COMBIVERT **T6**

PROGRAMMING MANUAL | DCU (DRIVE CONTROL UNIT) – **V2.5**

Translation of the original manual
Document 20211750 EN 00

1 Preface

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

1.1 Signal words and symbols

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

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

RESTRICTION

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

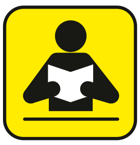
i	➢ Is used when the result will be better, more economic or trouble-free by following these procedures.

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	

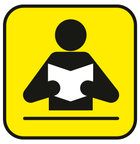
1.3 Laws and guidelines

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

The CE mark is located on the name plate. The EC declaration of conformity can be downloaded on demand via our website. Further information is provided in the chapter "Certification".

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

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

The use of our units in the target products is beyond of our control and therefore exclusively the responsibility of the machine manufacturer, system integrator or customer.

The information contained in the technical documentation, as well as any user-specific advice in spoken and written and through tests, are made to best of our knowledge and information about the application. However, they are considered for information only without responsibility. This also applies to any violation of industrial property rights of a third-party.

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

Tests can only be done 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.

Content

Figures

Tables

2 Basic Safety Instructions

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

The following safety instructions have been created by the manufacturer for the area of electric drive technology. They can be supplemented by local, country or application-specific safety instructions. This list is not exhaustive. Non-observance will lead to the loss of any liability claims.

NOTICE

Hazards and risks through ignorance!

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

- Knowledge and understanding of the safety instructions.
- Skills for installation and assembly.
- Start-up and operation of the product.
- Understanding of the function in the used machine.
- Detection of hazards and risks of the electrical drive technology.
- Knowledge about DIN IEC 60364-5-54.
- Knowledge of national safety regulations (e.g. *DGUV Regulation 3*).
- Operation with the operating software COMBIVIS requires basic knowledge of the operating system Windows.

2.2 Validity of this manual

This programming manual is part of the instructions for use.

The programming manual

- describes the parameterization of the T6 DCU
- contains only supplementary safety instructions.
- is only valid in connection with the installation instructions of the COMBIVERT T6.

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 unit 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 converters that are not isolated from the supply circuit (in accordance with *EN 61800-5-1*) all control lines must be included in other protective measures (e.g. double insulation or shielded, earthed and insulated).
- When using components without isolated inputs/outputs, it is necessary that equipotential bonding exists between the components to be connected (e.g. by the equipotential line). Disregard can cause destruction of the components by equalizing currents.

2.4 Start-up and operation

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

⚠ WARNING

Software protection and programming!
Hazards caused by unintentional behavior of the drive!

- ➢ Check especially during initial start-up or replacement of the drive converter if 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 converter.
- ➢ Secure motors against automatic restart.

3 Product Description

3.1 Product features

This manual describes the parameterization of the

- Device series: COMBIVERT T6
- Hardware: DCU (Drive Control Unit)
- Software: Version 2.5

3.2 Functional overview

- Operation of asynchronous and synchronous machines
- Open-loop and encoderless closed-loop operation
- Operation via state machine according to CiA 402
- Operating modes
  - Profile position mode
  - Velocity mode
  - Cyclic synchronous position mode
  - Cyclic synchronous velocity mode
- Programmable behaviour to errors and warnings
- Programmable display
- Automatic motor identification

3.3 Used terms and abbreviations

Term	Description
AC	AC current or voltage
ASCL	Asynchronous sensorless closed loop
Auto motor ident.	Automatic motor identification; Measurement of resistance and inductance
CAN	Fieldbus system
COMBIVERT	KEB drive converter
COMBIVIS	KEB start-up and parameterization software
DC	DC current or voltage
DIN	German Institute for Standardization
DS 402	CiA DS 402 - CAN unit profile for drives
EMC	Electromagnetic compatibility
EN	European standard
FI	Drive converter
GND	Reference potential, ground
HF filter	High frequency filter to the mains
I^2t-monitoring	Software function for thermal monitoring of the motor winding; The OL function works according to the principle.
IEC	International standard
Modulation	means in drive technology that the power semiconductors are controlled
OC	Overcurrent
OH	Overheating
OL	Overload
PDS	Power drive system incl. motor and sensor
PE	Protective earth
SCL	Sensorless Closed Loop

Table 3-1: Used terms and abbreviations

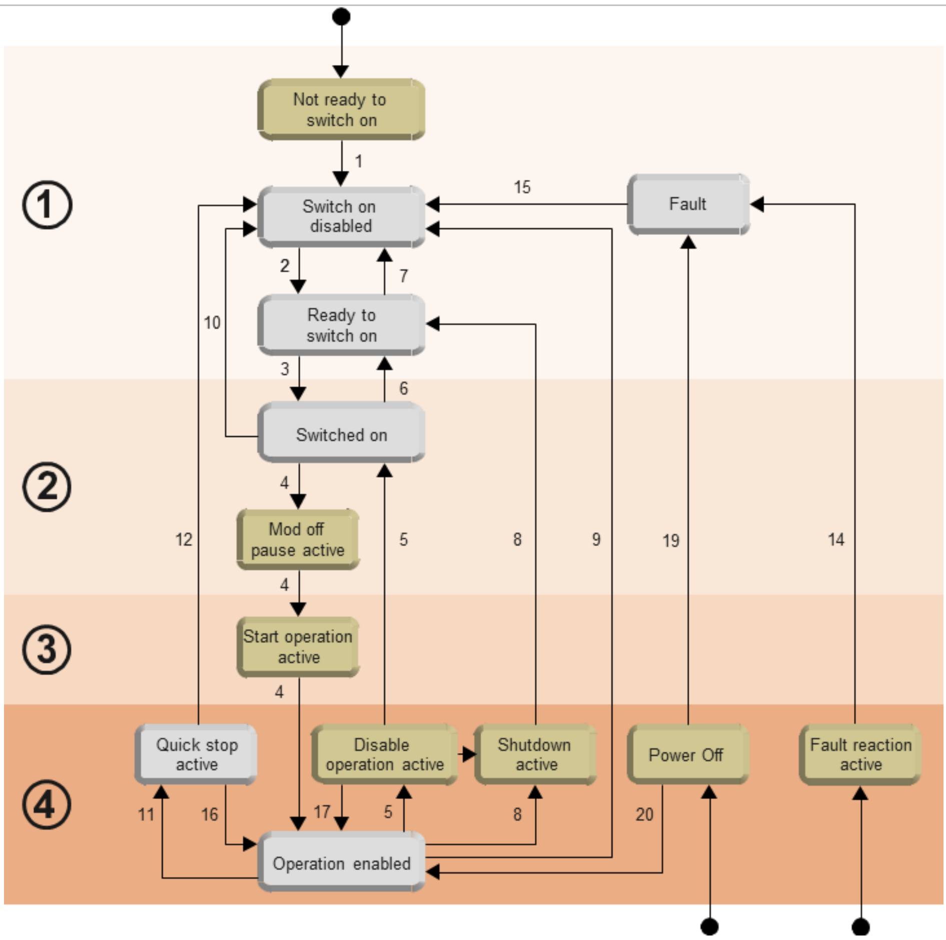
4 Motion Control

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 controlword and internal events (e.g. occurrence of an error). The actual state is displayed via st00 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	Control A	15V control voltage applied; voltage power unit can be applied.
2	Power B	Voltage power unit applied; no torque at the motor
3	Power B	Voltage power unit applied; Torque can be applied (flux build-up, speed search etc.)
4	Torque C	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 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 8 can be influenced by parameters.

=> 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.

=> Affect the behaviour of the state machine.

Mod off pause active

This state is reached when:

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

A minimum switch-off time must be kept after switching off the modulation until it can be switched on again. If **Enable operation** is set to 1 and the time has not yet expired, state **Mod off pause active** is active.

If the minimum off time of the unit is up, the drive changes into state **Start operation active**.

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) 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 4.2.3.18).

➢ 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 4 ***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 controlword. Access to the control word is possible via two addresses:

Index	Id-Text	Name	Function
0x2500	co00	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 of co31 controlword internal and the stop reactions

The controlword contains the following bits:

co00	controlword		0x2500
Bit	Name	Note	
0	Switch on	Command to the state change (see below)	
1	Enable voltage	Command to the state change (see below)	
2	no quick stop	0 activates quick stop (function must be activated in co32)	
3	Enable operation	Command to the state change (see below)	
4…6	Operation mode specific	Meaning is depending on the operating mode	
7	Fault reset	Command to the state change (see below)	
8	Halt	Stop is not supported in most operating modes	
9	Operation mode specific	Meaning is depending on the operating mode	
10	0x2C14		
11…14	Operation mode specific	Manufacturer-specific, without function	
15	0x2C14		

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 actual active controlword is co31 controlword internal.

It can be influenced via the bus controlword co00, (released for process data) or via digital inputs (description of the setting via digital inputs see chapter 7.1.6.1 Controlword functions via the digital inputs).

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.

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

The actual active controlword can be read in co31 (under consideration of the setting via digital inputs and the bus controlword).

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	statusword	KEB spec. object
0x6041			CiA402 object

The status word contains the following bits:

st00	statusword		0x2100
Bit	Name	Note	
0	ready to switch on	Display of the actual state (see below)	
1	switched on	Display of the actual state (see below)	
2	operation enabled	Display of the actual state (see 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 (see below)	
7	warning	1 = There is a warning	
8	synchron	Manufacturer-specific, 1 = Drive control synchronous to field bus	
9	remote	1 = Drive is controlled via bus	
10	target reached	1 = target position, target speed reached	
11	internal limit active	1 = Internal limitations	
12	op. mode spec. 12	Setpoint acknowledge in pp-mode	
13	op. mode spec. 13	Following error at active position controller	
14	manufacturer spec. 14	Manufacturer-specific, without function	
15	manufacturer spec. 15		

*) the speed controller output value reaches the torque- or current limit

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

Instead of evaluating the bits of the status word, the actual state of the state machine can be read directly.

Index	Id-Text	Name	Note
0x210C	st12	state machine display	KEB spec. object
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	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		

st13	state and error display		0x210D
Bit	Name	Note	
0…7	error display	Value of ru01 (see 4.2.1 Error)	
8…16	state display	Value of st12 * 256	

This parameter is used to indicate the reason for the triggering of a stop function (FaultReaction / 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 disabled (see description co00)
		256	Ramp generator options enabled
9	Enable Quickstop	0	Quickstop disabled
		512	Quickstop enabled

4.2 Exeption handling

4.2.1 Error

4.2.1.1 Error display

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

The faults are coded according to the following table:

ru01	Fault 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)	0x3210
6	ERROR under potential	Undervoltage in DC link	0x3220
7	ERROR overload	Module overload (I^2t) => 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	ERROR overheat internal power unit	0x4110
13	reset E. overheat intern PU	no overheat internal power unit	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 directly before the speed controller within a configurable time has re-sponded pn38/pn39)	0x1000
44	ERROR invalid power unit data	Invalid power unit data	0x1000
56	ERROR software switch left	Software limit switch has triggered an error	0x1000
57	ERROR software switch right		0x1000
58	ERROR fieldbus watchdog	Interlink Watchdog has responded	0x1000
59	ERROR prg. input	Error via programmable input	0x1000
62	ERROR power unit changed	Power unit changed (de20 / de21)	0x1000
64	ERROR power unit type changed	Power unit type changed (de26 / de27)	0x1000
66	ERROR overcurrent PU	Overcurrent	0x1000
67	ERROR max acc/dec	Max. acceleration/deceleration setting exceeded (monitoring especially necessary for cyclic synchro-nous operating modes)	0x1000
97	ERROR overspeed (EMF)	pn72 overspeed level (EMF) has been exceeded	0x1000
107	ERROR over frequency	The maximum output frequency de 120 has been exceeded. (599Hz)	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	Control board supply is down (15 V internally)	0x1000
119	ERROR extreme overpotential	extreme overpotential in DC link (can lead to damage of the DC capacities)	0x1000

4.2.1.2 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 shut-down can be set in the pn parameters.

4.2.1.2.1 Configurable error

The behaviour can be programmed for the following errors:

Index	Id-Text	Name	possible error response		
			Fault	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
0x2A10	pn16	ERROR OH2 stop mode	x*	x	x
0x2A14	pn20	ERROR SW-switch stop mode	x	x	x*
0x2A16	pn22	ERROR fb watchdog stop mode	x	x	x*
0x2A1B	pn27	ERROR overspeed stop mode	x*	x	x
0x2A1D	pn29	prg. error stop. mode	x	x	x*
0x2A25	pn37	ERROR max acc/dec stop mode	x	x	x*
0x2A28	pn40	ERROR speed diff stop mode	x	x	x*
0x2A47	pn71	E.overspeed (EMF) st. mode	x*	x	x

***** = Default value

4.2.1.2.2 Error reaction

The single error reactions are defined as follows:

Val-ue	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 enable operation bit is set again according to the controlword.
4	shut down	The switch on bit in the controlword is set to zero => "shut down" reaction is executed. If the error / malfunction signal is no longer present, the switch on 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 error resets itself. After fault reaction time the drive changes into state SWITCHED ON.
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.

The settings „0: fault“, „1: dec. ramp -> fault“ and „5: dec. ramp -> fault, auto retry“ are error responses where the error is displayed in ru01 and in st00 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.

- 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 32 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 32 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 32 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 statuswort st00 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.

4.2.1.2.3 Error reaction ramp

The used set speed ramp at error 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 error reaction ramp => error
0x2A2F	pn47	fault reaction ref velocity	Target speed of the error 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 pos. speed (start)
0x2A35	pn53	fr for acc jerk hs [s-3]	max. jerk at acceleration and pos. 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 e

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

After this time or if the selected digital input 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:

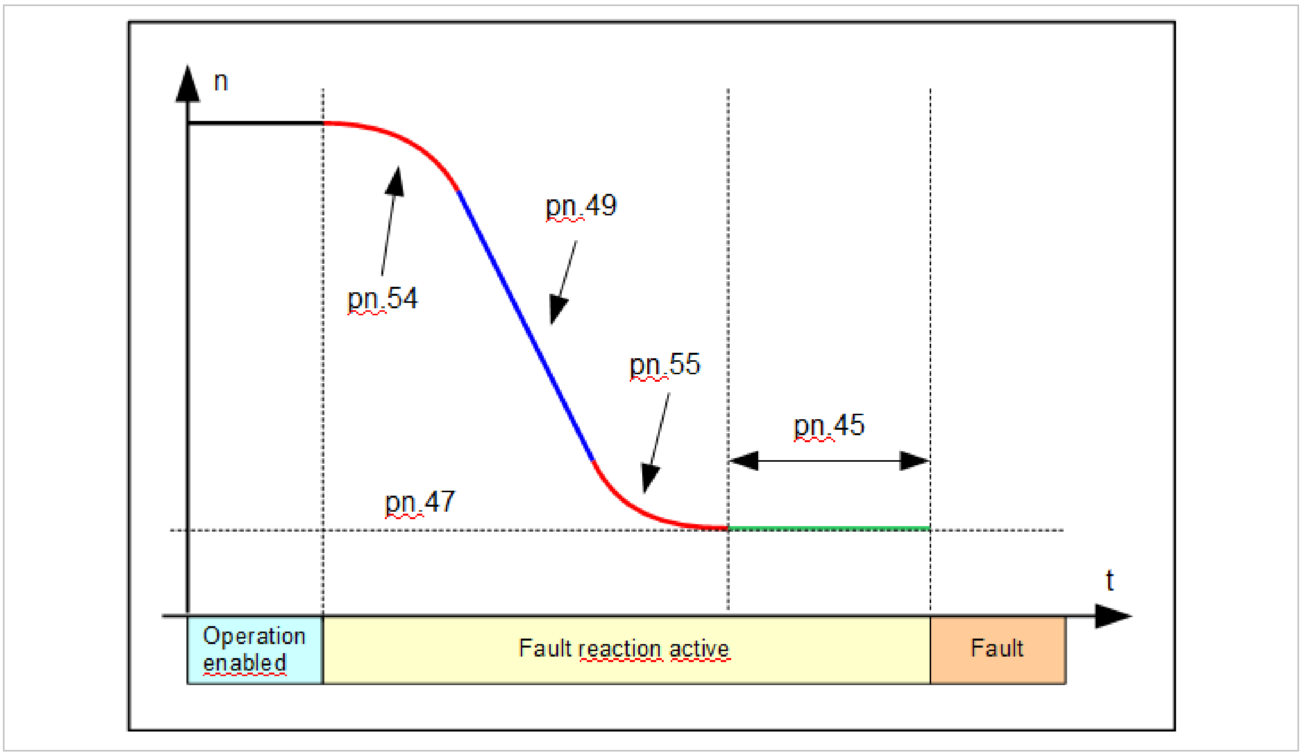


Figure 2: Process of a fault reaction

4.2.1.2.4 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	

4.2.1.2.5 Fault reaction-torque limit

Another (higher) torque limit is required in some applications for the state Fault reaction active. 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). This limit becomes not effective at „shutdown“ or „disable operation“.

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 watchdog	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	
9..10	dM/dt	0	off	No rate limitation effective
		512	on	Rate limitation (co63) when changing the torque limits also effective outside of the stop mode.
		1024	Stop,reached zero	Rate limitation (co63), effective in stop mode when zero speed is reached and change-over of the torque limit source "reached zero" bit6...8.

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]	The change of the torque limit is limited depending on the setting in co61 “dm/dt 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 %

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

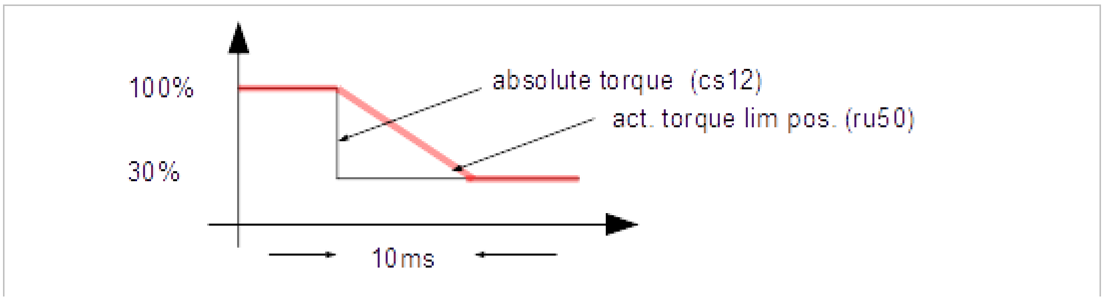


Figure 3: Example co63

4.2.2 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	Reserved	Reserved
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...16	Reserved	Reserved

The highest-priority status message is displayed in parameter ru03. Besides the warnings, also an ERROR status can be displayed in this object (see chapter 4.2.1 Error), if "warning" is programmed as error response for the appropriate error.

In addition the following warning messages can be displayed:

ru03	Fault text	Description
27	WARNING overload	Module overload ru29 (I^2t -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 > pn07
32	WARNING overheat intern.	Internal temperature ru26 or ru77 > pn09
34	WARNING motorprotection	motor protection counter ru32 > pn15 OH2 warning level
36	WARNING drive overheat	KTY: ru28 motor temperature > pn11 dOH 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

4.2.3 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.

4.2.3.1 Overload (OL)

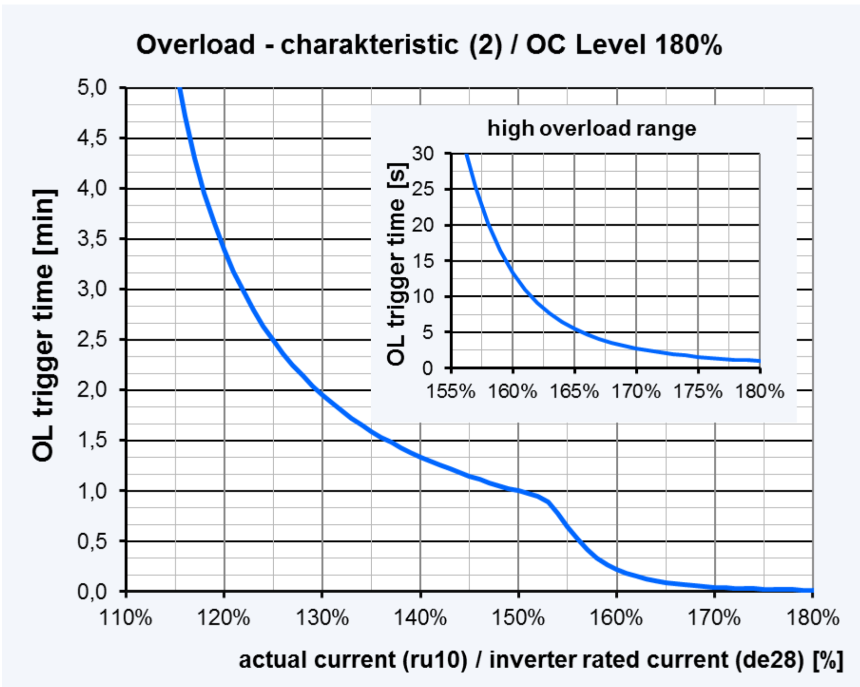
The monitoring of the continuous load of the inverter can be influenced via the following objects:

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 also chapter 4.2.1 Error)
0x2C02	ru02	warning bits	Display of the warnings bit-coded (see 4.2.2 Warnings)
0x2A1C	pn28	warning mask	Mask for warning bit in the status word (see 4.2.2 Warnings)

The OL function protects the inverter against permanent overload.

Depending on the cooling, a long-term operation in overload range can cause that the error „ERROR overheat powmod.“ (overtemperature power components) switches off the drive already before OL function response.

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



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

Figure 4: Overload characteristic

The overload characteristic valid for the respective inverter can be taken from the installation manual 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, if the OL-Counter has reached the of value pn03 OL warning level / 2.

4.2.3.2 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 (see 4.2.2 Warnings)
0x2A1C	pn28	warning mask	Mask for warning bit in the status word (see 4.2.2 Warnings)
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.	Safe distance to the OL2 limit at overload protection
0x2C49	ru73	Imot/ImaxOl2	Actual current / short time current limit

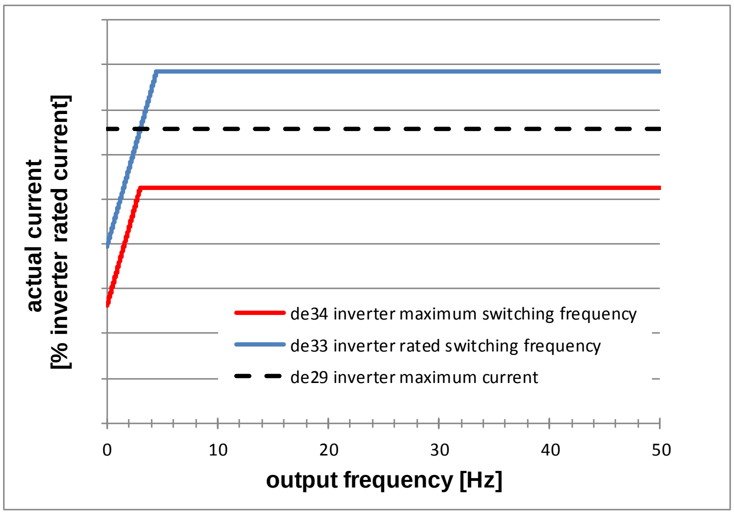
4.2.3.2.1 OL2 function

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 maximum current (de29 inverter maximum current).

Detailed information about the maximum currents can be found in the installation manual for the corresponding power unit-housing size.

The following diagrams show sample OL2 limiting characteristics:



output frequency:	ru07	output frequency
rated switching frequency:	de33	rated switching frequency
maximum switching frequency	de34	maximum switching frequency

Figure 5: 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 100ms.

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.

4.2.3.2.2 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.

4.2.3.2.3 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, but overload reserves are 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. Thus no short-term overload capacities are available in the lower frequency range, and the current is limited in the whole frequency range 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. The current is also continuously limited in the total frequency range 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.

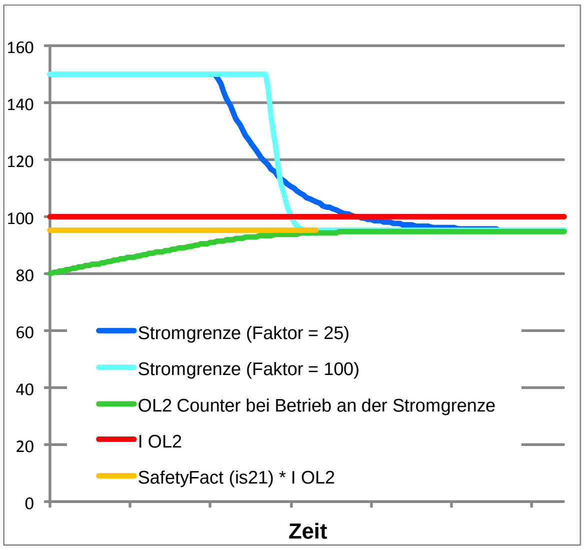


Figure 6: Characteristic of the current limit in relation to the time

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.

4.2.3.3 Overtemperature heat sink (OH)

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

Index	Id-Text	Name	Function
0x2C19	ru25	heatsink temperature	Display of the heat sink temperature
0x2A06	pn06	temperature warning setting mode	Selection of the reference level for generating the over-temperature warning
0x2A07	pn07	OH warning level	Temperature when a warning is triggered
0x2A08	pn08	E.OH stop mode	Error reaction (see also chapter 4.2.1 Error)
0x2A51	pn81	warning OH stop mode	Error reaction to pre-warning (=> also 4.2.1 Error)
0x2C02	ru02	warning bits	Display of the warnings bit-coded (see 4.2.2 Warnings)
0x2A1C	pn28	warning mask	Mask for warning bit in the status word (see 4.2.2 Warnings)

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

NOTICE

Change in overtemperature protective functions OH!

- If **Fault Reaction** is programmed as reaction to the overtemperature error and not an immediate shutdown, the modulation will be switched off at least 2 seconds after the occurrence of the overtemperature and if the OH error is still present

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.

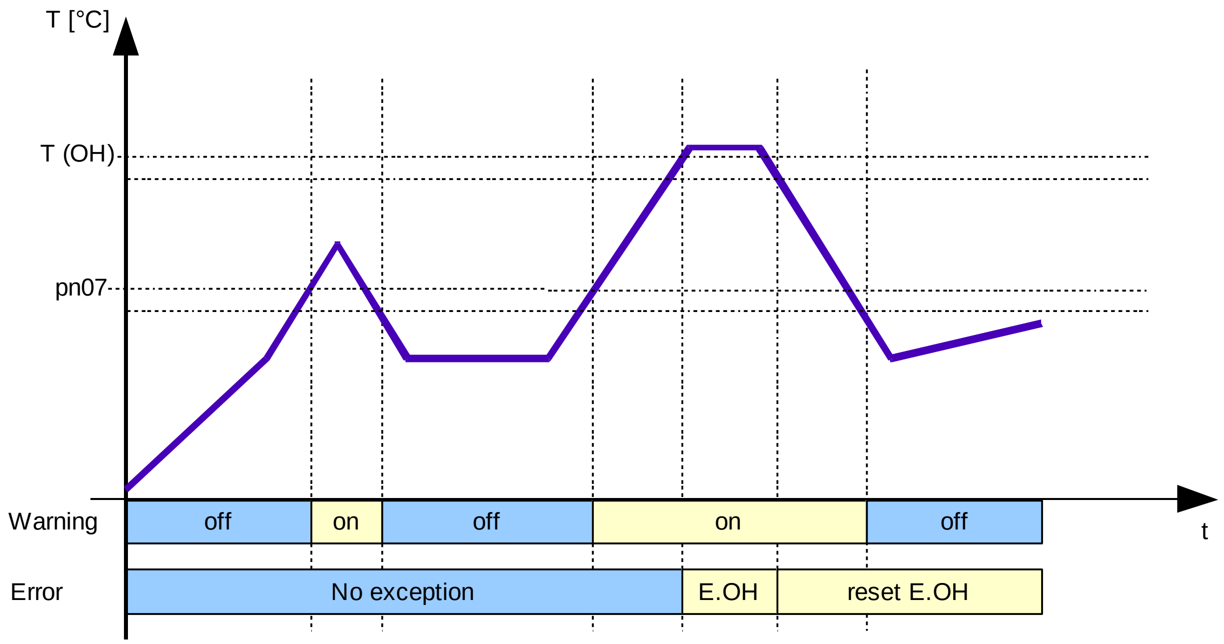
If these 2 seconds are too small to ensure a meaningful completion of the machine cycle, a warning level pn07 OH warning level can be programmed.

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

The default setting is "Warning". This means, upon reaching this 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 heatsink temperature is compared with pn07 OH warning level. If the heatsink temperature is higher than the reference value, the warning becomes activated. If all heatsink temperatures are lower than the reference 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 the heat sink temperature is nearer to its tripping threshold than pn07, the warning becomes activate. The warning will be reset if the heatsink temperature is outside the range of pn07 plus hysteresis (5 °C).	



T(OH): unit-dependent switch-off temperature
pn07: adjustable OH warning level

Figure 7: Overtemperature heat sink (OH)

4.2.3.4 Overtemperature unit (OHI)

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

Index	Id-Text	Name	Function
0x2C1A	ru26	internal temperature	Interior temperature
0x2A06	pn06	temperature warning setting mode	Selection of the reference level for generating the over-temperature warning
0x2A09	pn09	OHI warning level	Internal temperature (of power unit or control board) when OHI warning is triggered
0x2A0A	pn10	E.OHI stop mode	Error reaction (see also chapter 4.2.1 Error)
0x2A52	pn82	warning OHI stop mode	Error reaction to pre-warning (see also chapter 4.2.1 Error)
0x2C02	ru02	warning bits	Display of the warnings bit-coded (see 4.2.2 Warnings)
0x2A1C	pn28	warning mask	Mask for warning bit in the status word (see 4.2.2 Warnings)

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

NOTICE

Change in overtemperature protective functions OH!

- If **Fault Reaction** is programmed as reaction to the overtemperature error and not an immediate shutdown, the modulation will be switched off at least 2 seconds after the occurrence of the overtemperature and if the OH error is still present

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". 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 (for the description of pn06 see chapter 4.2.3.3 Overtemperature heat sink (OH)).

4.2.3.5 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, 3 = KTY 83 110, 4 = PT1000, 5 = free 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 also chapter 4.2.1 Error)
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 (see 4.2.2 Warnings)
0x2A1C	pn28	warning mask	Mask for warning bit in the status word (see Fehler**! Unbekanntes Schalterargument.** Warnings)
0x221E	dr30	motor sensor definition	Parameter structure for the definition of a customer-specific characteristic for detection of the motor temperature

4.2.3.5.1 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

4.2.3.5.2 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.

4.2.3.5.3 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 adjusted 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. (calculation is made using the EXCEL program) 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 - each 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 16 equidistant steps.

The corresponding temperatures can be calculated with an Excel table. This table uses the trendline function to calculate the temperature values which 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.

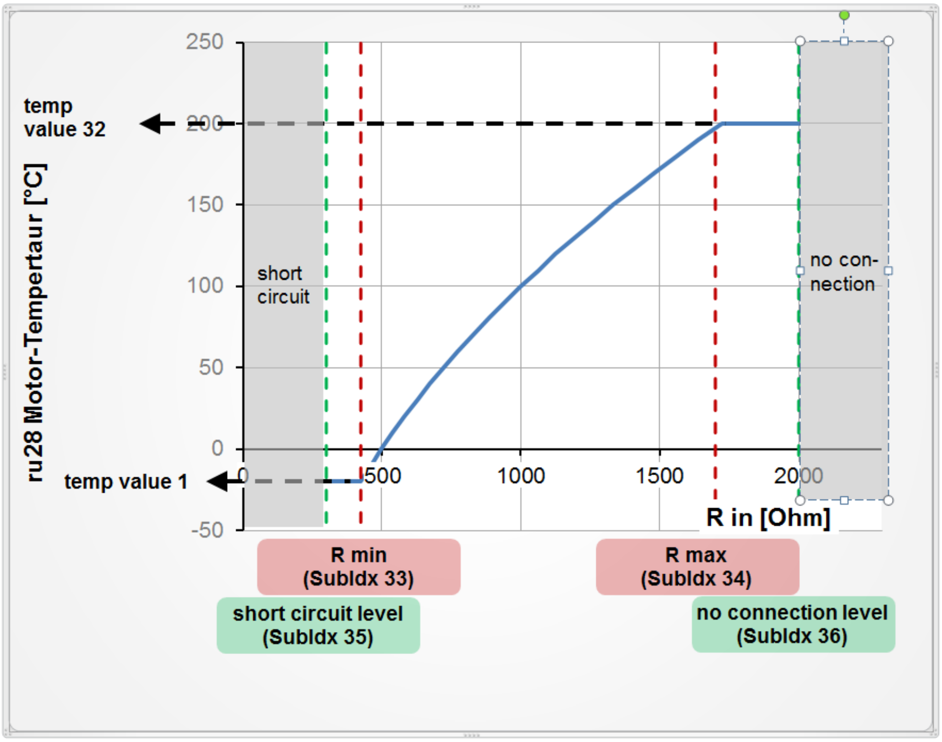
The following values must be defined for the calculation of the setting of dr30 by the EXCEL file:

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

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

Figure 8: Sensor calculation by Excel

4.2.3.6 Motor protection switch OH2

4.2.3.6.1 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.

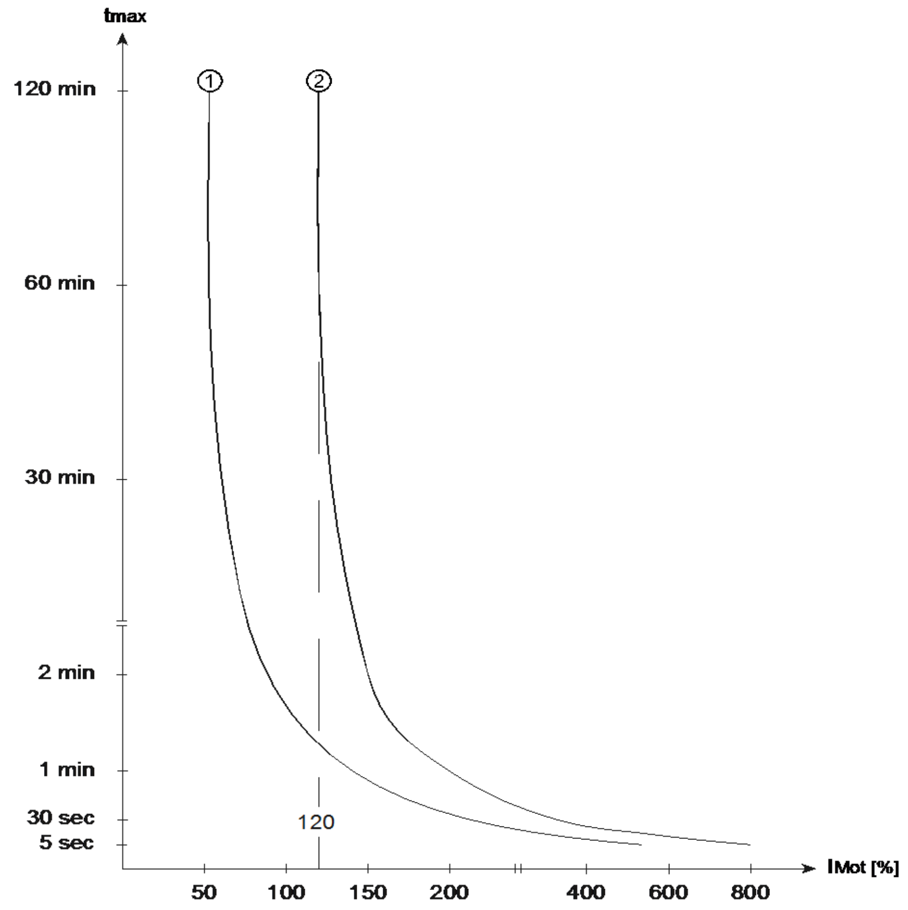
The function corresponds essentially to the mechanical motor protection components, whereby the influence of the motor speed to the cooling of the motor is additionally considered.

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 (VDE 0660, Part 104):			
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

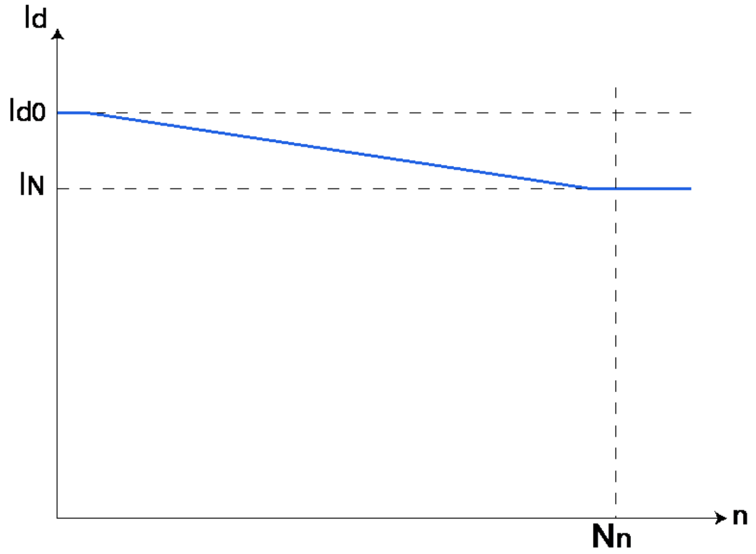
Figure 9: Tripping motor protection switch

4.2.3.6.2 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).

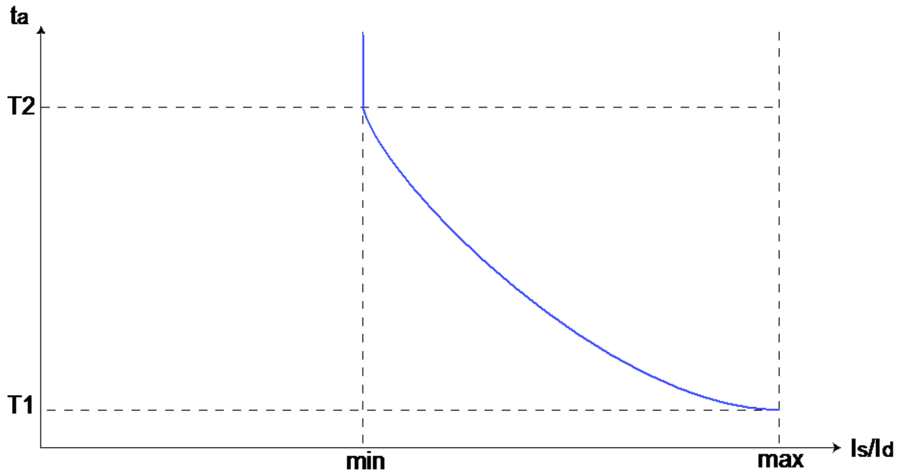
The continuous current (ID) is speed-dependent:



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

Figure 10: 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 11: 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. Error „ERROR OH2“ is triggered if the counter reaches 100%.

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%.

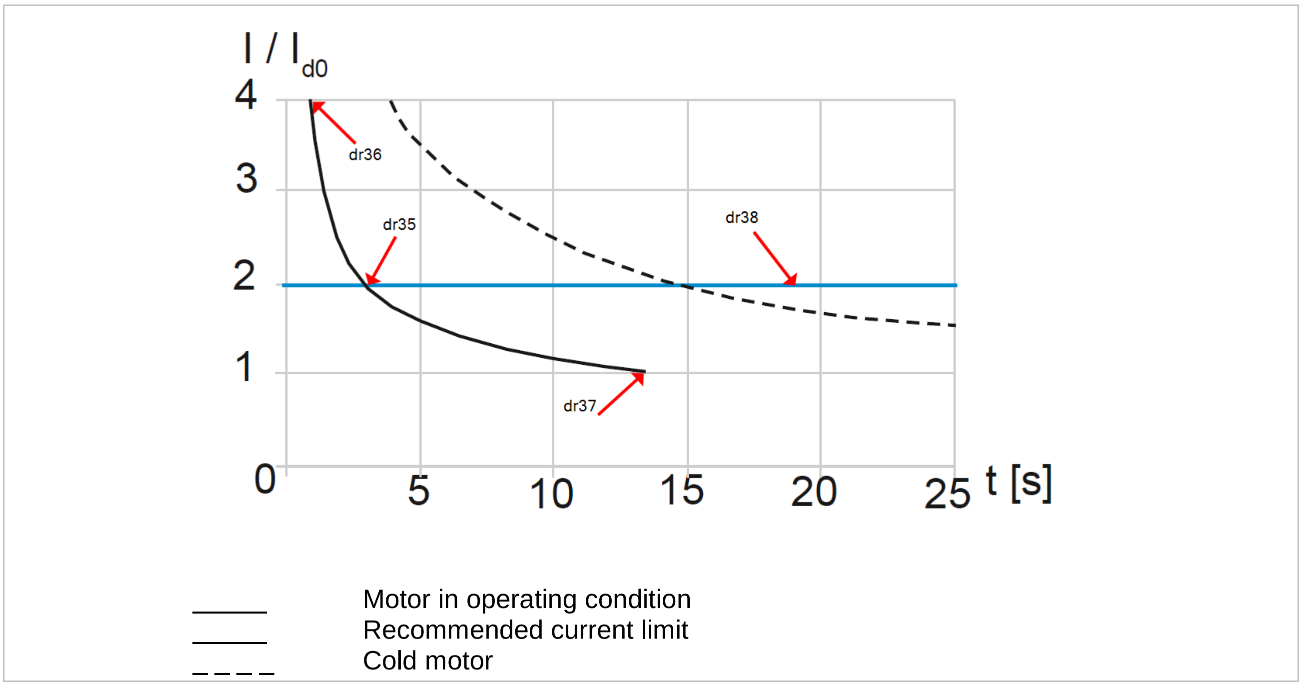


Figure 12: Determination of the motor protection function data from the characteristics of the motor manufacturer

4.2.3.7 Fieldbus watchdog

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

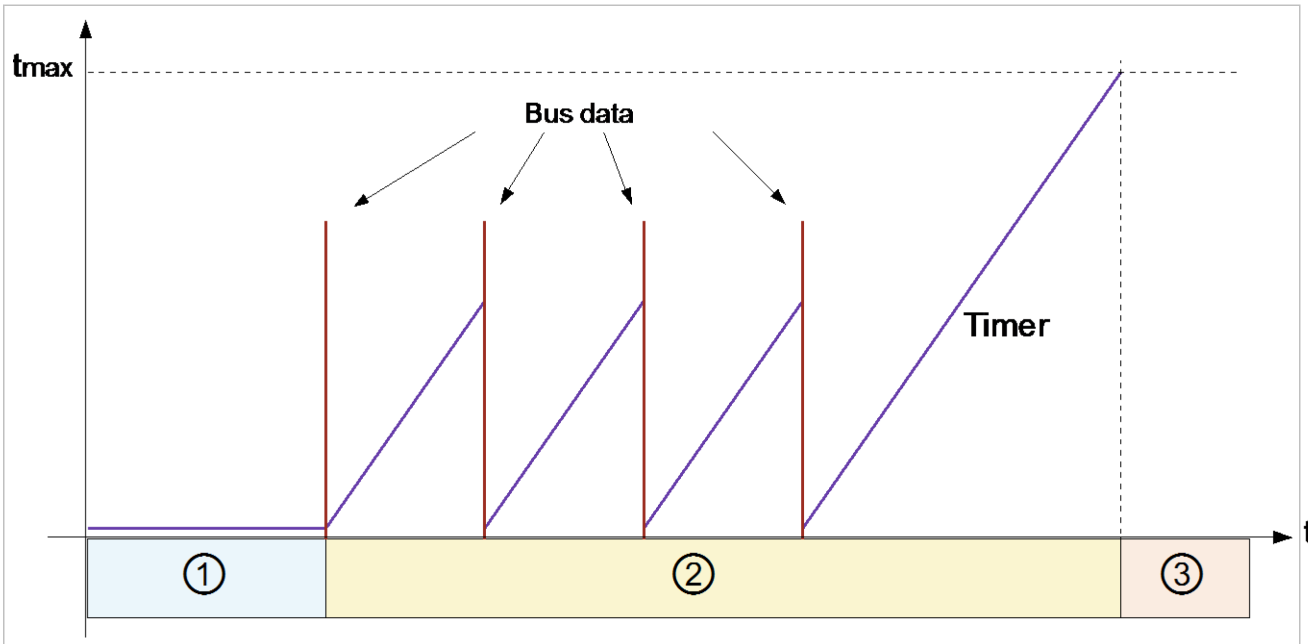
The function can be parameterized via the following objects:

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 (also see chapter 3.3.1 Errors)
0x2C02	ru02	warning bits	Display of the warnings bit-coded (=> 3.3.2 Warnings)
0x2A1C	pn28	warning mask	Mask for warning bit in the status word (see 3.3.2 Warnings)

The watchdog function is in state Ready after switching on or after reset of a watchdog error. That means one is waiting for the first communication process to activate the watchdog.

The internal timer starts with the activation. The timer is reset upon entering a process write data process.

If no processs writa data process occurs for a period longer than the time set in pn21 fieldbus watchdog time, the appropriate bit is set in the warning state and with programming of pn22 E.fb watchdog stop mode the watchdog error is triggered.



tmax	Triggering level
①	Waiting for activation
②	Communication
③	Error

Figure 13: Fieldbus watchdog

4.2.3.8 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)

The maximum apparent current (not for v/f operation) can be preset via parameters 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.

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➢ 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.

1. Example:

The motor parameter (dr12) also serves to the definition of the saturation characteristic, except for the limitation of the current (see chapter 6.1.11 Saturation characteristic (SM) Parameter ms00). This value may not be changed in some applications.

4.2.3.9 Effective motor utilization

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

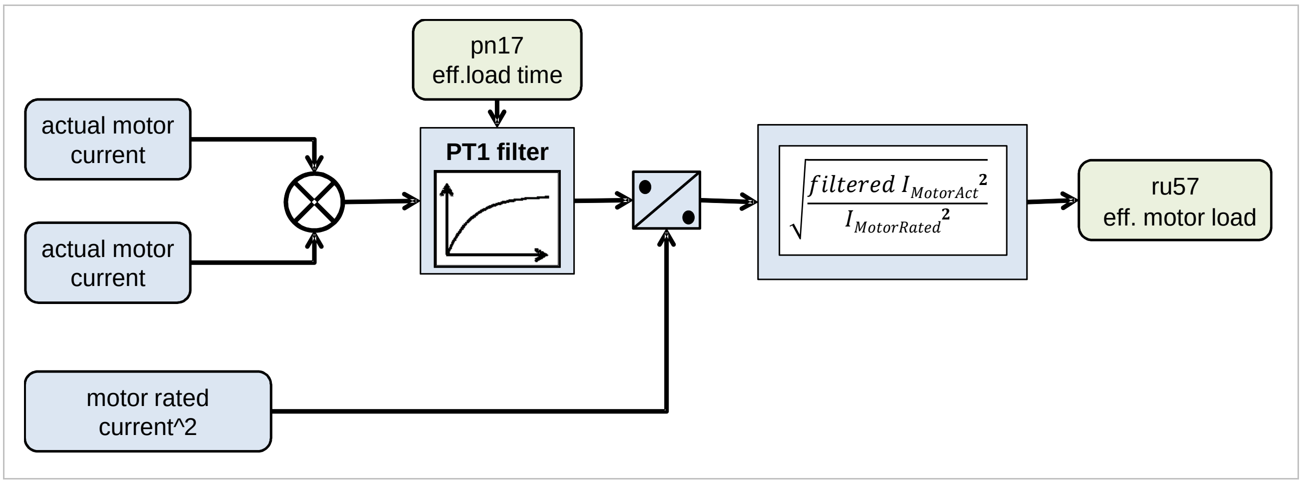

Figure 14: Effective motor utilization

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

The effective motor utilization 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.

4.2.3.10 Maximum acceleration or deceleration

Index	Id-Text	Name	Note
0x2A24	pn36	max acc/dec level [s-2]	Maximum acceleration / deceleration value
0x2A25	pn37	E.max acc/dec stop mode	Error reaction (also see chapter 3.3.1 Errors)

The maximum acceleration or deceleration can be monitored for all operating modes. The level in pn36 is standardized (in [s-2]) just like 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.

4.2.3.11 Monitor the speed difference

Index	Id-Text	Name	Note
0x2A26	pn38	speed diff level	Speed difference in % rated motor speed
0x2A27	pn39	speed diff time	Error is triggered if the time of the speed difference is longer than pn39
0x2A28	pn40	E.speed diff stop mode	Error reaction (also see chapter 3.3.1 Errors)

The difference between setpoint speed and actual speed directly before the speed controller can be monitored here.

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 speed diff time is selected sufficiently small.

4.2.3.12 External error / warning triggering

Index	Id-Text	Name	Note
0x2A1D	pn29	prg. error stop mode	Error reaction (also see chapter 3.3.1 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	reserved		
1	2	reserved		
2	4	reserved		
3	8	reserved		
4	16	reserved		
5	32	reserved		
6	64	reserved		
7	128	reserved		
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			0x2C14	

4.2.3.13 Error underpotential (UP)

Index	Id-Text	Name	Note
0x3512	is18	UP error level	Tripping level for the UP error
0x3513	is19	UP reset level	Reset level fo the UP error

The two levels for the UP error are preset to optimal values depending on the power unit.

The two levels can be lowered if this is not sufficient for the operation with lower DC voltage (e.g., battery).

4.2.3.14 Error 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 (also see chapter 3.3.1 Errors)
0x2A46	pn70	overspeed factor (EMF)	Tripping level ERROR overspeed (EMF)
0x2A47	pn71	E. overspeed EMF) st. mode	Error reaction (also see chapter 3.3.1 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. If the level is set to 0 "off", the protection function is out of order.

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 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 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.

4.2.3.15 Software limit switch

Index	Id-Text	Name	Note
0x2A12	pn18	sw.- switch limit left	Software position limits
0x2A13	pn19	sw.- switch limit right	
0x2A14	pn20	E.SW-switch stop mode	Error reaction (also see chapter 3.3.1 Errors)

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.

4.2.3.16 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.

4.2.3.17 DC link voltage fluctuations

E.Uph is triggered, if the ripple of ru14 exceeds 10 times successively within 16ms a value of 120V.

4.2.3.18 Power-off function

The "Power-off active" status is reached when the DC link voltage drops below a preset level.

If this level is not reached (= power failure), 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.

4.2.3.18.1 Restrictions due to the control model

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

cs00 control mode = 3: no encoder (ASCL/SCL)

The power-off DC link voltage control (Uic-Ctrl) only works in speed ranges where the motor model is also activated (ds41).

4.2.3.18.2 System recovery

There are two options for system recovery:

- the restart speed (cu32[4] restart speed level [Nn%]) was not fallen below. If the drive has comes from the state "operational enable", it can resume its operation.
  cu32[5] stopping speed level [Nn %] is irrelevant here.
- The restart speed (cu32[4] restart speed level [Nn%]) has been fallen below. Starting from the stopping level, (cu32[5] stopping speed level [Nn %]) 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).

4.2.3.18.3 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".

4.2.3.18.4 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
0x221C	dr28	Uic reference voltage	The rated DC link voltage is preset in this parameter. The power failure level is given as a percent value of the rated DC link voltage. The power recovery is detected if the DC link is for 50ms higher than (dr28 – 50V).
0x3911	cu17	intermediate capazity [uF]	Intermediate capacity of the entire system (including its own)

Index	Type	IDtxt	Name
3920h	RECORD	cu32	power-off

Subidx	Type	Name	Function
1	UINT8	power off mode	Activation of the power off function
2	UINT16	DC voltage trigger level [dr28%]	DC link voltage start level for power-off. Percentage related dr28.
3	UINT16	DC voltage ref. [dr28%]	DC link voltage setpoint, setting percentage related to dr28 If the setpoint is lower than the start level, it is internally limited to the start level.
4	UINT16	restart speed level [Nn%]	If the speed at power recovery detection is above the restart speed level, 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 link voltage control to speed control. (The speed setpoint is internally set to 0 rpm. The ramp values from co48-59 are used). The standard torque limit is applied (cs group). The stopping speed level must not be below the model shutdown level, otherwise control is no longer possible (ds group).
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: • The DC voltage has not fallen below the UP level (-> leads to undervoltage errors) • Parameter restart speed level is set to 0 • The drive was in state "operational enable" before power off has triggered

Su-bidx	Type	Name	Function
7	UINT8	state	Display of the state
10	UINT16	torque limit gen.	Torque limit during control to constant DC link voltage: The motor torque limit should not be set to ZERO. Due to sys-tem/model error, either an unwanted acceleration can occur, or the DC link voltage can rise up to OP error.
11	UINT16	torque limit mot.	
12	UINT16	DC-ctrl optimisa-tion factor	The DC controller (PI controller) is designed according to the symmet-rical 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 mode
Bit	Plaintext		Function
0	0: off 1: on		0 = Power – Off function deactivated 1 = Power – Off function activated

Index	Subidx	IdTxt	Name	
3920h	7	cu32	power-off . state	
Bit	Function	Val-ue	Plaintext	Note
0	mains ok	0	OK	Assumed mains status OK
		1	FALSE	Assumed mains status FALSE
1…3	power off state	0	off	not active
		2	activ	active
		4	active, no auto restart	active, no auto restart (more) possible
		6	stopping	Drive decelerates to ZERO
		8	stopping, no auto restart	Drive decelerates to ZERO, no auto restart (more) pos-sible
		10	end, reset	Power-Off expired, error message
4…8	reserved			

4.2.3.18.5 Figure in the drive state machine

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

A change into the state power-off-active (st00 Bit 14 and st12 Bit 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".

4.2.3.18.6 Power off DC link voltage - control structure

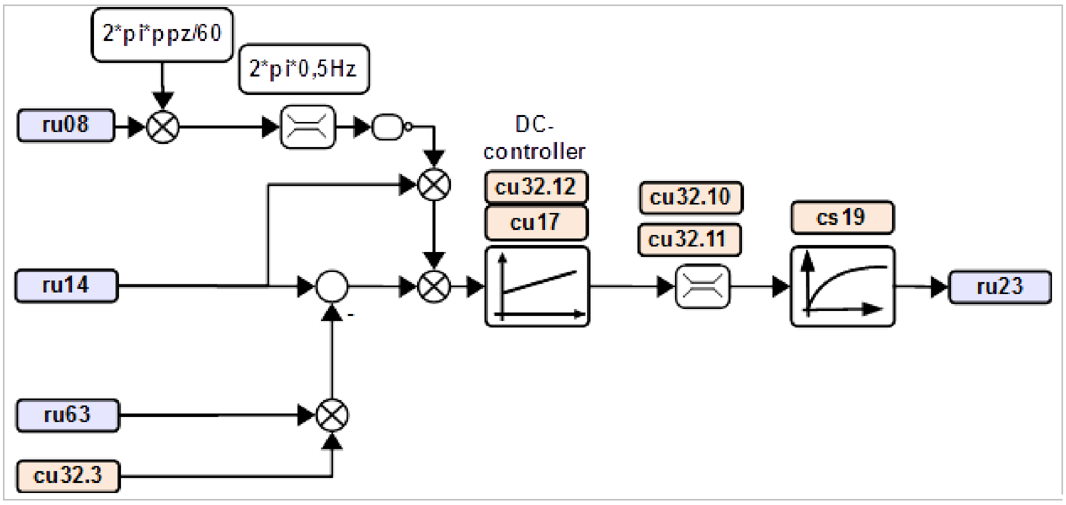

Figure 15: Circuit diagram of the DC control (ppz=number of pole pairs)

4.2.3.18.6.1 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

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

$$Tn = SymOp^2 * Tsum$$

4.2.3.18.6.2 Control to constant DC link voltage

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

4.2.3.18.6.3 Control to constant braking torque

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

- For this, parameter DC voltage ref has to be set to a value that cannot be reached (e.g. 200%). The DC link voltage controller is thereby driven into the regenerative torque limit. A braking transistor module, for example, is required to prevent shutdown due to overvoltage.

4.2.4 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" (see also description of the state machine in Chapter 3.1).

➢ 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 (see 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	

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.

4.3 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	
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	reserved		
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	
3…5, 7, 10	reserved	Reserved, do not use!	

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- Generally distinction is made between synchronous and non-synchronous operating modes. For synchronous operating modes (see 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.

4.3.1 Operating mode 1: Profile position mode

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

Both, setpoint speed and set position values can be preset for the drive also in operating mode 1.

If setpoint speeds are preset at activated position controller, they are integrated and a target position (st37 demand position) is calculated from this. If the drive can not exactly follow the setpoints, then the actual position is adjusted via the position controller.

If this permanent activity of the position controller is not requested it can be deactivated with ps00 position control mode = 0 „off“. st37 demand position and st36 following error are set to zero.

There are 2 modes for positioning operation:

- profile position mode with FIFO (see chapter 4.3.2 Profile Positioning mode with FIFO (pp-mode))
- Index positioning (see chapter 4.3.2.2 Index positioning

The change between the two modes occurs 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 selection	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 operation or position sets can be programmed which shall be reached one after another or which shall be passed through with defined speed.

There are also 2 modes for speed-controlled operation:

- Speed setpoint setting via vl parameters
- Index speed setting

(see chapter 4.3.1.4 Speed settings)

4.3.1.1 Ramps in profile position mode

Speed ramps with linear increasing acceleration are supported (s-curves) in the operating mode profile position mode (co01 = 1).

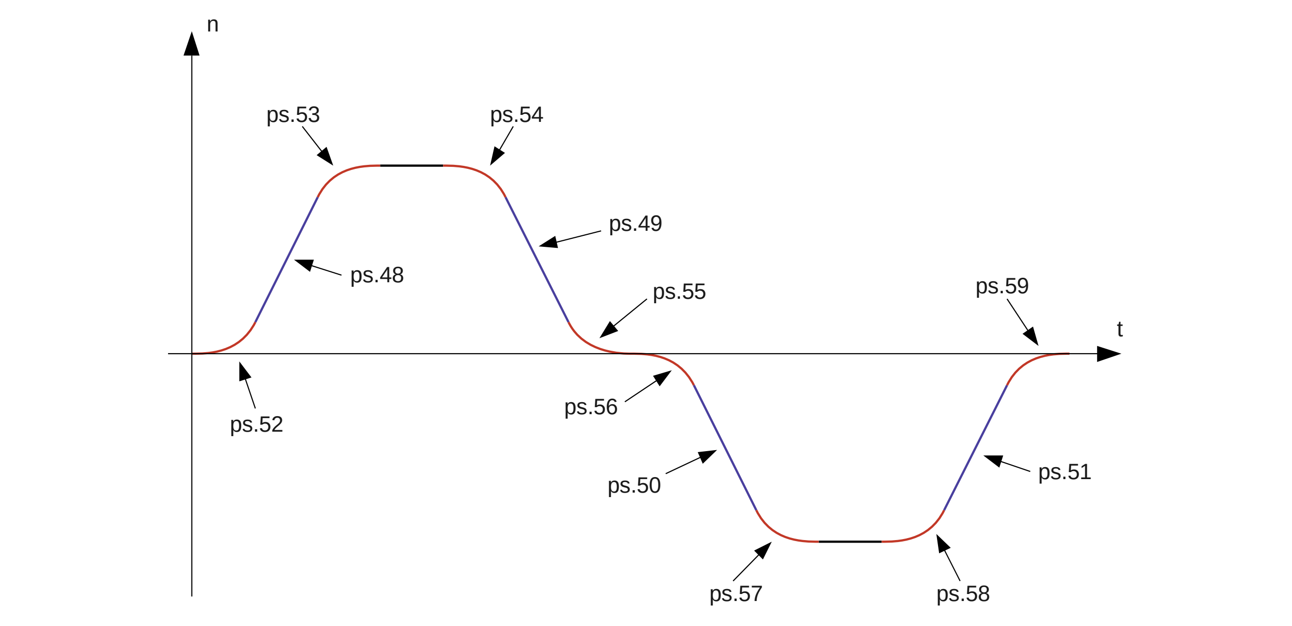


Figure 16: Ramps in profile position mode

4.3.1.2 Speed limits

The maximum speed is limited in the profile positioning mode via ps32max 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 exception of the position controller output.

This value can even be added to the max profile velocity ps32.

4.3.1.3 Position limits

The position setpoint and position actual value limits are described in chapter 6.4.1 Position values.

4.3.1.4 Speed settings

If no positioning and no index speed is active, the speed setpoint setting occurs via the vl parameters (see chapter 0

Set speed setting). The speed setting via the vl parameters is always limited by the vl velocity min / max amount parameters (vl04…vl07), additionally to the limit of ps32.

A simple fixed speed setting (index speed setting) of up to 32 different speeds can be realized in the following way:

- Operating mode 1 must be selected
- Value 6 "speed reference" must be entered in ps43 index mode [ ] for the used array indices.
- The setpoint speeds must be entered in the used array indices of ps40 index speed.

4.3.2 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.

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

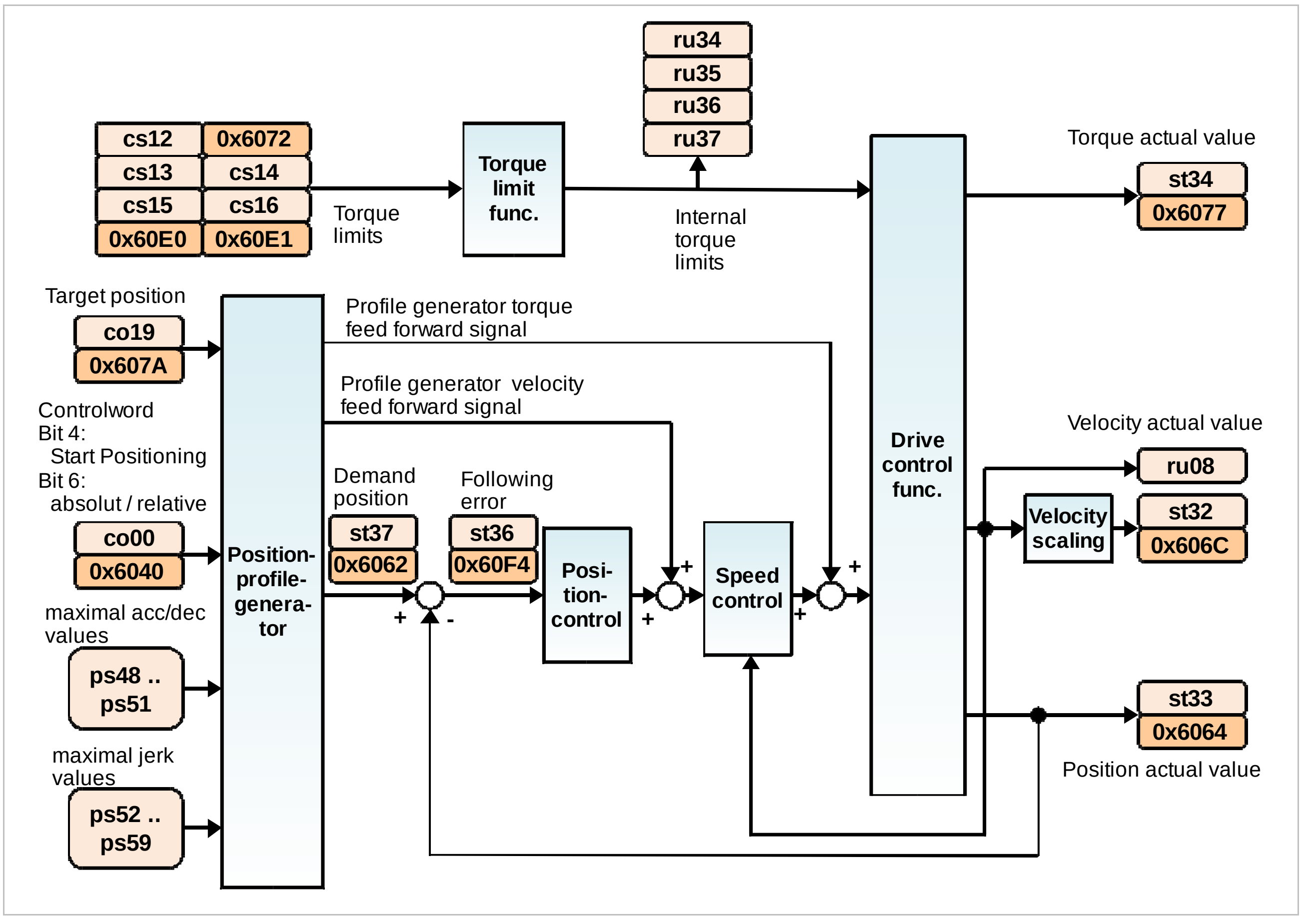


Figure 17: Profile positioning mode

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.

4.3.2.1.1 Single positioning (single set-point)

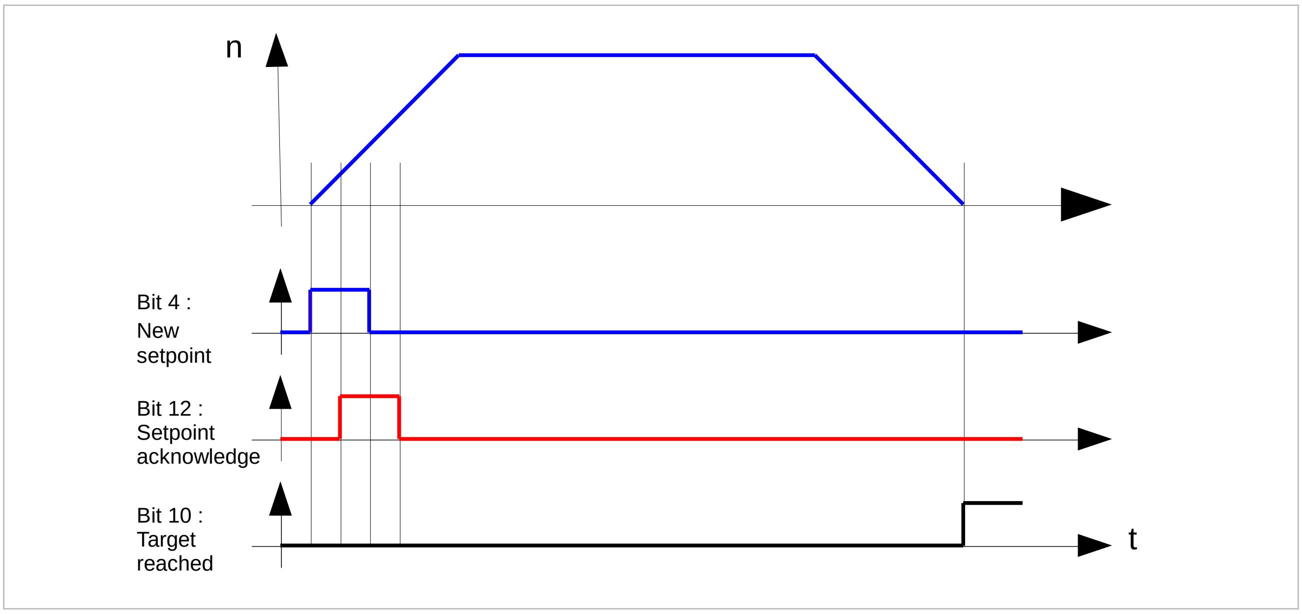


Figure 18: Single positioning

4.3.2.1.2 Multi positioning (Set of set-points)

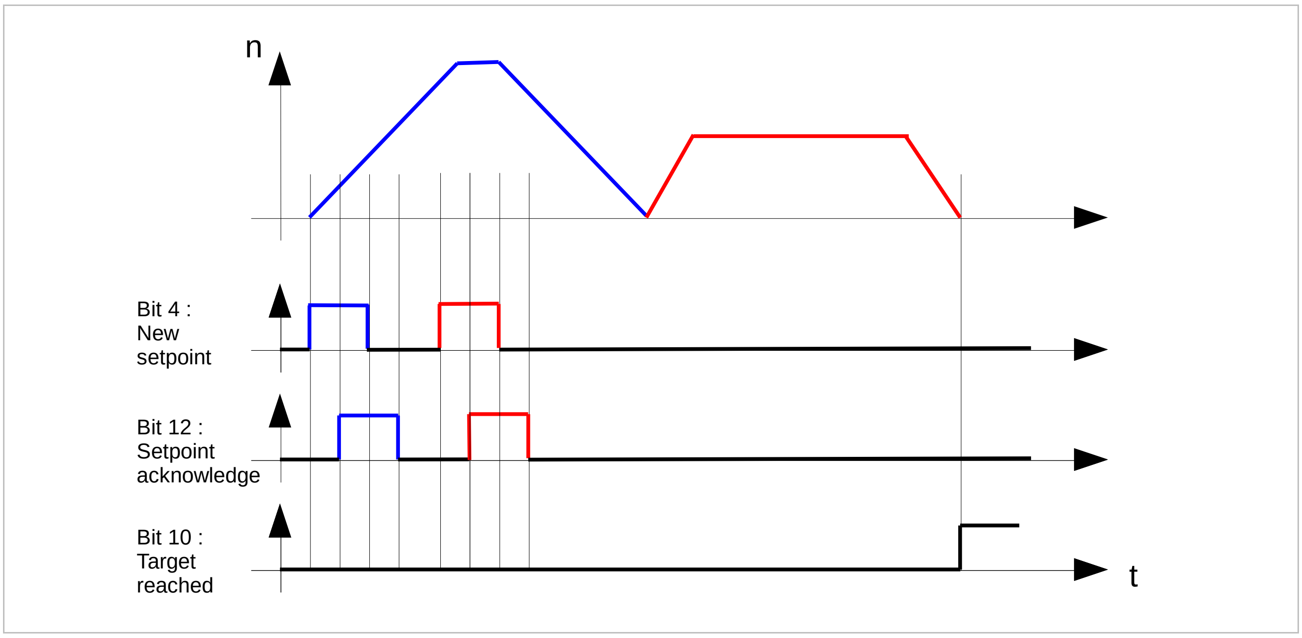


Figure 19: Multi positioning

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) remains set in the status word, until free memory space is available again.

4.3.2.1.3 Restart in a positioning (Change set immediately)

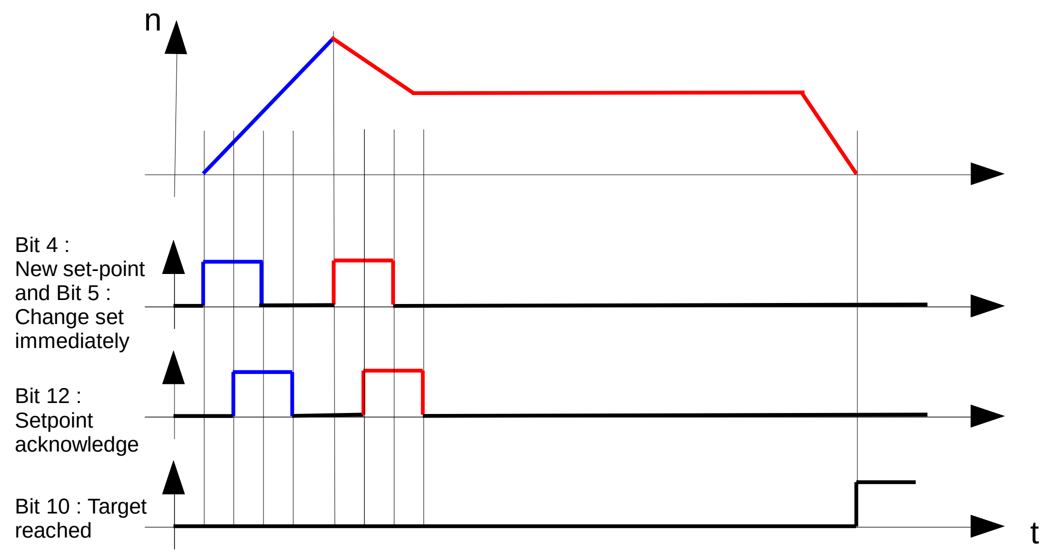


Figure 20: Restart of a positioning

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.

4.3.2.2 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] profile 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 for the abort of an index positioning
0x2E2D	ps45	immediately index	Index selection for the abort
0x2E2E	ps46	start index	This can also be done with ps46 independent of the index specified 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 by the digital inputs (defined by di21).

Positioning is started with bit 4 (new set-point) in the control word. This can also be done with a digital input (see chapter 7.1.6 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 virtual 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 the positioning can always be decreased with ps32 max profil 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.

4.3.2.2.1 Single positioning

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

If value -1 „with digital input“ is entered in ps46 start index, the index selected via digital inputs (see chapter) 7.1.6.3 Index setting via digital inputs) is used as start index.

4.3.2.2.2 Sequence control

There are 2 types of sequence control "auto index mode" or "stop after each index". The selection occurs 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 passed through in succession, until an index is reached for which the 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	In this index mode, the positioning is completed after each index in the case of subsequent positioning (ps42 next index unequal -1). The new index (ps42 next index) is automatically entered in ps46 start index. The index entered in ps46 is used with the next command "Start positioning". A "start positioning" command must always be given in order to pass the single positions of the programmed sequence. If a positioning sequence is completed (ps42 next index = -1) the value of ps42 next index (-1) is copied in ps46 start index with reaching the last target, so that the next positioning sequence would start again with the index selected via digital inputs.

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

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

4.3.2.2.3 Absolute / relative positioning

It can be selected in ps43 index mode if the position values shall be regarded as 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

There is a further differentiation at relative positioning:

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

If the sum of relative positionings related to a reference point shall be precisely as possible, the new position must be calculated relative to the actual 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

4.3.2.2.4 Relative to zero

ps43	index mode	
Value	Name	Note
5	relative to zero	Approach of an absolute position within one motor revolution (tool change).

The motor shall be stopped in a defined position within one motor revolution in ps43 index mode = 5 „relative to zero".

The selection of such a defined position index shall be done from a constant motion. The setpoint speed in this position index (ps40 index speed) must be greater or equal to the setpoint speed in the index selection.

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 = 0).

4.3.2.3 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 rotary table occurs according to the general set- / actual position limits and is described in chapter 6.4.1 Position values.

Also the cyclic referencing is possible in all position-controlled modes and is described in chapter **Fehler! Verweisquelle konnte nicht gefunden werden. Fehler! Verweisquelle konnte nicht gefunden werden.**.

4.3.2.3.1 Round table - operating modes

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

For round table positioning, 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.

Profile positioning mode with FIFO:

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).

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

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).

4.3.2.4 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 6.4.3.3 Following error.

4.3.2.5 Target reached

Bit 10 in the status word "target reached" is only operated in the profile positioning mode.

Bit "target reached" is only set on reaching an (intermediate) target, if

- there is no further position set in FIFO in the profile positioning mode with FIFO (i.e., a sequential positioning is not immediately started).
- the last position is reached in auto-index operation (ps38 positioning module Bit 1 index mode = 0 „auto index mode“) (ps42 next index [ ] = -1 „off“). Bit 10 target reached is never set if a loop is programmed (last index points to start index).
- the current target position is reached in the stop-after-each-index mode.

The behaviour depends on the setting in ps31 end velocity or ps41 index end speed. The bit "target reached" (TR) is set immediately after completion of the precontrol profile if the target speed (ps31 bzw. ps41) is unequal to 0. Otherwise, the target window (ps 14 positioning window and ps15 positioning window time) is also considered.

ps31 or ps41 ≠ 0	ps31 or ps41 = 0
The precontrol profile at "target reached" is expired.	The precontrol profile at "target reached" is expired. ➢ A position window is symmetrical defined to the target position (position window = target position +/- ps14 with ps14 positioning window). ➢ ps15 positioning window time defines the time for the drive to be in this target window. ➢ The drive is in the target window for the time ps15 (target position +/- ps14).

Attention: on reaching the target position, bit 4 in the co00 controlword must not longer be set, in order to trigger the bit 10 target reached in the st00 statusword.

The positioning must be completed in order to start a new positioning. A completed positioning means:

- bit "target reached" is set at single positioning
- the drive is in the target window during sequential positioning

If a new positioning shall be started without the previous has been completed, this is only possible via the bit "change set immediately" or the removal of the modulation release.

4.3.3 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.

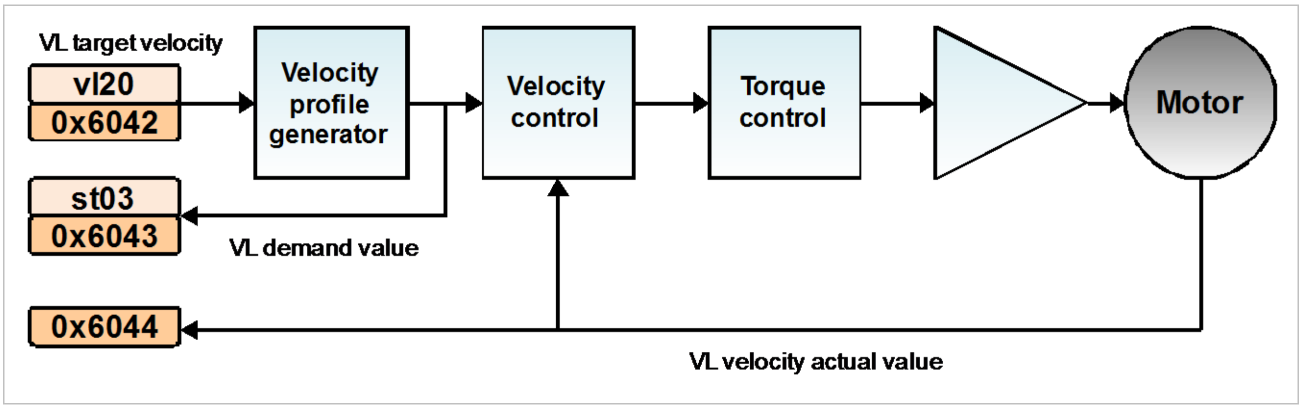


Figure 21: Velocity mode - overview

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.

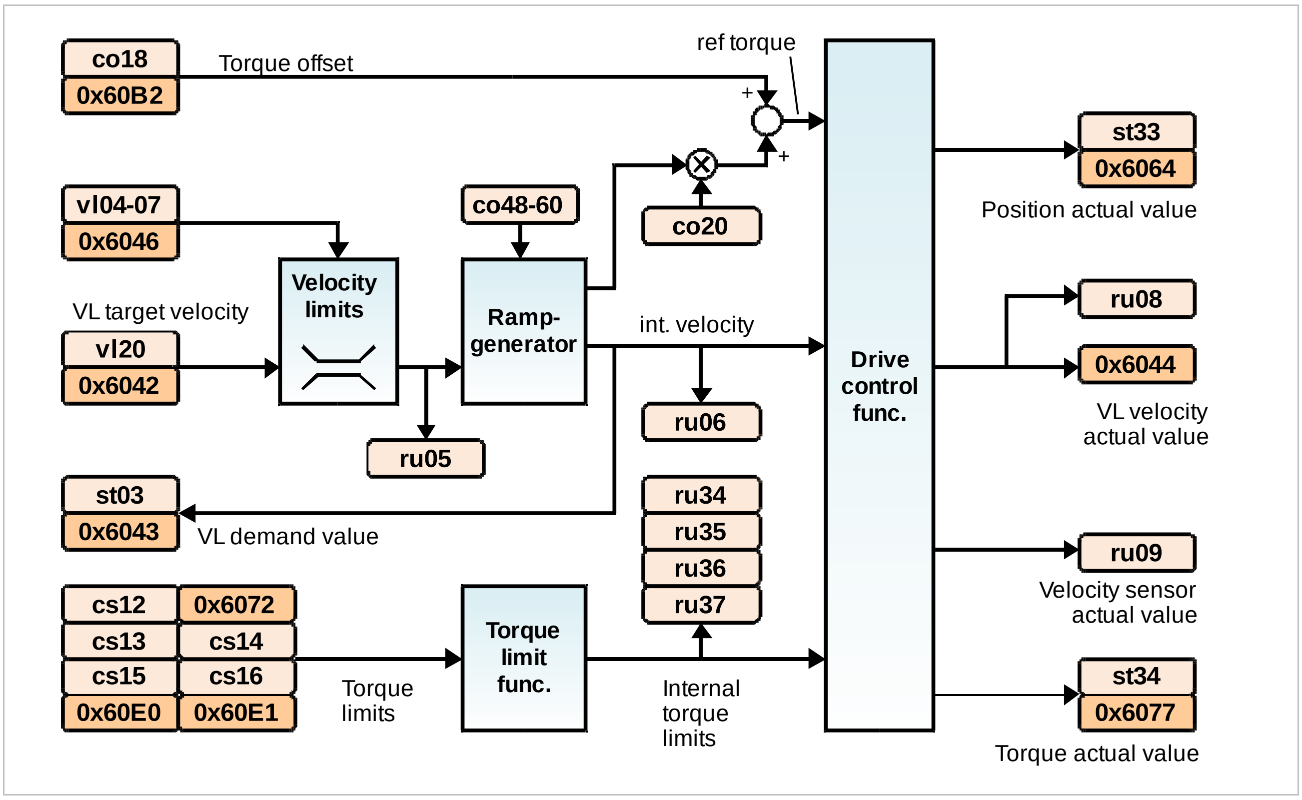


Figure 22: Velocity mode

4.3.3.1 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.

4.3.3.2 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)

Index	Subindex	Id-Text	Name	Function
0x6046	1		vl velocity min amount	Minimum speed FOR and REV
0x6046	2		vl velocity max amount	Maximum speed FOR and REV

The limits for both directions are set with the setting of the limits via the profile objects.

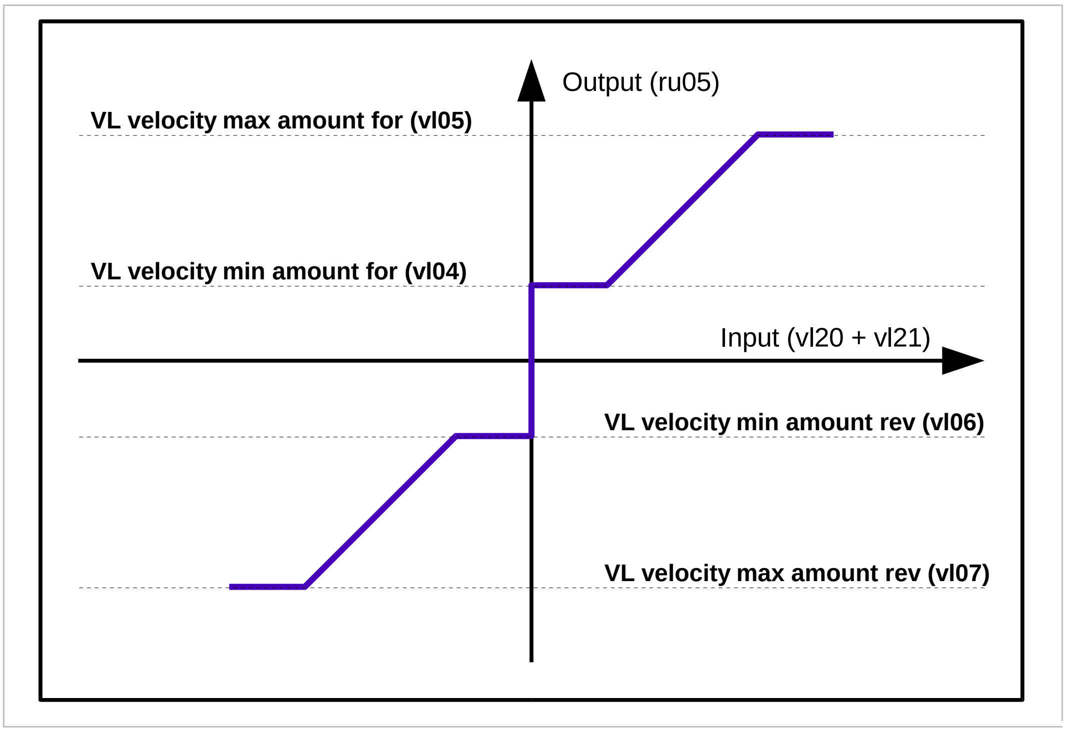


Figure 23: Target speed limitation

4.3.3.3 Controlword in the velocity mode

Additional bits in the velocity mode

co00	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.

4.3.3.4 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.

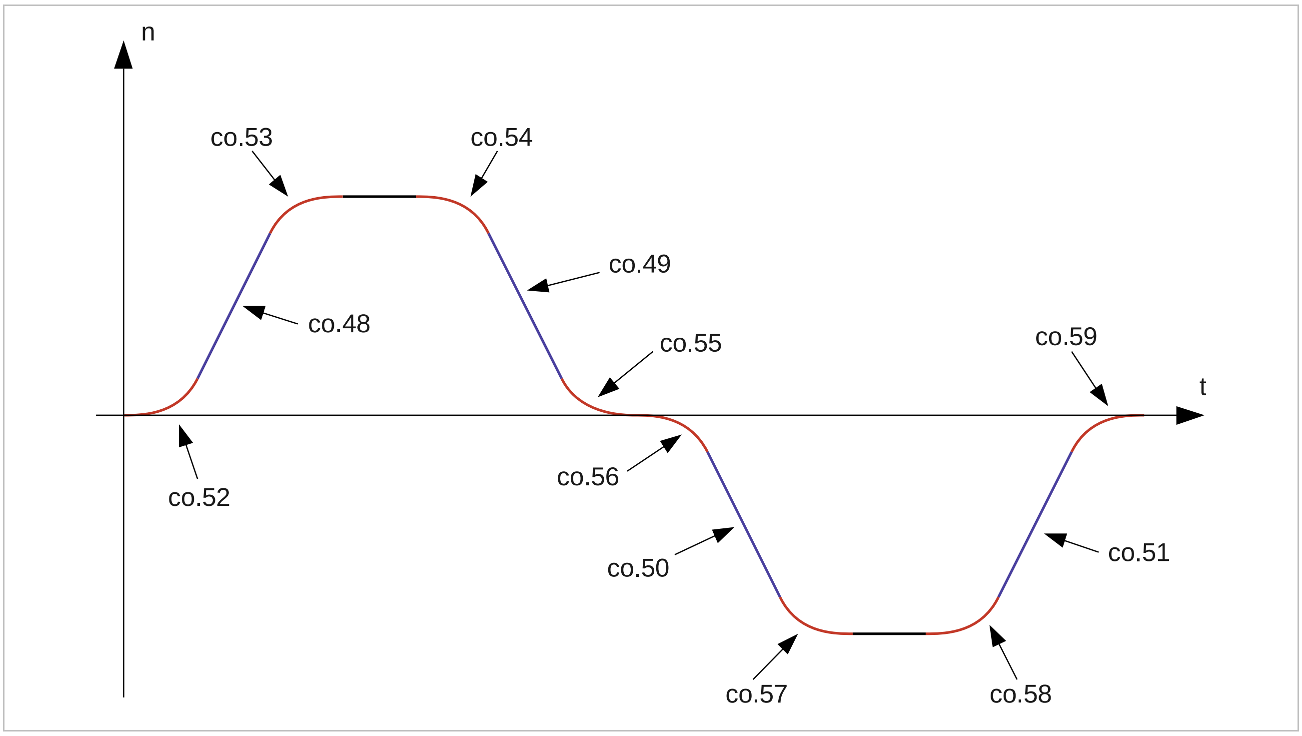


Figure 24: Ramp generator

4.3.3.4.1 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?

$a = \Delta n/\Delta t = 1000 / 60\ s^{-1} / 1\ s^{-1} = 16.67\ s^{-2}$

4.3.3.4.2 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:

$r = a / t = 16.67 s^{-2} / 1s = 16.67\ s^{-3}$

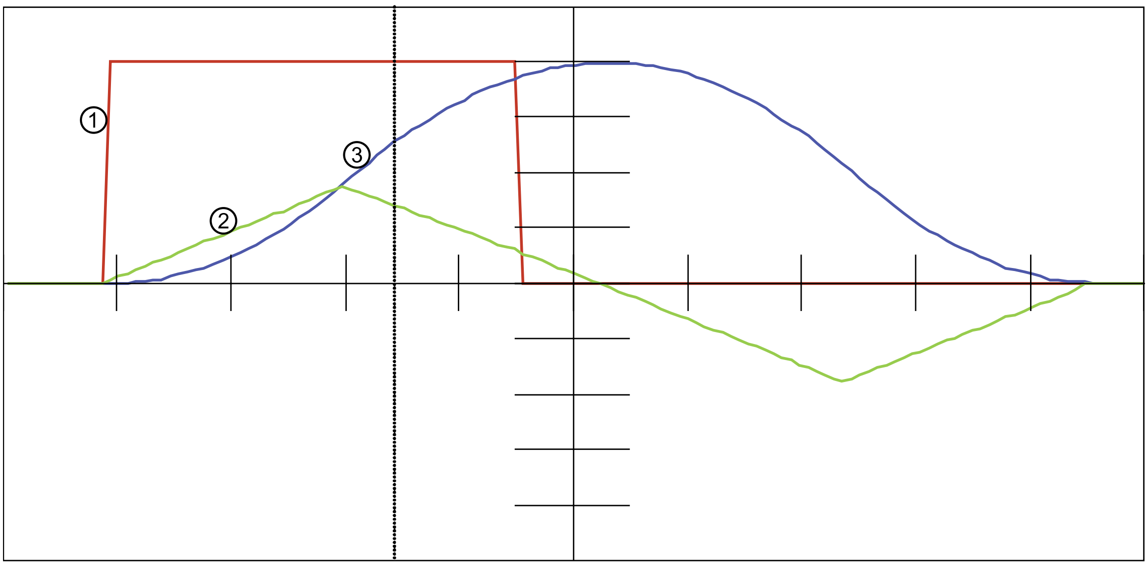
4.3.3.4.3 Operating modes of the ramp generator

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:

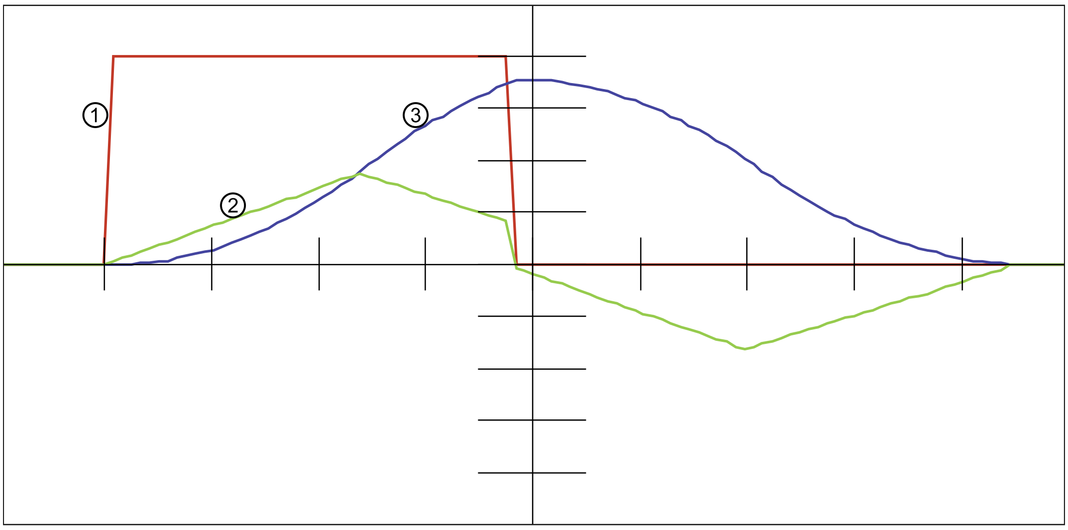
co60		ramp mode	0x253C
Bit	Function	Value	Function
0	ramp type	0: S-curve	S-curves
		1: lin	Linear ramps
1	linear ramp acc/dec	0: sep. para	co48…co51
		2: acc for para	co48 is acceleration/deceleration setting for all directions of rotation (only effective if linear ramps are selected; otherwise valid co48-cp51)
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	



1 Setpoint (vl20 vl target velocity)
2 Acceleration (defined by co48...co59)
3 Ramp output value (ru06 ramp out display)

Figure 25: s-curve type = 0: continous s-curve

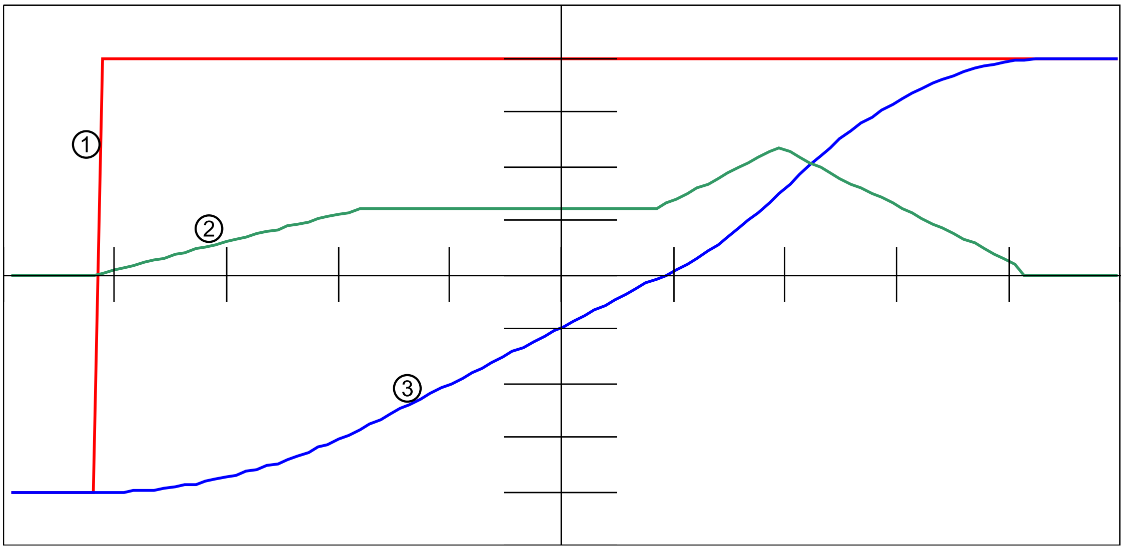
Actual acceleration is changed with actual jerk to the new setpoint. There is no jump in the acceleration.



1 Setpoint (vl20 vl target velocity)
2 Acceleration (defined by co48...co59)
3 Ramp output value (ru06 ramp out display)

Figure 26: s-curve type = 4: abort in s-curve

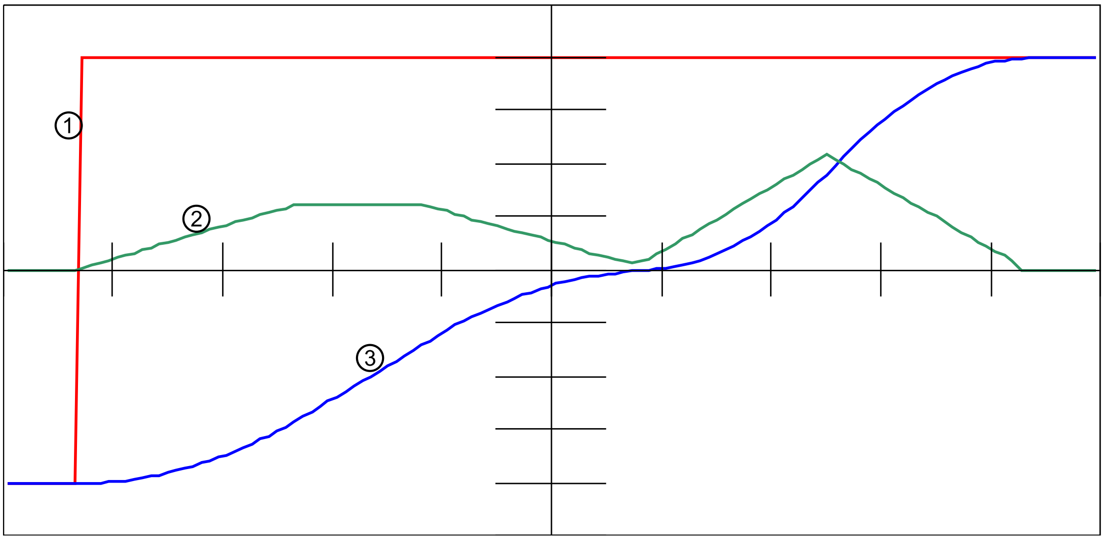
The actual acceleration is immediately limited to 0 if the setpoint is lower than the actual value. In acceleration there is a jump to 0 at this point.



1 Setpoint (vl20 vl target velocity)
2 Acceleration (defined by co48...co59)
3 Ramp output value (ru06 ramp out display)

Figure 27: 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 28: pass zero type = 8: zero

The acceleration is reduced to 0 when the ramp output changes the sign.

Calculation example with timing:

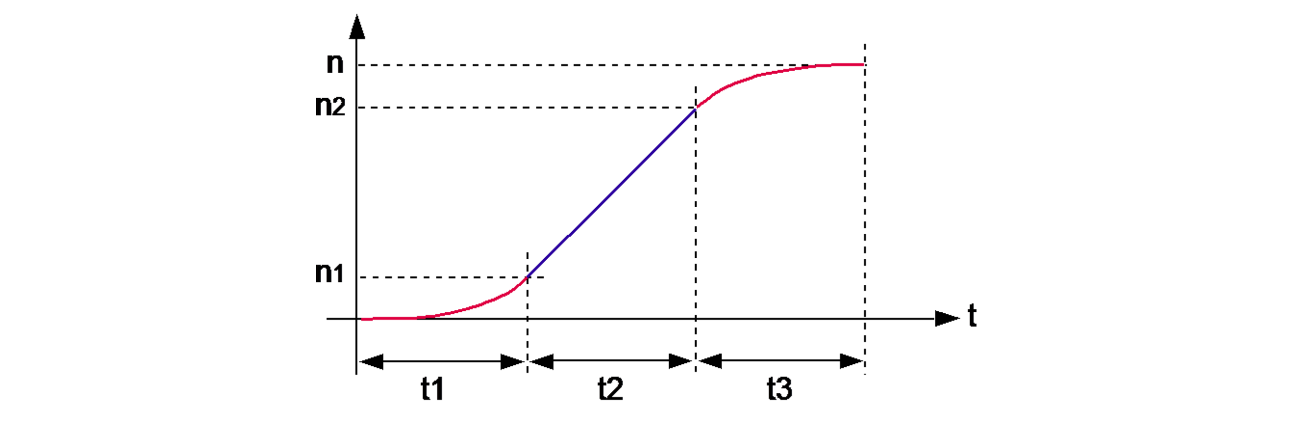


Figure 29: Calculation example30

An acceleration profile is given according to the graph above. 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:

$$n1 = \frac{a * t1}{2} \qquad n1 = \frac{4.17s^{-2} * 1s}{2} = 2.08s^{-1}$$

$$n2 = n1 + a * t2 \qquad n2 = 2.08s - 1 + 4.17s - 2 * 2s = 10.42s - 1$$

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.

4.3.4 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.

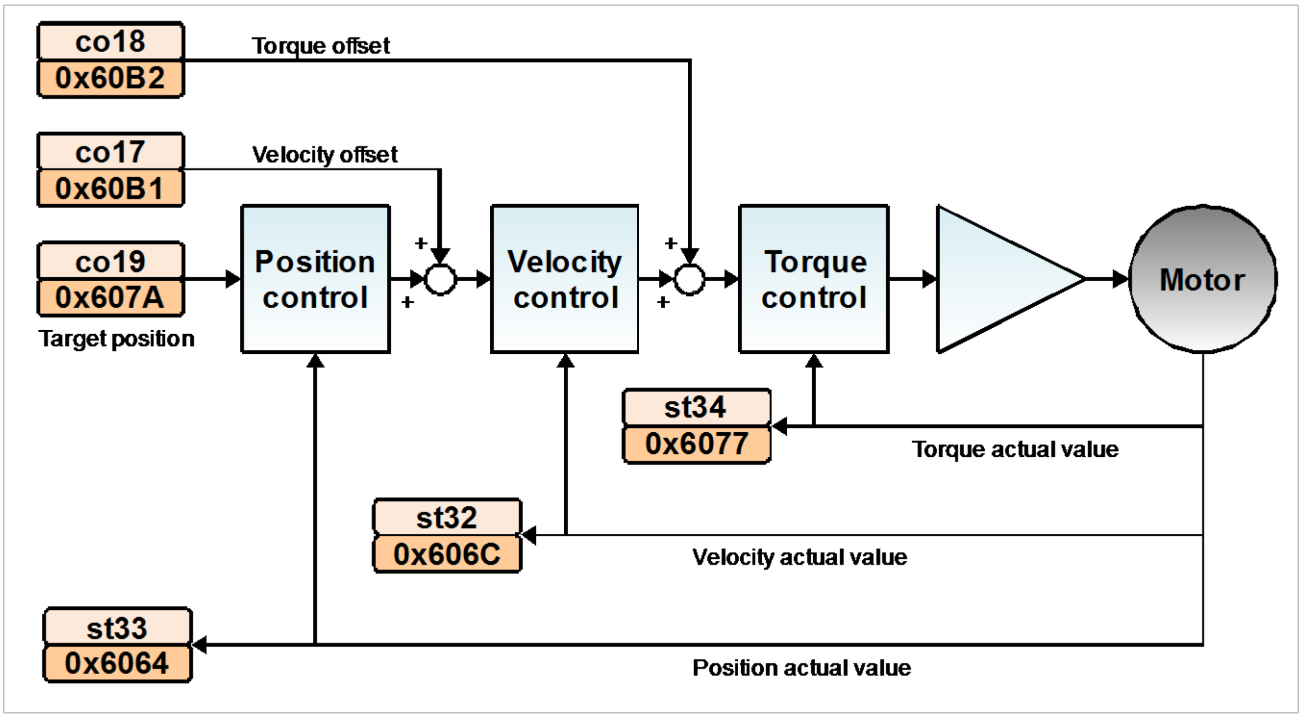


Figure 31: Cyclic synchronous position mode - overview

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.

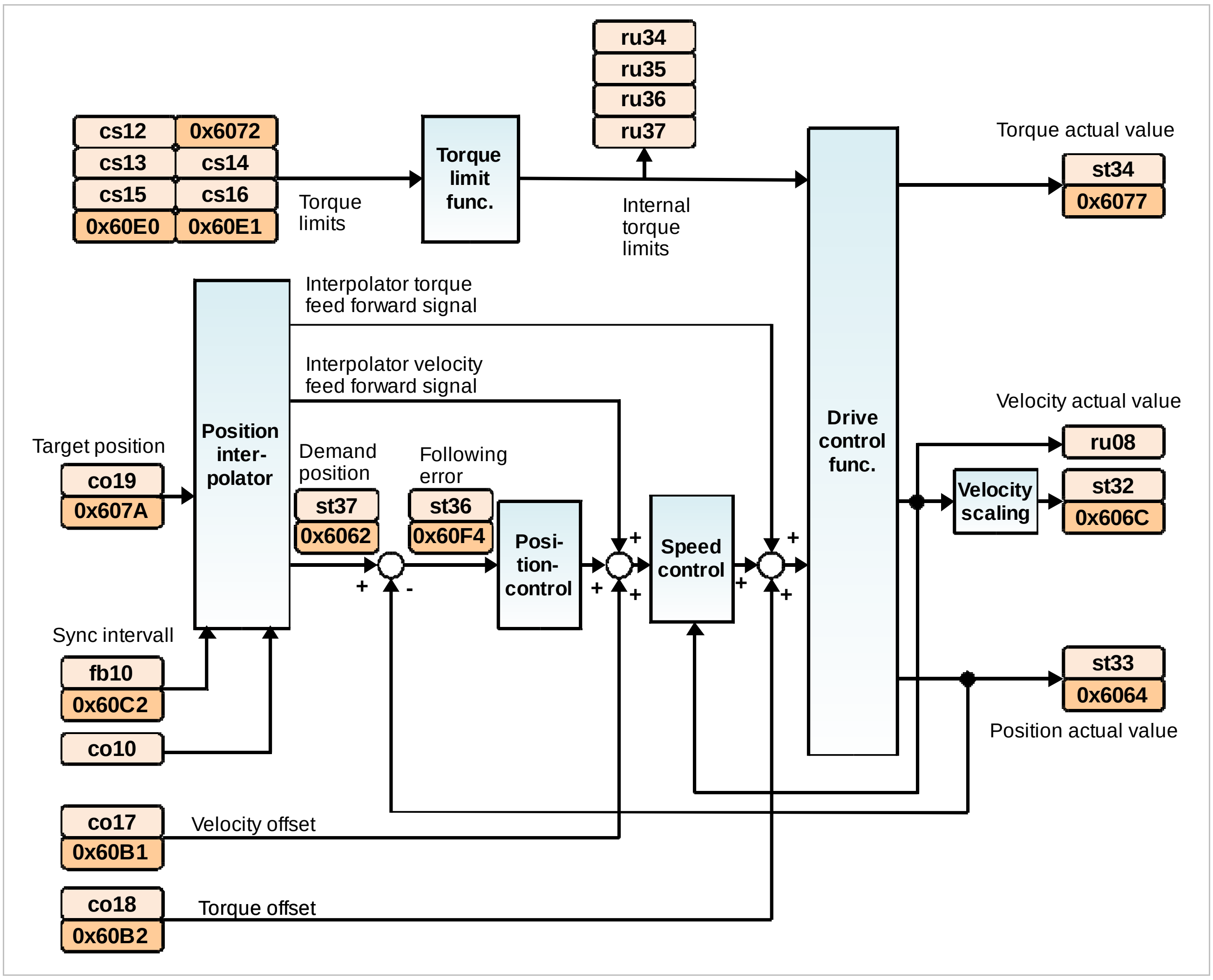


Figure 32: Cyclic synchronous position mode

The position setpoints are preset via the object co19.

Index	Id-Text	Name	Function
0x2513	co19	target position	Presetting the set position
0x607A			

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:

co10	position interpolator			0x250A
Bit	Function	Value	Plaintext	Notes
0…3	interpolator mode	0…3		do not use!
		4…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 (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.

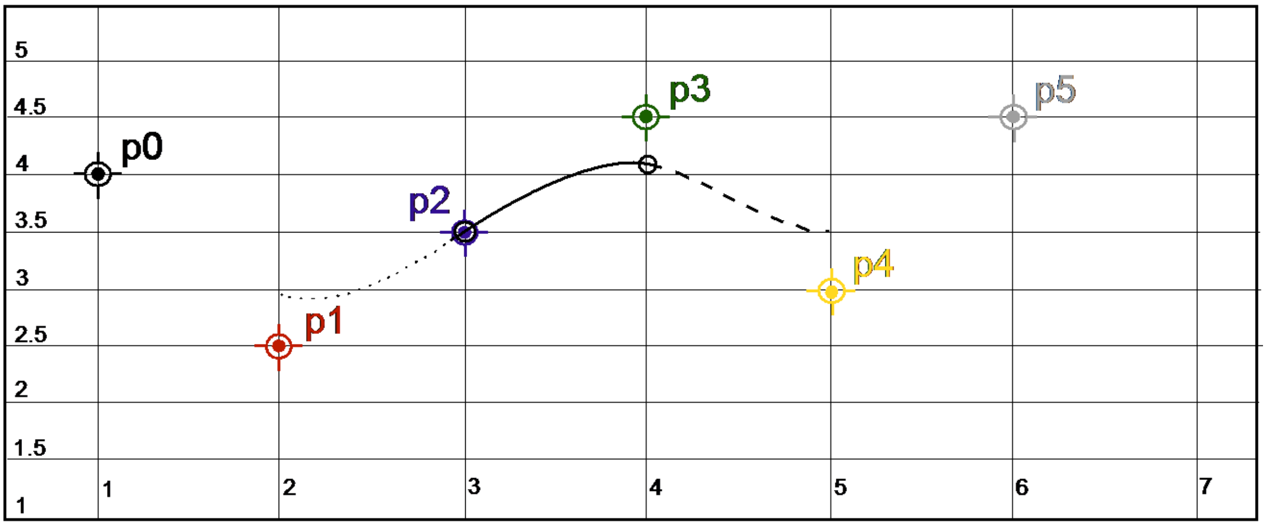


Figure 33: Example interpolation

If the number of grid points is increased with co10, any errors in the set profile can be compensated more 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.

The three control circuits 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.

Min. 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.

That 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 4.3.6 Operating mode-independent functions.

4.3.4.1 Position precontrol

In Cyclic Sync position mode, the spline interpolator provides a temporal shift between position setting by the superimposed control co19 target position and actual set position for the motor (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 delay.

If required, 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 delay for the process data communication.

Example: co10 = 4: B-Spline, 4points avg + actual value

fb10 = 1ms

co13 ≈ 0.5 * 4ms + 1ms ≈ 2500µs…3000µs

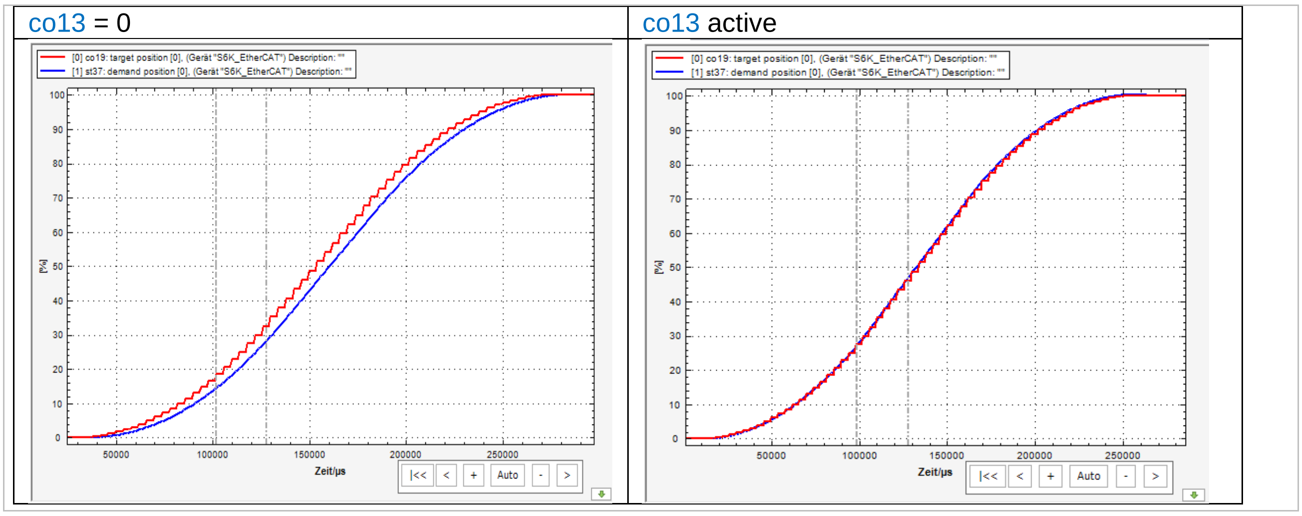


Figure 34: Position precontrol

4.3.5 Operating mode 9: Cyclic synchronous velocity mode

In operating mode „cyclic synchronous position mode", speed setpoints are cyclically pre-set 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.

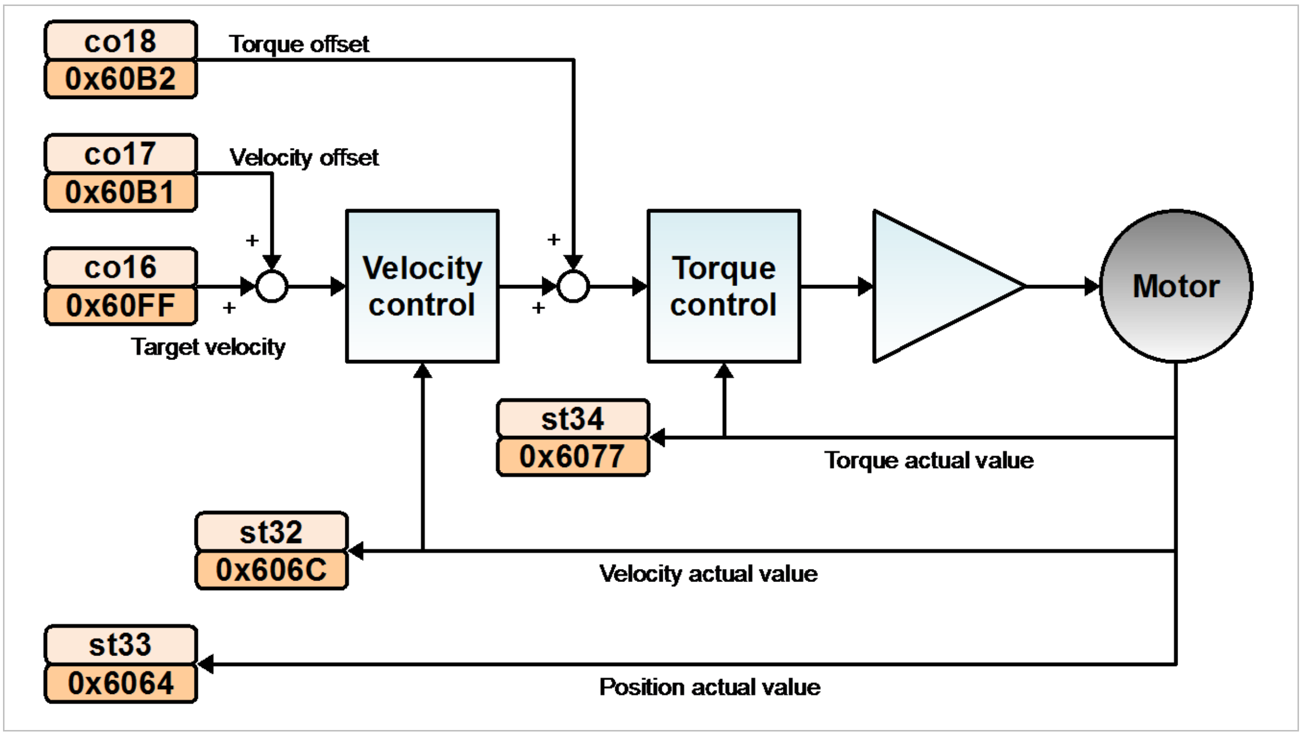


Figure 35: Cyclic synchronous velocity mode - principle

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.

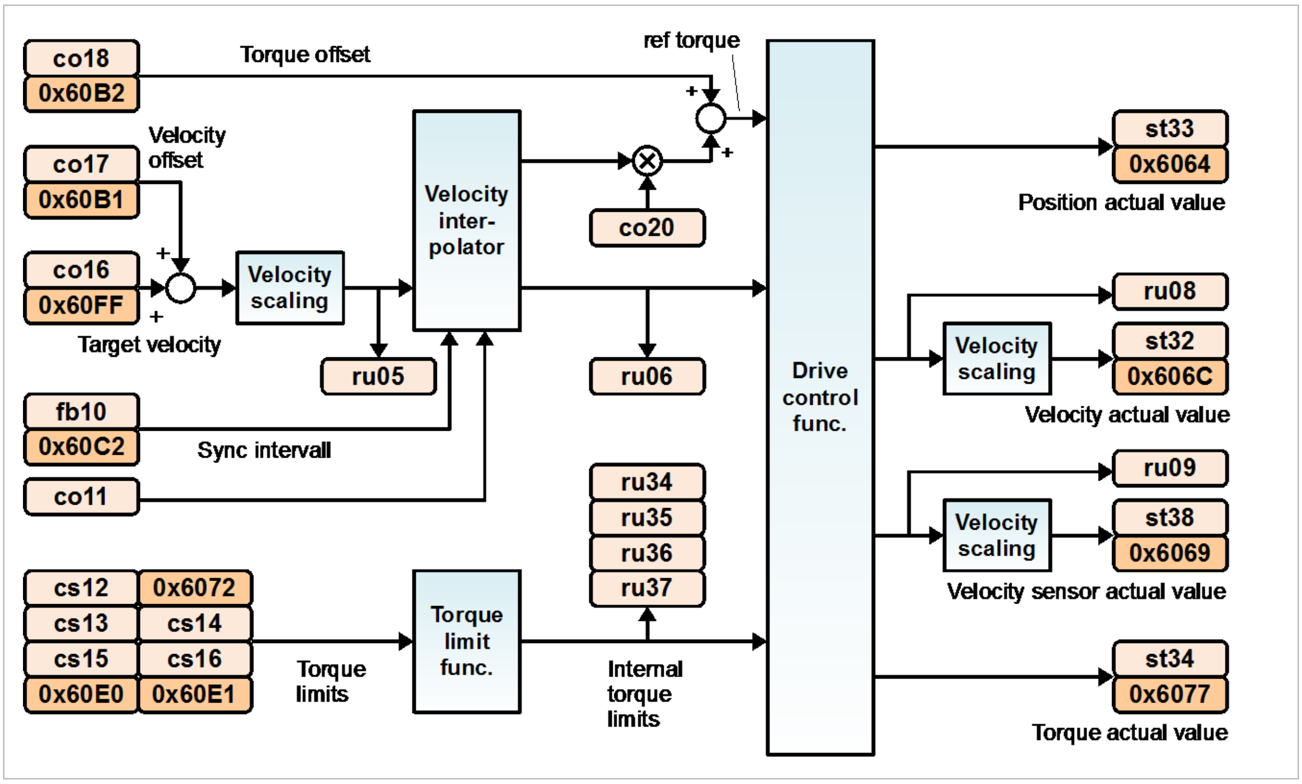


Figure 36: Cyclic synchronous velocity mode

The speed setpoints are preset via the objects co16 and co17.

Index	Id-Text	Name	Function
0x2510	co16	target velocity	Setting the setpoint speed
0x60FF			
0x2511	co17	velocity offset	Is added to target velocity
0x60B1			

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 and homing

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 and 0x2120, 0x606c st32 velocity actual value.

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	interpolator mode	0	0: linear, 2 points avg	Linear interpolation between the last two values
		1…2	0x2C14	
		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.

The function blocks **torque limiting** and **torque precontrol** are described in chapter 4.3.6 Operating mode-independent functions .

4.3.6 **Operating mode-independent functions**

4.3.6.1 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 motor direction can only be changed with this parameter. Thereby the setpoints and the actual position are inverted.

Index	Id-Text	Name	Function
0x2506	co06	system inversion	System inversion

4.3.6.2 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, see chapter 6.2.8 Torque precontrol).

i

- 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.

4.3.6.3 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)

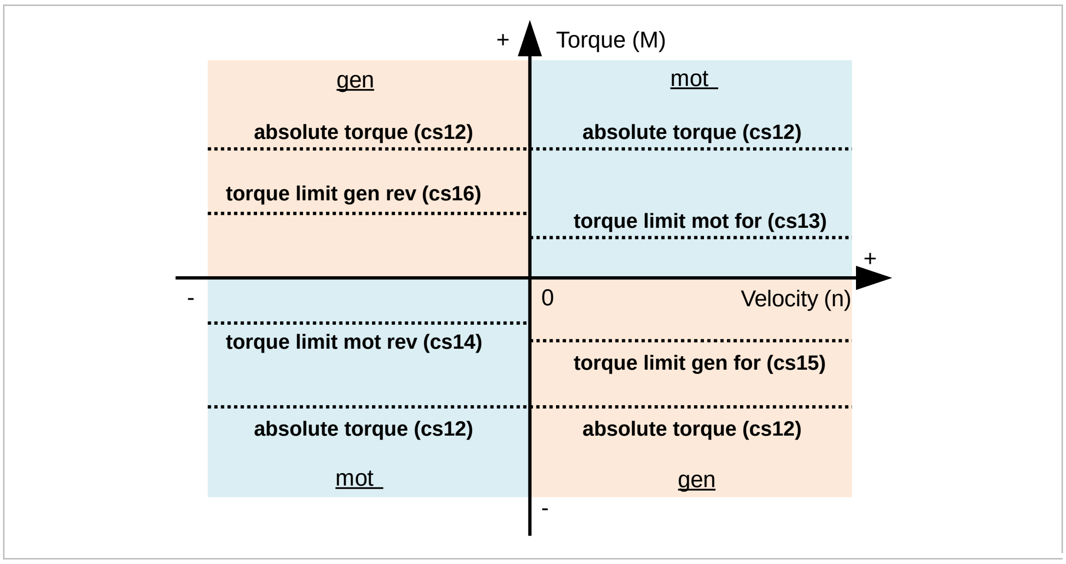


Figure 37: Torque limits in all quadrants

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.

4.3.6.4 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.

4.3.6.4.1 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.

4.3.6.4.2 Initialization of the interpolator with setpoints

Especially for operating mode switchover to 8: cyclic sync position mode during operation, it is more favorable if the initialisation of the interpolator occurs 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.

4.4 Synchronisation

The communication between Main Control Unit (MCU) and Drive Control Unit (DCU) supports the synchronous (cyclic synchronous) operating modes.

This means, each inverter has a PLL which automatically synchronizes with the fieldbus master.

A valid measured value (fb19) is set in fb10 after power-on and the PLL sets the drive in syncronous to the master signal of the MCU.

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).

It can be assumed that all inverters can be operated synchronously about +/- 100ns.

Alternatively the function of fb10 is also possible via the object 0x60C4 Interpolation time period.

Index	Id-Text	Name	Function
0x2B0A	fb10	sync interval	Value of the synchronization interval in [µs]. The synchronous operation is switched off at value 0.
0x2B0B	fb11	set sync level	Definition of the level for the synchronous bit
0x2B0C	fb12	KP sync PLLI	kp for the internal pll
0x2B14	fb18	sync PLL offset	Offset of the synchronization point of the DCU to the master signal (MCU) in µs
0x2B13	fb19	measured sync interval	Measured value of actual syncs

The default values for fb11 and fb12 are optimized for interlink. The internal behavior of the PLL can be adjusted 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 values of fb11 and fb12 have only an effect when fb10 is written again.

⚠ WARNING

Important note about fb18!
The KEB product T6 APD is subject to the requirements of the UNECE Regulation No.10 Electromagnetic compatibility. APPLICATION SOFTWARE must not lead to any impairment of the EMC behaviour of the KEB product T6 APD

- Particularly the synchronous switching offset of the inverter modules (KEB MCU software function PLL_Offset / DCU parameter fb18 sync PLL offset) must not be changed or deleted.
- **Non-compliance with this requirement will result in withdrawal of the type-approval (E1).**

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 (see chapter 4.2.1 Error)</td></tr>
<tr><td>0x2C02</td><td>ru02</td><td>warning bits</td><td>Display of the warnings bit-coded</td><td rowspan="2">(see chapter 4.2.2 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>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 (from motor model) for speed controller</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>0x2C13</td><td>ru19</td><td>internal output state</td><td colspan="2">State of the internal digital outputs</td></tr>
<tr><td>0x2C14</td><td>ru20</td><td>dig. output state</td><td colspan="2">State of the outputs (at the end of the processing block)</td></tr>
<tr><td>0x2C15</td><td>ru21</td><td>dig. output flags</td><td colspan="2">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>0x2C19</td><td>ru25</td><td>heatsink temperature</td><td colspan="2">Heatsink temperature</td></tr>
<tr><td>0x2C1A</td><td>ru26</td><td>internal temperature PU</td><td colspan="2">Internal temperature power unit</td></tr>
<tr><td>0x2C1B</td><td>ru27</td><td>OL2 counter</td><td colspan="2">Short-term overload level</td></tr>
</table>

<table>
<tr><th>Index</th><th>Id-Text</th><th>Name</th><th colspan="2">Function</th></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>0x2C20</td><td>ru32</td><td>motor prot. counter</td><td colspan="2">Level of the electronic motor protection relay</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>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">(see 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>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
(see chapter 0

Virtual 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>0x2C50</td><td>ru80</td><td>relative torque</td><td colspan="2">Current torque referred to a limit value
(Description => 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
		diff. speed [1]	Difference between speed setpoint (ru84) and actual speed value (ru08)
		diff. speed [2]	Difference between unsmoothed ramp output value and actual speed value (ru08)
		diff. speed [3]	Difference of smoothed ramp output value (smoothing according to cs19) and actual speed value (ru08)
0x2C54	ru84	ref. value display	preset setpoint speed (in each operating mode)

5.2 Speed displays

Set value displays:

Index	Id-Text	Name	Function	Resolution
0x2C05	ru05	set value display	Set value display before ramp generator in status 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

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: - estimated speed at ASCL / SCL - ramp output speed at v/f control	1/8192 rpm
0x2120	st32	velocity actual value	Current actual speed as ru08 normalized by the velocity shift factor co02	defined by co02

5.3 Position displays

Index	Id-Text	Name	Function
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
0x2C0E	ru14	act. Uic voltage	Voltage in DC link [0.1V]
0x2C0F	ru15	peak Uic voltage	Peak value of the DC voltage deleted by power on or overwriting with 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 deleted by power on or overwriting with value 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%
0x2C18	ru24	actual torque	Actual torque (COMBIVIS display in %)	
0x2122	st34	torque actual value	Actual torque (COMBIVIS display unnormalized)	
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%
0x2C1A	ru35	act torque lim mot rev		
0x2C24	ru36	act torque lim gen for		
0x2C25	ru37	act torque lim gen rev		
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		

Index	Id-Text	Name	Function	Resolution
0x2C50	ru80	relative torque	ru80 indicates the machine utilization regarding the torque: 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) **NOTICE** **The display is only valid in closed-loop operation in the state „*operation enabled*" !** **In open-loop operation or other states any values can be displayed.**	0,1%
0x2C51	ru81	act torque	Actual torque (identical ru24) in Nm	0.001 Nm

5.7 Power displays

Index	ID-Text	Subidx	Name	Function	Resolution
0x2C52	ru82	1	mechanical power [1]	Shaft power output	0.001 kW
		2	electrical output power [2]	Active power absorbed by the motor	
		3	electrical power loss [3]	Power losses = emitted active power by the inverter - emitted shaft power	
		4	out. energy mot.[4]	Motor-integrated "electrical output power[2]", energy	0.1 kWh
		5	out. energy mot. volatile[5]	The motor integrated "electrical output power[2]", energy (volatile, ZERO again after power on)	0.001 kWh
		6	out. energy gen.[6]	The generator-integrated "electrical output power[2]", energy	0.1 kWh
		7	out. energy gen. volatile[7]	The generator-integrated "electrical output power[2]", energy (volatile, ZERO again after power on)	0.001 kWh

NOTICE

➢ The display is only valid in closed-loop operation in the state „*operation enabled*"! In open-loop operation or other states any values can be displayed.

The power display can be filtered via „display power PT1" is34.

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…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	Val-ue	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. See ru01	
1	1	2	E.uic	The DC link in the power unit has not been charged. The voltage is below the UP level.	
2	1	4	E.STO	At least one STO input is not available. See 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 dispaly
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		

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 4.2.1 Error.	
	3		ERROR overcurrent PU		
	4		ERROR overcurrent analog		
	…		…		

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	

5.8.2 **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.

ru75	global 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…4	0	1	RFM	Modulation release can be made directly with setting the enable modulation bit in the control word.	
0	1	1	MON	Modulation is active	
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.	
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	
	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	Val-ue	Mult.	Plaintext	Notes	
12…14	0	4096	v/f	Voltage/frequency characteristic	
	1		rsvd	0x2C14	
	2		rsvd		
	3		Model	Operation without encoder with motor model (SCL / ASCL)	
	4…7			0x2C14	

5.8.2.5 State ramp generator (3 Bit)

ru76	drive state			Bit 15…17	ramp state
Bit	Val-ue	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			0x2C14	

5.8.2.6 Others (3 Bit)

ru76	drive state			Bit 18…20	others
Bit	Val-ue	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		rsvd	0x2C14	
	6		fault reaction	Fault reaction ramp is active	
	5, 7			0x2C14	

5.8.2.7 Example

If the drive is in the following state:

ru76	drive state			
State	Bit group	Val-ue	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	3 2	4096	Operation without encoder (SCL)
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 + 3 * 4096 + 3 * 32768 + 0 * 262144 = 111169dez. = 0001B241hex.

Display:

MON + VL + SM + Model / SCL + 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.

5.9 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 4.2.1 Error)	
0x2C02	ru02	warning bits	Display of the warnings bit-coded	(=> Chapter 4.2.2 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 deactivated)
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	0.1 [A]
0x2C0E	DC link voltage	ru14	0.1 [V]
0x2C09	no	rsvd	
0x2C19	Temperature	ru25	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 parameters 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 error, de29 inverter maximum current).

The actual limit can be changed by parameter settings.

Index	Id-Text	Name	Function
0x2000	de00	device serial number	Serial number of the inverter
0x2002	de02	device production info	only for internal use
0x2004	de04	AB number	
0x2006	de06	customer number	
0x2008	de08	device configuration ID	Configurations ID (number of the parameter description for COMBIVIS)
0x200C	de12	ctrl serial numer	Serial number of the control card
0x200D	de13	ctrl hw type	Control card type
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
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
0x202C	de44	KTY software version	Motor temperature measuring software version
0x202D	de45	KTY software date	Motor temperature measuring software date

5.11.1 Product code

The product code identifies the inverter in the bus so that the control can recognize the device type.

Range 0x00900000 to 0x0090FFFF is reserved for unit type T6.

	product code	0x1018[2]
Value	Device type	
0x00900000	T6 DCU	

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
0...5	Hw version	0	0	PCB version A
		1	1	PCB version B
		2...63	2...63	reserved

The device type can be distinguished within a unit series with de15.

de15	ctrl type			0x200F
Bit	Function	Value	Plaintext	Notes
0...3	software type	0	Drive Unit	Determination of the software type (axis module, DCU)
		1...15	reserved	
4...7	reserved			

The software version of the single modules can be read with de16 / de44. The display is a hexadecimal value.

de16	ctrl software version		0x2010
de44	KTY software version		0x202C
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)

Major version: 2

Minor version: 1 standard version datecode: 12dec (=0C hex)

The software date can be read with de17 / de45:

de17	ctrl software date		0x2011
de45	KTY software date		0x202D
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 with dots.

de26	saved inverter data ID		0x201A
de27	inverter data ID		0x201B
Bit	Function	Value	Notes
0…7	Power unit code	0…255	Identification number of different power units within one unit size class
8…15	Version number		Version number of the power unit data
16…23	Housing identification		
24…31	Unit size		Identification for inverter rated power (see operating instructions with technical data)

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 that the inverter changes into 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. 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]	

5.11.4 Serial numbers

de00 device serial number contains the serial number of the T6 DCU module.

6 Motor Control

6.1 Motor parameterization

6.1.1 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.

dr99	motordata control			
Bit	Function	Value	Plaintext	Function
0	motordata control	0	store motordata, init reg.	The new motor data are transferred and initialization of all standardizations
		1	store motordata, no reg.	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)

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 out 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	motordata state	0	fill motordata	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 with parameter 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 described in a separate manual

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 star (Y)	Inverter value = Phase value * 2
Switching type delta (Δ)	Inverter value = 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.

6.1.2 Asynchronous motor

6.1.2.1 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:

$$\text{dr09 rated torque} = \frac{\text{rated power [kW]} * 9550}{\text{rated power } [\frac{}{\text{rpm}}]}$$

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 (see also 6.2.6 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.

6.1.2.2 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.

With the identification steps at standstill the motor can be moved easily by the test signals.

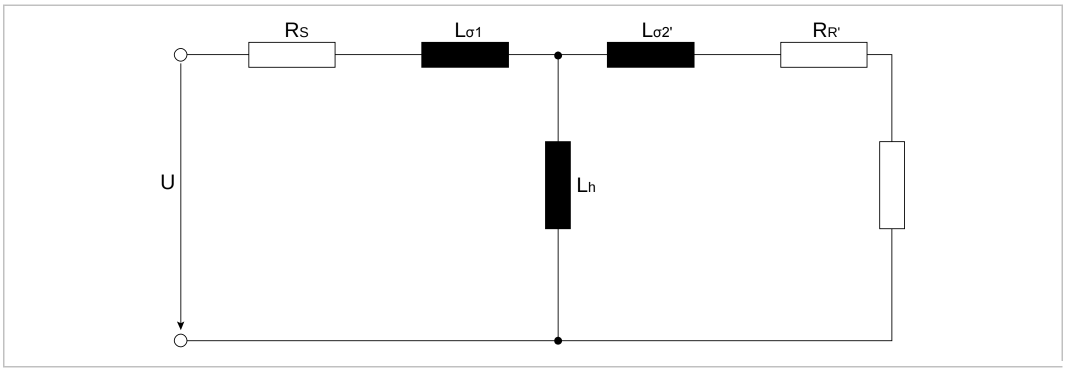


Figure 38: Equivalent circuit diagram motor

6.1.2.3 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 (=> 6.1.4 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 (=> 6.1.8 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 ($\sqrt{2} * U_{mains}$) or the AFE voltage should be entered in this object (see chapter 6.1.8 Field weakening).

dr28	uic reference voltage	0x221C
Value	Note	
200…830V	DC reference voltage in V	

6.1.2.4 Motor protection

Index	Id-Text	Name	Function
0x2221	dr33	motor temp sensor type	0 = KTY 84-130, 1 = PTC, 3 = KTY 83 110, 4 = PT1000
0x2222	dr34	motorprotection curr. %	Rated current for software motor protection funktion in % rated motor current
0x2227	dr39	ASM prot. mode	Cooling type (self or separately cooled)

The overtemperature motor protection is parameterized with this objects (see chapter 4.2.3.5 Overtemperature motor (dOH) and chapter 4.2.3.6 Motor protection switch OH2).

6.1.2.5 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 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 / 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 => motor rated current
- dr04 rated speed / dr06 rated frequency => number of pole pairs
- dr04 rated speed / dr05 rated voltage => rated point (voltage for rated speed)
- dr45 ASM u/f boost => Voltage for frequency = 0Hz
- 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.

The following data are ***additionally*** required for closed-loop operation 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, operating mode „no encoder (SCL/ASCL)“ must be selected in cs00 control mode (cs00 Bit 0…3 = 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.

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 monitored 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 (see description of dr57 in chapter 6.1.16 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 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 the 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).

Ramps

co48…co51 Values for acceleration / deceleration

co52…co59 Values for the jerk in different ramp phases

co60 General parameterization of the ramp generator

Protective 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 (ds28) 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 (see chapter 6.1.8.3.2 Maximum voltage controller).

Deadtime compensation

The dead time compensation should be switched on for operating modes with motor model. If the complete identification has been executed for the drive + motor, is07 deadtime comp mode = 2 „ident“ is the best value.

Switching conditions

The output management (determination of the switching conditions, assignment, filtering, etc.) is carried out in the do parameters.

6.1.3 Synchronous motor

6.1.3.1 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 (=> 6.2.6 Determination of the mass moment of inertia).

6.1.3.2 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.

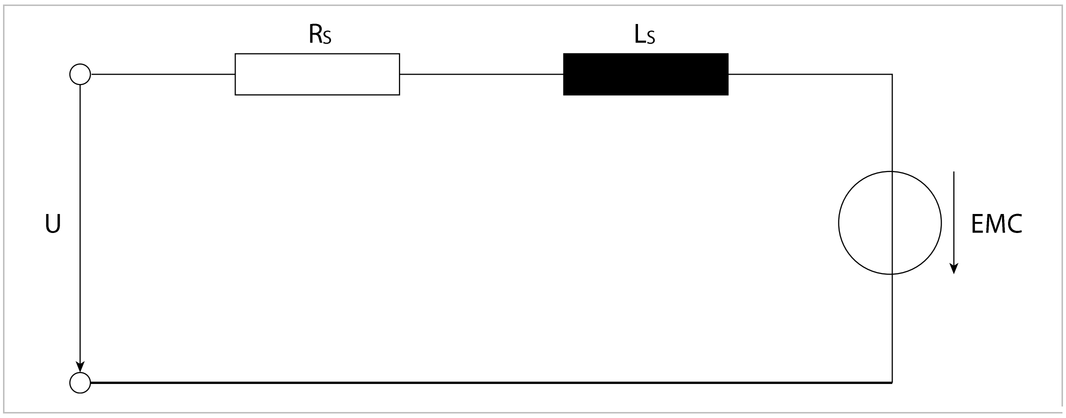


Figure 39: Equivalent circuit diagram synchronous motor

6.1.3.3 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

For a synchronous motor dr08 should always be set to "off" (=> 6.1.4 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 (=> 6.1.11 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) (see Chapter 6.1.8 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 (see 6.1.8.3.2.1 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 (=> 6.1.8.4.2 DC link voltage dependence).

dr28	uic reference voltage	0x221C
Value	Note	
200…830V	DC reference voltage in V	

6.1.3.4 Motor protection

Index	Id-Text	Name	Function
0x2221	dr33	motor temp sensor type	0 = KTY 84-130, 1 = PTC, 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 by dr38).
0x2224	dr36	SM prot. time Imax	Time, after the protection function is triggered at min. current flow (defined by 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 (=> 4.2.3.5 Overtemperature motor (dOH) and chapter 4.2.3.6 Motor protection switch OH2).

6.1.3.5 System offset

6.1.3.6 General

The knowledge of the rotor position is mandatory necessary for the closed-loop operation of a synchronous motor.

System position measurement is started/controlled by dd01 and must be redetermind at each modulation release.

The determination mode of the system offset is adjusted in parameter dd01 SCL rotor detection.

dd01	SCL rotor detection		0x3601
Bit	Function	Value	Function SCL
0…2	mode	0, 6, 7	off
		1	reserved
		2	reserved
		3	cvv only (SCL)
		4	five step
		5	hf detection
3	start after process	0	No
		8	yes
4…5	cvv finished	0	hold rotor current
		16	current to zero
		32	to standstill current
		48	reserved

Bit 3 determines after completion of the position identification if it is immediately started with the actual setpoint (standard), 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).

dd01	SCL rotor detection		0x3601
Bit	Function	Value	Function
3	start after process	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 current.

This adjustment is only effective with "start after process = no".

dd01	SCL rotor detection			0x3601
Bit	Function	Value	Function	Note
4…5	cvv finished	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 current	The current of ds38 is output after the end of the threading process (only available at SCL).
		48	reserved	

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.

6.1.3.6.1 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.

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	

6.1.3.6.2 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.

6.1.3.6.3 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, see previous chapter).

The level for the information content of the second test signal when an error shall be triggered 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.

6.1.3.7 Rotor position detection in operation at SCL (hf injection)

Index	Id-Text	Name	Function
0x3615	dd21	hf injection mode	Off/on of the rotor position detection by hf injection
0x3616	dd22	hf inj. frequency	Frequency of the test signal. The switching frequency should be min. 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 therm (ds30).

The stator resistance adaptation is internally deactivated with activation of the HF injection.

6.1.3.8 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 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 / 3 = without encoder, with modell = 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 required for closed-loop operation without encoder:

- dr00 motor type => 1: Synchronous motor
- dr03 rated current => motor rated current
- dr04 rated speed / dr06 rated frequency => number of pole pairs
- 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).
- dr14, dr15, dr16, dr17 => equivalent circuit data

There are 2 possibilities for the parameterization of the equivalent circuit data.

- The equivalent circuit data are taken from one data sheet.
- 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 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.

Prepare system position-identification

The knowledge of the system position is mandatory necessary for the operation of a synchronous motor (also called systemoffset).

When operating without encoder (SCL) the system position measurement is checked by dd01 .

For SCL operation dd01 is set to the correct value after default loading (point 2).

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 (see description of dr57 in chapter 6.1.16).
- Lock the modulation again (co00 = 0).
- dr54 = 0, store 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 characteristic. This value must be increased, if the torque reduction according to a 1/x characteristic starts to early.

Current limits

de29 inverter maximum current — only display / maximum current for the 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).

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. Protection functions can also 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 ds28 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 (see chapter 6.1.8.3.2 Maximum voltage controller).

Dead time compensation

The dead time compensation should be switched on for operating modes with motor model. If the complete identification has been executed for the drive + motor, is07 deadtime comp mode = 2 „ident“ is the best value.

Switching conditions

The output management (determination of the switching conditions, assignment, filtering, etc.) is carried out in the do parameters.

6.1.4 **Magnetizing current**

6.1.4.1 Magnetizing current asynchronous motor

The rated magnetizing current of an asynchronous motor can be calculated via cos(phi) and rated current or directly preset by 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	

6.1.4.1.1 Generation of the magnetizing current (overview)

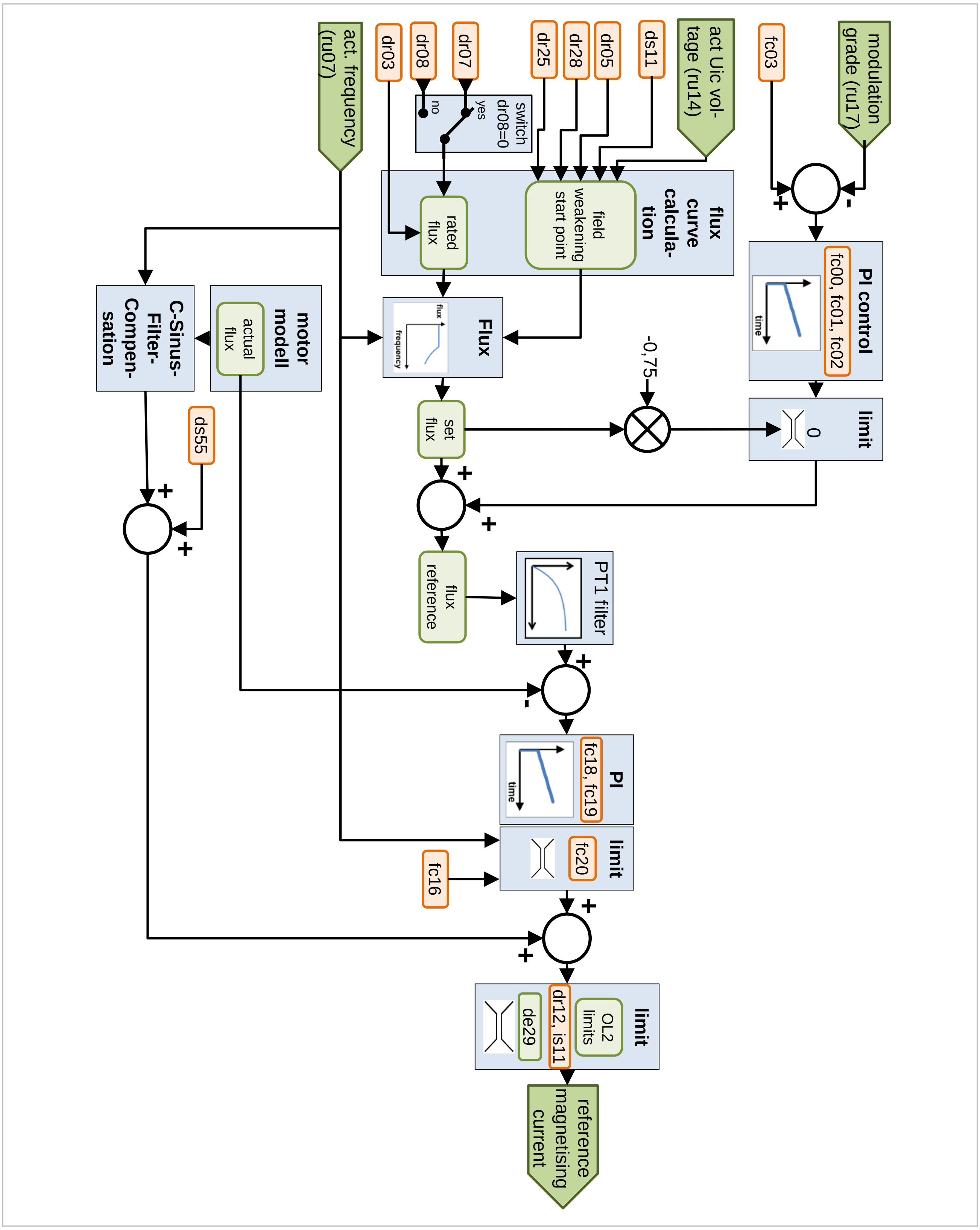


Figure 40: Generation of the magnetizing current

6.1.4.2 d-current cmponent synchronous motor

6.1.4.2.1 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.

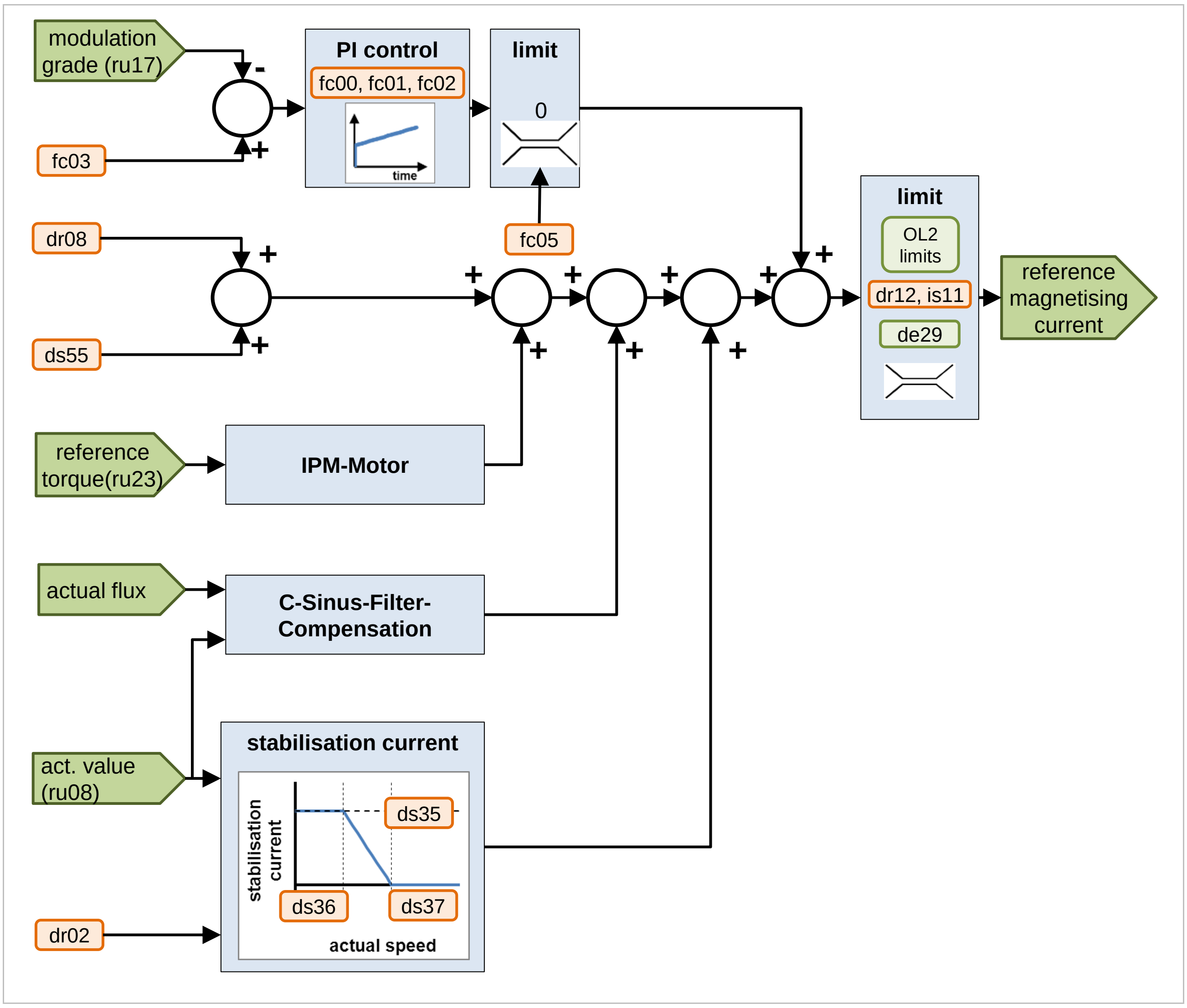


Figure 41: Generation of the d-component

6.1.4.2.2 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 magnetising current is required in the field weakening. This current is automatically given via the maximum voltage controller (=> 6.1.8 Field weakening).

6.1.4.2.3 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 (magnetising current) that amplifies the torque generated by the magnets.

This effect is particularly pronounced at IPM motors.

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.

6.1.5 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 manually adjusted, dr99 motordata control is automatically 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 ds14current control factor.

Index	Id-Text	Name	Function
0x240E	ds14	current ctrl. factor	Percentage factor for proportional and integral gain of both current controller (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 the following 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 Iq-controller are adjusted
		8192	kp	Only proportional gain of Iq controller is adjusted
		12288	reserved	

The saturation characteristic in dr and mo parameters must be parameterized accordingly to activate this function (=> 6.1.11 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	reserved	
		48	auto select (ASM)	The current controller priority is changed depending on the operating point. Initial setting for ASM

6.1.6 Measurement / model currents

6.1.6.1 Control to model currents

At operation with model (cs00 bit 0…3 = 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.

6.1.6.2 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.

6.1.6.3 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.

6.1.6.4 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 de-coupling 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.

.

6.1.7 Maximum current

The maximum permissible or possible current for the motor is limited by several parameters.

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

The maximum permissible current for the motor is entered in dr12 max current %. Exceeding of this current could e.g. demagnetize a synchronous motor or the motor winding can be overloaded.

The current limit defined by the inverter is displayed in de29 inverter maximal current. Additionally an inverter-dependent current limit can be preset in is11 max current [de28 %].

The permissible maximum current can be reduced with is11, if the safety distance between de29 and overcurrent tripping threshold is too small due to very high current ripple.

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 (=> 4.2.3.2 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) (=> 4.2.3.2 Overload power components (OL2)).

6.1.8 Field weakening

6.1.8.1 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 magnetising current (Id), that 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.

$$Rotor\ voltage = \frac{EMC\ Spannungskonstante * actual\ speed}{1000}$$

This voltage must not be higher than the overvoltage threshold, otherwise the inverter will be damaged.

$$Maximum\ speed = \frac{Max..voltage\ * 1000 \quad \text{rpm}}{voltage\ constant\ (dr14)}$$

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

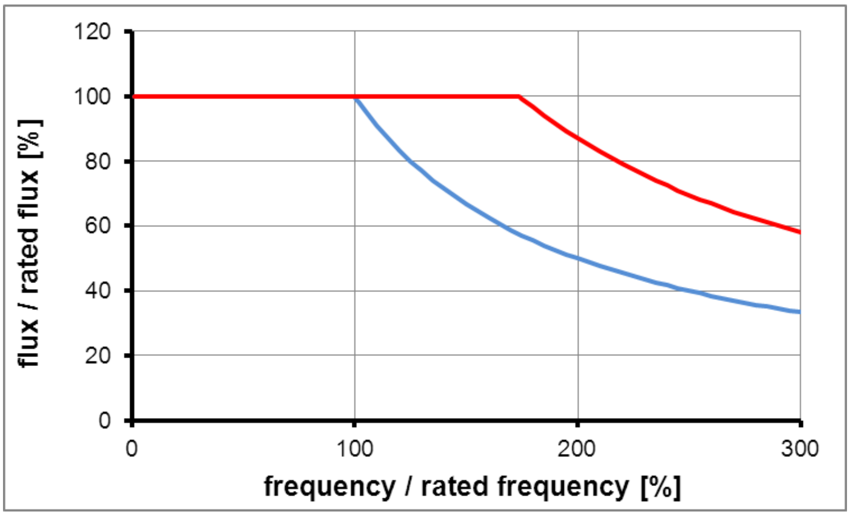
The advantage of higher max. speed is contrary to several disadvantages:

- 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.

6.1.8.2 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 (see field weakening / Limiting characteristic chapter 6.1.8.4).



Parameter	Name	blue characteristic	red characteristic
dr28	Uic reference voltage	565V	565V
dr05	rated voltage	400V	230V
dr25	breakdown speed [%]	100%	100%

Figure 42: Field weakening range asynchronous motor

6.1.8.3 Maximum voltage

6.1.8.3.1 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.

6.1.8.3.2 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

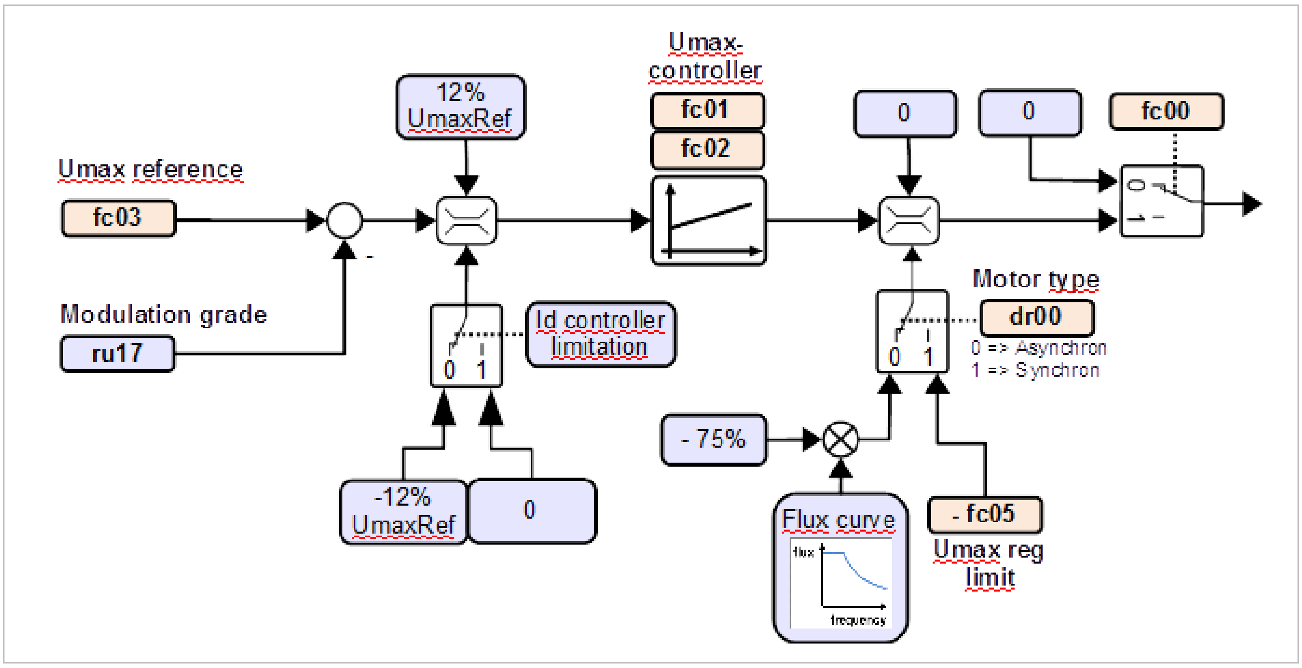


Figure 43: Maximum voltage controller

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.

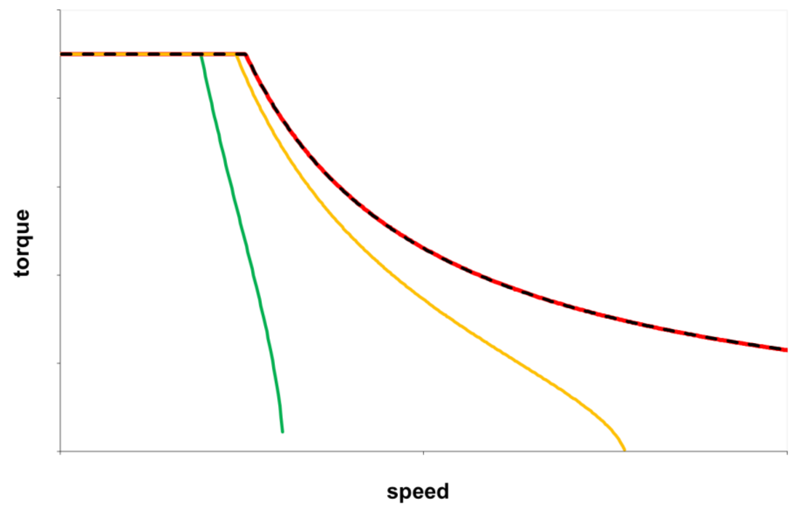
6.1.8.3.2.1 Limit value at synchronous motors

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	green line	without maximum voltage controller, Id=0
2	yellow line	with maximum voltage controller, Id < opt. Id
3	red line	with maximum voltage controller, Id = opt. Id
4	black dashed line	1/x

Figure 44: Limit value at synchronous motors

6.1.8.3.2.2 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%.

6.1.8.4 Limiting characteristic

6.1.8.4.1 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

6.1.8.4.2 DC link voltage dependence

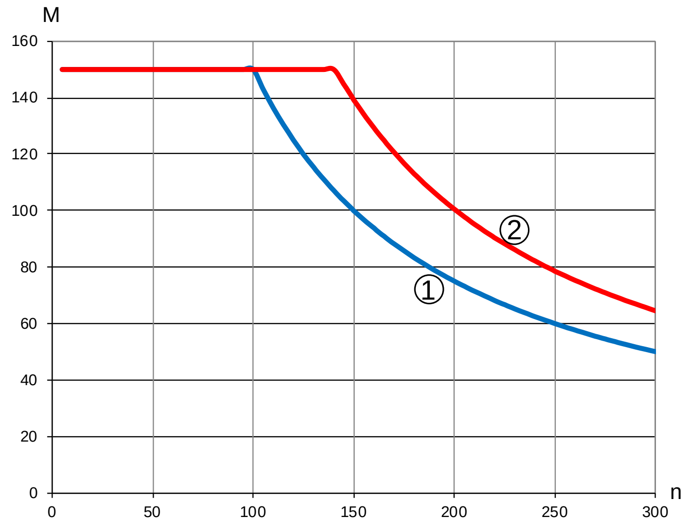
The maximum achievable torque is dependent on the DC link voltage.

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.

For higher DC link voltages the limiting characteristic would shift to higher speed and with lower DC link values 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 45: 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 FaultReaction	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“):

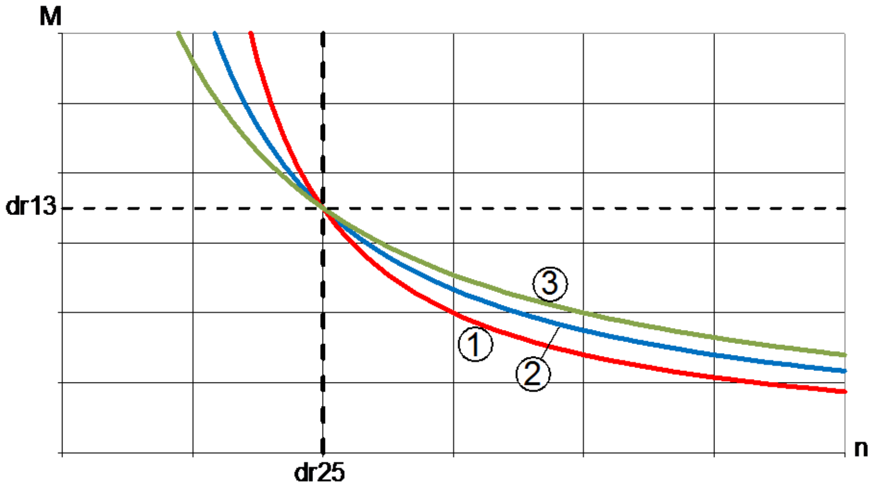
This is the recommended setting. The shifting of the limiting characteristic to lower speeds (left) is executed, physically necessary due to low DC link voltage. A shifting to higher speeds, at higher DC link voltage, does not take place. That means, the characteristic is only shifted if the DC link voltage is lower than dr28 „uic reference voltage".

Bit2-3 = 12 („reduction, on at FaultReaction“):

Behaviour as for value 8 with one exception: In order to reach the maximum torque during the fault reaction ramp, the limiting characteristic is shifted in operating mode "fault reaction active" at higher DC link voltage to higher speeds.

6.1.8.5 Adjustment of the limiting characteristic

Since the $1/x$ or $1/x^2$ run of the limiting characteristic is only approximately, the characteristic can be adjusted by ds13torque limit curve factor.



M	Torque	-
N	Speed	-
1	Limiting characteristic	ds13=150%
2	Limiting characteristic	ds13=100%
3	Limiting characteristic	ds13=75%

Figure 46: Adjustment of the torque limiting characteristic

6.1.8.5.1 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%

$$\text{dr13} = \frac{limit\ torque}{rated\ torque} * 100\% = \frac{breakdown\ torque}{rated\ torque} * 100\% = 200.0\%$$

6.1.8.5.2 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/x²	for ASM		

That means ds11 bit (0,1) must be set to 0. 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

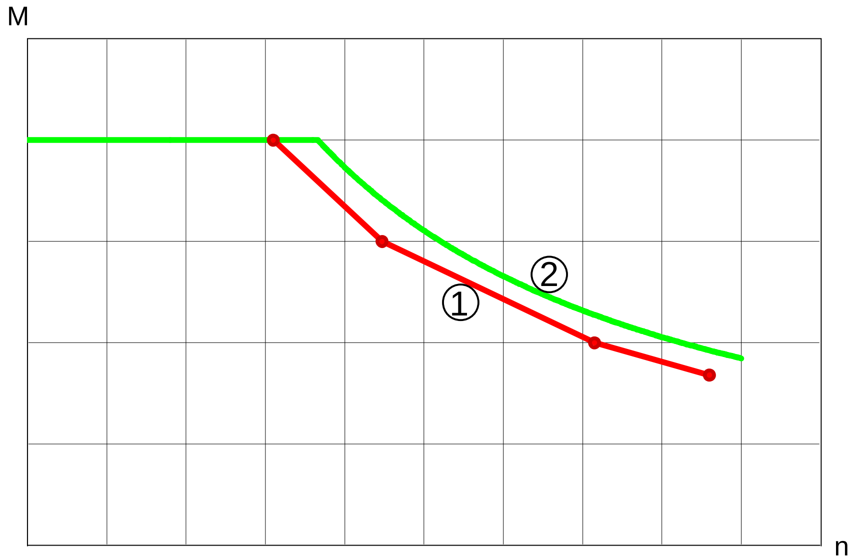
Rated motor values		Reference voltage	
Rated voltage	330 V	Mains / AFE voltage	400 V
Rated frequency	200 Hz	Reference-DC link voltage	565 V
Pole-pair number	6	**Point of the limiting characteristic (e.g. from data sheet) for ref. voltage**	
Rated speed	2000 rpm	Torque of the limiting characteristic	350 Nm
Rated torque	150 Nm	Speed for limit torque	2000 rpm

$$\text{Rated field weakening speed} = \frac{2000\ rpm * 565\ V}{330\ V * \sqrt{2}} = 2421.3\ rpm$$

$$\text{dr25} = \frac{speed\ for\ torque\ limit}{rated\ weakening\ speed} * 100\% = \frac{2000\ rpm}{2421.3\ rpm} * 100\% = 82.6\%$$

$$\text{dr13} = \frac{limit\ torque}{rated\ torque} * 100\% = \frac{350\ N}{\text{m}Nm} * 100\% = 233.3\%$$

If a limiting characteristic is specified for a motor, a safety distance should always be maintained to this characteristic, since all parameters have tolerances and temperature deviations.



M	Torque
N	Speed
1	M (single values measured)
2	M (calculated)

Figure 47: 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:
- $M = \sin(20°) * fc0505 * dr0909 = 0{,}34 * fc0505 * dr0909$
- 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.

6.1.9 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 as long as in status "Start opertion active"
		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)

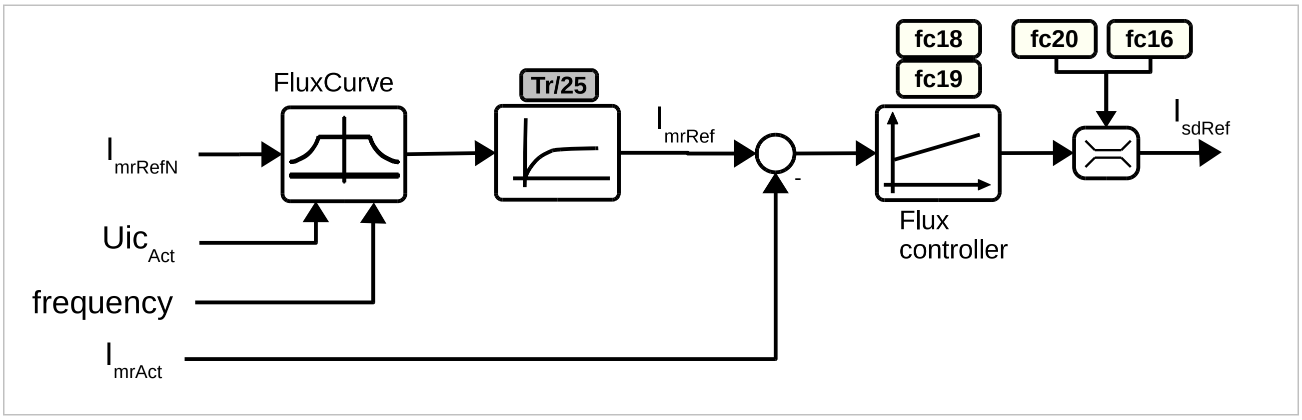


Figure 48: Flux controller (ASM)

6.1.10 **Adaption**

ds12	adaption mode			0x240C
Bit	Function	Value	Plaintext	Notes
0…1	stator resistance	0	off	Stator resistance adaption off
		1	on, no storing	Adaption on, is reset when the modulation is removed
		2	on, storing till power off	Adaption on, is reset by power on
		3	reserved	
2…3	reserved	0		
4…5	reserved	0		

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.

6.1.11 **Saturation characteristic (SM)**

6.1.11.1 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.

This is currently preset by the dr 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.

$$EMF\ (at\ I = Irated) = \frac{dr09}{dr03} * 85.5$$

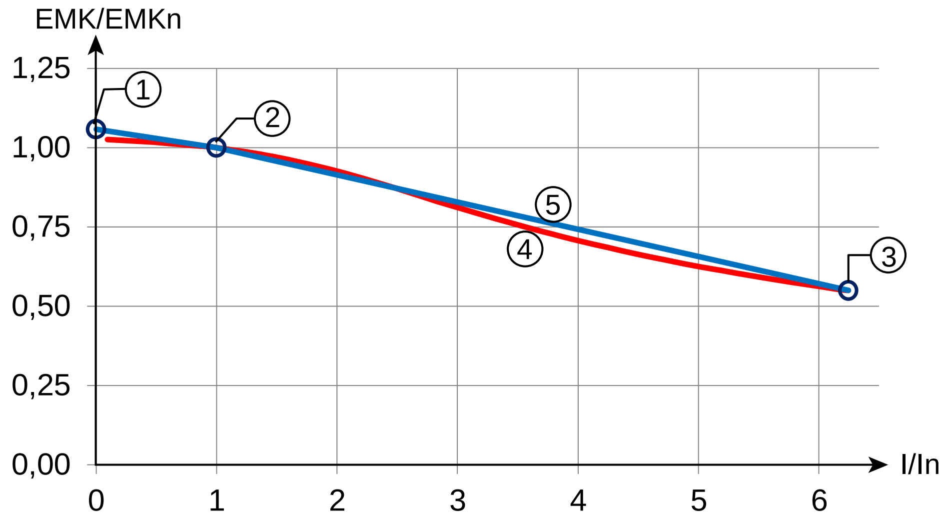
- The EMF at maximum current is calculated from dr12 and dr11.

$$EMF\ (at\ I = Imax) = \frac{dr11 * dr09}{dr12 * dr03} * 85.5$$

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 (=> 6.1.5 Current control) or the torque accuracy shall be improved under load.

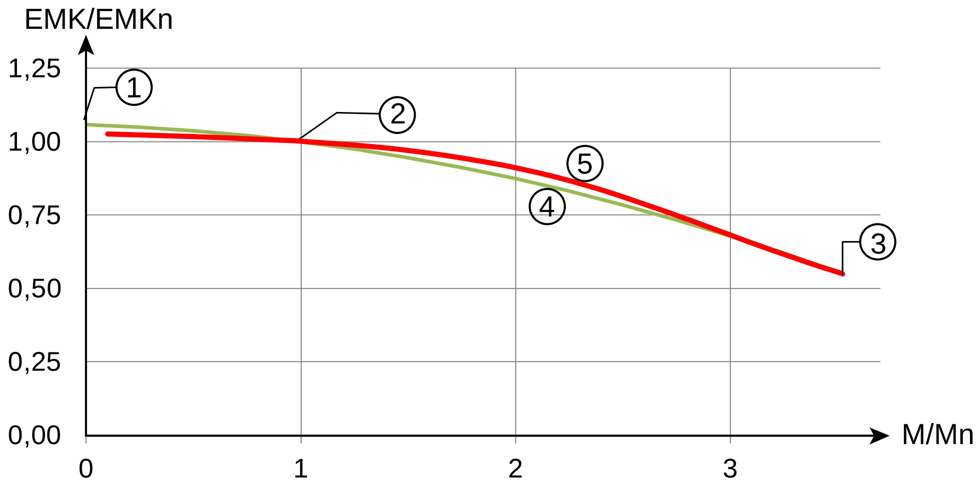
The following figure shows the characteristic of the torque constant or the EMF over the active current of the motor.



1 no-load operation
2 nominal setpoint
3 max. value
4 red characteristic = real characteristic
5 blue characteristic = from data sheet points linear approximated characteristic
I/In motor current / rated current

Figure 49: Torque constant depending on the active current

The inverted saturation characteristic is required to calculate the set current from the set torque. This characteristic is also calculated from the same 3 data sheet values for no-load operation, nominal setpoint and maximum value:



1 no-load operation
2 nominal setpoint
3 max. value
4 green characteristic = from data sheet points inverted approximated characteristic
5 red characteristic = real characteristic
M/Mn torque/rated torque

Figure 50: Torque constant depending on the torque

Since both characteristics are approximations different factors can be used at first (set current from set torque) and return calculation (actual torque from actual current).

Thus the actual torque display is not equal to the set torque display in static, steady state.

Example:

For set torque = 3-fold rated torque the calculated EMF factor is 0.678. Means, the set current is 3/0.678 = 4.42-fold rated current.

For 4.42-fold rated current the factor 0.706 amounts from the picture above on the previous page.

That means: the indicated actual torque is 4.42 * 0.706 = 3.12-fold rated torque. An output set torque of 300.0% leads thereby to an actual value display of 312.0%.

Which of the two values is near to the real torque is depending on approximation characteristic that is near to the real saturation curve and can be different for each range of the characteristic.

In a later version it should be possible to store the saturation characteristic tabularly.

Since these data are rarely supplied by the motor manufacturer, currently the saturation is defined by the values for no-load operation, rated current and maximum current (indicated in the data sheet).

6.1.11.2 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(=> 6.1.5 Current control).

6.1.12 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 results from the interference of the sine waves.

Index	Subidx	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:

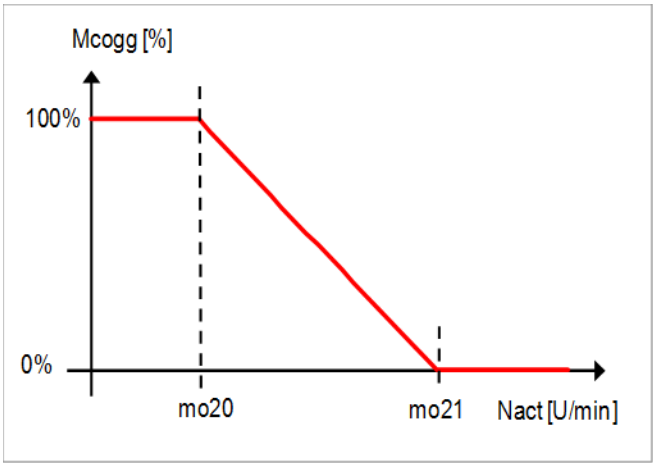


Figure 51: Cogging torque compensation

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%.

6.1.13 Control mode

The control mode is preset with cs00 (without control / control with encoder / encoderless speed control).

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.

cs00	control mode			0x2700
Bit	Function	Value	Plaintext	Notes
0…3	control mode	0	uf-control	Voltage/frequency characteristic
		1	reserved	
		2	reserved	
		3	no encoder (ASCL/SCL)	Operation with encoder with motor model
		4…15	reserved	
4	reserved		reserved	

6.1.13.1 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.

6.1.13.1.1 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.

6.1.13.1.2 0 Hz voltage

The voltage at frequency 0 Hz is defined with dr45 ASM v/f boost.

6.1.13.1.3 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 v/f V1. If the additional point of support shall not be used, dr47 must be set to zero. Then parameter dr46 has no function.

6.1.13.1.4 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 compensation 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	
200V…800V	Maximum output voltage (effective value)	

With is00 Uic mode = „3: on, voltage limited“, the output voltage is limited at is02 voltage limit.

6.1.13.1.5 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.

6.1.13.1.6 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.

6.1.13.1.7 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

6.1.13.1.7.1 Influence of the additional point of support

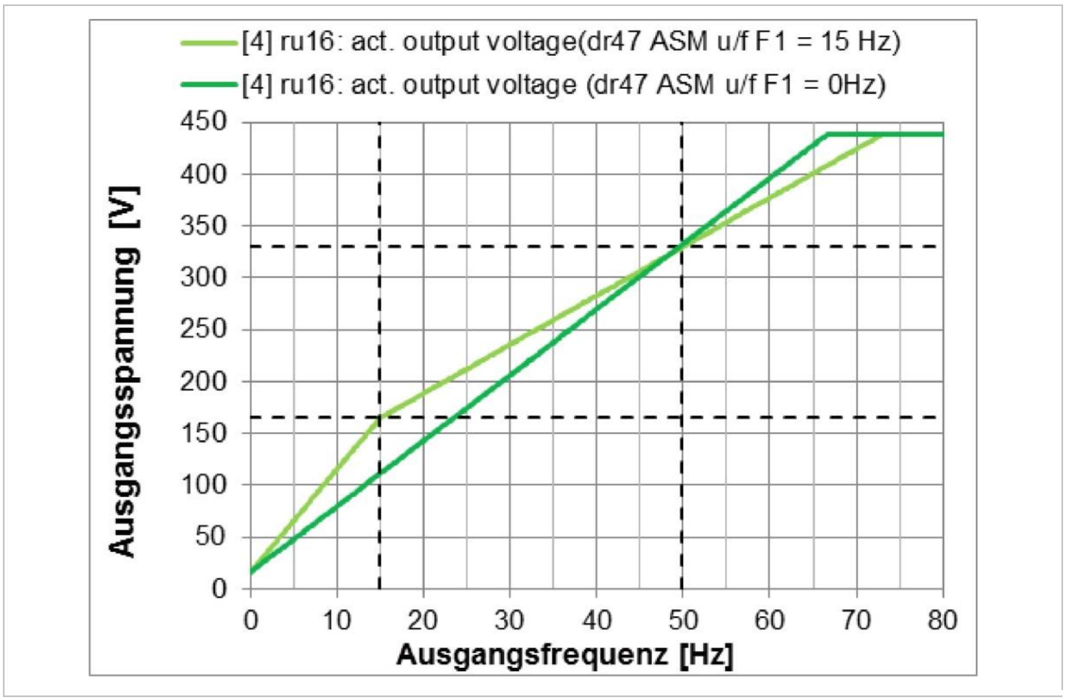


Figure 52: v/f – Influence of the additional point of support

6.1.13.1.7.2 Influence of the DC link voltage compensation

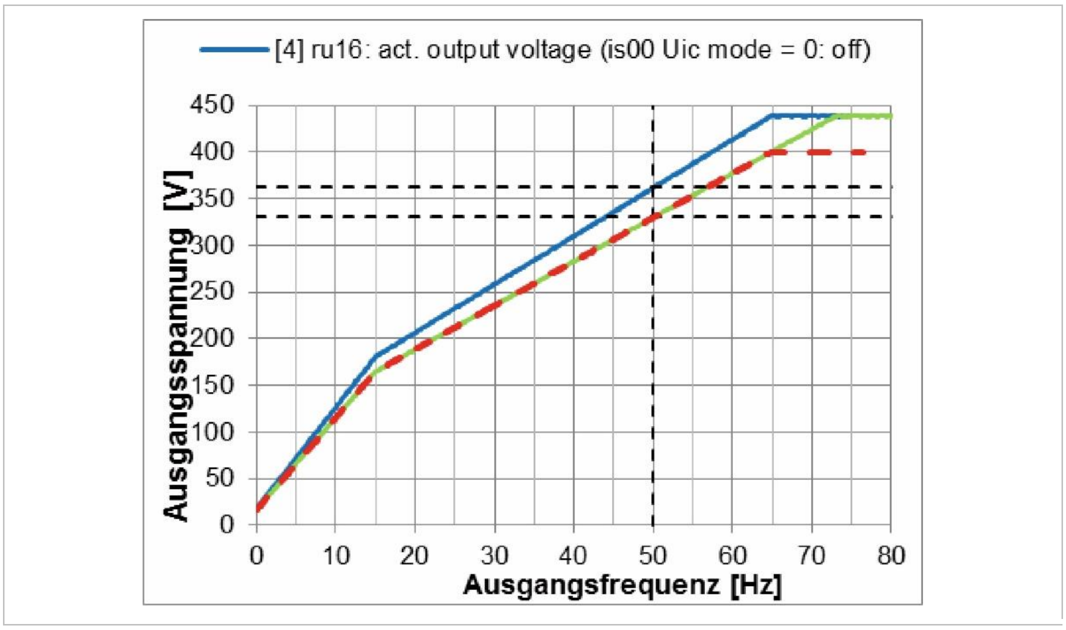


Figure 53: v/f – Influence of the DC link voltage compensation

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

6.1.13.1.7.3 Influence of the maximum degree of modulation

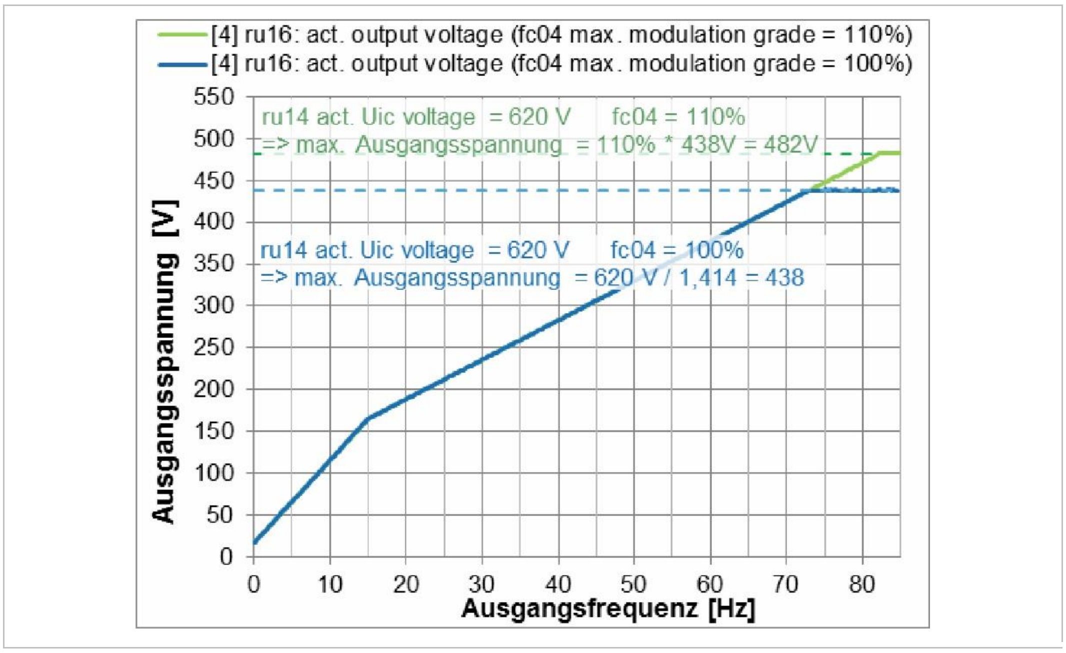


Figure 54: v/f – Influence of the maximum degree of modulation

6.1.13.1.7.4 Influence of dr48 v/f characteristic mode

Boost: dr45 ASM v/f boost = 20%

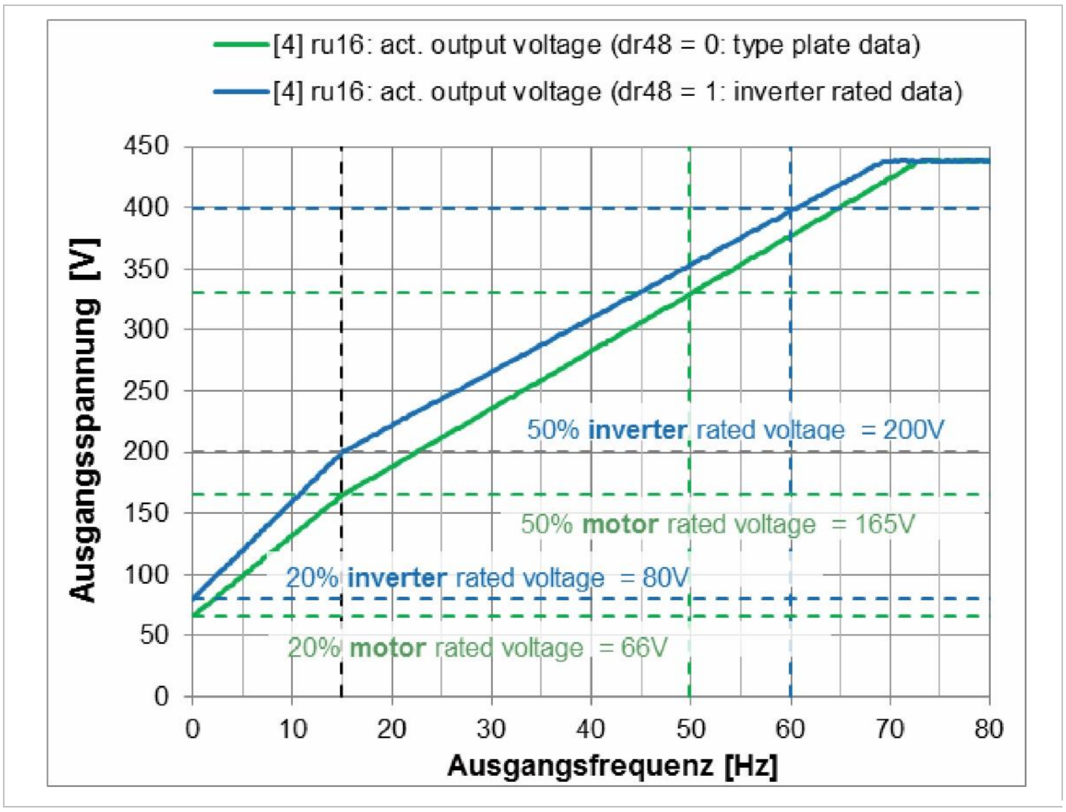


Figure 55: v/f - Influence of dr48 v/f characteristic mode

6.1.13.2 Operation with encoder with motor model

The type of model control is important in this mode (see chapter 6.1.14 Model control (ASM and SM)).

The model cannot be operated stable at small 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 deor the torque accuracy shall be improved under loadpendent on the operating mode and motor.

	cs00 control mode		**Activation**	**ASM**	**SM**
	0 (v/f)	3 (A)SCL			
emf adaption	-	x	ds12 bit 4-5	-	x
Tr adaption	-	-	ds12 bit 4-5	x	-
current offset adaption	-	x	ds12 bit 2-3	x	x
estimated current control	-	x	ds04 bit 7	x	x
stabilisation current	-	x	ds30 bit 0	-	x
stabilisation therm	-	x	ds30 bit 1	-	x
deviation	-	x	ds04 bit 7	x	x
observer	-	x	ds04 bit 6	x	x

6.1.14 Model control (ASM and SM)

In which speed ranges the model should be active or which rule structure serves as a replacement is adjusted with this parameter in operating modes with motor model.

6.1.14.1 Modes for switching the model on/off and setting the model alternative for operation (A)SCL

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…7	reserved	
		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…768	reserved	

Model deactivation level / time

The model deactivation can be adjusted via parameters ds42 to ds47. There are different reference values for parameters ds44 to 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
0x242B	ds43	model ctrl. act. speed time	
0x242C	ds44	model ctrl. ref. speed level	Level of the set speed value for model deactivation (ds44=0%) and hysteresis of the tripping threshold (ds45=20%) in %. Not visible/changeable !
0x242D	ds45	model ctrl. ref. speed hyst.	
0x242E	ds46	model ctrl. act. speed level	Level of the actual speed value for model deactivation (ds46) and hysteresis of the tripping 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 speed

Asynchronous machine: 100% ≙ 2 * rated slip speed

ppz = rotations (60*dr06/dr04), whole-numbered

ns = (dr06 / ppz * 60) - dr04

Example:

Asynchronous machine (rated frequency = 50Hz, rated speed = 1450 rpm, pole-pair number = 2)

with ds46 = 100%, default; ds47= 20%,   default

$ns = \frac{50Hz*60}{ppz} * 2$ = 100 rpm

LowLevel = ns * ds46 = 100 rpm

HystLevel = ns * ds47 = 20 rpm

HighLevel = LowLevel + HystLevel = 100 rpm + 20 rpm = 120 rpm

Model activation/deactivation 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 and for the time in ds43 the **actual value** is below the low level.

With deactivation of the model in encoderless operation ((A)SCL) it is switchted to the model replacement („low speed ctrl“ ds41 Bit 6..7).

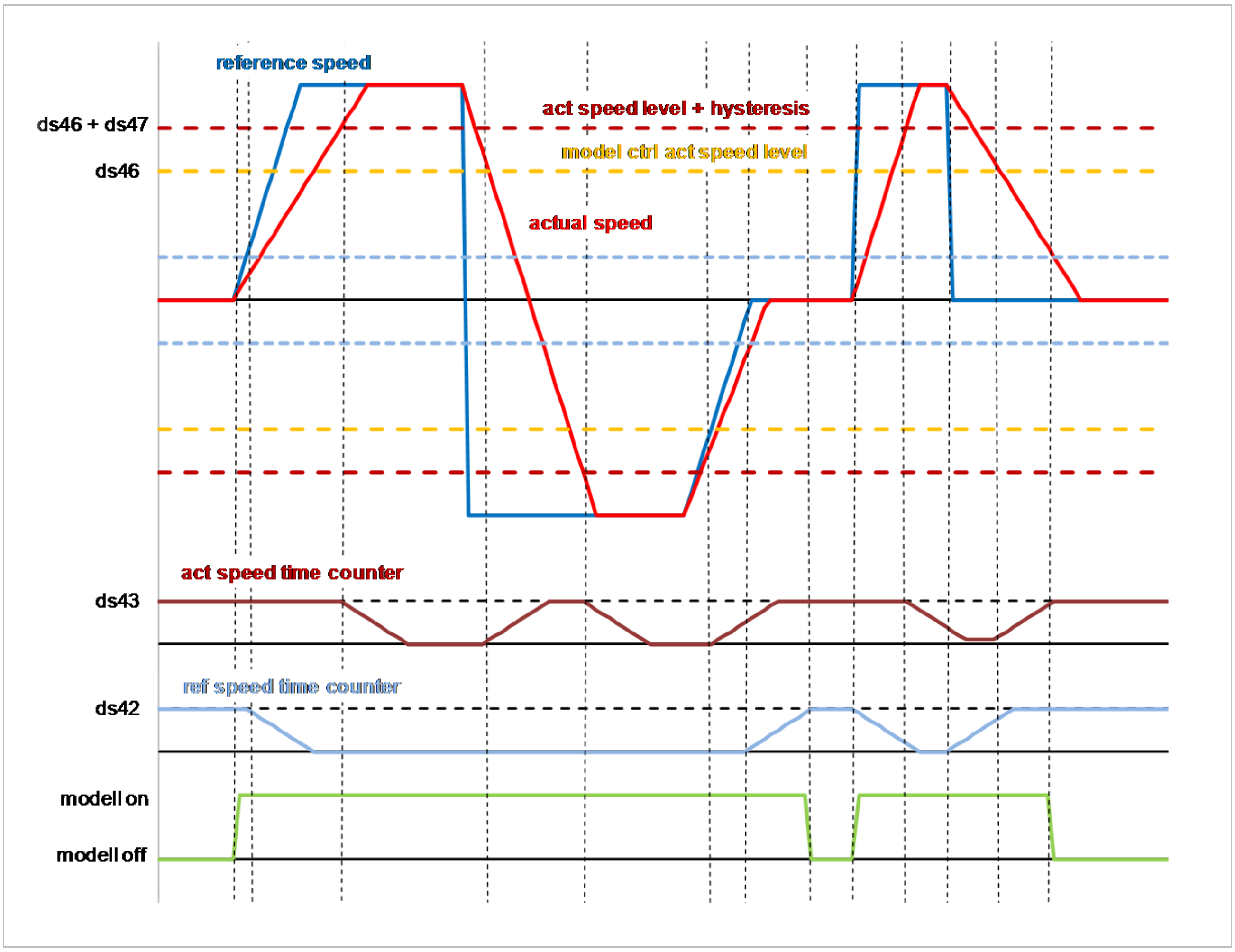


Figure 56: Model deactivation depending on the motor type

Model deactivation (bit0...2) and (bit3...5) = always on:

The model is active after magnetisation and remains, independent of the set / actual speed.

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 HighLevel.

The Model deactivation occurs, if the **actual value** is below the LowLevel**.**

With deactivation of the model in encoderless operation ((A)SCL) it is switchted to the model replacement („low speed ctrl“ ds41 Bit 6..7).

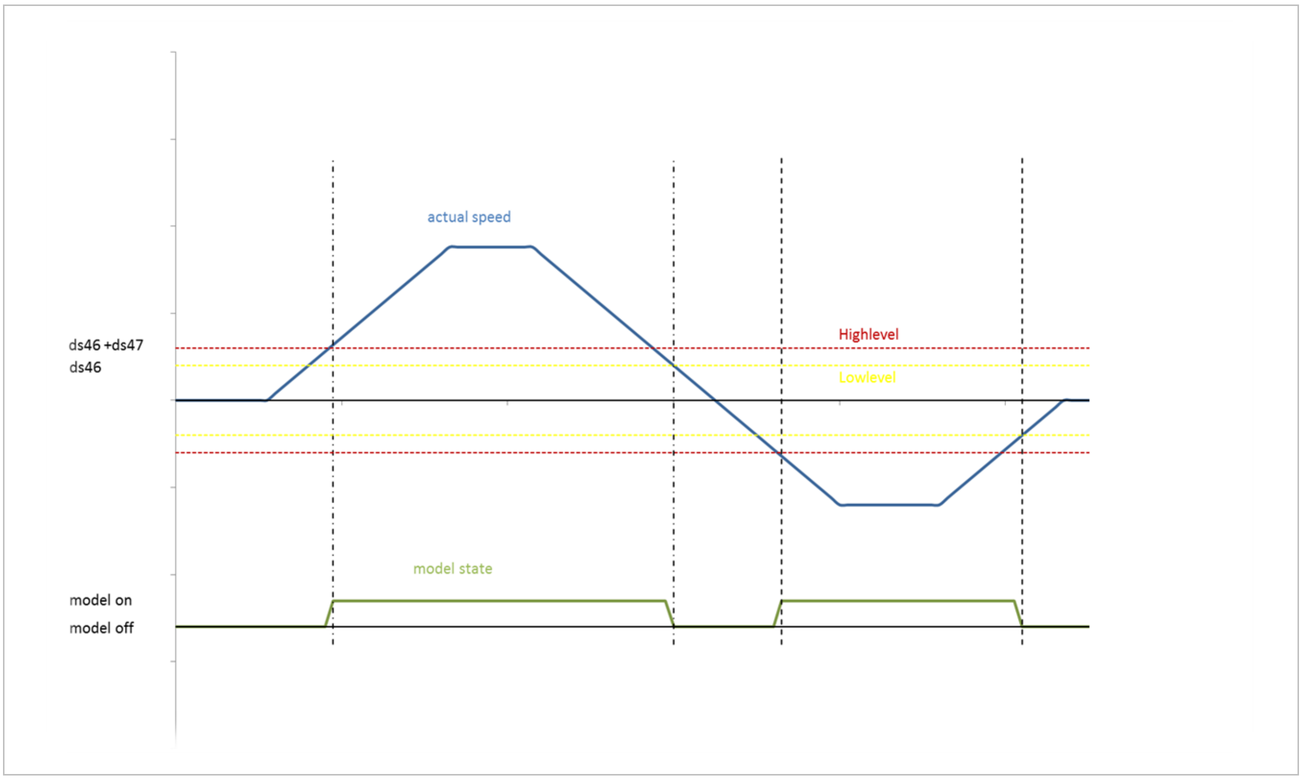


Figure 57: Model deactivation

Model replacement ("low speed ctrl" ds41 (Bit 8…9) = (A)ViCL)

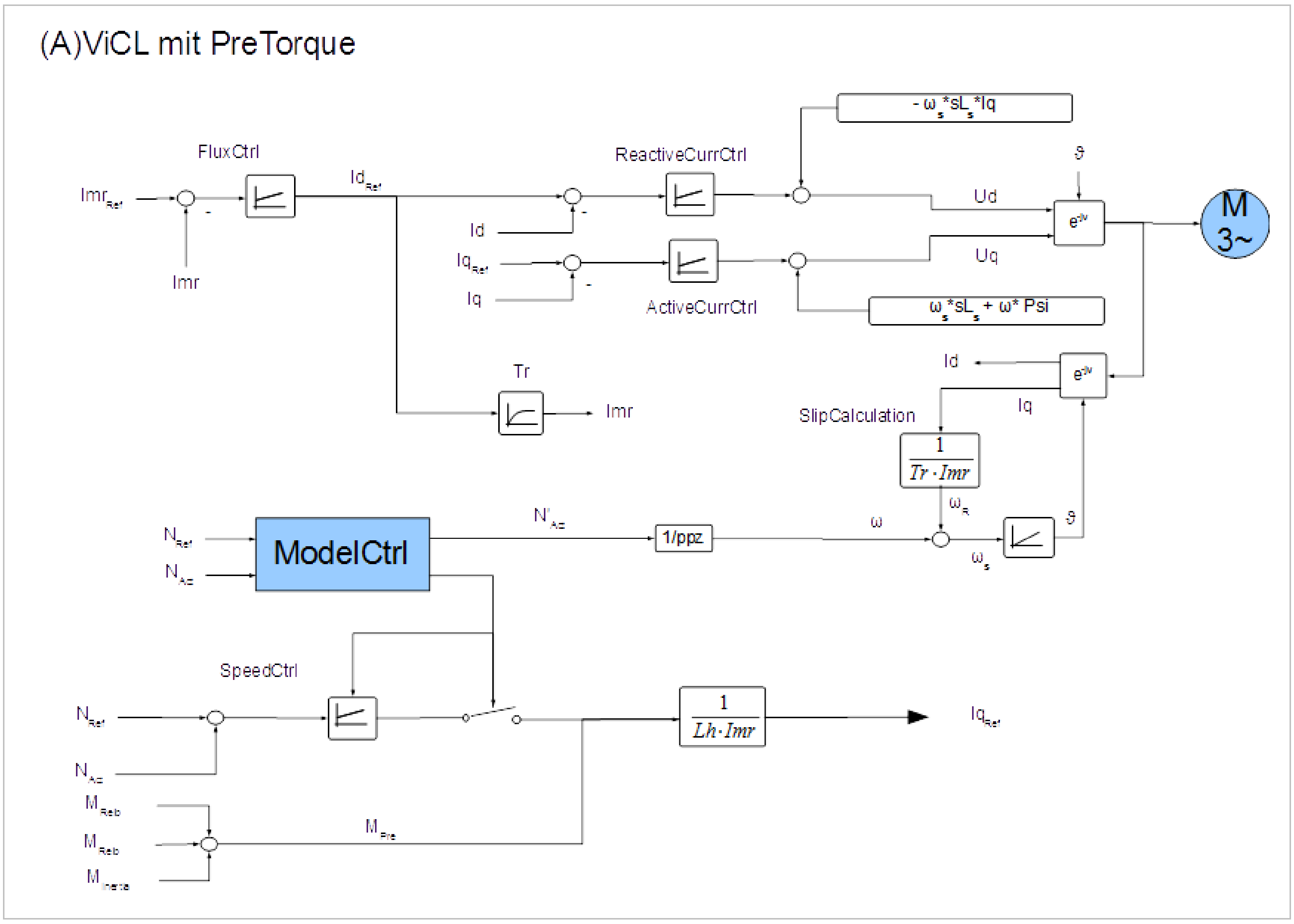


Figure 58: Model replacement Low speed control

Structure figure for the asynchronous machine, the slip calculation and the flux controller are omitted at the synchronous machine. The actual value (N_{Act}) is set with a transition function (=> ds48) to the setpoint (N_{Ref}).

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.

6.1.14.2 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	

- 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.

- 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.

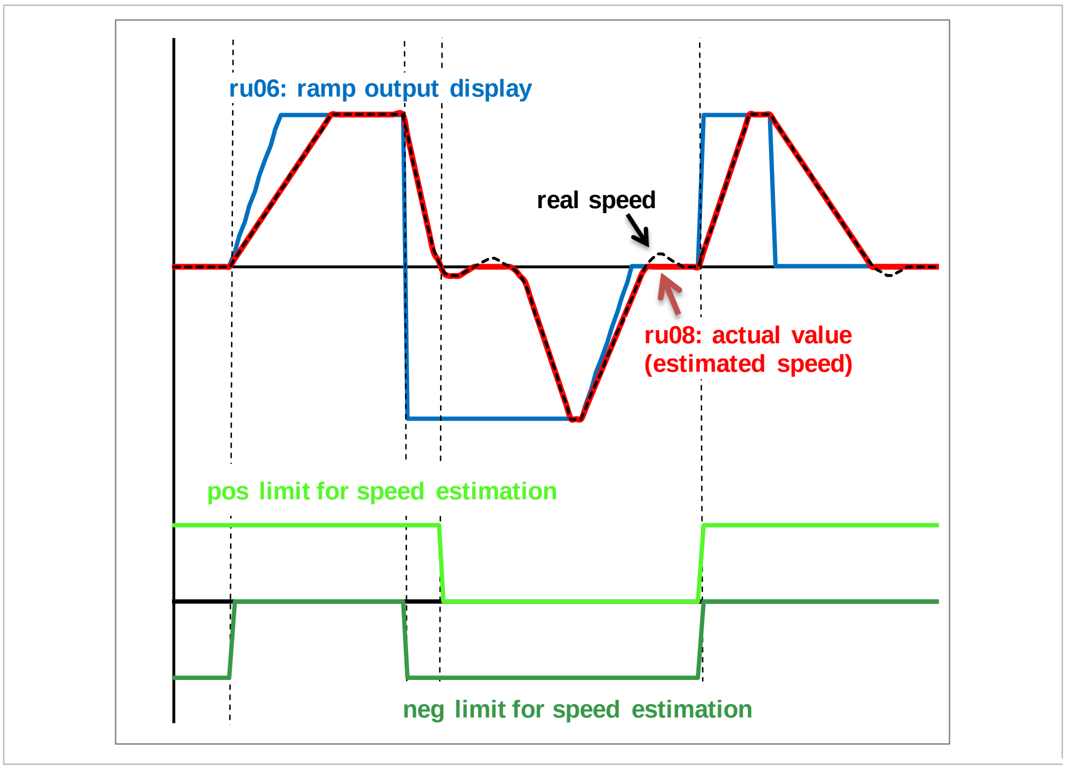


Figure 59: Torque limit depending on the setpoint value

The estimated speed is idealized displayed, in reality there can be more deviations between real and estimated (calculated) speed.

6.1.14.3 Stabilisation current / standstill current (only SCL)

6.1.14.3.1 Stabilisation current

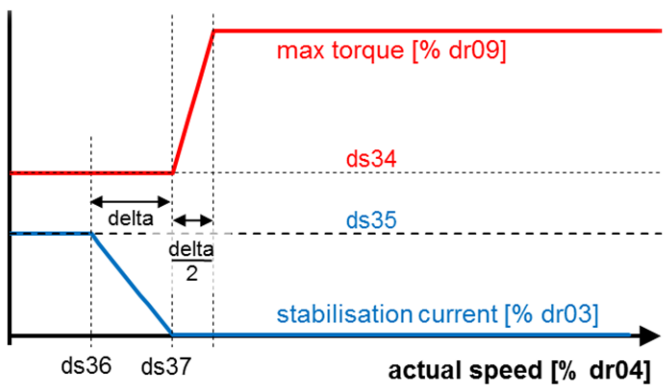
The stabilisation current stabilises the model at lower speeds. Only active for operation without encoder.

It is reduced to zero in the speed range of ds36 to ds37.

ds30	SCL model mode			0x241E
Bit	Function	Value	Plaintext	Notes
0	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
0x2422	ds34	SCL 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).
0x2423	ds35	scl stabilisation current	Stabilisation current in % of the rated motor 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	



ds34 off
ds35 50% rated motor current
ds36 5% rated speed
ds37 10% rated speed

Figure 60: Stabilisation characteristic

6.1.14.3.2 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).

6.1.14.4 Model stabilisation therm

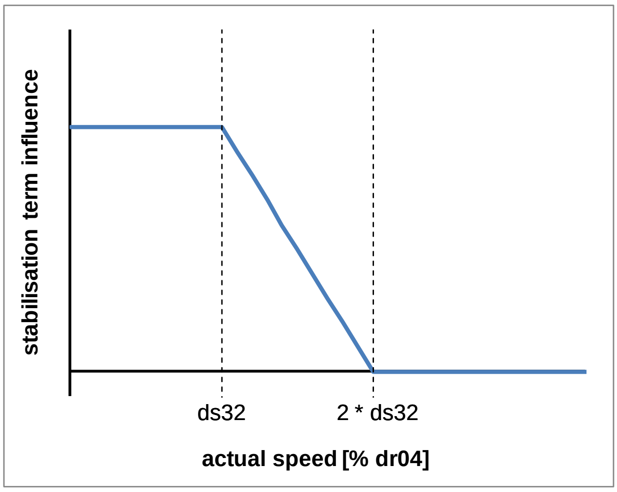
The model stabilisation therm stabilises the model at lower speeds. Only active for operation without encoder.

ds30	SCL model mode			0x241E
Bit	Function	Value	Plaintext	Notes
1	model stab. term	0	off	Activates / deactivates the model stabilisation therm
		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 therm is reduced to 0.
0x2421	ds33	scl stab term time	Time constant of the stabilisation therm !!! do not adjust !!!

The influence of the model stabilisation therm is reduced by ds32 to 2 * ds32 to 0.

The therm time (ds33) is calculated from the motor data and should not be changed.



Default value ds32 20% rated motor speed

Figure 61: Model stabilisation therm depending on motor speed

6.1.14.5 Motor model selection

ds30	SCL model mode			0x241E
Bit	Function	Value	Plaintext	Notes
2	model	0	Highspeed*	Default, required for operation at output frequencies > 400 Hz.
		4	Ld not* equal Lq	Only mandatory for a reluctance machine.

*) Influence on the setting of the optimum current setting in tables mo04,mo05

6.1.15 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 chapter 6.1.13.1 Voltage frequency operation.

is00	Uic mode			0x3500
Bit	Function	Value	Plaintext	Notes
0…2	Uic compen-sation mode	0	off	No DC link voltage compensation
		1	off, only curr, de-coupling	No compensation for the current control, but for the decoupling (see 6.1.6.4 Decoupling)
		2	on	completely compensation
		3	on, voltage limited	Compensation and limitation of the maximum out-put 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 fil-ter. 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	
200V…800V	Maximum output voltage (effective value)	

6.1.16 **Identification**

6.1.16.1 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.

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 dr.15
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 (e.g.) a resistance measurement at operating temperature or a repeated measurement of the head inductance after changing of parameter dr08magnetising 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.

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.
		8	ASM head inductance	Measurement of the head inductance (asynchronous motor)
		9	SM EMF	Measurement of the EMF (synchronous motor)
		10…15	reserved	

The procedure for the inductance measurement of a synchronous motor within a complete identification 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" procedure. The measurement of the stator resistance Rs. Depending on the motor time constant, the optimum procedure for this motor is selected. Time constant < 10ms => using the “amplitude modulation” procedure.

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)	Rotor position identification according to "constant voltage vector", "hf detection" or "five-step" procedure running (see also chapter 6.1.3.5 System offset).
18	rotor detection (hf detection)	
19	rotor detection (five step)	

6.1.16.2 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.

6.1.16.3 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.

6.1.16.4 ASM head inductance dr19

The head inductance dr19 can only be determined if the motor can rotate freely.

The identification is also possible with a load torque, as long as the acceleration to the 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:

$$Rated\ active\ current = Rated\ motor\ current * (1 - (1 - \cos(phi) * 0.64))$$

$$Imr = \sqrt{Rated\ motor\ current^2 - Rated\ active\ current^2}$$

$$Start\ value\ of\ the\ Hauptinduktivität = \frac{Rated\ torque}{(Imr * Rated\ active\ current * Number\ of\ pole\ pairs)} * \left(\frac{2}{3}\right)$$

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).

An incorrectly adjusted speed controller or too slow ramp times for the ramp-up can lead to errors in the identification of the head inductance.

6.1.16.5 EMF identification

The counter voltage EMF (dr14) of the motor can only be determined if the motor can rotate freely.

The identification is also possible with a load torque, as long as the acceleration to the identification speed dr44 is possible with this torque. With identification of the EMF with load, however, the determined EMF can no 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 acceleration in the unidentified state difficult. If the 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 is calculated in the motor data with the selection mode = 1 or 2 in dr54 (after writing on dr99).

Then the EMF is real identified with the adjustment 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 effect when the saturation characteristic mo00saturation mode is activated or source in ds11 torque mode is set to 16 = EMF.

6.1.16.6 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 with 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 maintained 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 500Hz (for asynchronous motors with 125Hz). 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.).

6.1.16.7 Deadtime characteristic

The identification of the deadtime characteristic should be done after identification of the stator resistance, in order that the stator winding has the same temperature and thus the same resistance.

A table is filled by the identification, wherein the compensation values for 4 and 8 kHz are stored (depending on the current).

The measured values can be read out with parameters is05 deadtime index and is06 deadtime coeff.

6.1.16.8 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	Note	
ASM rotor resistance (Rr)	11	Rotor resistance out of range.	
	13	Current limit is reached, no lower frequency possible but phase shifting not within permissible range.	
	14	Voltage limit is reached, not current limit, phase angle not in permissible range, no lower frequency possible.	
SM inductance (Lsd/Lsq)	21	Ld out of range (lower limit).	
	23	Amplitude modulation procedure: Current limit is reached, no lower frequency possible but phase shifting not within permissible range.	
	24	Amplitude modulation procedure: Voltage limit is reached, not current limit, phase angle not in permissible range, no lower frequency possible.	
	28	Lq out of range (upper limit)	
	29	Lq out of range (lower limit)	
	32	five step procedure: Current not reached	
	33	five step procedure: found no voltage, that the current can be reached within specified time limits.	
ASM leakage inductance (sLs)	41	Leakage inductance out of range (upper limit)	
	42	Leakage inductance out of range (lower limit)	
	43	Current limit is reached, no lower frequency possible but phase shifting not within permissible range.	

dr57	ident error info	0x2239
Identification step	Value	Note
	44	Voltage limit is reached, not current limit, phase angle not in permissible range, no lower frequency possible.
ASM main inductance (Lh)	51	Head inductance out of range (upper limit)
	52	Head inductance out of range (lower limit)
	61	Identification speed not reached (oscillation or limitation)
SM counter voltage (Emf)	55	EMF out of range (upper limit)
	56	Ld out of range (lower limit)
	61	Identification speed not reached (oscillation or limitation)
Stator resistance (Rs)	72	Current actual value unequal current set value
	73	Stator resistance out of range (upper limit)
	74	Stator resistance out of range (lower limit)
Dead time compensation	82	Current actual value unequal current set value
Rotor position detection (5-step procedure)	102	Current not reached
	105	Information content too small (dd08 < dd07)
Rotor position detection (Hf detection procedure)	112	Current not reached
	115	Information content is too small (dd08 < dd07 or/and dd10 < dd09)

In most error messages, the most probable cause is a faulty wiring of the motor (check phase connection) or wrong input of the name plate motor data (e.g., wrong rated motor current, wrong rated frequency, or similar).

If the head inductance at the asynchronous machine or the Emf at the synchronous machine is not identified, because the target speed is not reached, this can also be due to slow ramps or bad adjusted speed controller (continuous oscillations, no stable final speed).

The rotor position identification by "five step" or "hf detection" can also be done during identification. However, it is better to perform it before, since the current for the detection of the position can be optimally adjusted then (=> 6.1.3.5System offset).

6.1.17 Dead time compensation

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.

Index	Id-Text	Name	Function
0x3505	is05	deadtime index	Index to read out the deadtime compensation characteristic
0x3506	is06	deadtime coeff	Compensation characteristic values
0x3507	is07	deadtime comp mode	Selection of the compensation mode
0x3508	is08	comp limit fact	Adjustment of the deadtime characteristic (only for tests) Values should always be set to 100%
0x3509	is09	comp current fact	

The compensation type is selected with parameter is07:

is07	deadtime comp mode		0x3507
Value	Name	Meaning	
0	off	No dead time compensation	
1	e-function	Deadtime compensation according to the default-e-function	
2	ident	Deadtime compensation with inverter identified characteristic	
3	reserved		

Mode „e-function“:

In this mode the deadtime compensation is executed with a stored function in the inverter.

Mode „ident“:

In this mode the identification of the deadtime characteristic must be done before via dr54 =1.2 or 5. Then the compensation occurs with the inverter determined characteristic.

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	

6.1.18 Switching frequency

6.1.18.1 Variables Tp

The T6 does not support a variable basic switching frequency.

The value of is22 must always be 0 and must not be changed.

Index	Id-Text	Name	Function
0x3516	is22	basic Tp	Preset the basic switching frequency

The basic switching frequency is preselected with parameter is22.

is22	basic Tp	0x3516
Value	Name	Meaning
0	62.5 us / 16 kHz, 8 kHz	The us 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.
1	reserved ⚠ CAUTION **do not adjust !**	
2		
3		

6.1.18.1.1 Scan times of position, speed and current controller

The following scan times of the control loops result from the control grid:

Basic control grid Tp	Scan times			
	fast irq (controller, motor model)		mid irq	Slow irq
	Current controller, motor model, hf injection	Speed controller, position controller	Communication, digital inputs, analog inputs, state machine, operating modes	Digital outputs, analog output
62.5 µs	62.5 µs	250 µs	500 µs	1000 µs

.

6.1.18.2 Switching frequency adjustment

Index	Id-Text	Name	Function
0x2021	de33	inverter rated switching frequency	Rated switching frequency
0x2022	de34	inverter max switching frequency	Maximum switching frequency (maximum 8 kHz)
0x350A	is10	switching frequency	Selected switching frequency
0x350F	is15	temp dep derating	Activation of temperature-dependent switching frequency reduction
0x3510	is16	min. derating frequency	Lower limit for the current-/ temperature-dependent switching frequency reduction
0x2C48	ru72	act.switch.freq (kHz)	Actual switching frequency

6.1.18.2.1 Set switching frequency

The switching frequency can be selected in parameter is10.

is10	switching frequency	0x350A
Value	Meaning	
0…16.0 kHz	Set – switching frequency in 0.1 kHz resolution (valid values are depending on the setting of is22)	

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 (8 kHz) 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 (see chapter 4.2.3.2 Overload power components (OL2)).

6.1.18.2.2 Current-dependent derating

With the T6 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.

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 min. switching frequency is defined (e.g.) with sinus filt.min.switch.freq. dr53 or limited by the power unit (see installation manual power unit).

If the value of is16 is higher or equal to is10, there is also no "derating".

An increase of the switching frequency occurs if the current is again within the permissible range (limit – hysteresis).

The actual switching frequency of the inverter is displayed in ru72 act.switch.freq (kHz).

6.1.18.2.3 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 T_{DR}
- Temperature for switching frequency increase T_{UR}
- Temperature for change-over to rated switching frequency T_{EM}

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 heatsink temperature) 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 heatsink temperature) 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.

6.1.19 Hardware Current Control (HSR)

Is36	Hardware current ctrl.	0x3524
Value	Plaintext	Meaning
0	0: off	off
1	1:on	on

Is37	HSR Current [de28%]	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 [de28].	

Is38	HSR active counter	0x3526
Value	Meaning	
0… 4294967295	If the HSR is active, this cell is increased by one in the base interrupt.	

6.1.20 **Sinus filter**

6.1.20.1 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).

6.1.20.2 Conditions for the operation of a sinus filter

cs00 control modes				
ASM		SM		
ASCL	v/f	SCL		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)

6.1.20.3 Parameterization

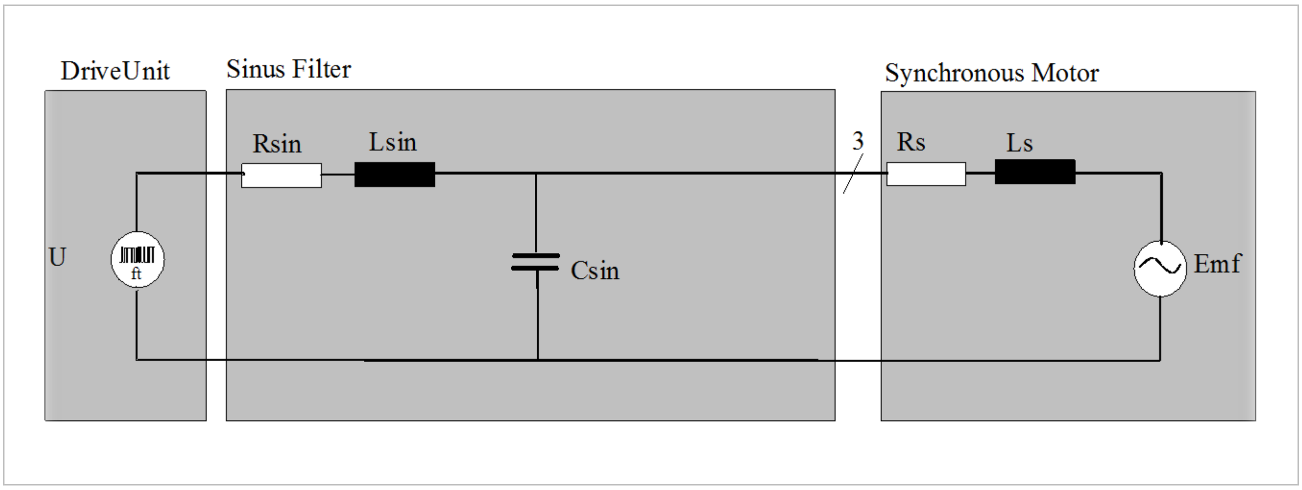
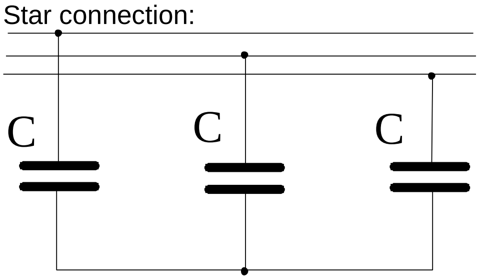
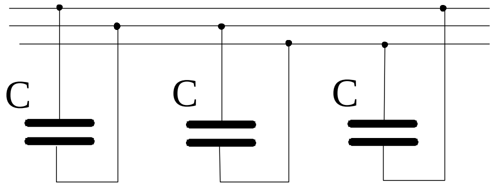


Figure 62: Connection example sine-wave filter

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 phase to phase (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	
0x2234	dr52	sinus filter cap. UV [uF]	Csin / 2	If C is the capacity value in the data sheet for one phase of the filter, Csin can be calculated according to the formulas listed below. The phase-to-phase capacity of the sinus filter must be entered in dr52 (phase-to-phase value UV) = Csin/2. Star connection:  Csin =C Delta connection:  Csin = 3 * C
0x2235	dr53	sinus filter min. switch. freq.		Minimum switching frequency whereby the sinus filter may be operated (typical values are 4kHz, 8kHz). "error norm motordata" 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
Band-pass 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.
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 chracteris-tic.
0x2409	ds09	bp filter coeff index		The default value for ds10 and index0 is the value =131068 (over dr-para). That means the filter parameters of the band-stop filter are calculated from the dr parameters for frequency (dr65) and quality (dr66). Alternatively, the filter coefficients can be preset directly via ds09 and ds10. Thereby the filter can be adjusted with any characteristic.
0x240A	ds10	bp filter coeff		
Band-pass filter activation				
0x2404	ds04	current mode		Activate the bandpass filter in ds04 bit 3 „bandpath filter = on“!

6.1.21 Speed search

With each switching on of the modulation, the drive can carry out an automatic speed search and thus connecting to a running motor. The speed search can be activated in dd16. Internally, the more favourable procedure is selected automatically.

When operating without encoder, the motor speed and the electrical position are determined 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	

The modulation is switched on briefly with zero voltage for speed search. The speed and the 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.

6.1.22 **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 acceleration / 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, 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, ds62[4] max. DC current

6.1.23 **DC braking**

6.1.23.1 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
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

6.1.23.2 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

6.1.23.3 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“

ds62	DC braking mode			0x243E Sub Idx. 1
Bit	Function	Value	Plaintext	Notes
		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.
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

6.1.23.3.1 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

6.1.23.3.2 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	reserved	no hardware inputs available
1	2	reserved	
2	4	reserved	
3	8	reserved	
4	16	reserved	
5	32	reserved	
6	64	reserved	
7	128	reserved	
8	256	IA	Input IA
9	512	IB	Input IB
10	1024	IC	Input IC
11	2048	ID	Input ID
12…15			0x2C14

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].

6.1.23.3.3 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.

6.1.23.3.4 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 can be 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].

6.1.23.3.5 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 for encoderless drives is less than 5% of the rated motor speed, it is evaluated as "0". In this case the mode „Start after switched on“ is executed.

6.1.23.4 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.

6.1.23.4.1 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.

6.1.23.4.1.1 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.

6.1.23.4.1.2 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.

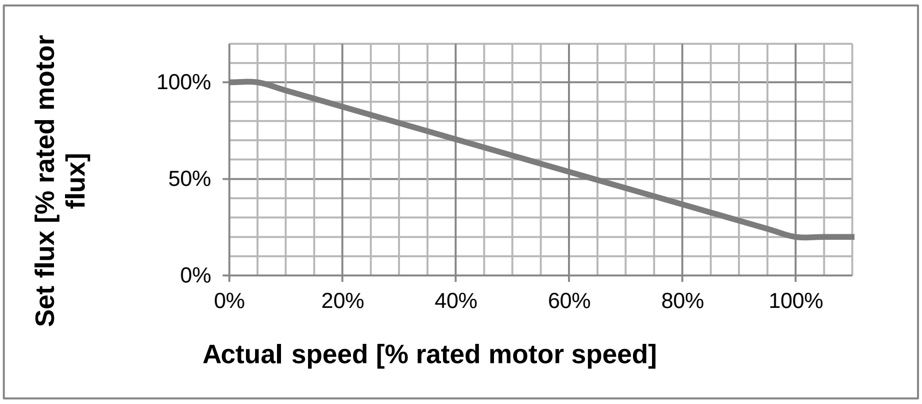


Figure 63: Motor de-excitation time ASCL

6.1.23.4.2 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 in order 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.

6.1.23.5 DC braking procedure

6.1.23.5.1 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.

6.1.23.5.2 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.

6.2 Speed controller

6.2.1 Overview

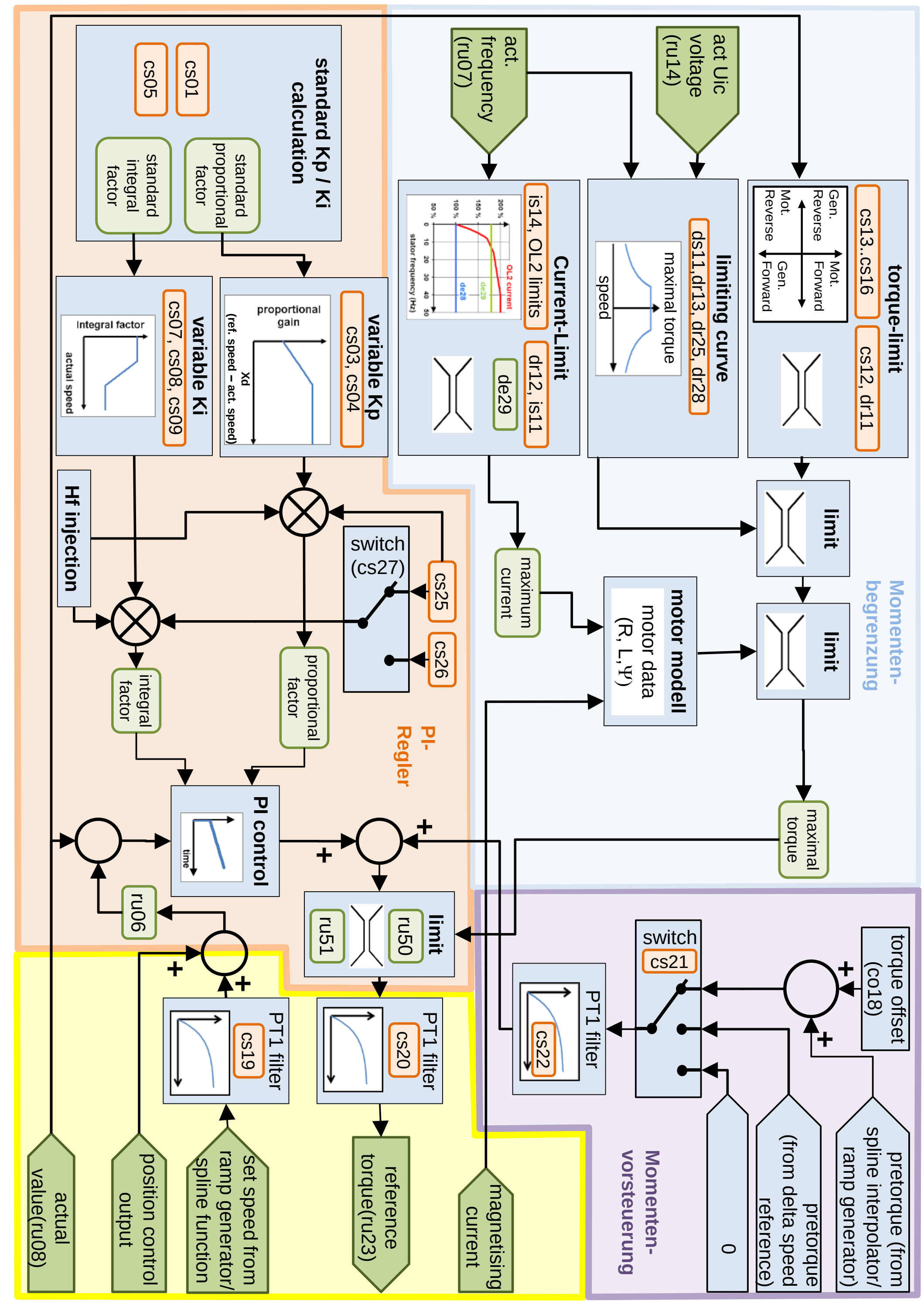


Figure 64: Speed controller overview

6.2.2 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.

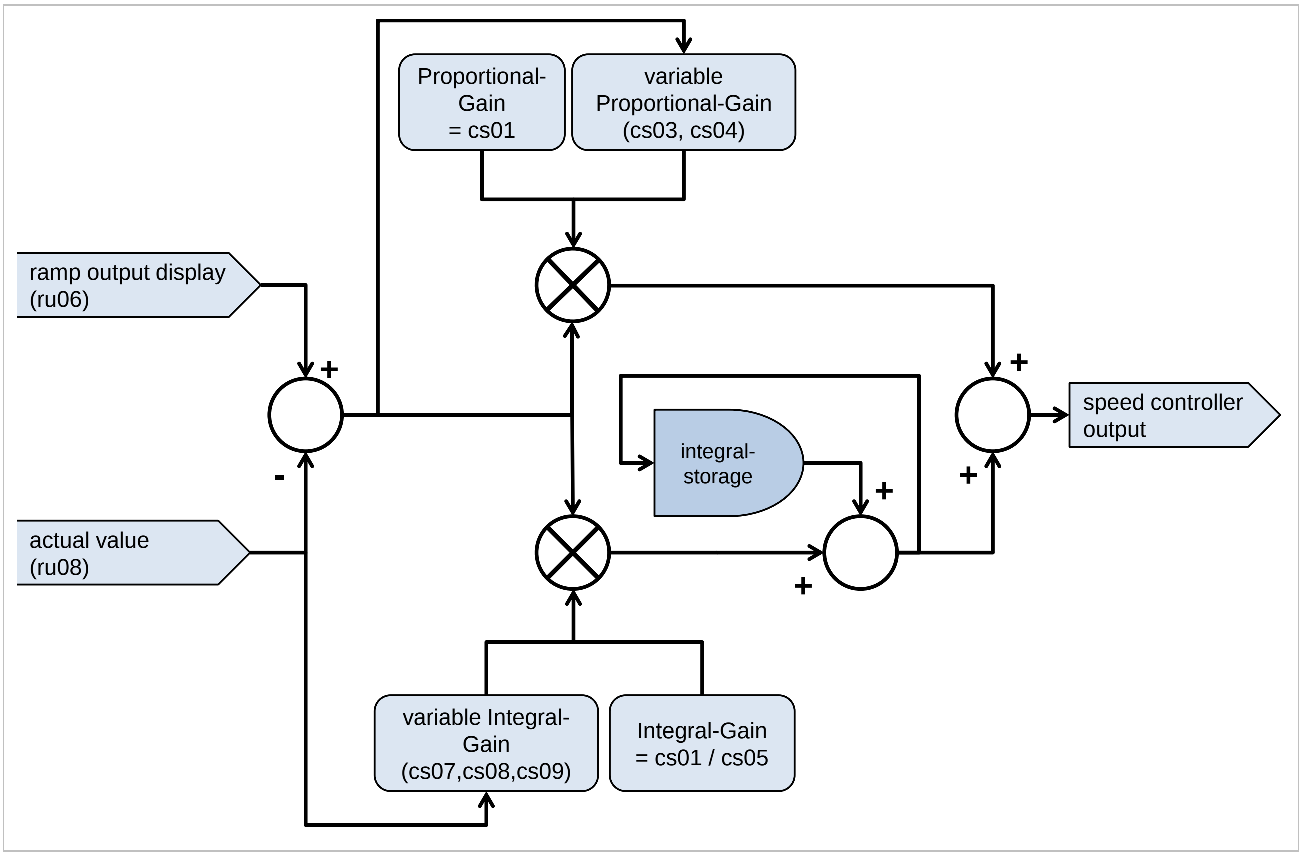


Figure 65: Pi-speed controller

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 total 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	

With the symmetrical optimisation cs99 optimisation factor, a value for cs01 KP speed and cs05 Tn speed is set in a coordinated ratio depending on the adjusted mass moment of inertia and the required control dynamics.

Parameters for a dynamic, hard speed controller adjustment are calculated with cs99 = 2.0.

Interference factors, such as torsion or clearance inertia effects that this adjustment often leads to oscillations of the total system. Therefore a subsequent manual fine adjustment of the controller may 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 speed controller parameters are changed with writing on cs99. The automatic pre-charging 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.

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

6.2.3 Variable proportional factor (control 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

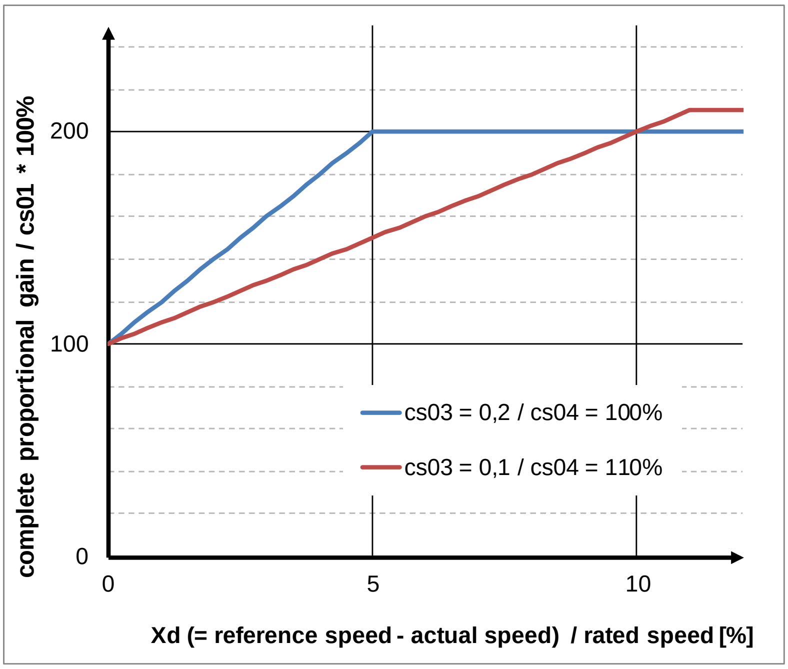


Figure 66: Variable proportional factor

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

6.2.4 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)

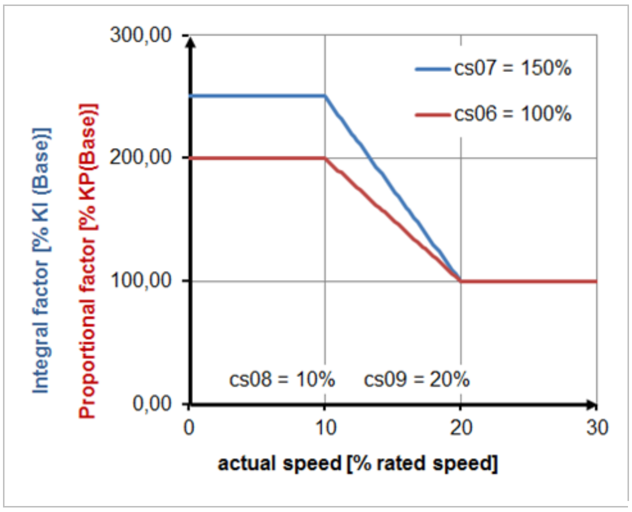


Figure 67: Variable proportional factor (kp) / integral factor (ki) for cs08=10%, cs09=20%

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)

cs09 = 20% => $n_{for\ min\ KP,\ KI}$ = 400rpm

cs01 KP speed [%Mn/rpm] = 1

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

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

6.2.5 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.

6.2.6 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:

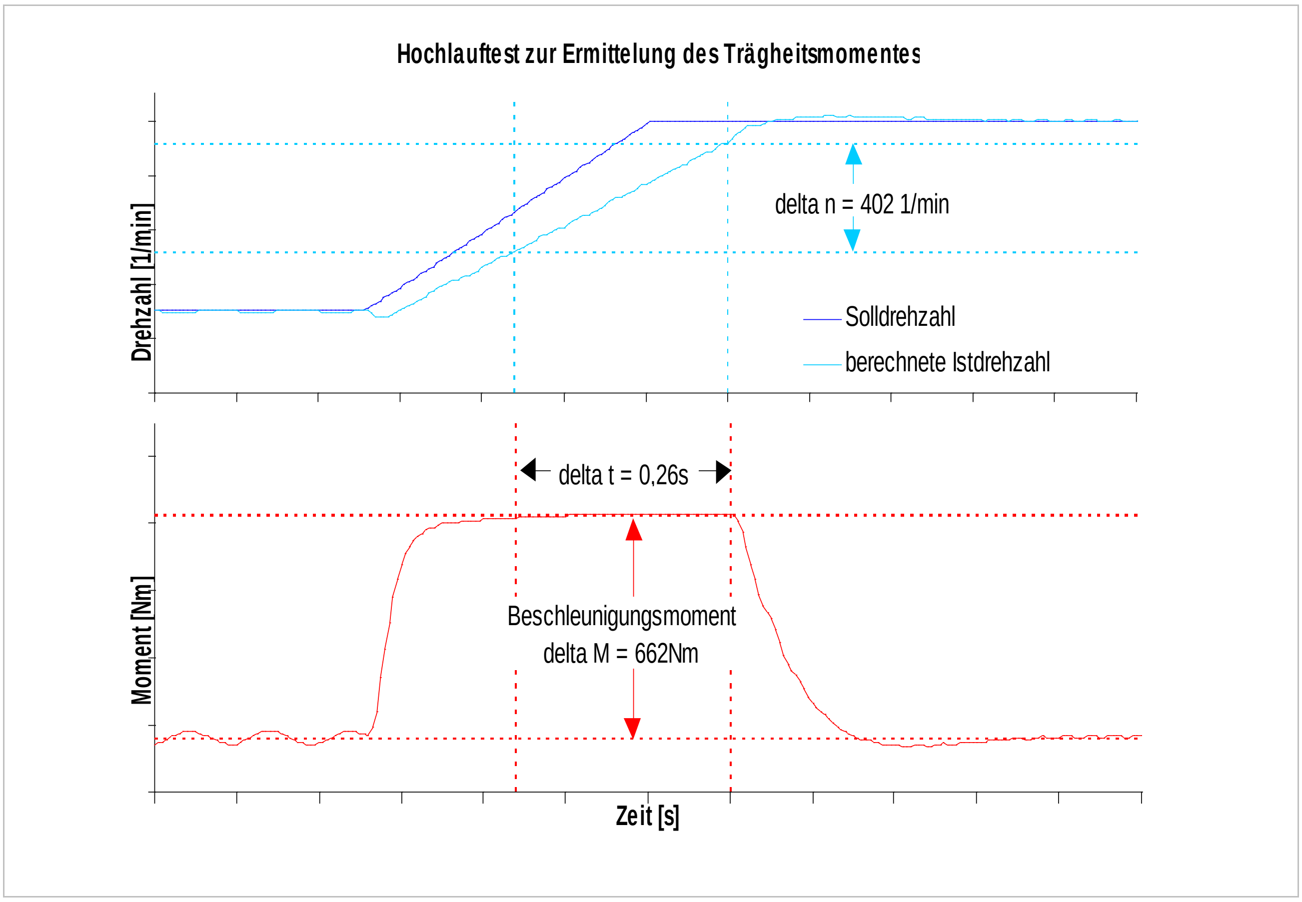


Figure 68: High-run test with COMBIVIS

$$J\,[kg*cm^2] = 95493 * 662\,Nm * \frac{0{,}26\,s}{402\,min^{-1}} = 40886\,kgcm^2$$

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.

6.2.7 Speed controller PT1 output filter

A PT1 low pass filter is series-connected to the speed controller.

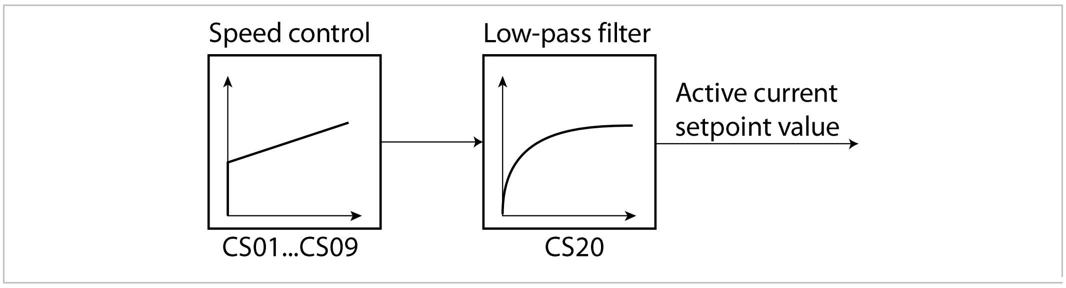


Figure 69: PT1 output filter

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 (cs20isq 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.

6.2.8 Torque precontrol

The required torque to accelerate/decelerate the drive can be calculated if the mass moment of inertia of a drive is known.

The torque can additionally precontrolled by the control via co18 torque offset.

This function is defined with the following parameters.

<table>
<tr><th>Index</th><th>Id-Text</th><th>Name</th><th colspan="2">Function</th></tr>
<tr><td>0x2715</td><td>cs21</td><td>pretorque mode</td><td colspan="2">Source selection for the torque precontrol</td></tr>
<tr><td>0x2716</td><td>cs22</td><td>pretorque PT1-time</td><td colspan="2">Filter time for torque precontrol (PT1 filter)</td></tr>
<tr><td>0x2717</td><td>cs23</td><td>pretorque delta time</td><td>Time for speed setpoint difference</td><td rowspan="2">at cs21 pretorque mode = 1</td></tr>
<tr><td>0x2718</td><td>cs24</td><td>pretorque factor</td><td>Access of the precontrol</td></tr>
<tr><td>0x2512</td><td>co18</td><td>torque offset</td><td>Offset preset via the control</td><td rowspan="2">at cs21 pretorque mode = 2</td></tr>
<tr><td>0x2514</td><td>co20</td><td>internal pretorque fact</td><td>Access of the precontrol</td></tr>
</table>

6.2.8.1 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.

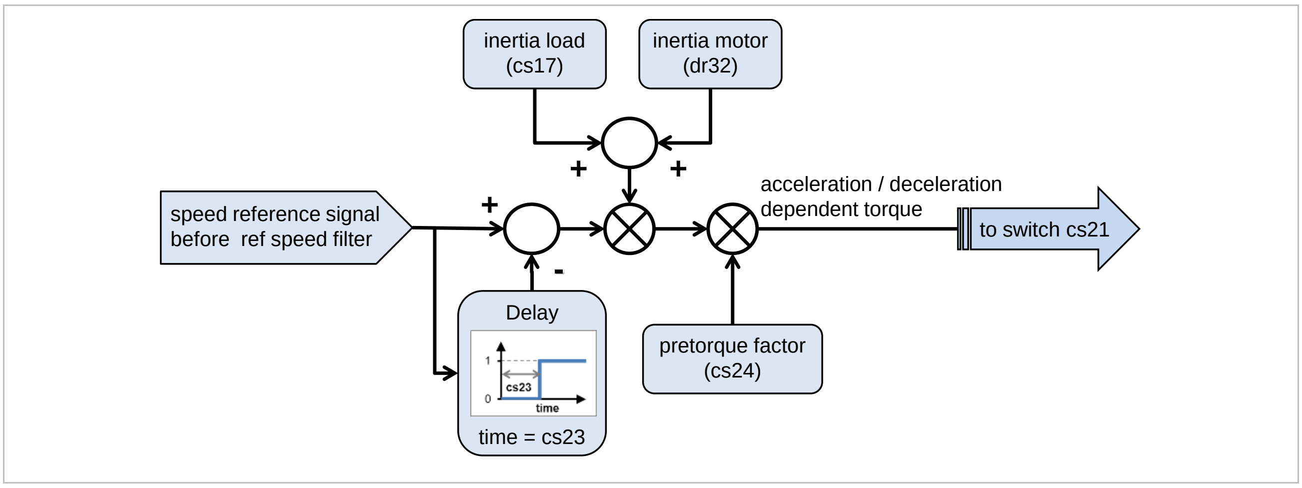


Figure 70: Torque precontrol mode 1

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.

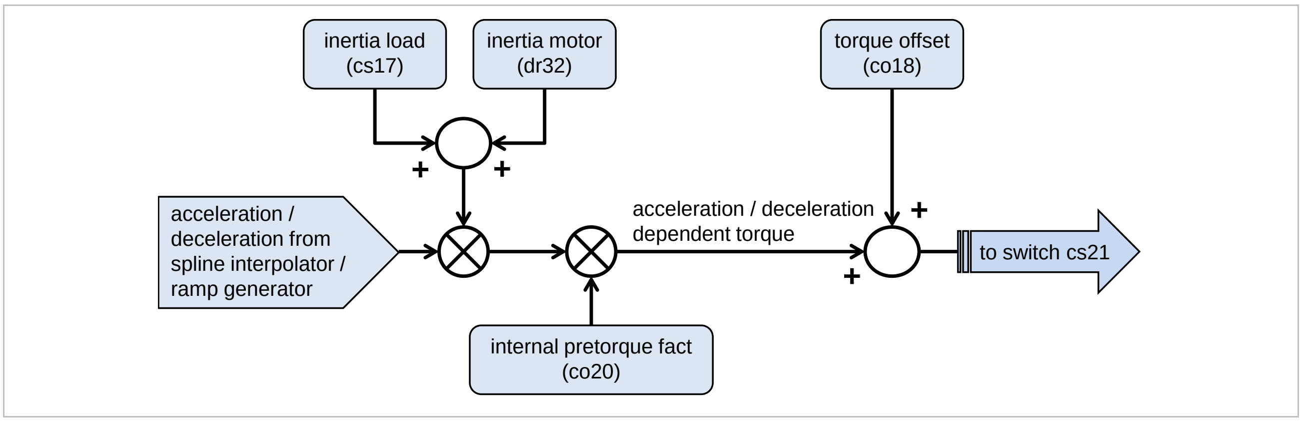


Figure 71: Torque precontrol mode 2

6.2.8.2 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.

The reciprocal of amplification for the torque offset (co18 torque offset) in mode 2 is not adjustable, since the values preset by the control shall not be falsified.

6.2.8.3 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.

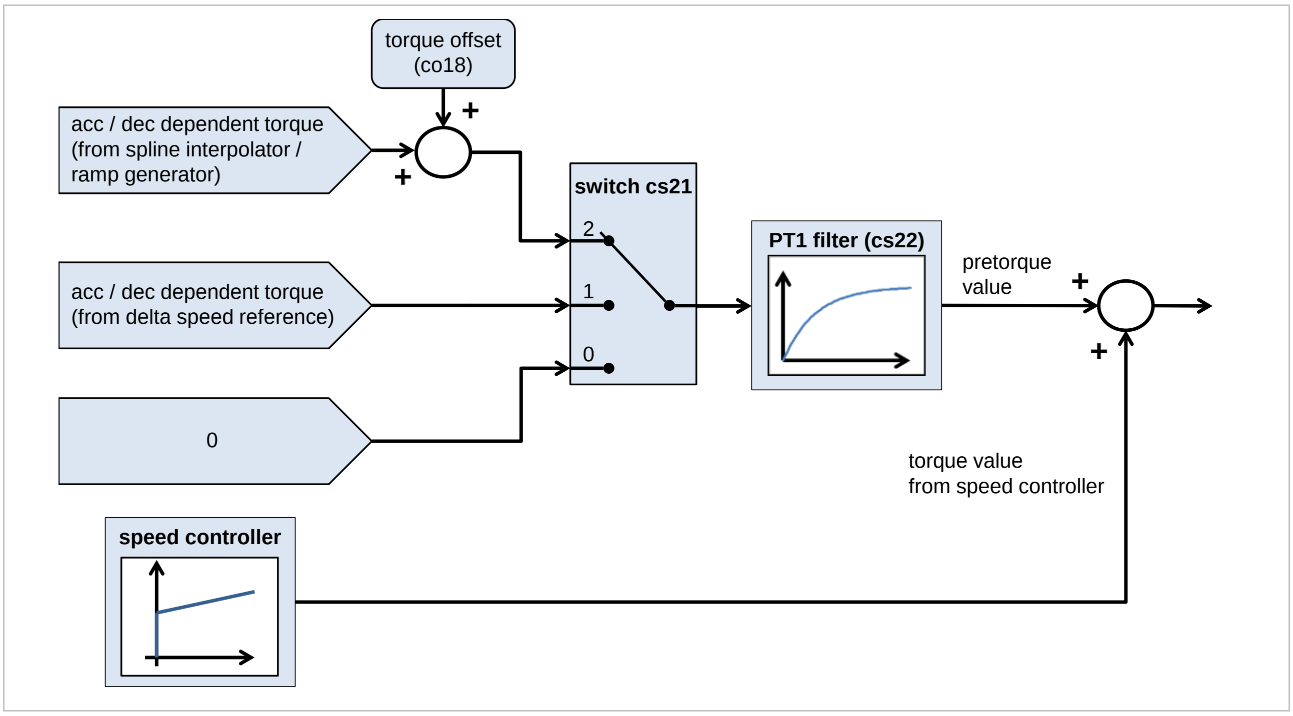
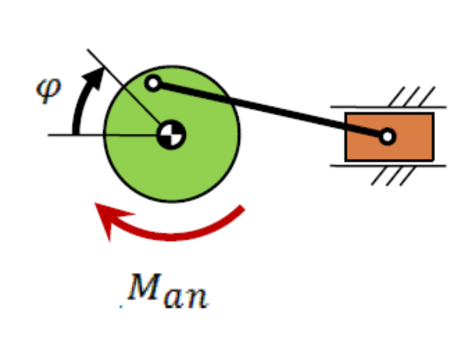


Figure 72: Torque precontrol smoothing

6.2.8.4 Non-linear torque precontrol

6.2.8.4.1 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	Note
0x2524	co36	inertia reducing mode	0…23
0x2525	co37	inertia reducing fact	0…255 -> 0…1,0, Array64
0x2526	co38	inertia derivation fact	-127…0…127 -> -1…0…1, Array64
0x2527	co39	inertia derivation [kg*cm^2]	

Index	Id-Text	Name	Note
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, Array64

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 M_w = 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

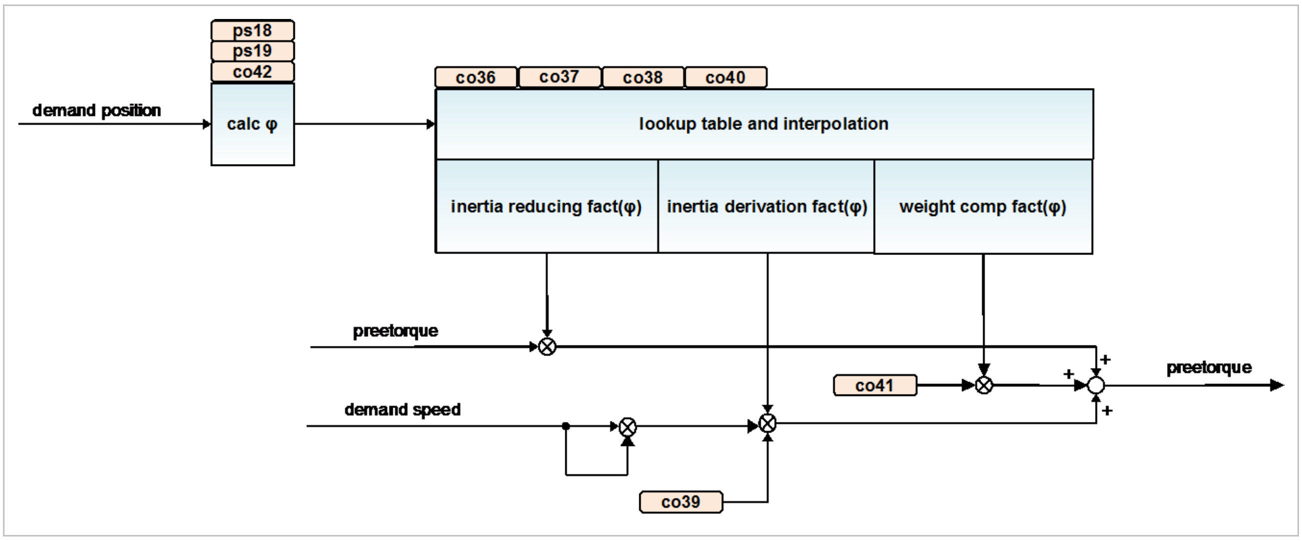


Figure 73: Non-linear torque precontrol

6.2.8.4.2 Linear value range

The linear value range is activated with ps38 positioning module / round table mode position = 0 „off“.

The limits of ps18 min position range limit and ps19 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.

6.2.8.4.3 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.

6.2.8.4.4 Internal value range

The angle φ is between these two limits of 0 to 2π.

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.

6.2.8.4.5 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 max. values of the respective inertia.

There are 3 different modes which are dependent 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 lowest value in the array co37 inertia reduce fact determines the speed controller gain. The minimum value of the array is always used as reduce factor for the speed controller.
8	on with co37	The interpolated factor from the values of co37 for the respective position is taken as reduce factor for the speed controller.
16	on with co43	The interpolated factor from the values of co43 for the respective position is taken as reduce factor for the speed controller.

Another array is available with co43 speed control reduce fact only for the scaling of the speed controller. The same values must be entered in co43 and in co37 for the start.

Application-dependent separate adjustments for the speed controller can be done for optimization.

6.2.9 Speed setpoint deceleration

With absolutely correct precontrol, the drive would follow exactly the setpoint even without speed controller.

However, the speed estimation always causes a deceleration of the estimated speed actual value ((A)SCL time speed calc. ds28).

The speed controller wants to control the decelerated actual speed equal to the speed setpoint and accelerates faster than required.

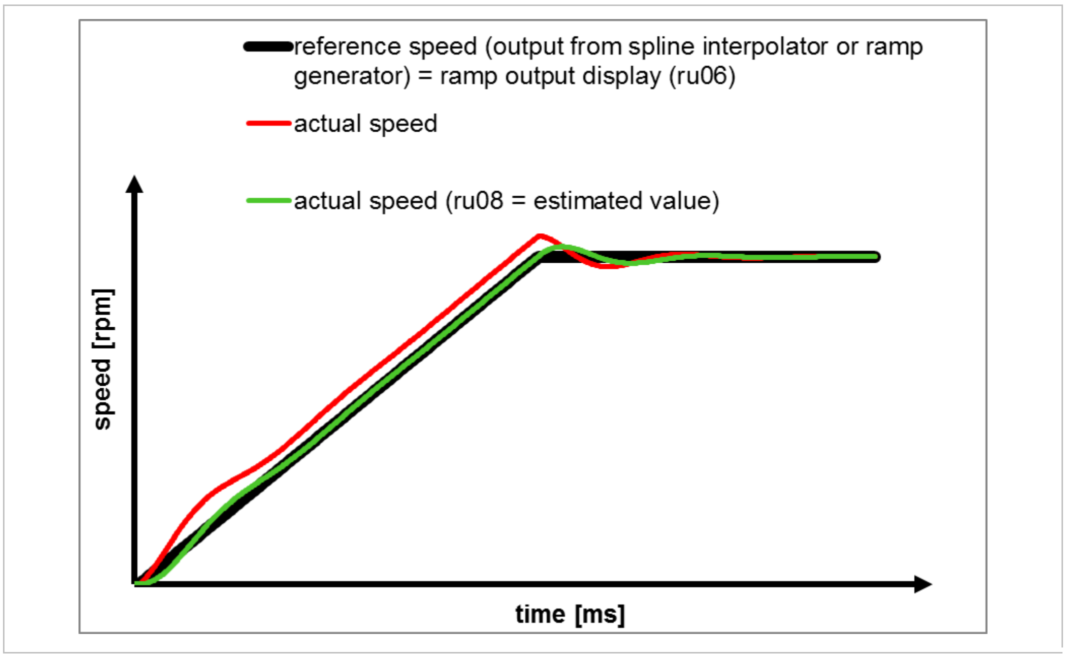


Figure 74: Overshoots in the speed setpoint

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).

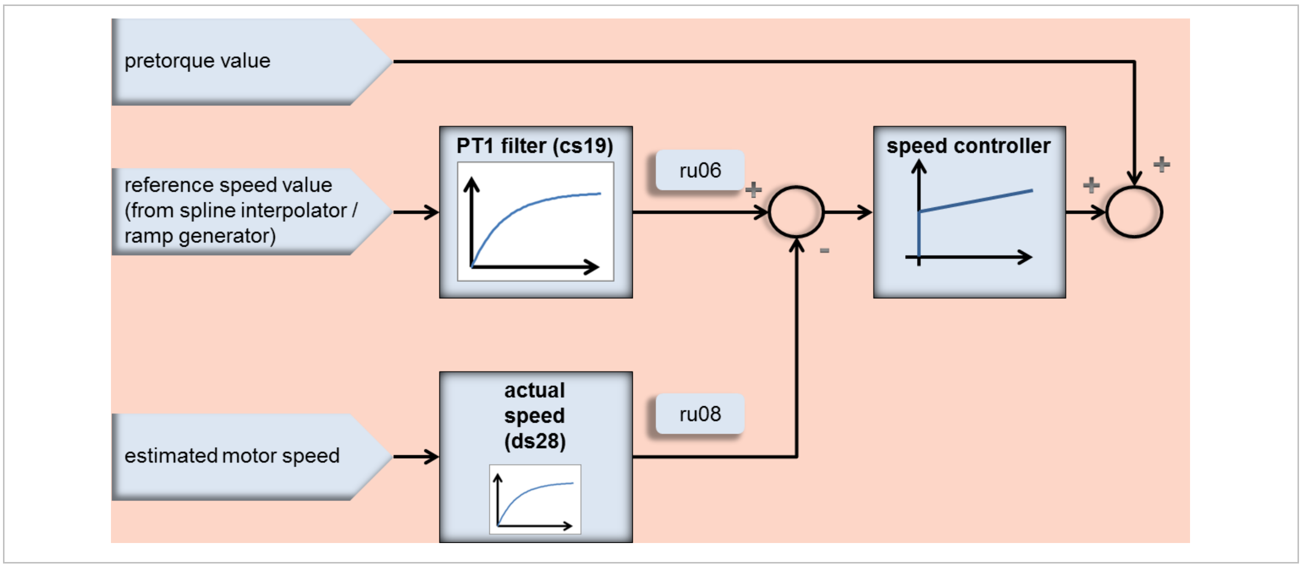


Figure 75: Speed setpoint deceleration

The value for cs19 ref speed PT1-time is calculated as follows:

encoderless operation ((A)SCL)
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 set-point speed of the ramp generator / spline interpolator are suitable.

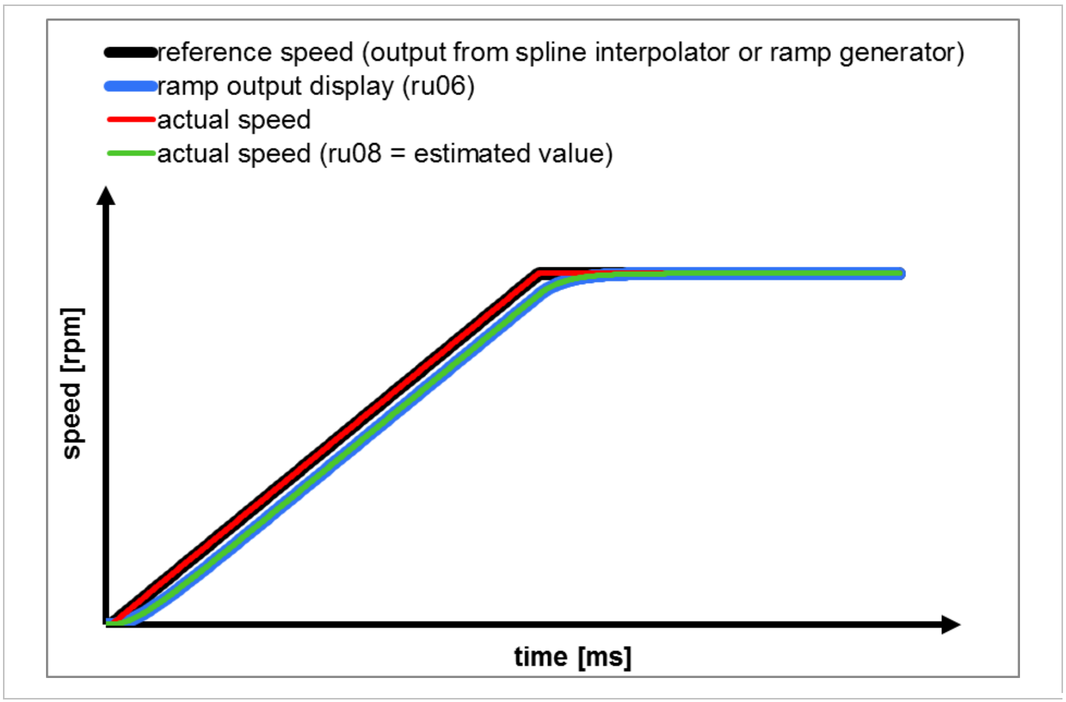


Figure 76: Optimal precontrol behaviour

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 6.5) 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.

6.3 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. for 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) (=> 4.2.1.2.5 Fault reaction-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

6.4 Position control

6.4.1 Position values

The following parameters contain position values:

Index	Id-Text	Name	Function
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	Actual position value (estimated)
0x2124	st36	following error	Actual contouring error
0x2E0C	ps12	following error window	Admissible contouring error window
0x2E0E	ps14	positioning window	Target window
0x2E10 / 0x2E11	ps16 / ps17	sw position limit pos / neg	Position setpoint limit
0x2E12 / 0x2E13	ps18 / ps19	min / max position range limit	Position range limit

The resolution of all position values 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 / ps19).

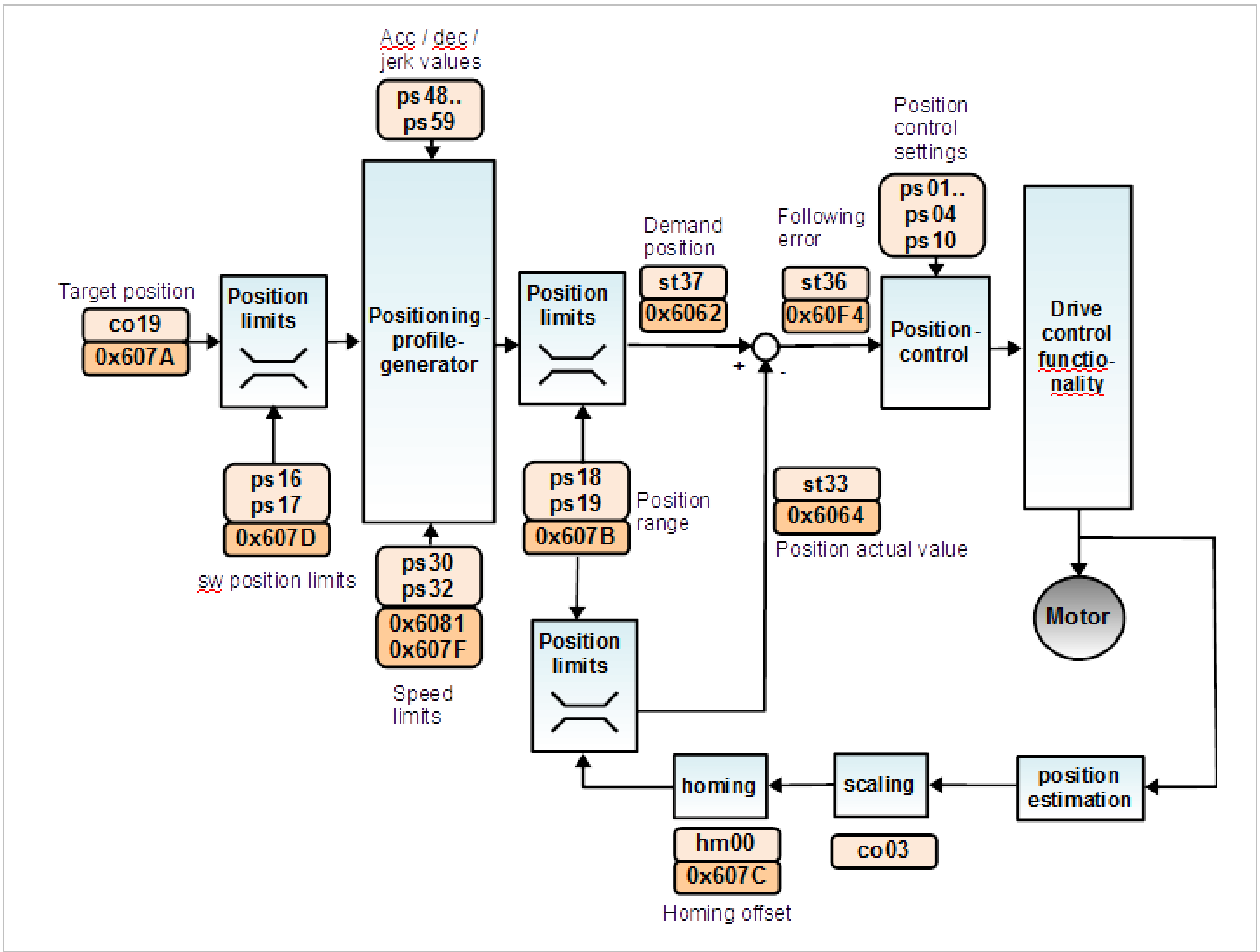


Figure 77: Position control overview

6.4.1.1 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: $\pm 2^{(31 - co03)}$

NOTICE

Max. 2^{16} whole revolutions are internally counted.
If a value < 16 is selected for co03, then the upper bits of the position specifications and displays are not valid.
(number of invalid bits =16 – co03)

6.4.1.2 Software position limits

The limits for the set position (ps16 sw position limit pos and ps17 sw position limit neg) are checked at the start of the positioning. The positioning is not carried out if the set value is outside of these limits.

If a continuous operation above the 32-bit value range is permitted (continuous positioning in one direction) ps16 sw position limit pos 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	sw position limit pos	0x2E10
ps17	sw position limit neg	0x2E11
Value	Meaning	
$+(2^{31} - 1)...-(2^{31} - 1)$	Set position limits	

6.4.1.3 Position range limits

The value range of the position set- and actual values can be limited with the position range limits ps18 min. position range limit and ps19 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 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.

6.4.1.4 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 2^{31}.
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)

6.4.2 **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 “velocity mode” or 9 “cyclic synchronous velocity mode” => position controller off)	
2 : on	Position controller generally 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".

6.4.3 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

Since the controlled system has an integral behavior, the position controller is a pure P controller.

The amplification 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 in Kp.

Example amplification 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 profile generator and the output value of the position controller.

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	

6.4.3.1.1 Standard position controller

ps01	KP position controller	0x2E01
Value	Meaning	
0.0…6500.0 rpm	Amplification factor	

ps01 KP position controller determines the proportional gain of the position controller.

Since the ideal setting for the target position is often too hard for positioning process with high speed (i.e. at low speeds at the end of the positioning profile), the gain can be decreased 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 decrease is dependent 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.

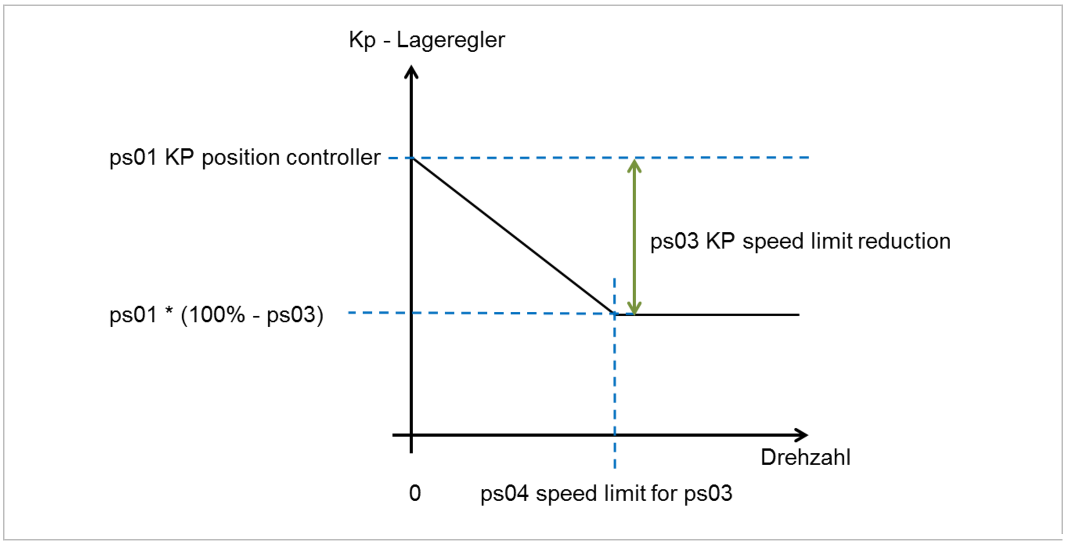


Figure 78: KP reduction in the position controller

The gain is decreased from speed 0 to the level of ps04 speed limit for ps03 by the adjusted value in ps03 KP speed limit reduction.

That means: If ps03 is 75% and ps04 = 1000 rpm, then the gain (Kp from ps01) is reduced from 100% to 25% (decreased by 75%) from profile speed 0 to 1000 rpm.

6.4.3.1.2 Standstill position control

ps02	KP zero speed position ctrl	0x2E02
Value	Meaning	
0.0…6500.0 rpm	Additional amplification factor at setpoint speed 0	

If a very high position rigidity is required only in standstill, the gain (Kp) of the position control can be increased at profile setpoint speed = 0 rpm with ps02 KP zero speed position ctrl.

6.4.3.2 Position controller source

The source for the position information is determined with co04 position source.

co04	position source		0x2504
Value	Name	Meaning	
0, 1	reserved		
2	estimated position	Estimated position from the motor model	

The position control occurs via the estimated position of the motor model.

6.4.3.3 Following error

The following error st36 following error can be monitored in all operating modes with active position controller.

If the limit of ps12 following error window is exceeded and additionally the preset time in ps13 following error time out has elapsed, bit 13 „following error“ is set in the status word.

6.5 Structure position / speed control

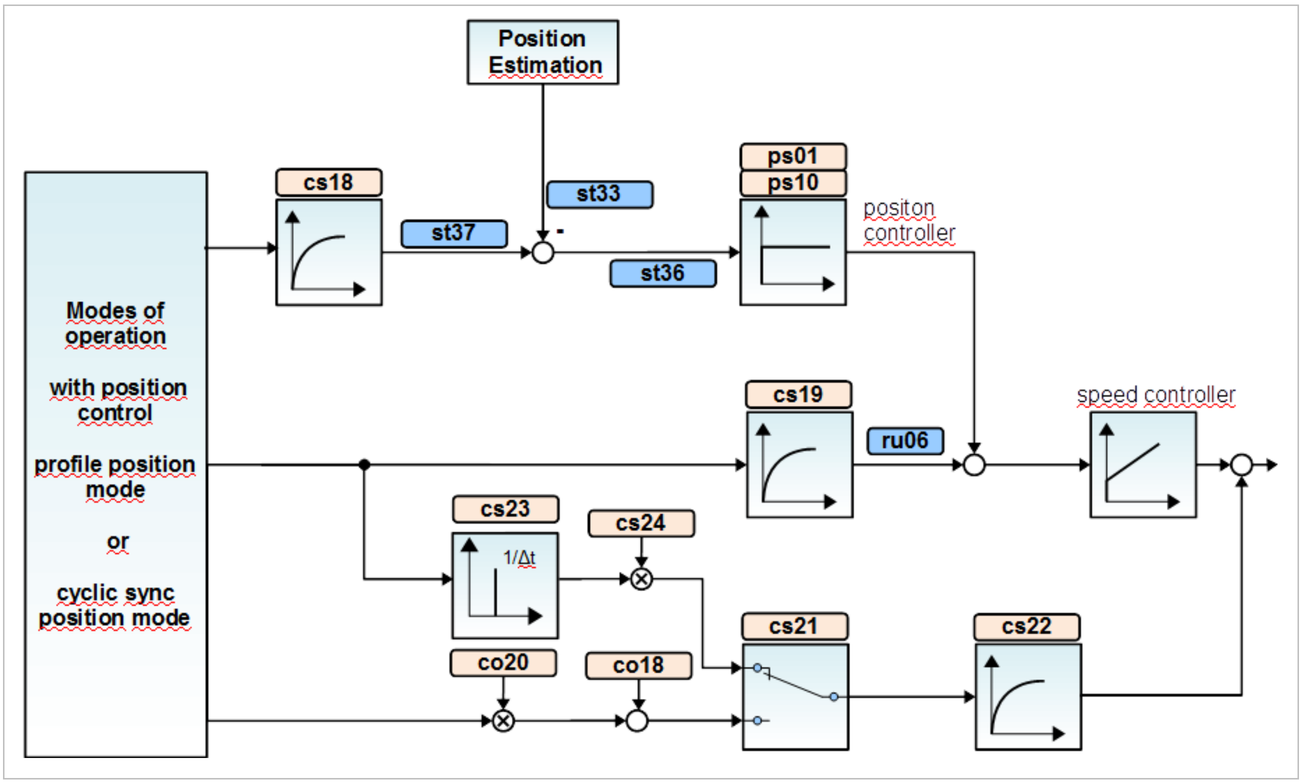


Figure 79: Structure position / speed control

7 I/O functions

7.1 Digital Inputs

7.1.1 Overview

The T6 axis module has no digital hardware inputs, only virtual inputs.

Number	Description
	Virtual inputs I1…I8 and IA…ID (IA…D are fixed assigned to the virtual outputs OA…OD).

The virtual digital inputs can be preset via the 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 inputs after passing the input block is displayed in ru18 dig. input state.

Block diagram:

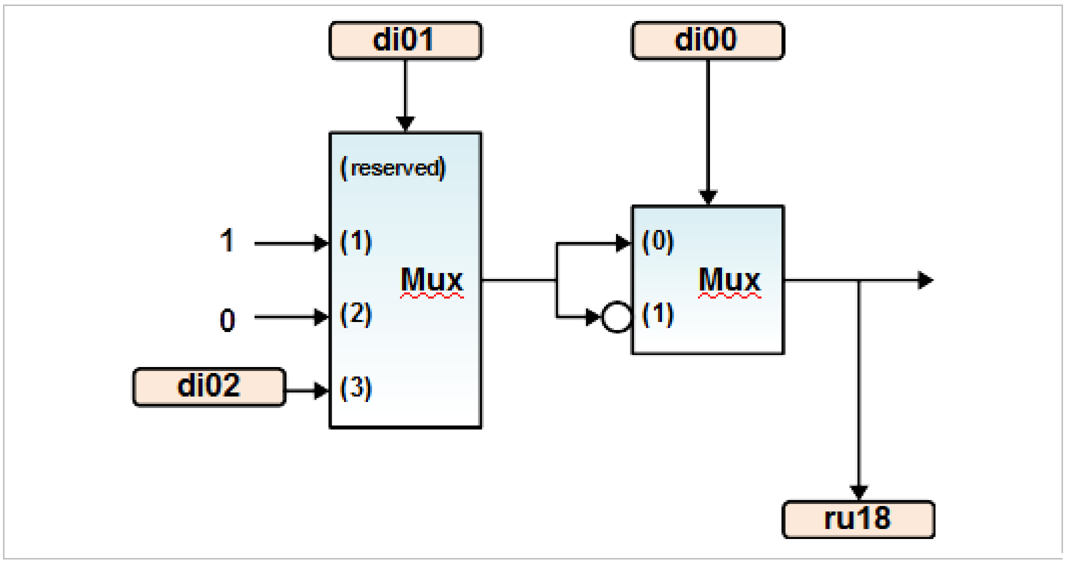


Figure 80: Digital inputs block diagram

7.1.2 Terminal state

The terminal state can be read out via object ru18.

Index	Id-Text	Name	Function
0x2C12	ru18	dig. input state	Display of the software internal input state after passing the input block

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	rsvd	0x2C14
2	1	rsvd	
4	2	rsvd	
8	3	rsvd	
16	4	rsvd	
32	5	rsvd	
64	6	rsvd	
128	7	rsvd	
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	rsvd	0x2C14
8192	13	rsvd	
16384	14	STO-1	
32768	15	STO-2	

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

For the inputs I1…I8 the selection can be made from three, at IA…ID from 4 sources.

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.			0x2601
Bit	Function	Value	Plaintext	Function
0, 1 2, 3 4, 5 6, 7 8, 9 10, 11 12, 13 14, 15	reserved reserved reserved reserved reserved reserved reserved reserved	0	term.	Reserved, no hardware digital input available.
		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 23, 22	IA src IB src IC src ID 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

7.1.4 External setting of the input state

Object di02 dig. input ext. src can be used as source for the internal input state.

Index	Id-Text	Name	Function
0x3202	di02	dig. input ext. src	External setting of the input status

The meaning of the bits in di02 dig. input ext. src corresponds to ru18 dig. input state.

- 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 ru18dig. 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)

The virtual inputs I1…I8 and IA…ID can be inverted. An inversion of the STO inputs is not possible.

7.1.6 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 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	With active RST input, value 0x80 (fault reset) is OR connected into the internal control word.
0x320C	di12	CA input	With active CA input, the CA mask is OR connected into the internal control word.
0x320D	di13	CA mask	
0x320E	di14	CB input	With active CB input, the CB mask is OR connected into the internal control word.
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 input	If defined and input active, Bit 4 is set in the internal control word.
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	With active halt input, value 0x0100 (halt) is OR connected into the internal control word.

7.1.6.1 Controlword functions via the digital inputs

All controlword functions can also be activated with digital inputs by di10…di15 and di18, di19.

The internal controlword co31 is the active controlword for the drive.

It is generated by linking the settings via the parameters (objects) and the settings via the digital inputs.

With co30 controlword mask it is defined, which bits are written to the internal controlword c031 by writing to co00 controlword (Addr.: 0x2500) or writing to the controlword in the pr parameters (Addr.: 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 via the controlword parameters, co30 should contain a "0" for all bits which are preset via the digital inputs.

> - 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.

7.1.6.1.1 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 (000bh) 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.

7.1.6.1.2 Reset

Which input shall cause an error reset can be defined with di11 RST input.

Bit 7 (0080h) fault reset is set in the internal controlword via active **RST input**. When the RST input is inactive, bit 7 is set to zero.

7.1.6.1.3 Operation mode specific Bit 4

Which input sets or resets bit 4 in the internal controlword is defined with di19 start posi input.

Bit 4 (0010h) is set in the internal controlword via an active **start posi 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.

7.1.6.1.4 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 (0100h) 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.

7.1.6.1.5 Controlword mask CA / CB

Any controlword bits can be set with parameters di12...di15.

Which bits are preset via the digital inputs can be selected via the mask objects di13 CA mask and di15 CB mask.

The inputs, which determine the state (set = 1 / inactive = 0) for the selected bits are selected with di12 CA input and di14 CB input.

7.1.6.2 Rotation setting via digital inputs

7.1.6.2.1 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.

7.1.6.2.2 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.

7.1.6.2.3 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.

7.1.6.3 Index setting via digital inputs

7.1.6.3.1 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.

Example for index calculation:

Inputs IA, IB and IC are selected in di21 for index selection:

di21 = 1792: IA + IB + IC

Thereby input I1 receives the value 1, input I3 the value 2 and input I5 the value 4.

Inputs IA and IC are set:

Index = 1 + 2 = 3

Inputs IB and IC are set:

Index = 2 + 4 = 6

The actual index can be read out in ru58 actual index.

7.1.6.3.2 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.

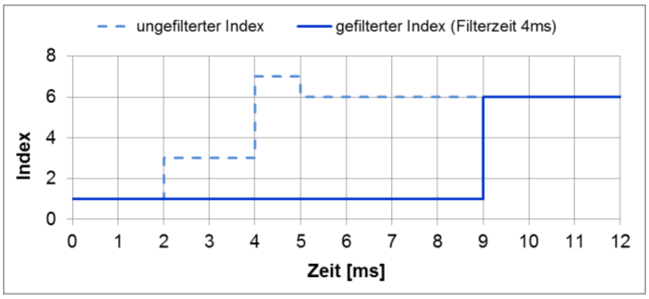


Figure 81: Example 1 to the index filter

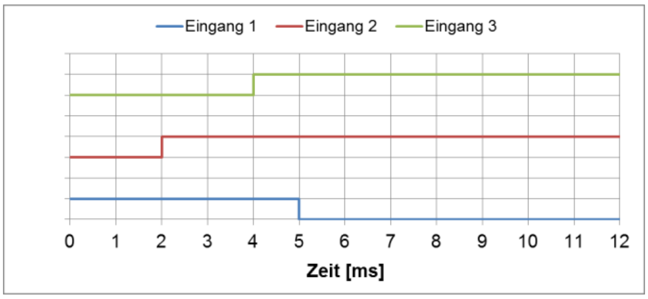


Figure 82: Example 2 to the index filter

If the unfiltered index remains constant for the filter time (4ms), it is accepted as valid index.

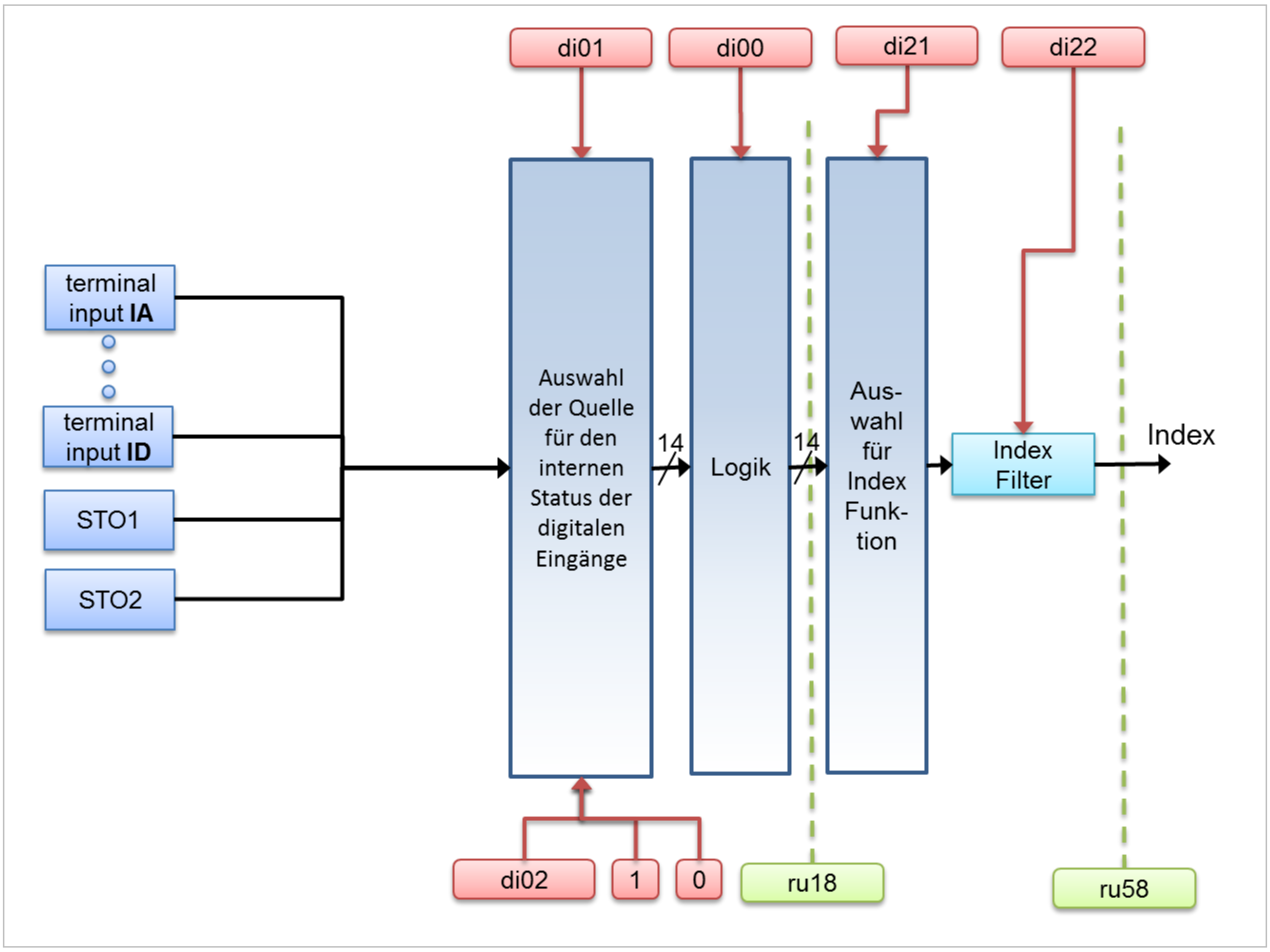


Figure 83: Overview indexing with all filters

7.1.7 Overview of the input functions

Index	Id-Text	Name	Function
0x3226	di38	IA input function	An overview can be obtained in these read parameters, which functions are triggered / influenced by the respective input. The STO1 / STO2 inputs are internal hardware signals
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…di43	Ix input function	0x321E…322B
Bit	Value	Plaintext / function	
0…18	0	No function is assigned to the input	
0	1	di10: Run	For a description of the input function refer to the respective parameter which they are assigned to.
1	2	di11: RST	
2	4	di12: CA mask	
3	8	di14: CB mask	
4	16	di16: FOR	
5	32	di17: REV	
6	64	di18: Stop	
7	128	di19: Start Posi	
8	256	di20: invert	
9	512	di21: index	
10	1024	hm06: negative limit switch	
11	2048	hm07: positive limit switch	
12	4096	hm08: home switch	
13	8192	hm14: home mode source	
14	16384	ps44: immediately input	
15	32768	pn30: prg error source	
16	65536	pn31: enable braking trans. source	
17	131072	pn46: fault reaction end src	
18	262144	of05: trigger source	
19	524288	di23: HALT	

7.2 Virtual digital outputs

The T6 axis module has no hardware outputs, only virtual software outputs

Number	Description	Notes
4	OA…OD	Software outputs (connected with the digital inputs IA-ID)

7.2.1 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.

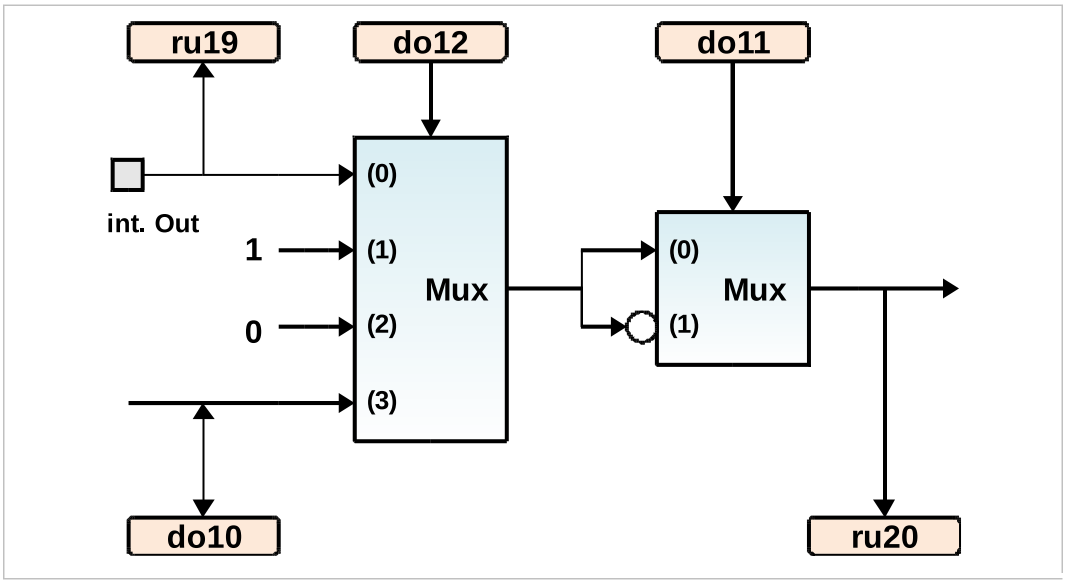


Figure 84: Digital outputs block diagram

7.2.2 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…3			0x2C14
4	16	OA	Virtual output A (virtual input IA)
5	32	OB	Virtual output B (virtual input IB)
6	64	OC	Virtual output C (virtual input IC)
7	128	OD	Virtual output D (virtual input ID)
8…15			0x2C14

1 means the output is set.

7.2.3 Source selection for the digital outputs

The source for the state of the digital outputs can be selected via object do12 digital output source.

Index	Id-Text	Name	Function
0x260C	do12	dig. output src. sel.	Source selection of the output state

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…7				0x2C14
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	OD 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
16…31				0x2C14

7.2.4 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 stored **not** non-volatile.

7.2.5 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 ru20 dig. output 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

7.2.6 The comparator level

7.2.6.1 Overview

The comparator level is generated from 4 programmable function blocks which output as result 0 (FALSE) or 1 (TRUE). 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. The internal output state ru19 is generated from these flags via a mapped linkage in objects do20…do27.

The function blocks can be parameterized via the objects do01 to do07.

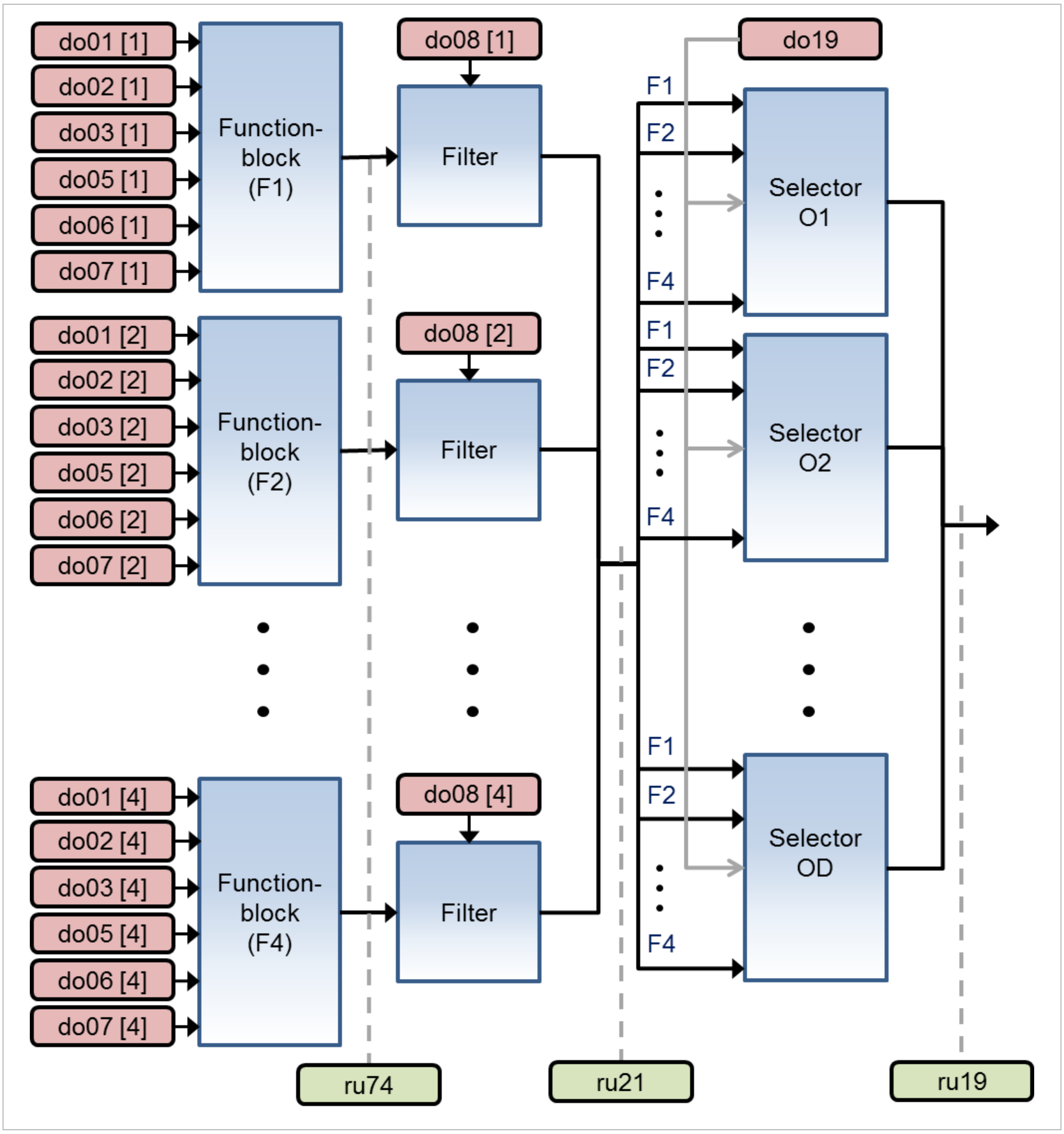


Figure 85: Comparator level

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.

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 be set only 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).

7.2.6.2 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…4	do01	flag operand A	Operand A for comparison operation
0x2602	1…4	do02	flag operand B	Operand B for comparison operation

The following operands can be selected in do01flag operand A and do02flag operand B:

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 display (ru06)	Speed controller input variable [in rpm] (set speed after ramp/spline/position control and PT1 element)	
7	act. frequency (ru07)	Stator frequency [in Hz]	
8	act. value (ru08)	Actual speed for speed control (measured or estimated) [in rpm]	
9	reserved		
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 (ru25)	Heatsink temperature [in °C]	
33	internal temperature (ru26)	Internal 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	
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	act torque limit pos (ru50)	actual resulting positive torque limit (mot. limit forward / gen. limit reverse) [in % rated torque]	
42	act torque limit neg (ru51)	actual resulting negative torque limit (gen. limit forward / mot. limit reverse) [in % rated torque]	
43	eff motor load (ru57)	Long-term load of the motor [in %]	
44	act switch freq (ru72)	Switching frequency [in kHz]	

do01	flag operand A		0x2601
do02	flag operand B		0x2602
Value	Plaintext	Note	
45	I / ImaxOL2 (ru73)	Motor current [in % short-time current limit]	
46…55	reserved		
56	diff. speed [1] (ru83)	ru84 – ru08 [in rpm]	
57	diff. speed [2] (ru83)	Ramp output value (internally) – ru08 [in rpm]	
58	diff. speed [3] (ru83)	ru06 – ru08 [in rpm]	

7.2.6.3 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…4	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
		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

7.2.6.4 Constant 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…4	do05	flag level 1	Comparison level 1 (resolution 0.0001)
0x2606	1…4	do06	flag level 2	Comparison level 2 (resolution 1)

7.2.6.5 Hysteresis

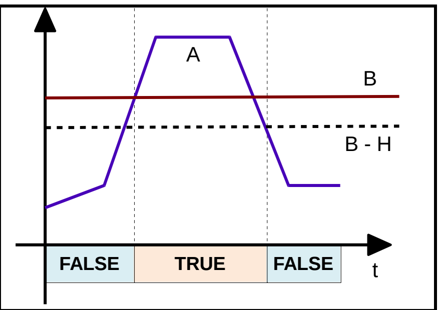
A hysteresis for comparison operations can be preset in do07.

Index	Subidx	Id-Text	Name	Function
0x2607	1…4	do07	flag hysteresis operand B	Hysteresis

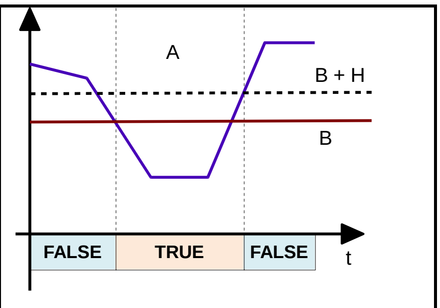
The function of the hysteresis is depending on the selected operator. No hysteresis function is possible for the operations AND or OR.

The hysteresis is defined as follows for the operators **>=**, **<=**, **=** and **!=**:

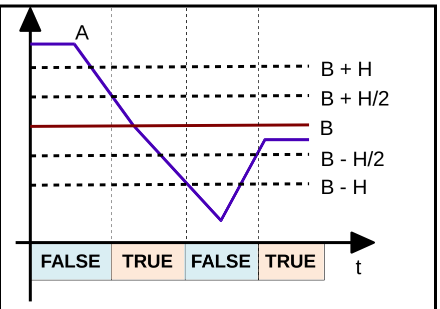
> =	Function:	Result:
	A >= B	TRUE
	A < (B – H)	FALSE
	(B – H) < A < B	unchanged



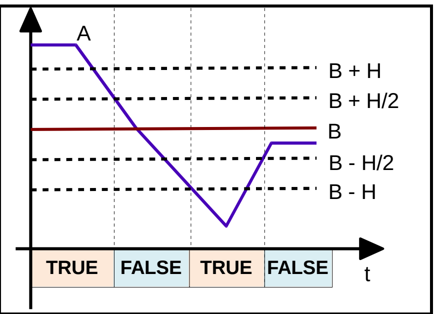
< =	Function:	Result:
	A <= B	TRUE
	A > (B + H)	FALSE
	(B + H) > A > B	unchanged



=	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



7.2.6.6 Filter

A filter can be series-connected for each comparison operation.

Index	Subidx	Id-Text	Name	Function
0x2608	1…4	do08	filter time flags	Filter for the comparison operation

The filter is incremented if the output of the comperator level is = TRUE, at False it is decremented.

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.

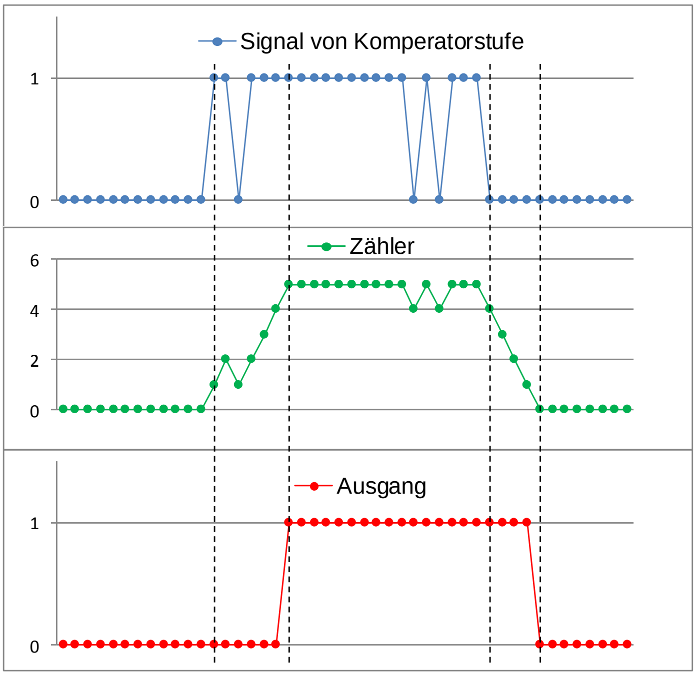


Figure 86: Filter for the comparison operation

7.2.7 Generation of the internal outputs

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 do24...do27.

Index	Id-Text	Name	Function
0x2613	do19	AND operation for output	Selection of the link type for output OA…OD
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 OD	Selection of the flags for internal output OD

The meaning of the values is identical for do24…do26.

do24…do27		select flag OA…OD		0x2618…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	
2	4	F3	Result function block 3	
3	8	F4	Result function block 4	

do19		AND operation for output	0x2613
Bit	Value	Name	Function
0…3			0x2C14
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	OD	Selected flags for OD are OR-connected
	64		Selected flags for OD are AND-connected

Example: Output O1 shall be set if the 3 inputs I1 and I2 and I3 are set:

Definition flag 1 (I1 is set => Bit 0 ru18 is 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 is set => Bit 1 ru18 is 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 is set => Bit 2 ru18 is 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.

8 Communication over Interlink

The T6 devices offer a serial Interlink connection with the Main Control Unit (MCU).

8.1 Request/Response-Identifier (SDO)

Any CAN node can request the reading or writing of a parameter value via the request identifier.

The response identifier is reserved for the corresponding response from the frequency inverter.

The mechanism of request and response is also referred to as confirmed service.

The SDO channel is constantly operated independently of the process data traffic. The cycle time results from the programming period of the Main Control Unit .

8.2 Out/In-Identifier (PDO)

The CAN master can preset unaddressed and unconfirmed data to the frequency inverter via the Out identifier.

The term Out is based on the data direction from the master to the slave.

The frequency inverter transfers itself via the In identifier new data unaddressed and unconfirmed to the CAN master.

This functionality is identified from the communication profile as process-data-object (PDO).

Process data processing occurs with the minimum cycle time of 1000 µs per activated PDO.

For the DCU, 3 process data objects (PDOs) are available with the two object parts Out/In.

They are addressed as follows:

- PDO1(rx) = Out-Identifier
- PDO1(tx) = IN-Identifier
- PDO2(rx) = Out-Identifier
- PDO2(tx) = IN-Identifier
- PDO3(rx) = Out-Identifier
- PDO3(tx) = IN-Identifier

The 3 process data objects (PDOs) can be assigned each with 20 bytes per direction. This means, up to five objects with a total of 20 bytes can be transmitted per PDO.

8.2.1 Process data mapping

Address	Parameter		
0x1600	1st transmit PDO mapping	0x1A00	1st transmit PDO mapping
0x1601	2st transmit PDO mapping	0x1A01	2st transmit PDO mapping
0x1602	3st transmit PDO mapping	0x1A02	3st transmit PDO mapping

The 3 process data objects (PDOs) can be assigned via the mapping parameters each with 20 bytes per direction. The following combinations of objects with a certain data size are possible:4 x Long + 1 x Byte, 5 x Word, 2 x Long + 2 x Word + 1Byte

Both, the data size of a parameter as well as the characteristic "available for process data" can be checked in the "property editor" in COMBIVIS 6.

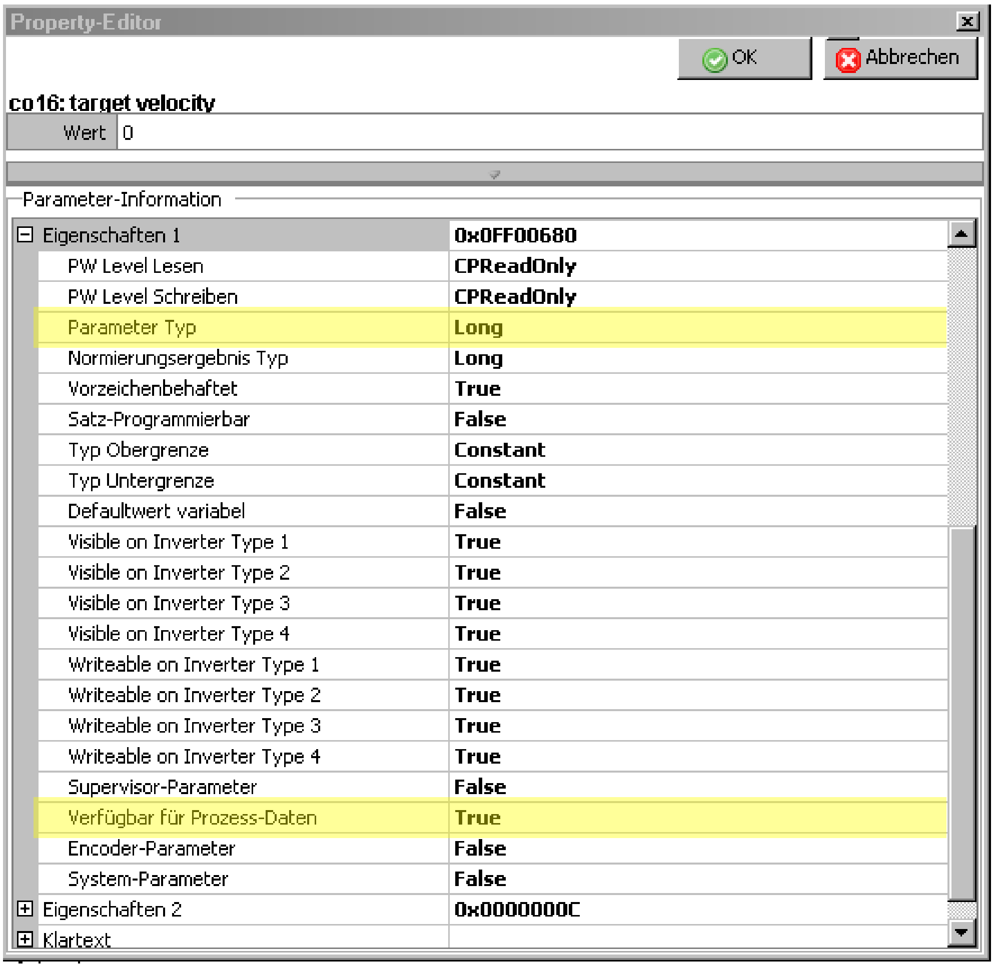


Figure 87: target velocity

A complex structured object (parameter) defines for each data direction the PDO mapping (PDO mapping).

<table>
<tr><td colspan="3">1st receive PDO mapping
2st receive PDO mapping
3st receive PDO mapping</td><td>Array</td><td>0x1600
0x1601
0x1602</td></tr>
<tr><td colspan="5">Subindex 0: Number (Byte)</td></tr>
<tr><td>Value</td><td colspan="4">Function</td></tr>
<tr><td>0…5</td><td colspan="4">Indicates the number of the mapped objects.
The offset is determined (successive, no gaps possible like in the fb mapping parameters!).</td></tr>
<tr><td colspan="5">Subindex 1…8 (long)</td></tr>
<tr><td>Bit</td><td>Function</td><td colspan="3">Meaning</td></tr>
<tr><td>0…7</td><td>Object length</td><td>Byte: 0x08
Word: 0x10
Long: 0x20</td><td colspan="2" rowspan="3">Defines an object image. The index, subindex and the object length are specified in bits.
Writing of subindex 1...5 requires that the count (subindex 0) is set to 0.</td></tr>
<tr><td>8…15</td><td>Subindex</td><td>Subindex</td></tr>
<tr><td>16…31</td><td>Index</td><td>Parameter address (Bit 16…23 = Lowbyte/
Bit 24…31 = Highbyte)</td></tr>
</table>

<table>
<tr><td colspan="3">1st transmit PDO mapping
2st transmit PDO mapping
3st transmit PDO mapping</td><td>Array</td><td>0x1A00
0x1A01
0x1A02</td></tr>
<tr><td colspan="5">Subindex 0: Number (Byte)</td></tr>
<tr><td>Value</td><td colspan="4">Function</td></tr>
<tr><td>0…5</td><td colspan="4">Indicates the number of the mapped objects.
The offset is determined (successive, no gaps possible like in the fb mapping parameters!).</td></tr>
<tr><td colspan="5">Subindex 1…8 (long)</td></tr>
<tr><td>Bit</td><td>Function</td><td colspan="3">Meaning</td></tr>
<tr><td>0…7</td><td>Object length</td><td>Byte: 0x08
Word: 0x10
Long: 0x20</td><td colspan="2" rowspan="3">Defines an object image. The index, subindex and the object length are specified in bits.
Writing of subindex 1...5 requires that the count (subindex 0) is set to 0.</td></tr>
<tr><td>8…15</td><td>Subindex</td><td>Subindex</td></tr>
<tr><td>16…31</td><td>Index</td><td>Parameter address (Bit 16…23 = Lowbyte/
Bit 24…31 = Highbyte)</td></tr>
</table>

9 Special Functions

Some functions, such as hardware limit switch functionality and the homing operating mode are normally not usable for the T6, because digital inputs and the possibility of connecting an encoder are missing.

The use of the associated parameters (hm parameters, limit switch parameters in the pn group) should only be carried out in consultation with KEB.

10 Object Dictionary

10.1 Parameterizing data

10.1.1 Display of parameterizing data in COMBIVIS 6

COMBIVIS 6 uses for communication protocol DIN66019II via Ethernet. Access to the T6 DCU is done via a gateway functionality of the T6 MCU.

The elements are displayed on access to arrays or structures and optionally also the number (subindex 0).

The characteristics of an object can be displayed via editor for the values.

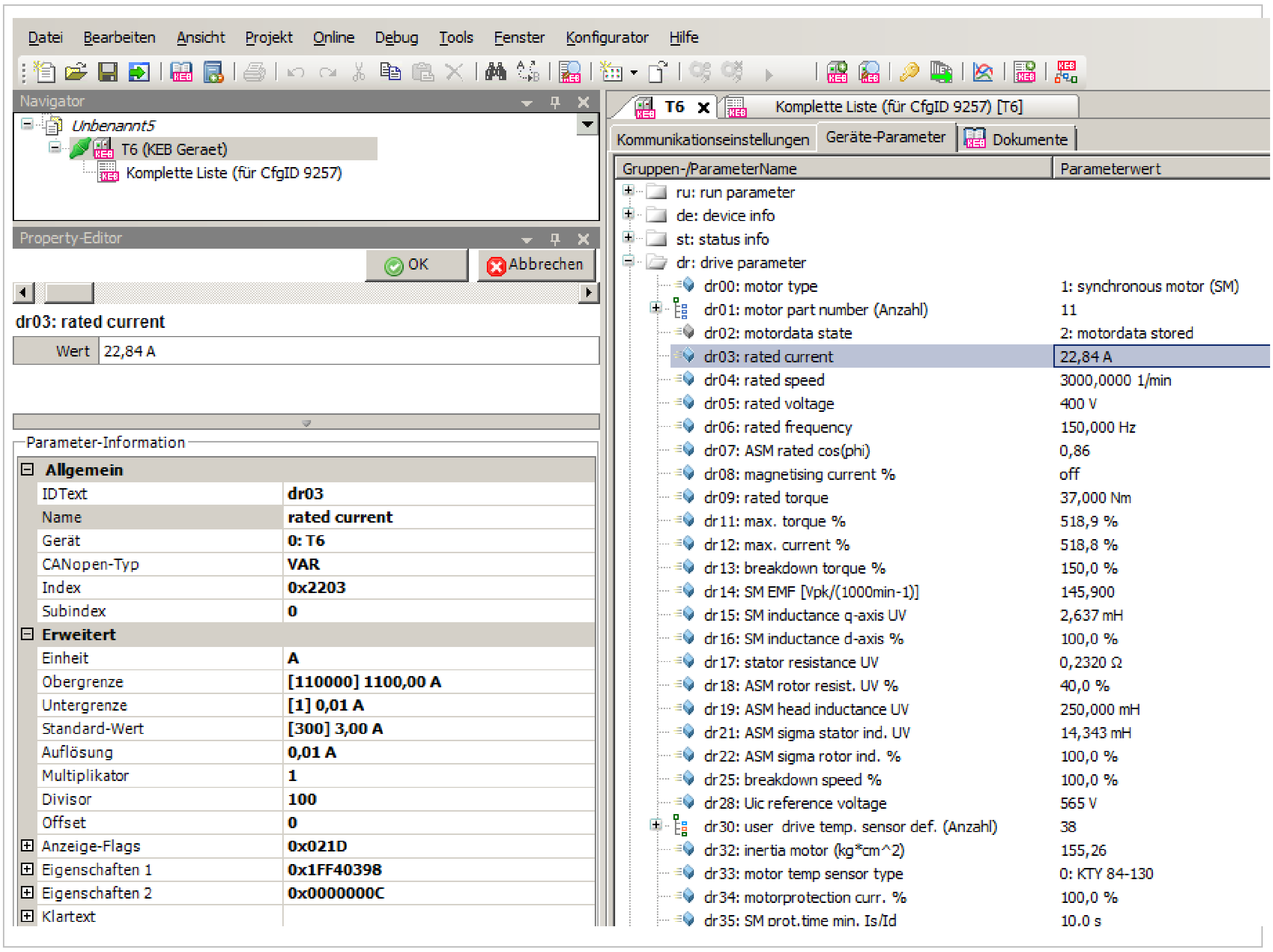


Figure 88: Display object data in COMBIVIS

Object do01 is displayed in the editor: Index 0x2203, Subindex 0 (Typ VAR)

10.2 CanOpen conform parameters

The com profile objects group combines all CanOpen conform objects.

Most of the parameters are identical to KEB specific objects and provide access to the same object only at a different address.

10.2.1 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
0x60B1	0	velocity offset	0x2511	0	co17
0x60B2	0	torque offset	0x2512	0	co18
0x60B8	0	touch probe function	0x310A	0	hm10
0x60B9	0	touch probe status	0x310B	0	hm11
0x60BA	0	touch probe pos1 pos value	0x310C	0	hm12
0x60BB	0	touch probe pos1 neg value	0x310D	0	hm13
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

10.2.2 Not identical objects

10.2.2.1 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 state shutdown is reached by removing of bit 0 in the controlword (switch on) (=> 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) (=> 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 shut-down the modulation and when value 1 is selected as response (stop mode) (=> 4.2.1 Error).

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

10.2.2.2 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 89: Interpolation

10.2.2.3 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	KEB = 20 Manufacturer-Id assigned by the CiA.
		2	product code	00900000h (identical de09)
		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	0x000001A2 => supported drive modes = bit 8 “cyclic sync velocity (csv)”, bit 7 “cyclic sync positioning (csp)” and bit 1 “velocity (vl)”

10.2.2.4 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	0x2C14
7	KEB specific

A value of 0 (no bit set) means: No error

10.2.2.5 Speed displays

There are no KEB specific objects in the same resolution for the following objects:

Index	Sub-Idx	Name	Function
0x606B	0	velocity demand value	Setpoint speed for speed controller (as ru06) but in the resolution of the speed defined by co02
0x6044	0	vl velocity actual value	Actual speed for speed control (as ru08) but with the resolution 1 = 1rpm (resolution of the velocity modes)

10.3 Store data non-volatile

Read-only parameters display only the actual operating state and are not stored. Additionally some parameters must always be set to a defined start value at power on. That means, they are never stored.

These are the following parameters:

ru parameters		Peak value memory are deleted by power on
dr parameters		Parameter changes, which have not yet been confirmed by dr99 are not stored.
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
Interlink parameter		fb10
SACB diagnosis parameters (sb group)		all

All other data, which are not changed for longer than approx. 80ms will be stored. Whether they need to be stored is checked every 2.5 seconds.

The longest time from changing a parameter up to storing into non-volatile memory takes about 2.5 seconds.

- The T6 devices store some parameters automatically non-volatile when the 24V supply voltage for the control part is switched off. The time which is then still available for storing the parameters is dependent on the load on the voltages. Since this time is not sufficient to store all parameters, only data such as error and operating hour counters are stored. The other data are always automatically stored in the background during operation.
- In order to receive a confirmation after parameter download, when the parameters have been stored, each parameter list should be completed by writing of co07 = 0 and then co07 = 1. The second write access is only acknowledged positive when the storing is completed.

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 are automatically stored in the background.
1	manual mode	Changed data are not stored automatically, but only when the 24V supply is switched off (providing that is still possible). To safe the data change into "automatic mode“.

- The „automatic mode“ (co83 = 0) is always active after power on or reset

The actual state of 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 complet-ed 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 T6-DCU 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 only ends after the storage process.

Additionally the setting of co07 non volatile memory state to 0 causes that the memory delay is set to 0 until the next change of co07non volatile memory state to 1.

10.3.1 Reset drive parameterization

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 execute.
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.	

10.3.1.1 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.

10.3.1.2 Triggering of "loading of default values" in download lists

The following must be observed if you want to use the function "loading of default values" in a download list:

Insert object co08 reset options at the first place with value 2.

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 90: Loading of default values in download lists

- Complete the download list with the other required parameters.

10.3.2 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		

11 Annex

11.1 Inverter parameters (address / resolution /type)

Abbreviations	RO	ReadOnly		
	nPD	not available for ProcessDataCommunication		
	CAN	CAN-OPEN type	V	VAR
			ST	Structure
			A	Array

For structures, the name of the structure is entered in the row of subindex 0 (number).

Index	Su-bidx	CAN	Type	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
1000h	0	V	UINT32	device type	4294967295	0	1	1	---	---	x
1018h	0	ST	UINT8	identity object	4	4	1	1	---	---	x
	1		UINT32	vendor ID	20	20	1	1	---	---	x
	2		UINT32	product code	6291456	6291456	1	1	---	---	x
	3		UINT32	revision number	1451	1450	1	1	---	---	x
	4		UINT32	device serial number	4294967295	0	1	1	---	---	x

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
1600h	0	ST	UINT8		1st receive PDO mapping	8	0	1	1	---	x	---
	1…8		UINT32			4294967295	0	1	1	---	x	---
1601h	0	ST	UINT8		2st receive PDO mapping	8	0	1	1	---	x	---
	1…8		UINT32			4294967295	0	1	1	---	x	---
1602h	0	ST	UINT8		3st receive PDO mapping	8	0	1	1	---	x	---
	1…8		UINT32			4294967295	0	1	1	---	x	---
160Fh	0	V	UINT32	in15	configuration ID	9257	9257	1	1	---	x	x
1A00h	0	ST	UINT8		1st transmit PDO mapping	8	0	1	1	---	x	---
	1…8		UINT32			4294967295	0	1	1	---	x	---
1A01h	0	ST	UINT8		2st transmit PDO mapping	8	0	1	1	---	x	---
	1…8		UINT32			4294967295	0	1	1	---	x	---
1A02h	0	ST	UINT8		3st transmit PDO mapping	8	0	1	1	---	x	---
	1…8		UINT32			4294967295	0	1	1	---	x	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2000h	0	V	INT32	de00	device serial number	2147483647	-1	1	1	---	x	x
2002h	0	V	UINT32	de02	device production info	2147483647	0	1	1	---	x	x
2003h	0	V	UINT32	de03	device type	2147483647	0	1	1	---	x	x
2004h	0	V	UINT32	de04	AB number	2147483647	0	1	1	---	x	x
2006h	0	V	UINT32	de06	customer number	2147483647	0	1	1	---	x	x
2008h	0	V	UINT16	de08	device configuration ID	32767	0	1	1	---	x	x
200Ch	0	V	UINT32	de12	ctrl serial number	2147483647	-1	1	1	---	x	x
200Dh	0	V	UINT32	de13	ctrl hw type	2147483647	0	1	1	---	x	x
200Eh	0	V	UINT32	de14	ctrl production info	2147483647	0	1	1	---	x	x
200Fh	0	V	UINT32	de15	ctrl type	2147483647	0	1	1	---	x	x
2010h	0	V	UINT32	de16	ctrl software version	2147483647	0	1	1	---	x	x
2011h	0	V	UINT32	de17	ctrl software date	2147483647	0	1	1	---	x	x
201Ah	0	V	INT32	de26	saved inverter data ID	2147483647	-1	1	1	---	x	x
201Bh	0	V	INT32	de27	inverter data ID	2147483647	-1	1	1	---	x	x
201Ch	0	V	UINT32	de28	inverter rated current	2147483647	0	1	100	A	x	x
201Dh	0	V	UINT32	de29	inverter maximum current	2147483647	0	1	100	A	x	x
201Eh	0	V	UINT16	de30	inverter rated voltage	65535	0	1	10	V	x	x
201Fh	0	V	UINT16	de31	inverter maximum DC voltage	65535	0	1	10	V	x	x
2020h	0	V	UINT16	de32	inverter minimum DC voltage	65535	0	1	10	V	x	x
2021h	0	V	UINT32	de33	inverter rated switching frequency	65535	0	1	100	kHz	x	x
2022h	0	V	UINT32	de34	inverter maximum switching frequency	65535	0	1	100	kHz	x	x
2023h	0	V	UINT16	de35	inverter intermed.circiut capacity[uF]	65535	0	1	1	uF	x	x
202Ch	0	V	UINT32	de44	KTY software version	2147483647	0	1	1	---	x	x
202Dh	0	V	UINT32	de45	KTY software date	2147483647	0	1	1	---	x	x
2039h	0	V	UINT8	de57	OC filter value	255	0	1	1	---	x	
203Ah	0	V	UINT8	de58	adjust data control	3	0	1	1	---	x	
203Bh	0	V	UINT16	de59	Uic gain ctrl	32767	0	1	1	---	x	
203Ch	0	V	UINT16	de60	Iu gain ctrl	32767	0	1	1	---	x	
203Dh	0	V	UINT16	de61	Iv gain ctrl	32767	0	1	1	---	x	
203Eh	0	V	UINT16	de62	Iw gain ctrl	32767	0	1	1	---	x	
2042h	0	V	INT16	de66	Uic offset ctrl	16384	-16384	1	1	---	x	
2043h	0	V	INT16	de67	Iu offset ctrl	16384	-16384	1	1	---	x	
2044h	0	V	INT16	de68	Iv offset ctrl	16384	-16384	1	1	---	x	
2045h	0	V	INT16	de69	Iw offset ctrl	16384	-16384	1	1	---	x	
2064h	0	V	UINT32	de100	hour counter	4294967295	0	1	3600	h	---	x

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2065h	0	V	UINT32	de101	mod hour counter	4294967295	0	1	3600	h	---	x
2066h	0	V	UINT32	de102	OC error count	4294967295	0	1	1	---	---	x
2067h	0	V	UINT32	de103	OL error count	4294967295	0	1	1	---	---	x
2068h	0	V	UINT32	de104	OP error count	4294967295	0	1	1	---	---	x
2069h	0	V	UINT32	de105	OH error count	4294967295	0	1	1	---	---	x
206Ah	0	V	UINT32	de106	OHI error count	4294967295	0	1	1	---	---	x
206Bh	0	V	UINT8	de107	get MD5 hash	1	0	1	1	---	x	---
206Ch	0	A	UINT8	de108	MD5 hash	4	4	1	1	---	x	x
	1…4		UINT32			4294967295	0	1	1	---	---	x
2073h	0	V	UINT32	de115	global drive status mask	4294967295	0	1	1	---	x	
2078h	0	V	UINT32	de120	max output frequency	2147483647	0	1	1	Hz	x	x
2079h	0	V	UINT32	de121	internal service	2147483647	-2147483647	1	1	---	x	

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2100h	0	V	UINT16	st00	statusword	65535	0	1	1	---	---	x
2101h	0	V	UINT16	st01	errorcode	65535	0	1	1	---	---	x
2102h	0	V	INT8	st02	modes of operation displ	127	-1	1	1	---	---	x
2103h	0	V	INT32	st03	vl velocity demand	32767	-32767	1	1	rpm	---	x
2104h	0	V	UINT16	st04	brake ctrl status	65535	0	1	1	---	---	x
210Ch	0	V	UINT16	st12	state machine display	65535	0	1	1	---	---	x
2120h	0	V	INT32	st32	velocity actual value	2147483647	-2147483647	1	1	---	---	x
2121h	0	V	INT32	st33	position actual value	2147483647	-2147483647	1	1	---	---	x
2122h	0	V	INT16	st34	torque actual value	32767	-32767	1	1	---	---	x
2123h	0	V	UINT32	st35	system counter	4294967295	0	1	1	---	---	x
2124h	0	V	INT32	st36	following error	2147483647	-2147483647	1	1	---	---	x
2125h	0	V	INT32	st37	demand position	2147483647	-2147483647	1	1	---	---	x
2130h	0	V	INT16	st48	rho actual value	32767	-32768	1	1	---	---	x

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2200h	0	V	UINT8	dr00	motor type	1	0	1	1	---	x	---
2201h	0	A	UINT8	dr01	motor part number	11	11	1	1	---	x	x
	1...11		UINT8			255	0	1	1	---	x	---
2202h	0	V	UINT8	dr02	motordata state	3	0	1	1	---	x	x
2203h	0	V	UINT32	dr03	rated current	110000	1	1	100	A	x	---
2204h	0	V	UINT32	dr04	rated speed	8192000	1	1	64	rpm	x	---
2205h	0	V	UINT16	dr05	rated voltage	830	120	1	1	V	x	---
2206h	0	V	UINT32	dr06	rated frequency	3200000	1	1	1000	Hz	x	---
2207h	0	V	UINT8	dr07	ASM rated cos(phi)	100	1	1	100	---	x	---
2208h	0	V	UINT16	dr08	magnetising current %	1000	0	1	10	%	x	---
2209h	0	V	UINT32	dr09	rated torque	128000000	0	1	1000	Nm	x	---
220Bh	0	V	UINT16	dr11	max. torque %	60000	0	1	10	%	x	---
220Ch	0	V	UINT16	dr12	max. current %	60000	0	1	10	%	x	---
220Dh	0	V	UINT16	dr13	breakdown torque %	60000	0	1	10	%	x	---
220Eh	0	V	UINT32	dr14	SM EMF [Vpk/(1000min-1)]	60000000	0	1	1000	---	x	---
220Fh	0	V	UINT32	dr15	SM inductance q-axis UV	6000000	1	1	1000	mH	x	---
2210h	0	V	UINT16	dr16	SM inductance d-axis %	10000	1	1	10	%	x	---
2211h	0	V	UINT32	dr17	stator resistance UV	2500000	1	1	10000	Ohm	x	---
2212h	0	V	UINT16	dr18	ASM rotor resist. UV %	6000	1	1	10	%	x	---
2213h	0	V	UINT32	dr19	ASM head inductance UV	6000000	1	1	1000	mH	x	---
2215h	0	V	UINT32	dr21	ASM sigma stator ind. UV	6000000	1	1	1000	mH	x	---
2216h	0	V	UINT16	dr22	ASM sigma rotor ind. %	10000	1	1	10	%	x	---
2219h	0	V	UINT16	dr25	breakdown speed %	10000	1	1	10	%	x	---
221Ch	0	V	UINT16	dr28	Uic reference voltage	830	200	1	1	V	x	---
221Dh	0	V	UINT16	dr29	max. id current fct. [Imax]	1000	0	1	1000	---	x	---
221Eh	0	V	UINT16	dr30	user drive temp. sensor def.	38	38	1	1	---	x	---
221Eh	1	V	INT16		temp value 1	999	-999	1	1	°C	x	---
221Eh	2	V	INT16		temp value 2	999	-999	1	1	°C	x	---
221Eh	3	V	INT16		temp value 3	999	-999	1	1	°C	x	---
221Eh	4	V	INT16		temp value 4	999	-999	1	1	°C	x	---
221Eh	5	V	INT16		temp value 5	999	-999	1	1	°C	x	---
221Eh	6	V	INT16		temp value 6	999	-999	1	1	°C	x	---
221Eh	7	V	INT16		temp value 7	999	-999	1	1	°C	x	---
221Eh	8	V	INT16		temp value 8	999	-999	1	1	°C	x	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
221Eh	9	V	INT16		temp value 9	999	-999	1	1	°C	x	---
221Eh	10	V	INT16		temp value 10	999	-999	1	1	°C	x	---
221Eh	11	V	INT16		temp value 11	999	-999	1	1	°C	x	---
221Eh	12	V	INT16		temp value 12	999	-999	1	1	°C	x	---
221Eh	13	V	INT16		temp value 13	999	-999	1	1	°C	x	---
221Eh	14	V	INT16		temp value 14	999	-999	1	1	°C	x	---
221Eh	15	V	INT16		temp value 15	999	-999	1	1	°C	x	---
221Eh	16	V	INT16		temp value 16	999	-999	1	1	°C	x	---
221Eh	17	V	INT16		temp value 17	999	-999	1	1	°C	x	---
221Eh	18	V	INT16		temp value 18	999	-999	1	1	°C	x	---
221Eh	19	V	INT16		temp value 19	999	-999	1	1	°C	x	---
221Eh	20	V	INT16		temp value 20	999	-999	1	1	°C	x	---
221Eh	21	V	INT16		temp value 21	999	-999	1	1	°C	x	---
221Eh	22	V	INT16		temp value 22	999	-999	1	1	°C	x	---
221Eh	23	V	INT16		temp value 23	999	-999	1	1	°C	x	---
221Eh	34	V	INT16		temp value 24	999	-999	1	1	°C	x	---
221Eh	25	V	INT16		temp value 25	999	-999	1	1	°C	x	---
221Eh	26	V	INT16		temp value 26	999	-999	1	1	°C	x	---
221Eh	27	V	INT16		temp value 27	999	-999	1	1	°C	x	---
221Eh	28	V	INT16		temp value 28	999	-999	1	1	°C	x	---
221Eh	29	V	INT16		temp value 29	999	-999	1	1	°C	x	---
221Eh	30	V	INT16		temp value 30	999	-999	1	1	°C	x	---
221Eh	31	V	INT16		temp value 31	999	-999	1	1	°C	x	---
221Eh	32	V	INT16		temp value 32	999	-999	1	1	°C	x	---
221Eh	33	V	UINT16		R min	32767	0	1	1	Ohm	x	---
221Eh	34	V	UINT16		R max	32767	0	1	1	Ohm	x	---
221Eh	35	V	UINT16		short circuit level	32767	0	1	1	Ohm	x	---
221Eh	36	V	UINT16		no connection level	32767	0	1	1	Ohm	x	---
221Eh	37	V	UINT16		act. calc. resistance (R)	32767	0	1	1	Ohm	x	---
221Eh	38	V	UINT16		Rv	32767	0	1	1	Ohm	x	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2220h	0	V	UINT32	dr32	inertia motor (kg*cm^2)	2000000000	0	1	100	---	x	---
2221h	0	V	UINT8	dr33	motor temp sensor type	1	0	1	1	---	x	---
2222h	0	V	UINT16	dr34	motorprotection curr. %	10000	1	1	10	%	x	---
2223h	0	V	UINT8	dr35	SM prot. time min. Is/Id	255	1	1	10	s	x	---
2224h	0	V	UINT8	dr36	SM prot. time Imax	255	1	1	10	s	x	---
2225h	0	V	UINT16	dr37	SM prot. recovery time	6000	1	1	10	s	x	---
2226h	0	V	UINT16	dr38	SM prot. min. Is/Id	5000	1	1	10	%	x	---
2227h	0	V	UINT8	dr39	ASM prot. mode	1	0	1	1	---	x	---
222Ch	0	V	UINT16	dr44	speed (Lh/EMF ident.) %	10000	0	1	10	%	x	---
222Dh	0	V	UINT16	dr45	ASM u/f boost	4096	0	100	16384	%	x	---
2231h	0	V	UINT32	dr49	sinus filter ind. UV	6000000	0	1	1000	mH	x	---
2233h	0	V	UINT32	dr51	sinus filter resistance UV	2500000	0	1	10000	Ohm	x	---
2234h	0	V	UINT16	dr52	sinus filter cap. UV [uF]	65535	0	1	10	---	---	---
2235h	0	V	UINT16	dr53	sinus filt. min. switch. freq.	65535	0	1	100	kHz	---	---
2236h	0	V	UINT16	dr54	ident	47	0	1	1	---	x	---
2237h	0	V	UINT16	dr55	ident state	255	0	1	1	---	---	---
2238h	0	V	UINT16	dr56	ident Ls/sigma curr. (ampl. mod.)	10000	1	1	10	%	x	---
2239h	0	V	UINT16	dr57	ident error info	255	0	1	1	---	---	---
2240h	0	V	UINT16	dr64	bp filter critical freq. calc.	200	1	1	10	kHz	x	x
2241h	0	V	UINT16	dr65	bp filter frequency set	65535	0	1	10	kHz	---	---
2242h	0	V	UINT16	dr66	bp filter q-factor	10	0	1	10	---	---	---
2263h	0	V	UINT8	dr99	motordata control	2	0	1	1	---	x	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2304h	0	V	UINT32	vl04	vl velocity min amount for	128000	0	1	1	rpm	x	---
2305h	0	V	UINT32	vl05	vl velocity max amount for	128000	0	1	1	rpm	x	---
2306h	0	V	UINT32	vl06	vl velocity min amount rev	128000	0	1	1	rpm	x	---
2307h	0	V	UINT32	vl07	vl velocity max amount rev	128000	0	1	1	rpm	x	---
2314h	0	V	INT32	vl20	vl target velocity	128000	-128000	1	1	rpm	---	---
2315h	0	V	INT32	vl21	target velocity high res	1048576000	-1048576000	1	8192	rpm	---	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2400h	0	V	UINT32	ds00	KP current q-axis [V/A]	2147483647	0	1	10000	---	x	---
2401h	0	V	UINT32	ds01	Tn current q-axis	2147483647	0	1	1000	ms	x	---
2402h	0	V	UINT32	ds02	KP current d-axis [V/A]	2147483647	0	1	10000	---	x	---
2403h	0	V	UINT32	ds03	Tn current d-axis	2147483647	0	1	1000	ms	x	---
2404h	0	V	UINT16	ds04	current mode	16383	0	1	1	---	x	---
2405h	0	V	UINT16	ds05	speed decoupling time	60000	0	1	1000	ms	---	---
2406h	0	V	UINT16	ds06	current decoupling time	60000	0	1	1000	ms	---	---
2407h	0	V	UINT16	ds07	observer factor	600	0	1	10	%	x	---
2408h	0	V	UINT16	ds08	deviation control time	60000	0	1	1000	ms	x	---
2409h	0	V	UINT8	ds09	bp filter coeff. index	8	0	1	1	---	---	---
240Ah	0	V	INT32	ds10	bp filter coeff.	131068	-131068	1	1	---	---	---
240Bh	0	V	UINT16	ds11	torque mode	63	0	1	1	---	x	---
240Ch	0	V	UINT16	ds12	adaption mode	63	0	1	1	---	x	---
240Dh	0	V	UINT16	ds13	torquelimit curve factor	16000	1	1	10	%	x	---
240Eh	0	V	UINT16	ds14	current ctrl. factor	8000	1	1	10	%	x	---
240Fh	0	V	UINT16	ds15	dyn dec curr. ctrl. factor	1000	1	1	10	%	x	---
241Bh	0	V	UINT16	ds27	(A)SCL time speed calc.	65535	0	1	1000	ms	x	---
241Ch	0	V	UINT16	ds28	(A)SCL filter speed calc.	65535	0	1	1000	ms	x	---
241Eh	0	V	UINT16	ds30	SCL model mode	15	0	1	1	---	x	---
241Fh	0	V	UINT16	ds31	SynRM nest optimisation fct.	100	19	1	10	---	x	---
2420h	0	V	UINT16	ds32	SCL stab.term speed	3999	0	1	10	%	x	---
2421h	0	V	UINT32	ds33	SCL stab.term time	2147483647	0	1	1000	ms	x	---
2422h	0	V	UINT16	ds34	stab term max. torque	8000	0	1	10	%	x	---
2423h	0	V	UINT16	ds35	scl stabilisation current	8000	0	1	10	%	x	---
2424h	0	V	UINT16	ds36	min speed for stab.curr.	3999	0	1	10	%	x	---
2425h	0	V	UINT16	ds37	max speed for stab.curr.	3999	0	1	10	%	x	---
2426h	0	V	UINT16	ds38	scl standstill current	8000	0	1	10	%	x	---
2429h	0	V	UINT16	ds41	model ctrl	127	0	1	1	---	x	---
242Ah	0	V	UINT16	ds42	model ctrl. ref. speed time	60000	0	1	1	ms	x	---
242Bh	0	V	UINT16	ds43	model ctrl. act. speed time	60000	0	1	1	ms	x	---
242Eh	0	V	UINT16	ds46	model ctrl. act. speed level	3999	0	1	10	%	x	---
242Fh	0	V	UINT16	ds47	model ctrl. act. speed hyst.	3999	0	1	10	%	x	---
2430h	0	V	UINT16	ds48	model ctrl min. acc/dec [s-2]	1747626666	0	1	100	---	x	---
2437h	0	V	INT16	ds55	Isd offset	8000	-8000	1	10	%	x	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2500h	0	V	UINT16	co00	controlword	65535	0	1	1	---	---	---
2501h	0	V	UINT8	co01	modes of operation	10	0	1	1	---	---	---
2502h	0	V	UINT8	co02	velocity shift factor	13	0	1	1	---	x	---
2503h	0	V	UINT16	co03	position rot.scale (bit)	30	2	1	1	---	---	---
2504h	0	V	UINT8	co04	position source	2	0	1	1	---	---	---
2506h	0	V	UINT8	co06	system inversion	1	0	1	1	---	---	---
2507h	0	V	UINT8	co07	Non volatile memory state	1	0	1	1	---	x	---
2508h	0	V	UINT8	co08	reset options	3	0	1	1	---	x	---
2509h	0	V	UINT16	co09	reset ctrl	1	1	1	1	---	x	---
250Ah	0	V	UINT8	co10	position interpolator	31	4	1	1	---	x	---
250Bh	0	V	UINT8	co11	velocity interpolator	31	0	1	1	---	x	---
250Ch	0	V	UINT8	co12	torque interpolator	31	0	1	1	---	x	---
250Dh	0	V	UINT32	co13	pos. pre control	150000	0	1	1	µs	x	---
250Fh	0	V	INT16	co15	target torque	32767	-32767	1	1	---	---	---
2510h	0	V	INT32	co16	target velocity	2147483647	-2147483647	1	1	---	---	---
2511h	0	V	INT32	co17	velocity offset	2147483647	-2147483647	1	1	---	---	---
2512h	0	V	INT16	co18	torque offset	32767	-32767	1	1	---	---	---
2513h	0	V	DINT32	co19	target position	4294967295	0	1	1	---	---	---
2514h	0	V	UINT32	co20	internal pretorque fakt	655360	0	25	16384	%	x	---
251Eh	0	V	UINT16	co30	controlword mask	65535	0	1	1	---	x	---
251Fh	0	V	UINT16	co31	controlword internal	65535	0	1	1	---	x	---
2520h	0	V	UINT16	co32	state machine properties	255	0	1	1	---	x	---
2521h	0	V	UINT16	co33	ctrlword mirror bit	65535	0	1	1	---	x	---
2522h	0	V	UINT16	co34	statusword mirror bit	65535	0	1	1	---	x	---
2524h	0	V	UINT8	co36	inertia reducing mode	15	0	1	1	---	---	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2525h	0	A	UINT8	co37	inertia reduce fact	64	64	1	1	---	x	x
	1…64		UINT8			255	0	1	1	---	x	---
2526h	0	A	UINT8	co38	inertia derivation fact	64	64	1	1	---	x	x
	1…64		INT8			127	-127	1	1	---	x	---
2527h	0	V	INT32	co39	derivation norm fact	2147483647	0	1	1	---	---	---
2528h	0	A	UINT8	co40	weight comp fact	64	64	1	1	---	x	x
	1…64		INT8			127	-127	1	1	---	x	---
2529h	0	V	INT16	co41	weight comp torque	32767	0	1	1	---	---	---
252Ah	0	V	INT32	co42	speed angle offset	57266231	-57266231	1	572662	ms	---	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2530h	0	V	INT32	co48	acceleration for [s-2]	1747626666	1	1	100	---	---	---
2531h	0	V	INT32	co49	deceleration for [s-2]	1747626666	1	1	100	---	---	---
2532h	0	V	INT32	co50	acceleration rev [s-2]	1747626666	1	1	100	---	---	---
2533h	0	V	INT32	co51	deceleration rev [s-2]	1747626666	1	1	100	---	---	---
2534h	0	V	INT32	co52	for acc jerk ls [s-3]	104857600	50	1	100	---	---	---
2535h	0	V	INT32	co53	for acc jerk hs [s-3]	104857600	50	1	100	---	---	---
2536h	0	V	INT32	co54	for dec jerk hs [s-3]	104857600	50	1	100	---	---	---
2537h	0	V	INT32	co55	for dec jerk ls [s-3]	104857600	50	1	100	---	---	---
2538h	0	V	INT32	co56	rev acc jerk ls [s-3]	104857600	50	1	100	---	---	---
2539h	0	V	INT32	co57	rev acc jerk hs [s-3]	104857600	50	1	100	---	---	---
253Ah	0	V	INT32	co58	rev dec jerk hs [s-3]	104857600	50	1	100	---	---	---
253Bh	0	V	INT32	co59	rev dec jerk ls [s-3]	104857600	50	1	100	---	---	---
253Ch	0	V	UINT8	co60	ramp mode	15	0	1	1	---	---	---
253Dh	0	V	UINT16	co61	stop mode torque lim. src.	511	0	1	1	---	---	---
253Eh	0	V	UINT16	co62	selectable stop mode torque	10000	0	1	10	%	---	---
2553h	0	V	UINT8	co83	non volatile memory mode	1	0	1	1	---	x	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2601h	0	A	UINT8	do01	flag operand A	4	4	1	1	---	x	x
	1…4		UINT16			53	0	1	1	---	---	---
2602h	0	A	UINT8	do02	flag operand B	4	4	1	1	---	x	x
	1…4		UINT16			53	0	1	1	---	---	---
2603h	0	A	UINT8	do03	flag operator mode	4	4	1	1	---	x	x
	1…4		UINT16			255	0	1	1	---	---	---
2605h	0	A	UINT8	do05	flag level 1	4	4	1	1	---	x	x
	1…4		INT32			2147483647	-2147483648	1	10000	---	---	---
2606h	0	A	UINT8	do06	flag level 2	4	4	1	1	---	x	x
	1…4		INT32			2147483647	-2147483648	1	1	---	---	---
2607h	0	A	UINT8	do07	flag hyst. operand B	4	4	1	1	---	x	x
	1…4		INT32			2147483647	0	1	10000	---	---	---
2608h	0	A	UINT8	do08	filter time flags	4	4	1	1	---	x	x
	1…4		UINT32			10000000	0	1	1000	ms	---	---
260Ah	0	V	UINT16	do10	dig. out ext. source	255	0	1	1	---	---	---
260Bh	0	V	UINT16	do11	dig. out logic	255	0	1	1	---	x	---
260Ch	0	V	UINT32	do12	dig. output src. sel.	65535	0	1	1	---	x	---
2613h	0	V	UINT16	do19	AND operation for output	255	0	1	1	---	x	---
2618h	0	V	UINT16	do24	select flag OA	15	0	1	1	---	---	---
2619h	0	V	UINT16	do25	select flag OB	15	0	1	1	---	---	---
261Ah	0	V	UINT16	do26	select flag OC	15	0	1	1	---	---	---
261Bh	0	V	UINT16	do27	select flag OD	15	0	1	1	---	---	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2700h	0	V	UINT8	cs00	control mode	19	0	1	1	---	x	---
2701h	0	V	UINT32	cs01	KP speed [%Mn/rpm]	10737418	0	1	10000	---	x	---
2703h	0	V	UINT16	cs03	Viable KP speed gain	10240	0	1	1024	---	x	---
2704h	0	V	UINT16	cs04	V.KP speed max. offset	5120	0	100	1024	%	x	---
2705h	0	V	UINT32	cs05	Tn speed	1073741823	0	1	1000	ms	x	---
2706h	0	V	UINT16	cs06	variable kp speed offset	65535	0	1	10	%	x	---
2707h	0	V	UINT16	cs07	variable ki speed offset	65535	0	1	10	%	x	---
2708h	0	V	UINT16	cs08	speed for max. kp/ki	10000	0	1	10	%	x	---
2709h	0	V	UINT16	cs09	speed for normal kp/ki	10000	0	1	10	%	x	---
270Ch	0	V	INT16	cs12	absolute torque	10000	-10000	1	10	%	---	---
270Dh	0	V	INT16	cs13	torque limit mot. for	10000	0	1	10	%	---	---
270Eh	0	V	INT16	cs14	torque limit mot. rev.	10000	-1	1	10	%	---	---
270Fh	0	V	INT16	cs15	torque limit gen. for.	10000	-2	1	10	%	---	---
2710h	0	V	INT16	cs16	torque limit gen. rev.	10000	-2	1	10	%	---	---
2711h	0	V	UINT32	cs17	inertia load (kg*cm^2)	2000000000	0	1	100	---	x	---
2712h	0	V	UINT16	cs18	ref. position PT1-time	60000	0	1	1000	ms	---	---
2713h	0	V	UINT16	cs19	ref. speed PT1-time	60000	0	1	1000	ms	---	---
2714h	0	V	UINT16	cs20	torque ref. PT1-time	60000	0	1	1000	ms	---	---
2715h	0	V	UINT16	cs21	pretorque mode	2	0	1	1	---	x	---
2716h	0	V	UINT16	cs22	pretorque PT1-time	60000	0	1	1000	ms	x	---
2717h	0	V	UINT16	cs23	pretorque delta time	8	1	1000	4000	ms	x	---
2718h	0	V	UINT16	cs24	pretorque factor	60000	0	1	10	%	x	---
2719h	0	V	UINT16	cs25	speed ctrl (KP) adaption	1000	0	1	10	%	---	---
271Ah	0	V	UINT16	cs26	speed ctrl (KI) adaption	1000	0	1	10	%	---	---
271Bh	0	V	UINT16	cs27	speed ctrl KP/KI adapt mode	1	0	1	1	---	---	---
2763h	0	V	UINT8	cs99	optimisation factor	100	19	1	10	---	x	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2900h	0	V	UINT8	aa00	simulation mode	255	0	1	1	---	---	---
2910h	0	V	UINT32	aa16	user parameter 0	4294967295	0	1	1	---	---	---
2911h	0	V	UINT32	aa17	user parameter 1	4294967295	0	1	1	---	---	---
2912h	0	V	UINT32	aa18	user parameter 2	4294967295	0	1	1	---	---	---
2913h	0	V	UINT32	aa19	user parameter 3	4294967295	0	1	1	---	---	---
2914h	0	V	UINT32	aa20	user parameter 4	4294967295	0	1	1	---	---	---
2915h	0	V	UINT32	aa21	user parameter 5	4294967295	0	1	1	---	---	---
2916h	0	V	UINT32	aa22	user parameter 6	4294967295	0	1	1	---	---	---
2917h	0	V	UINT32	aa23	user parameter 7	4294967295	0	1	1	---	---	---
2950h	0	V	UINT8	aa80	found optimal current	1	0	1	1	---	---	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2A03h	0	V	UINT16	pn03	OL warning level	1000	0	1	10	%	---	---
2A04h	0	V	UINT8	pn04	E.OL stop mode	1	0	1	1	---	---	---
2A05h	0	V	UINT16	pn05	OL2 warning level	1000	200	1	10	%	---	---
2A06h	0	V	UINT8	pn06	temperature warning setting mode	1	0	1	1	---	---	---
2A07h	0	V	UINT16	pn07	OH warning level	1500	0	1	10	°C	---	---
2A08h	0	V	UINT8	pn08	E.OH stop mode	1	0	1	1	---	---	---
2A09h	0	V	UINT16	pn09	OHI warning time	6000	0	1	10	s	---	---
2A0Ah	0	V	UINT8	pn10	E.OHI stop mode	1	0	1	1	---	---	---
2A0Bh	0	V	UINT16	pn11	dOH warning level	2000	0	1	10	°C	---	---
2A0Ch	0	V	UINT8	pn12	E.dOH stop mode	8	0	1	1	---	---	---
2A0Dh	0	V	UINT16	pn13	E.dOH delay time	1200	0	1	10	s	---	---
2A0Eh	0	V	UINT16	pn14	dOH error level	2000	0	1	10	°C	---	---
2A0Fh	0	V	UINT16	pn15	OH2 warning level	1000	0	1	10	%	---	---
2A10h	0	V	UINT8	pn16	E.OH2 stop mode	8	0	1	1	---	---	---
2A11h	0	V	UINT16	pn17	eff. load time	30000	1	1	100	s	---	---
2A12h	0	V	INT32	pn18	sw.- switch limit left	2147483647	-2147483648	1	1	INC	---	---
2A13h	0	V	INT32	pn19	sw.- switch limit right	2147483647	-2147483648	1	1	INC	---	---
2A14h	0	V	UINT8	pn20	E.SW-switch stop mode	8	0	1	1	---	---	---
2A15h	0	V	UINT16	pn21	fieldbus watchdog time	16000	0	1	4	ms	---	---
2A16h	0	V	UINT8	pn22	E.fb watchdog stop mode	8	0	1	1	---	---	---
2A1Ah	0	V	UINT16	pn26	overspeed level	8000	0	1	10	%	---	---
2A1Bh	0	V	UINT8	pn27	E.overspeed stop mode	8	0	1	1	---	---	---
2A1Ch	0	V	UINT16	pn28	warning mask	65535	0	1	1	---	---	---
2A1Dh	0	V	UINT8	pn29	prg. error stop. mode	8	0	1	1	---	---	---
2A1Eh	0	V	UINT16	pn30	prg. error source	4095	0	1	1	---	---	---
2A24h	0	V	INT32	pn36	max acc/dec level [s-2]	1747626666	1	1	100	---	---	---
2A25h	0	V	UINT8	pn37	E.max acc/dec stop mode	8	0	1	1	---	---	---
2A26h	0	V	UINT16	pn38	speed diff level	8000	0	1	10	%	---	---
2A27h	0	V	UINT16	pn39	speed diff time	65535	0	1	4	ms	---	---
2A28h	0	V	UINT8	pn40	E.speed diff stop mode	8	0	1	1	---	---	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2A2Dh	0	V	INT16	pn45	fault reaction time	30000	0	1	4	ms	---	---
2A2Eh	0	V	UINT16	pn46	fault reaction end src	4095	0	1	1	---	---	---
2A2Fh	0	V	INT32	pn47	fault reaction ref velocity	128000	-128000	1	1	rpm	---	---
2A30h	0	V	INT32	pn48	fr acceleration for [s-2]	1747626666	1	1	100	---	---	---
2A31h	0	V	INT32	pn49	fr deceleration for [s-2]	1747626666	1	1	100	---	---	---
2A32h	0	V	INT32	pn50	fr acceleration rev [s-2]	1747626666	1	1	100	---	---	---
2A33h	0	V	INT32	pn51	fr deceleration rev [s-2]	1747626666	1	1	100	---	---	---
2A34h	0	V	INT32	pn52	fr for acc jerk ls [s-3]	104857600	50	1	100	---	---	---
2A35h	0	V	INT32	pn53	fr for acc jerk hs [s-3]	104857600	50	1	100	---	---	---
2A36h	0	V	INT32	pn54	fr for dec jerk hs [s-3]	104857600	50	1	100	---	---	---
2A37h	0	V	INT32	pn55	fr for dec jerk ls [s-3]	104857600	50	1	100	---	---	---
2A38h	0	V	INT32	pn56	fr rev acc jerk ls [s-3]	104857600	50	1	100	---	---	---
2A39h	0	V	INT32	pn57	fr rev acc jerk hs [s-3]	104857600	50	1	100	---	---	---
2A3Ah	0	V	INT32	pn58	fr rev dec jerk hs [s-3]	104857600	50	1	100	---	---	---
2A3Bh	0	V	INT32	pn59	fr rev dec jerk ls [s-3]	104857600	50	1	100	---	---	---
2A3Ch	0	V	UINT8	pn60	fault reaction ramp mode	15	0	1	1	---	---	---
2A3Eh	0	V	UINT8	pn62	fault reaction properties	1	0	1	1	---	---	---
2A46h	0	V	UINT16	pn70	overspeed factor (EMF)	1000	0	1	10	%	x	---
2A47h	0	V	UINT8	pn71	E. overspeed (EMF) st. mode	8	0	1	1	---	---	---
2A48h	0	V	UINT32	pn72	overspeed level (EMF)	2147483647	0	1	8192	rpm	---	x

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2B0Ah	0	V	UINT16	fb10	sync interval	16000	0	1	1	µs	x	---
2B0Bh	0	V	UINT16	fb11	set sync level	1000	0	1	10	µs	x	---
2B0Ch	0	V	UINT16	fb12	KP sync PLL	256	0	1	1	---	x	---
2B12h	0	V	UINT16	fb18	sync PLL offset	2500	0	1	10	µs	x	---
2B13h	0	V	UINT16	fb19	measured sync interval	65535	0	4	5	µs	x	x

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2C01h	0	V	UINT8	ru01	exception state	255	0	1	1	---	---	x
2C02h	0	V	UINT16	ru02	warning bits	65535	0	1	1	---	---	x
2C03h	0	V	UINT8	ru03	warning state	255	0	1	1	---	---	x
2C04h	0	V	UINT8	ru04	supply unit state	255	0	1	1	---	---	x
2C05h	0	V	INT32	ru05	set value display	2147483647	-2147483647	1	8192	rpm	---	x
2C06h	0	V	INT32	ru06	ramp out display	2147483647	-2147483647	1	8192	rpm	---	x
2C07h	0	V	INT32	ru07	act. frequency	2147483647	-2147483647	1	8192	Hz	---	x
2C08h	0	V	INT32	ru08	act. value	2147483647	-2147483647	1	8192	rpm	---	x
2C0Ah	0	V	INT32	ru10	act. apparent current	110000	-110000	1	100	A	---	x
2C0Bh	0	V	INT32	ru11	act. active current	110000	-110000	1	100	A	---	x
2C0Ch	0	V	INT32	ru12	act. reactive current	110000	-110000	1	100	A	---	x
2C0Dh	0	V	INT32	ru13	peak apparent current	110000	-110000	1	100	A	---	x
2C0Eh	0	V	UINT16	ru14	act. Uic voltage	65535	0	1	10	V	---	x
2C0Fh	0	V	UINT16	ru15	peak Uic voltage	65535	0	1	10	V	---	x
2C10h	0	V	UINT16	ru16	act. output voltage	10000	0	1	10	V	---	x
2C11h	0	V	UINT16	ru17	modulation grade	1100	0	100	16384	%	---	x
2C12h	0	V	UINT16	ru18	dig. input state	65535	0	1	1	---	---	x
2C13h	0	V	UINT16	ru19	internal output state	65535	0	1	1	---	---	x
2C14h	0	V	UINT16	ru20	dig. output state	65535	0	1	1	---	---	x
2C15h	0	V	UINT16	ru21	dig. output flags	65535	0	1	1	---	---	x
2C17h	0	V	INT16	ru23	reference torque	32767	-32768	100	1024	%	---	x
2C18h	0	V	INT16	ru24	actual torque	32767	-32768	100	1024	%	---	x
2C19h	0	V	INT16	ru25	heatsink temperature	32767	-32767	1	10	°C	---	x
2C1Ah	0	V	INT16	ru26	internal temperature PU	32767	-32767	1	10	°C	---	x
2C1Bh	0	V	UINT16	ru27	OL2 counter	1000	0	1	10	%	---	x
2C1Ch	0	V	INT16	ru28	motor temperature	32767	-32767	1	10	°C	---	x
2C1Dh	0	V	UINT16	ru29	OL counter	100	0	1	10	%	---	x
2C20h	0	V	UINT16	ru32	motor prot. counter	1000	0	1	10	%	---	x

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2C22h	0	V	INT16	ru34	act. torque lim. mot for	10000	0	1	10	%	---	x
2C23h	0	V	INT16	ru35	act. torque lim. mot rev	10000	0	1	10	%	---	x
2C24h	0	V	INT16	ru36	act. torque lim. gen for	10000	0	1	10	%	---	x
2C25h	0	V	INT16	ru37	act. torque lim. gen rev	10000	0	1	10	%	---	x
2C32h	0	V	INT16	ru50	act. torque lim. pos.	10000	0	1	10	%	---	x
2C33h	0	V	INT16	ru51	act. torque lim. neg.	10000	0	1	10	%	---	x
2C34h	0	V	UINT32	ru52	system date	4294967295	0	1	1	---	---	x
2C35h	0	V	UINT32	ru53	system time	4294967295	0	1	1	---	---	x
2C39h	0	V	UINT16	ru57	eff. motor load	65535	0	1	10	%	---	x
2C3Ah	0	V	UINT8	ru58	actual index	31	0	1	1	---	---	x
2C48h	0	V	UINT16	ru72	act. switch. freq	3200	0	1	100	kHz	---	x
2C49h	0	V	INT16	ru73	Imot/ImaxOl2	8000	0	1	10	%	---	x
2C4Ah	0	V	UINT16	ru74	unfiltered flags state	65535	0	1	1	---	---	x
2C4Bh	0	V	UINT32	ru75	gloabl drive state	4294967295	0	1	1	---	---	x
2C4Ch	0	V	UINT32	ru76	drive state	4294967295	0	1	1	---	---	x
2C50h	0	V	INT16	ru80	relative torque	10000	0	1	10	%	---	x
2C51h	0	V	INT16	ru81	act torque	500000000	0	1	1000	Nm	---	x
2C52h	0	V	INT16	ru82	actual power	2	2	1	1	---	---	x
2C52h	1	V	INT16		mechanical power	2147483647	-2147483647	1	1000	kW	---	x
2C52h	2	V	INT16		electrical output power	2147483647	-2147483647	1	1000	kW	---	x

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2D00h	0	V	INT16	of00	graph 1 para select	32767	-1	1	1	---	---	x
2D01h	0	V	INT16	of01	graph 2 para select	32767	-1	1	1	---	---	x
2D02h	0	V	INT16	of02	graph 3 para select	32767	-1	1	1	---	---	x
2D03h	0	V	INT16	of03	graph 4 para select	32767	-1	1	1	---	---	x
2D04h	0	V	UINT16	of04	time base	32000	63	1	1	µs	---	x
2D05h	0	V	UINT16	of05	trigger source	65535	0	1	1	---	---	x
2D06h	0	V	UINT8	of06	trigger position	100	0	1	1	%	---	x
2D07h	0	V	UINT8	of07	Synchronisation	255	0	1	1	---	---	x
2D08h	0	V	UINT8	of08	trigger status	255	0	1	1	---	---	x
2D09h	0	V	UINT8	of09	select graph adr	0	0	1	1	---	---	x
2D0Ah	0	V	INT32	of10	read para 1	2147483647	-2147483648	1	1	---	---	x
2D0Bh	0	V	INT32	of11	read para 2	2147483647	-2147483648	1	1	---	---	x
2D0Ch	0	V	INT32	of12	read para 3	2147483647	-2147483648	1	1	---	---	x
2D0Dh	0	V	INT32	of13	read para 4	2147483647	-2147483648	1	1	---	---	x
2D21h	0	V	INT16	of33	scope data 1 defin.	32767	-1	1	1	---	---	x
2D22h	0	V	UINT8	of34	scope data 1 set	128	1	1	1	---	---	x
2D23h	0	V	INT16	of35	scope data 2 defin.	32767	-1	1	1	---	---	x
2D24h	0	V	UINT8	of36	scope data 2 set	128	1	1	1	---	---	x
2D25h	0	V	INT16	of37	scope data 3 defin.	32767	-1	1	1	---	---	x
2D26h	0	V	UINT8	of38	scope data 3 set	128	1	1	1	---	---	x
2D27h	0	V	INT16	of39	scope data 4 defin.	32767	-1	1	1	---	---	x
2D28h	0	V	UINT8	of40	scope data 4 set	128	1	1	1	---	---	x

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2E00h	0	V	UINT16	ps00	position control mode	2	0	1	1	---	---	---
2E01h	0	V	UINT16	ps01	KP position controller	65000	0	1	10	rpm	---	---
2E02h	0	V	UINT16	ps02	KP zero speed position ctrl	65000	0	1	10	rpm	---	---
2E03h	0	V	UINT16	ps03	KP speed limit reduction %	1000	0	1	10	%	x	---
2E04h	0	V	INT32	ps04	Speed limit for ps03	128000	0	1	1	rpm	---	---
2E0Ah	0	V	UINT16	ps10	position ctrl limit %	10000	0	1	10	%	x	---
2E0Ch	0	V	UINT32	ps12	following error window	2147483647	0	1	1	---	x	---
2E0Dh	0	V	UINT16	ps13	following error time out	65535	0	1	4	ms	---	---
2E0Eh	0	V	UINT32	ps14	positioning window	2147483647	0	1	1	---	x	---
2E0Fh	0	V	UINT16	ps15	positioning window time	65535	0	1	4	ms	---	---
2E10h	0	V	INT32	ps16	sw position limit pos	2147483647	-2147483647	1	1	---	---	---
2E11h	0	V	INT32	ps17	sw position limit neg	2147483647	-2147483647	1	1	---	---	---
2E12h	0	V	INT32	ps18	min position range limit	2147483647	-2147483647	1	1	---	---	---
2E13h	0	V	INT32	ps19	max position range limit	2147483647	-2147483647	1	1	---	---	---
2E14h	0	V	INT32	ps20	range ref window	2147483647	0	1	1	---	---	---
2E15h	0	V	UINT16	ps21	ref error count	65535	0	1	1	---	---	x
2E16h	0	V	UINT16	ps22	posi setup state	2	0	1	1	---	---	x
2E17h	0	V	UINT16	ps23	position range periods	32767	0	1	1	---	x	---
2E18h	0	V	UINT16	ps24	range correction	2048	0	1	1	---	x	---
2E1Eh	0	V	INT32	ps30	profile velocity	128000	-128000	1	1	rpm	---	---
2E1Fh	0	V	INT32	ps31	end velocity	128000	-128000	1	1	rpm	---	---
2E20h	0	V	INT32	ps32	max profile velocity	128000	-128000	1	1	rpm	---	---
2E21h	0	V	UINT8	ps33	absolute positioning	4	0	1	1	---	---	---
2E26h	0	V	UINT8	ps38	positioning module	1	0	1	1	---	---	---
2E27h	0	A	UINT8	ps39	index position	32	32	1	1	---	x	x
	1…32		INT32			2147483647	-2147483647	1	1	---	---	---
2E28h	0	A	UINT8	ps40	index speed	32	32	1	1	---	x	x
	1…32		INT32			128000	-128000	1	1	rpm	---	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
2E29h	0	A	UINT8	ps41	index end speed	32	32	1	1	---	x	x
	1…32		INT32			128000	-128000	1	1	rpm	---	---
2E2Ah	0	A	UINT8	ps42	next index	32	32	1	1	---	x	x
	1…32		INT8			32	-1	1	1	---	---	---
2E2Bh	0	A	UINT8	ps43	index mode	32	32	1	1	---	x	x
	1…32		UINT8			5	0	1	1	---	---	---
2E2Ch	0	V	UINT16	ps44	immediately input	16383	0	1	1	---	---	---
2E2Dh	0	V	INT8	ps45	immediately index	31	0	1	1	---	---	---
2E2Eh	0	V	INT8	ps46	start index	31	-1	1	1	---	---	---
2E2Fh	0	V	INT8	ps47	active index	31	-1	1	1	---	---	x
2E30h	0	V	INT32	ps48	ps acceleration for [s-2]	1747626666	1	1	100	---	---	---
2E31h	0	V	INT32	ps49	ps deceleration for [s-2]	1747626666	1	1	100	---	---	---
2E32h	0	V	INT32	ps50	ps acceleration rev [s-2]	1747626666	1	1	100	---	---	---
2E33h	0	V	INT32	ps51	ps deceleration rev [s-2]	1747626666	1	1	100	---	---	---
2E34h	0	V	INT32	ps52	ps for acc jerk ls [s-3]	104857600	50	1	100	---	---	---
2E35h	0	V	INT32	ps53	ps for acc jerk hs [s-3]	104857600	50	1	100	---	---	---
2E36h	0	V	INT32	ps54	ps for dec jerk hs [s-3]	104857600	50	1	100	---	---	---
2E37h	0	V	INT32	ps55	ps for dec jerk ls [s-3]	104857600	50	1	100	---	---	---
2E38h	0	V	INT32	ps56	ps rev acc jerk ls [s-3]	104857600	50	1	100	---	---	---
2E39h	0	V	INT32	ps57	ps rev acc jerk hs [s-3]	104857600	50	1	100	---	---	---
2E3Ah	0	V	INT32	ps58	ps rev dec jerk hs [s-3]	104857600	50	1	100	---	---	---
2E3Bh	0	V	INT32	ps59	ps rev dec jerk ls [s-3]	104857600	50	1	100	---	---	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
3001h	0	V	INT16	ud01	password	9999	0	1	1	---	---	---
300Ah	0	A	UINT8	ud10	exception history date	16	16	1	1	---	x	x
	1…16		UINT32			4294967295	0	1	1	---	---	x
300Bh	0	A	UINT8	ud11	exception history time	16	16	1	1	---	x	x
	1…16		UINT32			4294967295	0	1	1	---	---	x
300Ch	0	A	UINT8	ud12	history exception state	16	16	1	1	---	x	x
	1…16		UINT8			255	0	1	1	---	---	x
300Dh	0	A	UINT8	ud13	exception history data 1	16	16	1	1	---	x	x
	1…16		UINT32			4294967295	0	1	1	---	---	x
300Eh	0	A	UINT8	ud14	exception history data 2	16	16	1	1	---	x	x
	1…16		UINT32			4294967295	0	1	1	---	---	x
300Fh	0	A	UINT8	ud15	exception history data 3	16	16	1	1	---	x	x
	1…16		UINT8			255	0	1	1	---	---	x
23010h	0	A	UINT8	ud16	exception history data 4	16	16	1	1	---	x	x
	1…16		UINT8			255	0	1	1	---	---	x
3011h	0	V	INT16	ud17	history data 1 selector	32767	-1	1	1	---	x	---
3012h	0	V	INT16	ud18	history data 2 selector	32767	-1	1	1	---	x	---
3013h	0	V	INT16	ud19	history data 3 selector	32767	-1	1	1	---	x	---
3014h	0	V	INT16	ud20	history data 4 selector	32767	-1	1	1	---	x	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
3200h	0	V	UINT16	di00	dig. input logic	4095	0	1	1	---	---	---
3201h	0	V	UINT32	di01	dig. input src. sel.	16777215	0	1	1	---	x	---
3202h	0	V	UINT16	di02	dig. input ext. src.	4095	0	1	1	---	---	---
320Ah	0	V	UINT16	di10	RUN input	16383	0	1	1	---	---	---
320Bh	0	V	UINT16	di11	RST input	16383	0	1	1	---	---	---
320Ch	0	V	UINT16	di12	CA input	16383	0	1	1	---	---	---
320Dh	0	V	UINT16	di13	CA mask	65535	0	1	1	---	---	---
320Eh	0	V	UINT16	di14	CB input	16383	0	1	1	---	---	---
320Fh	0	V	UINT16	di15	CB mask	65535	0	1	1	---	---	---
3210h	0	V	UINT16	di16	forward input	65535	0	1	1	---	---	---
3211h	0	V	UINT16	di17	reverse input	65535	0	1	1	---	---	---
3212h	0	V	UINT16	di18	vl zero speed input	65535	0	1	1	---	---	---
3213h	0	V	UINT16	di19	start posi input	65535	0	1	1	---	---	---
3214h	0	V	UINT16	di20	REV input	16383	0	1	1	---	---	---
3215h	0	V	UINT16	di21	index input	16383	0	1	1	---	---	---
3216h	0	V	UINT16	di22	index noise filter	4000	0	1	2	ms	---	---
3217h	0	V	UINT16	di23	HALT input	16383	0	1	1	---	---	---
3226h	0	V	UINT32	di38	IA input function	4294967295	0	1	1	---	---	x
3227h	0	V	UINT32	di39	IB input function	4294967295	0	1	1	---	---	x
3228h	0	V	UINT32	di40	IC input function	4294967295	0	1	1	---	---	x
3229h	0	V	UINT32	di41	ID input function	4294967295	0	1	1	---	---	x
322Ah	0	V	UINT32	di42	STO1 input function	4294967295	0	1	1	---	---	x
322Bh	0	V	UINT32	di43	STO2 input function	4294967295	0	1	2	---	---	x

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
3500h	0	V	UINT16	is00	Uic mode	15	0	1	1	---	---	---
3501h	0	V	UINT16	is01	Uic PT1-time	60000	63	1	1000	ms	---	---
3502h	0	V	UINT16	is02	Uic comp voltage limit	800	200	1	1	V	---	---
3505h	0	V	UINT8	is05	deadtime index	255	0	1	1	---	x	---
3506h	0	V	UINT8	is06	deadtime coeff.	255	0	1	1	---	x	---
3507h	0	V	UINT16	is07	deadtime comp mode	3	0	1	1	---	x	---
3508h	0	V	UINT16	is08	comp limit fact	20000	0	1	100	%	x	---
3509h	0	V	UINT16	is09	comp current fact	20000	0	1	100	%	x	---
350Ah	0	V	UINT16	is10	switching frequency	800	200	1	100	kHz	---	---
350Bh	0	V	UINT16	is11	max current [de28%]	8000	0	1	10	%	x	---
350Ch	0	V	UINT16	is12	display apparent current PT1	65535	0	1	1000	ms	---	---
350Dh	0	V	UINT16	is13	display torque PT1	65535	0	1	1000	ms	---	---
350Eh	0	V	UINT16	is14	overload protect mode	2	0	1	1	---	---	---
350Fh	0	V	UINT8	is15	temp dep derating	1	0	1	1	---	---	---
3510h	0	V	UINT16	is16	min. derating frequency	800	0	1	100	kHz	---	---
3512h	0	V	UINT16	is18	UP error level	10000	500	1	10	V	---	---
3513h	0	V	UINT16	is19	UP reset level	10000	500	1	10	V	---	---
3514h	0	V	UINT16	is20	OL2 prot gain	45000	0	1	100	---	---	---
3515h	0	V	UINT16	is21	OL2 safety fact	1000	500	1	10	%	---	---
3516h	0	V	UINT8	is22	basic Tp	0	0	1	1	---	---	---
3522h	0	V	UINT16	Is34	display power PT1	65535	0	1	1000	ms	---	---
3524h	0	V	UINT8	Is36	hardw.curr.ctrl. (HSR) mode	1	0	1	1	---	---	---
3525h	0	V	UINT16	Is37	HSR current [OCLimit%]	1000	0	1	10	%	---	---
3526h	0	V	UINT32	is38	HSR active counter	4294967295	0	1	1	---	---	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
3601h	0	V	UINT16	dd01	SCL rotor detection	255	0	1	1	---	---	---
3602h	0	V	UINT16	dd02	rotor detection current	3999	1	1	10	%	---	---
3603h	0	V	UINT16	dd03	cvv current ramping time	16000	0	1	1	ms	---	---
3604h	0	V	UINT16	dd04	cvv waiting time	16000	0	1	1	ms	---	---
3607h	0	V	UINT16	dd07	rotor det. 1.order level	500	1	1	10	%	---	---
3608h	0	V	UINT16	dd08	rot. det. inf. (1.order)	1000	0	1	10	%	---	x
3609h	0	V	UINT16	dd09	rotor det. 2.order level	500	1	1	10	%	---	---
360Ah	0	V	UINT16	dd10	rot. det. inf. (2.order)	1000	0	1	10	%	---	x
3610h	0	V	UINT16	dd16	speed search mode	4	0	1	1	---	---	---
3612h	0	V	UINT16	dd18	speed search current [In]	1999	250	1	10	%	---	---
3615h	0	V	UINT16	dd21	hf injection mode	1	0	1	1	---	x	---
3616h	0	V	UINT16	dd22	hf inj. frequency	20	5	1	10	kHz	x	---
3617h	0	V	UINT16	dd23	hf inj. optimisation factor	100	19	1	10	---	x	---
3618h	0	V	UINT16	dd24	hf inj. ampl. factor	1999	250	1	10	%	x	---
3619h	0	V	UINT16	dd25	hf inj. speed ctrl red. factor	1000	100	1	10	%	x	---
361Ah	0	V	INT16	dd26	hf inj. scan time	7	-1	1	1	---	x	---
361Bh	0	V	UINT16	dd27	hf inj. angle precontrol mode	1	0	1	1	---	x	---
361Ch	0	V	INT16	dd28	hf inj. angle prec. factor [° @ InMot]	1800	-1800	1	10	---	---	---
361Dh	0	V	UINT32	dd29	hf inj. dev. time	64000	8000	1	1000	ms	x	---
361Eh	0	V	INT16	dd30	hf inj. diff. rho current res. [°]	32767	-32768	1	100	---	x	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
3700h	0	V	UINT16	fc00	Umax regulation mode	17	0	1	1	---	---	---
3701h	0	V	UINT32	fc01	KP Umax [%Irated/%U]	10000000	0	1	1000	---	x	---
3702h	0	V	UINT32	fc02	Ki Umax [%Irated/%U s]	24000000	0	1	1000	---	x	---
3703h	0	V	UINT16	fc03	Umax reference	1100	0	1	10	%	---	---
3704h	0	V	UINT16	fc04	max. modulation grade	1100	0	1	10	%	---	---
3705h	0	V	UINT16	fc05	Umax reg. limit	4000	0	1	10	%	---	---
3710h	0	V	UINT16	fc16	ASM flux mode	31	0	1	1	---	---	---
3711h	0	V	UINT16	fc17	ASM min. flux	1000	0	1	10	%	---	---
3712h	0	V	UINT32	fc18	ASM KP flux [A/A]	2147483647	0	1	1000	---	x	---
3713h	0	V	UINT32	fc19	ASM Tn flux	2147483647	0	1	1000	ms	x	---
3714h	0	V	UINT16	fc20	ASM flux reg. limit	1999	0	1	10	%	---	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
3800h	0	V	UINT16	mo00	saturation mode	2047	0	1	1	---	x	---
3801h	0	ST	Uint8	mo01	saturation coefficients (number)	13	0	1	1	---	x	x
	1		float32		Ld0 [H]			1	1	---	x	---
	2		float32		Ld1 [H]			1	1	---	x	---
	3		float32		Kd [1/A^2]			1	1	---	x	---
	4		float32		Kdq [1/A^2]			1	1	---	x	---
	5		float32		Lq0[H]			1	1	---	x	---
	6		float32		Lq1[H]			1	1	---	x	---
	7		float32		Kq [1/A^2]			1	1	---	x	---
	8		float32		Kqd [1/A^2]			1	1	---	x	---
	9		float32		Psi0 [Vs]			1	1	---	x	---
	10		float32		Psi1 [Vs]			1	1	---	x	---
	11		float32		Kpd [1/A^2]			1	1	---	x	---
	12		float32		Kpq [1/A^2]			1	1	---	x	---
	13		float32		I0 [A]			1	1	---	x	---
3802h	0	ST	Uint8	mo02	saturation coef dr-group (number)	13	0	1	1	---	x	x
	1		float32		Ld0 [H]			1	1	---	x	x
	2		float32		Ld1 [H]			1	1	---	x	x
	3		float32		Kd [1/A^2]			1	1	---	x	x
	4		float32		Kdq [1/A^2]			1	1	---	x	x
	5		float32		Lq0[H]			1	1	---	x	x
	6		float32		Lq1[H]			1	1	---	x	x
	7		float32		Kq [1/A^2]			1	1	---	x	x
	8		float32		Kqd [1/A^2]			1	1	---	x	x
	9		float32		Psi0 [Vs]			1	1	---	x	x
	10		float32		Psi1 [Vs]			1	1	---	x	x
	11		float32		Kpd [1/A^2]			1	1	---	x	x
	12		float32		Kpq [1/A^2]			1	1	---	x	x
	13		float32		I0 [A]			1	1	---	x	x
3803h	0	V	Uint16	mo03	fill table sel. (ms04…ms10)	1	0	1	1	---	x	---
3804h	0	A	Uint8	mo04	Isq opt. array (Iq=f(M))	16	0	1	1	---	x	---
	1…16		float32					1	1	---	x	---
3805h	0	A	Uint8	mo05	Isd opt. array (Id=f(M))	16	0	1	1	---	x	---
	1…16		float32					1	1	---	x	---
3806h	0	A	Uint8	mo06	MLim array (M=f(Imax))	16	0	1	1	---	x	---
	1…16		float32					1	1	---	x	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
3808h	0	A	Uint8	mo08	IqLim array (I=f(IdRef))	16	0	1	1	---	x	---
	1…16		float32					1	1	---	x	---
3809h	0	V	float32	mo09	Current Tab. x-axis [A]			1	1	---	x	---
380Ah	0	V	float32	mo10	Torque Tab. x-axis [Nm]			1	1	---	x	---
3810h	0	V	UINT8	mo16	cogging mode	1	0	1	1	---	---	---
3811h	0	A	UINT8	mo17	cogg. frequency factor	4	4	1	1	---	x	x
			INT8			127	0	1	1	---	x	---
3812h	0	A	UINT8	mo18	cogg. magnitude [%Mn]	4	4	1	1	---	x	x
			INT16			1024	0	100	1024	%	x	---
3813h	0	A	UINT8	mo19	cogg. phase [°]	4	4	1	1	---	x	x
			INT16			32767	-32768	10000	1820444	---	x	---
3814h	0	V	INT32	mo20	cogg. fade out speed 100% [rpm]	819200000	0	1	8192	rpm	---	---
3815h	0	V	INT32	mo21	cogg. fade out speed 0% [rpm]	819200000	0	1	8192	rpm	---	---
3816h	0	V	INT16	mo22	cogging PT1-time	32767	0	1	4096	ms	---	---

Index	Su-bidx	CAN	Type	IDtxt	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
3A00h	0	V	UINT16	ai00	freq. ident	65535	0	1	1	Hz	---	---
3A01h	0	V	UINT16	ai01	freq.decoup	65535	0	1	1	Hz	---	---
3A02h	0	V	UINT32	ai02	amp. ident	4294967295	0	1	1	V	---	---
3A03h	0	V	UINT32	ai03	amp. decoup	4294967295	0	1	1	V	---	---
3A04h	0	V	UINT8	ai04	set RhoDC mode	1	0	1	1	---	---	---
3A05h	0	V	UINT32	ai05	RhoDC[°]	4294967295	0	1	1	---	---	---
3A06h	0	V	UINT32	ai06	Isd ref.	4294967295	0	1	1	A	---	---
3A07h	0	V	UINT32	ai07	Isq ref.	4294967295	0	1	1	A	---	---
3A08h	0	V	UINT8	ai08	ident start	1	0	1	1	---	---	---
3A09h	0	V	UINT32	ai09	RhoHF[°]	4294967295	0	1	1	---	---	---
3A0Ah	0	V	UINT32	ai10	theta1	4294967295	0	1	1	---	---	---
3A0Bh	0	V	UINT32	ai11	theta2	4294967295	0	1	1	---	---	---
3A0Ch	0	V	UINT32	ai12	theta3	4294967295	0	1	1	---	---	---
3A0Dh	0	V	UINT32	ai13	L	4294967295	0	1	1	mH	---	---
3A0Eh	0	V	UINT8	ai14	ready flag	1	0	1	1	---	---	---
3A0Fh	0	V	UINT8	ai15	USearch start	1	0	1	1	---	---	---
3A10h	0	V	UINT32	ai16	USearch I ref.	4294967295	0	1	1	A	---	---
3A11h	0	V	UINT32	ai17	USearch result	4294967295	0	1	1	V	---	---
3A12h	0	V	UINT8	ai18	USearch info	4	0	1	1	---	---	---
3A13h	0	V	UINT8	ai19	ident coeff.	8	0	1	1	---	---	---
3A14h	0	V	INT32	ai20	Ud	2147483647	-2147483648	1	1	---	---	---
3A15h	0	V	INT32	ai21	Uq	2147483647	-2147483648	1	1	---	---	---
3A16h	0	V	INT32	ai22	Id	2147483647	-2147483648	1	1	---	---	---
3A17h	0	V	INT32	ai23	Iq	2147483647	-2147483648	1	1	---	---	---

Index	Su-bidx	CAN	Type	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
603Fh	0	V	UINT16	error code	65535	0	1	1	---	---	x
6040h	0	V	UINT16	controlword	65535	0	1	1	---	---	---
6041h	0	V	UINT16	statusword	65535	0	1	1	---	---	x
6042h	0	V	INT32	vl target velocity	128000	-128000	1	1	rpm	---	---
6043h	0	V	INT32	vl velocity demand	32767	-32767	1	1	rpm	---	x
6044h	0	V	INT32	vl velocity actual value	32767	-32767	1	1	rpm	---	x
605Ah	0	V	INT16	Quickstop option code	0	-2	1	1	---	x	---
605Bh	0	V	INT16	shutdown option code	1	-1	1	1	---	x	---
605Ch	0	V	INT16	disable operation option code	1	-1	1	1	---	x	---
605Eh	0	V	INT16	fault reaction option code	0	-1	1	1	---	x	---
6060h	0	V	UINT8	modes of operation	10	0	1	1	---	---	---
6061h	0	V	INT8	modes of operation display	127	-1	1	1	---	---	x
6062h	0	V	INT32	position demand value	2147483647	-2147483647	1	1	---	---	x
6064h	0	V	INT32	position actual value	2147483647	-2147483647	1	1	---	---	x
6065h	0	V	UINT32	following error window	2147483647	0	1	1	---	x	---
6066h	0	V	UINT16	following error time out	65535	0	1	1	---	---	---
6067h	0	V	UINT32	positioning window	2147483647	0	1	1	---	x	---
6068h	0	V	UINT16	positioning window time	65535	0	1	1	---	---	---
606Bh	0	V	INT32	velocity demand value	2147483647	-2147483647	1	1	---	---	x
606Ch	0	V	INT32	velocity actual value	2147483647	-2147483647	1	1	---	---	x
6071h	0	V	INT16	target torque	32767	-32767	1	1	---	---	---
6072h	0	V	INT16	max torque	10000	-10000	1	1	---	---	---
6077h	0	V	INT16	torque actual value	32767	-32767	1	1	---	---	x
607Ah	0	V	UINT32	target position	4294967295	0	1	1	---	---	---

Index	Su-bidx	CAN	Type	Name	Upper limit	Lower limit	Mult.	Div	Unit	nPD	RO
607Bh	0	A	UINT8	position range limit	2	2	1	1		x	x
	1…2		INT32		2147483647	-2147483647	1	1	---	---	---
607Ch	0	V	INT32	home offset	2147483647	-2147483647	1	1	---	---	---
607Dh	0	A	UINT8	software position limit	2	2	1	1	---	x	x
	1…2		INT32		2147483647	-2147483647	1	1	---	---	---
607Fh	0	V	INT32	max profile velocity	128000	-128000	1	1	---	---	---
6081h	0	V	INT32	profile velocity	128000	-128000	1	1	---	---	---
6082h	0	V	INT32	end velocity	128000	-128000	1	1	---	---	---
60B1h	0	V	INT32	velocity offset	2147483647	-2147483647	1	1	---	---	---
60B2h	0	V	INT16	torque offset	32767	-32767	1	1	---	---	---
60B8h	0	V	UINT16	touch probe function	55	0	1	1	---	---	---
60B9h	0	V	UINT16	touch probe status	255	0	1	1	---	---	x
60BAh	0	V	INT32	touch probe pos1 pos value	2147483647	-2147483647	1	1	---	---	x
60BBh	0	V	INT32	touch probe pos1 neg value	2147483647	-2147483647	1	1	---	---	x
60C2h	0	A	UINT8	interpolation time period	2	2	1	1	---	x	x
	1		INT8		127	0	1	1	---	x	---
	2		INT8		127	-127	1	1	---	x	---
60E0h	0	V	INT16	positive torque limit value	10000	0	1	1	---	---	x
60E1h	0	V	INT16	negative torque limit value	10000	-1	1	1	---	---	x
60F4h	0	V	INT32	following error actual value	2147483647	-2147483647	1	1	---	---	x
60FFh	0	V	INT32	target velocity	2147483647	-2147483647	1	1	---	---	x
6502h	0	V	INT32	supported drive modes	2147483647	-2147483647	1	1	---	---	x

11.2 History of changes

Revision	Chapter	Change
Start		Programming manual DCU 2.3
00	4.2.3.18	Description Power Off function
	5.6	new parameter ru80 / ru81
	5.7	Extension ru82
	4.1.4	new parameter st13
	4.2.3.2.3	Correction of description for is21
	4.1.5	Extension of the setting options in co32
	4.2.3.3 4.2.3.4	Changing the behaviour in case of overtemperature (new parameters pn81/pn82)
	4.2.3.3 4.2.3.2	new function pn06
	5.1, 5.2	New function display/evaluation „diff speed“ (ru83, pn40, switching conditions)
	4.2.1.2.2	new programmable error reactions added
	4.2.4	new values for the quickstop option code
	4.3.3.4.3	co60 Bit 2 (texts s-curve) corrected
	6.1.3.6.3	Information content from parameters (dr15/dr16)
	6.2.4	new image variable proportional/integral factor
	6.1.8.4.2	new plaintexts ds11
	10.3	Description of co07 changed
	6.1.23	DC Brake introduction
	6.1.22	Introduction controlled protection features
	11.1	Type changed from co19 // 607D to INT32
	5.6	Changed resolution of torque displays
	5.8	Change heading level ru75, ru76, de115
	6.1.22	Extension of value range dr99 to 2
	6.1.13.1	Introduction dr48,dr46,dr47,mo32 new description of the v/f characteristic
		Homing function deleted in all chapters from description
		Revision of the description of is22 Basic Tp and is10 switching frequency => removal of setting options that cannot be used with T6
		Description ERROR extreme overpotential and ERROR capacitor damaged removed, not present at T6
	4.2.3.17	Chapter DC link voltage fluctuations added
	5.11.1	Parameter de09 no longer available

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