switching frequency and a defined control mode. Therefore, the required settings in the associated parameters is10 switching frequency and cs00 control mode must be carried out before the measurement routine is executed.

Außerdem muss der Antrieb so parametriert sein, dass er nicht schwingt und den Drehzahlsollwerten auch folgen kann.

NOTICE

- ➢ In controlmode cs00 = v/f-control there is no torque calculation and thus no torque offset compensation.
- ➢ An error is triggered if a measurement is tried to start in this mode.

The activation of the automatic measurement routine occurs by parameter mo35 torque offset ident.

mo35	torque offset ident		0x3823
Value	Plaintext	Function	
0	0: off	Measurement routine deactivated	
1	1: on	Measurement routine activated	

Activation of the measurement routine is only possible with modulation switched off. The measurement routine is executed in the operating state st12 state machine display = 5: **start operation active**.

By starting the measurement routine the parameters of moxx torque torque offset data fswx are described. starting speed [2] and speed step [3] are automatically calculated from the settings of mo38. The value of data status [1] is "0: not available“. The control mode for which the measurement is performed is stored in control mode [4].

The switching frequencies for which identification can be performed are defined by the parameterization of is22 Basic Tp. If value 0: 62.5µs is selected for "basic Tp“, mo39 torque offset data fsw0 and mo43 torque offset array fsw0 contain the values for 2 kHz, mo40 torque offset data fsw1 and mo44 torque offset array fsw1 contain the values for 4 kHz, mo41 torque offset data fsw2 and mo45 torque offset array fsw2 contain the values for 8 kHz and mo42 torque offset data fsw3 and mo46 torque offset array fsw3 contain the values for 16 kHz.

If "basic Tp" is value 1: 71.4us is fsw0 = 1.75 kHz, fsw1 = 3.5 kHz, fsw2 = 7 kHz and fsw3 = 14 kHz.
Thus, fsw0 is always the lowest switching frequency defined by is22, fsw3 is the highest one.

For the identification, the speed mo38 [1] start speed (= moxx torque torque offset data fswx => starting speed [2]) is approached first. Offset measurement occurs when the speed is stable.

A waiting time of 1 second is generally maintained for this after the ramp output value has reached the setpoint (= speed for which the torque offset shall be identified).

Then it is checked whether the actual speed value deviates more than + / - mo38 [6] ident max speed deviation from the setpoint.

If the actual value remains within this window for the time defined in mo38 [8] ident speed stability check duration the speed is considered stable and the measurement starts.

An error is triggered if the required stability has not been reached after the maximum allowed time mo38 [9] ident speed max settle duration. (See description of mo37 torque offset ident error info in the following chapter)

The maximum total time for speed stabilization is total: 1 second. + mo38 [9]

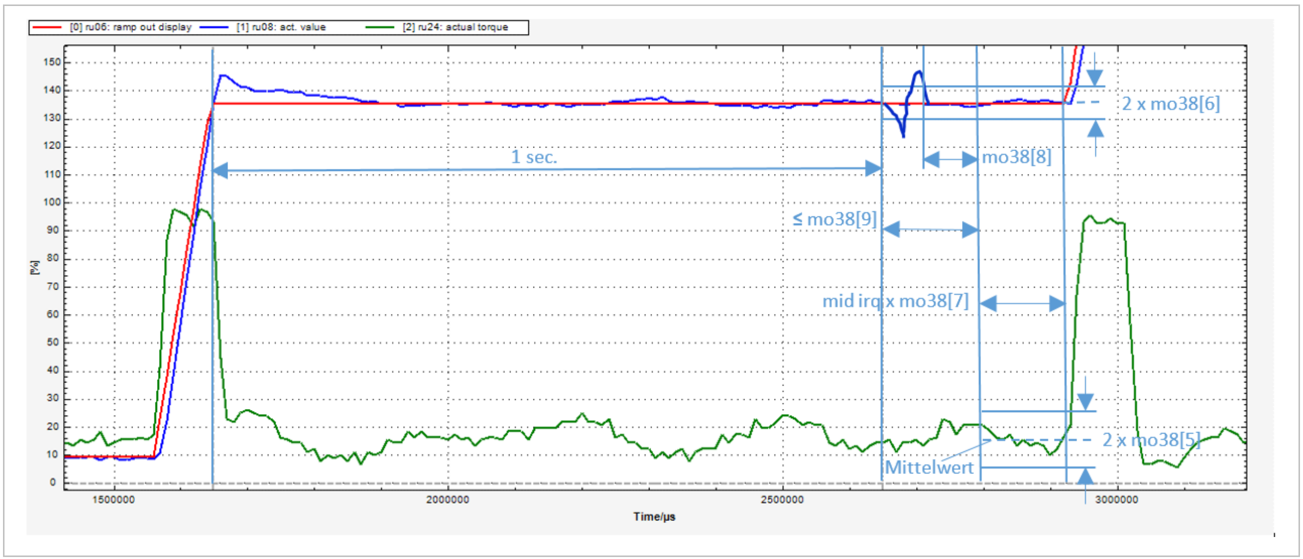


Figure 71: Procedure of the offset measurement

After the actual speed has reached a stable status, the average value of the torque is formed via mo38 [7] ident torque number of samples values. mo38 [3] ident torque source specifies whether the filtered or the unfiltered actual torque value should be used for averaging.

During this time, the speed stability is further monitored. The deviation from the setpoint shall not be greater than +/- mo38 [6] ident max speed deviation.

The deviation of the individual torque samples from the calculated average value shall not be greater than mo38 [5] ident max torque deviation.

If the measurement is completed at one speed, the setpoint speed is increased by moxx speed step fswx and the torque offset is measured for the next speed point.

After all points have been approached, the drive returns to speed 0 and then switches off the modulation automatically.

If the measurement procedure is interrupted (e.g. due to instabilities of the torque measurement or the actual speed value), the drive retuens to 0 from the last approached speed point.

The measurement can be cancelled manually at any time with mo35 torque offset ident = 0: off.

In addition, the measurement is aborted by deactivation of the modulation - e.g. by an inverter error (see ru01).

6.2.9.3 Display of the identification

The start of the automatic identification occurs in mo35 torque offset ident.

The identification process is then visible in mo36 torque offset ident state.

mo36	torque offset ident state	0x3824
Value	Plaintext	Meaning
0	Off	The measurement is not active.
1	Running	The measurement is running. The "**data status**" of the corresponding offset characteristic (mo39...mo42) is set to "Not Available".
2	Aborting	The measurement was interrupted. The drive moves to speed 0.
3	Ready	The measurement was completed successfully. The "**data status**" of the corresponding measured values (mo39...mo42) changes to "Available".
4	Error	The measurement was completed with an error.The "**data status**" of the corresponding measured values (mo39...mo42) remains at "Not Available".

If an error has occurred during identification, the cause of the error is displayed in mo37 torque offset ident error info.

mo37	torque offset ident error info	0x3825
Value	Plaintext	Meaning
0	No error	The measurement routine is still active or has been completed successfully.
1	Init error	Initialization error => invalid calibration configuration. (e.g. invalid control mode "v/f - control" selected in cs00 or wrong parameterization of start speed / end speed in mo38.
2	Mode error	During torque averaging, the controlmodecs00 was changed.
3	Speed unstable	The speed is unstable. The deviation from the speed setpoint is greater than mo38[6].
4	Torque unstable	The torque is unstable. During averaging, the deviation of individual torque measured values from the average value is greater than mo38[5].
5	Switching freq. unstable	There was a change of the switching frequency during torque averaging (e.g. due to derating).
6	Aborted on demand	The measurement procedure was interrupted manually (by parameter mo35).

If the torque offset identification has been carried out successfully, the result of the measurement can be seen in parameters mo39...mo42 torque offset data fswx and mo43...mo46 torque offset array fswx.

Index	Idx text	Name	Function
0x3827 0x3828 0x3829 0x382A	mo39 mo40 mo41 mo42	torque offset data fsw0 torque offset data fsw1 torque offset data fsw2 torque offset data fsw3	Characteristic values of the torque-offset characteristic
	Su-bidx	Name	Function
	1	data status fsw	Status of the torque offset characteristic
	2	starting speed fsw	Starting speed of the offset characteristic
	3	speed step fsw	Distance between the speed interpolation points of the offset characteristic
	4	control mode fsw	Control mode which is valid for the offset characteristic (values see description of cs00)

data status fsw0 / data status fsw1 / data status fsw2 / data status fsw3		0x3827 [1]...0x382A [1]
Value	Plaintext	Function
0	0: Not Available	The torque offset values for the switching frequency are not available
1	1: Available	The torque offset values for the respective switching frequency are valid

The individual torque offset values for the 16 speed interpolation points can be read out for the respective switching frequency in parameters mo43...mo46 torque offset array fswx.

mo43 mo44 mo45 mo46	torque offset array fsw0 torque offset array fsw1 torque offset array fsw2 torque offset array fsw3	0x382B [1...16] 0x382C [1...16] 0x382D [1...16] 0x382E [1...16]
Subidx	Value range	Meaning
1	Float32 Parameter	Torque offset value for starting speed fsw in Nm
...		Torque offset value (in Nm) for speed starting speed fsw + (SubIdx – 1) * speed step fsw
16		Torque offset value (in Nm) at final speed of the characteristic starting speed fsw + 15 * speed step fsw

The torque offset value is reduced to zero between zero speed and starting speed fsw. The offset value is assumed to be constant above the end value of the compensation characteristic (starting speed fsw + 15 * speed step fsw).

The offset table torque offset array and the characteristic values of the offset characteristic torque offset data can not only be identified, but also be described manually. This means that data that has been determined once for an application can be transferred to other inverters.

6.2.9.4 Torque correction by identified setpoint

After a compensation characteristic has been identified or externally filled with data, it must be enabled with mo34 torque offset correction enable by way that the torque correction is executed.

mo34	torque offset corr. enable		0x3822
Value	Plaintext	Function	
0	0: off	the torque offset compensation is deactivated	
1	1: on	the torque offset compensation is activated	

The compensation value calculated by interpolation for the current speed and current switching frequency is displayed in parameter mo33: act. torque offset.

If the offset compensation is deactivated or has not been measured for the current switching frequency or the active control mode, parameter mo33 displays the value 0 Nm.

The torque offset characteristic is only measured for the positive direction of rotation. An identical offset curve is assumed for the negative direction of rotation.

The offset compensation causes the torque limits apply to the load and not to the internal motor torque. In the same way, the actual torque display applies to the torque on the load and not on the motor.Therefore, torque limits are increased by the identified offset value and actual torques are reduced accordingly.The physical torque limits (e.g. maximum current of inverter and motor, maximum possible / permissible torque of the motor) remain unaffected by the compensation characteristic.

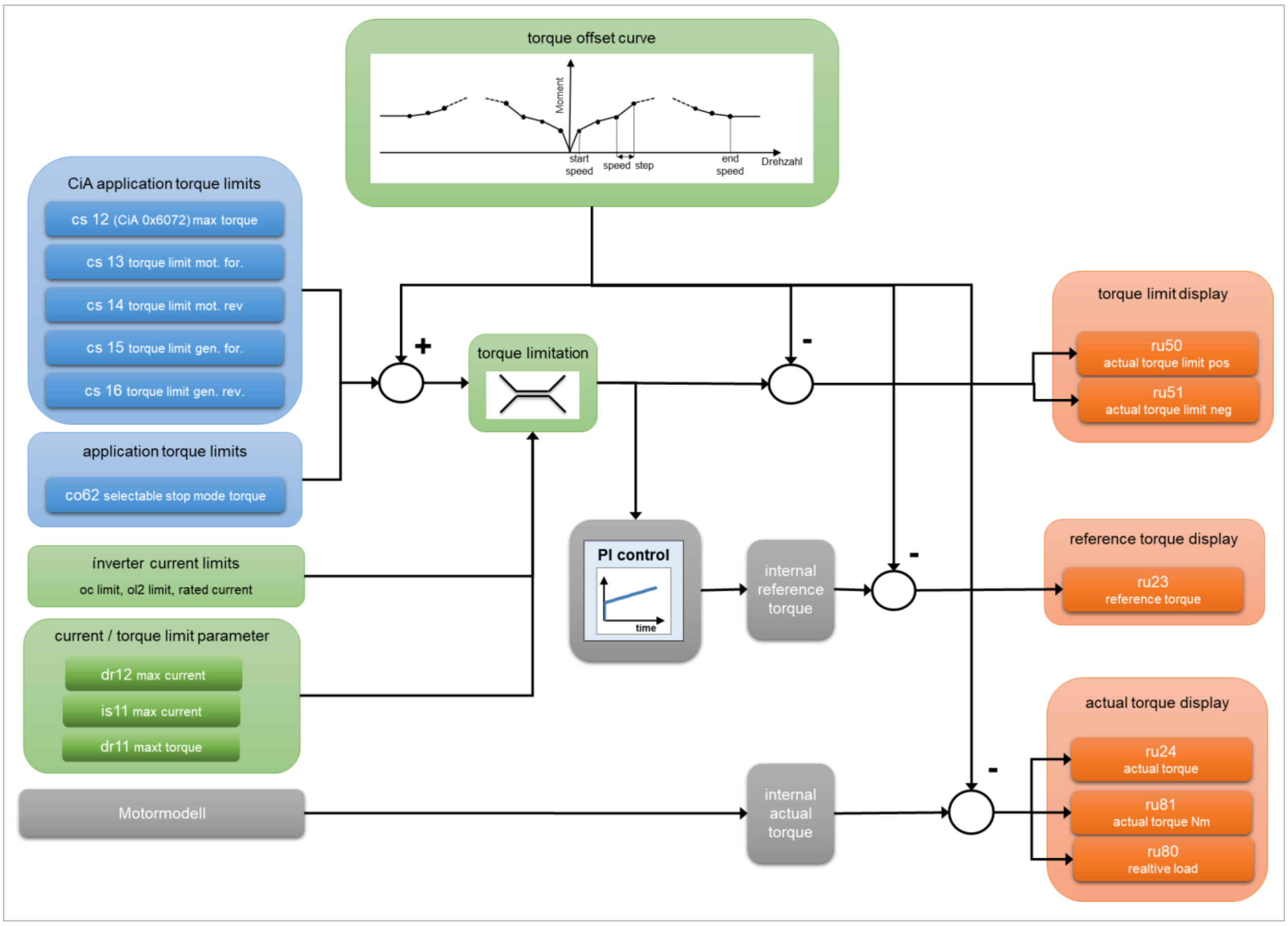


Figure 72: simplified representation of the torque offset compensation

If torque setpoints / precontrol values are directly preset (co15 (CiA 0x6071) target torque and co18 (CiA 0x60B2) torque offset), **no** torque offset is added to these values.

6.2.10 Field weakening

6.2.10.1 Synchronous motor

The d-current component is normally equal to zero in a synchronous motor.

The "field weakening range" is the speed range, which can only be reached if a negative Id is set.

This negative magnetizing current (Id), which counteracts the pulse wheel voltage, is preset by the maximum voltage controller. Thus higher speeds can be reached with the same torque (but higher total current).

If the inverter is in error state, the magnetising current is = 0 A.

The motor regenerats the full rotor voltage into the inverter.

$$Rotor\ voltage = \frac{EMC\ voltage\ constant * actual\ speed 1000\ rpm}{}$$

This voltage must not be higher than the overvoltage threshold, otherwise the inverter will be damaged.

$$Maximum\ speed = \frac{max.voltage\ * 1000\ rpm\ voltage\ constant\ (dr14)}{}$$

The safety distance which should be maintained to the max. speed is preset with pn70 overspeed factor (EMF). A value of 90% for pn70 means, the error is triggered at 90% of the max. theoretically permissible speed value. The resulting limit value is displayed in pn72.

The response to the error is defined with pn71 E. overspeed (EMF) st. mode. Since this speed range should only be reached when the motor "runs away" or the controllers are badly adjusted, the safe response is 0: fault.

If the speed measurement is decelerated (smoothing by Pt1 and scan time) this deceleration must be considered and pn70 must be selected lower.

NOTICE

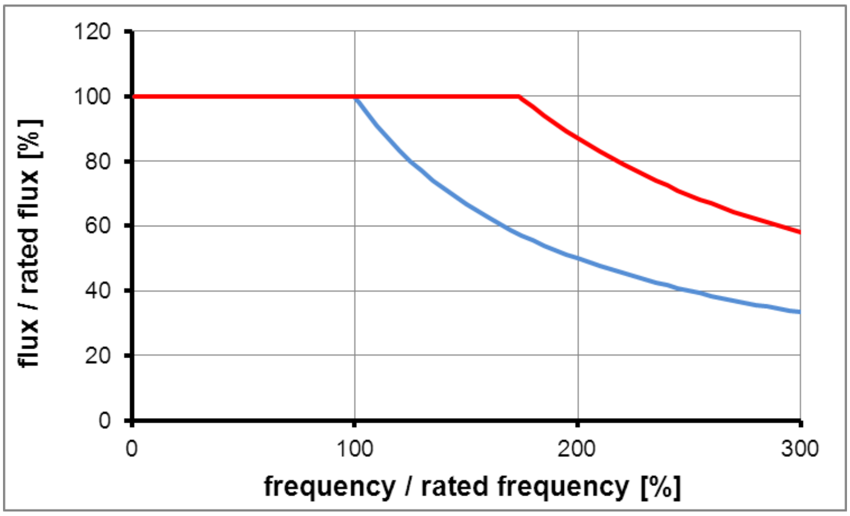
The advantage of higher max. speed is contrary to several disadvantages:

- the drive has more „speed oscillation“ as in the base speed range
- Not all motors are suitable for field weakening operation. That means, a very high magnetizing current is required to reduce the voltage, and thus be able to reach higher speed.
- The rotor position information must be very exactly. A system position error of a few degrees (e.g. through malfunctions or inaccurate encoder mounting) can make the drive out of control.

6.2.10.2 Asynchronous motor

The rated flow is reduced according to a 1/x characteristic in the field weakening range, dependent on the output frequency.

The weak time (n_W) is calculated from parameters dr05, dr28, dr25 (=> Field weakening / Torque limiting characteristic Chapter 6.2.10.4).



Parameter	Name	blue characteristic	red characteristic
dr28	Uic reference voltage	565V	565V
dr05	rated voltage	400V	230V
dr25	breakdown speed [%]	100%	100%

Figure 73: Field weakening range asynchronous motor

6.2.10.3 Maximum voltage

6.2.10.3.1 Maximum output voltage

The output voltage of the inverter is generated by a pulse-width modulation of the DC link voltage.

A modulation factor of 100% means, that the amplitude of the motor voltage (phase-phase voltage) is equal to the DC link voltage.

The effective value of the motor voltage can be increased over 100%, however the output voltage differ from the sinusoidal form.

Therefore additional harmonics occur at a modulation factor over 100% that generate oscillating torque or additional losses in the motor. The voltage distortion from approx. 103% often effects unsmooth motor and control behavior.

Index	Id-Text	Name	Function
0x3704	fc04	max. modulation grade	Adjustment of max. permitted modulation grade.

6.2.10.3.2 Maximum voltage controller

The maximum voltage controller servers for a reduction of the „counter voltage“ at asynchronous motor via the flux and at synchronous motor via the reactive current (Id).

The voltage limitation occurs by flux reduction for the asynchronous machine. The motor flow can be reduced by the controller to ¼ of the value (according to the magnetization characteristic).

For the synchronous machine, voltage limitation occurs by providing a negative magnetization current. The maximum value of this current is defined with parameter fc05 Umax reg. limit.

The controller can only reduce the flow or regulate the Id to negative values.

Index	Id-Text	Name	Function
0x3700	fc00	Umax regulation mode	Maximum voltage controller activation
0x3701	fc01	KP Umax [%Irated/%U]	Proportional gain of the controller usually only causes trouble and should normally remain at 0
0x3702	fc02	Ki Umax [%Irated/%U s]	Integral gain of the controller
0x3703	fc03	Umax reference	The setpoint for the maximum voltage controller (fc03) should be at least 2% lower than the maximum modulation grade (fc04). Higher differences can also be required dependent on the desired dynamics.
0x3704	fc04	max. modulation grade	
0x3705	fc05	Umax reg limit	Limit for maximum voltage controller

fc00	Umax regulation mode			0x3700
Bit	Function	Value	Function	Notes
0…3	mode	0	off	Controller off
		1	on	Controller on / setpoint = fc03
		2,3	reserved	
4	stopping	0	yes, usd ctrl	The maximum voltage controller is stopped if the current controller in the d component has reached the voltage limit. Initial setting for SM
		16	No	No stopping of the maximum voltage controller. Initial setting for ASM

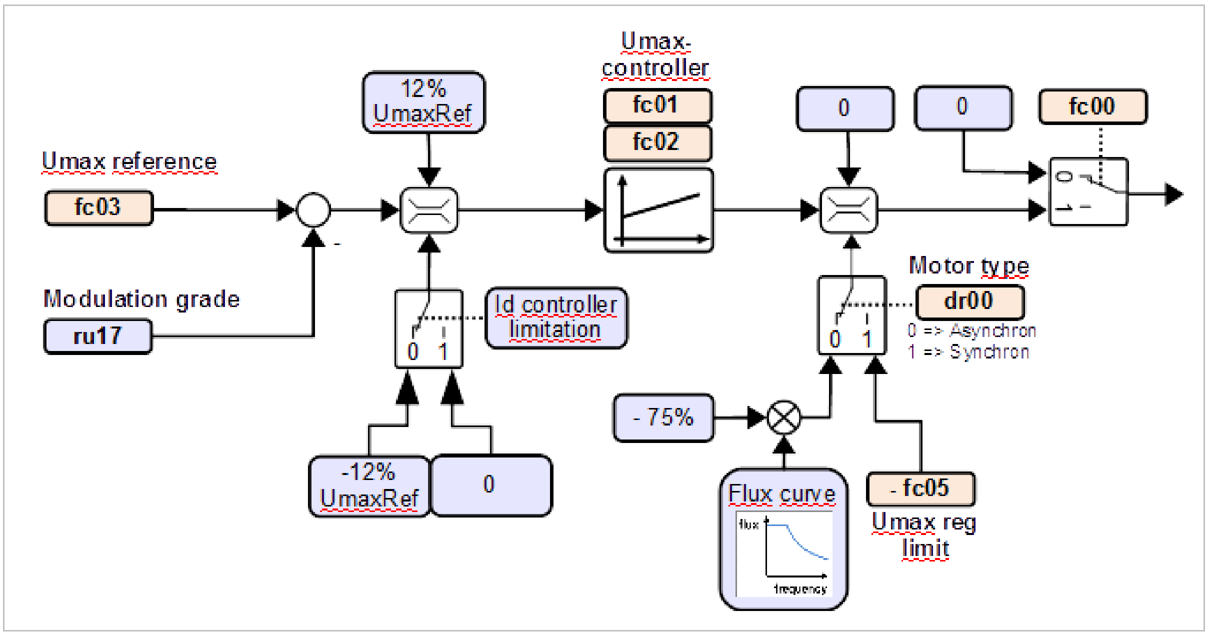


Figure 74: Maximum voltage controller

The optimal integral gain of the maximum voltage controller can not be calculated from the equivalent circuit data of the motor.

The minimum required value for fc02 can be rough calculated from the desired dynamics of the application.

Example:

A negative Id of 100% Irated shall be build up in 20ms. The setpoint fc03 shall be 97% and the maximum value fc04 shall be 103%.

%Irated	100
%U	= fc04 – fc03 = 6%, if the controller is inside the limit
Time	20ms = 0.02s
Ki	= 100 / 6 / 0.02 = 833 %Irated / %U / second => Ki (fc02) must be selected >833%, because the voltage limitation is to be avoided.

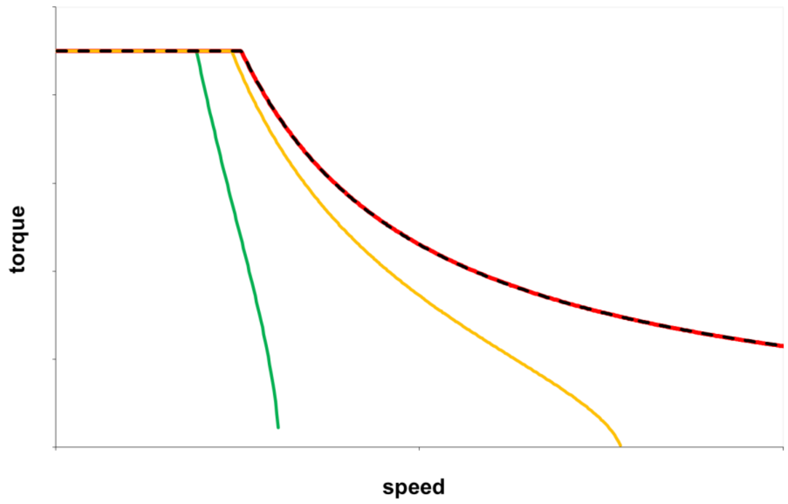
6.2.10.3.2.1 Limit value at synchronous motors

The negative limit for the maximum voltage controller for synchronous motors is defined with fc05:

Index	Id-Text	Name	Function
0x3705	fc05	Umax reg. limit	Maximum current, that shall be supplied from the maximum voltage controller for compensation of the pulse wheel voltage (% to rated motor current).

The optimal limit value is depending on the motor data (motors designed for field weakening) and is often in the range of 100%...200% of the rated current.

The maximum possible torque can not be reached if the limit is selected too low. The controller can remain at the limit if it is selected too high.



1	without maximum voltage controller, Id=0
2	with maximum voltage controller, Id < opt. Id
3	with maximum voltage controller, Id = opt. Id
4	1/x

Figure 75: Limit value at synchronous motors

6.2.10.3.2.2 Limit value at asynchronous motors

The limit value at asynchronous motors is selected by way that the set flow by the controller can be reduced always about 75%.

6.2.10.4 Torque limiting characteristic

6.2.10.4.1 Function

If the motor is overloaded, i.e. if a torque is required, beyond its limit torque, the current controller reaches their voltage limit. Furthermore the maximum voltage controller reduces the flux or the Id too strong and by way the maximum reachable torque is also reduced.

Therefore the limiting characteristic becomes effective at higher speeds.

The maximum reachable torque is reduced approximately at asynchronous motors to a $1/x^2$ function and at synchronous motors to a 1/x function. This is parameterized in ds11.

This parameter is automatically adjusted with the setting in dr00 asynchronous motor or synchronous motor.

ds11	torque mode			0x240B
Bit	Function	Value	Plaintext	Notes
0…1	field weak curve limit	0	1/x	Synchronous motor
		1	$1/x^2$	Asynchronous motor

6.2.10.4.2 DC link voltage dependence

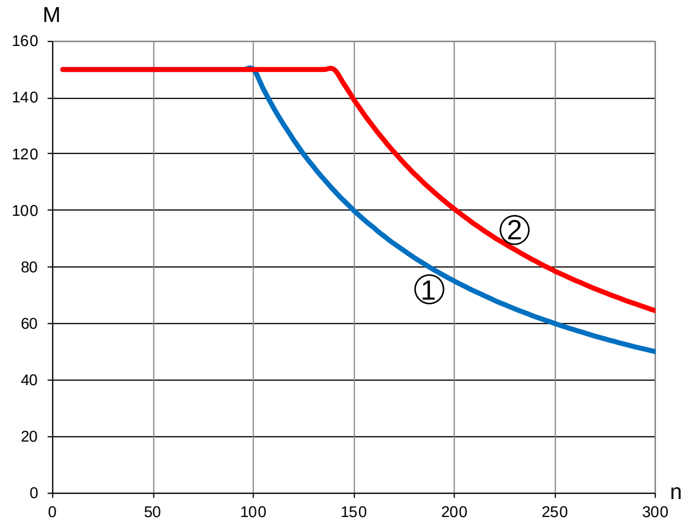
The maximum achievable torque is dependent on the DC link voltage.

The DC link voltage is entered in dr28, valid for the limiting characteristic.

Index	Id-Text	Name	Function
0x221C	dr28	Uic reference voltage	Reference value of the DC link voltage for the definition of the field weakening range and the limiting characteristic in V.

With higher DC link voltages, the limiting characteristic would shift to higher speeds, correspondingly lower DC link values lead to lower speeds.

Example: maximum reachable torque of a synchronous motor depending on the DC link voltage:



1	DC link voltage	565V
2	DC link voltage	680V

Figure 76: Maximum torque depending on the DC link voltage for the synchronous motor

If the characteristic shall be adjusted automatically to the actual DC link voltage can be defined with ds11 bit 2 and 3.

ds11	torque mode			0x240B
Bit	Function	Value	Plaintext	Notes
2…3	Uic dependant torque curve adaption	0	off	no adaption
		4	generally on	Adaptation in both speed directions
		8	only reduction	Adaption only to lower speeds
		12	reduction, on at FaultReact.	in standard operation only adaption to lower speeds, while the fault-reaction ramp also to higher speeds

Bit2-3 = 4 "generally on“:

The maximum torque of the motor is generated at this value. The disadvantage is that an unstable or dynamic changing DC link voltage can cause unsmooth at operation at the limiting characteristic.

Bit2-3 = 8 (only reduction):

This is the recommended setting. The shifting of the characteristic curve to the left towards lower speeds is carried out, which is physically necessary due to a too low DC link voltage. A shifting to higher speeds, with higher DC link voltage, does not take place. That means, the characteristic is only shifted if the DC link voltage is lower than dr28 "uic reference voltage“.

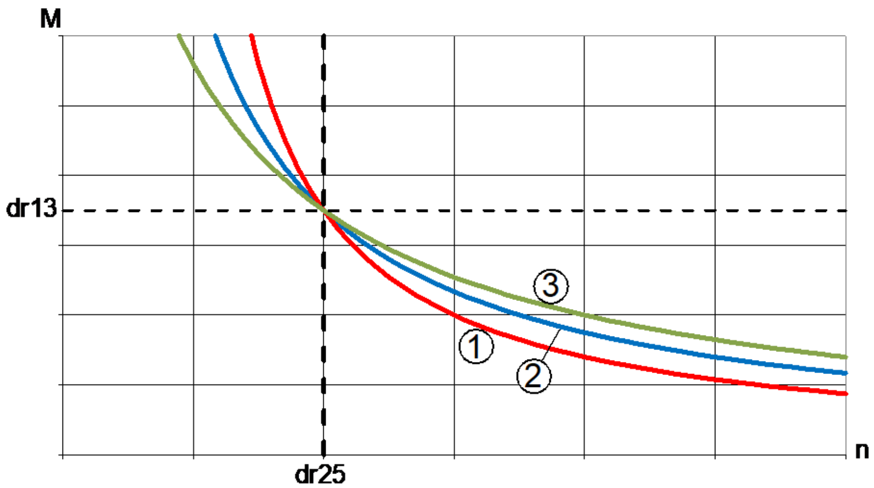
Bit2-3 = 12 (reduction, on at FaultReact):

Behavior as for value 8 with one exception: In order to be able to reach the maximum torque during the fault reaction ramp, the limiting characteristic is shifted towards higher speeds in the operating mode "fault reaction active" at higher DC link voltage.

If in co61 torque lim mode bit 12 Uic dep. torque curve options is set to “1: at usage of fault reaction ramp” this setting will also be valid if the fault reaction ramp is used.

6.2.10.5 Adjustment of the torque limiting characteristic

Since the 1/x or 1/x² run of the limiting characteristic is only approximately, the characteristic can be adjusted by ds13 torque limit curve factor.



M	Torque	-
N	Speed	-
1	Limiting characteristic	ds13=150%
2	Limiting characteristic	ds13=100%
3	Limiting characteristic	ds13=75%

Figure 77: Adjustment of the torque limiting characteristic

6.2.10.5.1 Asynchronous motor

The physical stall torque characteristic of the motor is a squared characteristic.

The squared limit characteristic must be activated if the motor shall be used upto its limit (ds11 torque mode bit (0,1) = 1).

ds11	torque mode				0x240B
Bit	Function	Value	Plaintext	Notes	
0…1	field weak curve limit	0	1/x	for SM	Adjusts itself automatically depending on the selected motor type
		1	1/x²	for ASM	

The function is defined by parameters dr13 and dr25.

Index	Id-Text	Name	Function
0x220D	dr13	breakdown torque %	Breakdown torque at start of field weakening
0x2219	dr25	breakdown speed %	Field weakening point

The breakdown torque in % of the rated torque is entered in dr13 breakdown torque %. 100% can always be entered in dr25 for an asynchronous motor.

Example: Parameterization of dr13 and dr25 for an asynchronous motor

Rated values		**Limiting characteristic**	
Rated voltage	330 V	Reference-DC link voltage	565 V
Rated frequency	50 Hz	$M_{breakdown}$ / M_{rated}	2
Pole-pair number	2		
Rated speed	1460 rpm		

$$\text{Rated field weakening frequency} = 50\ Hz * \frac{565\ V}{330\ V * \sqrt{2}} = 60.5\ Hz$$

The field weakening shall start at this frequency => dr25 = 100%

$$\text{dr13} = \frac{limit\ torque}{rated\ torque} * 100\% = \frac{breakdown\ torque}{rated\ torque} * 100\% = 200.0\%$$

6.2.10.5.2 Synchronous motor

Theoretically, the maximum torque must decrease at sufficient high current in the d-axis according 1/x characteristic.

ds11	torque mode				0x240B
Bit	Function	Value	Plaintext	Notes	
0…1	field weak curve limit	0	1/x	for SM	Adjusts itself automatically depending on the selected motor type
		1	$1/x^2$	for ASM	

This means: ds11 torque mode Bit 0/1 field weak curve limit must be set to 0: 1/x. A 1/x function is defined by specifying a single point which is passed through. This point is determined by parameters dr13 and dr25.

Index	Id-Text	Name	Function
0x220D	dr13	breakdown torque %	Torque and speed for the definition of the limiting characteristic
0x2219	dr25	breakdown speed %	

dr25 defines the speed and dr13 defines the limit characteristic (max.) torque which is appropriate to this speed.)

The torque value is entered in dr13 breakdown torque % in % of the motor rated torque.

The speed value is entered in dr25 breakdown speed % in % of the rated field weakening speed . This is calculated as follows:

$$\text{Rated field weakening speed } = \frac{rated\ speed * dr28}{dr05 * \sqrt{2}}$$

Example: Parameterization of dr13 and dr25 for a synchronous motor

Rated motor values		**Reference voltage**	
Rated voltage	330 V	Mains / AFE voltage	400 V
Rated frequency	200 Hz	Reference-DC link voltage	565 V
Pole-pair number	6	**Point of the limiting characteristic (*1) for reference voltage**	
Rated speed	2000 rpm	Torque of the limiting characteristic	350 Nm
Rated torque	150 Nm	Speed for limit torque	2000 rpm

$$\text{Rated field weakening speed} = \frac{2000\ rpm * 565\ V}{330\ V * \sqrt{2}} = 2421{,}3\ rpm$$

$$\text{dr25} = \frac{Speed\ für\ limit\ torque}{Nennfeldschwächdrehzahl} * 100\% = \frac{2000\ rpm}{2421.3\ rpm} * 100\% = 82.6\%$$

$$\text{dr13} = \frac{limit\ torque}{rated\ torque} * 100\% = \frac{350\ Nm}{150\ Nm} * 100\% = 233.3\%$$

(*1) only data sheets can be used where a limit characteristic is specified considering the optimum field weakening. In this case the limit characteristic is approximately a 1/x characteristic curve. No speed/torque data pair can be read from the green characteristic curve.

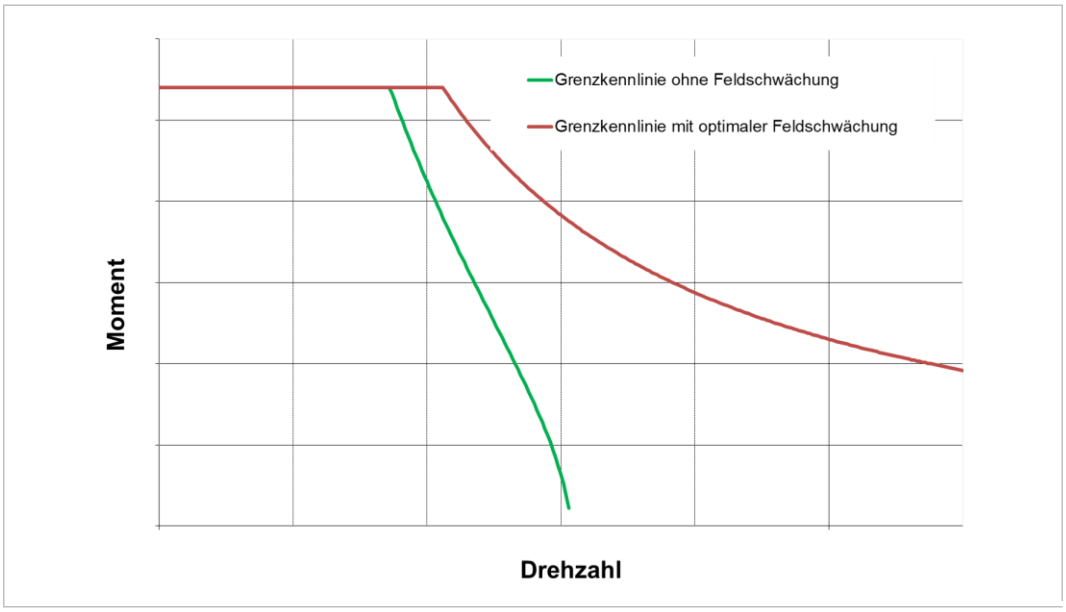
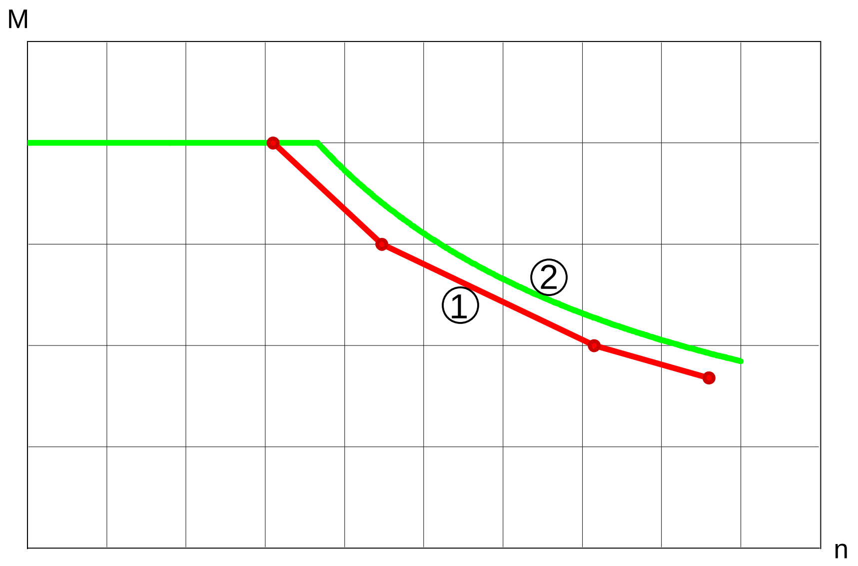


Figure 78: Limit characteristic curve

If a corresponding limit characteristic curve is specified for a motor, a safety distance should always be maintained to this curve, since all parameters have tolerances and temperature drifts.



M	Torque
N	Speed
1	M (single values measured)
2	M (calculated)

Figure 79: Safety distance to the limit characteristic

In practice, this optimal d-current can not be supplied because it is higher than the maximum current of the motor or inverter (par example), or the limiting characteristic due to saturation, iron losses or similar is not a 1/x characteristic.

Therefore the characteristic must be determined by tests in the application.

The value of dr25 should be selected lower than the measured value in order to keep a safety distance.

NOTICE

- An error in the position detection leads to the fact that a torque is generated by the magnetizing current.
- An error of 20° electrically causes an undesired torque by the magnetising current of maximum:

$$M = \sin(20°) * fc05 * dr09 = 0.34 * fc05 * dr09$$

- The drive is uncontrollable if this missing torque due to the limiting characteristic cannot be compensated by the speed controller.
- All torque limits must be selected high enough that the position error can always be compensated.

6.2.11 Flux controller (ASM)

The flux controller for the asynchronous motor is a PI controller.

The set flow (ImrRef) is made up of a characteristic value (flux control) and the output of the maximum voltage controller.

Different options for the flux controller can be selected with fc16 ASM flux mode.

fc16	ASM flux mode			0x3710
Bit	Function	Value	Plaintext	Notes
0…1	flux regulation	0	off	Flux controller off (limit = 0)
		1	on	Flux controller limits constant = fc20
		2	start off, cubic	cubic => Flux controller limit rises cubically (x^3) from 0 at speed 0 to fc20 at speed dr25 (breakdown speed) start off => the flux controller is not active at flux build-up start on => the flux controller limit fc20 applies at flux build-up
		3	start on, cubic	
2…3	wait for flux	0	off	on => the flux build-up is await for starting normal operation (e.g. transfer of speed setpoints). The drive remains in the "Start operation active" status during the waiting time
		4	on	
4	reserved	0	off	reserved
		8	reserved	

Index	Id-Text	Name	Function
0x3711	fc17	ASM min. flux	Flux in % of the rated flow, when the magnetization is considered as completed
0x3712	fc18	KP flux (A/A)	Flux controller-total gain
0x3713	fc19	Tn flux	Reset time
0x3714	fc20	ASM flux reg. limit	Flux controller limit in % of the rated motor current (dr03)

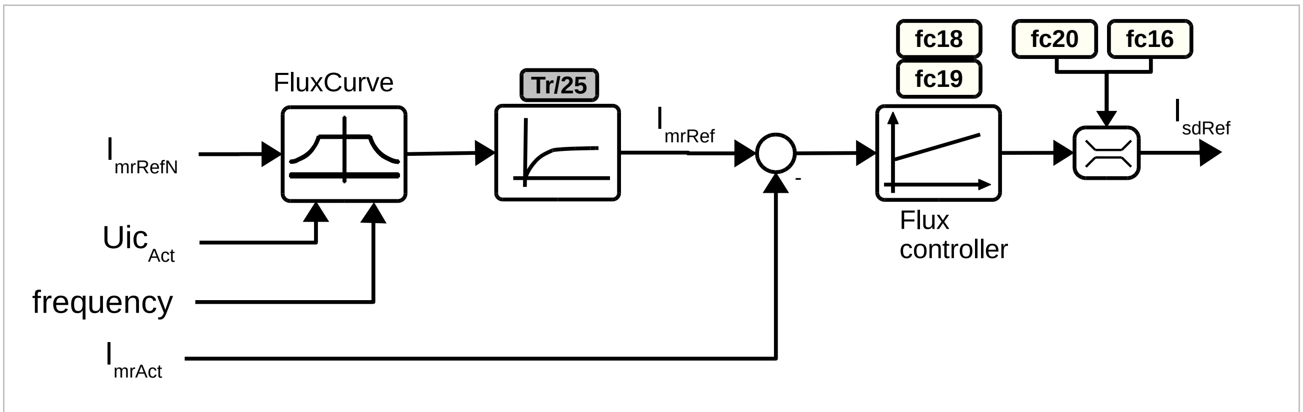


Figure 80: Flux controller (ASM)

6.2.12 Adaption

<table>
<tr><td>ds12</td><td colspan="3">adaption mode</td><td>0x240C</td></tr>
<tr><td>Bit</td><td>Function</td><td>Value</td><td>Plaintext</td><td>Notes</td></tr>
<tr><td rowspan="4">0…1</td><td rowspan="4">stator resistance</td><td>0</td><td>off</td><td>Stator resistance adaption off</td></tr>
<tr><td>1</td><td>on, no storing</td><td>Adaption on, is reset when the modulation is removed</td></tr>
<tr><td>2</td><td>on, storing till power off</td><td>Adaption on, is reset by power on</td></tr>
<tr><td>3</td><td>reserved</td><td></td></tr>
<tr><td>2…3</td><td>reserved</td><td>0</td><td>off</td><td>do not use</td></tr>
<tr><td rowspan="4">4…5</td><td rowspan="4">Tr(ASM) / EMC (SM)</td><td>0</td><td>off</td><td>Adaption of the rotor time constant off</td></tr>
<tr><td>16</td><td>on, no storing</td><td rowspan="3">same options as with stator resistance adaption</td></tr>
<tr><td>32</td><td>on, storing till power off</td></tr>
<tr><td>48</td><td>reserved</td></tr>
</table>

Stator Resistance Rs:

The adaptation of the stator resistance can only be done below 20% of the rated speed, if at least 25% of the rated active current is flowing. The adaptation limits can be adapted in the structure "Rs stab./adpt. model" under ds18[2]/ds18[3].

Tr (Asm) /Emf(SM):

In order to achieve the best possible torque accuracy, in operation with encoder, an adaptation of the counter voltage (synchronous motor, Emc) or rotor time constants (asynchronous motor, Tr) is possible. This applies for both motors: Adaptation is not possible in the dynamics or leads to invalid values.

Emc (SM):

The adaptation time constants for the synchronous motor is 4 seconds, whereby only long-term effects to the Emc can be compensated, not dynamic changes, such as saturation.

Adaptation occurs above 25% of the rated speed.

Tr (ASM):

In the asynchronous machine, the adaptation constant depends on the rotor time constants.

Adaptation occurs above 50% of the rated speed in regenerative operation or 6.25% in motor operation, if at least 25% of the rated active current is flowing.

6.2.13 Saturation characteristic (SM)

6.2.13.1 Determination of the saturation characteristic

The adaptation can only compensate slow changes (like e.g. temperature effects). If dynamic changes, such as the current-dependent saturation, shall also be taken into account, a saturation characteristic must be defined.

Since real saturation characteristic is rarely supplied by the motor manufacturer, the saturation can be defined from the data sheet values for no-load operation, rated current and maximum current.

NOTICE

Data must be consistent

- The EMF value is often specified for 25°C, but the rated torque at rated current is specified for e.g. 120°C. If the emf is strongly temperature-dependent, temperature influences are interpreted as saturation effects and falsify the torque display.

Alternatively, the saturation characteristic can be preset via the mo parameters.

Index	Id-Text	Name	Function
0x220E	dr14	SM EMF [Vpk/(1000min-1)]	Peak value of the linked EMF
0x2203	dr03	rated current	Rated current
0x2209	dr09	rated torque	Rated torque
0x220C	dr12	max current %	Maximum current in % rated current
0x220B	dr11	max torque %	Max. torque in % rated torque

- dr14 "SM EMF“ is the EMF in no-load operation (current = 0).
- The EMF at rated current is calculated from dr03 and dr09.

$$EMF\ (at\ I = Irated) = \frac{dr09}{dr03} * 85.5$$

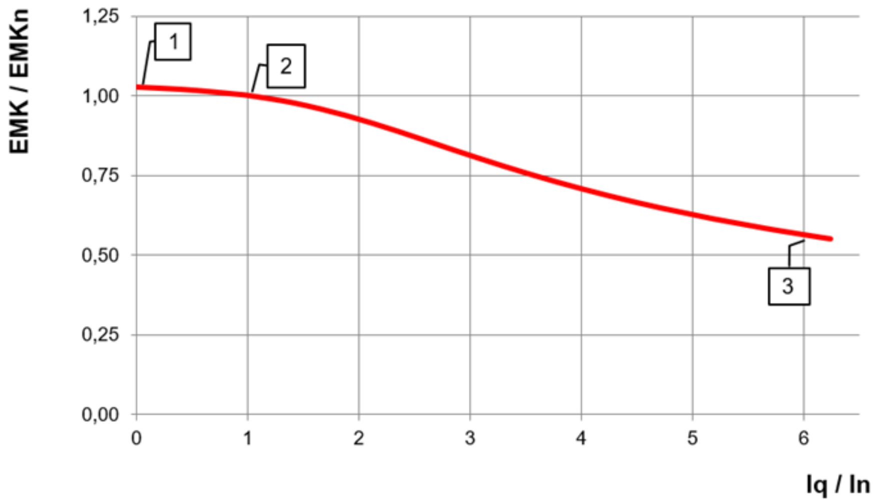
- The EMF at maximum current is calculated from dr12 and dr11.

$$EMF\ (at\ I = Imax) = \frac{dr11 * dr09}{dr12 * dr03} * 85.5$$

This calculation is only valid if the current-to torque data for Id=0 are specified and no field weakening current is required for reaching the maximum torque.

The saturation must only be taken into account when the motor is driven so far into saturation that, due to the strongly changed motor parameters, also the controllers must be adjusted (=> Chapter 6.2.6 Current control) or the torque accuracy shall be improved under load.

The following figure shows the internally presumed curve of the torque constant or the emf over the active current of the motor, given the 3 characteristics:



1	no-load operation
2	nominal setpoint
3	max. value
4	red characteristic = internal course of the saturation characteristic
Iq/In	Active motor current / rated current

Figure 81: Torque constant depending on the active current

6.2.13.2 Effect of the saturation characteristic

Which control parameters are influenced by the saturation can be selected with mo00:

mo00	saturation mode			0x3800
Bit	Function	Value	Plaintext	Notes
0…1	curve source	0	off	No change of the EMF
		1	dr14, dr09/dr03, dr11/dr12	Change of the EMF according to the 3 points characteristic (no-load operation, nominal setpoint, maximum point)
		2	saturation coefficients (mo01)	The saturation coefficients of the motor are determined via an external tool and entered in mo01.
		3	reserved	
2	EMF depending	0	isq	Change of the EMF proportional to the active current
		4	reserved	

The consideration of the saturation characteristic for the EMF and thus for torque => current or current => torque conversion is activated with bit 0,1 = 1.

Bit 2 defines the factors determining the saturation characteristic. Currently, the saturation factor is always considered as active current-dependent.

mo00	saturation mode			0x3800
Bit	Function	Value	Plaintext	Notes
3…4	Lsd curve source	0	EMF proportional	Ld changes according to the EMF
		8	off	no change of Ld
		16, 24	reserved	
5…6	Lsd depending	0	isq	Do not adjust for future extensions!
		32, 64, 96	reserved	
7…8	Lsq curve source	0	EMF proportional	Lq changes according to the EMF
		128	off	no change of Lq
		256, 384	reserved	
9…10	Lsq depending	0	isq	Do not adjust for future extensions!
		512, 1024, 1536	reserved	

The consideration of the saturation characteristic for inductances is activated wit bit 3,4 = 0 or bit 7,8 = 0.

Currently the inductances can only be changed according to the saturation characteristic (EMF proportional).

Then the adapted inductance values are considered by the decoupling, the motor model and used by the torque calculation.

In order to adjust the current controller gain to the inductance change, additionally function "sat L on I control" must be activated in ds04 (=> Current control Chapter 6.2.6).

6.2.14 Cogging torque compensation (SM)

Harmonics occur at some synchronous machines and linear drives due to fluctuations of the magnetic flux. This leads to the ripple of the motor torque at constant load or no-load operation. This superimposed torque is named cogging torque or "cogging". For motors with (approximately) periodic process of the cogging torque whose compensation is possible.

Parameterization of the compensation

Maximum four sine-wave generators can be parameterized via parameters mo17 frequency factor mo18 magnitude and mo19 phase. The compensation torque is created by overlaying of the sine waves.

Index	Id-Text	Name	Function	
0x3811	1…4	mo17	cogg. frequency factor	Frequency of the sine-wave generator in multiples of one electrical revolution
0x3812	1…4	mo18	cogg. magnitude [%Mn]	Output amplitude of the sine-wave generator in % of the rated torque
0x3813	1…4	mo19	cogg. phase [°]	Phase shifting of the sine-wave generator in °
0x3814	---	mo20	cogg. fade out speed 100% [rpm]	Definition of the fading out range of the cogging function
0x3815	---	mo21	cogg. fade out speed 0% [rpm]	
0x3816	---	mo22	cogging PT1 time	PT1 time for current control loop emulation. Do not change!

COMBIVIS 6 provides an online wizard for parameterization of the compensation.

- **"fade out" function:**

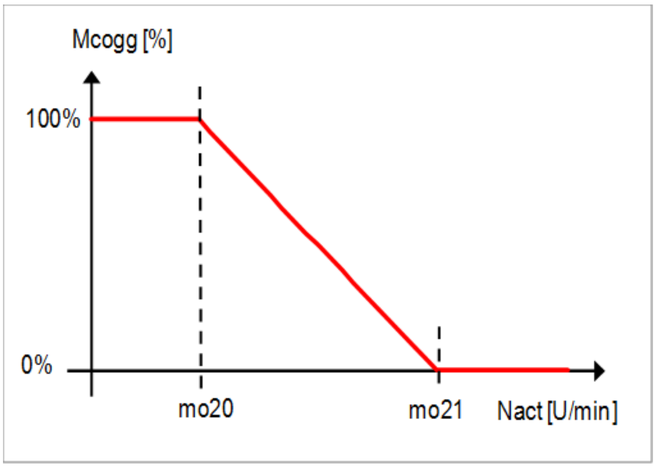


Figure 82: Cogging torque compensation

Usually the effect of the cogging torque decreases with increasing motor speed, therefore the compensation can be faded-out for high speeds.

The amplitude of the compensation torque is set from speed 0 to speed mo20 to the adjusted value in mo18.

The amplitude of the compensation torque is decreased to zero within the speed band of mo20fade out speed 100% to mo21fade out speed 0%.

6.2.15 Control mode (with encoder / encoderless)

The control mode is preset with cs00 (without control / control with encoder / encoderless speed control).

Channel A is used as speed encoder feedback in modes with encoder as standard.

The speed controller values arising from the automatic calculation by cs99, are depending on the selected speed smoothing times. These are defined for modes with encoder in the ec parameters and for encoderless operation in the ds parameters.

With the switching between the modes with and without encoder, eventually also an adjustment of the controller gain is necessary.

An automatic adjustment can be activated with bit 4: speed control mode.

cs00	control mode			0x2700
Bit	Function	Value	Plaintext	Notes
0…3	control mode	0	uf-control	Voltage-/frequency characteristic
		1	encoder, without model	Operation with encoder without motor model
		2	encoder, with model	Operation with encoder and motor model
		3	no encoder (ASCL/SCL)	Operation without encoder with motor model
		4…15	reserved	

cs00	control mode			0x2700
Bit	Function	Value	Plaintext	Notes
4	speed ctrl mode	0	Kp/Tn, no adapt	The calculation of KP/Tn is done with the actual adjusted mode (with encoder or encoderless). The controller gain remains unchanged at mode change
		16	kp/Tn, adapt internal	The calculation of KP/Tn always occurs for the mode with encoder. At mode change the controller gain is internal adjusted depending on the smoothing times. The ratio of the smoothing times for encoderless operation (ds28) and operation with encoder (ec26/2 + ec27) should be in the range of 1/16….16.

6.2.15.1 Voltage frequency operation

This operation mode is intended for an easy start-up.

The v/f operation is defined by these parameters:

Index	Id-Text	Name	Function
0x2205	dr05	rated voltage	Rated motor voltage (resolution 1V)
0x2206	dr06	rated frequency	Rated motor frequency (resolution 0.001Hz)
0x222D	dr45	ASM u/f boost	Standstill voltage (resolution 0.1 % rated motor voltage dr45)
0x222E	dr46	ASM v/f V1	Point of support 1, voltage (resolution 0.1% rated motor voltage dr45)
0x222F	dr47	ASM v/f F1	Point of support 1, frequency (resolution 0.001Hz). dr46 has no effect with ZERO.
0x2230	dr48	v/f characteristic mode	Type of calculation of the v/f characteristic
0x3500	is00	Uic mode	Mode DC link voltage compensation
0x3502	is02	Uic comp voltage limit	Limit DC link voltage compensation
0x3820	mo32	ASM v/f offset	Voltage offset (after power off = 0, resolution 0.1% rated motor voltage)

The voltage-frequency characteristic is defined by 3 voltage /frequency pairs:

- The voltage at frequency 0 Hz is defined with dr45 ASM v/f boost.
- An additional point of support for the characteristic can be set with dr46 ASM v/f V1 and dr47 ASM v/f F1
- dr05 rated voltage and dr06 rated frequency define the rated point of the voltage frequency characteristic.

The dr48 v/f characteristic mode defines how the characteristic is calculated and which is the reference value for the percentage voltage specifications.

The DC link voltage compensation and the maximum modulation level also influence the voltage/frequency characteristic.

A superimposed control can adapt the voltage online via process data with parameter mo32. After power off/on, mo32 is zero again.

The rated motor speed (dr04 rated speed) is required to calculate the number of pole pairs. Since all setpoint specifications must be made in revolutions per minute, the required frequency is only reached if dr04 is correctly parameterized.

6.2.15.1.1 Rated point determination

dr48 v/f characteristic mode defines the type of calculation of the rated point.

dr48	v/f characteristic mode	0x2230
Value	Plaintext	Notes
0	use type plate data	The v/f characteristic passes point dr06 rated frequency / dr05 rated voltage. dr45 ASM v/f boost, dr46 ASM v/f V1 and mo32 ASM v/f offset are values in % of the rated motor voltage dr05.
1	use inverter rated voltage	The v/f characteristic passes through point de30 inverter rated voltage / projected rated point frequency. dr45 ASM v/f boost, dr46 ASM v/f V1 and mo32 ASM v/f offset are values in % of the inverter rated voltage de30.

The value dr48 determines the definition of the rated point (third point of the v/f characteristic curve).

This point is directly defined at value 0 "use type plate data" by dr06 rated frequency and dr05 rated voltage.

f (rated point) = dr06 rated frequency

U (rated point) = dr05 rated voltage

If dr48 is 1 "use inverter rated voltage“, the third point is calculated from the inverter rated voltage (de30 inverter rated voltage) and the motor data dr06 rated frequency and dr05 rated voltage :

f (rated point = de30 inverter rated voltage / dr05 rated voltage * dr06 rated frequency

U (rated point) = de30 inverter rated voltage

The reference value of the percentage voltage settings dr45, dr46 and mo32 is at value 1 the rated inverter voltage instead the rated motor voltage.

6.2.15.1.2 0 Hz voltage

The voltage at frequency 0 Hz is defined with dr45 ASM v/f boost.

6.2.15.1.3 Additional point of support

The voltage of the v/f characteristic increases linearly with the frequency.
Two ranges with different voltage rise can be defined by using dr47 ASM v/f F1 and dr46 ASM u/f V1. If the additional point of support shall not be used, dr47 must be set to zero. Then parameter dr46 has no function.

6.2.15.1.4 DC link voltage compensation

The DC link voltage compensation is activated with "Uic compensation mode“ = 2 or 3. Means, as long as the voltage is supplied, the output voltage depends only on the programmed characteristic (not from the current DC link voltage).

is00	Uic mode			0x3500
Bit	Function	Value	Plaintext	Notes
0…2	Uic compen-sation mode	0	off	off
		1	off, only curr decoupling	
		2	on	on
		3	on, voltage limited	on / with voltage limitation
		4…7	reserved	

If the DC link voltage compensation is switched off, the output voltage changes with the DC link voltage. The calculation of the characteristic is based on the inverter rated data. The deviation of the DC link voltage from the inverter rated voltage has directly influence to the output voltage.

is02	Uic comp voltage limit	0x3502
Value	Meaning	
10V…800V	Maximum output voltage (effective value)	

With is00 Uic mode = "3: on, voltage limited“, the output voltage is limited at is02 voltage limit.

6.2.15.1.5 Maximum modulation grade fc04

Index	Id-Text	Name	Function
0x3704	fc04	max. modulation grade	Adjustment of max. permitted modulation grade.

A modulation factor of 100% means, that the amplitude of the motor voltage (phase-phase voltage) is equal to the DC link voltage.

The effective value of the motor voltage can be increased over 100%. The output voltage then deviates from the sinusoidal form.

6.2.15.1.6 Online adaptation of the characteristic

With the exception of mo32 ASM v/f offset, all parameters for defining the v/f characteristic are part of the dr parameter group. They must always be confirmed with dr99 motordata control und cannot be changed via process data.

If an online adaptation of the v/f characteristic is necessary, the control can additionally adapt the voltage via process data via parameter mo32.

Parameter mo32 ASM v/f offset is directly added to the value of the v/f characteristic. mo32 is not saved. After power off/on, the value of mo32 is zero again.

v/f operation example of an asynchronous machine:

Unless otherwise specified, the following settings apply:

Rated voltage:	dr05 rated voltage = 330V
Rated frequency:	dr06 rated frequency = 50 Hz
Boost:	dr45 ASM v/f boost = 5%
Point of support V1	dr46 ASM v/f V1 = 50%
Point of support F1	dr47 ASM v/f F1 = 15 Hz
DC link voltage compensation	is00 compensation mode = 2 is02 Uic comp voltage limit = 400V
Maximum modulation grade fc04 max. modulation grade = 100%	
DC link voltage:	ru14 act. Uic voltage = 620 V

6.2.15.1.6.1 Influence of the additional setpoint

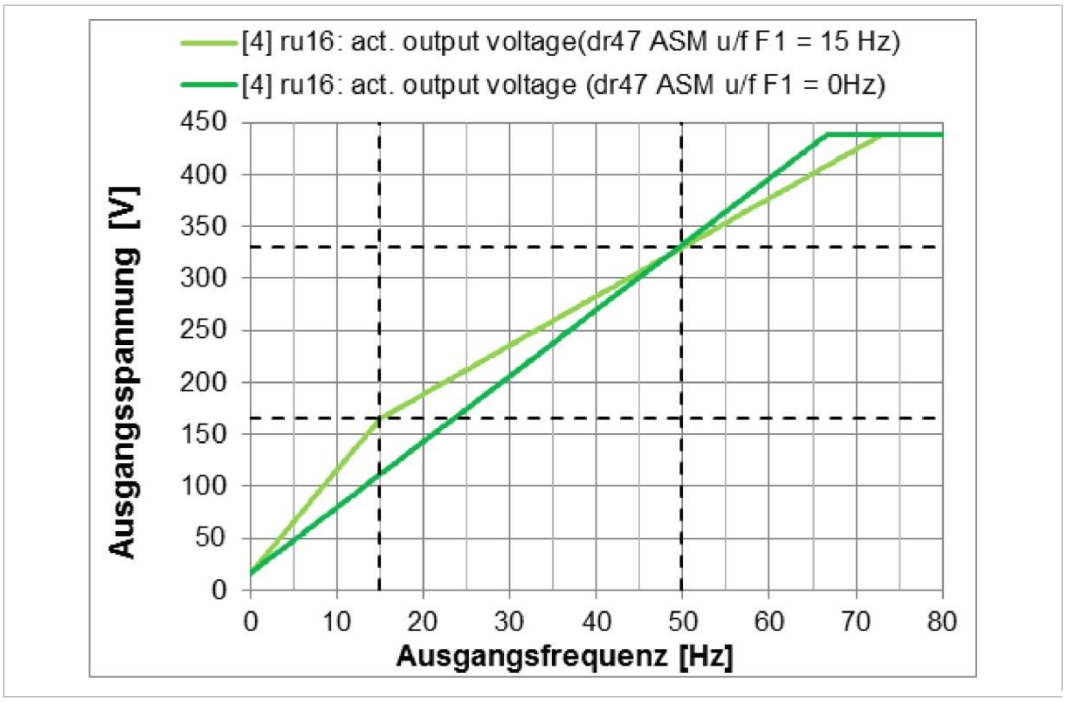


Figure 83: v/f – Influence of the additional setpoint

The characteristic curve runs from 0Hz / boost to the defined additional setpoint dr46 ASM u/f V1 / dr47 ASM u/f F1.

From this additional setpoint the characteristic runs straight to the defined nominal point dr05 rated voltage / dr06 rated frequency.

In the second section, the characteristic is flatter than the v/f characteristic without an additional setpoint.

6.2.15.1.6.2 Influence of the DC link voltage compensation

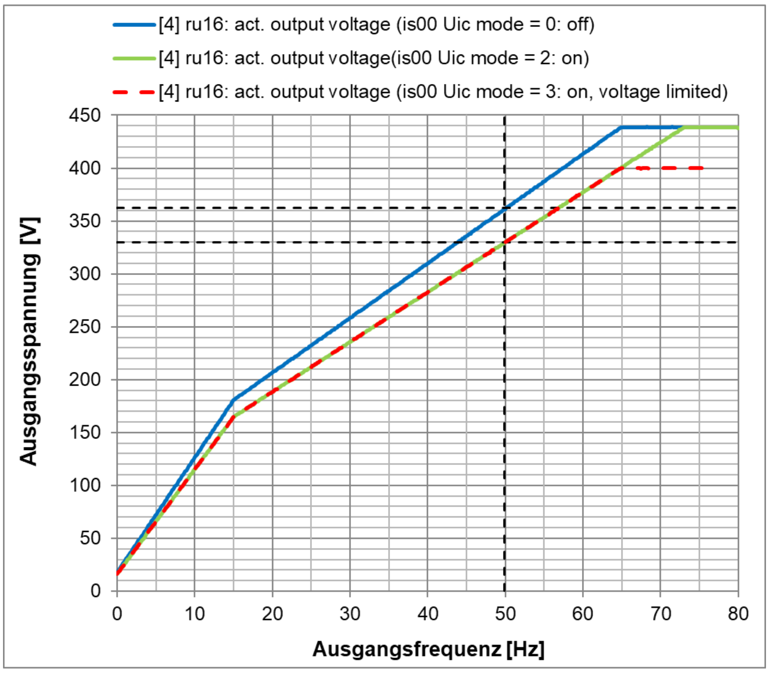


Figure 84: v/f – Influence of the DC link voltage compensation

All voltage values of the blue characteristic are increased compared to the characteristic with DC link voltage compensation by the factor real DC link voltage to rated DC link voltage: ru14 Uic voltage / rated DC link voltage = 620V / 565V = 1.1
Voltage at 50Hz in graphic: 362V to 330V = 1.1

6.2.15.1.6.3 Influence of the maximum degree of modulation

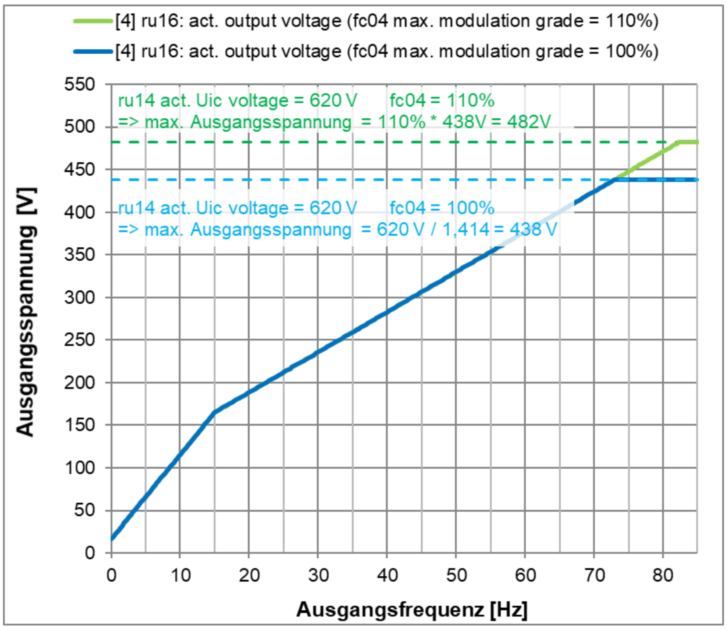


Figure 85: v/f – Influence of the maximum degree of modulation

6.2.15.1.6.4 Influence of dr48 v/f characteristic mode

Boost: dr45 ASM v/f boost = 20%

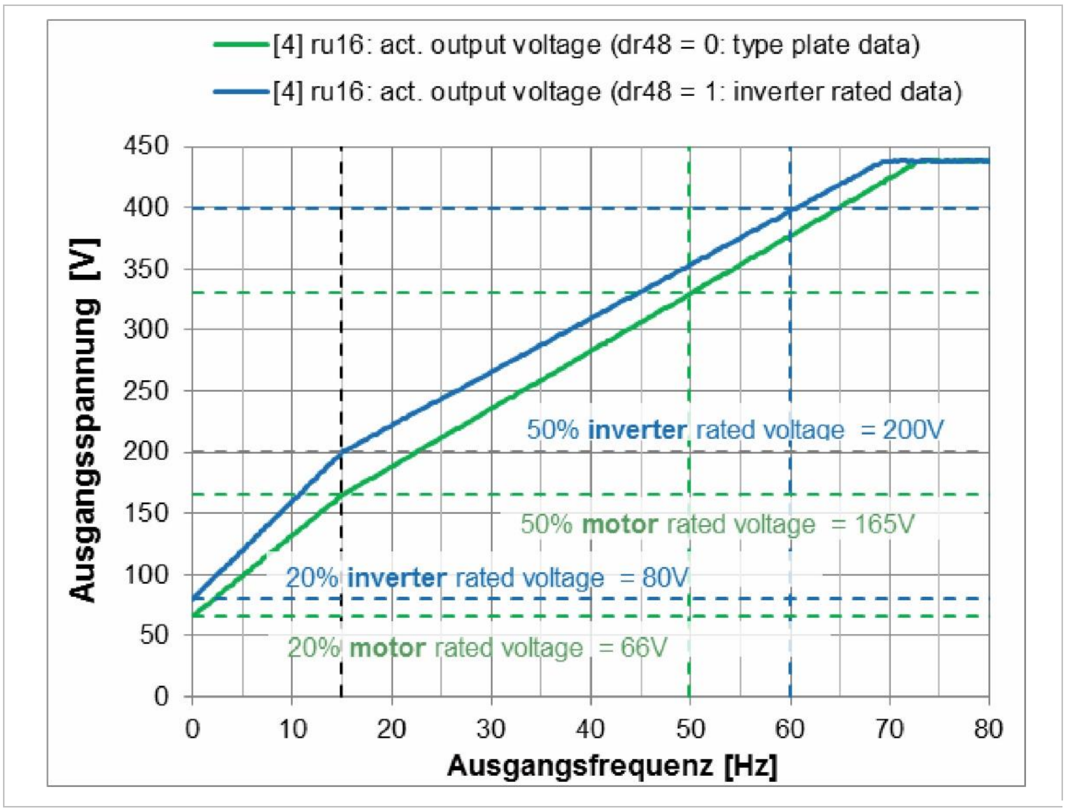


Figure 86: v/f - Influence of dr48 v/f characteristic mode

6.2.15.2 Operation with encoder without motor model

This operating mode has almost no validity.

The possibility to activate the EMF adaptation or to operate on model currents is missing at the synchronous machine in this mode.

The slip is determined from the equivalent circuit data (not from the rated speed) at the asynchronous machine in this mode. That means, identification of the motor data is mandatory.

Additional possibilities, like Tr-adaption or driving on model currents can not be activated in this mode.

6.2.15.3 Operation with encoder with motor model

This is the operating mode for speed-controlled operation with encoder.

Advantages at operation with model:

- The flux at the asynchronous machine is adapted by the model.
- The adaption of EMF or rotor time constant is possible. This increases the torque accuracy.
- Driving on model currents (ds04 bit 07) is possible, advantageous at output frequencies > 400Hz.

6.2.15.4 Operation without encoder with motor model

The type of model control is important in this mode (=> Chapter 6.2.16 Model control (ASM and SM)).

The model cannot be operated stable at low output frequencies. Make sure that this range is quickly passed.

A degree of freedom for the asynchronous motor is speed, i.e. it can differ from the estimated speed. The torque accuracy is given.

Overview of the functions which can be activated dependent on the operating mode and motor:

	cs00 control mode				Activation	ASM	SM
	0 (v/f)	1 encoder/ no model	2 encoder/ with model	3 SCL / ASCL			
emf adaption	-	-	x	x	ds12 bit 4-5	-	x
Tr adaption	-	-	x	-	ds12 bit 4-5	x	-
estimated current control	-	-	x	x	ds04 bit 6	x	x
stabilisation current	-	-	-	x	ds30 bit 0	-	x
stabilisation term	-	-	-	x	ds30 bit 1	-	x
deviation	-	-	x	x	ds04 bit 6	x	x
observer	-	-	x	x	ds04 bit 7	x	x

6.2.16 Model control (ASM and SM)

In which speed ranges the model should be active is adjusted with this parameter in operating modes with motor model.

6.2.16.1 Model deactivation

ds41	model ctrl			0x2429
Bit	Function	Value	Plaintext	Notes
0…2	model (A)SCL	0	dep. on ref/act speed	Model deactivation in encoderless operation
		1	always on	
		2	dep. on act speed	
		3…7	reserved	
3…5	model with encoder	0	dep. on ref/act speed	Model deactivation in operation with speed encoder
		8	always on	
		16	dep. on act. speed	
		24…56	reserved	
6…7	reserved		reserved	
8…9	low speed ctrl (A)SCL	0	(A)ViCL	(Asynchron) Vektore Current Close Loop. Current-controlled operation, operates with precontrol of the torque
		256	ASiCL	Asynchron Single Current Close Loop This operating mode is designed for stable concentricity at low speeds and motor operation. The error in the stator resistance is important for the stability of the operation, by way there are deviations from the real speed under load.
		512…768	reserved	

6.2.16.1.1 Model deactivation level / time

The model deactivation can be adjusted via parameters ds42 to ds47. There are different reference values for parameters ds46 and ds47 for the output frequency (speed) at the asynchronous machine and synchronous machine.

Index	Id-Text	Name	Function
0x242A	ds42	model ctrl. ref. speed time	Time, the speed setpoint must be set to 0 or the actual speed value below the "speed level" (ds46), until the switch off occurs. These times have no influence in the "dep. on act speed" mode (ds41)
0x242B	ds43	model ctrl. act. speed time	
0x242E	ds46	model ctrl. act. speed level	Level of the actual speed value for model deactivation (ds46) and hysteresis of the switch-off threshold (ds47) in %
0x242F	ds47	model ctrl. act. speed hyst.	
0x2430	ds48	model ctrl min acc/dec [s^2]	The current deceleration/acceleration is calculated from the actual speed before the transition into the "low speed control" range, which sets the actual value to the setpoint. The minimum acceleration / deceleration is parameterized in this parameter.

The reference value for speed levels and hystereses for model deactivation are dependent on the motor type:

Synchronous machine: 100% = 7.5% * rated frequency

Asynchronous machine: 100% = 2 * rated slip frequency

$$\text{rated slip speed (ns)} = \frac{\text{dr06 (rated frequency} * 60)}{number\ of\ pole\ pairs} - \text{dr04 (rated speed)}$$

Example:

Asynchronous machine
(rated frequency = 50Hz, rated speed = 1450 rpm, pole-pair number = 2)

ds46 = 100%, ds47 = 20% (default values)

$$ns = \frac{50Hz * 60}{ppz} - 1450 \;=\; 50\,rpm$$

Model deactivation threshold: = rated slip speed * 2 * ds46 model ctrl. act. speed level = 100 rpm

Hysterese = rated slip speed * 2 * ds47 model ctrl. act. speed hyst = 20 rpm

Model activation threshold: = Model deactivation threshold + hysterese = 100 rpm + 20 rpm = 120 rpm

6.2.16.1.2 Model on/off ds41 (Bit 0…2) and (Bit 3…5) = "dep. on ref./act. speed“

The **model activation** is a function of the setpoint speed. The model is switched on immediately with **setpoint unequal zero** (independent of the setting in ds42).

The **model deactivation** occurs if the **setpoint = zero** for the time in ds42 model ctrl. ref. speed time and for the time in ds43 model ctrl. act. speed time the actual value is below the switch-off threshold.

With deactivation of the model in encoderless operation ((A)SCL) it is switchted to the model replacement („low speed ctrl“ ds41 Bit 6…7).

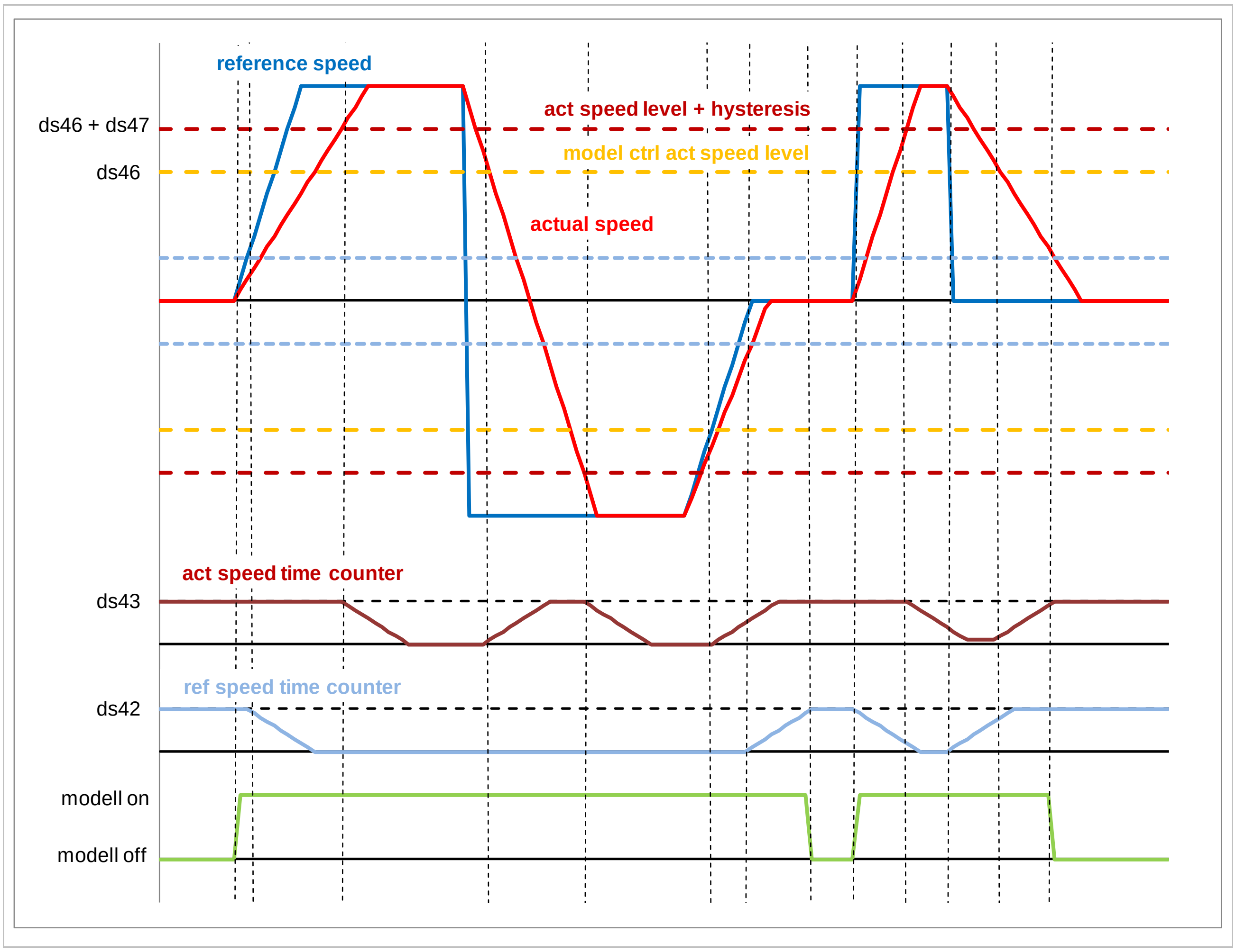


Figure 87: Model deactivation depending on the motor type

6.2.16.1.3 Model deactivation (bit0...2) and (bit3...5) = always on

The model is active after magnetisation and remains, independent of the set / actual speed.

6.2.16.1.4 Model deactivation ds41 (Bit 0…2) and (Bit 3…5) = „dep. on act. speed“

The **model activation** occurs if the actual value is above the model activation threshold
(= model deactivation threshold ds46 hysterese ds47).

The **model deactivation** occurs when the actual value is below the model deactivation threshold (ds46).

With deactivation of the model in encoderless operation ((A)SCL) it is switchted to the model replacement („low speed ctrl“ ds41 Bit 8…9).

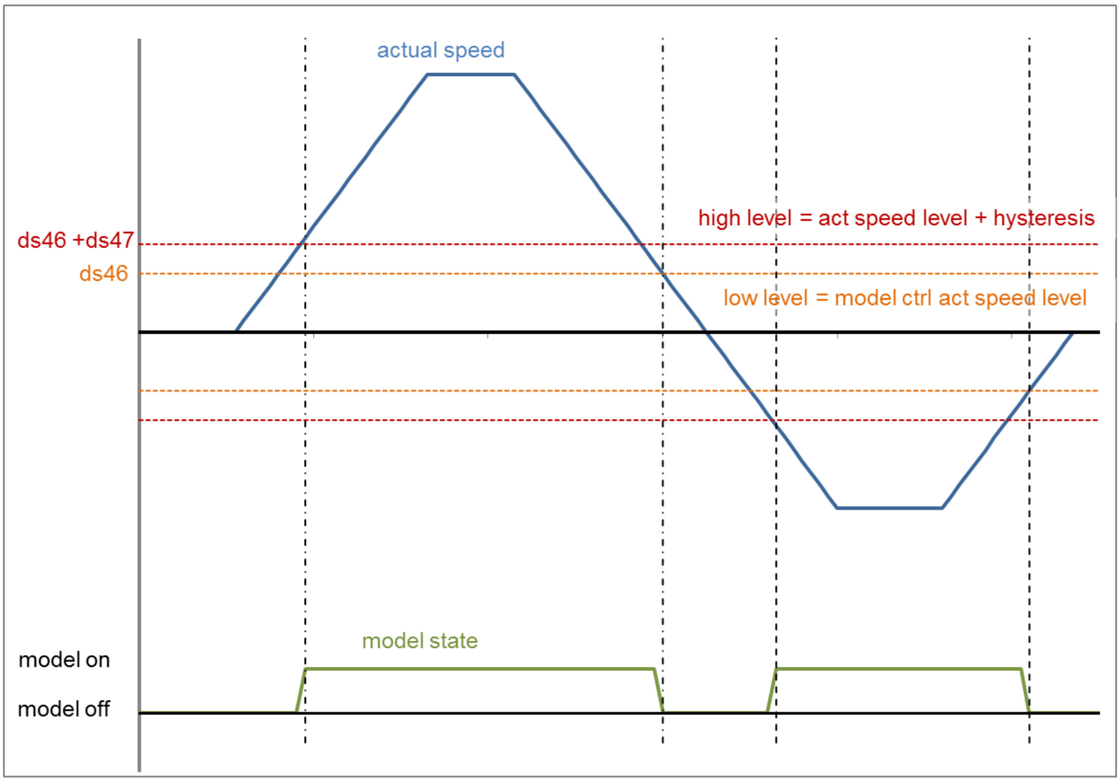


Figure 88: Model deactivation depending on the motor type

6.2.16.1.5 Model replacement (“low speed ctrl” ds41 (Bit 8…9) = (A)ViCL)

The following structure figure describes the asynchronous machine. With the synchronous machine, the slip calculation and the flux controller are omitted.

The actual value (NAct) is set with a transition function (=> description ds48 model ctrl min. acc/dec [s^2]) to the setpoint (NRef).

A torque jump on the shaft is to be expected during activation/deactivation of model operation.

The PI component of the speed controller is stopped when the model is switched off until the actual value has reached the setpoint and the state constant run (in 10 ms grid) is detected. Then the PI component is set to ZERO.

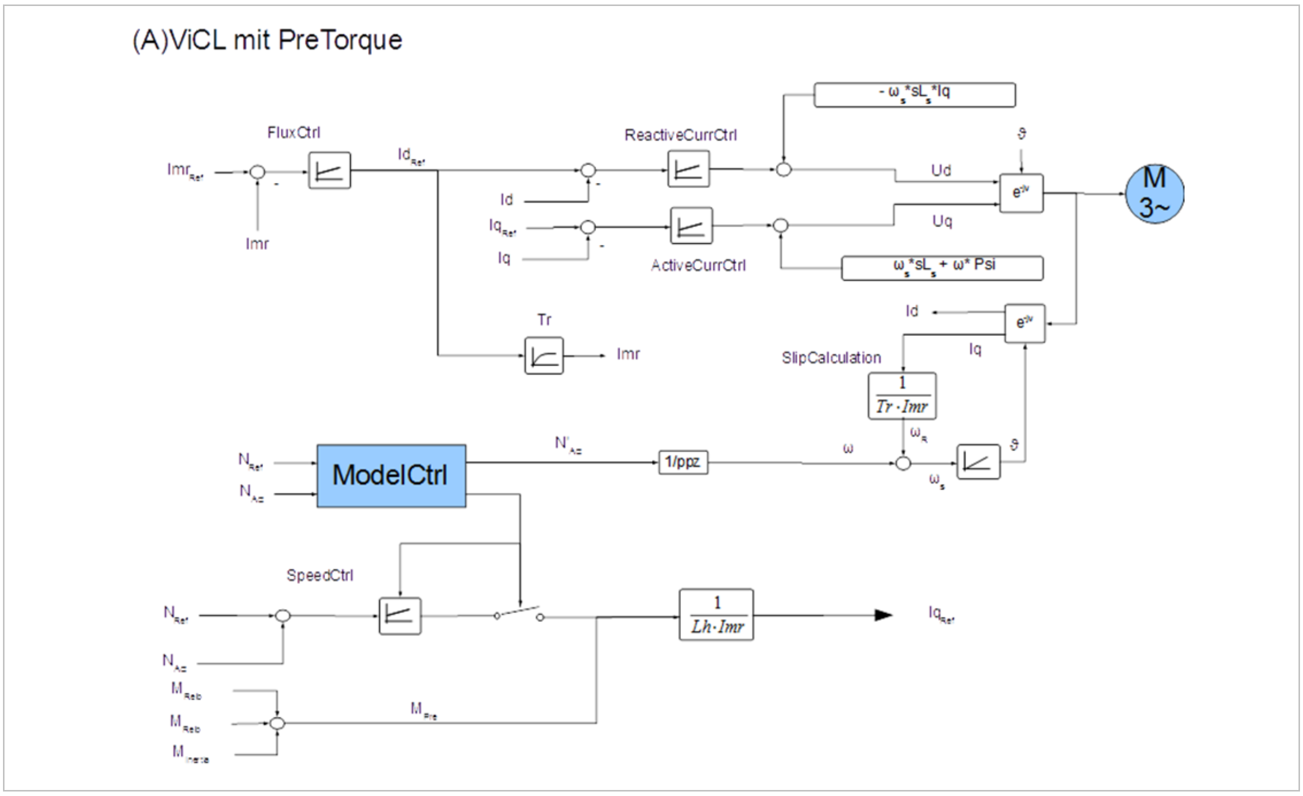


Figure 89: Model deactivation depending on the motor type

6.2.16.1.6 Model replacement ("low speed ctrl" ds41 (Bit 8…9) = ASiCL), only for asynchronous machine

The ASiCL mode is based on the equivalent circuit data (Lh,Rs,Rr,sLs,sLr), which are also required for model operation.

The settings for the speed controller and the torque limits from closed-loop operation have no effect. The current limits are active. The actual torque is calculated, but only serves as a guide value.

This operating mode is designed for stable concentricity at low speeds and motor operation.

Applications such as lifting/lowering are not possible, as regenerative operation is only reliably detected from approx. 5% of the rated speed.

The error in the stator resistance is important for the stability of the operation. However, this inevitably results in deviations between estimated and real speed under load at low speeds.

The setpoint speed serves as precontrol. Therefore, the ramp times must be adapted to the mass inertia and the possible currents. If this mode is used as bridging to model operation, this must be taken into account. This means that acceleration at the torque limit is not possible!

The magnetizing current setpoint is calculated identically to the closed-loop operation and is controlled by a current controller in the d-axis. The active current adjusts itself automatically, thus "boost and slip" is set.

Index	Subidx	Id-Text	Name	Function
0x243F	0	ds63	ASiCL ctrl. mode	
	1		ASiCL curr. ctrl IsqPt1	Filter time (Pt1 element) for smoothing the active current during voltage generation
	2		ASiCL slip calculation IsqPt1	Filter time (Pt1 element) for smoothing the active current during slip calculation
	3		ASiCL curr.ctrl. delay at zero	Switch-off time of the slip compensation on reaching setpoint speed ZERO (60000 = always active). Also fading time to enable soft switching on at start after magnetization.
	4		ASiCL Rs model stabilisation mode	Selection of the Rs adaptation mode for model stabilisation
	5		ASiCL Rs adaption high limit	upper limit (regenerative operation), default value 120%
	6		ASiCL Rs adaption low limit	lower limit (motor operation), default value 80%
	7		ASiCL Rs adaption factor	Factor for the Rs adaption, default value 80%

ds63 [4]	ASiCL Rs model stabilisation mode			0x243F [4]
Bit	Function	Value	Plaintext	Notes
0…2	stator resistance mode (ASiCL)	0	off	Stator resistance adaption from
		1	stabilisation mot/gen	Depending on the operating condition, the stator resistance is set motor-driven to the lower limit (ds63[6] ASiCL Rs adaption low limit) and regenerative to the higher limit (ds63[5] Rs stab./adpt. high limit ASiCL Rs adaption high limit).
		2	stabilisation ACC/DEC	The stator resistance is set into the limits depending on the ramp status. ACC => motor => lower limit CONST => motor => lower limit DEC => regenerative => upper limit
		3	constant factor (ds63[7])	The stator resistance adaption is done with a constant factor (ds63 [7] ASiCL Rs adaption factor). Only useful for applications in which the drive is motor or generator driven only.

Parameterization depending on the operation:

pure motor operation		
Parameter	**Name**	**Value**
ds63[1]	ASiCL curr. ctrl IsqPt1	3*Tr
ds63[2]	ASiCL slip calculation IsqPt1	3*Tr
ds63[3]	ASiCL curr.ctrl. delay at zero	Tr/20
ds63[4]	ASiCL Rs stab. mode	constant factor (ds63[7])
ds63[7]	Rs stabilisation factor	80%

motor and regenerative operation		
Parameter	**Name**	**Value**
ds63[1]	ASiCL curr. ctrl IsqPt1	3*Tr/50…3*Tr/10
ds63[2]	ASiCL slip calculation IsqPt1	3*Tr
ds63[3]	ASiCL curr.ctrl. delay at zero	Tr/20
ds63[4]	ASiCL Rs stab. mode	stabilisation mot/gen
ds63[5]	ASiCL Rs stab. high limit	120%
Ds63[6]	ASiCL Rs stab. Low limit	80%

The rotor time constant (Tr in [ms]) is calculated from:

$$Tr = \frac{Lh + sLr}{Rr}$$

$$Lh = dr19$$

$$sLr = dr21 * \frac{dr22}{100\%}$$

$$Rr = dr17 * \frac{dr18}{100\%}$$

Note:

The inertia and dynamics of the load change are also taken into account in the design, thus parameterization, here only dependent on the rotor time constant, can only serve as a guide value.

6.2.16.2 Limits for estimate speed controller

ds41	model ctrl				0x2429
Bit	Function	Value	Plaintext	Notes	
6	estimated speed limit	0	free	No limitation	of the estimated speed
		64	depending on reference	Limitation	

6.2.16.2.1 Free

In this mode there is no estimated speed limit. Mandatory for the operation in torque limitation, if the drive is pulled in inverse direction to the target speed.

6.2.16.2.2 depending on reference:

The limits are preset depending on the set speed. Useful to avoid an estimation fault in negative direction and thus a turn into the "blocked direction" at start from standstill e.g. with positive set speed.

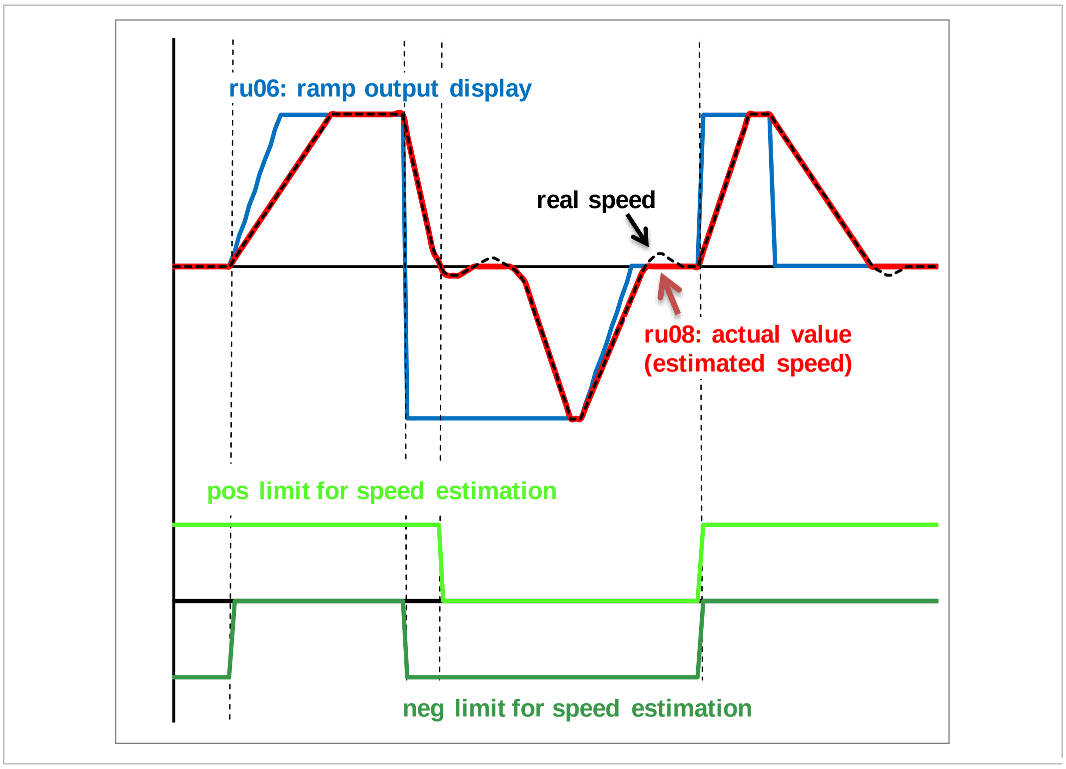


Figure 90: Torque limit depending on the setpoint value

The estimated speed is idealized displayed, in reality there can be more deviations between real and estimated (calculated) speed.

6.2.16.3 Model stabilization

6.2.16.3.1 Stabilisation current / standstill current (only SCL)

The stabilisation current stabilises the model at lower speeds. Only active for operation without encoder.

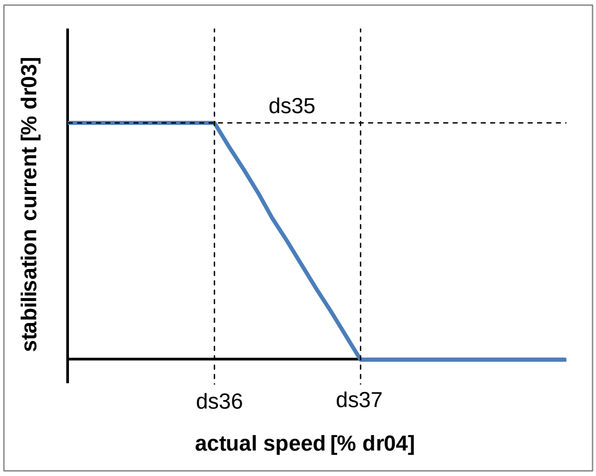
It is reduced to zero in the speed range of ds36 to ds37.

> ➢ Note for synchronous reluctance motor: From version V2.9, ds35 also serves as stabilisation current for the synchronous reluctance motors. Parameters ds36 and ds37 have no effect. The stabilisation current is permanently necessary, independent of the speed.

ds30	model mode			0x241E
Bit	Function	Value	Plaintext	Notes
0	scl stabilisation current	0	off	Activates / deactivates the stabilisation current in encoderless operation (SCL)
		1	on	

The stabilisation current characteristic is parameterized with ds35…ds37.

Index	Id-Text	Name	Function
0x2423	ds35	scl stabilisation current	Stabilisation current in % of the rated motor current. Only for the synchronous machine it can be useful to specify a negative stabilisation current.
0x2424	ds36	min. speed for stab. current	Speed limits (in % rated motor speed), which lowering the stabilisation current to 0 (value programmed in ds35)
0x2425	ds37	max. speed for stab. current	



ds35 50% rated motor current
ds36 5% rated speed
ds37 10% rated speed

Figure 91: Stabilisation current depending on speed

Standstill current

Index	Id-Text	Name	Function
0x2426	ds38	scl standstill current	

The standstill current (ds38 default value 100%) is impressed when the model deactivation is made.

The switch on/off occurs with a ramp time, which is calculated from the double motor time constant (T = 2 * Ld / Rs).

6.2.16.3.2 Model stabilization term (SCL only)

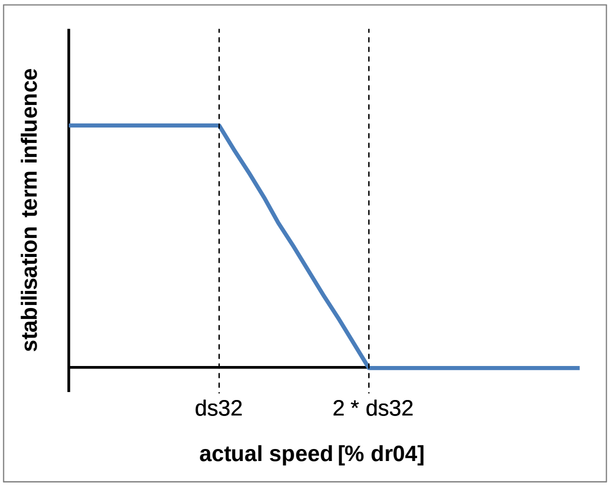
The model stabilisation term stabilises the model at lower speeds. Only active for operation without encoder.

ds30	model mode			0x241E
Bit	Function	Value	Plaintext	Notes
1	SCL model stab. term	0	off	Activates / deactivates the model stabilisation term
		4	on	

Index	Id-Text	Name	Function
0x2420	ds32	scl stab term speed	Speed limit (in % rated motor speed), when the influence of the stabilisation term is reduced to 0.
0x2421	ds33	scl stab term time	Time constant of the stabilisation term !!! do not adjust!

The influence of the model stabilisation term is reduced by ds32 to 2 * ds32 to 0.

The term time (ds33) is calculated from the motor data and should not be changed.



Default value ds32 20% rated motor speed

Figure 92: Model stabilisation term depending on motor speed

6.2.16.3.3 Model stabilisation by the stator resistance

In motor operation, the model is stable if the parameterized stator resistance is lower than the real resistance in the motor.

In regenerative operation, the model is stable if the parameterized stator resistance is higher than the real resistance in the motor.

The lower the output frequency, the greater the influence of the stator resistance. Thus, this function works to stabilize the motor model at low speeds (<30%Nn). Very important in regenerative operation, at high load (>50%Mn).

Index	Subidx	Id-Text	Name	Function
0x2412	0	ds18	Rs model stabilisation	
	1		Rs model stabilisation mode	Selection of the Rs adaptation mode for model stabilisation
	2		Rs adaption high limit	upper limit (regenerative operation), default value 140%
	3		Rs adaption low limit	lower limit (motor operation), default value 80%
	4		Rs adaption factor	Factor for the Rs adaption Default value 80%

ds18 [1]	Rs stab. model mode			0x2412[1]
Bit	Function	Value	Plaintext	Notes
0…2	stator re-sistance mode	0	off	Stator resistance adaption from
		1	stabilisa-tion mot/gen	The stator resistance is set motor-driven into the lower limit (ds18[3] Rs adaption low limit) and into the upper limit (ds18[2] Rs adaption high limit) by regeneration, depending on the operating condition. **NOTICE!** This setting is only suitable for the start with (A)SCL if the speed estimation ds41model ctrl is limited with bit 6 estimated speed limit = "64: depending on reference“.
		2	stabilisa-tion ACC/DEC	The stator resistance is set into the limits depending on the ramp status. ACC => motor => lower limit CONST => motor => lower limit DEC => regenerative => upper limit
		3	constant factor (ds18[4])	The stator resistance adaption is done with a constant factor (ds18[4] Rs adaption factor). Only useful for applications in which the drive is motor or generator driven only.

The settings in ds12 adaption mode for the stator resistance have priority

6.2.16.4 Motor model selection

ds30	model mode			0x241E
Bit	Function	Value	Plaintext	Notes
2	SCL model	0	standard*	Default setting, mandatory for operation at output frequencies > 400 Hz.
		4	SRM / IPM	Useful if Ld is very different from Lq. Therefore mandatory for a reluctance machine.

*) Influence on the parameterization of the optimum current specification in the tables mo04, mo05

6.2.16.5 Consider deactivation of the dead time compensation in the motor model

ds30	model mode			0x241E
Bit	Function	Value	Plaintext	Notes
5	consider dead-time losses (only for IGBT-model)	0	off	The voltage losses can be considered in the motor model with deactivation of the dead time compensation depending on the speed (is03). This is only possible with the IGBT model as dead time compensation type (is07, is24).
		32	on	

6.2.17 DC link voltage compensation

The current controller is pre-controlled by the DC link voltage compensation. The output voltage can be limited to a max. value.

The influence of the DC link voltage compensation in open-loop operation is described in the chapter 6.2.15.1 Voltage frequency operation.

is00	Uic mode			0x3500
Bit	Function	Value	Plaintext	Notes
0…2	Uic compensation mode	0	off	No DC link voltage compensation
		1	off, only curr, decoupling	No compensation for the current control, but for the decoupling (=> 6.2.7.4 Decoupling)
		2	on	completely compensation
		3	on, voltage limited	Compensation and limitation of the maximum output voltage
		4…7	reserved	
2…3	Uic filter	0	off	Activation of the PT1 filter
		8	on	

If the DC link voltage can oscillate due to the application, it can be smoothed by a PT1 filter. Thus, a resonance can be avoided.

is01	Uic PT1 time	0x3501
Value	Meaning	
0.063…60 ms	PT1 time for DC link voltage filtering	

The DC link voltage compensation is activated with "Uic compensation mode“ = 2 or 3. That means, changes in the DC link voltage have no effect on the behavior of the current control.

The maximum output voltage of the current controller is limited in mode 3 to the value of is02.

is02	Uic comp voltage limit	0x3502
Value	Meaning	
10V…800V	Maximum output voltage (effective value)	

6.2.18 Identification

6.2.18.1 Function

Motor parameters, which are not specified on the type plate or in the data sheet can be determined with the identification.

The dead-time characteristic of the inverter can be determined additionally.

Condition for starting the identification is the correct input of the motor type and rated current, rated voltage, rated speed and rated frequency.

Presettings for the controller and limitations for the test signals are determined from this data.

Also the encoder parameters (type, increments, etc.) must be preset at speed control with encoder.

The identification determines the following motor data:

Asynchronous machine

Index	Id-Text	Name	Function
0x2211	dr17	stator resistance UV	Stator resistance in Ohm
0x2212	dr18	ASM rotor resist. UV %	Rotor resistance in % of the stator resistance
0x2213	dr19	ASM head inductance UV	Head inductance
0x2215	dr21	ASM sigma stator ind. UV	Stator leakage inductance in mH
0x2216	dr22	ASM sigma rotor ind. %	Rotor leakage inductance in % of the stator value

Synchronous machine

Index	Id-Text	Name	Function
0x220E	dr14	SM EMF [Vpk/(1000min-1)]	EMC (peak value of the phase-to-phase voltage) at 1000 rpm in V
0x220F	dr15	SM inductance q-axis UV	Cross inductance (inductance q-axis) in mH
0x2210	dr16	SM inductance d-axis %	Series inductance (inductance d-axis) in % of dr15.
0x2211	dr17	stator resistance UV	Stator resistance in Ohm

Inverter

Index	Id-Text	Name	Function
0x3506	is06	deadtime coeff	Deadtime characteristic

Either all or only single motor parameters can be identified.

The automatic mode (mode 1 or 2 "all") is the simplest method of parameter identification.

Single identifications should not be used for the first measurement of the motor parameters, since wrong measurement results can occur with wrong identification order or missing of single points.

The single identification can always be used if a complete automatic measurement has been executed and only single parameters should be identified new. This can be a resistance measurement (e.g.) in operating temperature or a new measurement of the main inductance after changing the parameter dr08 magnetising current.

The measurement of most parameters occurs in standstill. Movement or rotation of the motor by the test signals is possible.

Only the head inductance (at asynchronous machine) or EMF (at synchronous machine) must be identified at higher speed. The speed is determined by parameter dr44.

NOTICE

No automatic brake opening for the ramp-up to dr44

- Since no defined torque can be built up during identification, the brake is not automatically released - regardless of the setting in co21 brake ctrl mode. If necessary, the brake can be opened in brake ctrl mode „0: controlword“ via the controlword.
- Ideally, the identification should be done approximately in no-load operation. If no-load operation is not possible, the identification can also be executed out with partial load.

NOTICE

- **The following applies to the safety module type 5 for control type P: While the motor identification is being carried out, encoderless speed detection activated in the safety module can lead to error trigering of the safety module and switching off the modulation release. For motor identification, deactivate the encoderless speed detection on the safety module.**

dr54 Bit 0...3 ("mode“) determines which identification shall be executed:

dr54	ident			0x2236
Bit	Function	Value	Plaintext	Notes
0…3	mode	0	off	
		1	all (with movement)	**! Attention: requires motor rotation in no-load operation !** automatic measurement of the dead-time characteristic and all equivalent circuit data- also the head inductance or the EMF. The motor accelerates to dr44.
		2	all (without movement)	Automatic measurement of the dead-time characteristic and all equivalent circuit data- with the exception of head inductance or EMF. This measurement occurs in standstill, but rotation of the motor by the test signals is possible.
		3	stator resistance (Rs)	Measurement of the stator resistance
		4	SM inductance (di/dt)	Measurement of the inductance of a synchronous motor with the "five-step" procedure
		5	dead time	Measurement of dead time characteristic for all available switching frequencies
		6	ASM rotor resistance (Rr)	Measurement of the rotor resistance (asynchronous motor)
		7	ASM sigma ind./SM ind. (ampl.Mod)	Measurement of the inductance of a synchronous motor or the leakage inductance of an asynchronous motor with the "Amplitude-Modulation” procedure

dr54	ident			0x2236
Bit	Function	Value	Plaintext	Notes
		8	ASM head inductance	Measurement of the head inductance (asynchronous motor)
		9	SM EMF	Measurement of the EMF (synchronous motor)

The procedure for the inductance measurement of a synchronous motor within a complete identification can can be selected in bit 4 and 5.

dr54	ident			0x2236
Bit	Function	Value	Plaintext	Notes
4…5	SM ind. mode for all ident	0	amplitude modulation	Using the "amplitude-modulation" procedure
		16	di/dt (five step)	Using the "five-step" procedure
		32	auto select	Estimation of Ls with the "five-Step" method. Then measurement of the stator resistance Rs. Depending on the motor time constant, the optimal procedure for this motor is selected: Time constant < 10ms => Use of the "amplitude modulation" method.

The process of the identification can be monitored in dr55.

dr55	ident state	0x2237
Value	Name	Note
0	off	
1	stator resistance	Measurement of the stator resistance
2	SM inductance (five step)	Inductance measurement according to the "five-step" procedure running
3	dead time	Measurement of the dead time characteristic running
4	init current ctrl (only Ls identified)	Current controller-initialisation for the following identification steps
5	init current ctrl (with identified values)	
6	rotor resistance (ASM)	Measurement of the stator resistance
7	not defined	
8	wait bg norm	Internal standardization routines are pass through
9	ASM sigma ind. / SM ind. (ampl.modl)	Inductance measurement according to the "amplitude-modulation" procedure running
10	head inductance (ASM)	Head inductance measurement running
11	EMF (SM)	Measurement of the EMF running
12	error	The identification was aborted with error
13	ident ctrl nop	Internal interim status
14	ready	The identification has been completed
15	wait state	Internal interim status
17	rotor detection (cvv)	
18	rotor detection (hf detection)	

dr55	ident state		0x2237
Value	Name	Note	
19	rotor detection (five step)	Rotor position identification according to "constant voltage vector", "hf detection" or "five-step" procedure running (=> see Chapter 6.2.3.5 System offset)	
23	least square ident (RsPre)		
24	IGBT-model + Rs ident		
25	IGBT-model + Rs background calc.		

6.2.18.2 Stator resistance dr17

Basically valid for the operation at low output frequency, the model is stabilized motor-driven with too small stator resistance and regenerative with too high resistance. If the identification of the dead time is made to a resistance which is adjusted too low/high, the preset error factor compensates itself again.

6.2.18.3 ASM rotor resistance dr18

The rotor resistance changes with the temperature. To what extent also the rotor time constant is changed and therefore the effect on the slip (e.g.) is dependent on the construction of the motor.

6.2.18.4 ASM main inductance dr19

The main inductance dr19 can only be determined if the motor can rotate freely.

Identification is also possible with a load torque as long as the rump-up to identification speed dr44 is possible with this torque.

The speed setpoint is determined via dr44 (default value 65% of the rated speed). The acceleration / deceleration ramp is defined by co48…co60.

A start value for the head inductance is calculated with the selection in dr54 "mode" = 1 or 2 (after writing on dr99). The head inductance is real identified with "mode“ = 1.

Calculation of the start value from:

- dr03 rated motor current
- dr09 rated torque
- dr07 ASM rated cos(phi)
- Pole-pair number of the motor (integer (rated frequency * 60 / rated speed))

The calculation occurs according to the following formula:

$$rated\ active\ current = rated\ motor\ current * (1 - (1 - \cos(phi) * 0.64))$$

$$Imr = \sqrt{rated\ motor\ current^2 - rated\ active\ current^2}$$

$$Start\ value\ of\ the\ head\ inductance = \frac{rated\ torque}{(Imr * rated\ active\ current * number\ of\ pole\ pairs)} * \left(\frac{2}{3}\right)$$

If the motor does not rotate during the identification, although the load torque is smaller than the rated torque, the start value for the head inductance was eventually calculated too high. Then the value in dr19 must be reduced and the identification must be started again with the single measurement (dr54=8). Also an incorrectly set speed controller or too slow ramp times for the ramp-up can lead to errors in the identification of the main inductance.

6.2.18.5 EMF Identification

The counter voltage EMF (dr14) of the motor can only be determined if the motor can rotate freely.

Identification is also possible with a load torque as long as the rump-up to identification speed dr44 is possible with this torque.
When identifying the EMF with load, however, the determined EMF can no longer be used to define the saturation characteristic.

The speed setpoint is determined via dr44 (default value 65% of the rated speed). The ramps are determined in co48…co60. Too slow ramps can make the ramp-up difficult in unidentified state. If error message 61 "Emf / Lh, speed <> ref" (= identification speed not reached) is displayed in dr57 ident error info, the acceleration should be increased or the speed controller setting should be adjusted.

A start value for the EMF of the motor data is calculated with the selection mode = 1 or 2 in dr54 (after writing on dr99).

Then the EMF is real identified with mode = 1 in dr54.

Calculation of the start value:

given: rated motor current (dr03)
rated torque (dr09)

calculated:

$$\text{Start value of the EMF (dr14)} = \frac{\text{rated motor torque}}{\text{rated motor current}} * 85.05$$

Parameter dr14 has only influence on the torque calculation when the saturation characteristic mo00 saturation mode is activated or the source in source in ds11 torque mode is set to 16 = EMF.

6.2.18.6 SM inductance

The inductance of the synchronous motor can be determined over two procedures. If value 32 = "auto select“ is selected in dr54 at SM ind. mode for all ident, the "five step“ procedure is executed first. If this determines a time constant < 10ms, the result is considered as insufficient reliable and the inductance is identified according to the "amplitude modulation" procedure. The inductance of the asynchronous motor is always performed by the amplitude modulation procedure.

a) "five step“ – procedure (dr54 = 4)

Five different voltage vectors are given to the motor within a view ms. The current level to be reached can be preset via parameter dd02.

The default value of 100% can be kept for the determination of the inductance. The voltage rate is determined by test jumps.

b) "Amplitude modulation“ procedure (dr54 = 7)

Here a test sinus signal is given to the motor.

The test frequency starts with 500 Hz (125 Hz for asynchronous motor). If the current level for the identification (selectable in dr56) should not be reached with this frequency, it is reduced by half. Significant noise development is to be expected on some motors due to the test signal. Here the current level dr56 should be reduced to 20% (e.g.).

6.2.18.7 Deadtime characteristic

The identification of the dead time should be done after identification of the stator resistance, by way that the stator winding has the same temperature and therefore the same resistance.

6.2.18.8 Possible error messages

If the identification is interrupted, the cause of the error can be read in parameter dr57 ident error info.

dr57	ident error info	0x2239
Identification step	Value / text	Note
ASM rotor resistance (Rr)	11: ident Rr > limit	Rotor resistance out of range
	13 ident Rr code 0	Current limit is reached, no lower frequency possible but phase shifting not within permissible range
	14 ident Rr code 1	Voltage limit is reached, not current limit, phase angle not in permissible range, no lower frequency possible
SM inductance (Lsd/Lsq)	21 ident Lsd < limit	Ld out of range (lower limit)
	23 ident Lsdq code 0	Amplitude modulation procedure: Current limit is reached, no lower frequency possible but phase shifting not within permissible range
	24 ident Lsdq code 1	Amplitude modulation procedure: Voltage limit is reached, not current limit, phase angle not in permissible range, no lower frequency possible
	28 ident Lsq > limit	Lq out of range (upper limit)
	29 ident Lsq < limit	Lq out of range (lower limit)
	32 ident Ldq di/dt curr.	five step procedure: Current not reached
	33 ident Ldq di/dt no volt. found	five step procedure: no voltage found with which the current can be reached within specified time limits
ASM leakage inductance (sLs)	41 ident sLs > limit	Leakage inductance out of range (upper limit)
	42 ident sLs < limit	Leakage inductance out of range (lower limit)
	43 ident sLs code 0	Current limit is reached, no lower frequency possible but phase shifting not within permissible range
	44 ident sLs code 1	Voltage limit is reached, not current limit, phase angle not in permissible range, no lower frequency possible
ASM main inductance (Lh)	51 ident Lh >limit	Head inductance out of range (upper limit)
	52 ident Lh < limit	Head inductance out of range (lower limit)
	61 EMF/Lh, speed <> ref.	Identification speed not reached (oscillation or limitation)
SM counter voltage (Emf)	55 ident EMF > limit	EMF out of range (upper limit)
	56 ident EMF < limit	EMF out of range (lower limit)
	61 EMF/Lh, speed <> ref.	Identification speed not reached (oscillation or limitation)

dr57	ident error info	0x2239
Identification step	Value / text	Note
Stator resistance (Rs)	72 ident Rs, current <> ref.	Current actual value unequal current set value
	73 ident Rs > limit	Stator resistance out of range (upper limit)
	74 ident Rs <=0	Stator resistance out of range (lower limit)
Deadtime compensation	82 ident dt current <> ref	Current actual value unequal current set value
Rotor position detection (5-step procedure)	102 rot. det. (5step) curr.	Current not reached
	105 rot. det. (5step) inf < dd07	Information content too small (dd08 < dd07)
Rotor position detection (Hf detection procedure)	112 rot. det. (hf det) curr.	Current not reached
	115 rot. det (hf det.) inf. < level	Information content is too small (dd08 < dd07 or/and dd10 < dd09)
Rotor position detection (cvv)	122 rotor det. (cvv) curr.	Current stiff could not be executed
	123 rotor det. (cvv) pos.	Encoder position has not rotated electrically by at least 12° in the preset direction.
Motor phase failure detection (DC signal)	131 least square, max. voltage reached	The maximum voltage was output for 50ms without reaching the current setting. Error, if e.g. two phases are missing
	132 least square, current not symmetrical	Current setting: • for ASM => 0.5 * dr03 • for SM / IPM / SRM => 0.25 * dr03 Evaluation of two voltage vectors Error when from a phase current not 30% of the expected value is exceeded, or the sign of a phase current does not agree with the expectation.
	133 LeastSquare DC, current not zero	The sum of the phase currents should be ZERO, if the sum is greater than 30% of the expected total current, this error is triggered.
Motor phase failure detection (HF signal)	140 LeastSquareHf, no information	The level of information is too low, e.g. due to the existing maximum output voltage or the minimum excitation frequency. Error: the current of 5% InMot cannot be reached **Cause: wrong parameterization** Perform check of the parameterized inductance, rated voltage of the motor, rated current of the motor.
	141 LeastSquareHf, negativ values	The detected inductance is <=NULL **Cause: real phase failure**
	142 LeastSquareHf, differenz > limit	The inductance is calculated from the Hf signal and the maximum / minimum value is determined. Error limit: Lmax / Lmin > 10 **Cause: real phase failure**

dr57	ident error info		0x2239
Identification step	Value / text	Note	
	143 LeastSquareHf, phase current to low	A current of 5% rated motor current is expected. Error limit: the detected phase current is less than 1.5% rated current **Cause: wrong parameterization** Perform check of the parameterized inductance, rated voltage of the motor, rated current of the motor	

For most error messages, the most likely cause is incorrect wiring of the motor (check phase connection) or incorrect entry of nameplate motor data (e.g. wrong rated motor current, wrong rated frequency or similar).

If the main inductance of the asynchronous machine or the Emf of the synchronous machine is not identified because the target speed is not reached, this can also be caused by too slow ramps or badly adjusted speed controller (continuous oscillation, no stable final speed).

The rotor position identification by "five step" or "hf detection" can also be done during the identification. However, it is better to do it beforehand, because the current for the detection of the position can be optimally adjusted then (=> Chapter 6.2.3.5 System offset).

6.2.19 Deadtime compensation

6.2.19.1 General modification

A distortion of the output voltage occurs by the deadtimes of the power modules, which causes negative effects (e.g.) for the calculation of the motor model or in voltage-frequency-characteristic operation. This distortion can be compensated partly by the activation of the deadtime compensation.

NOTICE

The dead time compensation has been generally revised in the software 2.10 / 3.0.
Instead of the previous dead time compensation based on an e-function, an IGBT model is now used.
The values identified with the e-function compensation (is05, is06 or is40...is43 deadtime coeff fswx) can no longer be used.

- ➢ The compensation was deactivated by default in all previous software versions. Now the compensation is activated on the basis of the IGBT model calibrated in the factory, independent of the control mode (also in v/f mode).
- ➢ For is07 deadtime comp mode value "**2: ident**" is no longer allowed. Attempting to write this value results in the error message "Data invalid".
- ➢ Value "**1: e-function**" is still possible for is07 for compatibility with already existing applications. Then the dead time compensation continues with the e-function compensation values calibrated at the factory.
- ➢ Parameters is05, is06 and is40...is43 are internally available for download compatibility reasons, but they have no function and they are not visible in COMBIVIS.

Index	Id-Text	Name	Function
0x3503	is03	deadtime switch on/off	Enables speed-dependent activation/deactivation of the dead time compensation. Setting of the speed level in % dr04 rated speed.
0x3504	is04	deadtime IGTB model	Evaluation/parameterization of the IGBT model.
0x3507	is07	deadtime comp mode	Selection of the compensation mode
0x3508	is08	comp limit fact	Adjustment of the dead time characteristic (only for e-function) Values should always be set to 100%
0x3509	is09	comp current fact	

6.2.19.2 Dead time compensation - fade out

Deactivation of the dead time compensation at high frequencies is useful in many applications, especially for high-frequency applications. At low frequencies, however, compensation is absolutely necessary for stability and concentricity. Therefore, the compensation can be deactivated at high speeds.

The connection / disconnection must not occur abruptly. The fading time must be adapted to the dynamics of the application.

Index	Idx text	Name	Function
0x3503	is03	deadtime switch on/off	Deactivation of the dead time compensation is reasonable from an output frequency of approx. 300 Hz.
	Subidx	Name	Function
	1	speed level [%Nn]	Setting of the switch on/switch off level in % of the rated speed (dr04)
	2	fading time	With exceeding / falling below the speed level, the dead time compensation influence within the fading time is reduced or increased in percentage terms.

6.2.19.3 Dead time compensation mode selection

The compensation type is selected with parameter is07:

is07	deadtime comp mode			0x3507
Bit	Function	Value	Plaintext	Notes
0…2	mode	0	off	No dead time compensation
		1	e-function	Dead time compensation with the e-function compensation values measured in the factory **Compatibility mode**
		2	reserved	Identification of the e-function dead time compensation values is no longer supported from V.2.10 / 3.0. Writing this value will be rejected.
		3	factory setting	**New default value of is07** The factory calibrated values are used for compensation. If the IGBT model values are available for the concerned power unit, the improved IGBT model compensation is used. If only data of the e-function are available, the compensation occurs with the e-function values.
		4	ident IGBT-model	In the application, deviations from the values measured in the factory may occur for the IGBT model due to the overall design (e.g. cable lengths used). These optimized values can be determined with the identification (dr54 ident). In this mode, these values determined in the application are used for compensation.

The currently used type of compensation is displayed in parameter is24 act. deadtime mode. This shows whether the IGBT model or the e-function is used when mode = "3: factory setting“.

is24	act. deadtime mode			0x3518
Bit	Function	Value	Plaintext	Notes
0…2	mode	0	off	No dead time compensation
		1	e-function	Deadtime compensation according to the default-e-function
		3	standard IGBT-model	factory calibrated IGBT model
		4	ident IGBT-model	identified IGBT model

Mode "e-function“:

Compensation method used up to software version 2.9.

In this mode, the dead time compensation is performed with an e-function stored in the inverter.

The compensation characteristic can be modified with is08 and is09.

is08	comp limit fact	0x3508
Value	Meaning	
0,00…200%	Determination of the compensation degree 100% => compensation value = deadtime value	

is09	comp current fact	0x3509
Value	Meaning	
0.00…200%	Determination of the current for which the dead time characteristic is recorded 100% => the default value of the inverter is used	

Mode "standard IGBT-model“:

In this mode, the dead time compensation is performed based on an IGBT model.

The parameters of the model have been calibrated at the factory.

Mode "ident IGBT-model“:

In the application, deviations from the values measured in the factory may occur for the IGBT model due to the overall design (e.g. cable lengths used).

These optimized values can be determined with the identification (dr54 ident).

The result of the identification is displayed in parameter is04 in subindices 1...3.

Index	Idx text	Name	Function
0x3504	is04	deadtime IGBT-model	Identification IGBT parameters
	Su-bidx		
	1	delta UDiode	Difference of the model parameters identified by the inverter, compared to the values from the power unit data (de80[7...9])
	2	delta tDelay [ns]	
	3	delta C [nF]	

If an error occurs during the identification of the IGBT model parameters, this error is displayed in dr57 ident error info.

dr57	ident error info	0x2239
Value	Meaning	
9: searching reached limit (Dt, Rs)	The parameter search of the IGBT model for the dead time compensation has reached a value range limit.	

6.2.19.4 Dead time compensation - options

6.2.19.4.1 Weakening

"Undercompensation" of the dead time is sometimes reasonable for open-loop operation (v/f). This is caused by coupling effects, which may result from a current offset of the measurement, for example.

In this case, the compensation can be optimized with the safety factor.

The factor is effective only in combination with the use of the IGBT model (factory setting or identified).

Index	Idx text	Name	Function
0x3504	is04	deadtime IGBT-model	Identification IGBT parameters
	Subidx		
	12	safety factor	The compensation can be weakened with this factor. 100% corresponds to full compensation.

6.2.19.4.2 Filtering

is07	deadtime comp mode			0x3507
Bit	Function	Value	Plaintext	Notes
3	pt1-filter	0	off	no filtering
		8	on	Filtering active By activating the filtering (even with a filter time of is23 = 0ms), the time delay between current detection and voltage output is considered. This improves the performance, but costs computing time. The filter should not be activated in combination with other time consuming functions (Hf-Injection, use of 32 PDOs, ...).

Index	Id-Text	Name	Function
0x3517	Is23	deadtime pt1- time	Filtering of input values, activation via is07.Bit3

6.2.19.4.3 Compensation current

By default, the compensation is always dependent on the actual current value.

In applications with a sine-wave filter, the reference to the set currents can help to avoid effects of the resonance frequency on the compensation.

is07	deadtime comp mode			0x3507
Bit	Function	Value	Plaintext	Notes
4	source	0	measured values	Dead time compensation on measured actual variables
		16	reference values	Dead time compensation on setpoints

6.2.20 Switching frequency adjustment and derating

Index	Id-Text	Name	Function
0x2021	de33	inverter rated switching frequency	Rated switching frequency
0x2022	de34	inverter max switching frequency	Maximum switching frequency
0x350A	is10	switching frequency	Selected switching frequency
0x350F	is15	temp dep derating	Activation of the temperature-dependent switching frequency reduction
0x3510	is16	min. derating frequency	Lower limit for the current / temperature-dependent switching frequency reduction
0x3516	is22	basic Tp	Selection of the switching frequency group
0x2C48	ru72	act.switch.freq (kHz)	Actual switching frequency

6.2.20.1 Set switching frequency

is10	switching frequency	0x350A
Value	Meaning	
2…16.0 kHz	Set switching frequency in 0.1 kHz resolution	

is22	basic Tp			0x3516
Bit	Function	Value	Plaintext	Notes
0…2	basic Tp	0	62.5 µs / 16 kHz, 8 kHz, 4 kHz, 2 kHz	Selection of the switching frequency group
		1	71.4 µs / 14 kHz, 7 kHz, 3.5 kHz, 1.75 kHz	
		2	83.3 µs / 12 kHz, 6 kHz, 3 kHz, 1.5 kHz	
		3	100 µs / 10 kHz, 5 kHz, 2.5 kHz, 1.25 kHz	

The switching frequency can be selected in parameter is10. Only data that are permitted as associated values for the selected switching frequency group are accepted.

If the switching frequency group 0: 62.5 µs / 16 kHz, 8 kHz, 4 kHz, 2 kHz is parameterised in is22, only 2, 4, 8 or 16 kHz can be set for is10.

Due to the used power unit, further restrictions on the possible switching frequencies can become effective.

The indicated values in the manual for the maximum current are valid for the rated switching frequency (de33).

Parameter de34 indicates the maximum switching frequency which is permissible for this inverter.

The lower limit of the switching frequency is determined by the used inverter and the minimum application-specific switching frequency (sinus filter dr53).

These limits have priority to the settings of is10 switching frequency or is16 min. derating frequency.

The output frequency-dependent short-time current limits reduce at increased switching frequency (=> Chapter 4.4.2 Overload power components (OL2)).

6.2.20.2 Current-dependent derating

With the current-dependent derating it can be selected if the switching frequency should be reduced automatically on exceeding the short-time limiting currents in order to avoid an OL2 error. In the same way, if a power unit-dependent temperature value is exceeded, the switching frequency can be reduced in order to reduce the internal losses of the inverter. The reduction of the switching frequency can be configured with this parameter.

is16	min. derating frequency		0x3510
Value	Name	Meaning	
0	no derating	The switching frequency is not changed current-dependent	
0…1600	0…16kHz	Lower limit for switching frequency reduction	

The min. switching frequency is never fallen below (independent of the adjustment). The minimum switching frequency is e.g. defined by sinus filt.min.switch.freq. dr53 or limited by the power unit (=> installation instructions power unit).

If the value of is16 is higher or equal to is10, there is also no "derating“.

The switching frequency is increased when the current is once again within the permissible range (limit – hysteresis).

The actual switching frequency of the inverter is displayed in ru72 act.switch.freq (kHz).

Like is10, is16 is also dependent on the used switching frequency group.

6.2.20.3 Temperature-dependent derating

Additionally to the current-dependent derating, a temperature-dependent derating can be activated with parameter is15 temp dep.

is15	temp dep derating		0x350F
Value	Plaintext	Meaning	
0	0: off	Temperature-dependent derating deactivated	
1	1: on	Additionally to the current-dependent derating, also the temperature-dependent derating is activated with corresponding setting of is16	

The lower limit for the temperature-dependent derating is the rated switching frequency of the inverter (de33), if the lower limit is not set to a higher value via other parameters (sinusfilter min. switch. freq. dr53 or min. derating frequency is16).

There are 3 temperature values for each inverter:

- Temperature for switching frequency reduction TDR
- Temperature for switching frequency increase TUR
- Temperature for change-over to rated switching frequency TEM

These values are dependent on the inverter and can be taken from the installation manual for the respective power unit.

If the heatsink temperature (ru25 SubIdx 1 heatsink temperature 1) exceeds the temperature for switching frequency reduction while the switching frequency is higher than the derating lower limit, then the switching frequency is reduced to the next lower stage.

Further reduction occurs after the expiry of 30s if the heatsink temperature is too high (if the derating lower limit has not been reached yet).

If the heatsink temperature (ru25 SubIdx 1 heatsink temperature 1) falls below the temperature for switching frequency increase and if at least 30s have been elapsed since the last temperature-dependent reduction / increase of the switching frequency, the switching frequency is increased to the next higher stage (Condition: the switching frequency is lower than the set switching frequencyis10).

If the temperature is exceeded for the change-over to the rated switching frequency, the switching frequency is immediately reduced to the rated switching frequency (provided always the lower limit has not been reached yet).
After 30s it is checked whether the switching frequency can be increased again.

The 30s waiting time serves for transient oscillation of the temperature profile.

The current-dependent derating is always superimposed on the temperature-dependent derating.

6.2.21 Interrupt structure of the software

6.2.21.1 Time allocation

Depending on their time priority, various functions of the inverter run in various tasks (time slices, interrupt levels).

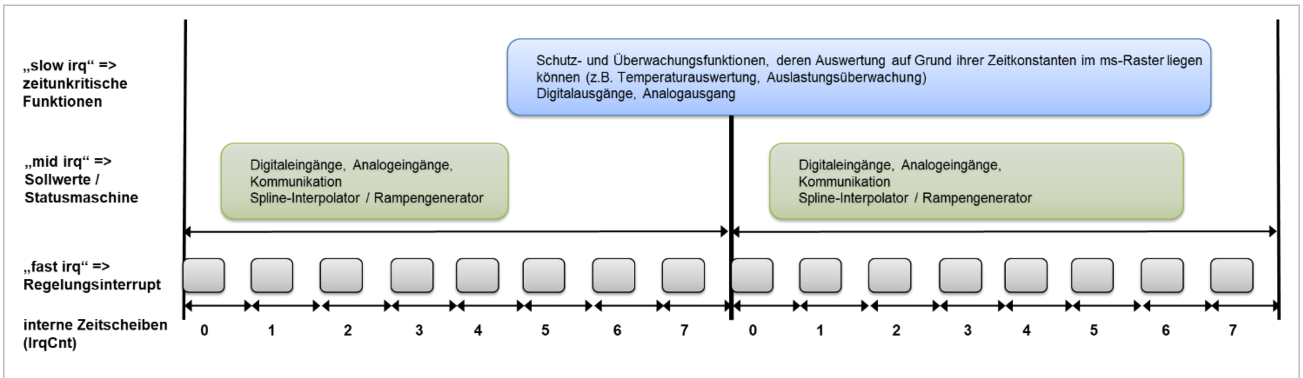


Figure 93: Time allocation

The fastest grid is the basic control grid (also called "basic Tp" or "fast irq"). The basic control grid depends on the switching frequency group. It contains the essential control functions, e.g. for current, speed, etc.

Not all of these control functions are executed in every cycle (see chapter 6.2.21.2 Scan times of position, speed and current controller)

Above there is the middle grid ("mid irq"), in which a lot of the functions for processing the communication (fieldbus, serial interface), for handling the status machine, for processing the setpoints and for error handling are processed.

The slowest grid ("slow irq") contains all functions that are not particularly time-critical (e.g. load and overload monitoring), but which nevertheless require a fixed processing grid.

The configuration of the task times occurs by parameter is22 basic Tp.

is22	basic Tp			0x3516
Bit	Func-tion	Value	Plaintext	Notes
0…2	basic Tp	0	62.5 µs / 16 kHz, 8 kHz, 4 kHz, 2 kHz	Selection of the switching frequency group and thus the basic control grid
		1	71.4 µs / 14 kHz, 7 kHz, 3.5 kHz, 1.75 kHz	
		2	83.3 µs / 12 kHz, 6 kHz, 3 kHz, 1.5 kHz	
		3	100 µs / 10 kHz, 5 kHz, 2.5 kHz, 1.25 kHz	
3, 4	mid irq	0	8 x TpBase	Configuration of the middle interrupt grid as a multiple of the basic control grid
		4	4 x TpBase	
		8	reserved	
		12	reserved	

NOTICE

A changed value in is22 is only effective after the next power-on.

NOTICE

is10 switching frequency and is16 min. derating frequency are automatically adapted to the new switching frequency group.

➢ This means: if is10 previously is set to 8 kHz, the value of is10 after PowerOn is automatically changed to 6 kHz by changing the switching frequency group from 0 to 2.

Bit 0…2 basic Tp

The "µs value" indicates the basic process time (e.g. 62.5 µs). The kHz values are the switching frequencies which can be adjusted with the selected basic process time.

Precondition: The switching frequency is supported by the respective inverter (=> Installation manual).

Bit 3…4 mid irq

Digital inputs, analog inputs, state machine, operating modes, PDOs, system counters run in the middle interrupt level (in the task "mid irq").

This is called with the setting 0: 8xTpBase every eight "basic Tp". If 0 is selected as switching frequency group and the control grid is 62.5µs, the average interrupt is called every 8 X 62.5µs = 500µs.

Smaller grids for the middle interrupt level can only be set under certain conditions due to the time load of the control card:

*The following applies to all control types (**A, K, P**):*

If value 3: 100µs is parameterized as "basic Tp“, value 4: 4xTpBase can also be selected as time grid for "mid irq“ . The task "mid irq“ is then called every fourth "basic Tp", i.e. every 400µs.

*Applies only to control type **P** :*

For each setting for "basic Tp“, the value "4: 4 x TpBase" can be parameterised for mid irq. The smallest cycle time of the middle interrupt level is then 250 µs with the setting basic Tp = 62.5 µs and mid irq = 4 x TpBase.

6.2.21.2 Scan times of position, speed and current controller

The following scan times of the internal control circuits also occur by the setting of is22.

Table with scan times of some functions:

Basic grid Tp	Scan times			
	Current controller, motor model, hf injection	Speed controller, position controller	Digital inputs, analog inputs, state machine, operating modes	Digital outputs, analog output
62.5 µs	62.5 µs	250 µs	500 µs	1000 µs
71 µs	71 µs	286 µs	571 µs	1143 µs
83 µs	83 µs	333 µs	667 µs	1333 µs
100 µs	100 µs	400 µs	800 µs	1600 µs

Assignment of some functions to the interrupt levels

Interrupt level	Assigned functions (selection)
fast irq	Motor model, current controller, speed controller, position controller, encoder interface, hf injection
mid irq	Digital inputs, analog inputs, status machine, operating modes, PDOs, system counter
slow irq	Digital outputs, analog output

There is another dependency for the effective controller cycle times: the actual active switching frequency (displayed in ru72 act. switch. freq (kHz)).

Although the controller is called in a faster grid, only 2 voltage values per modulation period can be output at a switching frequency of 2 kHz. This means that, despite a current controller cycle of 62.5 µs, the voltage can only be changed every 250 µs (with switching frequency group 0: 62.5 µs).

6.2.21.3 Task setting and synchronous fieldbus operation

For the influences of the task setting on the fieldbus operation please also read the manual ma_dr_x6_fbs_phb_20191938_en.

The minimum value for synchronous fieldbus operation is dependent on ***is22.***

The changeover of the basic process time has the following effects on the synchronous PDOs:

> ➢ **The minimum value for synchronous fieldbus operation is equal to the cycle time of the middle interrupt level (the task "mid irq)**

Value is22	**mid irq = minimum cycle time PDOs**
0: 62.5 µs / 16 kHz, 8 kHz, 4 kHz, 2 kHz + 8 x TpBase	500µs
7: 100 µs / 10 kHz, 5 kHz, 2.5 kHz, 1.25 kHz + 4 x TpBase	400µs
4: 62.5 µs / 16 kHz, 8 kHz, 4 kHz, 2 kHz + 4 x TpBase	250µs (only control type P)

Further allowed values for the sync interval are multiples of "mid irq“. With is22 = 0, multiples of 500µs, i.e. 1ms, 1.5ms etc.

minimum sync interval all cards				
Value is22	0: 62.5 µs 8 x TpBase	1: 71 µs 8 x TpBase	2: 83 µs 8 x TpBase	7: 100 µs 4 x TpBase
Minimum sync interval	500 µs	571.4 µs	666.7 µs	400 µs
Minimum sync interval P card				
Value is22	4: 62.5 µs 4 x TpBase	5: 71 µs 4 x TpBase	6: 83 µs 4 x TpBase	7: 100 µs 4 x TpBase
Minimum sync interval	250 µs	285.7 µs	333.3 µs	400 µs

The following sync intervals, which represent an integer multiple of 1ms, are possible for the switching frequency groups for all control types:

Sync interval	Value of is22		selectable switching frequencies
	Basic Tp	mid irq	
1 ms	0	0, 4	16 kHz, 8 kHz, 4 kHz, 2 kHz
	2	4	12 kHz, 6 kHz, 3 kHz, 1.5 kHz
2 ms	2	0, 4	12 kHz, 6 kHz, 3 kHz, 1.5 kHz
	1	4	14 kHz, 7 kHz, 3.5 kHz, 1.75 kHz
	3	4	10 kHz, 5 kHz, 2.5 kHz, 1.25 kHz
4 ms	Is possible with all settings of is22 for all switching frequencies		

6.2.21.4 Further task dependencies

- Parameter st35 system counter increases by the value 2 after 8 times the "basic Tp" time.
- The times for the offline mode of04 time base must be written with a multiple of the basic Tp.
- By increasing the Tp, more computing power is available for additional functions.
- The cycle times of the controllers and I/O functions increase by the same factor as the basic process time.

6.2.21.5 Runtime monitoring

The maximum running time of the three main interrupt sources is monitored. If too many functions are activated and the limit value is exceeded, "error runtime" is triggered.

Index	Id-Text	Name	Function
0x2955	aa85	period fast irq	Time measurement of the periodic call of the fast interrupt in µs
0x2956	aa86	time fast irq	Current runtime of the fast interrupt in µs.
0x2957	aa87	mean time fast irq	Mean value of the runtime of the fast interrupt in µs.
0x2958	aa88	max time fast irq	Drag pointer of aa86. The maximum runtime is determined in the fast interrupt. Resettable with reset.
0x2959	aa89	error level fast irq	ERROR runtime is triggered, if the value in aa88 exceeds the limit value of aa89 defined by KEB.
0x295A	aa90	period mid irq	Time measurement of the periodic call of the mean interrupt in µs.
0x295B	aa91	time mid irq	Current runtime of the mean interrupt in µs.
0x295C	aa92	mean time fast irq	Mean value of the runtime of the mean interrupt in µs.
0x295D	aa93	max time mid irq	Drag pointer of aa91.
0x295E	aa94	error level mid irq	ERROR runtime is triggered, if the value in aa93 exceeds the limit value of aa94 defined by KEB.
0x295F	aa95	period slow irq	Time measurement of the periodic call of the slow interrupt in µs.
0x2960	aa96	time slow irq	Current runtime of the slow interrupt in µs.
0x2961	aa97	mean time fast irq	Mean value of the runtime of the slow interrupt in µs.
0x2962	aa98	max time slow irq	Drag pointer of aa96.
0x2963	aa99	error level slow irq	ERROR runtime is triggered, if the value in aa98 exceeds the limit value of aa99 defined by KEB.

Which interrupt level is responsible for this error can be determined in aa88, aa93 and aa98 and appropriate measures can be initiated.

Increasing the "basic Tp" in is22 always leads to an improvement of the time utilization.

The following factors have a special influence on the time load of the individual interrupt levels (only exemplary, can vary depending on the control type)

aa88 max time almost too long	Resolver evaluation hf injection Consider saturation influences
aa93 max time mid too long	Number and type of process data
aa98 max time slow too long	Special functions: Coolant management Power-dependent speed limitation

"Error runtime" can be reset by a reset in the controlword.

6.2.22 Hardware/software current control

is36	hard./software current reg.			0x3524
Bit	Function	Value	Plaintext	Notes
0…1	mode	0	off	off
		1	reserved	
		2	SSR on	If one of the phase currents is above the level, all IG-BTs in the basic time are switched off. If the current is below the level again, activation occurs in the next basic time.
		3	reserved	reserved
2	sel. cur-rent limit	0	is37	HSR/SSR Current [OcLim%], is37
		8	application para.	The lowest current limit from the is/dr - groups

is37	HSR/SSR current [OcLim%]	0x3525
Value	Meaning	
0…100 %	Current level for the phase currents when the modulation is switched off. When falling below the modulation is switched on again. The percentage value refers to the OC current of the device.	

is38	HSR/SSR activ counter	0x3526
Value	Meaning	
0…4294967295	In the basic interrupt this cell is increased by one, if HSR is active	

6.2.23 Sinus filter

6.2.23.1 Start-up instructions

If a sinus filter is connected between inverter and synchronous motor, no identification of the motor data or the sinus filter data is possible. The capacity (Cf) would falsify the measured values.

Thus, the motor data must be determined before the connection. The filer data are shown in the respective data sheet. The ultimate value is the critical frequency fk (dr64). It is calculated from the motor/filter data.

The current that flows into the capacitor is calculated depending on the output voltage and frequency and preset inverted in the reactive current setpoint (this setting is not possible in v/f operation).

6.2.23.2 Conditions for the operation of a sinus filter

cs00 control modes				
ASM		SM		
all closed-loop operating modes	v/f	all closed-loop operating modes		v/f
		4kHz	8kHz	
yes	yes	fk < 2kHz fout < 0.8 kHz	fk < 4kHz fout <1.6 kHz	yes

fout = output frequency
fk = critical frequency (dr64)

6.2.23.3 Parameterization

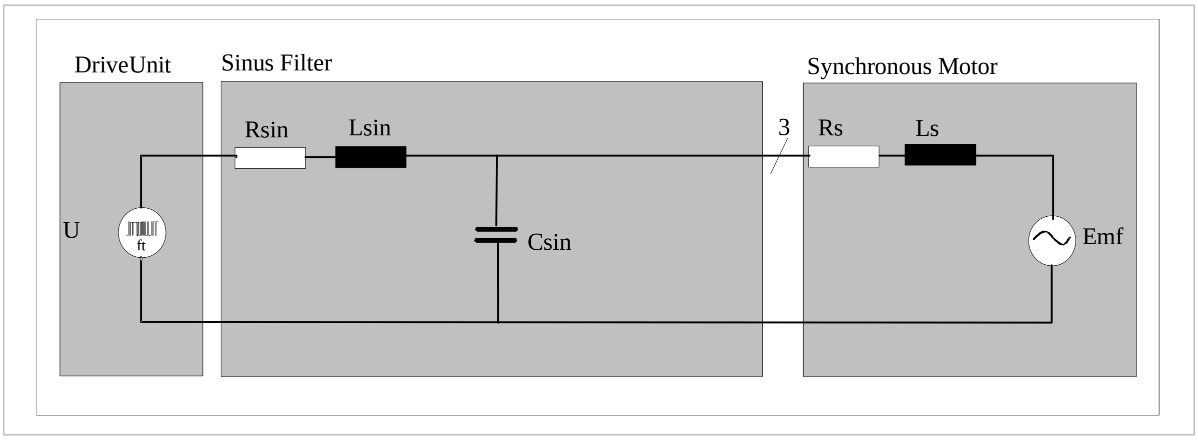
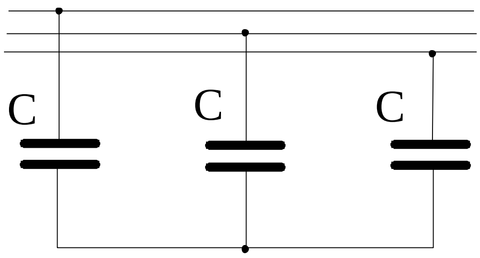
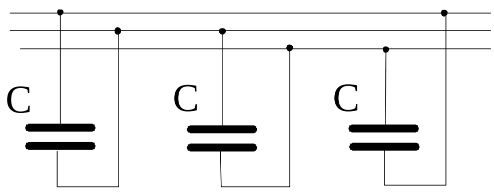


Figure 94: Connection example sinus filter

Index	Id-Text	Name	Value	Description
Sinus filter				
0x2231	dr49	sinus filter ind. UV	2 * Lsin	If Lsin and Rsin are the data sheet values for one phase of the filter, then the concatenated (UV) value must be entered in dr49 and dr51 according to the adjacent formula. Example: The inductance Lsin is 0.2 mH per phase => then dr49 = 0.4 mH must be parameterized.
0x2233	dr51	sinus filter resistance UV	2 * Rsin	

Index	Id-Text	Name	Value	Description
0x2232	dr50	sinus filter cap. UV high resolution [uF]		If C is the capacitance value in the data sheet for one phase of the filter, Csin can be determined according to the formulas listed below. The phase-to-phase capacity of the sinus filter must be entered in dr50 (phase-to-phase value UV) = Csin/2. **Note:** Parameter dr52 is still visible with a lower resolution for compatibility reasons, if it is not equal to ZERO, this value is used internally.
0x2234	dr52	sinus filter cap. UV [uF]	Csin / 2	**Star connection:**  Csin =C **Delta connection:**  Csin = 3 * C

Index	Id-Text	Name	Value	Description
0x2235	dr53	sinus filter min. switch. freq.		Minimum switching frequency whereby the sinus filter may be operated (typical values 4kHz, 8kHz). "error norm motor-data" is displayed in dr02 if the max. switching frequency (de38) of the inverter is smaller than this value. Otherwise the smallest switching frequency that is higher or equal to dr53 is used. Then the parameterization of is10 has no effect. Example: is10 = 4kHz dr53 = 8kHz de33 = 8kHz => switching frequency = 8kHz

Index	Id-Text	Name	Value	Description
Bandpass filter				
0x2240	dr64	bp filter critical freq. calc.		Displays the critical frequency calculated from the motor/filter data. This frequency is filtered by the bandstop filter from the current signal.
0x2241	dr65	bp filter freq set		The default value = 0 (over dr64) means, the automatically calculated critical frequency is taken from dr64. Since the critical frequency decreases with the output frequency, it is reasonable to parameterize e.g. dr65 = dr64 - fn/2.
0x2242	dr66	bp filter q-factor		Degree of the quality of the filter. Default value =0.5. The higher the value, the more narrowband the filter chracteristic. To consider that the critical frequency decreases with the output frequency, a broadband filter is useful, so dr66=0.1 should be parameterized.
0x2409 0x240A	ds09 ds10	bp filter coeff index / bp filter coeff		These parameters are only available for download compatibility with old lists. The content is identical with ds17. The value of ds09 + 1 corresponds to the subindex of ds17.
0x2411	ds17	bp filter coeff[1].. bp filter coeff[9]		The default value for ds17[1] is the value 131068 (over dr-para). That means: The filter parameters of the band-stop filter are automatically calculated from the dr parameters for the parameterised frequency (dr65 bp filter frequency set) and the requested quality (dr66 bp filter q-factor). Alternatively, the filter coefficients can be preset directly via ds17 . Thereby the filter can be adjusted with any characteristic.
Band-pass filter activation				
0x2404	ds04	current mode		Activate the bandpath filter in ds04 bit 3 "bandpath filter = on“!

ds30	model mode			0x241E
Bit	Function	Value	Plaintext	Notes
4	sinus filter (only for standard mode)	0	off	**Only active in "standard" mode“ (ds30.bit2=0)** The sinus filter is considered in the motor model. With motor inductance Ld = Lq, there is no position error in SCL operation, the torque is generated with optimum current. The filter time in ds27 may have to be increased from the default value of 0.25ms to 0.5..1ms, which restricts the dynamics of the drive. **Note:** with activation of this function, the set torque will deviate from the actual torque. The set torque is set by the speed controller, the conversion to the set currents occurs **without** consideration of the sinus filter. However, the actual torque is calculated from the calculated motor currents and should therefore correspond to the real shaft torque.
		16	on	

6.2.24 Speed search

Each time the modulation is switched on, the drive can perform an automatic speed search and thus connect to a running motor. The speed search can be activated in dd16. The most favorable procedure is automatically selected internally.

When operating with an absolute value encoder, directly the speed and electrical position are accepted.

When operating without encoder, the motor speed and the electrical position are measured by test signals.

Index	Id-Text	Name	Function
0x3610	dd16	speed search mode	Activation of the automatic speed search
0x3612	dd18	speed search current [In]	Selection of the measuring current for speed determination

dd16	speed search mode		0x3610
Value	Name	Meaning	
0	off	No automatic speed search	
1	On	Automatic speed search	
5	On, high speed, emf based	Speed search for synchronous high-frequency spindles. The counter-voltage constant of the motor is used for the calculation of the speed.	

During the speed search, the modulation is switched on briefly with zero voltage. The speed and position are determined from the step responses of the current. The maximum measuring current for this function can be preset with dd18.

Precondition for a successful speed search is the identification / parameterization of the equivalent circuit data, also in v/f operation.

6.2.25 Protection functions (ramp stop, current limitation in open-loop (v/f) operation)

Overview of protection functions

Function	Target	Intervention	modes of operation (co01)	control mode (cs00)
v/f current limit control	Limitation of the current	Voltage	all	v/f
LA(I)	Limitation of the current	Ramp setpoint at acceleration (ACC)	velocitiy	v/f*
LD(I)	Limitation of the current	Ramp setpoint at deceleration (DEC)	velocitiy	v/f*
LD(U)	Limitation of the DC link voltage	Ramp setpoint at deceleration (DEC)	velocitiy	all

*) only useful in v/f, but active in all control modes

Index	Id-Text	Name	Function
0x243C	ds60	protection function	Parameter structure for the definition of overcurrent / overvoltage behaviour
Subidx	Name		Function
1	v/f current limit control mode		Current controller access in v/f operating mode
2	ramp stopping mode		Mode for LAD-Stop (I/U)
3	LD-U stop voltage level		DC link voltage setpoint for the LD (U) stop function
4	LAD-I KI [1/As]		Integral gain factor (KI) for current-dependent change of acceleration / deceleration ramps
5	LAD-I KDI [1/As]		Differential + integral gain factor (KD + KI) Evaluation of the current rise with integration. The ACC/DEC ramp is also reduced below the current level Imax(*1) depending on the rate of current rise
6	LD-U KI [1/Vs]		Integral gain factor (KI) for DC voltage-dependent change of the deceleration ramps
7	LD-U KDI [1/Vs]		Differential + integral gain factor (KD + KI) Evaluation of the voltage rise with integration. The DEC ramp is also reduced below ds60[3] LD-U stop voltage level depending on the rate of voltage rise.

(*1) The maximum current "Imax" is formed from the following parameters: dr12 max. current %, is11 max current [de28%], is35 set current limit, is14 overload protect mode

ds60	v/f current limit control			0x243C SubIdx 1
Bit	Function	Value	Plaintext	Function
0	always activ	0	off	No current controller active
		1	on	Current controller becomes active if the activation condition is fulfilled
1	active at n < 10%Nn	0	off	Activation if the speed is less than 10% of the rated speed (dr04 rated speed)
		2	on	

The maximum current is formed from the following parameters: dr12 max. current %, is11 max current [de28%], is35 set current limit, is14 overload protect mode and (only when DC braking is active) ds62[4] max.DC current

Ramp state ACC or CONST:

If the apparent current is higher than the maximum current, the current controller intervenes. The current controller (ds00…ds03) is parameterized via the equivalent circuit data (dr17, dr18, dr21 and dr22) of the motor. The default values for the equivalent circuit data can be calculated from the nameplate data with dr99 motor data control = 2. Better results for the current controller parameterization are achieved with the motor identification.

Ramp state DEC:

If the apparent current is higher than the maximum current, the modulation is switched off for one current measurement cycle.

ds60	ramp stopping mode			0x243C SubIdx 2
Bit	Function	Value	Plaintext	Function
0	LD (I) - Stop	0	off	The speed setpoint ramp is decelerated / stopped during deceleration (DEC) if the apparent current > Imax(*1) or the rate of current rise is too high.
		1	on	
1	LD (U) - Stop	0	off	The speed setpoint ramp is decelerated / stopped during deceleration (DEC) if the DC link voltage > ds60[3] LD-U stop level or the rate of voltage rise is too high.
		2	on	
2	LA (I)-Stop	0	off	The speed setpoint ramp is decelerated / stopped during acceleration (ACC) if the apparent current > Imax(*1) or the rate of current rise is too high.
		4	on	

(*1) The maximum current "Imax" is formed from the following parameters: dr12 max. current %, is11 max current [de28%], is14 overload protect mode

6.2.26 DC braking

6.2.26.1 Overview

The DC braking is used to decelerate/stop the drive if no braking energy shall enter the DC link. No braking resistor is required. The braking is caused by DC voltage, which is applied onto the motor winding.
The braking energy is converted into heat loss in the motor.

NOTICE	➢ Select the DC braking time and the max. DC braking current by way that the motor is not overheated.

DC braking is available for the following motor / control types:

Motor type	ASM	x
	SM	-
	SyncRM	-
Control mode	v/f	x
	ASCL	x
	Encoder	-
Mode of operation	velocity mode	x
	profil position mode	-
	cycle syn position	-
	cycle syn velocity	-

DC braking is available for:

- operation mode 2: velocity mode
- control mode v/f or ASCL
- Motor type: Asynchronous motor

6.2.26.2 Parameter overview

Index	Id-Text	Name	Function
0x243D	ds61	DC braking source	Selection of the inputs that trigger DC braking

Index	Id-Text	Name	Function
0x243E	ds62	dc braking	Parameter structure for defining the behavior at DC braking
Sub Idx	**Name**		**Function**
1	DC braking mode		Different modes of braking adjustable
2	DC timing mode		Parameterization of the modulation switch-off time and activation mode of the DC brake when using a digital input
~~3~~	modulation off time		Display parameter of the hardware-dependent modulation switch-off time of the device
4	max. DC current[%In]		Current limit to which the higher-level boost controller limits the motor current, with regard to the rated current of the motor.
5	DC boost [%Un]		Max. DC voltage during DC braking proportionally to the rated voltage (Un) of the motor
6	braking time		Braking time
7	braking speed level [%Nn]		Speed level in % of the rated motor speed to activate the braking
8	braking state		State of DC braking 0 = ready, 1 = flux reducing, 2 = activ

6.2.26.3 Activation of DC braking

ds62[1] DC braking mode defines the activation and mode of DC braking.

ds62	DC braking mode			0x243E Sub Idx. 1
Bit	**Function**	**Value**	**Plaintext**	**Notes**
0…2	mode	0	off	Off
		1	DC-braking	DC braking mode 1
3…5	start by digital input	0	off	No start by digital input
		8	on	Start by digital input
		16	On + speedlevel	Start by digital input and additionally dependent on the actual speed
6…8	start in stopping state	0	off	No status-dependent start
		64	on	Start in state: “quickstop“, “fault reaction“, “shut down“, “disable operation active”
		128	on + speed level	Start in state: “quickstop“, “fault reaction“, “shut down“, “disable operation active” and additionally dependent on the actual speed.
9…11	start at DEC	0	off	No ramp state dependent activation of the DC braking
		512	on	DC braking if decelerated => Ramp state “DEC“
		1024	speed level	Start of DC braking when the target speed (ru05 set value display) and the actual speed (ru08 actual value) are below the level (ds62[7] braking speed level [%Nn]). The condition is that the actual speed has been once above the level.

ds62	DC braking mode			0x243E Sub Idx. 1
Bit	Function	Value	Plaintext	Notes
12,13	start after switched on	0	off	No DC braking at the start
		4096	on	The DC braking is activated at the change from st12 state machine display 4: switched on to 11: start operation activ

6.2.26.3.1 DC braking: mode (Bit 0…2)

Currently, only one DC braking mode is implemented:

- Switching off the modulation for a preset time / reduction of the magnetic flux
- Connecting a DC voltage vector for a parameterizable time

6.2.26.3.2 DC braking: start by digital input sel (Bit 3…5)

An activation condition is the start by digital input (Bit 3: start by digital input selection = "8: on“ or "16: on + speed level“)

An activation input must be selected in ds61 DC braking source:

ds61	DC braking source		0x243D
Bit	Value	Name	Start by
0…15	0	no input	Function off
0	1	I1	Input I1
1	2	I2	Input I2
2	4	I3	Input I3
3	8	I4	Input I4
4	16	I5	Input I5
5	32	I6	Input I6
6	64	I7	Input I7
7	128	I8	Input I8
8	256	IA	Input IA
9	512	IB	Input IB
10	1024	IC	Input IC
11	2048	ID	Input ID
12…15			reserved

With “start by digital input selection = 16: on + speed level“ the requested actual speed level must additionally be set in ds62[7] braking speed level [%Nn].

6.2.26.3.3 DC braking: start in stopping state (Bit 6…8)

Start of the DC braking in state: “quickstop“, “fault reaction“, “shut down“, “disable operation active”. During operation in the torque limit, the speed setpoint at the ramp output can reach zero before the actual speed has fallen below ds62[7] braking speed level [%Nn].

To ensure that the DC braking is safely activated with the setting 128: on + speed level, the waiting time before the modulation switch-off (pn45 fault reaction time) must be configured accordingly.

6.2.26.3.4 DC braking: start at DEC (Bit 9…11)

With start at DEC = 512: on, the DC braking is started as soon as the ramp state DEC is active. If DC braking shall be started below a speed level, the setting 1024: speed level must be selected. During operation in the torque limit, the ramp state DEC may have been left and changed to state "CONST“ before the speed level ds62[7] braking speed level [%Nn] is fallen below. Therefore the mode "1024: speed level“ monitors whether both the target speed (ru05 set value display) and the actual speed (ru08 actual value) are below the level. The condition is that the actual speed has been once above the level ds62[7] braking speed level [%Nn].

6.2.26.3.5 Start after switched on (Bit 12, 13)

The DC braking is activated at the change from st12 state machine display 4: switched on to 11: start operation activ

If Speed Search (dd16) is activated, this function runs first.

If the identified speed is less than 5% of the rated motor speed for encoderless drives, it is evaluated as "ZERO". In this case, mode "Start after switched on“ is carried out.

6.2.26.4 DC braking Timing

ds62	timing mode			0x243E Sub Idx. 2
Bit	Function	Value	Plaintext	Notes
0…2	modulation off time	0	base block time (constant)	Setting the motor de-exitation time
3…4	digital input	0	braking time	Parameter ds62[6] braking time determines the time of the DC braking
		8	State	The digital input determines the time of the DC braking.

6.2.26.4.1 Motor de-exitation time (Bit 0…2)

Before DC braking can be started, the flux of the asynchronous machine must be reduced in order to reduce current peaks when switching to DC voltage.

Cause: The DC voltage reacts against the output voltage of the motor which depends on the speed * motor flux.

Depending on the selected control mode cs00 there are different methods for flux reduction.

6.2.26.4.1.1 Motor de-excitation time in v/f operation

In v/f mode, the modulation is switched off for an inverter-dependent constant time (minimum switch-off time).

If ru08 actual value at the start of the DC braking is less than 5% of the rated motor speed, the minimum switch-off time is omitted and the DC voltage is immediately switched to the motor.

6.2.26.4.1.2 Motor de-excitation time in encoderless speed-controlled operation (ASCL)

The modulation is not switched off in closed-loop operation (ASCL), but the flux is reduced by the control. The value to which the flux is to be lowered is calculated depending on the actual speed:

- Actual speed <= 5% rated speed => The flux must not be reduced, set flux = 100% rated flux
- Actual speed >= rated motor speed => The flux is reduced to 20% of the rated flux

The set flux is linearly interpolated between these two speed points.

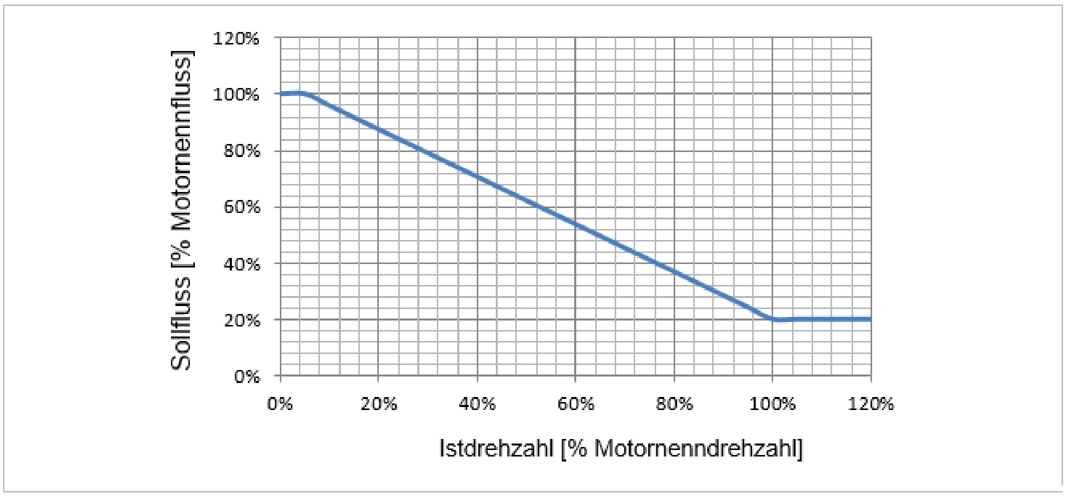


Figure 95: Motor de-excitation time ASCL

6.2.26.4.2 Braking time

- 0: braking time
  Parameter ds62[6] braking time determines the time of the DC braking. After the time has elapsed, "zero" must be detected at the digital inputs to restart the DC braking again.

- 8: state
  The digital input determines the time of the DC braking. As long as it is set, the DC braking is also active.

6.2.26.5 DC braking procedure

6.2.26.5.1 Start of the DC braking

The start condition is selected in ds62[1] DC braking mode.

- ➢ Activation by a digital input
  - Input programmable in ds61 DC braking source
  - Can be combined with falling below a speed level
- ➢ Start by the status of the ramp generator
  - Can be combined with a speed level ds62[7] braking speed level
- ➢ Start depending on the CIA state machine
  - State machine in a "stopping mode“ (quickstop, fault reaction, shut down active, disable operation active)
  - “stopping mode” can be combined with falling below a speed level
  - Change of the state machine to "switched on“
- ➢ Start depending on the state of the ramp generator
  - State DEC
  - Depending on target and actual speed

The flux of the asynchronous motor must be reduced to activate the DC braking. The method of flux reduction can be selected with ds62[2] timing mode Bit 0…2. Currently only one mode is available. Depending on the control mode, the modulation is switched off for a constant, hardware-dependent time or the flux is actively reduced. The modulation off time is displayed in ds62[3] modulation off time.

6.2.26.5.2 Braking time

The time of DC braking is determined by ds.62[6] braking time.

When using a digital input for control and selection of ds62[2] Bit 3…4 digital input = 8: state the duration of the DC braking is determined by the digital input.

6.3 Speed controller

6.3.1 Overview

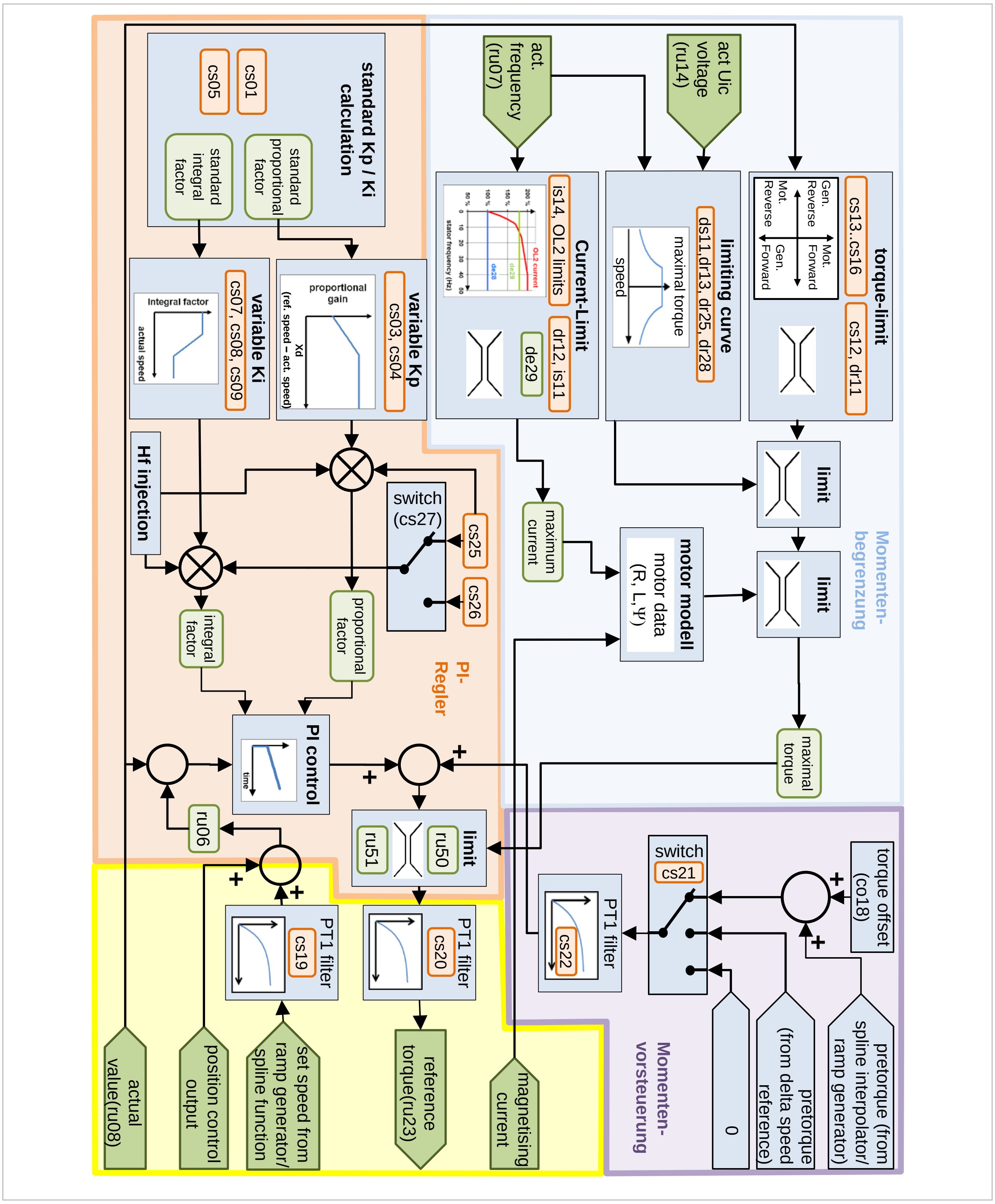


Figure 96: Speed controller overview

6.3.2 PI-speed controller

The speed controller is a PI controller which is defined by its total gain (cs01 / valid for the proportional and integral part) and the reset time Tn (cs05).

The proportional factor Kp and integral factor Ki of the controller is internally calculated from these parameters.

Additionally, there is the possibility to influence the proportional part depending on the system deviation and the integral part depending on the actual speed.

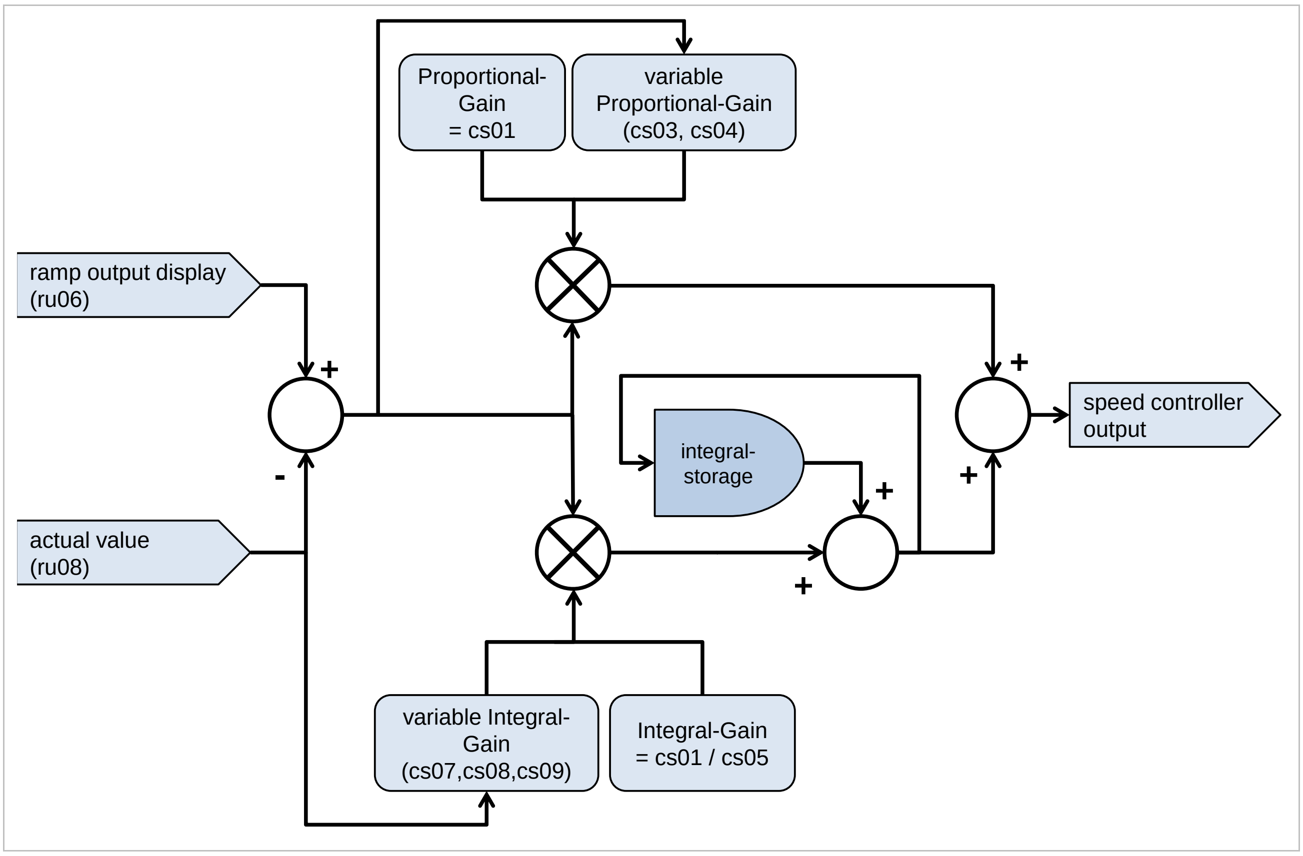


Figure 97: Pi-speed controller

In order to improve the control performance of the drive (smaller overshoot, higher dynamics), the speed controller can be pre-controlled with known mass moment of inertia.

The gain cs01 KP speed and reset time cs05 Tn speed of the speed controller can be calculated automatically by the drive. Therefore the mass moment of inertia of the entire system dr32 inertia motor (kg*cm^2) + rigidly coupled load cs17 inertia load (kg*cm^2) must be entered.

cs99	optimisation factor		0x2763
Value	Display		
19	off	Automatic controller calculation deactivated	
20…100	2.0…10.0	Hardest...softest automatic controller setting	

The symmetrical optimum cs99 optimisation factor is used to set a value for cs01 KP speed and cs05 Tn speed in a defined ratio depending on the set mass moment of inertia and the desired control dynamics.

Parameters for a dynamic, hard speed controller adjustment are calculated with cs99 = 2.0.

Disturbance factors - such as torsion or backlash of the load coupling - influence the entire system. A subsequent manual fine adjustment of the controller may therefore be necessary.

Parameters for a soft and slow speed controller adjustment are calculated with cs99 = 10.0.

A possible disturbance at encoderless operation is an oscillation on the estimated speed. An extension of the filter time ds28 (A)SCL filter speed calc. often allows a more dynamic speed controller adjustment, i.e. a smaller value for cs99.

The encoder resolution must be considered at operation with encoder. The lower the resolution, the higher the calculated gain.

The speed controller parameters are changed with writing on cs99.

The automatic precharging of the speed controller parameters can be deactivated with the adjustment of cs99 = 19 = off.

If cs01 KP speed or cs05 Tn speed is adjusted manually, the value of cs99 changes automatically to 19 "off“ = automatic calculation deactivated.

i

The adjustment cs01 = 10.0 = 10 %Mn / rpm means:

- at speed deviation of 1 rpm, 10% of the motor rated torque is output from the controller as proportional component
- the rated torque is output at a deviation of 10 rpm

6.3.3 Variable proportional factor ((system deviation)

The proportional gain (Kp) can be increased proportionally to the control deviation.

Thereby the total proportional gain is calculated to:

- variable factor = system deviation [% rated speed] * cs03
- the variable factor is limited by cs04 speed ctrl limit
- Total proportional gain = (1 + limited variable factor) * cs01

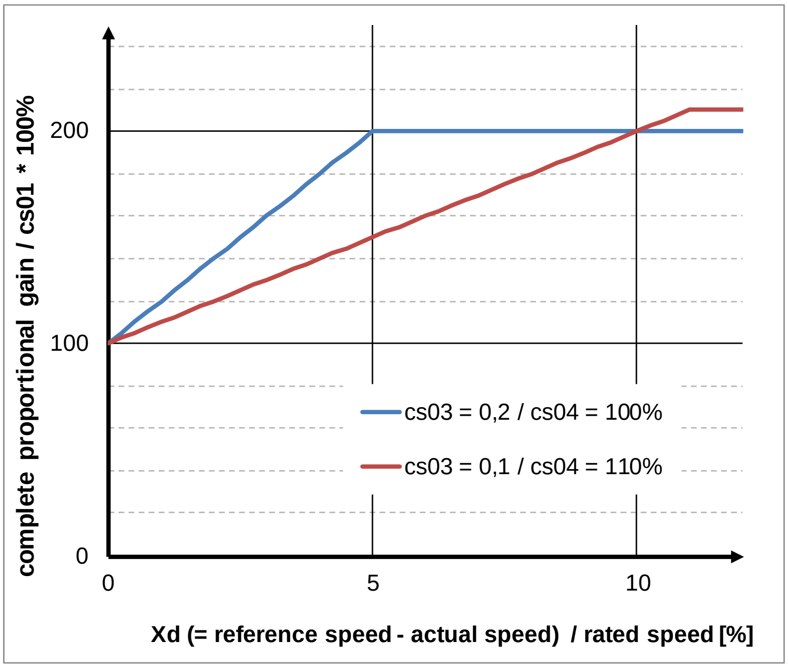


Figure 98: Variable proportional factor

Example:

cs01 = 1.2 [%Mn / rpm]
cs03 = 0.5
cs04 = 150%

Setpoint speed = 100 rpm
Actual speed = 80 rpm
Rated speed = 2000 rpm

=> Xd = (100 – 80) / 2000 * 100 = 1 % rated speed
=> variable factor = 0.5 * 1 = 0.5
=> limitation of the factor with cs04 = 1.5 => no limitation
=> total proportional gain = (1 + 0.5) * cs01 = 1.5 * 1.2 = 1.8

=> Maximum proportional gain = (1 + cs04) * cs01 = 2.5 * cs01 = 3

6.3.4 Variable proportional/integral factor (speed)

The proportional and integral factor can be changed speed-dependent in order to achieve a higher standstill rigidity.

The total proportional factor is made up of:

$KP_{total} = KP_{base} + KP_{var}$

KP_{base} = cs01

KP_{var} changes between cs08 speed for max. kp/ki and cs09 speed for normal kp/ki from value cs06 variable kp speed offset to 0.

Maximum KP = KP_{base} * (1 + cs06)

The total integral factor is made up of:

$KI_{total} = KI_{base} + KI_{var}$

KI_{base} = cs01 / cs05

KI_{var} changes between cs08 speed for max. kp/ki and cs09 speed for normal kp/ki from value cs07 variable ki speed offset to 0.

Maximum KI = KI_{base} * (1 + cs07)

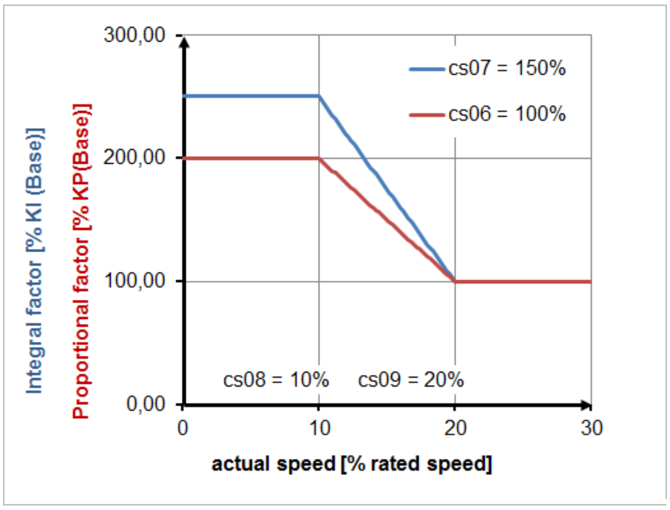


Figure 99: Variable proportional factor (kp) / integral factor (ki) with cs08=10%, cs09=20%

Example:

n_{rated} = 2000rpm

cs08 = 10% => $n_{for\ max\ KP,KI}$ = 200rpm

cs01 KP speed [%Mn/rpm] = 1

cs05 Tn speed = 20ms = 0.02 s

=> Ki_{Base} cs01 / cs05 = 50% M_{rated}/(rpm * s)

cs07 = 150% => (1 + cs07) = 2.5

KI = 125% M_{rated}/(rpm * s) to 200rpm

KI = 87.5% M_{rated}/(rpm * s) at 300rpm

KI = 50% M_{rated}/(rpm * s) from 400rpm

cs09 = 20% => $n_{for\ min\ KP,\ KI}$ = 400rpm

cs01 KP speed [%Mn/rpm] = 1

cs06 = 100% => (1 + cs06) = 2

KP = 2% M_{rated}/rpm to 200rpm

KP = 1.5% M_{rated}/rpm at 300rpm

KP = 1% M_{rated}/rpm from 400rpm

6.3.5 Speed controller adjustment via process data

The calculation of internal control proportional / integral factors can not be done quickly enough in order to preset cs01 and cs05 via process data.

To give the user the possibility of dynamic controller adjustment via process data, the proportional and/or integral factor can be weaken with cs25 and cs26 (writable via process data).

Index	Id-Text	Name	Function
0x2719	cs25	speed ctrl (KP) adaption	Presetting of the controller weakening in percent [jn 0.1%]. Depending on cs27, cs25 acts on integral and proportional or only on the proportional gain.
0x271A	cs26	speed ctrl (KI) adaption	Presetting of the controller weakening in percent [jn 0.1%]. Depending on cs27, cs26 has no function or acts on the integral gain.
0x271B	cs27	speed ctrl KP/KI adapt mode	Determines the influence of cs25 and cs26.

cs27	speed ctrl KP/KI adapt mode		0x271B
Value	Name	Meaning	
0	only cs25	cs25 affects integral and proportional gain.	
1	P=cs25, I=cs26	cs25 affects proportional and cs26 affects integral gain.	

If the Ki is set to zero by the controller weakening, the integral part is also deleted.

6.3.6 Determination of the mass moment of inertia

The mass moment of inertia of the total system must be known (i.e. motor + rigidly coupled load) both for the automatic calculation of the speed controller parameters and for the precontrol of the acceleration torque.

The mass moment of inertia can be determined by an acceleration test if it is unknown.

Therefore the system must be accelerated with defined, constant torque. It must be ensured that there is no significant, acceleration-independent load torque by the application.

The following formula is valid:

$$J\ [kg * cm^2] = 95493 * \Delta M\ [Nm] * {}^{\Delta t\ [s]}\!/_{\Delta n\ [rpm\ \ ]}$$

Example:

the following acceleration was recorded with COMBIVIS:

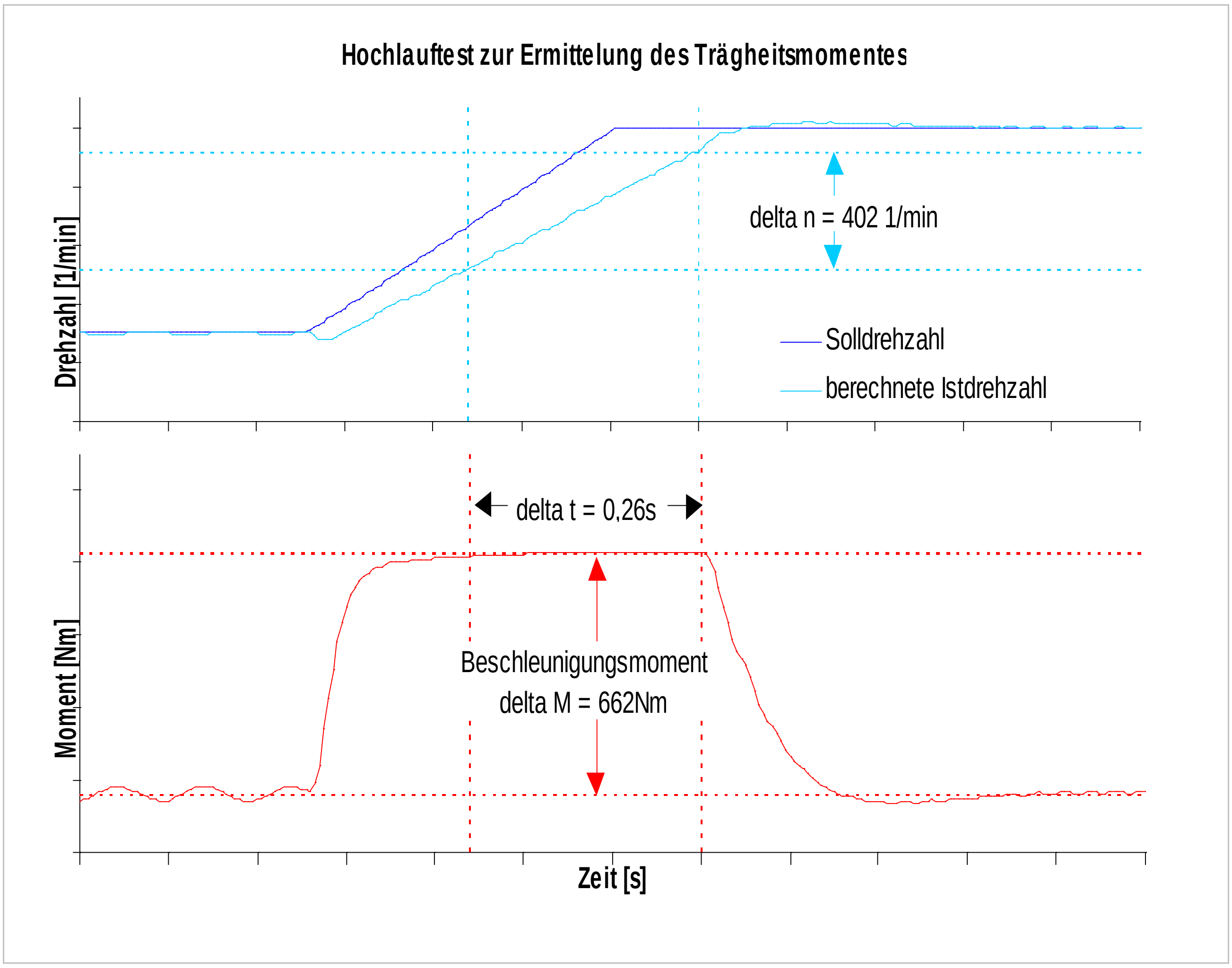


Figure 100: High-run test with COMBIVIS

$$J\ [kg * cm^2] = 95493 * 662\ Nm * \frac{0,.6\ s}{402\ rpm} = 40886\ kgcm^2$$

In order to eliminate the influence of friction from the calculation, the mass moment of inertia can be determined similarly a second time, however by deceleration test. The average value of both inertia, determined at acceleration or deceleration must be entered in parameter dr32 inertia motor (kg cm^2).

Since only one total inertia (motor + load) is determined cs17 must be set to 0.

6.3.7 Speed controller PT1 output filter

A PT1 low pass filter is series-connected to the speed controller.

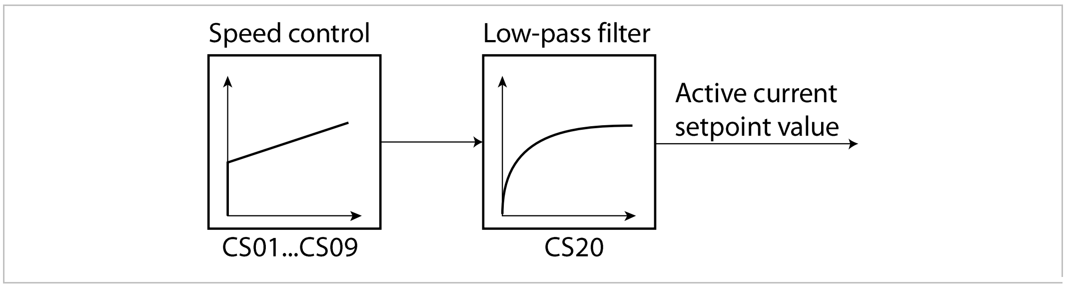


Figure 101: PT1 output filter

Thus, high-frequency oscillations (caused by spring elements in the mechanics of the drive train) can be filtered from the active current setpoint signal.

The filter time is adjusted in parameter (cs20 torque ref PT1 time). A longer time causes a stronger smoothing of the active current signal, but also a lower dynamic control behaviour and increased oscillation.

6.3.8 Torque precontrol

The required torque to accelerate/decelerate the drive can be calculated if the mass moment of inertia of a drive is known.

Additionally, the torque can also be pre-controlled by the control via co18 (CiA 0x60B2) torque offset.

This function is defined with the following parameters.

Index	Id-Text	Name	Function	
0x2715	cs21	pretorque mode	Source selection for the torque precontrol	
0x2716	cs22	pretorque PT1-time	Filter time for torque precontrol (PT1 filter)	
0x2717	cs23	pretorque delta time	Time for speed setpoint difference	at cs21 pretorque mode = 1
0x2718	cs24	pretorque factor	Access of the precontrol	
0x2512	co18	(CiA 0x60B2) torque offset	Offset can be preset via the control	at cs21 pretorque mode = 2
0x2514	co20	internal pretorque fact	Access of the precontrol	

6.3.8.1 Torque precontrol mode

Different modes can be adjusted via cs21 pretorque mode:

cs21	pretorque mode	0x2715
Value	Name	Meaning
0	off	no precontrol
1	delta speed ref	Mode 1: The precontrol is determined from the setpoint speed difference in the time of cs23 and the inertia.
2	reference torque	Mode 2: The precontrol is calculated in the spline interpolator or ramp generator from the acceleration-/deceleration values and the inertia. Additionally the control can preset an offset via co18.

Mode 1: Independent on the operating mode the torque precontrol is always generated from the difference of the speed setpoint and the previous value. Peaks in the precontrol signal can be reduced by selecting a higher delta time (cs23 pretorque delta time). A change of the reciprocal of amplification is possible with cs24.

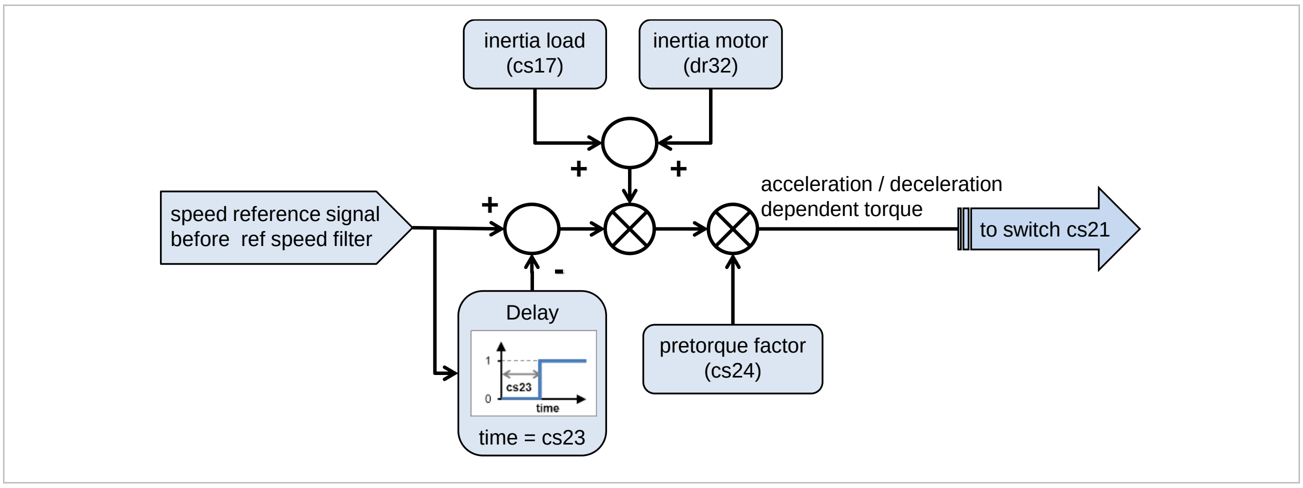


Figure 102: Torque precontrol mode 1

Mode 2: The torque precontrol is done directly from the actual operating mode. An offset can be added via the control to this signal to realize (e.g.) additional, application-specific precontrol. A change of the reciprocal of amplification is possible with co20.

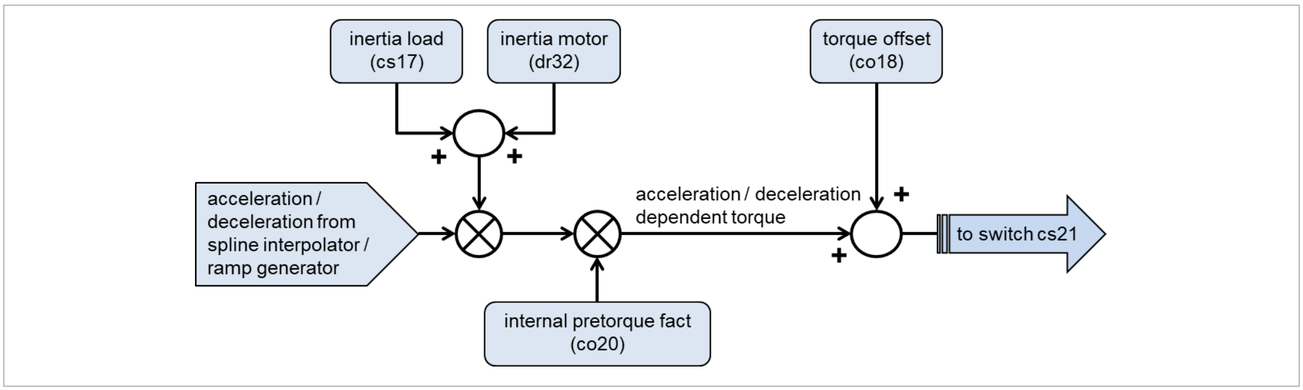


Figure 103: Torque precontrol mode 2

6.3.8.2 Torque precontrol reciprocal of amplification

The reciprocal of amplification of the acceleration/deceleration-dependent precontrol is adjustable. Parameter cs24 pretorque factor must be used in mode 1 and parameter co20 internal pretorque fact in mode 2.

Not always the best control result is reached with the precontrol reciprocal of amplification of 100%. This is partly due to the inaccuracy or change of the inertia, but also partly on the behaviour of the total control circuit. The required torque (motor and regenerative) can be different at the same acceleration (e.g. due to friction).

The control performance is significant improved with correctly adjusted precontrol.

6.3.8.3 Torque precontrol smoothing

Torque peaks, caused by discontinuous speed setpoint setting can be reduced by a low pass filter. Also valid here: the higher the filter time (cs22 pretorque PT1 time), the better the smoothing but the precontrol is more undynamic and decelerated.

An excessively decelerated precontrol can operate even against the speed controller output and lead to vibration. The parameter for the precontrol filter is valid for mode 1 and mode 2.

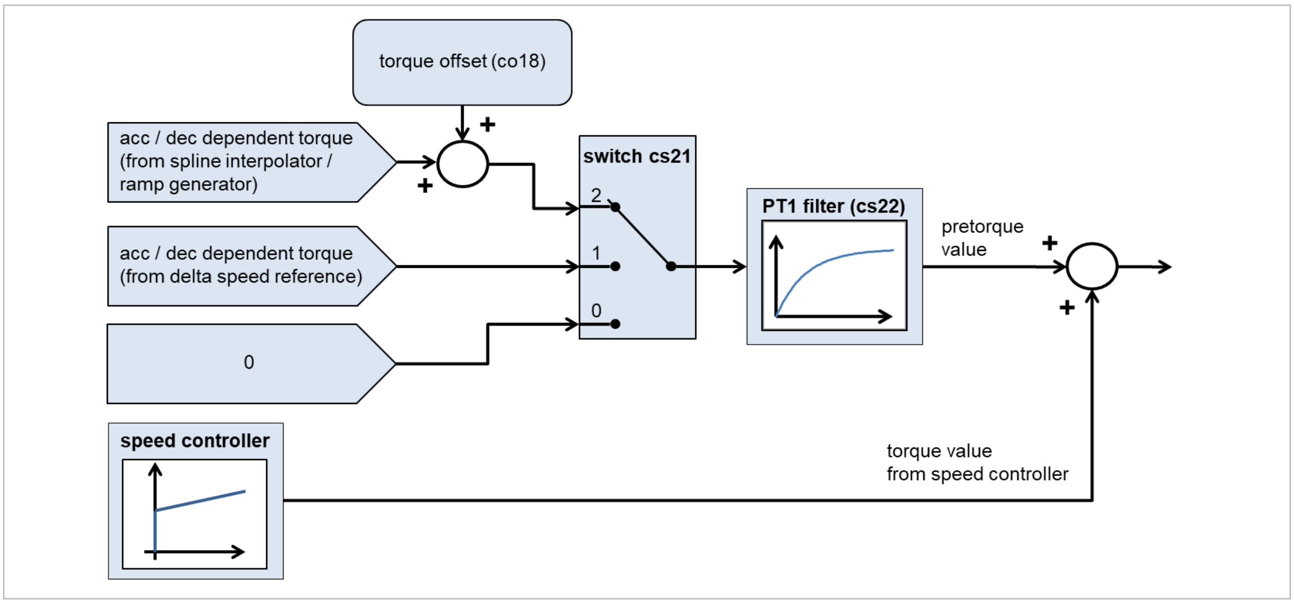
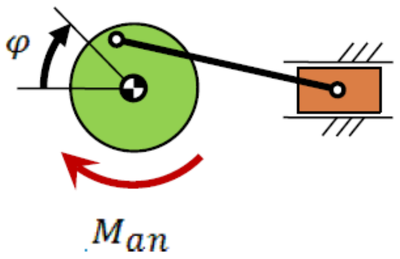


Figure 104: Torque precontrol smoothing

6.3.8.4 Not linear torque precontrol

6.3.8.4.1 Principle

The precontrol has not the desired effect proportional to the acceleration (e.g. at crank operation). Here observe non-linear relations.



$$M_{an}(\varphi) = M_w(\varphi) + J(\varphi) * \ddot{\varphi} + \frac{1}{2} * J'(\varphi) * \dot{\varphi}^2$$

Index	Id-Text	Name	Function
0x2524	co36	inertia reducing mode	0 … 23
0x2525	co37	inertia reducing fact	0 … 255 -> 0 … 1.0, Array 64
0x2526	co38	inertia derivation fact	-127 … 0 … 127 -> -1 …0…1, Array 64
0x2527	co39	inertia derivation [kg*cm^2]	
0x2528	co40	weight comp fact	-127 … 0 … 127 -> -1…0…1, Array 64
0x2529	co41	weight comp torque	1024 → Mn
0x252A	co42	speed angle offset	0 … 100 ms
0x252B	co43	speed ctrl reducing fact	0 … 255 -> 0 … 1.0, Array 64

co36	inertia reducing mode	
Bit	Name	Meaning
0	pretorque reducing	Scaling of the precontrol with the factor from co37(φ)
1	inertia derivation	Modification of the precontrol with co38(φ) * co39
2	weight compensation	Compensation of weights Mw = co40[φ] * co41
3,4	speed control reducing	Scaling of the gain of the speed controller with the factor from co37(φ) 0: off 1: on with the factor from co37 2: on with the factor from co43

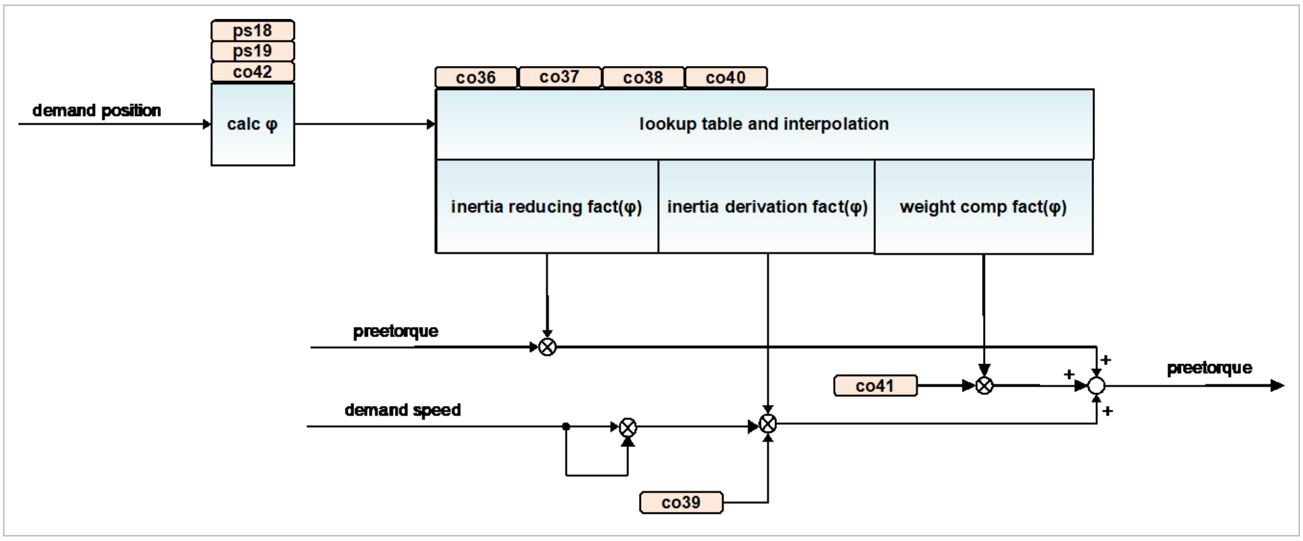


Figure 105: Not linear torque precontrol

6.3.8.4.2 Linear value range

The linear value range is activated with ps38 positioning module / round table mode position = 0 "off".

The limits of ps18 (CiA 0x607B [1]) min position range limit and ps19 (CiA 0x607B [2]) max position range limit are valid for the linear value range.

For positions below ps18 value [1] of the arrays is active. For positions above ps19 value [64] of the arrays is active.

In between there is interpolation.

6.3.8.4.3 Rotatory value range

The rotatory value range is activated with ps38 positioning module / round table mode position = 8 "on".

The periodic value range for the positions is defined with ps18 min position range limit and ps19 max position range limit. The positions of ps18 and ps19 in an imaginary circle are superimposed. Value [1] of the arrays is valid for the position with the value of ps18. Index [64] is not used in this operating mode.

With increasing position, after [63] it is interpolated to [1] again.

6.3.8.4.4 Internal value range

The angle φ is between these two limits of 0 to 2π. Referencing is possible with the homing function.

The minimum position range for non-linear torque pre-control is 2^{10} increments. If necessary, the position resolution can be adjusted with co03 position rotation scale (bit).

The angle φ can be corrected with co42 speed angle offset proportional to the speed setpoint.

There are two arrays, each with 64 entries which can preset a factor for J(φ) (co37 inertia reduce fact) and one for the first derivative of J'(φ) (co38 inertia derivation fact).

co37[1] corresponds to the angle φ = 0.

co37[64] corresponds to the angle $\varphi = \frac{2\pi * 63}{64}$

A compensation of a force can be made only as function of the angle φ with the 64 entries of co40 weight comp fact.

The precontrol is linearly interpolated from the table values in the time pattern of the speed controller.

Output of this function is the object pretorque which is directly accessible via the aa parameters. Scaling factor: 1024 -> rated motor torque

The inertia (virtual present at the motor) of motor + load is considered for the calculation of the precontrol. Load inertia after a gearbox must be converted accordingly. The calculated precontrol torque is the direct torque in the motor. A gear factor is considered with ps35/ps36.

The known precontrol can be reduced position-dependent via parameter co37 inertia reduce fact. A value of 255 (1.0) corresponds to the value for deactivated non-linear precontrol.

The proportion of the first derivative of J(φ) is formed via the factor of co38 * co39.

The value of the maximum value of the first derivative of J (φ) in [$kgcm^2$] is directly set in co39.

The data for the arrays co37, co38 and co40 can be determined from simulation data for the actual application.

For further information and tools, please contact KEB.

6.3.8.4.5 Scaling of the gain of the speed controller

The gain of the speed controller is also adapted as soon as values are entered into object co37 inertia reduce fact.

Simultaneously with the values for co37 also the inertia dr32 + cs17 must be set to the new max. values of the respective inertia.

There are 3 different modes, which depend on the parameterization co36 inertia reducing mode / speed control reducing.

co36	inertia reducing mode	
Bit 3…4	speed control reducing	
Value	Name	Note
0	off	The smallest value in array co37 inertia reduce fact determines the speed controller gain. The minimum value of the array is always used as a weakening factor for the speed controller.
8	on with co37	The interpolated factor for the respective position from the values of co37 is taken as weakening factor for the speed controller
16	on with co43	The interpolated factor for the respective position from the values of co43 is taken as weakening factor for the speed controller

Another array is only available for scaling the speed controller with co43 speed control reduce fact. The same values must be entered in co43 and in co37 for the start. For optimization, separate adjustments can then be made for the speed controller depending on the application.

When the homing function is active, speed control reducing mode 0 is always used, i.e. the gain is always performed with the minimum value of array co37.

6.3.9 Speed setpoint deceleration

With absolutely correct precontrol, the drive would follow exactly the setpoint even without speed controller.

The speed measurement however causes also a deceleration of the actual speed value (scan time ec26, PT1-time ec27). The speed controller wants to control the decelerated actual speed equal to the speed setpoint and accelerates faster than required.

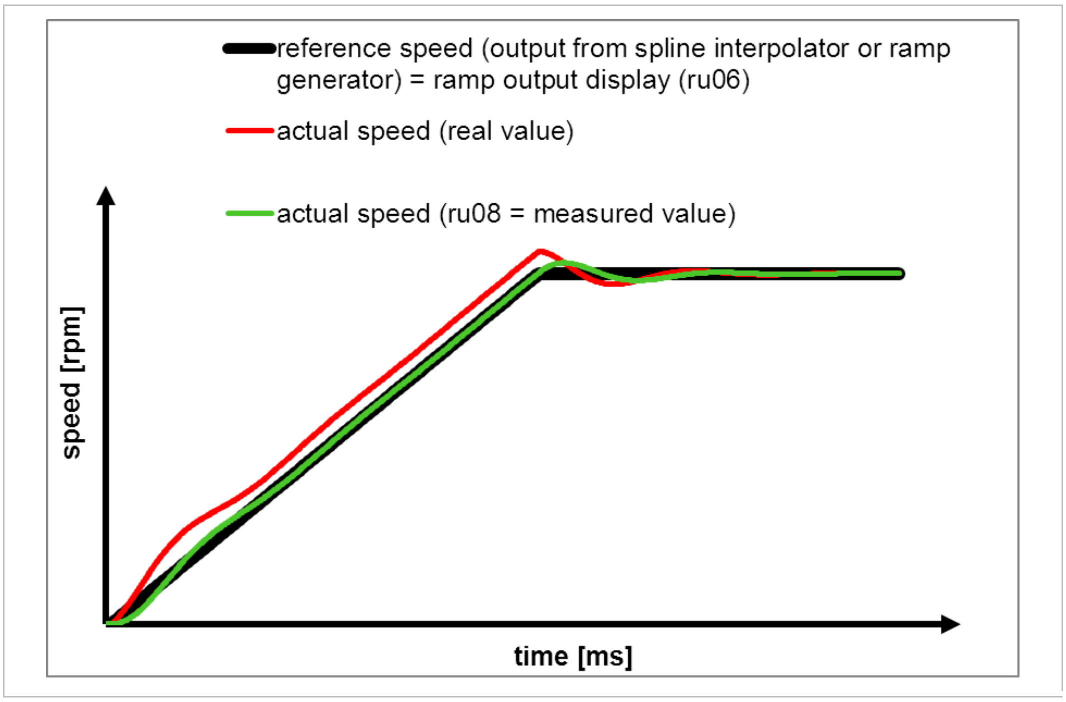


Figure 106: Overshoots in the speed setpoint

To avoid this effect, it is reasonable to decelerate the setpoint speed for the speed controller as well as the actual speed (Filter time + controller reciprocal of amplification time).

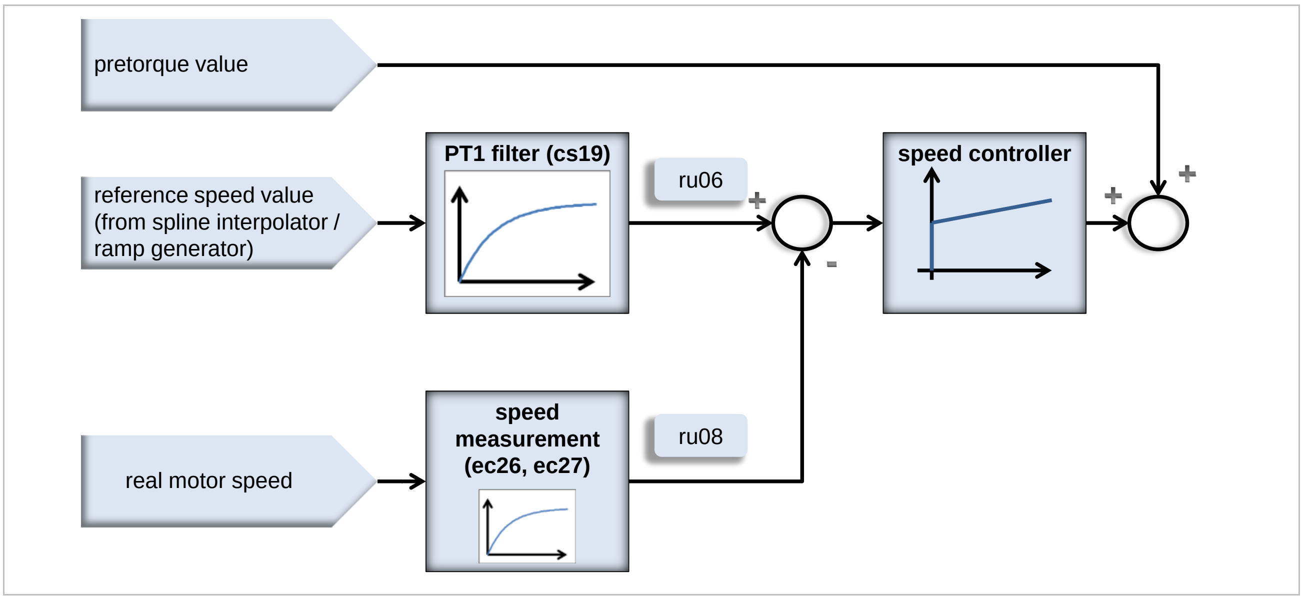


Figure 107: Speed setpoint deceleration

The value for cs19 ref speed PT1-time is calculated as follows:

with encoder	encoderless operation ((A)SCL)
cs19 = ec26 / 2 + ec27 + Td*1	cs19 = ds27 + ds28 + Td*1

*1 controller reciprocal of amplification time Td = 0.5…1.5ms

Thus for the speed controller the setpoint speed applies with the actual speed and the precontrol torque. Since both are decelerated the same, also the real speed and the setpoint speed of the ramp generator / spline interpolator are suitable.

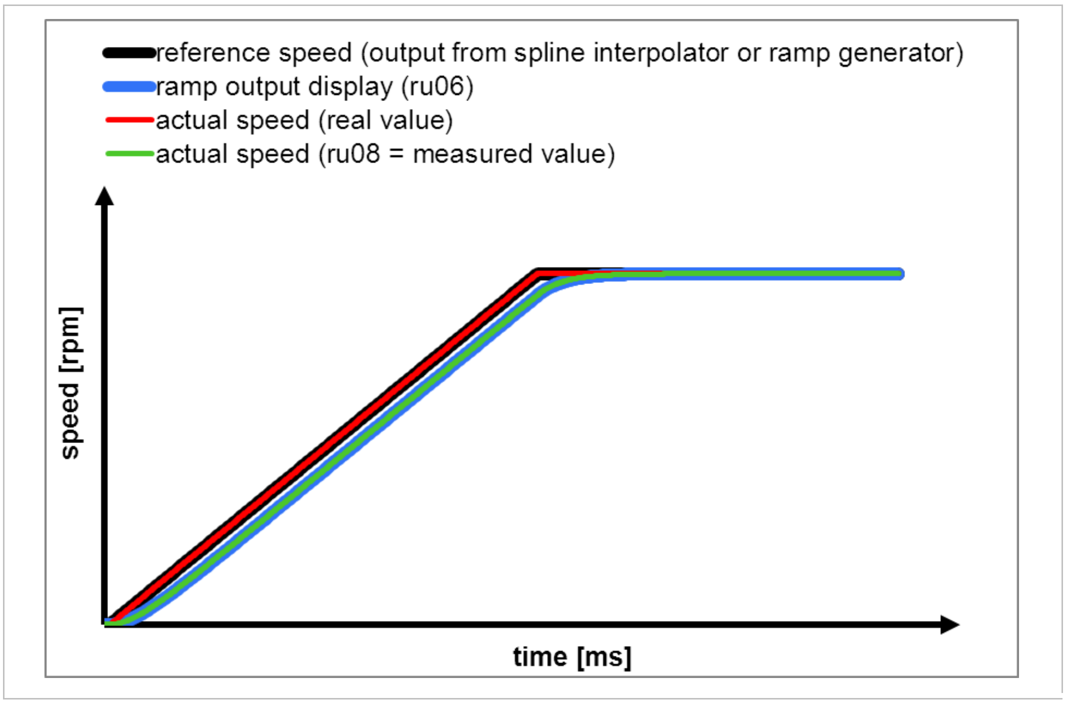


Figure 108: Optimal precontrol behaviour

The optimal behaviour, as shown in the figure above is only approximately reachable.

As shown in the figure for the structure of the position and speed control (Chapter 6.6) there are three Pt1 elements (cs18 ref position PT1 time, cs19 ref speed PT1 time and cs20 torque ref PT1-time) to adjust the three control circuits.

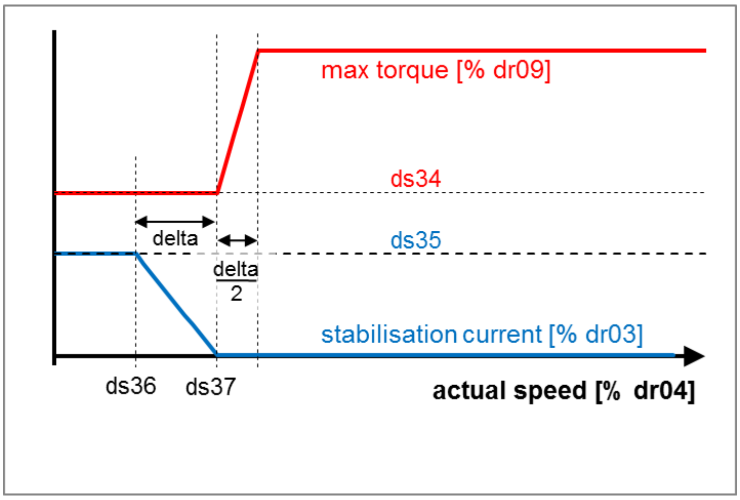
6.4 Torque limits

6.4.1 Physical torque limits

The torque limitation for the field weakening range is described in chapter 6.2.10.4 Torque limiting characteristic.

In the lower speed range, there is the possibility to adjust a limit via parameters of the stabilizing current, which operates independently of the motor type and controlmode.

Index	Id-Text	Name	Function
0x2422	ds34	stab term max. torque	Reduction of the maximum possible torque to small speeds. Particularly helpful in Hf operation. As a function of the speed, between ds37 and ds37 + (ds37- ds36)/2 (in % to rated torque, default value is 0 = Off).
0x2424	ds36	min. speed for stab. current	Speed limits (in % rated motor speed), which lowering the stabilisation current to 0 (value programmed in ds35).
0x2425	ds37	max. speed for stab. current	



Default value:

ds34	off
ds35	50% rated motor current
ds36	5% rated speed
ds37	10% rated speed

Figure 109: Torque limit in the lower speed range

6.4.2 application-dependent torque limits

In some applications it is not desired to set the maximum possible torque, but the application requires other process-related limits (e.g. protection of mechanical components).

This can be adjusted via parameters cs12…cs16 or via the CIA402 objects 6072h, 60E0h and 60E1h in 0.1% of the rated motor torque.

KEB Index	Id-Text	KEB Name	CIA 402 Object Index	CIA 402 Name
0x270C	cs12	absolute torque	0x6072	max torque
0x270D	cs13	torque limit mot for	0x60E0	positive torque limit value
0x270E	cs14	torque limit mot rev	0x60E1	negative torque limit value

The torque limiting characteristic, which is defined by the maximum current and available voltage, remains acitve as higher-level limit.

Index	Id-Text	Name	Function
0x270C	cs12	absolute torque	Max. torque (applies in all quadrants)
0x270D	cs13	torque limit mot. for	Torque limit mot., positive speed
0x270E	cs14	torque limit mot. rev	Torque limit mot., negative speed -1: mot. forward => Value is accepted from cs13
0x270F	cs15	torque limit gen. for	Torque limit gen., positive speed -1: mot. forward => Value is accepted from cs13 -2: mot. reverse => Value is accepted from cs14
0x2710	cs16	torque limit gen. rev	Torque limit gen., negative speed -1: gen. forward => Value is accepted from cs15 -2: mot. forward => Value is accepted from cs13

An absolute limit can be defined with parameter cs12 absolute torque which should not be exceeded in the application and remains active in all operating ranges.

Parameter cs13 torque limit mot can be used if only one limit is required for all operating ranges (forward, reverse, motor and regenerative operation). Then the limits cs14…cs16 must be set to -1.

If different torque limits are required, enter these limits in parameters cs14…cs16 (= torque limit for different operating ranges).

A special torque limit can additionally be set for the emergency stop (fault reaction ramp) (=> Chapter 4.3.1.2.5 Error reaction/stop_function torque limit).

Example:

The control presets only the motor torque limit, regenerative parameterization shall be effective for positive and negative speed in cs15 torque limit gen. for.

cs12	= 150%, absolute limitation
cs13	(mot. forward) is preset via the bus address 270Eh (value 1000 => 100% => Mn)
cs14	(mot. reverse) = -1: mot.forward = cs13
cs15	(gen. forward) = 90%
cs16	(gen. reverse) = -1: gen. forward = cs15

6.5 Position control

6.5.1 Position values

The following parameters contain position values:

Index	Id-Text	Name	Function
0x2C21	ru33	position actual value	Position value of the encoder after the gear factor ec24 / ec25
0x2C26	ru38	encoder positions	Structure of position values of encoder 1
		gearless pos [1]	Direct position value of the encoder 32bit without sign
		gearless pos high [2]	Upper 16bit of the direct position value
		gearless pos low [3]	Lower 16bit of the direct position value
0x2513	co19	target position	Set position setting
0x2E27	ps39	index position	Set positions for index positioning
0x2125	st37	demand position	Internal set position
0X2121	st33	position actual value	Position actual value
0x2124	st36	following error	Actual contouring error
0x2E0C	ps12	(CiA 0x6065) following error window	Admissible contouring error window
0x2E0E	ps14	(CiA 0x6067) positioning window	Target window
0x2E10 0x2E11	ps16 ps17	(CiA 0x607D [2]) max software position limit (CiA 0x607D [1]) min software position limit	Position setpoint limit
0x2E12 0x2E13	ps18 ps19	(CiA 0x607B [1]) min position range limit (CiA 0x607B [2]) max position range limit	Position range limit

The resolution of all position values except parameter ru33 position actual value and the structure ru38 encoder positions is defined by co03 position rot.scale (bit).

Parameters st33 position actual value and st37 demand position are influenced by the referencing and the position range limits (ps18 / p19).

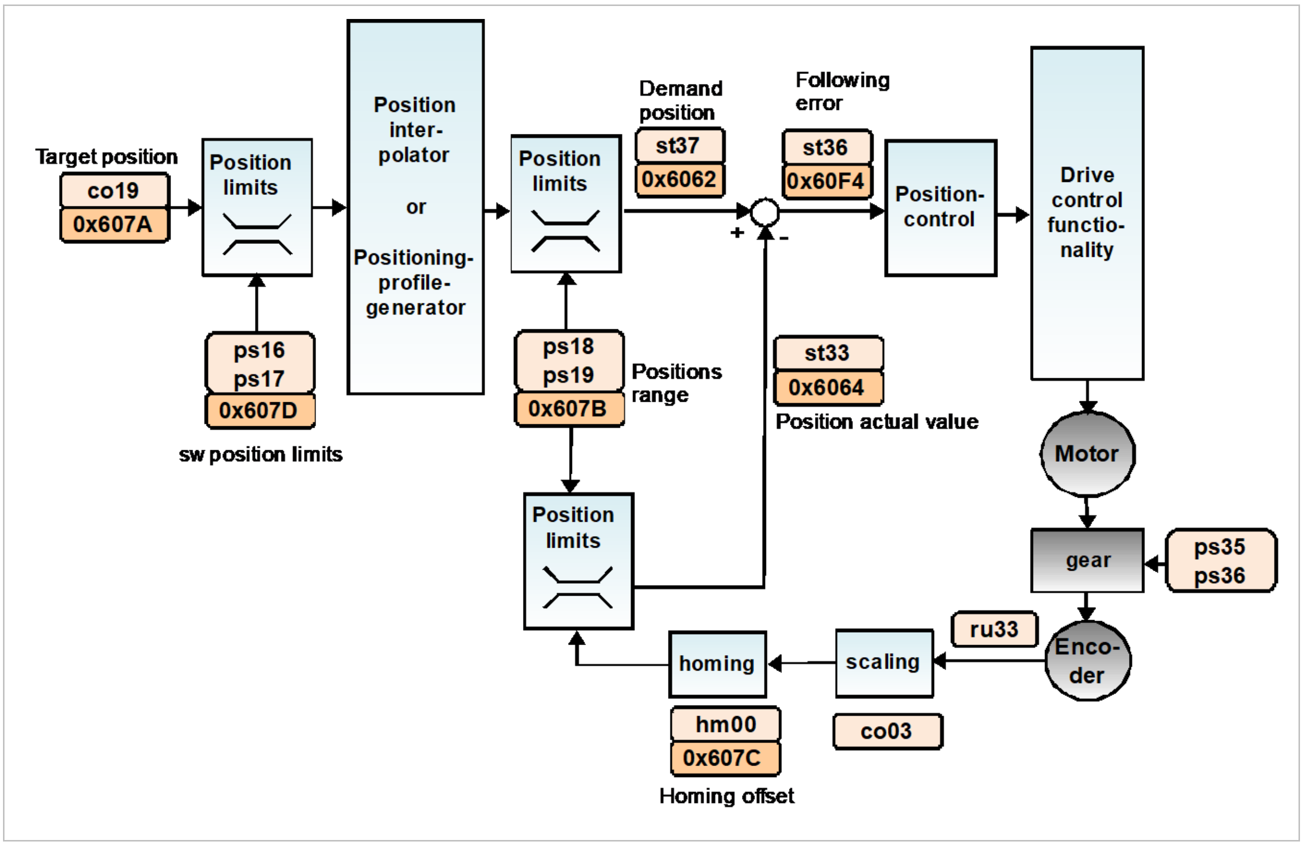


Figure 110: Position control overview

6.5.1.1 Resolution of the position values

The number of increments per position encoder rotation can be adjusted in co03 position rot.scale (bit).

Index	Id-Text	Name	Function
0x2503	co03	position rot.scale (bit)	Position resolution for a rotation of the position encoder

The position resolution for one revolution is adjusted here. The default value of 16 (bit) corresponds to a resolution of 65536 increments per revolution.

Since the objects for the positions all have a size of 32 bit, the maximum amount of whole revolutions result also from co03.

Maximum whole revolutions of the position encoder: $\pm 2^{(31 - co03)}$

6.5.1.2 Software position limits

The limits for the set position (ps16 (CiA 0x607D [2]) max software position limit and ps17 (CiA 0x607D [1]) min software position limit) are checked at the start of the positioning.

- The positioning is not carried out if the set value is outside of these limits. In this case, no error or warning is issued.

If a continuous operation above the 32-bit value range is permitted (continuous positioning in one direction) ps16 (CiA 0x607D [2]) max software position limit must be set to the maximum value and ps17 to the minimum value.

The position limits are also monitored at active speed setpoint value vl20 / vl21. If the drive reaches the software end positions, the drive decelerates at the ramp and drives to speed 0.

ps16	(CiA 0x607D [2]) max software position limit	0x2E10
ps17	(CiA 0x607D [1]) min software position limit	0x2E11
Value	Meaning	
+(231 – 1) … -231	Set position limits	

6.5.1.3 Position range limits

The periodic value range for the positions is defined with ps18 (CiA 0x607B [1]) min position range limit and ps19 (CiA 0x607B [2]) max position range limit . The positions of ps18 and ps19 in an imaginary circle are superimposed.

The value range of the position set and actual values can be limited with the position range limits ps18 (CiA 0x607B [1]) min position range limit and ps19 (CiA 0x607B [2]) max position range limit . The internal set position st37 demand position overflows at the maximum value and starts again at the minimum value.

The new value is calculated as follows: st37 (after limit) = st37 (before limit) - maximum value + minimum value

Accordingly, the internal set position overflows when it falls below the minimum value.

The same applies to the actual position: If st33 position actual value exceeds the limit of ps19 the internal value of hm09 is changed by way that st33 starts again at the lower limit of ps18 (CiA 0x607B [1]) min position range limit . In the negative direction accordingly.

This position limit is displayed only in st33 and st37. All other positions are not affected by the limits.

6.5.1.4 Monitoring the value ranges

Some internal values are depending on different objects. Here you can't decide when programming an object, if the value is valid or not, since this can be decided only after setting of all relevant parameters. The individual parameter setting may not be rejected by invalid data.

With parameter ps22 it is possible to check if the internal values are all within a valid range after parameterisation of the position value range. The result of the internal standardizations is displayed in this parameter.

For a disturbance-free operation always 0: coherently should be displayed in ps22.

Index	Id-Text	Name	Function
0x2E16	ps22	posi setup state	Monitoring of internal value ranges

ps22	posi setup state	
Bit	Name	Meaning
0	position range too small	The position range (ps19 - ps18) has fallen below the minimum value of 1024.
1	position range too large	The position range (ps19 – ps18) is higher than 231.
2	kp position limited	The internal value of ps01 is currently internally limited. (dr04, co03, ps35, ps36)
3	kp zero position limited	The internal value of ps02 is currently internally limited. (dr04, co03, ps35, ps36)

6.5.2 **Position control mode**

ps00	position control mode	0x2E00
Value	Meaning	
0 : off	Position controller is generally off. An existing position difference is deleted.	
1 : auto	Position controller is activated by the operating mode (default) (co01 = -2 "jog mode“ or 2 “velocity mode” or 9 “cyclic synchronous velocity mode” or 10 "cyclic sync torque mode => Position controller off).	
2 : on	Position controller generally switched on	

The position controller is activated / deactivated by the operating modes in mode 1 "auto". This behaviour can be modified with ps00.

Example: it shall be operated only speed-controlled in operating mode 1 "profile position mode". Then ps00 must be set to 0 "off“, since the position controller would be activated if the operating mode is set to 1 "auto".

6.5.3 **Position controller**

The position controller is active with the default setting of ps00 in the operating mode cyclic synchonous position mode and also in the profile positioning mode.

It is defined with the following parameters:

Index	Id-Text	Name	Function
0x2E00	ps00	position control mode	General activation of the position controller
0x2E01	ps01	KP position controller	Proportional gain of the position controller
0x2E02	ps02	KP zero speed position ctrl	Additional proportional gain of the position controller at standstill (speed setpoint= 0)
0x2E03	ps03	KP speed limit reduction	Setpoint-dependent reduction of the KP position controller
0x2E04	ps04	Speed limit for ps03	Speed value for KP reduction by the value of ps03
0x2E0A	ps10	position control limit %	Limitation of the output signal of the position controller in % of rated motor speed
0x2504	co04	position source	Selection of the source for the position signal
0x2E23	ps35	feed forward speed num	Definition of the gear factor between position encoder and motor
0x2E24	ps36	feed forward speed denum	

Since the controlled system has an integral behavior, the position controller is a pure P controller.

The gain factor KP of ps01 KP position controller and ps02 KP zero speed position ctrl is standardized by way that an angle difference of one revolution of the position encoder generates the specified speed setpoint for the position encoder specified in Kp.

Example gain factor Kp:

With an angular deviation of 5° at the position encoder and a Kp of 2000 rpm the output value of the position controller is = 5/360*2000 rpm = 27.8 rpm.

The total value of the setpoint speed (ru06) is added from the speed profile of the spline interpolator or the profile generator and the output value of the position controller.

The gear factor (ps35 / ps36) is considered for the conversion into motor speed setpoint.

The output of the position controller is limited by ps10 position control limit %.

ps10	position ctrl limit %	0x2E0A
Value	Meaning	
0.0…1000.0%	Limitation of the output signal of the position controller in % of rated motor speed	

The limitation of the position controller refers to the motor speed. It is no longer converted with the gear factor.

6.5.3.1 Standard position controller

ps01	KP position controller	0x2E01
Value	Meaning	
0.0…6500.0 rpm	Gain factor	

ps01 KP position controller determines proportional gain of the position controller.

Since the ideal setting for the target approach (i.e. at low speeds at the end of the positioning profile) is often too hard for the positioning process with high speed, the gain can be weakened with ps03 / ps04.

ps03	KP speed limit reduction %	0x2E03
Value	Meaning	
0.0…100.0%	Setpoint-dependent reduction of the KP position controller	

ps04	Speed limit for ps03	0x2E04
Value	Meaning	
0…128000 rpm	Speed value for KP reduction by the value of ps03	

The weakening depends on the setpoint speed, which is calculated from the positioning profile. The setpoint speed, which is the output of the position controller, is not considered.

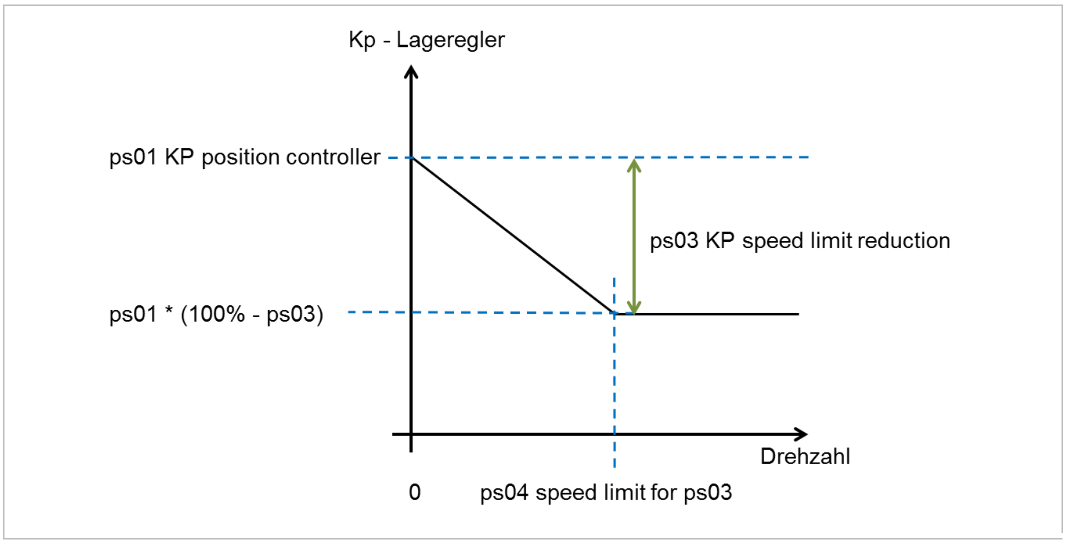


Figure 111: KP reduction in the position controller

The gain is weakened from speed 0 to the level of ps04 speed limit for ps03 by the value set in ps03 KP speed limit reduction.

This means: If ps03 is 75% and ps04 = 1000 rpm, the gain (the Kp from ps01) is reduced from 100% to 25% (weakened by 75%) from profile speed 0 to 1000 rpm.

6.5.3.2 Standstill position control

ps02	KP zero speed position ctrl	0x2E02
Value	Meaning	
0.0…6500.0 rpm	Additional gain factor at setpoint speed 0	

If a very high position rigidity is only required at standstill, the gain (Kp) of the position controller can be increased with ps02 KP zero speed position ctrl at a profile setpoint speed of 0 rpm.

6.5.3.3 Position controller source

The source for the position information is determined with co04 position source:

co04	position source		0x2504
Value	Name	Meaning	
0	channel A	Encoder channel A (terminal X3A) (motor encoder at speed control with encoder)	
1	channel B	Encoder channel B (terminal X3B)	
2	estimated position	Estimated position from the motor model	

The position control can be done - switchable with co04 position source - via encoder at the motor or via second encoder or the estimated position of the motor model.

6.5.3.4 Position controller gear factor

A gear ratio between this second encoder and drive is compensated with ps35 and ps36. This gear factor primarily affects the precontrol in operating modes with active position controller.

The position controller output (standard position controller and standstill position controller) is also converted with the gear factor. This means: the output value of the position controller is 200 rpm with an angular deviation of 1/10 revolution at the position encoder and Kp of 2000 rpm. If the motor rotates 5 times faster than the position encoder due to a gear, the output of the position controller is multiplied with 5, the position controller output value for the set motor speed is 1000 rpm.

ps35	feed forward speed num	0x2E23
Value	Meaning	
+(230 – 1) … -230	Gear factor numerator	

ps36	feed forward speed denom	0x2E24
Value	Meaning	
1 … +(230 – 1)	Gear factor denominator	

6.5.4 **Following error**

The following error st36 following error can be monitored in all operating modes with active position controller.

If the limit of ps12 (CiA 0x6065) following error window is exceeded and additionally the preset time in ps13 (CiA 0x6066) following error time out has elapsed, bit 13 "following error“ is set in the status word.

6.6 Structure position / speed control

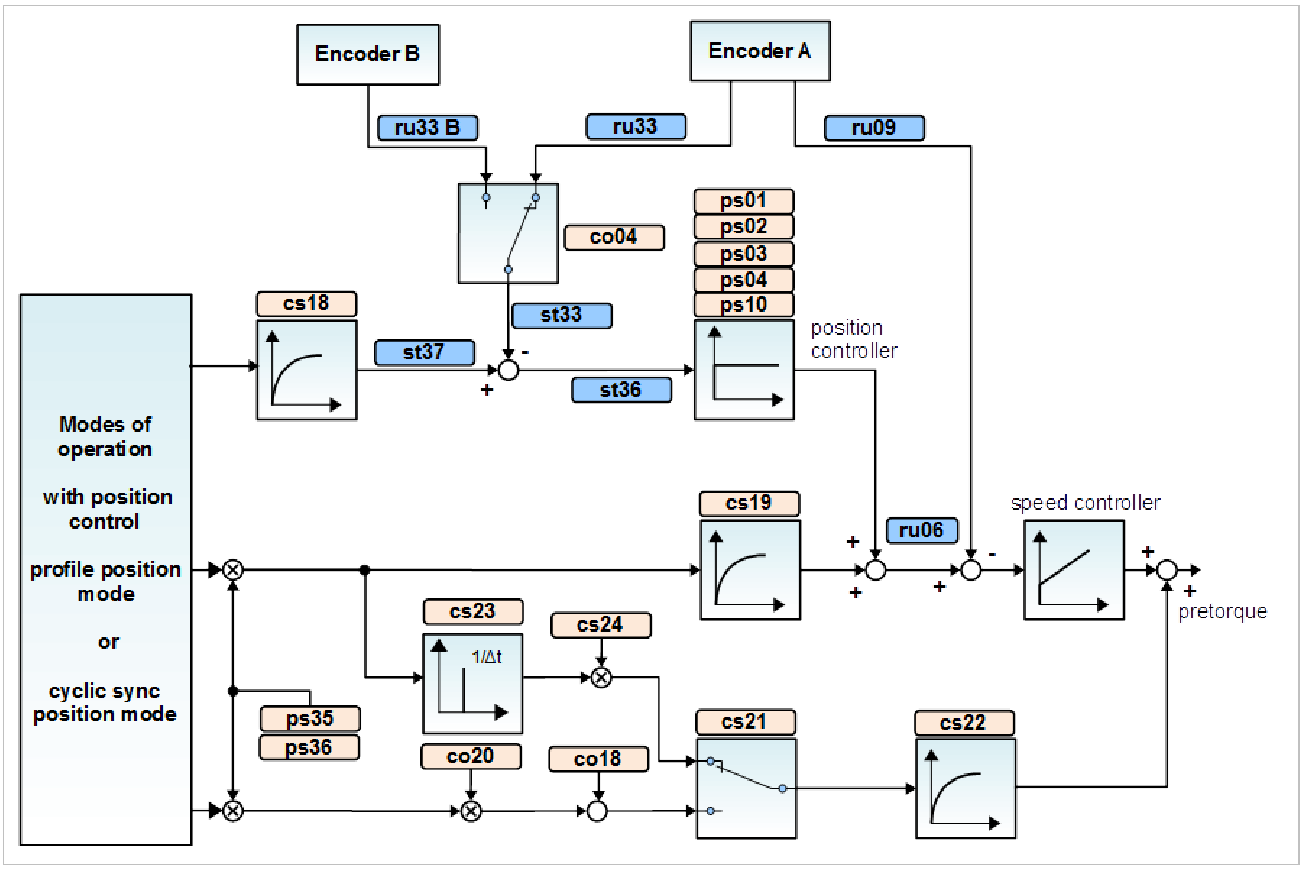


Figure 112: Structure position / speed control

7 I/O functions

7.1 Digital Inputs

7.1.1 Overview

The F6 / S6 inverters have the following digital inputs:

Num-ber	Description
8	Digital inputs on the terminal block X2A of the control board (I1…I8)
2	**Control type K:** Two separate STO inputs on terminal block X2B for modulation release/driver supply **Control type A or P:** Additional safety-relevant inputs on terminal block X2B (depending on the used safety module)
4	Virtual inputs (IA..ID, are fixed assigned to the virtual outputs (OA...OD) ID can only be set via the di parameters
2	"controlword“ inputs: If programmed accordingly, bits 13 and 12 of the digital input state ru18 can be set via the controlword.

The internal image of the digital inputs can be read either from the terminal block or alternatively preset via object di02 dig. input ext. src.

Additionally the inputs can be set to 0 or 1.

The selection of the source for the internal state of the digital inputs occurs via object di01 dig. input src. sel..

The result of the selection can be inverted via di00 dig. input logic.

The state of the terminal block or virtual inputs is displayed in ru41 dig. input terminal state, ru18 dig. input state displays the state of the inputs after passing the input block (i.e. after filtering, inverting, bus setting, etc.).

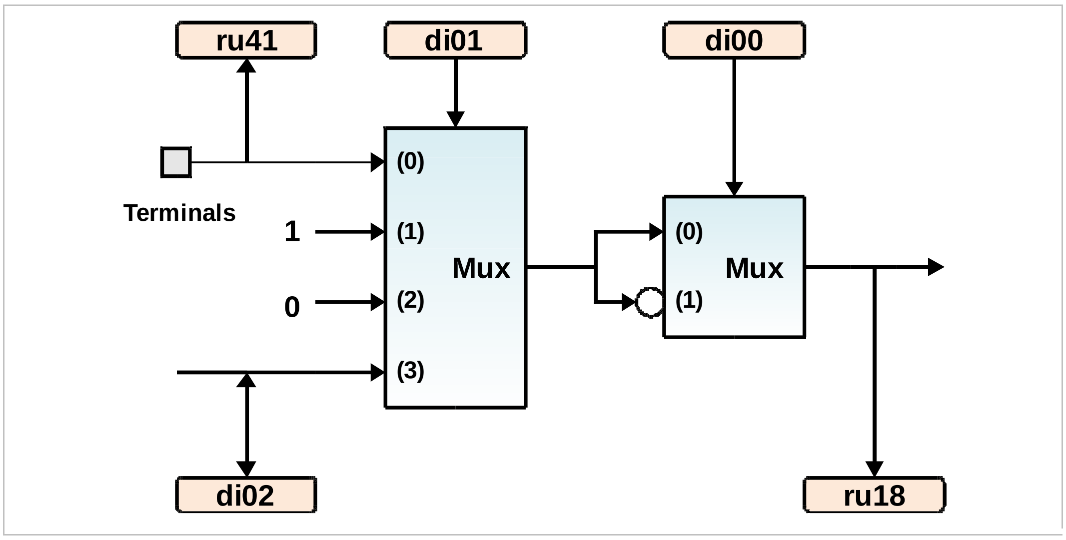


Figure 113: Digital inputs block diagram

7.1.2 Terminal state

The terminal state can be read out via the objects ru18 and ru41.

Index	Id-Text	Name	Function
0x2C12	ru18	dig. input state	Display of the software internal input state after passing the input block including the control-word inputs.
0x2C28	ru41	dig. input terminal state	Display of the status of the hardware or virtual input terminal. The controlword inputs are not displayed.

The meaning of the single bits in ru41 dig. input terminal state is defined as follows:

ru41		dig. input terminal state	0x2C29
Value	Bit	Name	Function
1	0	I1	Hardware input terminal Î1
2	1	I2	Hardware input terminal I2
4	2	I3	Hardware input terminal I3
8	3	I4	Hardware input terminal I4
16	4	I5	Hardware input terminal I5
32	5	I6	Hardware input terminal I6
64	6	I7	Hardware input terminal I7
128	7	I8	Hardware input terminal I8
256	8	IA	Virtual input (of virtual output OA)
512	9	IB	Virtual input (of virtual output OB)
1024	10	IC	Virtual input (of virtual output OC)
2048	11	ID	Virtual input (can only be set via the di parameters)
16384	14	STO-1	Channel 1 from the safety module
32768	15	STO-2	Channel 2 from the safety module

1 means the input is on high level (24V).

The meaning of the single bits in ru18 dig. input state is defined as follows:

ru18		dig. input state	0x2C12	
Value	Bit	Name	Function	
1	0	I1	Input state I1	
2	1	I2	Input state I2	
4	2	I3	Input state I3	
8	3	I4	Input state I4	
16	4	I5	Input state I5	
32	5	I6	Input state I6	
64	6	I7	Input state I7	
128	7	I8	Input state I8	
256	8	IA	Input state IA	
512	9	IB	Input state IB	
1024	10	IC	Input state IC	
2048	11	ID	Input state ID (can only be set by the input block)	
4096	12	CW 1	Controlword input 1	
8192	13	CW 2	Controlword input 2	
16384	14	STO-1	Channel 1 from the safety module	Can not be changed by the input block
32768	15	STO-2	Channel 2 from the safety module	

1 means that the state of the input is set to active at the output of the processing block of the digital inputs.

7.1.3 Selection of the input source

The source for the internal terminal state can be selected via the object di01 dig. input src. sel.

Index	Id-Text	Name	Function
0x3201	di01	dig. input src. sel.	Selection of the internal terminal state source

It can be selected from the 4 sources below for inputs I1...I8 and IA...ID.
The terminal block is always used as source for inputs STO-1 and STO-2.

The selection of the source is done for each input via 2 successive bits in di01 dig. input src. sel. The meaning of this source selection is identical for each input.

di01	dig. input src. sel.				0x3201
Bit	**Func-tion**	**Value**	**Plaintext**	**Function**	
0, 1 2, 3 4, 5 6, 7 8, 9 10, 11 12, 13 14, 15	I1 src I2 src I3 src I4 src I5 src I6 src I7 src I8 src	0	term.	Input state is transferred from the terminal strip X2A	
		1	on	Input state is 1	
		2	off	Input state is 0	
		3	ext. src.	Input state is transferred from di02	
17, 16 19, 18 21, 20	IA src IB src IC src	0	term.	Input state is transferred from the software output	
		65536	on	Input state is 1	
		131072	off	Input state is 0	
		196608	ext. src.	Input state is transferred from di02	
23, 22	ID src	0	term.	reserved, no associated software output available	
		4194304	on	Input state is 1	
		8388608	off	Input state is 0	
		12582912	ext. src.	Input state is transferred from di02	

7.1.4 External setting of the input state

Object di02 dig. input ext. src can also be used as source for the internal input state (except STO inputs).

Index	Id-Text	Name	Function
0x3202	di02	dig. input ext. src	External setting of the input state

The meaning of the bits in di02 dig. input ext. src corresponds to ru18 dig. input state.

i

- ➢ The value of di02 is stored **not** non-volatile.

7.1.5 Inversion of the digital input state

The internal terminal state can be inverted via object di00 dig. input logic.
The state after the inversion can be read out via the object ru18 dig. input state.

Index	Id-Text	Name	Function
0x3200	di00	dig. input logic	Inversion of the digital input state
0x2C12	ru18	dig. input state	Internal image of the digital inputs (after processing such as e.g. inversion)

Only the inputs I1..I8 and IA..ID can be inverted. An inversion of the STO inputs is not possible.

7.1.6 Filter for the digital inputs

The digital inputs I1 … I8 can be filtered via the object di04digital noise filter.

Index	Id-Text	Name	Function
0x3204	di04	digital noise filter	Filter time for the digital inputs in 0.5ms resolution

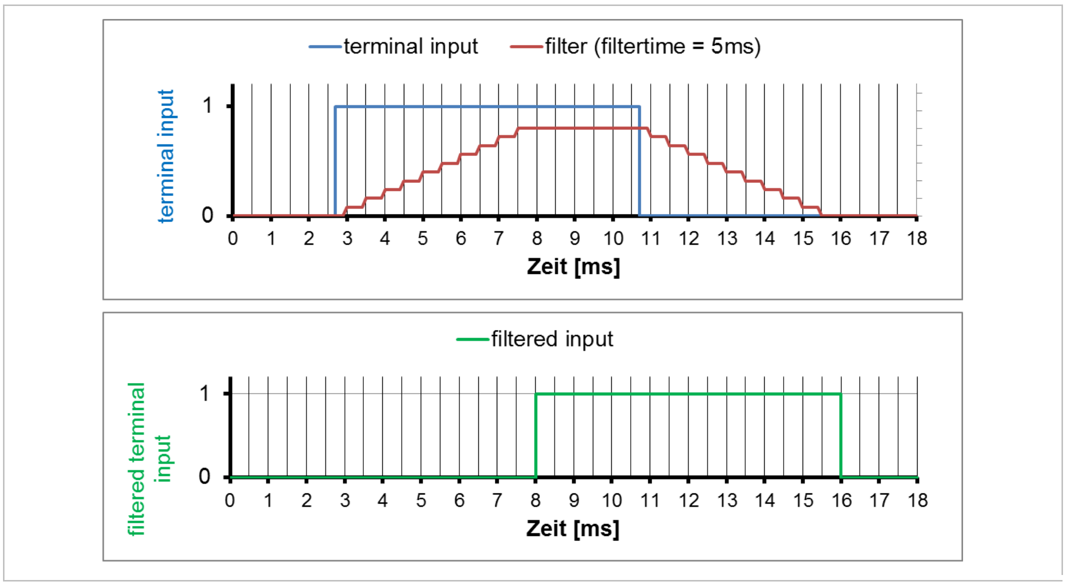


Figure 114: Filter of the digital inputs

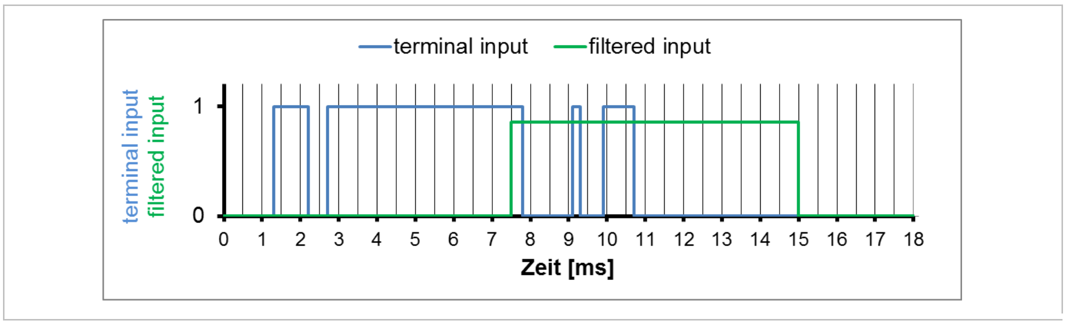


Figure 115: Filter of the digital inputs 2

7.1.7 Controlword inputs CW 1 / CW 2

In addition to the terminals and the software outputs, inputs can also be set via co00 (CiA 0x6040) controlword or address 0x6040.

This allows functions to be activated (e.g. brake chopper control) which can otherwise only be activated via digital inputs.

7.1.7.1 Configuration of the inputs

di28 defines the controlword bits on which the status of the controlword inputs depends on.

di28[1] di28[2]		cw input 1 cw input 2		0x321C
Bit	Value	Plaintext	Note	
0	1	copy bit 11 to cw input x	If one of the selected controlword bits is set, the corresponding controlword input (cw 1 or 2) is set	
1	2	copy bit 12 to cw input x		
2	4	copy bit 13 to cw input x		
3	8	copy bit 14 to cw input x		
4..15		reserved	without function	

7.1.7.2 Display of the inputs

there are 2 new bits in the display of ru18 and in the selection tables of the digital input functions for which the use of the controlword inputs seems reasonable: 12 / 13 controlword input x => CW x.

For functions for which the use of the controlword inputs is not recommended, "reserved" is displayed instead of CW 1 / CW 2. If this bit is used, the corresponding function is also executed.

ru18		dig. input state		0x2C12
Value	Bit	Name	Function	
1	0	I1	Input state I1	
2	1	I2	Input state I2	
4	2	I3	Input state I3	
8	3	I4	Input state I4	
16	4	I5	Input state I5	
32	5	I6	Input state I6	
64	6	I7	Input state I7	
128	7	I8	Input state I8	
256	8	IA	Input state IA	
512	9	IB	Input state IB	
1024	10	IC	Input state IC	
2048	11	ID	Input state ID	
4096	12	CW 1	Input state controlword input 1	controlword inputs
8192	13	CW 2	Input state controlword input 2	
16384	14	STO-1	Channel 1 from the safety module	Can not be changed by the input block
32768	15	STO-2	Channel 2 from the safety module	

7.1.7.3 Application of the inputs

For the following input functions, it may be useful to activate them via the control word:

Input functions			
ds61	DC braking source	di16	forward input
pn30	prg. error source	di17	reverse input
pn31	enable braking trans. source	di20	invert input
pn46	fault reaction end src	an70	PID reset I term
of05	trigger source	an71	deactivate PID
ps44	immediately input	an73	fade out input
hm14	home mode source		

Example: DC braking should be able to be activated by a controlword bit.
Bit 12 shall be used.

- Configuration of the controlword input:
    - in di28[1] set bit 1: copy bit 12 to cw input 1
    - the assignment of the controlword input to the function, activation of the DC braking, must be made in ds61

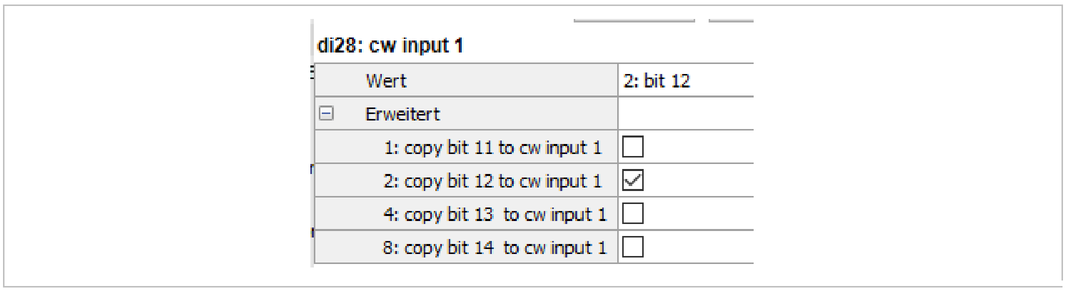


Figure 116: di28 cw input 1

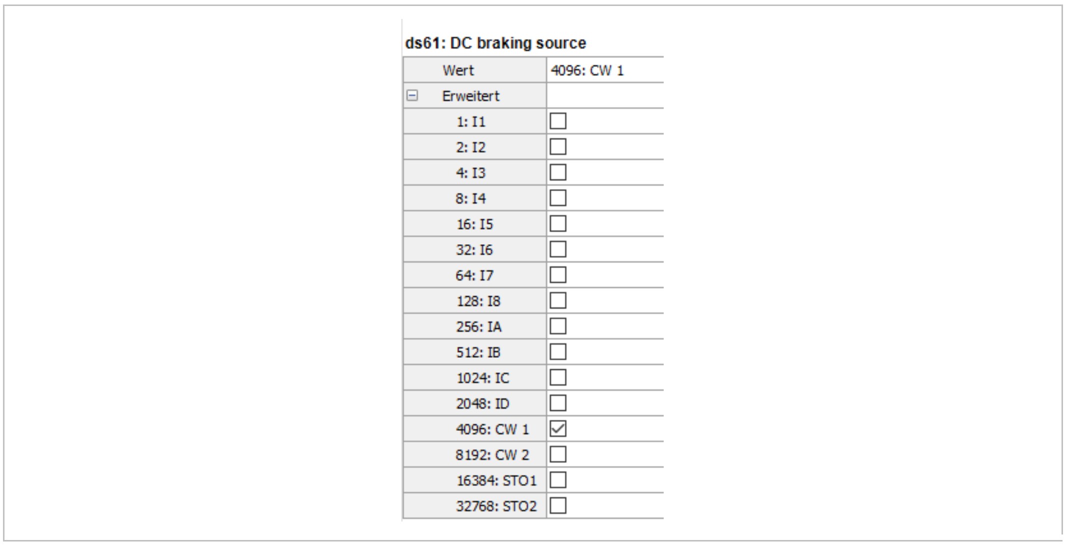


Figure 117: ds61: cw input 1

Now the DC braking can be activated by setting bit 12 in the controlword (0x2500 or 0x6040).

⚠ CAUTION

If bus communication is interrupted, the last status of the controlword inputs is retained. This can cause an unwanted permanent function activation

- The option deactivate braking transitor in error case in connection with suitable parameterization of the watchdog error can provide a remedy.

7.1.8 Overview of the evaluation of digital inputs

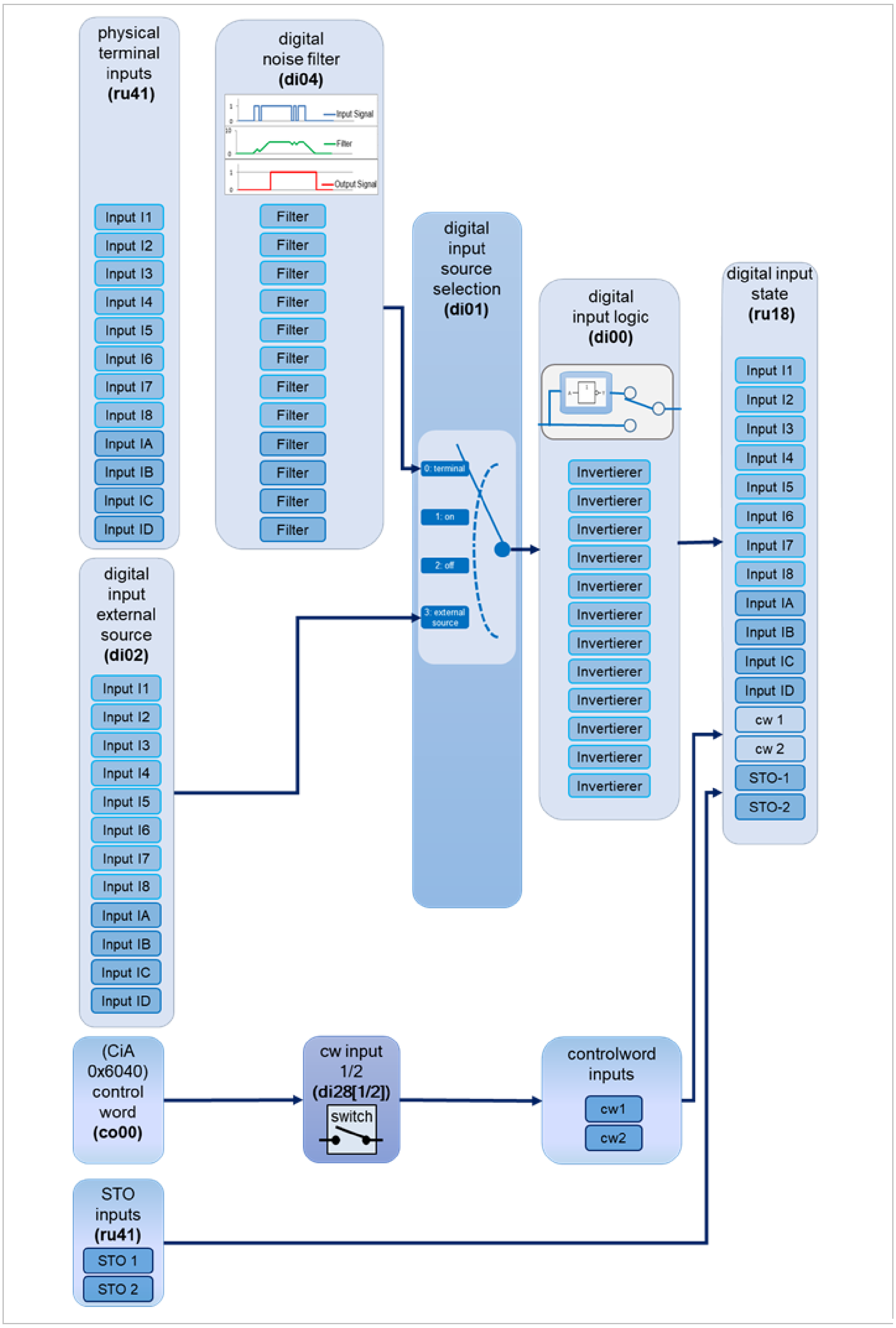


Figure 118: Structure: Evaltuation of the digital input status

7.1.9 Functions of the digital inputs

The control word is the central control object in the X6 unit series.
Alternatively or in combination, operation via digital inputs is also possible.
Parameters di10 to di21 are available to this.

If the parameters co28 / co29 are not used to link the controlword and digital input setting, the processing sequence is as follows:

- Processing of the process data
- Evaluation of the digital inputs
- Access via asynchronous communication (e.g. diagnostic interface or SDOs)
- Processing of the combination logic (7.1.9.1.2 Combined setting via controlword and digital inputs

If several inputs are selected for a function, these are OR operated.

Index	Id-Text	Name	Function
0x320A	di10	RUN input	With active RUN input, value 0x000b is written into the internal control word (=> leads only to status ***operation enabled*** at co32 Bit 3 = 0)
0x320B	di11	RST input	The selected input influences bit 7: "fault reset" of the controlword internal co31
0x320C	di12	CA input	The input selected as CA input influences the bits of the controlword internal selected by CA mask.
0x320D	di13	CA mask	
0x320E	di14	CB input	The input selected as CB input influences the bits of the controlword internal selected by CB mask.
0x320F	di15	CB mask	
0x3210	di16	forward input	Rotation setting via digital inputs
0x3211	di17	reverse input	
0x3212	di18	stop input	If defined and input active, the setpoint speed from the vl parameters is set to zero
0x3213	di19	start posi/homing input	The selected input influences bit 4:“op mode spec“ of the controlword internal co31
0x3214	di20	invert input	If set, the speed setpoint is inverted in operating modes 1 and 2.
0x3215	di21	index input	Actual index. Results from the state of the inputs, which are selected with di21 index input for the index setting.
0x3216	di22	index noise filter	Common filter for all inputs which form together the index
0x3217	di23	halt input	The selected input influences bit 8: halt in the internal controlword.
0x3218	di24	strobe input	Selection of the input which shall be used as strobe signal for index generation.
0x3219	di25	index strobe dependency	Definition of the strobe dependency of the index generation

7.1.9.1 Controlword functions via the digital inputs

All controlword functions can also be activated with digital inputs by di10… di15 and di18, di19:

- specific bits (di10 RUN input , di11 RST input, di19 start posi/homing input, di23 halt input)
- any bits of the controlword via di12..di15. (The mask objects di13 CA mask and di15 CB mask are used to select which bits are preset via the digital inputs.
  The inputs, which determine the state for the selected bits are selected with di12 CA input and di14 CB input).

The status of the digital inputs is taken from parameter ru18 digital input state. The status of the controlword bits influenced via digital inputs is visible in in di29 digital input controlword.

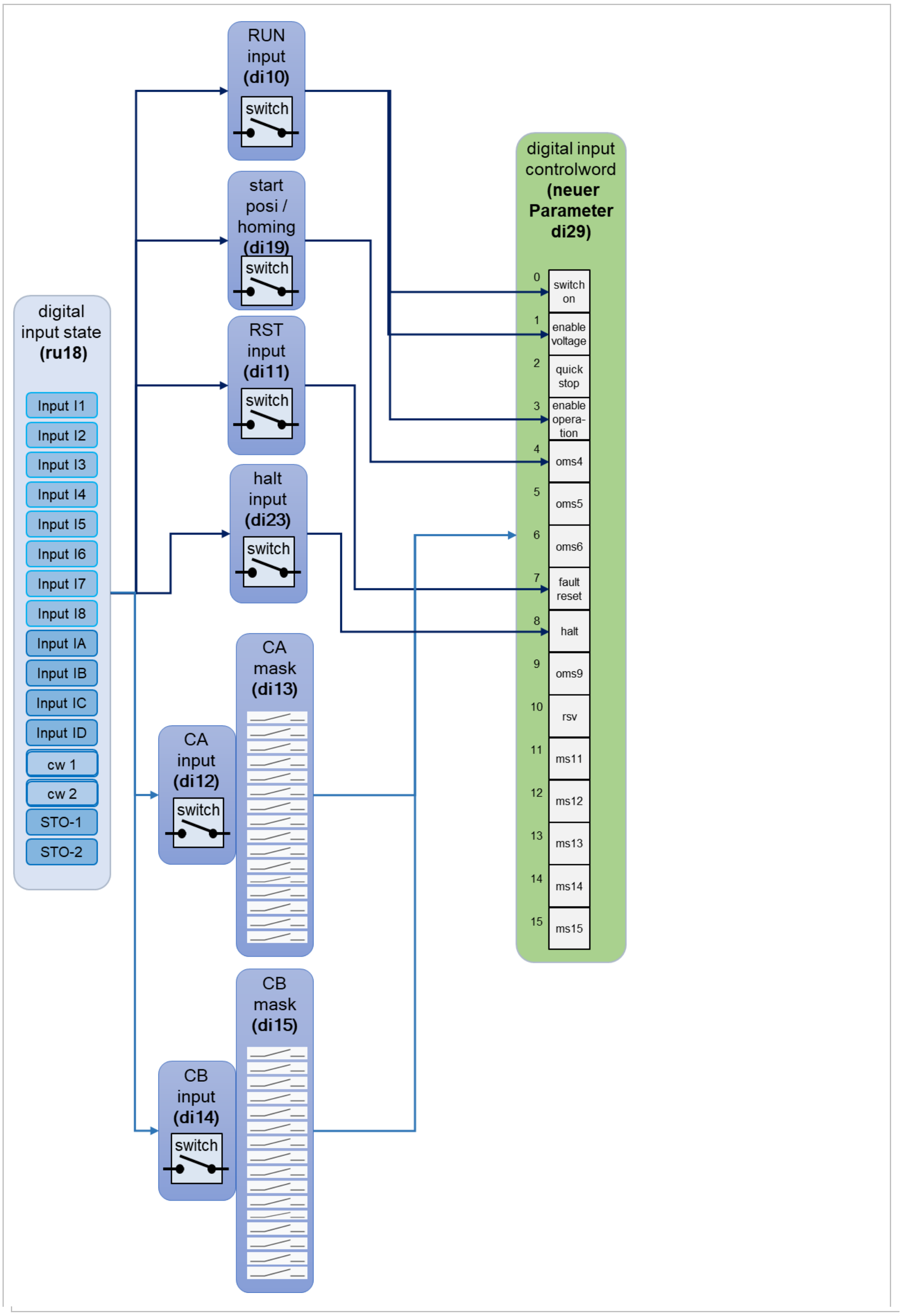


Figure 119: digital input controlword

The control via the fieldbus controlword (0x2500 or 0x0x6040) and the digital inputs can also be combined by parameters co28 combined controlword mask and co29 source connect type.

7.1.9.1.1 Setting via digital inputs

co30 controlword mask which bits are written to the internal controlword c031 by writing to co00 (CiA 0x6040) controlword (Adr. 0x2500) or the controlword in the pr parameters (Adr. 0x6040). "1“ for one bit in co30 causes that the respective bit is transferred into the internal controlword (co31 controlword internal). The default value for co30 is 0xFFFF, thus all bits of the controlword parameters are written into the internal controlword.

The second source for the internal controlword are the bits that are set or reset by digital inputs. The bits are set when the corresponding input is active and reset when the corresponding input is inactive.

If a bit is defined by a digital input, it should no longer be influenced by the controlword parameters, unless you use the combinatorics by co28 / co29. Parameter co30 should contain a "0" for all bits which are preset via the digital inputs.

i

If you have selected functions in the internal controlword with digital inputs, it is reasonable to block these functions for access via the process data.
Bits in the internal controlword can be affected simultaneously from both sources.
However, unintentional intermediate states can occur then, since both sources (controlword parameters and digital inputs) are sequentially processed and written into the internal controlword.

7.1.9.1.2 Combined setting via controlword and digital inputs

2 parameters are used to define the combination logic:

Index	Sub	Text	Name	Function
0x251C	0	co28	combined controlword mask	Number of programmable masks
	1..3			Mask 1..3

Index	Sub	Text	Name	Function
0x251D	0	co29	source connection definition	Number of sub-indices
	1..3			Selection of connection types and activation sources for mask 1..3

co28 combined controlword mask determines which bits of co31 internal controlword are evaluated by linking the "communication" controlword (co00 or 0x6040) and the "digital input" controlword (controlword combination block in figure 1).

"1" means the bit is generated by the "combination block".

In order to be able to select different connection types for different controlword bits, co28 is created as an array with 3 elements.

co29 source connection definition determines how the bits can be connected (function type 0 definition, function type 1 definition = 0..3).

Additionally it is defined with which controlword bits it is possible to switch between the connection types (function nr selector = 0..3).

co29	source connection definition			0x251D
Bit	Function	Value / plaintext		Description
0..4	function type 0 definition	0	only co00 bits	only controlword
		1	only digital inputs	only digital input controlword
		2	co00 AND digital inputs	Controlword AND digital input CW
		3	co00 OR digital inputs	Controlword OR digital input CW
5..9	function type 1 definition	0	only co00 bits	only controlword
		32	only digital inputs	only digital input controlword
		64	co00 AND digital inputs	Controlword AND digital input CW
		96	co00 OR digital inputs	Controlword OR digital input CW
20..22	function nr selector	0	connection type 0 active	connection type 0 always active.
		1048576	choose type with bit 11	Choose connection type with bit 11 of the „preliminary controlword“
		2097152	choose type with bit 12	Choose connection type with bit 12 of the „preliminary controlword“
		3145728	choose type with bit 13	Choose connection type with bit 13 of the "preliminary controlword“

Depending on the parameterization of co29 source connection definition => function nr selector, bits 11..13 of the "preliminary controlword" can be used to switch between the different connection types at runtime.

Alternatively, only one connection type can be used.

In this case, "the manufacturer specific" bits of the controlword remain usable for other extensions.

NOTICE

The bits defined by the combined controlword mask are serially evaluated. This means: a connection defined in combined controlword mask [1] is overwritten by another connection defined in combined controlword mask [2] or [3].

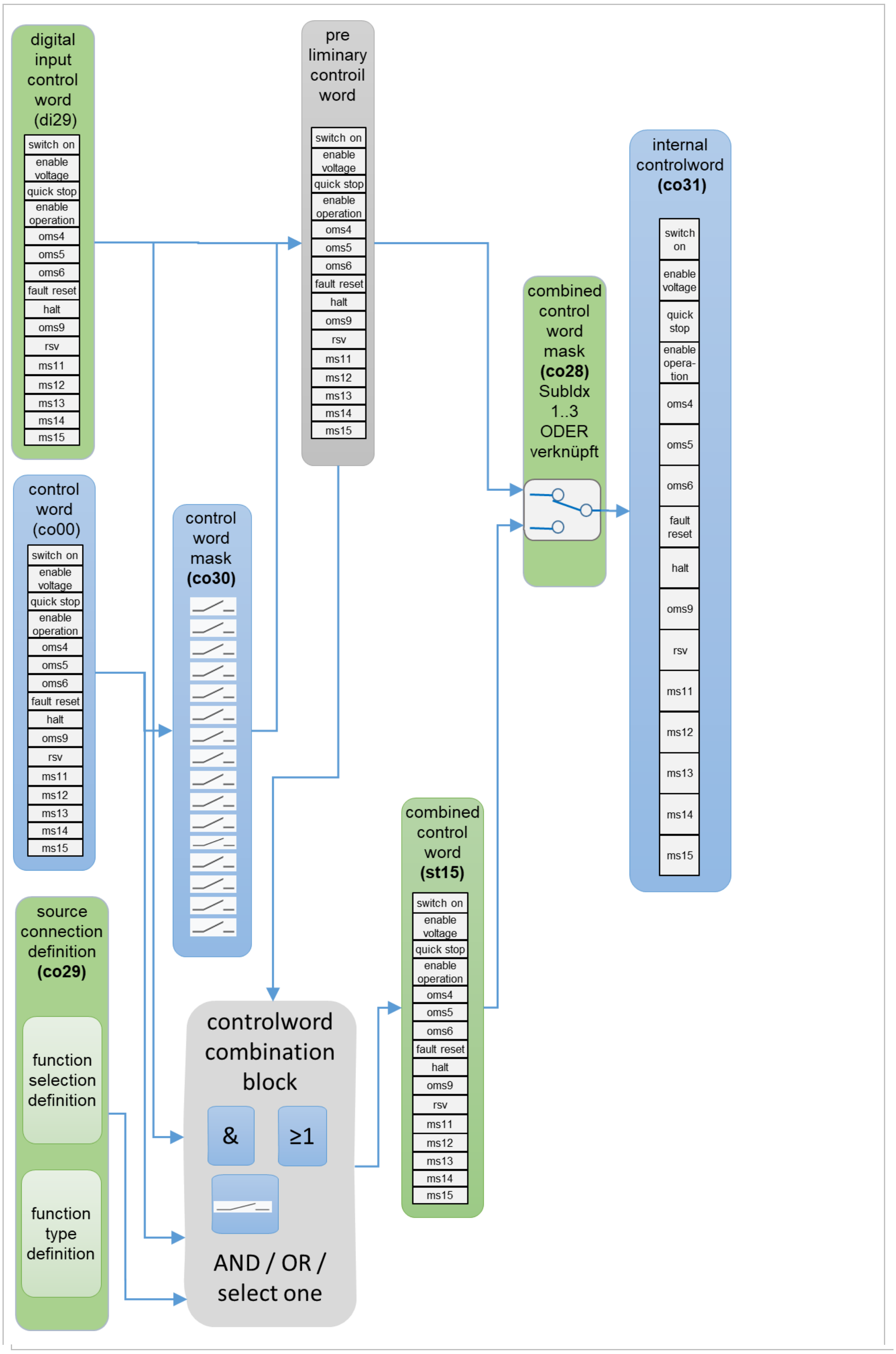


Figure 120: digital input controlword

7.1.9.1.3 Run

With di10 RUN input it can be defined, which input shall be used as release signal (control release) for the drive. The bits 0 (switch on), 1 (enable voltage) and 3 (enable operation) are set by the **RUN input**. That means, with active input, bits 0,1 and 3 (0x000bh) are set in the internal controlword. They are written to zero when the input is not active.

If bit 3 is parameterized with value 0 in co32 (enable operation mode = state), setting the RUN input leads to the status ***operation enabled***, if the drive is ready for modulation.

7.1.9.1.4 Reset

Which input shall cause an error reset can be defined with di11 RST input.

Bit 7 (0x0080h) fault reset is set in the internal controlword via active **RST input**. When the RST input is inactive, bit 7 is set to zero.

7.1.9.1.5 Operation mode specific Bit 4

Which input sets or resets bit 4 in the internal controlword is defined with di19 start posi/homing input. Bit 4 (0x0010h) is set in the internal controlword via an active **start posi/homing input**. Bit 4 is set to zero with inactive stop input.

Depending on the operating mode, the bit serves e.g. as start command for the positioning or approach to reference point.

7.1.9.1.6 Controlword bit 8 halt

Which input sets or resets bit 8 "halt" in the internal controlword can be defined with di23 halt input.

Bit 8 (0x0100h) is set in the internal controlword via active **halt input**. Bit 8 is set to zero with inactive **halt input**.

The function of the "halt“ bit depends on the operating mode.

7.1.9.1.7 Controlword mask CA / CB

Any controlword bits can be set with parameters di12...di15.

The mask objects di13 CA mask and di15 CB mask are used to select which bits are preset via the digital inputs.

The inputs, which determine the state (set = 1 / inactive = 0) for the selected bits are selected with di12 CA input and di14 CB input.

7.1.9.1.8 Examples

The first example shows the control of controlword bits directly via digital inputs without further influences.

The second example is a more complex control, combined of process data (0x2500 or 0x6040) and digital inputs.

7.1.9.1.8.1 Control of reset (bit 7) and brake (bit 15) via digital inputs

Brake control should be done via the digital input I1.

Reset should be done via the digital input I2.

The reset of co31 controlword internal shall be determined via the controlword parameters.

- Reset via I2:

  di11 RST input = 2 (setting/resetting of bit 7 fault reset via I2)
- Brake control via I1:

  di13 CA mask = 8000h (bit 15 of co31 is set via input)

  di12 CA input = 1 (setting/resetting of bit 15 via I1)
- Controlword bits 7 and 15 only via digital inputs:

  co30 controlword mask = 7F7Fh

7.1.9.1.8.2 Example (influence of bits 2, 3 and 4)

3 controlword bits shall be set by the "controlword combination block":

1. The quickstop bit shall **always** be set to zero alternatively by **co00** or digital input **I1**, thus triggering quickstop.
2. During a certain phase of the application cycle, positioning should **also** be started by digital input **I2**, but during the remaining time the signal should only be able to be set via the controlword (0x2500 or 0x6040).
3. The "enable Operation" bit should be set by default via digital input **I3** and via the controlword (0x2500 or 0x6040). However, the control should be able to deactivate the digital input influence.

1.) Quickstop:

There is no explicit di parameter for the quickstop bit. The generally usable CA mask must be used.

Input is I1 => di12 CA input = 1: I1

Bit 2 shall be influenced => di13 CA mask = 0004h: /QS

Bit 2 shall be evaluated by the "combination block":

co28 combined controlword mask [1] = 0004h: /QS

If digital input = 0, or "communication" controlword bit = 0, the bit in co31 controlword internal shall also become 0 => AND operation

co29 source connection definition[1] => function type definition 0 = 2: co00 AND digital inputs

This function shall be permanently active: no selection/switching signal necessary

co29 source connection definition[1] => function nr selector = "0: connection type 1 always active" => connection type 1 always active.

2.) OMS 4 (new set-point / start Posi)

There is an explicit di parameter for bit 4: di19 start posi/homing input

Input is I2 => di19 start posi/homing input = "2: I2"

Bit 4 shall be evaluated by the "combination block":

co28 combined controlword mask [2] = „16: op mode spec 4"

By default only the "communication" controlword determines the value of the bit:

co29 source connection definition[2] => function type definition 0 = "0: only co00 bits"

It shall be switched between the different types of OMS 4 setting via the controlword bit 11. From "exclusively via the communication controlword" (function type definition 0) to "via digital inputs **or** controlword" (function type definition 1).

co29 source connection definition[2] => function type definition 1 = "3: co00 OR digital inputs"

co29 source connection definition[2] => function nr selector = 1: choose type with bit 11

If bit 11 is zero, bit 4 in co31 is set via co00, if bit 11 is "one", the status of bit 4 in co31 is equal to the status of the digital input.

3.) Enable operation

There is no explicit di parameter for the enable operation bit. The generally usable CB mask must be used.

Input is I3 => di14 CB input = 8: I3

Bit 3 shall be influenced => di15 CB mask = 0008h: EO

Bit 3 shall be evaluated by the "combination block:

co28 combined controlword mask [3] = 8: enable operation

By default, bit 3 shall be set in co31 controlword internal, if either digital input I3 is set, or the bit in the controlword (0x2500 or 0x6040) is set.

co29 source connection definition[3] => function type definition 0 = 3: Controlword OR DigitalInput

The control shall be able to deactivate the digital input influence:

co29 source connection definition[3] => function type definition 1 = 0: only co00 bits

co29 source connection definition[3] => function nr selector = 2: choose type with bit 12

If bit 12 is zero, bit 3 is set in co31 via digital input I3 **or** the corresponding bit in co00; if bit 12 is "one", the status of bit 3 in co31 is **only** dependent on co00.

7.1.9.2 Rotation setting via digital inputs

7.1.9.2.1 Invert input

An input, which causes an inversion (sign reversal) of the setpoint speed from the VL parameters for operating modes 1 and 2 can be defined with di20 invert input.

Setting the input causes inversion.

The setpoint with the actual valid sign is displayed in ru05 set value display.

7.1.9.2.2 Halt

di18 vl zero speed input defines which input sets the setpoint speed of the vl parameters to zero.

The index speed setting and the output of the position controller are not set to zero.

7.1.9.2.3 Forward / Reverse

Two inputs, which determine the direction of rotation can be defined with di16 forward input and di16 reverse input.

The setting of the setpoint speed in the VL parameters must always be positive since the direction of rotation is determined by the digital inputs. A negative VL speed setpoint leads to the setpoint speed 0.

The direction of rotation (positive / forward) is selected if the **forward input** is active. The positive speed setpoint is displayed in ru05.

Reverse direction of rotation is selected (negative / reverse), if only the **reverse input** is active. The VL speed setpoint is inverted and the actual valid negative setpoint is displayed in ru05.

If both, the **forward input** and the **reverse input** are set, the forward direction of rotation (positive / forward) has priority.

If none of the two inputs is set, the setpoint speed is set to zero. However, automatic modulation switching off does not take place.

This function works only if the setpoint speed setting occurs via the vl parameters. The forward / reverse inputs have no function for speed setting via the index function in the ps parameters.

7.1.9.3 Index setting via digital inputs

7.1.9.3.1 Index calculation

The inputs which determine the index (e.g. for position or speed selection) can be selected with di21 index input.

The index is calculated binary coded from the digital inputs selected in di21. An active input is "1“, an inactive input "0“. The lower-order digital input generates also the lower-order bit in the index calculation.

The index is internally limited to 255. Therefore, a maximum of 8 inputs can be selected for indexing.

Example for index calculation:

Inputs I1, I3 and I5 are selected in di21 for index selection:

di21 = 21: I1 + I3 + I5

Thereby input I1 receives the value 1, input I3 the value 2 and input I5 the value 4.

Inputs I1 and I3 are set:

Index = 1 + 2 = 3

Inputs I3 and I5 are set:

Index = 2 + 4 = 6

The actual index (after passing the filter and strobe unit) can be read out in ru58 actual index.

7.1.9.3.2 Index filter

A filter time for the index calculation can be set in parameter di22 index noise filter.

di22	index noise filter	0x3216
Value	Meaning	
0.0…2000.0 ms	Filter time of the index value in 0.5 ms resolution	

Value 0 means that the calculated index value from the digital inputs is not filtered and immediately accepted as valid index. This can cause problems if the digital inputs are not set exactly at the same time.

If a filter time is entered, a new index is only accepted as valid index if it remains constant for the adjusted time.

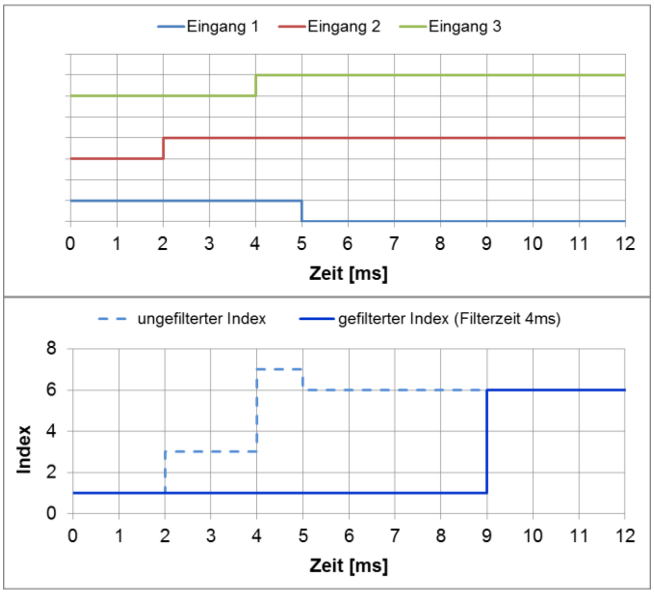


Figure 121: Example for the index filter

After the unfiltered index has remained constant for the filter time (4ms), it is accepted as a valid index.

7.1.9.3.3 Index Strobe

If the result of the temporal filtering is not sufficiently reliable, a strobe signal can also be defined to release / accept the filtered index as a valid index. This may be necessary, for example, when using the index for recipe selection.

With di24 strobe input can be defined which input / inputs shall serve as strobe signal. If several inputs are selected, their status is "OR" linked. The strobe signal is set when the status of one or more assigned inputs (after the input processing block di00.. di04) is set to "1".

How the strobe signal shall be act can be defined with di25.

di25	index strobe dependency		0x3219
Value	Plaintext	Note	
0	0: no strobe dependence	the time filtered index is always set as active index	
1	1: strobe edge	The index is set with a positive edge of the strobe signal. If several inputs are selected as strobe, the OR-linked total strobe signal is taken for the edge evaluation. This means: for a positive edge, the total strobe signal must be inactive beforehand. All inputs defined as strobe must have the status "0". Only then a positive edge is possible.	
2	2: static strobe	If the total strobe signal is active, the filtered index is set as active index	

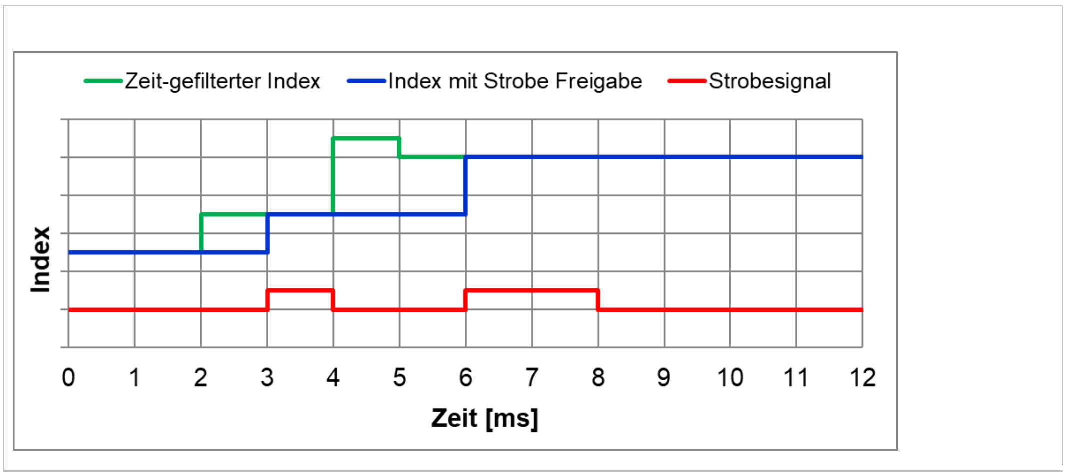


Figure 122: Example index generation with edge-active strobe

7.1.9.3.4 Total structure strobe generation

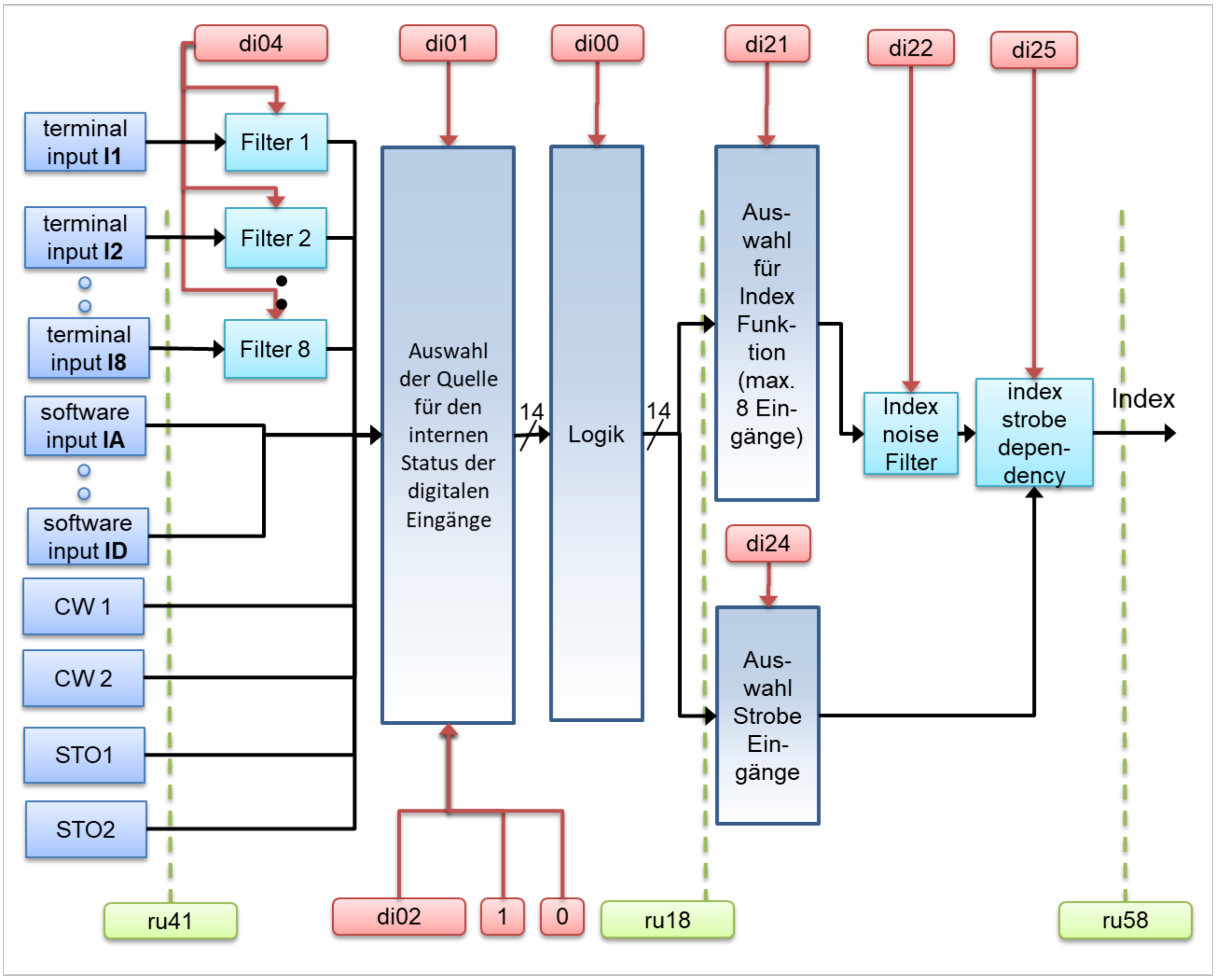


Figure 123: Overview index generation with filters and strobe

7.1.10 Overview of the input functions

Index	Id-Text	Name	Function
0x321E	di30	I1 input function	An overview can be obtained in these read parameters, which functions are triggered / influenced by the respective input.
0x321F	di31	I2 input function	
0x3220	di32	I3 input function	
0x3221	di33	I4 input function	
0x3222	di34	I5 input function	
0x3223	di35	I6 input function	
0x3224	di36	I7 input function	
0x3225	di37	I8 input function	
0x3226	di38	IA input function	
0x3227	di39	IB input function	
0x3228	di40	IC input function	
0x3229	di41	ID input function	
0x322A	di42	STO1 input function	
0x322B	di43	STO2 input function	

Several functions can be assigned to an input. Then the parameter value is the sum of the associated functions of an input.

The values in the input function parameters have the following meaning:

	di30…di45	Ix / STOx / CW x input function Subindex 1		0x321E…322B
Bit	Value	Plaintext	Function	
0…31	0	not defined	No function is assigned to the input	
0	1	Run	di10: Run	For a description of the input function refer to the respective parameter which they are assigned to.
1	2	RST	di11: RST	
2	4	CA	di12: CA mask	
3	8	CB	di14: CB mask	
4	16	FOR	di16: FOR	
5	32	REV	di17: REV	
6	64	Stop	di18: Stop	
7	128	OS4	di19: Start Posi, Start Homing	
8	256	inv	di20: invert	
9	512	index	di21: index	
10	1024	neg. lim	hm06: negative limit switch	
11	2048	pos. lim	hm07: positive limit switch	
12	4096	home	hm08: home switch	
13	8192	home src	hm14: home mode source	
14	16384	imm	ps44: immediately input	
15	32768	error	pn30: prg error source	
16	65536	brk. res.	pn31: enable braking trans. source	
17	131072	end src.	pn46: fault reaction end src	
18	262144	trigger	of05: trigger source	
19	524288	HALT	di23: HALT	
20	1048576	start recipe	ud03: start recipe	
21	2097152	start dc-braking	ds61: start dc-braking	
22	4194304	activate jog mode	cm34: activate jog mode	
23	8388608	jog positive	cm35: jog positive	
24	16777216	jog negative	cm36: jog negative	
25	33554432	act. jog speed 2	cm37: activate jog speed 2	
26	67108864	jog step mode	cm38: jog step mode	
27	134217728	jog inc MOP	cm31: jog inc MOP	
28	268435456	jog dec MOP	cm32: jog dec MOP	
29	536870912	jog reset MOP	cm33: jog reset MOP	

di30…di45		Ix / STOx / CW x input function Subindex 2		0x321E…322B
Bit	Value	Plaintext	Function	
0…31	0	not defined	No function is assigned to the input	
0	1	PID reset I term	an70: PID reset integral term input	For a description of the input function refer to the respective parameter which they are assigned to.
1	2	deactivate PID	an71: PID deactivation input	
2	4	fade out input	an73: PID fade out input	
3	8	USV enable input	pn43[2]: USV enable input	
4	16	strobe input	di24: strobe input	

7.2 Digital outputs

> ➢ The F6 / S6 drives have a different number of digital outputs depending on the control type.

7.2.1 Control type K (COMPACT)

Number	Description	Notes
4	O1…O4	Allocated on the terminal blocks X2A and X2B of the control board
3	OA…OC	Software outputs (connected with the digital inputs IA-IC)
1	Relay	1 relay output (specification => installation manual of the control board)

7.2.2 Control type A (APPLICATION)

Number	Description	Notes
2	O1…O2	2 digital outputs (specification => installation manual of the control board)
3	OA…OC	Software outputs (connected with the digital inputs IA-IC)
1	Relay	1 relay output (specification => installation manual of the control board)

When using control type A, the inverter always contains a safety module. This safety module has its own digital output functions.

The description of these outputs must be taken from the manual for the safety module.

7.2.3 Control type P (Pro)

Number	Description	Notes
2	O1…O2	2 digital outputs (specification => installation manual of the control board)
3	OA…OC	Software outputs (connected with the digital inputs IA-IC)
1	Relay	1 Relay output (Specification => Installation manual of the control board) In the case of control variants with positive-driven relays, the control depends on the safety module and cannot be influenced via the do parameters. (de13 ctrl hardware type -> hw version = 5 or 6 => .. + safety relay)

For a more detailed description of the digital outputs, please refer to the installation manual

7.2.4 Functional overview

The digital outputs can be generated from the image of the comparator level or alternatively preset via the object do10 dig. output ext. src.

➢ The value of do10 is stored **not** non-volatile.

Additionally the outputs can be set to 0 or 1.
The selection of the source for the state of the output terminals occurs via object do12 dig. output src. sel.

The result of the selection can be inverted then via do11 dig. out logic.

The result of the comparator level can be read in ru19 internal output state. The state of the outputs is available in ru20.

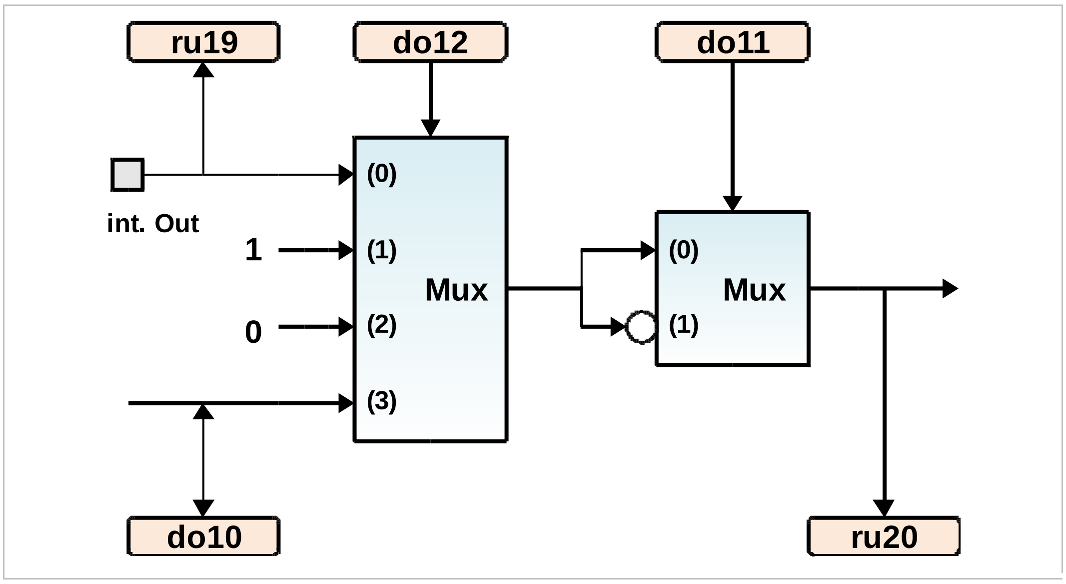


Figure 124: Digital outputs block diagram

7.2.5 Display internal digital outputs

The result of the internal digital outputs (= result of the comparator level) can be read out via object *ru19*.

Index	Id-Text	Name	Function
0x2C27	ru19	internal output state	Display internal digital outputs

The meaning of the individual bits in the internal output state is defined as follows:

ru19	internal output state		0x2C13
Bit	Value	Name	Function
0	1	O1	Digital outputs O1…O2
1	2	O2	
2	4	O3	Digital outputs O3…O4 (only available for control type K)
3	8	O4	
4	16	OA	Virtual output (virtual input IA)
5	32	OB	Virtual output (virtual input IB)
6	64	OC	Virtual output (virtual input IC)
7	128	Relay	Relay output (specification => installation manual of the control board) not available for all boards
8…15			reserved

1 means the output is set.

7.2.6 Source selection for the digital outputs

The source for the state of the digital outputs can be selected via the object do12.

Index	Id-Text	Name	Function
0x260C	do12	dig. output src. sel.	Source selection of the output state

It can be selected from the 4 sources below for the outputs O1-O4 (control type K) or O1-O2 (control type A), as well as OA-OC and the relay.

The source selection occurs for each output via 2 successive bits in do12.

do12	dig. output src. sel.			0x260C
Bit	Function	Value	Plaintext	Function
0…1	O1 source	0	flag	Output state is transferred from the comparator level
		1	on	Output state is 1
		2	off	Output state is 0
		3	ext. src.	Output state is transferred from do10
2…3	O2 source	0	flag	Output state is transferred from the comparator level
		4	on	Output state is 1
		8	off	Output state is 0
		12	ext. src.	Output state is transferred from do10
4…5	O3 source	0	flag	Output state is transferred from the comparator level
		16	on	Output state is 1
		32	off	Output state is 0
		48	ext. src.	Output state is transferred from do10
6…7	O4 source	0	flag	Output state is transferred from the comparator level
		64	on	Output state is 1
		128	off	Output state is 0
		192	ext. src.	Output state is transferred from do10
8…9	OA source	0	flag	Output state is transferred from the comparator level
		256	on	Output state is 1
		512	off	Output state is 0
		768	ext. src.	Output state is transferred from do10
10…11	OB source	0	flag	Output state is transferred from the comparator level
		1024	on	Output state is 1
		2048	off	Output state is 0
		3072	ext. src.	Output state is transferred from do10
12…13	OC source	0	flag	Output state is transferred from the comparator level
		4096	on	Output state is 1
		8192	off	Output state is 0
		12288	ext. src.	Output state is transferred from do10
14…15	Relais source	0	flag	Output state is transferred from the comparator level
		16384	on	Output state is 1
		32768	off	Output state is 0
		49152	ext. src.	Output state is transferred from do10
16…31				reserved

7.2.7 External setting of the output state

Object do10 can also be used as source for the state of the digital outputs.

Index	Id-Text	Name	Function
0x260A	do10	dig. output ext. source	External setting of the terminal state

The meaning of the bits in do10 corresponds to ru19.

The value of do10 is **not** stored non-volatile

7.2.8 Output signal generation

7.2.8.1 Function blocks

Index	Id-Text	Name	Function
0x2601	do01	flag operand A	Comparison operand A
0x2602	do02	flag operand B	Comparison operand B
0x2603	do03	flag operator mode	Linkage/comparison type of operands (> / < / logical / absolute value / etc.)
0x2604	do05	flag level 1	Comparison operand with 4 decimal places
0x2605	do06	flag level 2	32 Bit Integer Comparison operand
0x2606	do07	flag hyst. operand B	Hysteresis for operand comparison
0x2607	do08	filter time flags	Filter for the output signal

The comparator level is generated from max. 8 programmable function blocks which output as result 0 (FALSE) or 1 (TRUE).

- Four function blocks are calculated in the default setting.
- If more function blocks are needed do15 number of flags must be increased.

The output of the results of these function blocks are called "flags" and can be read out via object ru74 unfiltered flags state.

A filter is series-connected to each function block. The results of these filters can be read out via object ru21 dig. output flags.

7.2.8.2 Function block linkage

Index	Id-Text	Name	Function
0x260D	do13	select flag connection	Selection of the flags to be linked to "connected flags"
0x260E	do14	invert flags for connection	optional inverting of the flags that are to be linked to "connected flags"
0x2612	do018	AND operation for connected flags	Selection if the flags are input to an OR or an AND linkage.

As an intermediate level, the 8 "flags" (F1...F8) can be linked to max. 4 "connected flags" (CF1...CF4).

The type of linkage is selected in do18 AND operation for connected flags. The 8 "flags" plus the 4 "connected flags" can be read out in parameter ru88 complete flags state.

7.2.8.3 Output signal

Index	Id-Text	Name	Function
0x2614 .. 0x261B	do20 .. do27	select flag O1 .. OD select flag OA..OC select flag relais	Selection of the flags or "connected flags" that are to be linked to generate an output signal
0x2612	do19	AND operation for output	Selection if the flags are input to an OR or an AND linkage for the generation of the outputs

For each hardware output (O1..O4, relay) and each software output (OA..OC), parameters do20…do27 select flag Ox can be used to select the flags / connected flags wherefrom the output signal shall be generated.

Before the linkage, the flags for the respective output can be inverted with parameters do28[1..8] invert flags for output.

The type of linkage (OR / AND) is set with do19 AND operation for output.

The resulting internal output state is displayed in ru19 internal output state.

7.2.8.4 Structure overview

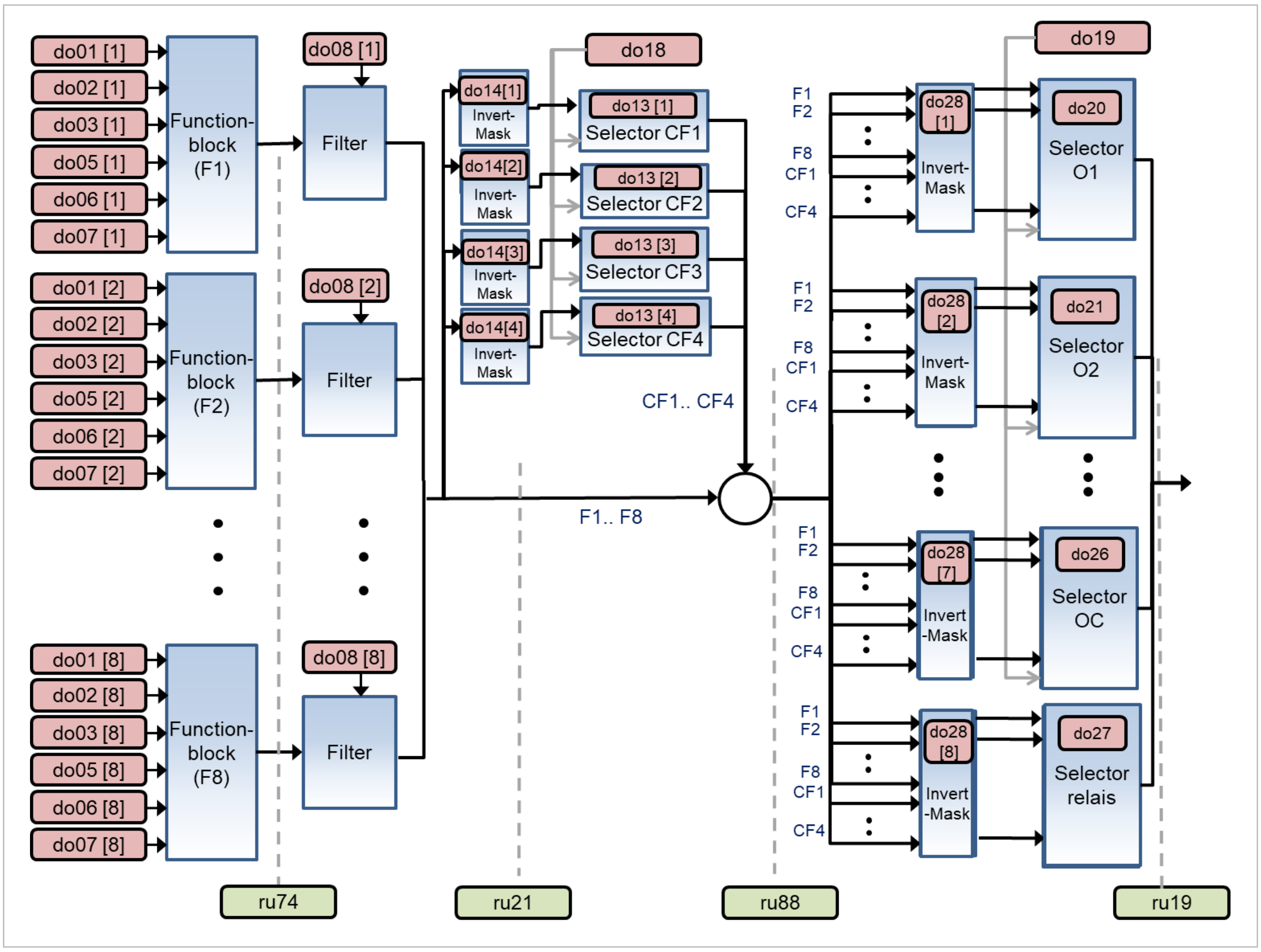


Figure 125: Comparator level

7.2.9 Function blocks

7.2.9.1 Number of function blocks

The calculation of the function block output value is time-consuming. For runtime optimisation, the number of calculated function blocks can be reduced to the required number.

do15	Number of flags	0x260F
Value	Function	
0	no function blocks are calculated	
1..8	1 ... 8 function blocks are generated. Function blocks that are not calculated lead to the value 0 for the respective flag F1..F8	

7.2.9.2 Operand selection

Each function block can execute a comparison operation with two operands. The operands are selected via do01 and do02.

Index	Subidx	Id-Text	Name	Function
0x2601	1…8	do01	flag operand A	Operand A for comparison operation
0x2602	1…8	do02	flag operand B	Operand B for comparison operation

The following operands can be selected in do01 flag operand A and do02 flag operand B. Depending on the used control type (A / K / P) or the used device type (F6 or S6), some setting options are not available. (e.g. comparisons with encoder speeds with control cards that do not allow an encoder connection)

do01	flag operand A		0x2601
do02	flag operand B		0x2602
Value	Plaintext	Note	
0	reserved		
1	exception state (ru01)	Error code	
2	reserved		
3	warning state (ru03)	Display of the highest priority warning message	
4	reserved		
5	set value display (ru05)	Set speed in velocity mode (before ramp) [in rpm]	
6	ramp out value (ru87)	Set speed [in rpm] after ramp/spline and PT1 element does not include the position controller influence	
7	act. frequency (ru07)	Stator frequency [in Hz]	
8	act. value (ru08)	Actual speed for speed control (measured or estimated) [in rpm]	
9	act. enc. speed (ru09)	Actual speed measured by the encoder [in rpm] selected for speed control (co05)	
10	act. app. curr. (ru10)	Apparent current [in A]	
11	act. active curr. (ru11)	Active current [in A]	
12	act. reactive curr. (ru12)	Magnetizing current [in A]	
13	peak app. curr. (ru13)	Peak value of the apparent current [in A]	
14	act. Uic voltage (ru14)	DC link (DC circuit) – voltage [in V]	
15	peak Uic voltage (ru15)	Peak value of the DC link voltage [in V]	
16	act. output voltage (ru16)	Output voltage [in V]	
17	modulation grade (ru17)	Modulation grade [in %]	
18	dig. input state (ru18)	Internal image of the digital inputs (after processing)	
19	Internal output state (ru19)	State of the internal digital outputs	
20	dig. output state (ru20)	State of the outputs (at the end of the processing block)	
21…22	reserved		
23	reference torque (ru23)	Set torque [in % rated torque]	
24	actual torque (ru24)	Actual torque [in % rated torque]	
25	int. data 1 (aa34)	Internal date 1 (only for test operation)	
26	int. data 2 (aa37)	Internal date 2 (only for test operation)	
27	level 1 (do05)	Comparison level with 4 decimal places	
28	level 2 (do06)	Comparison value without decimal places	
29	statemachine display (st12)	State of the state machine	
30	controlword (co00)	Value of the control word	
31	system counter (st35)	Continuous 250us counter	
32	heatsink temperature 1 (ru25[1])	Heatsink temperature [in °C]	
34	drive temperature (ru28)	Motor temperature [in °C] ***(only when using a KTY sensor)***	
35	statusword (st00)	Value of the status word	
36	position actual value (st33)	Actual position according CIA402 standard	

do01	flag operand A		0x2601
do02	flag operand B		0x2602
Value	Plaintext	Note	
37	following error (st36)	Contouring error according CIA402 standard	
38	OL2 counter (ru27)	Short-term overload level [in %]	
39	OL counter (ru29)	Long-term effective inverter load [in %]	
40	motor prot counter (ru32)	Motor protection counter [in %]	
41	positive torque limit (ru50)	resulting positive torque limit	
42	negative torque limit (ru51)	resulting negative torque limit	
43	eff motor load (ru57)	Long-term load of the motor [in %]	
44	act switch freq (ru72)	Switching frequency [in kHz]	
45	I / ImaxOL2 (ru73)	Motor current [in % short-time current limit]	
46	AN1 value display (ru42)	Analog input 1 before input level [in %]	
47	AN1 after gain display (ru43)	Analog input 1 after input level [in %]	
48	AN2 value display (ru44)	Analog input 2 before input level [in %]	
49	AN2 after gain display (ru45)	Analog input 2 after input level [in %]	
50...51	reserved		
52	analog REF display (ru48)	Value of the REF signal [in %]	
53	analog AUX display (ru49)	Value of the AUX signal [in %]	
54	Homing done	Run to the homing point is done	
56	diff. speed [1] (ru83)	ru84 – ru08 [in rpm]	
57	diff. speed [2] (ru83)	Ramp output value (internal) – ru08 [in rpm]	
58	diff. speed [3] (ru83)	smoothed ramp output value (internal) – ru08 [in rpm]	
59	brake control state (st04)	Status of the brake control	
60	heatsink PWM (ud54)	PWM signal for valve control of a liquid cooler	
61	actual speed PT1 (ru85)	filtered actual speed (ru08 after is39 time) [in rpm]	
62	diff. speed [4] (ru83)	ru06 – ru08 [in rpm]	
63	blockade status (pn87[6])	Status of the blockade handling	
64	motor cooling PWM out state	PWM signal for valve control of a liquid cooler	
65	ramp out display (ru06)	Setpoint speed [in rpm] after ramp/spline, PT1 element and position controller handle (input variable of the speed controller)	
66	ru09 (0x2C09 / A)	Encoder speed channel A	
67	ru09 (0x4C09 / B)	Encoder speed channel B	
68	timer value ru89[1]	Current value Timer 1	
69	timer value ru89[2]	Current value Timer 2	

7.2.9.3 Operators

The operator to be used is selected in do03 flag operator mode. Additionally the sign of the operands can be influenced.

Index	Subidx	Id-Text	Name	Function
0x2603	1…8	do03	flag operator mode	Operator (comparison operation >, <, =, etc.)

The bits in do03flag operator mode have the following meanings:

do03	flag operator mode				0x2603
Bit	Function	Value	Plaintext	Notes	
0…3	Selection operator	0	>=	A greater or equal B	
		1	<=	A less or equal than B	
		2	=	A equal B	
		3	AND	A AND B / TRUE, , if min 1 bit is set	
		4	OR	A OR B / TRUE, if min 1 bit is set	

do03	flag operator mode				0x2603
Bit	Function	Value	Plaintext	Notes	
		5	!=	A unequal B	
		6…15	reserved		
4…5	Type operand A	0	Parameter	Sign of operand A from selected operand	
		16	unsigned	Operand A unsigned	
		32	signed	Operand A signed	
		48	absolute	Operand A absolute	
6…7	Type operand B	0	Parameter	Sign of operand B from selected operand	
		64	unsigned	Operand B unsigned	
		128	signed	Operand B signed	
		192	absolute	Operand B absolute	

7.2.9.4 Comparison level

In selecting the operands, different process variables and also operands level 1 and level 2 can be selected.

Index	Subidx	Id-Text	Name	Function
0x2605	1…8	do05	flag level 1	Comparison level 1 (resolution 0.0001)
0x2606	1…8	do06	flag level 2	Comparison level 2 (resolution 1)

In order to compare the values, there are the parameters do05 flag level1 (4 decimal places) and do06 flag level2 (no decimal places).

flag level 1 is for all comparisons when a higher resolution is required.
flag level 2 is for all values that use the full value range (e.g. positions).

The comparison is made in the corresponding unit which displays the parameter in COMBIVIS.

7.2.9.5 Example

Example: The apparent current ru10 is displayed in COMBIVIS with a resolution of (0.01).

If a comparison with a current level of e.g. 1.25 A shall be executed, then 1.2500 must be adjusted in level 1 (do05).

With level 2, there is only comparison with integer current values possible (1A, 2A, 3A, etc.).

If operator 3 "AND“ or 4 "OR“ is selected, the internal value is compared with the assigned bit mask without re-standardization.

A linkage with flag level 1 is not reasonable for AND and OR.

Example:

Flag 1 (funktion block) shall be set if one of the inputs I1, I2 or I3 is set.

do01 flag operand A [1] = 18 “dig. input state (ru18)”

do02 do01 flag operand B [1] = 28 “level 2 (do06)”

do06 flag level 2 [1] = 7

do03 flag operator mode [1] = 3 “AND”

The inverter forms the logical link (value ru18) AND (value flag level 2).

For example, if input I2 is active, the result of the AND operation is:

2 (0010 binary) AND 7 (0111 binary) = 2 (0010 binary)

The flag is set if the result is unequal to 0.

If an output shall only be set if several conditions are fulfilled simultaneously, the single flags must be assigned AND-operated to an output (programmable with do19 AND operation for output and the select flag parameters do20…do27)

7.2.9.6 Hysteresis

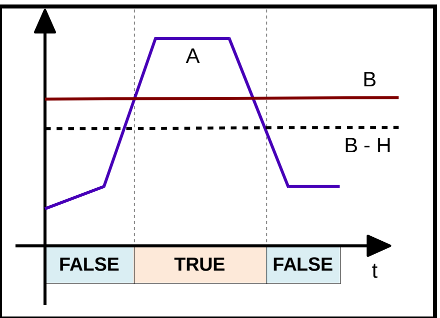
A hysteresis for comparison operations can be preset in do07.

Index	Subidx	Id-Text	Name	Function
0x2607	1…8	do07	flag hysteresis operand B	Hysteresis

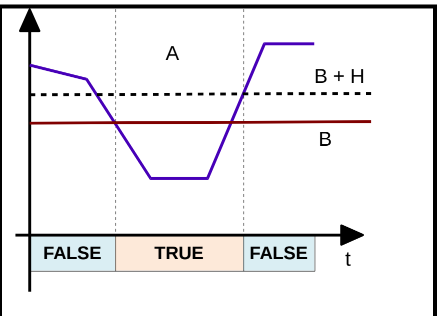
The function of the hysteresis is depending on the selected operator. No hysteresis function is possible for the operations AND or OR.

The hysteresis is defined as follows for the operators **>=**, **<=**, **=** and **!=**:

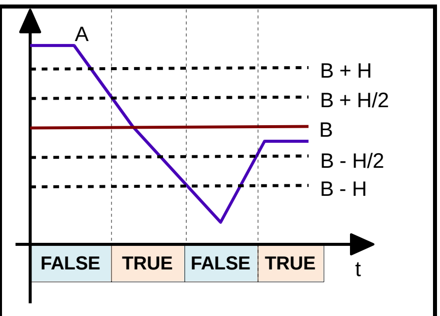
> =	Function:	Result:
	A >= B	TRUE
	A < (B – H)	FALSE
	(B – H) < A < B	unchanged



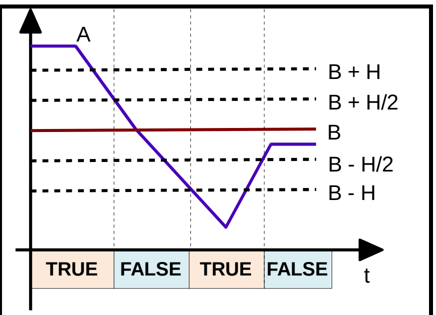
< =	Function:	Result:
	A <= B	TRUE
	A > (B + H)	FALSE
	(B + H) > A > B	unchanged



=	Function:	Result:
	inside ± H/2 (B - H/2) < A < (B + H/2)	TRUE
	outside ± H A > (B + H) or A < (B - H)	FALSE
	between H and H/2	unchanged



!=	Function:	Result:
	inside ± H/2 (B - H/2) < A < (B + H/2)	FALSE
	outside ± H A > (B + H) or A < (B - H)	TRUE
	between H and H/2	unchanged



7.2.9.7 Filter

A filter can be series-connected for each comparison operation.

Index	Subidx	Id-Text	Name	Function
0x2608	1…8	do08	filter time flags	Filter for the comparison operation

The filter is incremented if the output of the comparator level is = TRUE, at False it is dec-remented.

Switching the filter output occurs only at counter reading = 0 (clearing the filter output) or at counter reading = adjusted filter time (setting the filter output).

Times are rounded to ms.

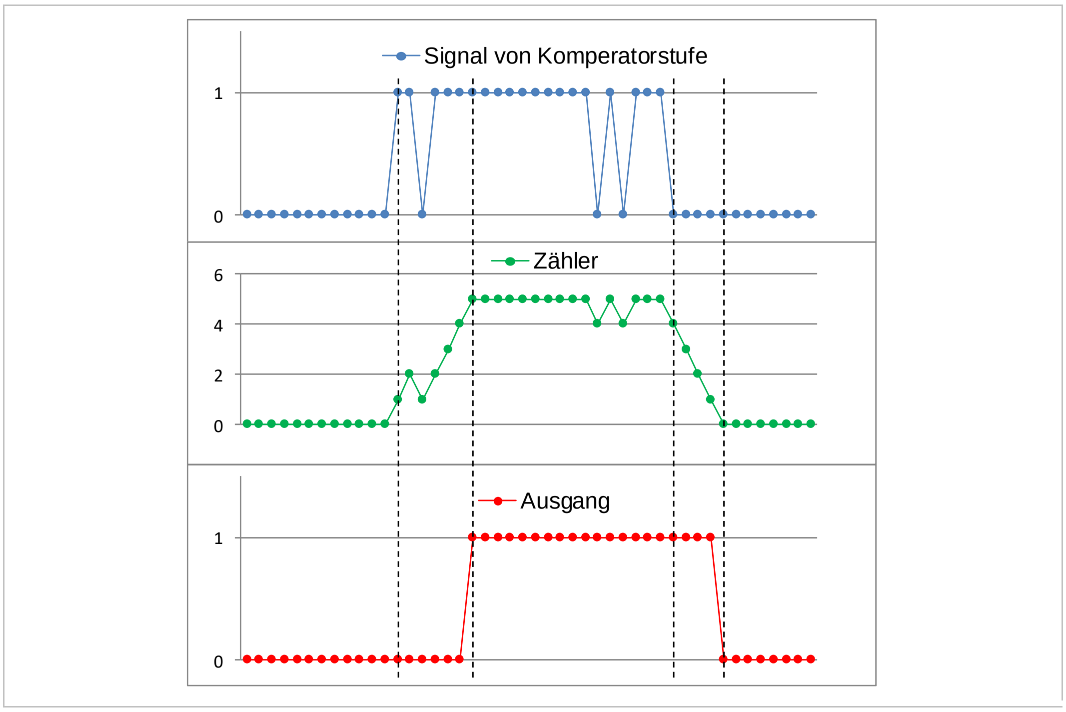


Figure 126: Filter for the comparison operation

7.2.10 Variable operands (not available for compact cards)

7.2.10.1 Function

Not all possible parameters can be selected as comparison operands via the list in do01.

To make comparisons with any parameters possible, 2 parameters can be selected in do45[1 / 2] variable operand address , whose value is copied into do47 variable operand value unsigned and do48 variable operand value signed.

do47 and do48 contain the same value, only their display in COMBIVIS is different.

do47/do48 must then be selected as comparison operand in the do table.

The comparison is only possible with do06 flag level 2, because do47/do48 cannot contain a unit and no decimal places.

For the evaluation of parameters containing various information, the relevant bits can be selected with do46 variabel operand mask.

7.2.10.2 Selection of the parameter

do45[1/2]	variabel operand address		0x262D
Value	Function	Description	
UINT32 SSSSIIII	Highword = Subindex (S) Lowword = Parameter address Index (I)	All parameters that are enabled for process data can be selected.	

If an attempt is made to set an address that does not meet the requirements for variabel operand address (e.g. parameter address does not exist), "invalid data" is returned.

7.2.10.3 Bit – Selection

do46[1/2]	variabel operand mask		0x262E
Value	Function	Description	
0…2^31 - 1	Selection mask	Mask with which the values of the variable operands are AND connected. If the value is FFFFFFFF, the value is output unchanged (plain text "no mask"). This makes it possible, for example, to isolate only the relevant bits (e.g. the ramp status) from ru75 global drive state and perform a comparison on them. The position of the bits in "read para" is not changed	

7.2.10.4 Parameter output

do47[1/2]	variabel operand value unsigned	**0x262F**
do48[1/2]	variabel operand value signed	**0x2630**

Value of the parameter selected in "variable operand address" after applying the read standardization and overlaying of the mask from do46.

This value is the comparison operand at do01 / do02 = "70: variable operand value [1]“ or "71: variable operand value [2]“.

The value is displayed in do47 as "unsigned" and in do48 as "signed" value. The value is the same, only the display is easier to read.

The evaluation alwaas occurs as INT32 comparison and is only possible with do06 flag level 2.

7.2.11 Generation of the linked function blocks

The maximum number of connected function blocks ("connected flags") is set in do16 number of connected flags.

In order to optimise the runtime, the number of "connected flags" can be reduced to the ones that are really required.

do16	number of connected flags	0x2610
Value	Function	
0	no linked function blocks are calculated	
1..4	1 ... 4 linked function blocks are generated. Non-generated linked function blocks lead to the value 0 for the respective flag CF1..CF4	

A "connected flag" is defined with a subindex in the array do13

do13		select flag connection		0x260D
Bit	Value	Name	Function	
0	1	F1	Result function block 1	In do13, it is determined from which function blocks linked function blocks (connected flags) shall be generated. Max. 4 linked function blocks (CF1..CF4) are possible The type of linkage is set in do18
1	2	F2	Result function block 2	
7	8	F4	Result function block 8	

With do18 it is selected whether the flags shall be OR or AND linked

do18		AND operation for connected flags		
Bit	Value	Name	Function	0x2612
0	0	CF1	Flags selected for CF1 are OR linked	
	1		Flags selected for CF1 are AND linked	
3	0	CF4	Flags selected for CF4 are OR linked	
	8		Flags selected for CF4 are AND linked	

7.2.12 Generation of the internal outputs

7.2.12.1 Parameter overview

The internal outputs (= outputs of the comparator level) can be used as source for generation of the output state.

It can be determined with do19 AND operation for output whether the flags should be linked OR (standard) or AND (adjustable with do19).

Which flags are used to generate an internal output is parameterized via the objects do20...do27.

Index	Id-Text	Name	Function
0x2613	do19	AND operation for output	Selection of the link type for output O1…OD
0x2614	do20	select flag O1	Selection of the flags for internal output O1
0x2615	do21	select flag O2	Selection of the flags for internal output O2
0x2616	do22	select flag O3	Selection of the flags for internal output O3
0x2617	do23	select flag O4	Selection of the flags for internal output O4
0x2618	do24	select flag OA	Selection of the flags for internal output OA
0x2619	do25	select flag OB	Selection of the flags for internal output OB
0x261A	do26	select flag OC	Selection of the flags for internal output OC
0x261B	do27	select flag Relais	Selection of the flags for the relay
0x261C	do28	invert flags for output	Selection of which flags are to be inverted before linking

The selection which flags are to be inverted for the generation of the respective output signal is made in the array do28.

The selection for output O1 is made in do28[1], for output O2 in do28[2], for output O3 in do28[3], etc. up to do28[8] for the relay output. Not all outputs are available on all control card types. (see also the overview in Figure 125: Comparator levelFigure 124: Digital outputs block diagram)

<table>
<tr><th colspan="2">do28</th><th colspan="3">invert flags for output</th><th>0x261C</th></tr>
<tr><th>Bit</th><th>Value</th><th>Name</th><th colspan="3">Function</th></tr>
<tr><td>0</td><td>1</td><td>F1</td><td>Invert flag 1</td><td colspan="2" rowspan="7">If several function blocks are selected for one output, the selected flags are OR-connected (output is set if at least one flag is set) or AND-connected (output is set if all assigned flags are set).

The type of connection is defined in do19.</td></tr>
<tr><td>1</td><td>2</td><td>F2</td><td>Invert flag 2</td></tr>
<tr><td>..</td><td>..</td><td>..</td><td>...</td></tr>
<tr><td>7</td><td>128</td><td>F8</td><td>Invert flag 8</td></tr>
<tr><td>8</td><td>256</td><td>CF1</td><td>invert linked function blocks 1</td></tr>
<tr><td>..</td><td>..</td><td>..</td><td></td></tr>
<tr><td>11</td><td>2048</td><td>CF4</td><td>invert linked function blocks 4</td></tr>
</table>

The meaning of the values is identical for do20…do27.

do20…do27		select flag O1…OC, Relais		0x2614…0x261B
Bit	Value	Name	Function	
0	1	F1	Result function block 1	If several function blocks are selected for one output, the selected flags are OR-connected (output is set if at least one flag is set) or AND-connected (output is set if all assigned flags are set). The type of connection is defined in do19.
1	2	F2	Result function block 2	
..	..	..	...	
7	128	F8	Result function block 8	
8	256	CF1	Result linked function blocks 1	
..	..	..		
11	2048	CF4	Result linked function blocks 4	

do19		AND operation for output	0x2613
Bit	Value	Name	Function
0	0	O1	Selected flags for O1 are AND linked
	1		Selected flags for O1 are AND linked
1	0	O2	Selected flags for O2 are OR linked
	2		Selected flags for O2 are AND linked
2	0	O3	Selected flags for O3 are OR linked
	4		Selected flags for O3 are AND linked
3	0	O4	Selected flags for O4 are OR linked
	8		Selected flags for O4 are AND linked
4	0	OA	Selected flags for OA are OR linked
	16		Selected flags for OA are AND linked
5	0	OB	Selected flags for OB are OR linked
	32		Selected flags for OB are AND linked
6	0	OC	Selected flags for OC are OR linked
	64		Selected flags for OC are AND linked
7	0	Relay	Selected flags for the relay are OR linked
	128		Selected flags for the relay are AND linked

7.2.12.2 Example

Example: Output O1 shall be set if the 3 inputs I1 and I2 and I3 are set:

Definition Flag 1 (I1 set => Bit 0* ru18 *set):

do01 flag operand A [1] = 18 "dig. input state (ru18)"

do02 flag operand B [1] = 28 "level 2 (do06)"

do06 flag level 2 [1] = 1

do03 flag operator mode [1] = 3 "AND"

Definition flag 2 (I2 set => Bit 1* ru18 *set):

do01 flag operand A [2] = 18 "dig. input state (ru18)"

do02 flag operand B [2] = 28 "level 2 (do06)"

do06 flag level 2 [2] = 2

do03 flag operator mode [2] = 3 “AND”

Definition flag 3 (I3 set => Bit 2** ru18 **set):

do01 flag operand A	[3]	= 18 “dig. input state (ru18)”
do02 flag operand B	[3]	= 28 “level 2 (do06)”
do06 flag level 2	[3]	= 4

do03 flag operator mode [3] = 3 “AND”

Linking the flags:

do20 select flag O1	= 7 “F1 + F2 + F3“
do19 AND operation for output	= 1 (selected flags for O1 are AND linked)

Output O1 is set only if the condition F1 (I1 is set) **and** F2 (I2 is set) **and** F3 (I3 is set) is fulfilled.

7.2.13 Inversion of the digital output state

The terminal state can be inverted via object do11 dig. output logic. The state after the inversion can be read out via the object ru18 dig. input state.

Index	Id-Text	Name	Function
0x260B	do11	digital out logic	Inversion of the digital output state
0x2C14	ru20	dig. output state	Terminal state of the digital outputs

Only outputs of the control board can be inverted via this parameter. The outputs of the safety module cannot be influenced by the control board.

7.2.14 Overcurrent of the digital outputs

All digital outputs are protected against overload by hardware. When this protection is activated, a separate error is generated for each output.

ru01	exception state	0x2C01
Value	**Function**	
68	Error overcurrent Brake	
100	Error overcurrent out1	
101	Error overcurrent out2	
102	Error overcurrent out3	
103	Error overcurrent out4	
105	Error overcurrent encoder	
106	Error overcurrent 24V (overcurrent on the 24V outputs of the control terminal)	

7.3 Analog inputs

The F6 interface contains 3 analog inputs, analog input 3 has several limitations and is not used in the standard software.

Two analog inputs AN1 and AN2 are supported for S6 application and Compact. Three analog inputs are supported with S6 Pro (like F6).

(For further information on the specifications of the analog inputs, see the installation manual of the respective control type).

The analog input values are displayed in the ru parameters.

Index	Id-Text	Name	Function	
0x2C2A	ru42	AN1 value display	Display of the analog input value AN1 in %	
0x2C2B	ru43	AN1 after gain display	AN1 after the input block in %	
0x2C2C	ru44	AN2 value display	Display of the analog input value AN2 in %	
0x2C2D	ru45	AN2 after gain display	AN2 after the input block in %	
0x2C2E	ru46	AN3 value display	Display of the analog input value AN3 in %	only F6
0x2C2F	ru47	AN3 after gain display	AN3 after the input block in %	

7.3.1 Overview of the analog inputs

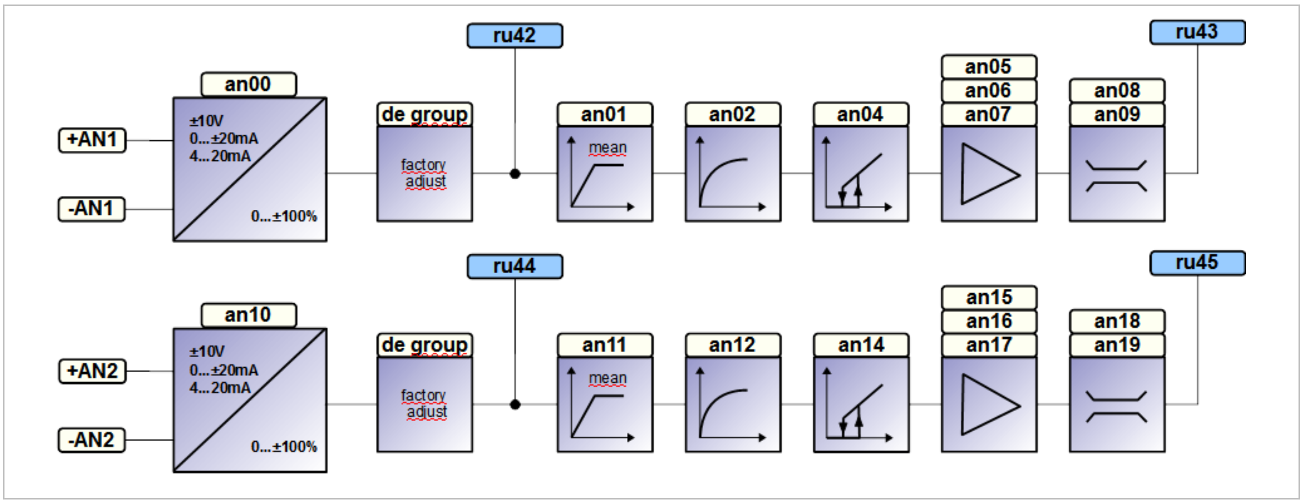


Figure 127: Analog inputs block diagram

7.3.2 Interface configuration

7.3.2.1 Interface selection

Analog inputs 1 and 2 are configurable with an00 and an10 as voltage inputs (+/-10 V) or current inputs (+/-20 mA, 4…20 mA).

Analog input 3 is always 0...10V voltage input.

Index	Id-Text	Name	Function
0x3300	an00	AN1 interface selection	+/-10V, +/-20mA, 4…20mA
0x330a	an10	AN2 interface selection	+/-10V, +/-20mA, 4…20mA

an00 / an10	AN1 interface selection / AN2 interface selection	0x3300 / 0x330A
Value	Configuration	
0	+/- 10 V	
1	+/- 20 mA	
2	4 … 20 mA	

7.3.2.2 Interface monitoring (not available for compact cards)

Only the 4...20mA interface can be monitored for line breakage.

All measured values are valid for the two remaining interface types, thus no line breakage can be detected.

Furthermore, a line breakage at the +/- 10V interface does not lead to a 0% input signal, because an undefined differential signal can be generated.

pn86	E.AnIn stop mode			**0x2A56**
Bit	Function	Value	Plaintext	Note
0...7	fault reaction	0	Stop mode selection (see description and notes about the stop modes at 4.3.1.2.2 Error reaction) Upper limit of this parameter is 8. It is not advisable to use a stop mode that enables a restart, since undefined behavior can occur if the contact is faulty ("loose contact").	
		..		
		8		
8	modulation dependance	0	always	Error is triggered independently of the modulation
		128	only at mod on	Error is only triggered when the modulation is switched on. The warning bit is always set. This setting must never be combined with "Auto-Retry", otherwise there will be a permanent change of restart and error triggering.

7.3.3 **Input level of the analog inputs**

Index	Id-Text	Name	Function
0x3301	an01	AN1 mean filter	Mean filter for the analog signal.
0x330b	an11	AN2 mean filter	
0x3302	an02	AN1 PT1 filter	PT1 filter for the analog input
0x330c	an12	AN2 PT1 filter	
0x3304	an04	AN1 zero point hysteresis	Zero point hysteresis
0x330e	an14	AN2 zero point hysteresis	
0x3305	an05	An1 gain	Gain of the analog signal
0x330f	an15	AN2 gain	
0x3306	an06	An1 offset X	Offset X for the analog signal
0x3310	an16	AN2 offset X	
0x3307	an07	AN1 offset Y	Offset y for the analog signal Out = gain * (In – OffsetX) + OffsetY
0x3311	an17	AN2 offset Y	

Index	Id-Text	Name	Function
0x3308	an08	AN1 neg limit	Lower limit for the analog setpoint
0x3312	an18	AN2 neg limit	
0x3309	an09	AN1 pos limit	Upper limit of the analog setpoint
0x3313	an19	AN2 pos limit	

The analog input signals can be filtered by means of averaging and PT1 element for interference suppression and provided with a zero point hysteresis.

Then, the gain can be adjusted and the signal with offset X and Y can be shifted:

ANx after gain display = (ANx value display – ANx offset X) * ANx gain + ANx offset Y

The limitation occurs at last.

Example 1:

A 0..8V signal shall be normalized after the input level to -100% ... +100%.

Then the following adjustments must be done:

generate symmetry to 0 with offset X: 4V shall correspond to 0%
=> ANx offset X = 40%

adjust the gain: +/-4V shall correspond to +/- 100%
=> ANx gain = 2.5

Example 2:

A sensor provides already a signal of 0.7V at pressure = 0 bar and a signal of 9.5V at the final pressure of 200 bar.

This voltage should be converted into a 0 ... 100% signal. The analog signal after the input level shall not leave the 0...100 % range.

Then the following adjustments must be done:

Perform the 0-adjustment with offset X: 0.7V shall correspond to 0%
=> ANx offset X = 7%

adjust the gain: (9.5-0.7)V shall correspond to 100%
=> ANx gain = 1.136

Limit: ANx neg limit = 0% // ANx pos limit = 100%

7.3.4 Calculation of REF and AUX

Subsequently the internal analog signals AUX and REF are generated from the three analog signals via another block.

REF is directly assigned to an analog input.

AUX can be calculated via different arithmetic operations from two analog inputs.

Index	Id-Text	Name	Function
0x331e	an30	ref and aux function	Calculation of AUX and REF
0x2C30	ru48	analog REF display	Display of the internal REF value from the analog values in %
0x2C31	ru49	analog AUX display	Display of the internal AUX value from the analog values in %

an30	ref and aux function			0x331E
Bit	Function	Value	Plaintext	Notes
0…3	ref input	0	off	REF = 0
		1	AN1	REF = AN1
		2	AN2	REF = AN2
		3	PID	REF = PID Output
4…7	A input	0	off	A input = 0
		16	AN1	A input = AN1
		32	AN2	A input = AN2
		48	PID	A input = PID Output
		64	ANOUT1	A input = ru78 Analog Output
		80	ANOUT2	A input = an44 ANOUT2 display
		96	ANOUT3	A input = an47 ANOUT3 display
8…11	B input	0	off	B input = 0
		256	AN1	B input = AN1
		512	AN2	B input = AN2
		768	PID	B input = PID Output
		1024	ANOUT1	A input = ru78 Analog Output
		1280	ANOUT2	A input = an44 ANOUT2 display
		1536	ANOUT3	A input = an47 ANOUT3 display
12…15	aux function	0	off	AUX = 0
		4096	A	AUX = A
		8192	A + B	AUX = A + B
		12288	A * (1+B)	AUX = A * (1+B)
		16384	A * B	AUX = A * B
		20480	|A|	AUX = |A| (absolute value of A)

7.3.5 Mapping of REF and AUX

AUX (ru49) and REF (ru48) are limited to +/- 400% after the calculation. Then these two values can be set to any objects with the following settings.

Index	Id-Text	Name	Function
0x331F	an31	REF selector	Determination which object is affected by REF
0x3320	an32	REF norm fact	Scaling of the analog setpoint to the selected object.
0x3321	an33	REF norm status	Status of the standardization function
0x3322	an34	AUX selector	Determination to which object AUX acts on
0x3323	an35	AUX norm fact	Scaling of the analog setpoint to the selected object.
0x3324	an36	AUX norm status	Status of the standardization function

The address of any object which is to be influenced by the analog values can be adjusted directly in an31 and an34.

All writable objects that are also permissible for process data are permitted.

If, for example, the setpoint speed shall be preset analog via vl20 target velocity (address 0x2314), an31 = 0x2314 must be adjusted.

The analog setpoint is standardized and by way adapted to the required value range of the objects with an32 REF norm fact and an35 AUX norm fact.

The values are written with the same standardization functions, over which the objects are accessible also via bus system.

If the permissible value range is exceeded, this can be seen in status an33 REF norm status or an36 AUX norm status with the display of 4 "data invalid". Then the converted analog value is not written into the parameter.

The scaling must be adjusted accordingly in these cases.

Example 1: Speed setting in vl20 target velocity via analog input 1

A speed in the range of +/- 3000 rpm shall be written into parameter vl20 vl target velocity with analog input 1.

The setting shall be done via the REF function, since only 1 input is required. Value 1 "AN1" is preset in an30 REF and AUX function under „ref input“ (Bit 0…3).

The REF signal shall write the vl target velocity. => an31 REF selector = 2314hex

A REF value of 100% → 4096 shall derive to a setpoint of 3000 rpm in vl20.
vl20 has a resolution of 1 rpm

$$=> an32 = \frac{setpoint}{4096 * Auflösung} = \frac{3000}{4096} = 0.7324$$

If the setting of vl20 shall be limited to +/-3000 rpm , the AN1 limit values must be set to -100% or +100% in an08 and an09.

If the value from the above example is increased by a factor of 100, a value of 100% for REF results in a setpoint of 100 * 3000 rpm = 300000 rpm. 40% REF results in 0.4 * 300000 rpm = 120000 rpm. The upper limit of the setpoint is 128000 rpm. If the analog value exceeds 42.67%, the upper limit of the parameter is exceeded by the scaling.

This is displayed in parameter an33 REF norm status, which changes from 0 "OK" to 4 "data invalid". The analog preset values are not accepted in this case.

Example 2: Additionally setting of the torque limit in cs12 absolute torque via analog input 2

In addition to example 1, the torque limit cs12 absolute torque shall be preset via analog input 2 in the range +/- 200%. Since the speed is already preset via REF, the torque limit must be written via AUX.

Value 32 "AN2" is preset in an30 REF and AUX function under "A input“ (Bit 4…7). In addition, "aux function" (bits 12 ... 15) must be set to 4096: A.

The AUX signal shall write cs12 absolute torque.

=> an34 AUX selector = 270C hex

A REF value of 100% → 4096 shall derive to a setpoint of 200.0% in cs12.
cs12 has a resolution of 0.1%

$$=> an35 = \frac{200\%}{4096 * 0.1\%} = \frac{200}{409.6} = 0.4883$$

7.3.6 PID process controller

To use the system it is often necessary to equip the drive controller with an internal process controller. This can be used to built up pressure or temperature controls, for example. The difference between setpoint and actual value (deviation) supplies the PID controller. The PID controller adjusts the output frequency of the drive to minimize the deviation, which allows accurate control of system variables.

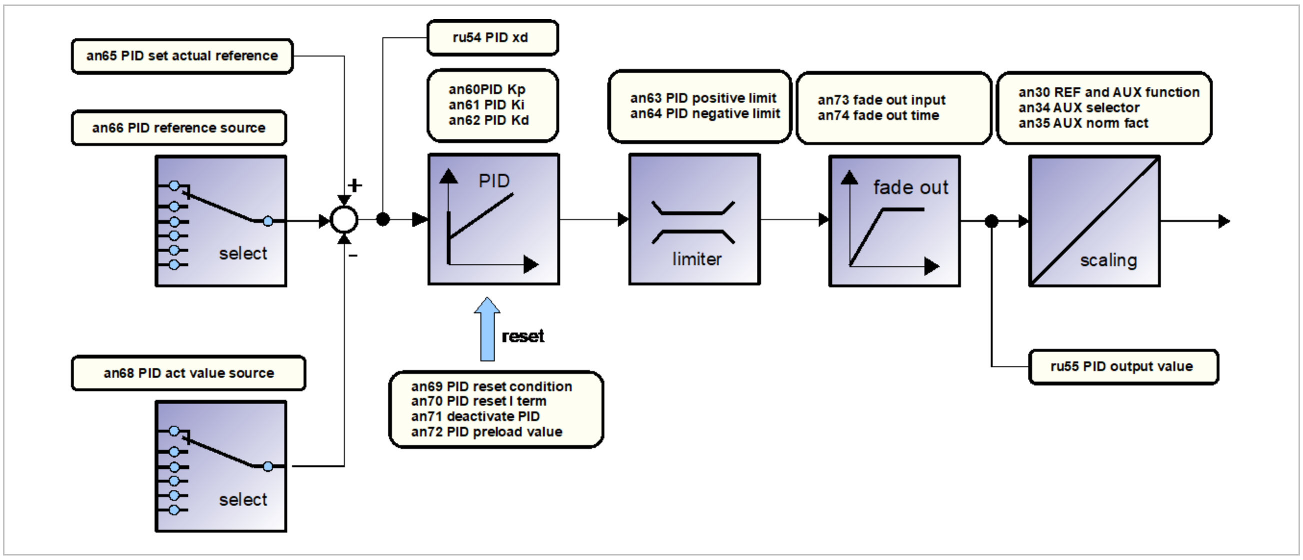


Figure 128: PID controller

The PID controller will be called by the MidIrq, scan times can be adjusted with is22 Basic Tp. The reset time T_N of the PID process controller is not affected by this.

7.3.6.1 PID controller

Definition of the PID process controller:

Index	Id-Text	Name	Function
0x333C	an60	PID Kp	Setting the P-gain Factor with 4 decimal places
0x333D	an61	PID Tn	Presetting of the reset time in ms with 3 decimal places
0x333E	an62	PID Kd	Setting gain for the D-component Factor with 4 decimal places
0x333F	an63	PID positive limit	Positive limit of the PID controller.
0x3340	an64	PID negative limit	Negative limit of the PID controller.
0x2C36	ru54	PID xd	System deviation at the input of the PID controller -400.0% ... 400.0%
0x2C37	ru55	PID output value	Output value of the PID controller -400.0% ... 400.0%

Input variables, limits and output are standardized in the same way as the analog values. 100.0% corresponds internally 4096. Value range +/-400.0% or +/- 16384.

7.3.6.2 Virtual analog outputs

Two new virtual analog outputs have been implemented in order to access any internal objects in the future. This allows you, for example, to use any two objects from the object dictionary as setpoint and actual value for the PID controller.

Index	Id-Text	Name	Function
0x332A	an42	ANOUT2 selector	The index is preset in the lower 16 bits, the subindex is set in the upper 16 bits.
0x332B	an43	ANOUT2 norm fact	Normalization factor for the value of an42
0x332C	an44	ANOUT2 display	Display of the read out value of an42. Values that are too large are limited to the int32 value range.
0x332D	an45	ANOUT3 selector	The index is preset in the lower 16 bits, the subindex is set in the upper 16 bits.
0x332E	an46	ANOUT3 norm fact	Normalization factor for the value of an45
0x332F	an47	ANOUT3 display	Display of the read out value of an45. Values that are too large are limited to the int32 value range.

Example for an43 or an46: The value of ru06 ramp output shall be set to an44 for the PID controller. The ramp output of 1000 ^{rpm} shall be displayed in an44 with 4096 or 100%. The value of ru06 has the resolution of 1 / 8192 ^{rpm}.

$$an43 = \frac{OutValue * InResolution}{InValue} = \frac{4096}{1000 * 8192} = 0.0005$$

ru06	ramp out display	1000,0000 1/min
an43	ANOUT2 norm fact	0,00050000
an44	ANOUT2 display	4096

7.3.6.3 Setpoint

Definition of the setpoint selection in the PID process controller:

Index	Id-Text	Name	Function
0x3341	an65	PID reference offset	Direct setting of the setpoint via this object. Always active, is added to the selectable setpoint source.
0x3342	an66	PID reference source	Setpoint selection for the PID controller

an66	PID reference source		
Value	Function	Function	
0	off	Off: no source active. Only the PID reference offset acts as setpoint	
1	An1	The analog value at analog input 1 is the setpoint source.	
2	An2	The analog value at analog input 2 is the setpoint source.	
3	ANOUT1	The value of ru78 Analog Out display is the setpoint source. 4096 → 100%	
4	ANOUT2	an44 ANOUT2 display is the setpoint source 4096 → 100%	
5	ANOUT3	an47 ANOUT3 display is the setpoint source 4096 → 100%	

7.3.6.4 Actual value

Definition of the actual value selection in the PID process controller:

Index	Id-Text	Name	Function
0x3343	an67	PID actual value setting	Digital actual value setting via this object
0x3344	an68	PID act value source	Actual value selection for the PID controller

an68	PID act value source		
Value	Function	Function	
0	off	The PID controller is completely deactivated	
1	An1	Analog input 1 is actual value source	
2	An2	Analog input 2 is actual value source	
3	an67	PID actual value is preset via an67 in the range -400.0% ... 400.0%	
4	active current	Active current ru11 act active current / rated motor current dr03 corresponds to 100.0%	
5	apparent current	Apparent current ru10 act. apparent current / rated motor current dr03 corresponds to 100.0%	
6	Uic	DC link voltage ru14 act Uic voltage / 1000V corresponds to 100%	
7	active power	Active power ru82[2] electrical output power Rated device power Un * In * √3 corresponds to 100%	
8	actual torque	Actual torque ru24 actual torque / rated motor torque dr09 corresponds to 100%	
9	utilization	Inverter utilization = apparent current / rated device current de28	
3	ANOUT1	The value of ru78 Analog Out display is the actual value source. 4096 → 100%	
4	ANOUT2	an44 ANOUT2 display is the actual value source. 4096 → 100%	
5	ANOUT3	an47 ANOUT3 display is the actual value source. 4096 → 100%	

7.3.6.5 Reset conditions

The PID controller or only the I-component of the PID controller can be reset depending on the state machine status but also depending on digital inputs.

The value to which the I-component is reset in this case can be parameterized.

By means of an adjustable fade-out time, the controller output value can be lowered on reset via an adjustable linear function or increased linearly at start-up.

Object an69 PID internal reset condition defines the conditions and how the PID controller shall be reset.

Index	Id-Text	Name	Function
0x3345	an69	PID internal reset condition	Reset conditions for the PID controller

an69	PID internal reset condition			
Bit	Function	Value	Plaintext	Notes
0…23	states for reset	0	no reset	All values of st12 state machine display can be selected as reset condition for the PID controller. Reset is preset when not in status "operation enabled".
		1	initialisation	
		2	not ready to switch on	
		4	switch on disabled	
		8	ready to switch on	
		16	switched on	
		32	operation enabled	
		64	quick stop reaction active	
		128	fault reaction active	
		256	fault	
		512	shutdown reaction active	
		1024	disable operation active	
		2048	start operation active	
		4096	mod off pause active	
		8192	power off active	
		16384	protection time active	
		32768	protection time end	
		65536	endless protection time	
		131072	suppressed error	
24...25	reset function	0	no PID reset	Selection how to reset the PID process controller. The I-part is set to the value of an72 PID preload value.
		2^{24}	reset I-part	
		2^{25}	disable PID	
26…27	fade out function	0	no reset	Selection how the fade out function shall be initialized.
		2^{26}	set fact to 1	
		2^{27}	reset fact to 0	

Index	Id-Text	Name	Function
0x3346	an70	PID reset integral term input	Preloading the I-part of the PID controller with activated digital input
0x3347	an71	PID deactivation input	Deactivation and and preloading of the complete PID controller. The output of the PID controller changes to the value of an72.
0x3348	an72	PID preload value	Setting of a value with which the I-part of the PID controller is preloaded.

7.3.6.6 Fade out function

A digital input must be defined in an73 PID fade out input to activate the fade out function.

When the digital input is set, the controller output is faded in with the time defined by an74 PID fade out time. If the digital input is not set, the controller output is faded out or reduced to 0 with the time defined in an74 PID fade out time.

The fade out function can be initialized with an69 PID internal reset condition, i.e. it can be determined whether the function should start faded in (set fact to 1) or faded out (reset fact to 0). Initialisation occurs depending on the current status of the state machine: if st12 state machine display displays one of the selected states in an69 PID internal reset condition.

Index	Id-Text	Name	Function
0x3349	an73	PID fade out input	Selection of the digital input for the fade out function.
0x334A	an74	PID fade out time	Time in s with three decimal places to fade out the controller output.

7.3.6.7 Scaling the output value

The PID controller output can be mapped to any objects with an30 ref and aux function. (See chapter 7.3.4 Calculation of REF and AUX)

7.4 Analog output

7.4.1 Hardware analog output

The F6 / S6 controllers have an unipolar analog output that can output signals of 0.1 ... 10V.

The linearity between output value and analog output voltage is not guaranteed in the range up to 0.1V.

Index	Id-Text	Name	Function
0x3325	an37	ANOUT1 function	Selection of the object for analog output
0x3326	an38	ANOUT1 value	Cell for direct output (an37=0)
0x3327	an39	ANOUT1 gain	Gain
0x3328	an40	ANOUT1 offset X	Out = (value + offset X) * gain + offset Y
0x3329	an41	ANOUT1 offset Y	

The values of an37 have the following meaning:

an37	ANOUT1 function	0x3325
Value	Function	Scaling at 10V
0	ANOUT1 value (an38)	100%
1	abs. set value display (ru05)	1000rpm
2	abs. ramp out display (ru06)	1000rpm
3	abs. actual value (ru08)	1000rpm
4	abs. ref torque (ru23)	100%
5	abs. actual torque (ru24)	100%
6	apparent current (ru10)	10A
7	abs. active current (ru11)	10A
8	abs. demand position (st37)	231
9	abs. actual position (st33)	231
10	actual output voltage (ru16)	1000V
11	actual Uic voltage (ru14)	1000V
12	heatsink temperature 1 (ru25[1])	100°C
13	drive temperature (ru28)	100°C
14	internal temperature 1 (ru26[1])	100°C

7.4.2 Virtual analog outputs

The description of the virtual analog outputs can be found at 7.3.6.2 Virtual analog outputs.

They are used to extend the flexibility of the PID technology controller and analog preset.

7.5 Status LED

F6 / S6 controls have 4 (control type K) or 5 (control type A or P) status LEDs on the top

View COMBIVERT F6	View COMBIVERT S6
	

FS ST: Safety status (only for control type A or P)

VCC: Voltage supply

NET ST: Network / fieldbus state (e.g. CAN, EtherCAT, VARAN, …)

DEV ST: Inverter / unit status Status (OK, error, without power supply)

OPT: for optional functions

7.5.1 Function of the status LEDs when switching on

VCC	NET ST	DEV ST	OPT

The 24V LED turns green immediately after switching on the 24V voltage supply.

VCC	NET ST	DEV ST	OPT

If the FPGA has been booted correctly, the drive controller and fieldbus status LED will turn yellow after about 6s.

VCC	NET ST	DEV ST	OPT
VCC	NET ST	DEV ST	OPT

The required configuration is copied into the MRTE module if a new fieldbus interface has been selected with fb68. During this time, the two LEDs flash yellow.

VCC	NET ST	DEV ST	OPT

The control is ready for operation after further 3s and the status LEDs change to their actual function.

7.5.2 Fieldbus state (NET ST)

A detailed description of the different light pattern for the different fieldbus types can be found in the installation manual of the control board.

7.5.3 Drive controller state (DEV ST)

red: There is an exception. ru01 != 0

yellow: no error, DC link not loaded

green: no error, ready for operation

Identification of the unit can additionally occur via the DEV ST LED. The DEV ST LED flashes permanently by activating with fb32.

Index	Id-Text	Name	Function
0x2B20	fb32	LED 'DEV ST' blink status	Visual identification of the unit

fb32	unit identification		0x2B20
Value	Name	Note	
0	off	DEV ST LED with continuous light	
1	on	DEV ST LED flashes	

7.5.4 FS Status (control type A and P)

The description of the function of the FS ST LED (status LED safety module) occurs in the safety manual for the corresponding module.

8 Timer

8.1 Function of timer / counter blocks

The software outputs can be used to set / reset software inputs and thus trigger reactions (e.g. switch off / set setpoint speed to zero).

In some cases, however, this reaction should only be carried out with a time delay.

It makes sense to insert a timer/counter element between the occurrence of an event and the activation of a software input.

A timer element counts in a fixed time pattern (e.g. ms), a counter counts the occurrence of certain events.

The timer/counter output value is made available as comparison operand in do01 / do02.

This allows a "successor flag" to be generated after a time has elapsed, which then acts on a software input, for example.

The timer / counter start / count / reset inputs are ru88 complete flag state, ru18 digital input state, ru19 internal output state or ru20 digital output state.

8.2 Number of timers

To avoid occupying programme runtime resources when the timer/counter unit is not required at all, the timer/counter unit must be explicitly activated.

The number of calculated/passing timer blocks can be defined with 0x261E do30 number of count units.

If number of count units is zero, the function block "Timer" is not called.

A maximum of 2 timer units can be used. The upper limit of do30 is thus set to 2.

8.3 Parameter

8.3.1 Overview

Index	Id-Text	Name	Function
0x261E	do30	number of count units	Number of passing timer units (max 2)
0x261F	do31	counter unit mode	Setting the mode for the timer / counter block: Function is timer or counter Definition of the reset behaviour Definition of the counting behaviour
0x2620	do32	run source parameter	Selection if ru88, ru19, ru20 or ru18 is used as release for the counter
0x2621	do33	run source bit	Selection which bit shall be used as release. Depending on the parameterization in do31 counter unit mode, inverting of the bit can also be used as reset or hold input
0x2622	do34	reset source parameter	Selection if ru88, ru19, ru20 or ru18 is used as reset input
0x2623	do35	reset source bit	Selection which bit is to be used as reset input If no bit is selected here, the inverted release signal must be programmed as reset source.
0x2624	do36	count source parameter	Selection if ru88, ru19, ru20 or ru18 is used as counting input
0x2625	do37	count source bit	Selection which bit is to be used as counting input
0x2626	do38	direction source parameter	Selection if ru88, ru19, ru20 or ru18 is used as counting direction input
0x2627	do39	direction source bit	Selection which bit is used to specify the counting direction
0x2628	do40	timer end value	End value at which the counter is stopped
0x2C59	ru89	timer value	Display of the counter value (identical parameter for the display in ms or events)

8.3.2 Configuration of the counting unit

do31	counter unit mode			0x261F
Bit	Function	Value	Plaintext	Note
0, 1	counter mode	0	Timer	The counter operates as timer Input is the ms grid
		1	Counter	The counter operates as event counter Input is an edge of an input bit (Definition of the bit with do37 count source bits, Definition of the edge with bit 5/6 of this parameter)
2..4	enable mode	0	use as reset	The inverted enable signal is simultaneously the reset. The counter counts events or time as long as the enable bit is set. If the enable bit is omitted, the counter is stopped and reset to zero
		4	use as halt	The counter counts events or time as long as the enable bit is set. The omission of the enable signal stops the counter. The counter can only be "set to zero" via the additional reset input
		8	only for start	If the counter has been started by the enable signal, it can only be stopped again and simultaneously set to zero by the separate reset input
5..7	count mode	0	only positive edge	positive edges are counted
		32	only negative edge	negative edges are counted
		64	both edges	both edges are counted

8.3.3 Selection of the start bit

In the array do32 run source parameter the parameters are defined to taken the enable / start bit of the counter. Subindex 1 defines counter 1, subindex 2 defines counter 2.

do32	run source parameter	0x2620
Value	Name	Function
0	ru88	Selection of the parameter, which bits can start or release the counter ru88: Bit 0 = F1 / Bit 1 = F2 /.. / Bit 8 = CF1 / .. / Bit 11 = CF4 ru19 / ru20: Bit 0 = O1 / .. / Bit 3 = O4 / Bit 4 = OA / .. / Bit 6 = OC / Bit 7 = Relay ru18: Bit 0 = I1 / .. / Bit 7 = I8 / Bit 8 = IA / .. / Bi11 = ID / Bit12/13 = CW1/CW2 / Bit 14/15 = STO1/STO2
1	ru19	
2	ru20	
3	ru18	

The bit (exactly 1 bit) that shall be used as run / start bit of the counter is selected in do33 run source bit. Subindex 1 applies to counter 1, subindex 2 to counter 2. If a bit is selected (e.g. bit 9 of ru19), that is not supported by the selected parameter, the counter is never started.

<table>
<tr><td>do33</td><td colspan="4">run source bit</td><td>0x2620</td></tr>
<tr><td>Value</td><td>Text</td><td>ru88</td><td>ru19 / ru20</td><td>ru18</td><td></td></tr>
<tr><td>1</td><td>Bit0</td><td>F1</td><td>O1</td><td>I1</td><td rowspan="16">Only one bit is selectable as run source bit. If this bit is set, the timer / counter starts

Depending on the parameterization in do30[1] mode, omitting of the bit while the counter is running either has no effect or the counter is set to zero, or the counter output is retained.

Attention parameter upper limit:
depending on the used software version, only the values 0 ... 2048 are adjustable. The control word inputs and STO inputs cannot be used for the timer / counter functions for these versions.</td></tr>
<tr><td>2</td><td>Bit1</td><td>F2</td><td>O2</td><td>I2</td></tr>
<tr><td>4</td><td>Bit 2</td><td>F3</td><td>O3</td><td>I3</td></tr>
<tr><td>8</td><td>Bit3</td><td>F4</td><td>O4</td><td>I4</td></tr>
<tr><td>16</td><td>Bit4</td><td>F5</td><td>OA</td><td>I5</td></tr>
<tr><td>32</td><td>Bit5</td><td>F6</td><td>OB</td><td>I6</td></tr>
<tr><td>64</td><td>Bit6</td><td>F7</td><td>OC</td><td>I7</td></tr>
<tr><td>128</td><td>Bit7</td><td>F8</td><td>Relay</td><td>I8</td></tr>
<tr><td>256</td><td>Bit 8</td><td>CF1</td><td></td><td>IA</td></tr>
<tr><td>512</td><td>Bit 9</td><td>CF2</td><td></td><td>IB</td></tr>
<tr><td>1024</td><td>Bit 10</td><td>CF3</td><td></td><td>IC</td></tr>
<tr><td>2048</td><td>Bit 11</td><td>CF4</td><td></td><td>ID</td></tr>
<tr><td>4096</td><td>Bit 12</td><td></td><td></td><td>CW1</td></tr>
<tr><td>8192</td><td>Bit 13</td><td></td><td></td><td>CW2</td></tr>
<tr><td>16384</td><td>Bit 14</td><td></td><td></td><td>STO1</td></tr>
<tr><td>32768</td><td>Bit 15</td><td></td><td></td><td>STO2</td></tr>
</table>

If the run bit is simultaneously set with the reset bit, the counter restarts immediately. This means, no positive edge is required at the run bit, but a stopped counter is started when the run bit is active.

8.3.4 Selection of the reset bit

The reset input must be defined in the same way as the start / run input (if you do not want to do without it)

do34 reset source parameter offers the same setting options as do32 run source parameter.

do35 reset source bit is identical with do33 run source bit.

Setting the reset bit always stops the counter and sets it to zero. Alternative possibilities of use do not exist.

The reset input is processed after the run input. If both bits fail simultaneously, the counter is stopped and set to zero.

8.3.5 Selection of the count event

If the counter shall not be used as timer which counts in the ms grid, but as event counter, the count event can be selected in the same way as the start and the reset bit with do36 count source parameter and do37 count source bits.

With do31 counter unit mode Bit 5/6 count mode you can select which edge is to be counted. (e.g. count mode 0: positive edge => A positive edge of the selected bit causes a counting pulse).

8.3.6 Selection of the bit for reversing the direction of rotation

In the same way as the start / run input, a bit for reversing the counting direction can also be defined.

If the bit is set, counting is reversed in both timer and event counter mode.

The counter is limited downwards to zero.

do38 direction source parameter offers the same setting options as do32 run source parameter

do39 direction source bit is identical with do33 run source bit.

8.3.7 Evaluation of the counter

The output value of the counter/counters is displayed for diagnostic purposes as array in the ru parameters.

Depending on the parameterisation, the displayed value means the number of ms or events. In order to use the counters, the output values must be available as comparison operand in do01 flag operand A and do02 flag operand B.

NOTICE

The timer levels can only be compared with do06 flag level 2

- Due to the value range, the timer levels cannot be converted to a value with 4 decimal places. A comparison with do05 flag level 1 is not possible. Since the timer value does not contain any decimal places, the comparison with do06 is also always sufficient.

When the final value is reached, the counter does not reset automatically but remains at the final value.

8.3.8 Overview of the counter structure

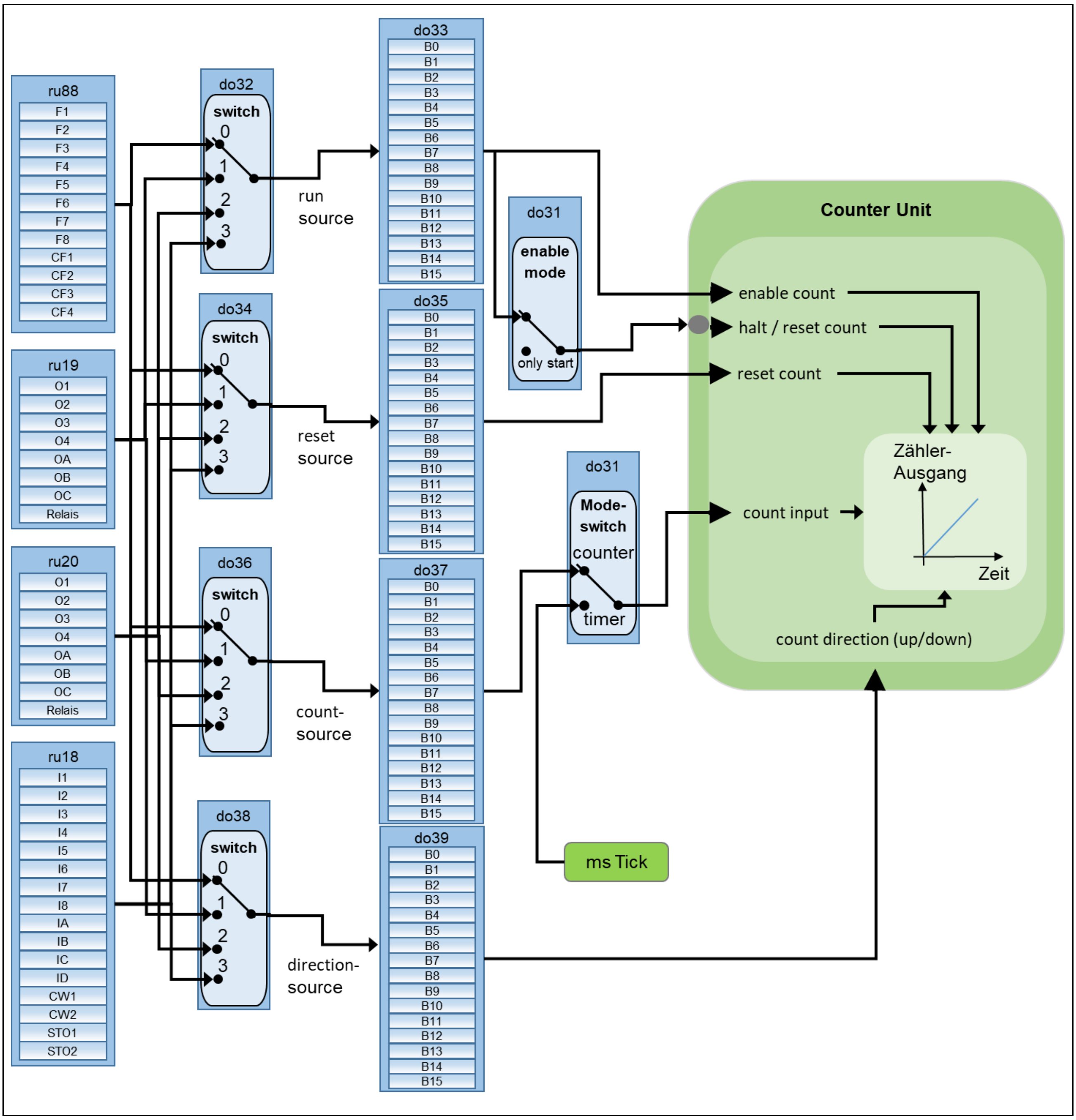


Figure 129: Timer / counter structure

9 Object directory

9.1 Glossary

The term "object dictionary" is used in this manual as name for an ordered collection of parameters / parameterizing data.

The terms parameter and parameterizing data are used synonymously in this manual. Both terms refer to an object in the inverter.

A parameter has an index, subindex and name. The user can read and / or write to a parameter to influence the functionality of the device.

Example of a parameter from chapter 4.1.2 Control word:

Index	Id-Text	Name	Function
0x2500	co00	(CiA 0x6040) controlword	KEB spec. Object
0x6040			CiA402 object

The parameters of a KEB inverter are collected in object dictionaries. Then they are sorted into groups (st, co, …) and according to their parameter index.

Access to an object dictionary allows access to the contained parameters. For access to a KEB object dictionary the KEB software tool COMBIVIS studio 6 is recommended.

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➢ The latest version of COMBIVIS studio 6 can be downloaded free of charge and without registration from the KEB website.
Link to the setup of COMBIVIS studio 6

9.2 Display of parameters in COMBIVIS 6

COMBIVIS 6 uses for communication protocol DIN66019II via Ethernet or via serial connection or USB.

Information to establish a connection between COMBIVIS and a KEB device can be found in the COMBIVIS 6 description and in the help menu of COMBIVIS 6.

9.2.1 For information on how to connect to the different object dictionaries on a KEB device, see chapter 9.5

9.2.2 Communication in this manual

In COMBIVIS, all parameters of an object directory are always displayed and sorted by groups and index. Only the index, subindex, name and value are displayed in the interface. Further information about a parameter can be seen via the property editor.

The following example shows the object an08 in COMBIVIS.

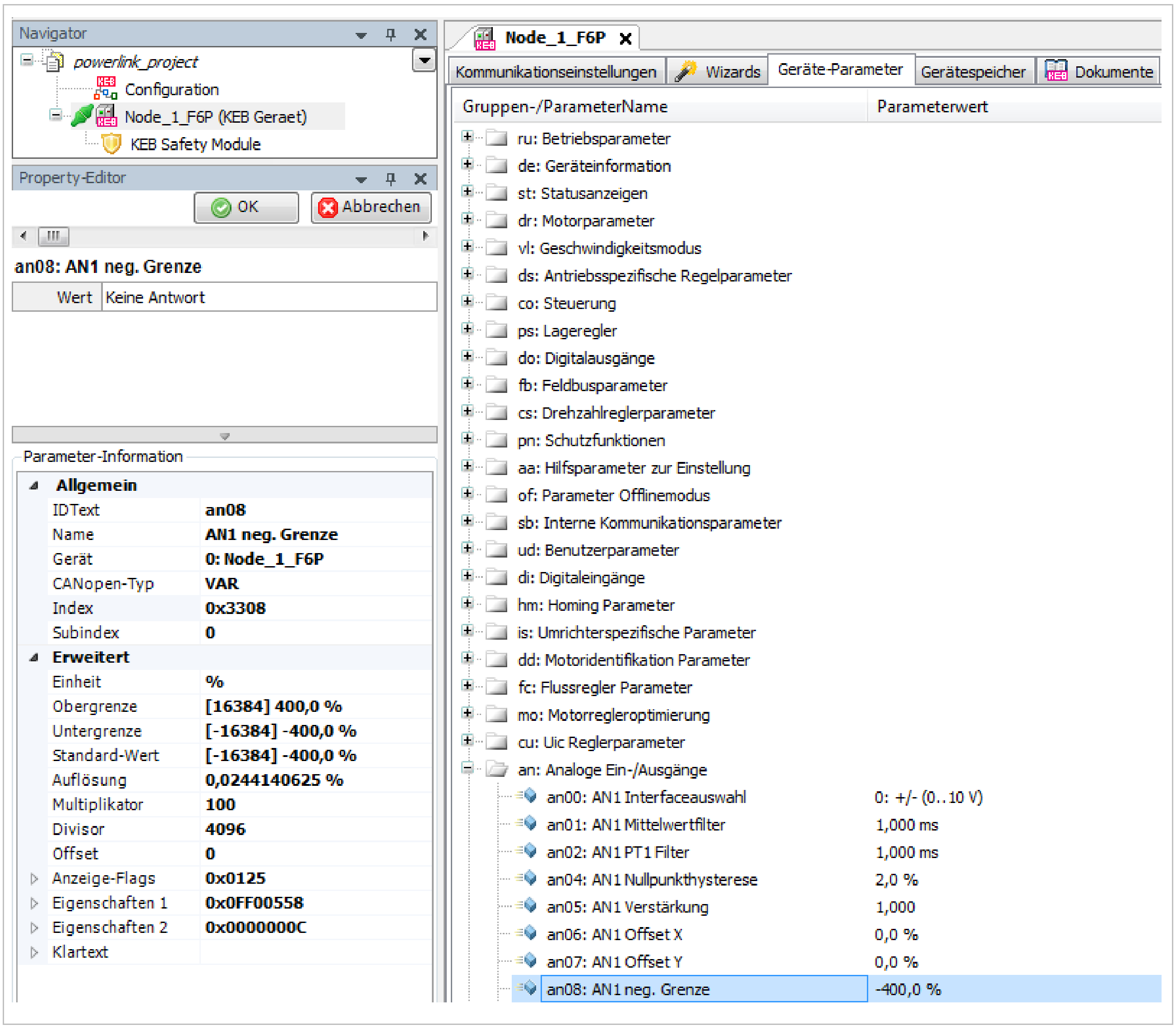

Figure 130: Display object data in COMBIVIS

9.3 KEB specific parameters and standard - conform parameters

The parameters in a KEB object dictionary are usually KEB specific.

Parameters that conform to a specific standard are listed in the pr: com profile objects – group. Most of the parameters are identical to KEB specific objects and provide access to the same object only at a different address.

9.3.1 EtherCAT conform parameters

KEB devices type F6 and S6 are certified EtherCAT slaves. All objects required for certification are supported. The objects for setting the process data mapping, the Sync Manager and the Sync Manager parameters are listed, among others in the pr - parameter group.

Further information on the implementation of EtherCAT on the devices of the F6 and S6 types can be found in the Programming manual | Fieldbus systems.

The Programming manual | Fieldbus systems can be downloaded from the KEB website. Registration is required.

9.3.2 CanOpen conform parameters

9.3.2.1 Identical objects

For all of these objects, the size of the array is always displayed for arrays in subindex 0.

CanOpen			KEB specific		
Index	Subidx	Name	Index	Subidx	Idx text
0x603f	0	error code	0x2101	0	st01
0x6040	0	controlword	0x2500	0	co00
0x6041	0	statusword	0x2100	0	st00
0x6042	0	vl target velocity	0x2314	0	vl20
0x6043	0	vl velocity demand	0x2103	0	st03
0x6060	0	modes of operation	0x2501	0	co01
0x6061	0	modes of operation display	0x2102	0	st02
0x6062	0	position demand value	0x2125	0	st37
0x6064	0	position actual value	0x2121	0	st33
0x6065	0	following error window	0x2E0C	0	ps12
0x6066	0	following error time out	0x2E0D	0	ps13
0x6067	0	positioning window	0x2E0E	0	ps14
0x6068	0	positioning window time	0x2E0F	0	ps15
0x606B	0	vl velocity demand	0x2103	0	st03
0x606C	0	velocity actual value	0x2120	0	st32
0x6071	0	target torque	0x250F	0	co15
0x6072	0	max torque	0x270C	0	cs12
0x6077	0	torque actual value	0x2122	0	st34
0x607A	0	target position	0x2513	0	co19
0x607B	1	position range limit	0x2E12	0	ps18
	2		0x2E13	0	ps19
0x607C	0	home offset	0x3100	0	hm00
0x607D	1	software position limit	0x2E11	0	ps17
	2		0x2E10	0	ps16
0x607F	0	max profile velocity	0x2E20	0	ps32
0x6081	0	profile velocity	0x2E1E	0	ps30
0x6082	0	end velocity	0x2E1F	0	ps31
0x6098	0	homing method	0x3101	0	hm01
0x6099	1	homing speeds	0x3102	0	hm02

CanOpen			KEB specific		
Index	Subidx	Name	Index	Subidx	Idx text
	2		0x3103	0	hm03
0x60E0	0	positive torque limit value	0x270D	0	cs13
0x60E1	0	negative torque limit value	0x270E	0	cs14
0x60F4	0	following error actual value	0x2124	0	st36
0x60FF	0	target velocity	0x2510	0	co16

9.3.2.2 Not identical objects

9.3.2.2.1 Shutdown modes

Index	Name	affects on KEB specific object:
0x605B	shutdown option code	co32 state machine properties->shutdown mode co32 state machine properties->shutdown ramp mode
0x605C	disable operation option code	co32 state machine properties->disable operation mode co32 state machine properties->disable op.ramp mode
0x605E	fault reaction option code	co32 state machine properties->fault reaction mode

The status shutdown is achieved by removing bit 0 in the controlword (switch on) (=> Chapter 4.1.2 Control word).

shutdown option code	0x605B
Value	Function
-1	Shutdown with ramp / fault reaction ramp (pn parameter) is used
0	Immediate shutdown of the modulation
1	Shutdown with ramp / standard ramp (co Parameter) is used

The state disable operation is reached by removing of bit 3 in the controlword (enable operation) (=> Chapter 4.1.2 Control word).

disable operation option code	0x605C
Value	Function
-1	Disable operation with ramp / fault reaction ramp (pn parameter) is used
0	Immediate shutdown of the modulation
1	Disable operation with ramp / standard ramp (co parameter) is used

The state fault reaction is reached when an error occurs which does not mandatory shutdown the modulation and when value 1 is selected as response (stop mode) (=> Chapter 4.3.1 Errors).

fault reaction option code	0x605E
Value	Function
-1	Disable operation with ramp / fault reaction ramp (pn parameter) is used
0	Immediate shutdown of the modulation

9.3.2.2.2 Communication

Index	Subidx	Name	affects on KEB specific object:
0x60C2	1	interpolation time period	fb10 sync intervall
	2		

interpolation time period [SubIdx 1] * 10^ interpolation time period [SubIdx 2] results in the synchronous cycle time in [s].

fb10 also affects the synchronous cycle time. The setting/display is in µs.

Example: 0x60C2 SubIdx 1 = 5 / SubIdx 2 = -3 => 5 * 10^-3 s = 5ms => fb10 = 5000(µs).

Adresse...	SubIndex	IdTxt	Name	Online-Wert
0x2B0A	0	fb10	sync interval	5000
0x60C2	1		interpolation time period	5
0x60C2	2		interpolation time period	-3

Figure 131: Interpolation

Restrictions and specifications regarding possible synchronous cycle times => Chapter 4.9 Synchronisation and 6.2.21.3 Task setting and synchronous fieldbus operation.

9.3.2.2.3 Information parameters

Index	Name	Function
0x1000	device type	402 => inverter supports the CIA402 profile

Index	Name	Subidx	Name	
0x1018	identity object	0	Number	Number of elements in the structure => 4
		1	vendor ID	EtherCAT / CAN: KEB = 20 Manufacturer-Id assigned by the CiA. VARAN: KEB = 26 Manufacturer-Id. assigned by the VNO
		2	product code	EtherCAT / CAN: 00800000h (identical de09) VARAN: 1157
		3	revision number	Configuration ID (number of the parameter description for COMBIVIS) (identical de08)
		4	device serial number	Serial number of the inverter (identical de00)

Index	Name	Function
0x6502	supported drive modes	0x000001A3 => supported drive modes = Bit 8 “cyclic sync velocity (csv)”, Bit 7 “cyclic sync positioning (csp)”, Bit 5 “homing (hm)” and Bit 1 “velocity (vl)”, Bit 0 “profile position” (pp)

9.3.2.2.4 Error messages

Index	Name	Function
0x1001	error register	Displays the error state of the CANopen client

error register	0x1001
Bit	Function
0	General error (is set with all other error messages)
1	Error overcurrent
2	Error overpotential or underpotential
3	Error overtemperature
4	Error communication
5	Error profile specific
6	reserved
7	KEB specific

A value of 0 (no bit set) means: No error

9.3.2.2.5 Speed displays

For the following object there is no KEB specific object in the same resolution:

Index	Sub-Idx	Name	Function
0x6044	0	vl velocity actual value	Actual speed for speed control (as ru08) but with the resolution 1 = 1rpm (resolution of the velocity modes)

9.3.3 Parameter conform to other fieldbus system standards

Other fieldbus systems which are supported on KEB devices of type F6 and S6 are VARAN on control type K and PROFINET, POWERLINK and EtherNetIP on control type A.

Information on these fieldbus systems and the associated parameters can be found in the Programming Manual | Fieldbus systems .

The Programming manual | Fieldbus systems can be downloaded from the KEB website. Registration is required.

9.4 Volatile and non-volatile parameters in the object dictionary

Parameters in the KEB object dictionary are stored either permanently in the device (non-volatile) or until the next reset (volatile).

Read-only parameters display only the actual operating state and are therefore only stored in volatile memory.

Additionally some parameters must always be set to a defined start value at power on (hardware reset). These parameters are also only stored volatile.

The following parameters must be set to a defined start value after power-on:

ru parameters		Peak value memory
dr parameters		Parameter changes, not yet confirmed by dr99
co parameters	controlword	co00
	Setpoint settings (target, offset)	co15, co16, co17, co18, co19
	Auto store	co83
external source for output		do10
external source for input		di02
position control parameters		ps30, ps31
Fieldbus parameters		fb10, error displays fb21…fb31
SACB diagnosis parameters (sb group)		all

All other parameters that are not changed for longer than approx. 80ms are permanently stored in the device.

The device requires approx. 2.5 seconds to check which parameters must be stored. The longest time from changing a parameter to saving it in the non-volatile memory takes about 2.5 seconds.

The F6 / S6 devices store changed parameters automatically non-volatile when the 24V supply voltage is switched off. The time still available for storing the parameters depends on the load of the voltages.

This time is not always sufficient to save all parameters. Therefore, the data is always automatically stored in the background, even during operation. Due to the slower storage medium, only data such as error and operating hours counters are stored on the VARAN card.

In order to receive a feedback after a parameter download when the saving of the parameters is completed, each parameter list should be completed by writing co07 = 0 and then co07 = 1.

The second write access is only acknowledged positively when saving is complete.

9.4.1 Save mode and status of the non-volatile memory

Index	Id-Text	Name	Function
0x2553	co83	non volatile memory mode	Select memory mode

The values of co83 non volatile memory mode have the following meaning

co83	Non volatile memory mode		0x2553
Value	Name	Note	
0	automatic mode	Data is automatically saved in the background.	
1	manual mode	Changed data are not saved automatically, but only when the 24V supply is switched off (if still possible). To safe the data change into "automatic mode"	

- After power-on or reset the "automatic mode" (co83 = 0) is always active.

The current state of the storing can be monitored via the object co07 Non volatile memory state.

Index	Id-Text	Name	Function
0x2507	co07	non volatile memory state	State of the memory manager

The values of co07 non volatile memory state have the following meaning

co07	Non volatile memory state		0x2507
Value	Name	Note	
0	Store process active	There are parameters to store.	
1	Store process completed	Memory cache empty. All data are stored non-volatile.	

Downloads can be secured with co07, by making sure that the download is only completed when the write cache is completely empty.

To this end add object co07 non volatile memory state twice at the end of the download list.

In the first entry co07 non volatile memory state must be written to 0. This immediately changes the state of the write cache to 0 (storage active).

In the second entry co07 must be written to 1. This write request is responded by the inverter with error code (inverter busy) until the storage process is completed and co07 non volatile memory state changes to 1.

COMBIVIS automatically repeats write processes which are answered with inverter busy. Therefore the download ends only when the storing is completed.

Additionally the setting ofco07 non volatile memory state 0, causes that the memory delay is set to 0 until the next change of co07 non volatile memory state to 1.

9.4.2 Resetting of the non-volatile parameters

The drive parameterization can be reset via the following objects:

Index	Id-Text	Name	Function
0x2508	co08	reset options	Determination when default-values-loading is carried out
0x2509	co09	reset control	Proceed reset

The values of co08 reset options have the following meaning

co08	reset options		0x2508
Bit	Name	Note	
0	default after every reset	Default values are loaded after every reset / restart. This bit is not reset by the reset / restart.	
1	default after next reset	Default values are loaded after next reset / restart. This bit is reset by reset / restart to 0.	

9.4.2.1 Release reset

A reset of the drive can be released via object co09 reset control during operating time. This is done by writing value 1 to the object co09 reset control.

Releasing a reset is only possible if the drive is not in state operation enabled or another state where the power modules are in operation.

The write access to object co09 reset control is positive acknowledged. An internal counter is started with this access. The progress of this counter can be read out in co09 reset control.

Further writes accesses are responded with the acknowledgement "inverter busy" during the timer increments. During this period the changed unit adjustments till then are stored non-volatile.

A reset of the unit is released after expiration of the counter.

9.4.2.2 Trigger loading of default values into download lists

If the function "Loading of default values" is used in a download list, please note the following:

- Insert the object co08 reset options with value 2 at the first place.
- Insert object co09 reset control with value 1 in the next row.
- Insert a waiting time for the time of execution of the reset command. This time is dependent on the parameter scope of the respective inverter and the adjusted time-out time in COMBIVIS. A waiting time of 20s should always be sufficient.

2	0	RW	co08	reset options	2: DNR
3	0	RW	co09	reset ctrl	1: activate reset
4				Pause	-20000 ms

Figure 132: Loading of default values in download lists

- Complete the download list with the other required parameters.

9.4.3 Checksum

It is possible to check the total non-volatile memory of the unit with a 128-bit hash value or a checksum. To this end the superior control can compare the 128 bit hash with the stored value after switching on. By way it can be checked whether the data in the unit have changed.

The MD5 hash is generated by writing 1 to de107. de107 and de108 are not stored. A new checksum must be requested after every power-on.

Even minor changes in only one parameter lead to a completely different MD5 hash.

Index	Id-Text	Name	Function
0x206B	de107	get MD5 hash	Generate the checksum
0x206C	de108	MD5 hash	Comparison of NV data
0x206D	de109	exclusion from MD5	Exclusions for some parameters

The 128 bits are stored in an array in de108 MD5 hash.

de108	MD5 hash		0x206C
Subidx	Function	Notes	
1	Hash Bits 0…. 31		
2	Hash Bits 32 …63		
3	Hash Bits 64 … 95		
4	Hash Bits 96 … 127		

The listed parameters can be excluded from the calculation of the checksum with de109 exclusions from MD5.

de109	exclusion from MD5		0x206D
Bit	Function	Notes	
0	ec23 system position		
1	ec23 system position B		

9.4.4 User Parameters

There are eight user parameters that have no function in the firmware. Since they are contained in the MD5 checksum, they can be used, for example, to secure a customer-specific parameterisation.

Index	Id-Text	Name	Function
0x2910	aa16	user parameter 0	No function in the firmware, included in the checksum
0x2911	aa17	user parameter 1	
0x2912	aa18	user parameter 2	
0x2913	aa19	user parameter 3	
0x2914	aa20	user parameter 4	
0x2915	aa21	user parameter 5	
0x2916	aa22	user parameter 6	
0x2917	aa23	user parameter 7	

9.5 Return codes at parameter accesses

If a parameter of the object dictionary is accessed (reading or writing) a feedback is sent by the KEB device.

In the case of a read access, this feedback contains the read parameter value.

Regardless of the access type, a return code is sent in each return message. This return value contains status information about the process of the parameter access.

For requests via the diagnostic interface, the return code is a KEB-specific value. The possible values are described below.

The KEB specific return code is converted into a fieldbus specific value for SDO requests via the fieldbus interface. The fieldbus-specific values are described in the Programming manual | Fieldbus systems.

The following KEB specific return codes are possible:

Return code 0: OK

The request was successful.

Return code 1: Device not ready

The request was not answered within the timeout time.

Return code 2: Invalid address or password

The requested parameter is not supported by the device or the adjusted password level is not sufficient for the request.

Return code 3: Invalid data

Occurs only with write requests. The written value is outside the parameter limits. Not all values within the parameter limits are valid for some parameters, e.g. ec16 encoder type. In this case the invalid values are also acknowledged with return code 3.

Return code 4: Parameter read only

A write request to a write protected parameter is acknowledged with this return code.

Return code 5: BCC-error

The BCC check has detected an error.

Return code 6: Device busy

The request cannot be processed at the moment. The device processes a previous request with extensive background routine, after which further requests are accepted again. Requests that are acknowledged with return code 6 should be repeated.

Return code 7: Invalid service

The requested service is not supported by the device. The supported services are listed in de10 operator config data subindex 5 and 6.

Return code 8: Invalid password

The adjusted level is not sufficient for the request.

Return code 9: Telegram-framing error

The checked telegram has either too few or too many characters.

Return code 10: Transmission error

A parity or overrun error was detected.

Return code 11: Invalid subindex

The requested subindex is invalid.

Return code 12: Invalid language

Not used with F6/S6.

Return code 13: Invalid address

The requested parameter is not supported by the device.

Return code 14: Function not possible

The request is currently not possible. Some parameters can only be written with modulation switched off. In this case a request with modulation switched on is acknowledged with return code 14.

10 Communication

10.1 Communication interfaces

F6 / S6 devices offer the following communication interfaces.

- A serial diagnostic interface for the connection with diagnostic tools (e.g. COMBIVIS) or an F6 operator.
- One CANopen fieldbus interface
- One real-time Ethernet interface

Depending on the control board, EtherCAT (control type P), EtherCAT or VARAN (control type K) or EtherCAT, PROFINET, POWERLINK and EtherNet / IP are available on the real-time Ethernet interface (control type A).

The diagnostic interface is always available parallel to the fieldbus interface. It can be changed between CAN interface and real-time Ethernet interface.

Parallel operation of CAN and real-time Ethernet interface is not possible.

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➢ The diagnostic interface is not intended for permanent operation of the device.

NOTICE

➢ The different versions of the real-time Ethernet interface in control type K are based on different hardware. Therefore the selection of the real-time Ethernet protocol must be observed when ordering.

10.2 Diagnostic interface

The diagnostic interface is used to connect the F6 / S6 device with diagnostic tools, such as COMBIVIS.

KEB DIN66019-II is used as protocol. This is an asynchronous serial protocol with the following basic data:

1 start bit, 7 data bits, 1 parity bit (even), 1 stop bit.

These settings are fixed and can not be configured at the drive.

A description of the protocol is available from the KEB website.

- The diagnostics interface supports point-to-point connections via RS232 or RS485 (full duplex). Networks via RS485 (half duplex) are not supported.

- The configuration of the diagnostic interface on the devices of control type P differs from the configuration on the devices of control type A and K.

- The term "node address" or "node ID" often used in this chapter refers to the identification number used by the DIN66019 protocol to address a KEB device.
- "Node address" or "Node ID" in this chapter does **not** mean the Node ID which can be set via the rotary coding switches which is used to identify the KEB device via the fieldbus interface (CAN or Ethernet).
- Information about the "Node ID" of the fieldbus interface can be found in the Programming manual | Fieldbus systems, which can be downloaded from the KEB website. Registration is required.

10.2.1 Configuration of the diagnostic interface on the devices of control type P

The diagnostic interface can be configured on the devices of control type P via the following options.

Index	Sub Index	Id-Text	Name	Function
0x2B0D	0	fb13	drive node ID	Node address of the inverter object dictionary
0x2B0E	0	fb14	DIN66019 baud rate	Baud rate
0x2B0F	0	fb15	node IDs	Number of node IDs
0x2B0F	1	fb15	application node ID	Node address of the application object dictionary
0x2B0F	2	fb15	debugger node ID	Node address of the debugger object dictionary
0x2B10	0	fb16	fieldbus node injection	Node address of the object dictionary to which the communication of the fieldbus interface is transmitted
0x200A	0	de10	operator cfg data	Structure with configuration data for F6 / S6 operators or for the application software and for the connection to the file system

10.2.1.1 Node address (Node IDs) for DIN66019

In the KEB DIN66019-II protocol, each node is identified by its own node address. Each node has a separate object directory.

A device of control type P can contain several object dictionaries in different parts of the device. Therefore, a device of control type P also has several DIN66019 nodes, each is identified by its own node address.

10.2.1.1.1 Node address of the inverter object dictionary

To address the object dictionary of the inverter via the diagnostic interface, the adjustable node address in fb13 drive node ID must be used.

The object dictionary of the inverter is available on each KEB device. Other object dictionaries are optional.

fb13	drive node ID	0x2B0D
Value	Meaning	Note
0-238	Node address of the inverter object dictionary	Default value = 1

➢ To enable automatic recognition of replacement devices, the default value should not be used in productive systems.

10.2.1.1.2 Node address of the application object dictionary

Devices of control type P can have a separate application object dictionary with its own node address.

To address the object dictionary of the application software via the diagnostic interface, the adjustable node address in fb15.1 application node ID must be used.

fb15.1	appliction node ID	0x2B0F
Value	Meaning	Note
0-255	Node address of the application object dictionary	Default value = 2

➢ A standard KEB device of control type P does not yet have a separate application object directory in the actual software version.

10.2.1.1.3 Node address of the debugger

A debugger object directory is available on the devices of control type P from which additional information can be read out.

To address the object directory of the debugger via the diagnostic interface, the adjustable node address in fb15.2 application node ID must be used.

fb15.2	debugger node ID	0x2B0F
Value	Meaning	Note
0-255	Node address of the debugger object dictionary	Default value = 255

10.2.1.1.4 Inserted fieldbus node address

Telegrams incoming at the device via the fieldbus interface are transmitted to the object directory of the inverter by default and after each reset of the device.

If it is requested to address another object directory with DIN66019 telegrams sent via the fieldbus interface, the corresponding node address can be set via parameter fb16 fieldbus node injection .

The DIN66019 telegrams of the fieldbus interface are transmitted to the object directory, which is addressed via the node address in fb16 .

fb16	fieldbus node injection		0x2B10
Value	Meaning	Note	
0-255	Node address of the object directory where the DIN66019 telegrams are sent which are sent to the fieldbus interface.	Default value = value in fb13	

➢ Fb16 is a volatile parameter and is set to the value of fb13 at every reset. Thus, the object directory of the inverter is automatically addressed after every reset.

10.2.1.2 DIN66019 baud rate

The communication speed can be adjusted via the baud rate. The following baud rates are available depending on the control type.

fb14	DIN66019 baud rate	0x2B0E
Value	Meaning	Note
5	38400 bit/s	Default value
6	55500 bit/s	
7	57600 bit/s	
8	100000 bit/s	
9	115200 bit/s	
10	125000 bit/s	
11	250000 bit/s	
12	500000 bit/s	

NOTICE

The baud rate is 38400 bit/s after a power-on reset or after switching on of the device and must be switched from the DIN66019 master to another value, if required. The baud rate is reset to 38400 bit/s after approx. 10s if the interface is not used.

10.2.1.3 Operator config data

An operator connected to the device via the diagnostic interface requires (for optimal operation) information about the characteristics of the diagnostic interface and the object directory.

These are provided via the structure de10 "Operator config data“.

de10	operator cfg data				0x200A
Subidx	Meaning			Note	
0	Structure length	byte	RO		

de10	operator cfg data			0x200A
Subidx	Meaning			Note
1	idx start object	long	RW	Contains index and subindex of the object that the operator shall display after the start. The possibility to specify a subindex is not supported by all ver-sions of the operator software.
2	supported baud rates	long	RO	List of supported baud rates
3	baud rate addr	word	RO	Address of the object to change the baud rate.
4	software version addr	long	RO	Address of the object of the software version.
5	software date addr	long	RO	Address of the object of the software date.
6	supported services 31-0	long	RO	List of supported DIN66019 services (31-0)
7	supported services 63-32	long	RO	List of supported DIN66019 services (63-32)
8	watchdog addr	long	RO	Address of the object of the watchdog function.
9	com mode	long	RW	Communication modes (see 0)
10	Node Id object	long	RO	Address of the object of the inverter Node ID
11	MAC address object	long	RO	Address of the object of the MAC address
12	IP address object	long	RO	Address of the object of the IP address (Ethernet)
13	IP subnet mask object	long	RO	Address of the object of the subnet mask
14	IP gateway address object	long	RO	Address of the object of the gateway address
15	IP scan name object	long	RO	Address of the object for the scan name function
16	EoE IP address obejct	long	RO	Address of the object of the EoE IP address
17	EoE IP subnet mask object	long	RO	Address of the object of the EoE subnet mask
18	EoE IP gateway address object	long	RO	Address of the object of the EoE gateway address

idx start object	0x200A [1]
Description	Default value:
Format: 0x00SSIIII (Highestbyte = 0, 3. Byte = Subindex Lowword = Parameter-Index)	0x00002C01 (ru01) The support of the subindex is depending on the version of the operator software
supported baud rates	**0x200A [2]**
Description	Default value:
Bit 0: Baud rate index 0 (1200 bit/s) Bit 1: Baud rate index 1 (2400 bit/s) Bit 2: Baud rate index 2 (4800 bit/s) Bit 3: Baud rate index 3 (9600 bit/s) Bit 4: Baud rate index 4 (19200 bit/s) Bit 5: Baud rate index 5 (38400 bit/s) Bit 6: Baud rate index 6 (55500 bit/s) Bit 7: Baud rate index 7 (57600 bit/s) Bit 8: Baud rate index 8 (100000 bit/s) Bit 9: Baud rate index 9 (115200 bit/s) Bit 10: Baud rate index 10 (125000 bit/s) Bit 11: Baud rate index 11 (250000 bit/s) Bit 12: Baud rate index 12 (500000 bit/s)	0x00001FE0 (Bit 5, 6, 7, 8, 9, 10, 11 and 12)
baud rate addr	**0x200A [3]**
Description	Default value:
Format: 0xIIII (index, subindex always 0, only VAR objects)	0x2B0E
software version addr	**0x200A [4]**
Description	Default value:
Format: 0xSSSSIIII (highword = subindex, lowword = index)	0x00002010
software date addr	**0x200A [5]**
Description	Default value:
Format: 0xSSSSIIII (highword = subindex, lowword = index)	0x00002011

supported services (31-0)		0x200A [6]
Description	Default value:	
Bit 31 = service 31 …… Bit 0 = service 0	0x00244003	
supported services (63-31)		0x200A [7]
Description	Default value:	
Bit 63 = service 63 …… Bit 32 = service 32	0x00000000	
watchdog addr		0x200A [8]
Description	Default value:	
Format: 0xSSSSIIII (highword = subindex, lowword = index)	-1 (not supported)	
com mode		0x200A [9]
Description	Default value:	
0: Default communication mode 1: KEB FTP Modus	0	
Node Id object		0x200A [10]
Description	Default value:	
Format: 0xSSSSIIII (highword = subindex, lowword = index)	0x00002B0D	
MAC address object		0x200A [11]
Description	Default value:	
Format: 0xSSSSIIII (highword = subindex, lowword = index)	0x00002B6A	
IP address object		0x200A [12]
Description	Default value:	
Format: 0xSSSSIIII (highword = subindex, lowword = index)	0x00012B6D	
IP subnet mask object		0x200A [13]
Description	Default value:	
Format: 0xSSSSIIII (highword = subindex, lowword = index)	0 x00022B6D	
IP gateway address object		0x200A [14]
Description	Default value:	
Format: 0xSSSSIIII (highword = subindex, lowword = index)	0 x00032B6D	
IP scan names object		0x200A [15]
Description	Default value:	
Format: 0xSSSSIIII (highword = subindex, lowword = index)	0x00002B6E	
EoE IP address object		0x200A [16]
Description	Default value:	
Format: 0xSSSSIIII (highword = subindex, lowword = index)	0x00012B6C	
EoE subnet mask object		0x200A [17]
Description	Default value:	
Format: 0xSSSSIIII (highword = subindex, lowword = index)	0x00022B6C	
EoE gateway address object		0x200A [18]
Description	Default value:	
Format: 0xSSSSIIII (highword = subindex, lowword = index)	0x00032B6C	

Subindex 11 to 18 exists only for P cards.

10.2.2 Configuration of the diagnostic interface on the devices of control type A and K

The diagnostic interface can be configured on the devices of control type A and K via the following options.

Index	Id-Text	Name	Function
0x2B0E	fb13	DIN66019 node id	Node address of the device
0x2B0D	fb14	DIN66019 baud rate	Baud rate
0x200A	de10	operator cfg data	Structure with configuration data for F6 / S6 operators and for connection to the file system

10.2.2.1 DIN66019 node id

In the KEB DIN66019-II protocol, each node is identified by its own node address. Each node has a separate object directory.

On the devices of control type A and K there is only one object directory. Thus there is one DIN66019-II node and one variable node address per device.

fb13	DIN66019 node id		0x2B0E
Value	Meaning	Note	
0-238	Node address	Default value = 1	

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➢ To enable (e.g.) an automated detection of device replacement, the default value in productive systems should not be used.

10.2.2.2 DIN66019 baud rate

The communication speed can be adjusted via the baud rate. The following baud rates are available depending on the control type.

fb14	DIN66019 baud rate		0x2B0F
Value	Meaning	Note	
5	38400 bit/s	Default value	
9	115200 bit/s		
11	250000 bit/s		

NOTICE

The baud rate is 38400 bit/s after a power-on reset or after switching on of the device and must be switched from the DIN66019 master to another value, if required. The baud rate is reset to 38400 bit/s after approx. 10s if the interface is not used.

10.2.2.3 Operator config data

An operator connected to the device via the diagnostic interface requires (for optimal operation) information about the characteristics of the diagnostic interface and the object directory.

These are provided via the structure de10 "Operator config data“.

de10	operator cfg data			0x200A
Subidx	Meaning			Note
0	Structure length	byte	RO	
1	idx start object	long	RW	Contains the index and subindex of the object which is displayed by the operator after the start.
2	supported baud rates	long	RO	List of supported baud rates
3	baud rate addr	word	RO	Address of the object to change the baud rate.
4	software version addr	long	RO	Address of the object of the software version.
5	software date addr	long	RO	Address of the object of the software date.
6	supported services 31-0	long	RO	List of supported DIN66019 services (31-0)
7	supported services 63-32	long	RO	List of supported DIN66019 services (63-32)
8	watchdog addr	long	RO	Address of the object of the watchdog function.
9	com mode	long	RW	Communication modes (see 0)

idx start object	0x200A [1]
Description	Default value:
Format: 0xSSSSIIII (highword = subindex, lowword = index)	0x00002C03
supported baud rates	0x200A [2]
Description	Default value:
Bit 0: Baud rate index 0 (1200 bit/s) Bit 1: Baud rate index 1 (2400 bit/s) Bit 2: Baud rate index 2 (4800 bit/s) Bit 3: Baud rate index 3 (9600 bit/s) Bit 4: Baud rate index 4 (19200 bit/s) Bit 5: Baud rate index 5 (38400 bit/s) Bit 6: Baud rate index 6 (55500 bit/s) Bit 7: Baud rate index 7 (57600 bit/s) Bit 8: Baud rate index 8 (100000 bit/s) Bit 9: Baud rate index 9 (115200 bit/s) Bit 10: Baud rate index 10 (125000 bit/s) Bit 11: Baud rate index 11 (250000 bit/s) Bit 12: Baud rate index 12 (500000 bit/s)	0x00000A20 (Bit 5, 9 and 11)
baud rate addr	0x200A [3]
Description	Default value:
Format: 0xIIII (index, subindex always 0, only VAR objects)	0x2B0E
software version addr	0x200A [4]
Description	Default value:
Format: 0xSSSSIIII (highword = subindex, lowword = index)	0x00002010
software date addr	0x200A [5]
Description	Default value:
Format: 0xSSSSIIII (highword = subindex, lowword = index)	0x00002011
supported services (31-0)	0x200A [6]
Description	Default value:
Bit 31 = service 31 …… Bit 0 = service 0	0x00244003
supported services (63-31)	0x200A [7]
Description	Default value:
Bit 63 = service 63 …… Bit 32 = service 32	0x00000000

watchdog addr	0x200A [8]
Description	Default value:
Format: 0xSSSSIIII (highword = subindex, lowword = index)	-1 (not supported)

com mode	0x200A [9]
Description	Default value:
0: Default communication mode 1: KEB FTP Modus	0

10.2.3 Communication modes

The selection of the communication mode is controlled via the following object:

Index	Id-Text	Name	Function
0x200A[9]	de10	Com mode	Selection of the communication mode

Value	Name	Note
0	Standard	Access to the object directory via DIN66019II
1	KEB-FTP	Access to the internal file system via KEB-FTP

Switching into the KEB-FTP mode via de10 is only possible if the device is in one of the following operating modes:

- Fault
- Switch on disabled

If the drive is in another operating state, the attempt to change into the KEB-FTP mode is acknowledged with "Operation not possible".

The communication mode controlled via de10 only refers to the diagnostic interface. Whether access to the object directory / file system is possible via the fieldbus interface is controlled by the active fieldbus system. Access to the file system via the fieldbus interface is independent of the operating state.

Access to the object directory via the fieldbus interface can be restricted in the communication mode "KEB-FTP". In order to transmit the information to the higher-level control that the drive can not be controlled by the control, the remote bit is set to zero in the status word.

The change back into the communication mode 0 occurs via a command of the KEB FTP master, after 10s timeout or with the next power-on.

10.3 Fieldbus interface

10.3.1 General information about the fieldbus interface

The fieldbus interface and the different fieldbus systems are described in detail in an additional document, independent of the control board in the Programming Manual | Fieldbus systems.

The Programming manual | Fieldbus systems can be downloaded from the KEB website. Registration is required. The Programming Manual | Fieldbus systems contains information about the following topics:

- Commissioning of the fieldbus interface
- Diagnosis and configuration of the fieldbus interface via the parameters of the fb group
- Handling of process data communication
- Mapping objects in the pr group
- Handling of the fieldbus watchdog
- Detailed description of the KEB-specific implementation of the fieldbus systems CANopen, EtherCAT, VARAN, PROFINET, POWERLINK and EtherNet/IP on the F6 and S6 devices

10.3.2 Use of KEB diagnostic tools via the fieldbus interface

Since DIN66019 telegrams can also be sent via Ethernet, a KEB diagnosis can also be carried out via the Ethernet fieldbus interface. For this, the active fieldbus system must support a corresponding Ethernet channel.

An EoE connection is required at EtherCAT, at PROFINET the parallel Ethernet channel must be used to use KEB diagnostic tools via the fieldbus interface. At Ethernet/IP, no additional settings are necessary at fieldbus level.

For the fieldbus systems CANopen, VARAN and POWERLINK it is not possible to work with KEB diagnostic tools via the fieldbus interface.

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➢ If there are several DIN66019 nodes on a KEB device, as for example on the devices of the control type P, incoming DIN66019 telegrams are transmitted to the node address set in fb16 fieldbus node injection . (see chapter 10.2.1 Configuration of the diagnostic interface on the devices of control type P)

10.4 COMBIVIS 6 process data assistant

Process data mapping can be adjusted via the process data assistant in COMBIVIS 6. COMBIVIS 6 uses the KEB specific objects to describe the process data mapping for setting the data.

At this all limit conditions are automatically observed:

- Data type
  (depending on the data type, the type and offset are determined automatically).
- Characteristics
  (the mapping is permitted or inhibited depending on the object characteristics (RO, RW, mapping permitted)

The objects are just drag and drop with the mouse in the appropriate process data buffer.

The assistants indicate how many PDOs are available, how many parameters can be used per PDO and how many bytes are available per PDO.

10.4.1 Process data assistant for VARAN

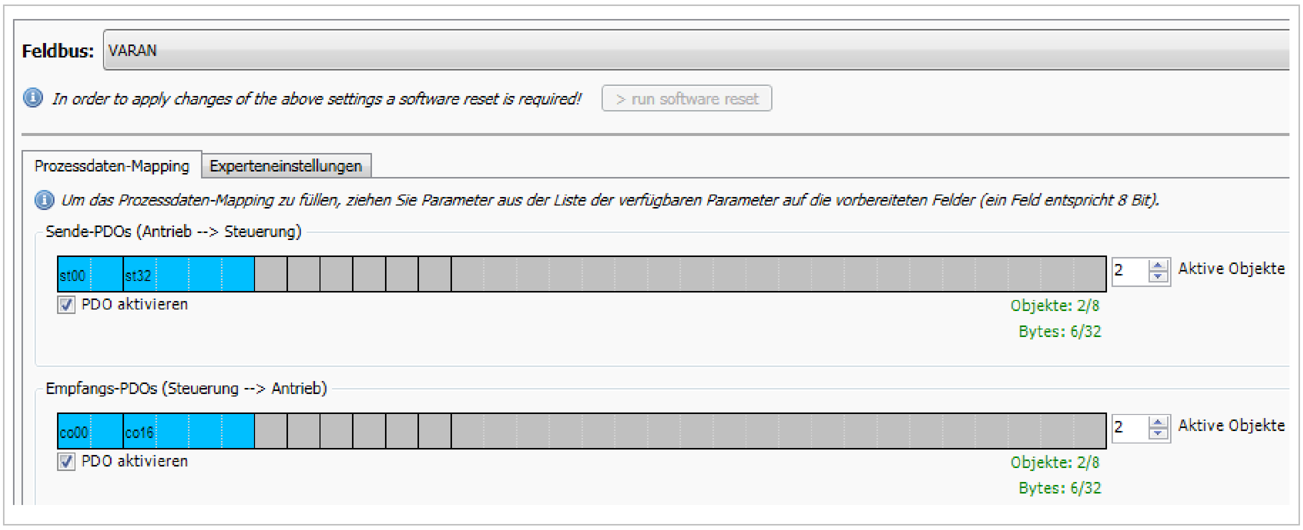

Figure 133: Process data assistant for VARAN

10.4.2 Process data assistant for EtherCAT

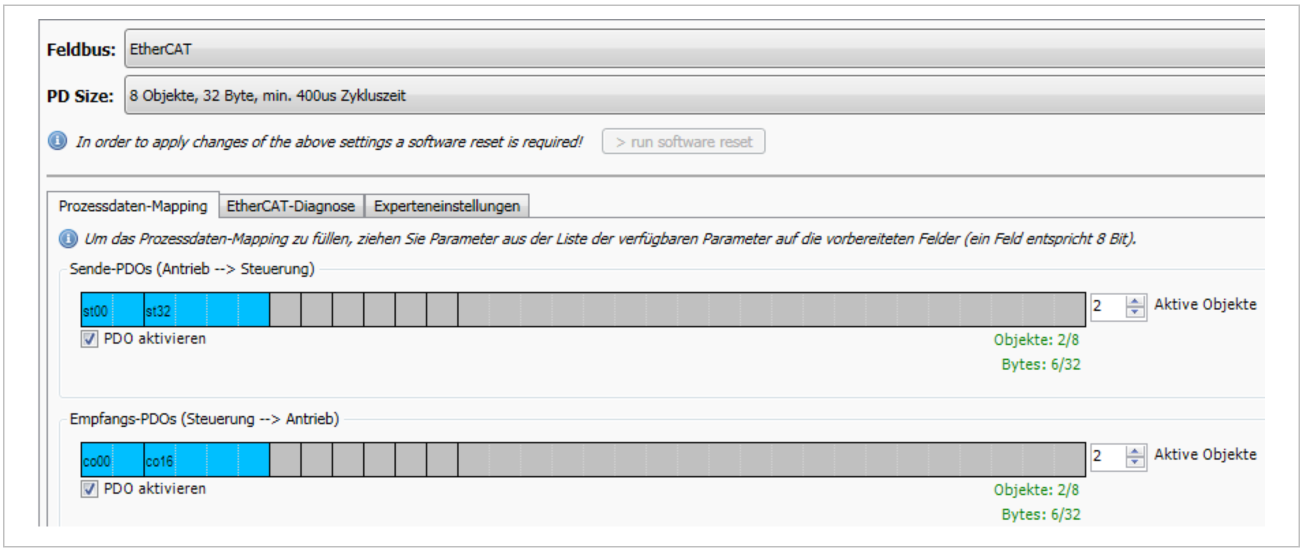

Figure 134: Process data assistant for EtherCAT

10.4.3 Process data assistant for CAN

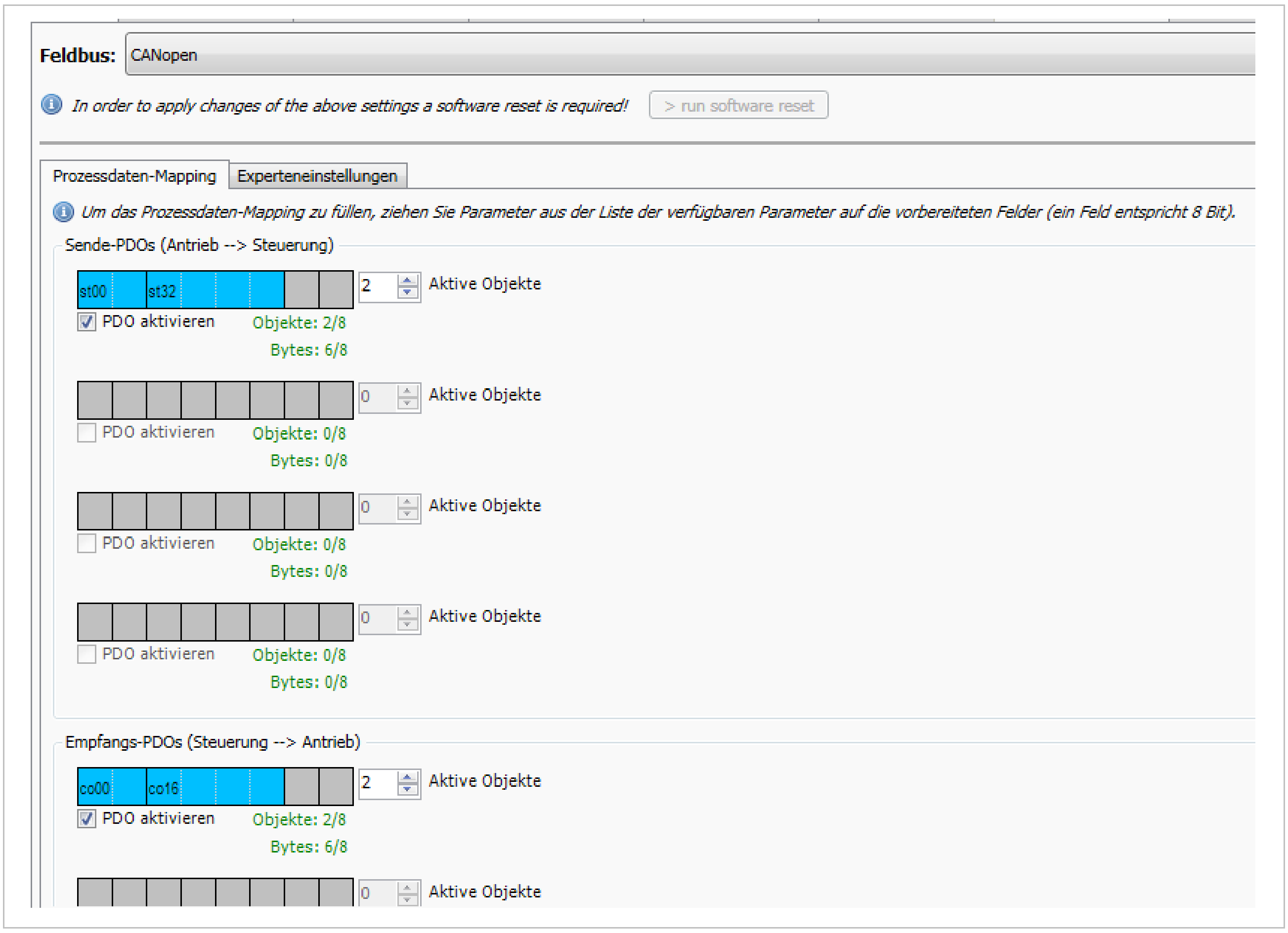

Figure 135: Process data assistant for CAN

10.5 Connection to the file system

The drive controller has a file system to store the recipe (download) files.

COMBIVIS 6 contains the program KEB FTP, which allows access to these files via the diagnostic interface. => See also the help contained in COMBIVIS 6.

The used interface adapter must support a direct connection.

- Connection directly to serial D-SUB 9-pole protocol DIN 66019 II: RS-232 cable PC / operator / Part No. 0058025-001D
- KEB USB serial converter - use only if the nameplate contains the imprint FTP Ready, otherwise KEB FTP does not work.

10.5.1 FTP connection set-up

Open KEB FTP and make the following settings. Do not press CONNECT yet!

Enter the used interface in COM.

With KEB FTP only 115200 baud are possible in conjunction with the drive controller, other settings do not work.

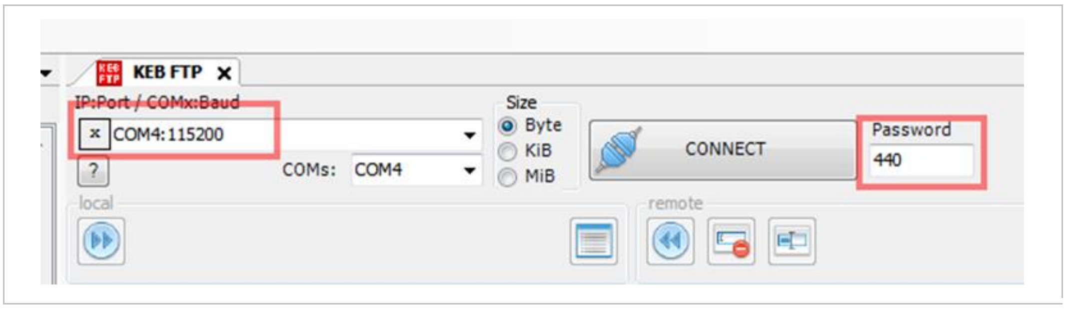

Figure 136: Set the baud rate

Set de10 operator cfg data SubIdx 9 com mode to 1 ⇒ to activate the FTP protocol with 115200 baud in the drive controller. FTP access is only possible if the drive does not modulate. Otherwise, the write access to this object is acknowledged negatively.

Then quickly disconnect the connection to the inverter in the communication settings.

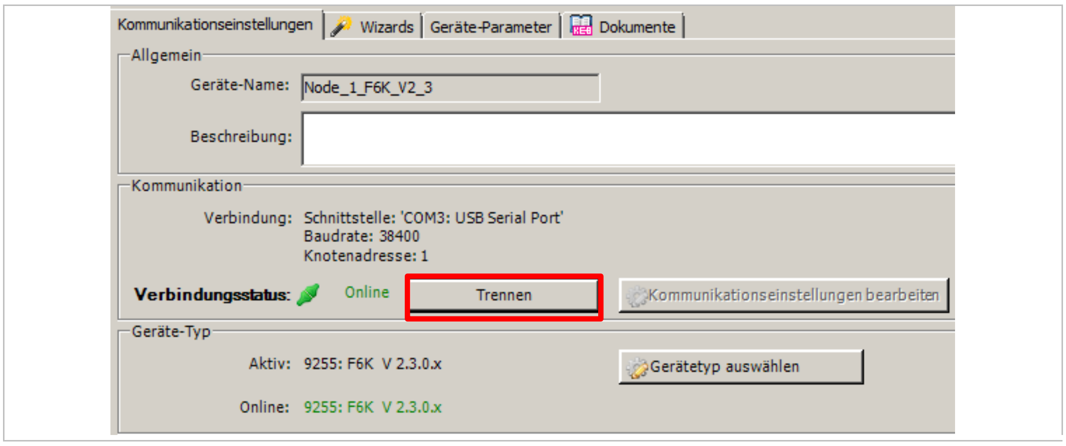

Figure 137: Disconnect the connection to the inverter

Then press CONNECT.

Figure 138: Connect drive controller

The status in KEB FTP should change to Connected, the connection is established.

If the time out time of 10s expires after writing de10[9]=1 without creating an FTP connection, the FTP mode is automatically left again.

If the connection has been established, the recipe files can be copied via KEB-FTP into the file system of the inverter.

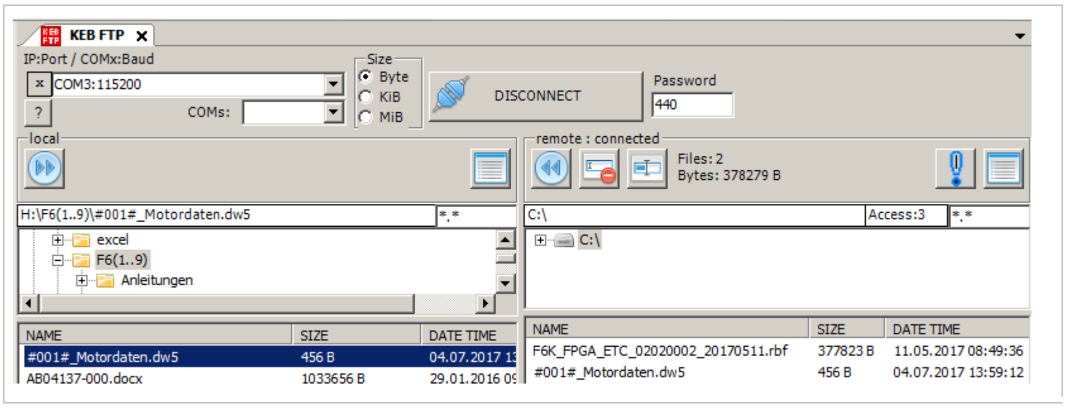

Figure 139: Copy recipe

11 Special Functions

Some parameters are only used in special functions.

These parameters are described in a separate manual.

The following special functions are implemented:

11.1 Compatibility objects

The description of the parameter ud 50 can be found in the Programming Note

www.keb.de/fileadmin/media/Techinfo/dr/pn/ti_dr_pn-f5-comp-objects-00005_de.pdf

Index	Sub-Idx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Default value	Mult.	Div	Unit	PD	RO	EOAD
3032h	0	ST	UINT8	ud50	F5 compatibility objects	---	---	---	1	1	---	x	x	9284, 9285
	1		UINT16		option code	255	0	0	1	1	---	---	---	
	2		UINT16		customer control-word 1	65535	0	0	1	1	---	x	---	
	3		UINT16		customer control-word 2	0	0	0	1	1	---	x	---	
	4		UINT16		customer status-word 1	---	---	---	1	1	---	x	x	
	5		UINT16		customer status-word 2	---	---	---	1	1	---	x	x	
	6		INT16		procentual set speed	16384	-16384	0	100	16384	%	x	---	
	7		INT16		actual speed	---	---	---	100	16384	%	x	x	
	8		INT16		actual torque	---	---	---	1	1	Nm	x	x	
	9		INT16		inverter tempera-ture	---	---	---	1	1	°C	x	x	
	10		INT16		motor tempera-ture	---	---	---	1	1	°C	x	x	
	11		UINT16		inverter tempera-ture	---	---	---	1	1	---	x	x	
	12		UINT16		relative load	---	---	---	1	1	%	x	x	
	13		UINT16		reference speed	65535	10	3000	1	1	rpm	x	---	

11.2 Power limitation

The description of these parameters can be found in the additional manual power-dependent speed limitation

www.keb.de/fileadmin/media/Techinfo/dr/pn/ma_dr_f6_Leistungsbegrenzung_20203475_deu.pdf

Index	Sub-Idx	CAN	Type	IDtxt	Name	Upper limit	Lower limit		Default value	Mult.	Div	Unit	PD	RO	EOAD
3028h	0	V	UINT16	ud40	vl velocity limit options	65535	0		0	1	1	---	---	---	✓
3029h	0	ST	UINT8	ud41	maximum speed	---	---		---	1	1	---	---	x	✓
	1		INT32		max speed mot for	32000	0		2000	1	1	rpm	---	---	
	2		INT32		max speed mot rev	32000	0		2000	1	1	rpm	---	---	
	3		INT32		max speed gen for	32000	0		2000	1	1	rpm	---	---	
	4		INT32		max speed gen rev	32000	0		2000	1	1	rpm	---	---	
302Ah	0	ST	UINT8	ud42	lower limit level	---	---		---	1	1	---	---	x	✓
	1		INT32		lower limit level mot for	32000	0		1000	1	1	rpm	---	---	
	2		INT32		lower limit level mot rev	32000	0		1000	1	1	rpm	---	---	
	3		INT32		lower limit level gen for	32000	0		1000	1	1	rpm	---	---	
	4		INT32		lower limit level gen rev	32000	0		1000	1	1	rpm	---	---	
302Bh	0	ST	UINT8	ud43	average times	---	---		---	1	1	---	---	x	✓
	1		UINT16		settle time	8000	0		100	1	1000	s	---	---	
	2		UINT16		average time dyn limit calculation	8000	0		1000	1	1000	s	---	---	
302Ch	0	ST	UINT8	ud44	maximal power	---	---		---	1	1	---	---	x	✓
	1		UINT32		max power mot for	1000000	0		4000	1	1000	kW	---	---	
	2		UINT32		max power mot rev	1000000	0		4000	1	1000	kW	---	---	
	3		UINT32		max power gen for	1000000	0		4000	1	1000	kW	---	---	
	4		UINT32		max power gen rev	1000000	0		4000	1	1000	kW	---	---	
302Dh	0	V	INT16	ud45	power hysteresis	2000	1000		1050	1	1000	---	---	---	✓
302Eh	0	V	UINT32	ud46	slow torque PT1	500000	0		20000	1	1000	ms	---	---	✓
302Fh	0	V	INT32	ud47	speed hysteresis for ramp out	262144000	0		40960	1	8192	rpm	---	---	✓
3030h	0	V	INT32	ud48	speed level for cont calc	262144000	0		40960	1	8192	rpm	---	---	✓
3031h	0	V	INT16	ud49	dyn vel limit state display	---	---		---	1	1	---	x	x	✓

11.3 Liquid cooling management

There are 2 structures for handling the cooling management for inverter and motor: ud53 liquid cooling control and ud55 motor cooling control.

Except for the selection and type of the actual value setting, both controls are absolutely identical.

The output signal of the control can alternatively be assigned to a digital output or an analog output.

NOTICE

Behaviour in case of sensor error or missing mains supply

- In error case (sensor short-circuit or sensor breakage, and in case of a missing power unit ready signal (missing mains voltage), the real temperature cannot be measured.
  Due to the risk of condensation, cooling is deactivated in these cases.

11.3.1 PI controller

11.3.1.1 Heat sink cooling

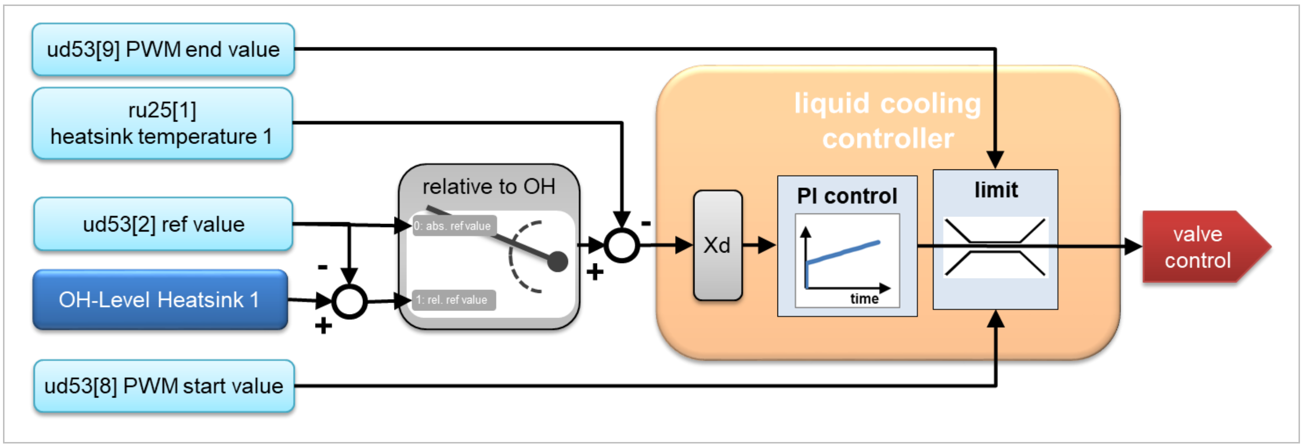

Figure 140: Overview controller

With this type of control, either a fixed setpoint or the distance of the heat sink temperatures from the corresponding OH threshold is preset.

ud53[1]		source select	
Bit	Value	Plaintext	Notes
0	1	activate	Activation of the controller
1	2	HS_1	The selected temperatures are used as actual values for the PI controller. Setting depends on inverter hardware. Currently, the setting must always be 2: HS_1
2	4	HS_2	
3	8	HS_3	

ud53[1]		source select		
Bit	Value	Plaintext	Notes	
4	16	realtive to OH	0:	The maximum difference between the selected temperatures and the setpoint ud53[2] ref value is assigned to input Xd of the PI controller
			16:	OH temperature - ud53[2] ref value is the set value of the respective heat sink temperature. The largest difference between setpoint and actual value is assigned to input Xd of the PI controller
5	32	manual setting	1:	The PWM control setting is preset manually The display of ud53[5] and ud53[11] also displays the manually preset value.

ud53[2]	ref value	
Value	Meaning	
0…100 °C	Set temperature or distance to OH threshold	

11.3.1.2 Motor cooling

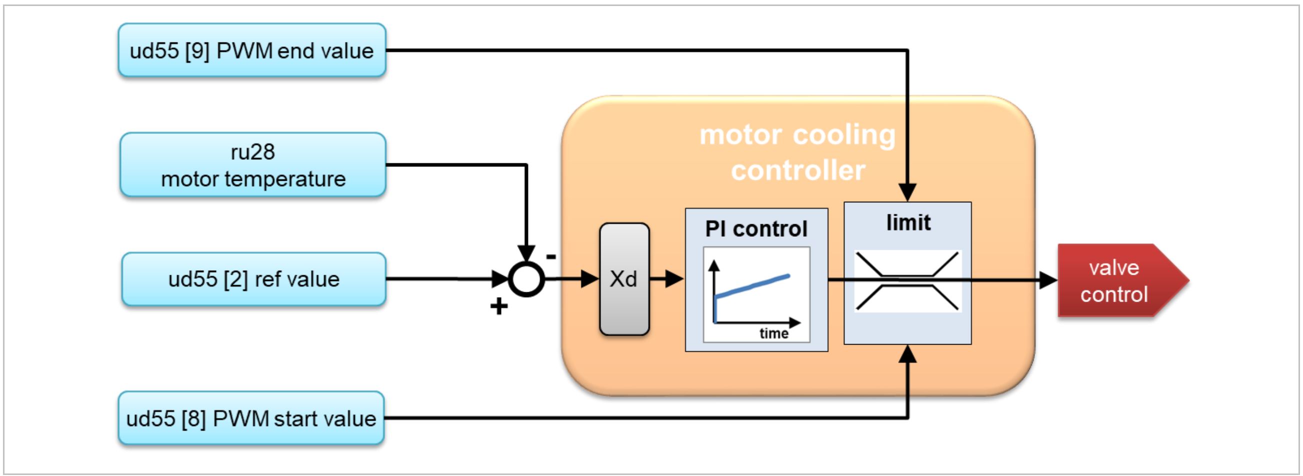

Figure 141: Overview controller motor cooling

ud55[1]		source select		
Bit	Value	Plaintext	Notes	
0	1	activate	Activation of the controller	
5	32	manual setting	1:	The PWM control setting is preset manually The display of ud55[5] and ud55[11] also displays the manually preset value.

ud55[2]	ref value	
Value	Meaning	
0 .. 100 °C	Set temperature of the motor	

11.3.1.3 Generally valid Pi controller parameters

ud53[3]/ ud55[3]	Kp [%PWM load per 1K]	
Value	Meaning	
0…100	Proportional component of the controller	

ud53[4] / ud55[4]	Tn	
Value	Meaning	
0.1…500000.000 ms	0 = off, Tn of the controller	

ud53[5] / ud55[5]	PI control out	
Value	Meaning	
0.1…100.00%	Output value of the controller	

11.3.2 **Manual setting**

If the value 32: manual is selected in ud53[1] or in ud55[1] source select, the manual setting is output instead of the PI controller output signal.

ud53[6] / ud55[6]	manual setting	
Value	Meaning	
0…100.0%	Control factor of the PWM / analog output	

Parameters ud53 / ud55 [8] PWM start value and ud53 / ud55 [9] PWM end value are not considered.
Only ud53 / ud55 [7] PWM period and ud53 / ud55 [10] PWM minimal pulse length remain effective.

11.3.3 **PWM**

11.3.3.1 Parameterization of the PWM

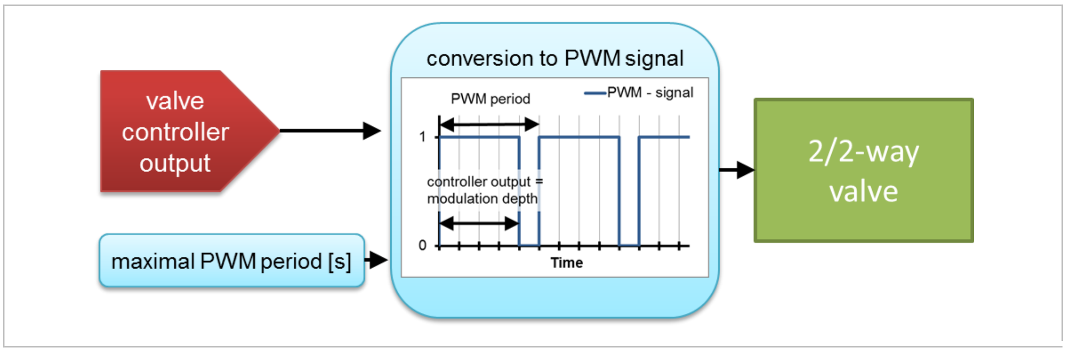

Figure 142: Structure PWM for cooling control

ud53 / ud55 [7]	PWM period		
Value	Meaning		
4.0…20.0 seconds	Value range ud53	Cycle duration of the PWM signal	
4.0…120.0 seconds	Value range ud55		

ud53 / ud55 [8]	PWM start value	
Value	Meaning	
0…100%	minimum PWM On pulse, which is always output even if the heat sink temperature is lower than the setpoint.	

ud53 / ud55 [9]	PWM end value	
Value	Meaning	
0…100%	maximum PWM control factor	

ud53 / ud55 [10]	PWM minimum pulse length	
Value	Meaning	
ud53[10]: 0…5.00 seconds ud55[10]: 0…6.00 seconds	The result of the PI controller output * PWM period is the length of the set-on pulse. The pulse is suppressed if this set-on pulse is < ½ * PWM minimal pulse length. If the set-on-pulse length is > ½ * PWM minimal pulse length but still below PWM minimal pulse length, PWM minimal pulse length is already output.	

Example:

The PWM period duration is set to 8 seconds.
The minimum pulse length is set to 400ms. => 400ms = 5% of the period duration.

If ud53[10] PWM actual load < 2.5%, the pulses are suppressed

If ud53[10] PWM actual load is between 2.5% and 5%, 400ms pulses are output

If ud53[10] PWM actual load is greater than 5%, the pulse length is proportional to the controller output.

ud53 / ud55 [11]	PWM actual load	
Value	Meaning	
0 .. 100,00%	Control setting of the PWM in % At the beginning of each new PWM period the actual control setting is calculated from the average of all PI controller output values of the last period.	

11.3.3.2 Display of the PWM modulation

ud54 ud56	heatsink cooling PWM out state motor cooling PWM out state	
Value	Meaning	
0,1	PWM out state 1 = On-pulse	

11.3.4 Signal output

11.3.4.1 via digital output

To output the PWM signal via a digital output, the following setting must be made in the do parameters:

Heatsink cooling:

do01[1] flag operand A = 60: heatsink cooling PWM out state (ud54)

Motor cooling:

do01[1] flag operand A = 64: motor cooling PWM out state (ud56)

always:

do02[1] flag operand B = “28: level 2” (do06)

do03[1] flag operator mode = "5: !=“   (unequal)

=> if ud54 is unequal 0, the digital output controlled by flag 1 is set.

do20 select flag O1 = "1: F1" => the PWM output signal is output via Out1.

11.3.4.2 via analog output

Heatsink cooling:

an37 ANOUT1 function = "15: PI Control Out“ => ud53 [5] PI control out is output via the analog output.

Motor cooling:

an37 ANOUT1 function = “16: PI Control Out” => ud55 [5] PI control out is output via the analog output.

always:

Scaling factor: 100% controller output = 10V analog output

The gain / offset of the analog output can be adjusted with an39 .. an41.

12 Safety modules

12.1 FSoE Watchdog time type 3 (only F6-A / S6-A)

The minimum watchdog time is specified with 80ms.

The watchdog time for FSoE should be set higher, because the runtime of the safe PLC and the EtherCAT cycle time must be considered.

> If a watchdog time lower than 80ms is set, it will be rejected by the safety module.

12.2 FSoE watchdog time type 5 (only F6-P / S6-P)

The minimum watchdog time is specified with 35ms.

The watchdog time for FSoE should be set higher, because the runtime of the safe PLC and the EtherCAT cycle time must be considered.

> If a watchdog time lower than 35ms is set, it will be rejected by the safety module.

12.3 Safety module objects

There are additional functional (not safety-related) objects for the safety module. These objects are in the "fs: safety drive profile parameters (FSoE):"- and in the "pa: PROFIsafe parameters" group.

fs: safety drive profile parameters (FSoE):

Index	Name	affects on KEB specific object:	Type 3	Type 5
0x6600	Time Unit	Resolution of objects which are time-specific.	●	●
0x6601	Position Unit	Resolution of objects which are position-specific.	●	
0x6602	Velocity Unit	Resolution of objects which are speed-specific.	●	●
0x6603	Acceleration Unit	Resolution of objects which are acceleration-specific.	●	●
0x6611	Safe position actual value 32Bit	Position calculated by the safety module. The number of decimal places is changed by the safe configuration parameter number of bits per revolution.	●	
0x6613	Safe velocity actual value 32 Bit	Speed calculated by the safety module. The scaling is 19 bit integer positions and 13 bit decimal places.	●	●
0x6620	Safe Controlword	Safety-oriented controlword.	●	●
0x6621	Safe Statusword	Safety-oriented statusword.	●	●

Index	Name	affects on KEB specific object:	Type 3	Type 5
0x6630	Restart_Ack (support)	Support of the error acknowledgement function.	●	●
0x6640	STO support	Support STO	●	●
0x6641	STO Restart_Ack_behaviour	If another safety function detects an error, this must be acknowledged by the acknowledge bit via FSoE.	●	●
0x6650	SS1 support	Number of supported instances of SS1. (8 pieces)	●	●
0x6651	T_SS1 (SS1C)	The time until the safety function STO is executed. Unit ms.	●	●
0x6656	a_ss1 32Bit	The acceleration for SS1B.	●	●
0x6660	SBC support	Number of supported instances of SBC (safe brake control). (8 pieces)	●	●
0x6668	SOS support	Number of supported instances of SOS (safe operation stop). (8 pieces)	●	
0x666A	S_Zero_SOS 32Bit	Position window when the safety function Safe operation stop is executed.	●	
0x6670	SS2 support	Number of supported instances of SS2. (8 pieces)	●	
0x6671	T_SS2 (SS2C)	The time until the safety function SOS is executed. Unit ms.	●	
0x6674	A_ss2 32Bit	The acceleration for SS1B.	●	
0x6677	Error Reaction SS2	The error reaction for the safety function SS2. Either SOS or STO.	●	
0x6690	SLS support	The safety module supports 8 instances of SLS.	●	●
0x6693	N_SLS_32_Bit	The upper speed limit of SLS. The scaling is 19 bit integer positions and 13 bit decimal places.	●	●
0x6698	Error Reaction SLS	Either STO or SS1.	●	●
0x66A0	SLP support	Number of supported instances of SLP. (8 pieces)	●	
0x66A2	S_UL_SLP_32Bit	The upper position limit of SLP.	●	
0x66A4	S_LL_SLP_32Bit	The lower position limit of SLP.	●	
0x66A5	Error Reaction SLP	Either STO or SS1.	●	
0x66A8	SMS support	Number of supported instances of SMS. (8 pieces)	●	●
0x66AA	N_pos_max_SMS_32Bit	The upper speed limit of SMS. The scaling is 19 bit integer positions and 13 bit decimal places.	●	●
0x66AC	N_neg_max_SMS_32Bit	The lower speed limit of SMS. The scaling is 19 bit integer positions and 13 bit decimal places.	●	●
0x66AD	Error Reaction SMS	Error reaction SMS. Either STO or SS1.	●	●

Index	Name	affects on KEB specific object:	Type 3	Type 5
0x66B8	SLI support	Number of supported instances of SLI. (8 pieces)	●	
0x66BA	S_UL_SLI_32 Bit	The upper position limit. This value is the adjusted position window / 2nd unit revolutions.	●	
0x66BC	S_LL_SLI_32 Bit	The lower position limit. This value is the adjusted position window / 2nd unit revolutions.	●	
0x66BD	Error Reaction SLI	Either STO or SS1.	●	
0x66D0	SDIp support	The safety module supports SDI positive.	●	
0x66D1	SDIn support	The safety module supports SDI negative.	●	
0x66D3	S_Zero_SDI_32Bit	The drive must not leave the adjusted position window at motor standstill. Unit revolutions.	●	
0x66E0	SSM support	Number of supported instances of SSM (Safe speed monitoring). (8 pieces)	●	●
066E2	N_UL_SSM_32Bit	The upper speed limit for SSM. The scaling is 19 bit integer positions and 13 bit decimal places.	●	●
0x66E4	N_LL_SSM32Bit	The lower speed limit for SSM. The scaling is 19 bit integer positions and 13 bit decimal places.	●	●
0xE600	FSoE Slave frame elements	The elements of the FSoE frames which are sent to the safe master. (raw data)	●	●
0xE601	FSoE SafeInputs	The elements of the FSoE frames which are sent to the safe master.	●	●
0xE700	FSoE Master frame elements	The elements of the FSoE frames which are sent by the safe master.	●	●
0xE701	FSoE SafeOutputs	The elements of the FSoE frames which are sent by the safe master.	●	●

Index	Name	affects on KEB specific object:	Type 3	Type 5
0xE800	Safety Device Info	Information about the safety module. This information includes: 1. COMBIVIS CRC: The CRC of the configuration data in the safety module. 2. Parameter main version: This version is currently 1 and will be transmitted to the safety module when FSoE is started. 3. Parameter sub version: This version can be set by the user in the safe FSoE configuration and read out by the safety module. 4. FSoE Data length: The data length of the safe FSoE data. This data length is set by the safety-oriented configuration of the safety module.	●	
0xE801	Safety Receive PDO mapping (Control ->Drive)	The active mapping in the safety module (for internal purposes)	●	●
0xE802	Safety Transmit PDO mapping (Drive -> Control)	The active mapping in the safety module (for internal purposes)	●	●
0xE803	Safety Device unit configuration	Unit of position and speed transmitted to the safety module via FSoE. This is the number of decimal places (bits for the decimal places). The default setting is 0 bits for the decimal places.	●	●
0xE80F	FSoE Safetymodule PD init	Only for internal purposes.	●	●

Index	Name	affects on KEB specific object:	Type 3	Type 5
0xE901	FSoE Connection Communication Parameter	Communication parameter. These parameters include: 1. Version (version number is always 1.) 2. Safety Slave Address. The safety module address set in the configuration data. 3. FSoE ConnectionID. This will be transmitted to the slave during FSoE start-up. 4. Watchdog Time. The watchdog time will be transmitted to the slave during FSoE start-up. 5. Unique Device ID. The serial number of the safety module. 6. Connection Type. The value is always 1, for slave. 7. Com Parameter Length. The communication parameter length is always 2 bytes. 8. Appl Parameter Length. The allication parameter length is always 20 bytes.	●	●
0xF980	Device Safety Address	The safety module address set in the configuration data.	●	

pa: PROFIsafe parameters:

Index	Name	affects on KEB specific object:	Type 3	Type 5
0x3D00	PROFIsafe device frame elements	1. Status byte of the PROFIsafe telegram (from SM3) 2. First part of the CRC2 of the status word 3. Second part of the CRC2 of the status word	●	
0x3D01	PROFIsafe safe inputs (SafetyModule -> Controller)	1. - 5. Listing of the contents of the RPOFIsafe telegram from the SM3 to the safe controller in 16-bit values.	●	
0x3D02	PROFIsafe controller frame elements	1. Control byte of the PROFIsafe telegram (to the SM3) 2. First part of the CRC2 of the control word 3. Second part of the CRC2 of the control word	●	
0x3D03	PROFIsafe safe outputs (Controller -> SafetyModule)	1. - 5. Listing of the contents of the RPOFIsafe telegram from the safe controller to the SM3 in 16-bit values.	●	
0x3D04	PROFIsafe state machine info	Display of the internal PROFIsafe state machine and the status of the F parameters (on the SM3).	●	
0x3D05	PROFIsafe alarms	1. – 10. Display of alarms sent by the SM3 via PROFIsafe.	●	
0x3D08	PROFIsafe safety module PD init	1. Address of the PROFIsafe Rx mapping 2. Address of the PROFIsafe Tx mapping 3. ID of the configured PROFIsafe telegram sent by the controller during startup.	●	
0x3D09	PROFIsafe F-Parameter	F parameters sent by the controller: 1. PrmFlag1 2. PrmFlag2 3. Source Address 4. Destination Address 5. watchdog time 6. watchdog time 2 7. iPar CRC 8. parameter CRC	●	

12.4 Safety module diagnostic objects

For the diagnosis of safety-relevant errors, certain parameters of the safety modules (3 and 5) are available and readable in the Combivis parameter group "sm: safety module parameters". Furthermore, it is possible to set a defined reaction to "STO" and "Fail Safe" in the drive controller. These objects and functions require prior knowledge of the contents of the safety module manuals and the handling of the safety modules in COMBIVIS.

- The following objects (sm group) are currently only available for safety module types 3 and 5. For other types, these objects are either not displayed or filled with a "0" (e.g. for type 1).
- Furthermore, the objects (sm group) shall not be used for safety-related/critical functions. They are only used for diagnostic support in case of problems and errors.

sm10	inverter reaction in case of "fail safe“	0x3C0A
Value	Name	Note
0	fault	If fail safe is active, error "140: ERROR Fail Safe" is set.
1 - 5	reserved	reserved
6	warning	If fail safe is active, the warning "fail safe" is set.
7	off	no response

sm11	inverter reaction in case of "STO“	0x3C0B
Value	Name	Note
0	fault	If STO is active, error "139: ERROR STO“ is set.
1 - 5	reserved	reserved
6	warning	If STO is active, the warning "STO" is set.
7	off	no response

The drive controller provides an object in which the customer can configure a visual response to a triggered error by STO or Fail Safe. The ("OPT") LED (red) on the control boards is used for this.

sm12	opt. inverter reaction in case of "STO” or “fail safe”	0x3C0C
Value	Name	Note
0	none	There is no optical response in case of "Fail Safe" or STO.
1	enable (OPT-)LED	If a warning or error message has been configured as response to "STO" or "Fail Safe" and this bit is active, a red LED (->"OPT" LED) at the inverter starts to light up (see 7.5 Status LED).

The error and warning information for STO or Fail Safe are also available in the do parameters for switching an output.

The following table shows the safety module-specific diagnostic parameters. These are read out from the safety module via an internal communication channel and correspond to the parameters that are visible in the Safety Wizard. They are for diagnostic purposes only. Subindices 1 to 14 are identical for safety modules 3 and 5. Subindices 15 to 18 are only available in safety module 5.

Index	Id-Text	Sub-Idx	Name	Function
0x3C03-0x3C05	sm03-sm05	0	safety module (number)	-
		1	enabled safety function	enabled safety functions
		2	bus safety function state	Safety functions enabled via bus
		3	global safety state	Global state of the safety module
		4	error state	Error state of the safety module
		5	last error / warning	Last error state of the safety module
		6	bus error	Bus error state of the safety module
		7	I/O state	State of the inputs/outputs
		8	encoder (-less) speed	Speed (detected with/without encoder depending on safety module)
		9	encoder position (full rounds)	Position in full revolutions (detected with/without encoder depending on safety module)
		10	encoder position (partial rounds)	Position in partial revolutions (detected with/without encoder depending on safety module)
		11	safety module date and time	Time/date of the safety module
		12	safety module LED blinking	LED status/control of the safety module
		13	safety fieldbus type	configured bus type
		14	safety fieldbus data length	configured bus data length
0x3C05	sm05	15	electrical current in percent (0.001% resolution)	electrical current in percent
0x3C05	sm05	16	electrical current speed	Speed and position data calculated from the current values.
0x3C05	sm05	17	electrical current position actual value (full rounds)	
0x3C05	sm05	18	electrical current position actual value (partial rounds)	

Via these parameters it is also possible to change the time of the safety module and to activate the LED flashing. Due to a limitation in the safty module software, the time can only be adjusted once without a user log-in with minimal authorization level (or performing a power-on reset). To change the time, only subindex 11 of the above-mentioned safety module-specific parameter group must be set to "1". Then the time is transferred from parameter ru52 to the safety module. Please note that only data from 01.01.2014 are accepted by the safety module type 5. By writing "2" in subindex 11, the time is taken over from the safety module into parameters ru52 and ru53.

Subindex 12 can be used to activate the LED flashing. This indicates the current flashing status of the safety module. "1" indicates "flashing active", "0" indicates "flashing inactive". Writing the corresponding values to this parameter leads to the respective functionality.

In addition, it is possible to read out the last ten protocol or log entries of certain error categories of the safety module, which can also be read out via COMBIVIS. For this purpose, a configuration parameter (sm18), a status parameter (sm19) and ten protocol information parameters (sm20 to sm29) are available.

Parameter sm18 is used to select the error category to be read out. Writing the parameter starts the readout of the log.

sm18	log read out type	0x3C12
Value	Name	Note
-1	none	The reading of the log is deactivated.
0	error	The entries in the "error" category are read out from the safety module when this value is written.
3	safety function request	The entries in the "safety function request" category are read out from the safety module when this value is written.
5	configuration errors	The entries in the "configuration errors" category are read out from the safety module when this value is written.
6	bus errors	The entries in the "bus errors" category are read out from the safety module when this value is written.
7	bus configuration errors	The entries in the "bus configuration errors" category are read out from the safety module when this value is written.
8	bus safety function request	The entries in the "bus safety function request" category are read out from the safety module when this value is written.

Parameter sm19 indicates the actual status of the readout and possible errors. It can therefore only be read.

sm19	log read out state	0x3C13
Value	Name	Note
-1	log read out timeout error	The readout could not be completed within 5 seconds. Please check the status and connection to the safety module and try again.
0	nothing to do	-
1	log read out active	The log is currently being read out.
2	log read out finished	The log read out was finished successfully.

The parameters read from the safety module are written in structures sm20 to sm29 and contain information on errors of the category selected in sm18. The structure corresponds to the structure of the protocol in the Safety Wizard in COMBIVIS 6. The entry with the lowest log entry number (-> "log entry 0") contains the latest information. The "date and time" specification can be inconsistent, depending on the time of configuration by the user. However, the sequence of parameters sm20 to sm29 is always correct. Sub-indices 5 and 6 differ only in the plaintexts assigned to the explicit values. They are filled according to the selected category (see sm18). Thus, sub-index 5 contains the details of categories 3 and 8, whereas sub-index 6 contains the details of categories 0, 5, 6, and 7. The value of the sub-index that is not required is filled with "0" (the plaintext for "0" is consequently invalid in this case).

Index	Id-Text	Sub -Idx	Name	Function
0x3C14-0x3C1D	sm20-sm29	0	log entry [0...9]	Number of the log entry
		1	date and time	Date and time
		2	position	Postition
		3	speed	Speed
		4	time slice per 62.5 µs	Time slice per 62.5µs grid for more precise error analysis
		5	details of "(bus) safety function request“	Details of the safety function request
		6	details of "error“	Error details

12.5 Safety module statusword

Parameters sb29 and sb40 display the complete safety module statusword for safety module type 3 and safety module type 5.

sb29 must be used if the complete statusword of safety module type 1 shall be read, since only the lowest 3 bits, which have the same meaning as safety module type 3, are displayed in sb40. The exact assignment can be found in the corresponding safety manual

sb40 safety module status word is provided with plain texts and therefore more suitable for visual analysis.

Function	Bit No			executed safety function (if not specified: 1 = active)
	Type 1	Type 3	Type 5	
error	0	0	0	Error triggering in the safety module
not STO	1	1	1	0 active – SafeTorqueOff
not SBC	2	2	2	0 active – SafeBrakeControl
SS1		3	3	Safe Stop 1
SS2		4		Safe Stop 2
SLS		9	4	Safely Limited Speed
Fail Safe		8	8	Fail Safe set => The limits of an active safety function have been violated
SLA		10	9	Safe Limited Acceleration
SMS		17	16	Safe Maximum Speed
SSM		16	5	Safe Speed Monitor
SOS		5		Safe Operating Stop
SDI forward		6		Safe Direction forward
SDI reverse		7		Safe Direction reverse
SLP		11		Safe Limited Position
SLP set ref pos		12		SLP Set Reference Position
SEL		13		Safe Emergency Limits
SLI		14		Safely Limited Increment
SLI activation		15		SLI activation
SDLC			6	Safe Door Lock
SDLC door release			7	SDLC door release
BCF1			10	Brake ControlFeedback 1
BCF2			11	Brake ControlFeedback 1
FB1W			12	Feedback Warning 1
FB2W			13	Feedback Warning 2
BR1T+			14	Brake Test Plus
BR1T-			15	Brake Test Minus

13 Recipe management (storage of parameter files in the drive controller)

Several recipes (parameter files / name *.dw5) can be stored in the file system of the device (see chapter 10.5 Connection to the file system).

The recipes contain objects which can be written to the object directory of the drive controller during runtime.

The download of a recipe is triggered by writing on object ud04 or the edge of a previously configured digital input.

➢ To transfer recipes, an access level is requested in -> COMBIVIS Manual Chapter „Device Memory Wizard“.

13.1 Definition of terms

Recipe is the list of parameter addresses and associated values which can be executed on request (i.e. the parameters are written with the appropriate values). In the further process of the document, the term recipe is synonymous with download list or configuration list.

13.2 Basic function

13.2.1 Contents of the configuration lists

Recipes contain only parameters to be written.

Each entry contains the following information:

- Address (=Index) of the parameter to be written
- SubIndex of the parameter to be written
- Value to be written

The * .dw5 file format is used

13.2.2 Storage / identification of the recipes

Recipes are stored as files in the file system of the devices.

The file name must have the following structure in order to recognize a recipe in the drive controller:

The recipe files are identified by a "recipe ID". This is a 3-digit number between 1 and 240. This must be enclosed by "#" characters at the beginning of the file name.

This means, the first five characters of the file name must correspond to the following example: #001# ⇒ A three-digit number enclosed by # characters

The remainder of the file name is irrelevant to the function and can be used to be written. A total of 60 characters can be used.

Each number may only exist once in the file system. If there are still several lists with the same ID in the file system, the first recipe will be used.

Example: A recipe with motor data should be available under ID 5:

⇒ Possible name for the list: #005#_Motordownload_1.dw5

There are 2 special functions for the recipe download:

By the naming #pon#, a recipe download is automatically triggered after power on or software reset by co09.

By the naming #def#, a recipe download is automatically triggered after loading the default values.

The two lists #def# and #pon# should be used with special care and should first be tested under a different name. Entries from co08 and co09 should not be used in these two lists. Before a software update, such lists must be removed from the file system for security reasons.

13.2.3 Limitations

- The maximum number of recipes is limited to 255, the values of 240 ... 255 are reserved for KEB internal functions.
- The maximum number of parameters per list is limited by the size of the file system.
- In the KEB file system, each file always occupies a multiple of the block size of the storage medium (64Kbyte). With 1MB free memory, a maximum of 1024KB/64KB = 16 files can be stored (if the files are not larger than 64KB each).

NOTICE

The recipe activation runs in the non-interrupt controlled part of the software. The time to the start and the duration of the recipe execution depend on the time utilization of the control card software. This is dependent on a different variables, such as the type and operating point of the control, speed measurement, fieldbus functions, etc.

The behaviour is very different depending on the control type. With control type P (Pro), an input must remain set for at least approx. 150ms so that the input is safely set to the recipe selection.
Further 150ms may pass before the first recipe entry is processed.
The times are shorter for A and K cards.

13.3 Parameter structure

The following parameters are available for managing and execution of recipes:

Index	Id-Text	Name	Function
0x3002	ud02	recipe options	Options for recipe lists
0x3003	ud03	recipe inputs	Input selection to start the recipe download
0x3004	ud04	start recipe	Direct start of a recipe download, specifying a recipe ID
0x3007	ud07	recipe status	Status of the last started recipe download

13.3.1 Parameter "recipe options“

ud02	recipe options			0x3002
Bit	Function	Value	Plaintext	Note
0…3	error behaviour	0	abort on error	Abort on first error
		1	ignore errors	Errors are ignored, the recipe download continues
4…7	coding	0	input coded	the number of the highest set input defines the recipe to be started
		16	binäry coded via ru58	the index (display of the value in ru58) calculated from the inputs selected in di21, determines the recipe to be started. If the index is invalid (higher than 240), it is internally set to zero and no recipe is started.
8..31	reserved			

If different settings of the "error behaviour" are required, this object can be inserted into a recipe.

Additionally it can be defined whether the selection of the recipe via the digital inputs shall be input-coded (definition of the inputs in ud03) or binary-coded (definition of the binary-coded index in di21).

13.3.2 Input-coded recipe selection

Inputs that are used for input-coded recipe selection can be selected via parameter ud03 recipe input.

ud03	recipe input			0x3003
Bit	Function	Value	Plaintext	Note
0	I1	1	I1	Selection which of the inputs I1 to I8 can be used to activate a recipe download. The input number is assigned to a recipe number: ⇒ I1 starts #001#, I2 starts #002#, etc.
1	I2	2	I2	
…		…		
7	I8	128	I8	
8	IA	256	IA	Software inputs, can be activated via the software outputs OA..OC ⇒ IA starts #009#, IB #010# etc.
9	IB	512	IB	
10	IC	1024	IC	
11	ID	2048	ID	Can only be activated with corresponding programming via di00 or di01/di02 ⇒ ID starts #012#,
12	CW1	4096	CW1	Controlword inputs, can be activated via the controlword if programmed accordingly. ⇒ CW 1 starts #013#, CW 2 starts #014#
13	CW2	8192	CW2	

The hardware inputs I1 to I8, the software inputs IA to ID and the control word inputs CW 1 and CW 2 can be used. Use of the STO inputs is not possible.

Up to 14 recipes can be selected with the digital inputs. Only the highest number is relevant. If, for example, I1 and I2 are activated, #002# is executed.

If such a programmed input is already set during power on, this recipe is automatically started. (If additionally a #pon# recipe is available, this will be started first and then the one selected by the input. This is only possible if Ud03 has been reactivated in #pon#).

NOTICE

If the highest number of the inputs selected for recipe selection in ud03 changes, a new recipe download is triggered. This is especially important for the software and controlword inputs.

If their status is influenced by the recipe download, this can trigger unwanted follow-up reactions. This can even set the inverter into a "continuous loop" where the recipe automatically restarts itself permanently.

Example:

- I1 is activated and IA is also activated by the software output OA
- Recipe #009# is executed
- The execution of this recipe causes that OA and also IA are no longer set
- Recipe #001# is executed immediately after completion of recipe #010# if I1 is still active.

13.3.3 Binary coded recipe selection

If the recipe selection shall be binary coded, in order to minimise the required digital inputs, the index ru58 actual index defined in the di parameters by di21 index input can be used for this purpose. For more details on index generation, see chapter 7.1.9.3 Index setting via digital inputs.

NOTICE

This index is primarily used for index positioning. For binary coded recipe selection, it can only be used if it is not used by the positioning.

The behavior is identical to the input-coded recipe selection, except that the number of the executed recipe is defined by the index ru58 and not by the number of the most significant input.Only the values 1 to 239 are permitted for recipe selection. If the index is above this value, it is treated as index = 0.

13.3.4 Parameter "start recipe"

Index	Id-Text	Name	Function
0x3004	ud04	start recipe	Start a recipe download by writing to this object.

The recipe download is started by writing the required recipe number. That means, the selected file is read from the file system and then written line by line into the parameters of the drive.

13.3.5 Parameter "recipe status"

All information about the status of the recipe download is displayed in the structure ud07 recipe status.

Index	Id-Text	Sub-Idx	Name	Function
0x3007	ud07	1	last successful recipe ID	ID of the last successfully executed recipe
		2	recipe download status	Status of the last started recipe download
		3	info recipe ID	ID of the last executed recipe download
		4	actual line	Last read line of the dw5 file
		5	error code	Error messages of the object dictionary

Sub-index 1 last successful recipe id contains the number of the last recipe transmitted without errors.

ud07[1]	last successful recipe id		0x3007 SubIdx 1
Value	Name	Meaning	
0	not completed	As handshake as soon as a recipe download has been started.If the download cannot be carried out **without errors**, the status "not completed" remains, even if some of the parameters of the recipe have been written.	
1…253		ID of the last **successfully executed recipe**	
254	power on recipe (#pon#)		
255	default recipe (#def#)		

Sub-Index 3 info recipe id contains the number of the last selected recipe.

ud07[3]	info recipe ID		0x3007 SubIdx 3
Value	Name	Meaning	
0	not completed	no recipe download has been started	
1…253		ID of the **last / currently selected** recipe. The number is displayed even if the corresponding recipe was not found or the download was aborted due to errors.	
254	power on recipe (#pon#)		
255	default recipe (#def#)		

Parameter ud07[2] download status provides the following information:

ud07[2]	download status		0x3007 SubIdx 2
Value	Name	Meaning	
0	no recipe started	No recipe download completed	
2	running	Recipe download is currently running	
3	completed	Recipe download successfully completed (without errors)	
4	aborted after error	Recipe download aborted due to an error	
5	completed with errors	Download has been executed, errors have been occurred. The errors have been ignored due to the configuration (=> 13.3.1 Parameter "recipe options“).	
6	recipe does not exist	The started recipe is not available.	

Parameter ud07[5] error code provides the following information:

ud07[5]	error code		0x3007 SubIdx 5
Value	Name	Meaning	
0	OK (No error)	Corresponds to the error codes of the object dictionary	
1	invalid index		
2	invalid subindex		
3	invalid access		
4	data invalid		
5	read only		
7	invalid password		

If errors are ignored during the download (depending on parameter ud02) this parameter contains information about the error which occurred ***last***.

13.4 Operating conditions

Only one recipe download can be executed at the same time. During the recipe download, the start of another will be prevented.

In addition, there are no special starting conditions.

The download can be started by digital inputs or by writing of ud04 start recipe.

Exceptions:

⇒ The download of the #pon# file occurs with starting the drive controller (power on or co09).

⇒ The download of the #def# occurs at default set loading (power on or co09, if co08 has been parameterized accordingly).

During downloading, the same checks are made for each individual write operation, likewise a write operation from an external source (e.g., COMBIVIS, external PLC, operator, etc.). The recipe management processes entries which contain a write request for a parameter (values WA/WO/RW in column "R/W").

Only write requests with index/subindex addressing are processed. (Default for all generation 6 devices).

All other entries (blank lines, pause, RO, set-addressed entries) are skipped.

14 Annex

14.1 Inverter parameters (address / resolution /type)

An overview of the parameters supported by the individual inverter types can be found in a separate document. Inverter type means: F6 or S6, C(ompact) / A(pplication) or P(rofessional) control board.

The overview contains a list of the parameter addresses, as well as the associated default values, resolutions, units and limits.

	Note to further documentation. https://www.keb.de/nc/suche?tx_solr%5Bq%5D=parameterliste+30	

14.2 History of changes

From revision	Chapter	Change
00	Start	Programming manual Control Application / Compact / Pro - V2.9
	4.4.7	Description of fieldbus watchdog replaced by reference to programming manual | Fieldbus systems
	4.8.3	Homing 35 is supplemented by 37 (new default value)
	4.9	Reference to programming manual | Fieldbus systems added for synchronization
	7.3.4 7.3.6.2 7.3.6.3 7.3.6.4	Ref and Aux calculation Virtual analog outputs Revision of the PID controller
	4.3.1.2.1 4.3.1.2.2	New stop modes Attention note added
	7.3.2.2	New: Monitoring of the 4...20mA interface
	4.4.21	New: UPS mode
	7.2.10	New: variable operands for output switching condition
	6.1.6.6	ec40, ec41 also show the resolution of digital intelligent encoders, so they are suitable for all encoder types with el. nameplate. ec42 is now only for SSI and has a new default value. New notes about power fail bit and fir tree format.
	4.5	**Absolutely observe:** Revision of the complete chapter. Previously unsupported subindices of is31 renamed. Smoothing time constants changed. Extension of pn33. Function submounted braking resistor protection
	6.2.19	**Absolutely observe:** General revision of the dead time compensation
	14.1	Chapter Inverter parameters (address / resolution /type) moved to separate document
	4.4.2.1.2	Extension of is17
	6.2.9	Increasing the accuracy of the torque display by offset adjustment
	4.4.20	New function => Motor phase failure detection
	7.1.9.3	**Absolutely observe:** Change in the index definition. Maximum 8 inputs selectable in di21. Function extension of the index generationStrobe dependency
	13.3.3	New function: Binary coded recipe selection
	4.8.2.4.1	0x6083 profile acceleration

From revision	Chapter	Change
	6.2.23	ds30 extension Introduction of dr50
	6.2.16.5	ds30 extension
	6.2.18.7	Identification not only at 4 and 8kHz, is05/06 no longer have any effect
	13.2.2	Warning notice for#pon# and #def# recipes
	4.4.16	Description of the effect of pn26 = 0 was wrong => protection function is not switched off via pn26 but only via pn27.
	8.3.3	Correction of the table and the value range to do33

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