Drive System SD2

Device Control

SIEB & MEYER AG

Auf dem Schmaarkamp 21 * D-21339 Lüneburg * (Germany)
Telephone: +49 - 4131 - 203 - 0 * Telefax: +49 - 4131 - 203 - 2000
E-Mail: documentation@sieb-meyer.de
Internet: http://www.sieb-meyer.de

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Identification Key

036-servo_bed_sinudyn36.21Gerätesteuerung/R03-SM-EN-HG/SÜ/UH
May 22, 2012

1 Symbols

The following table explains the symbols used in this manual for describing purposes. Technical symbols and signs are supposed to be known and therefore not explained.

Symbol	Meaning	
	Warning: danger	
	Warning: electrostatically sensitice devices (ESD)	
	Warning: dangerous voltage	
	Warning: hot surfaces	
	Indicates general notes, to which special attention should be paid to.	
	Indicates measures or steps to be taken by the user.	
	LEDs indicating the module status	LED on
		LED off
		LED flashes
	Earthing	
	PE-connector (protective earth connector)	
	Ground (GND)	

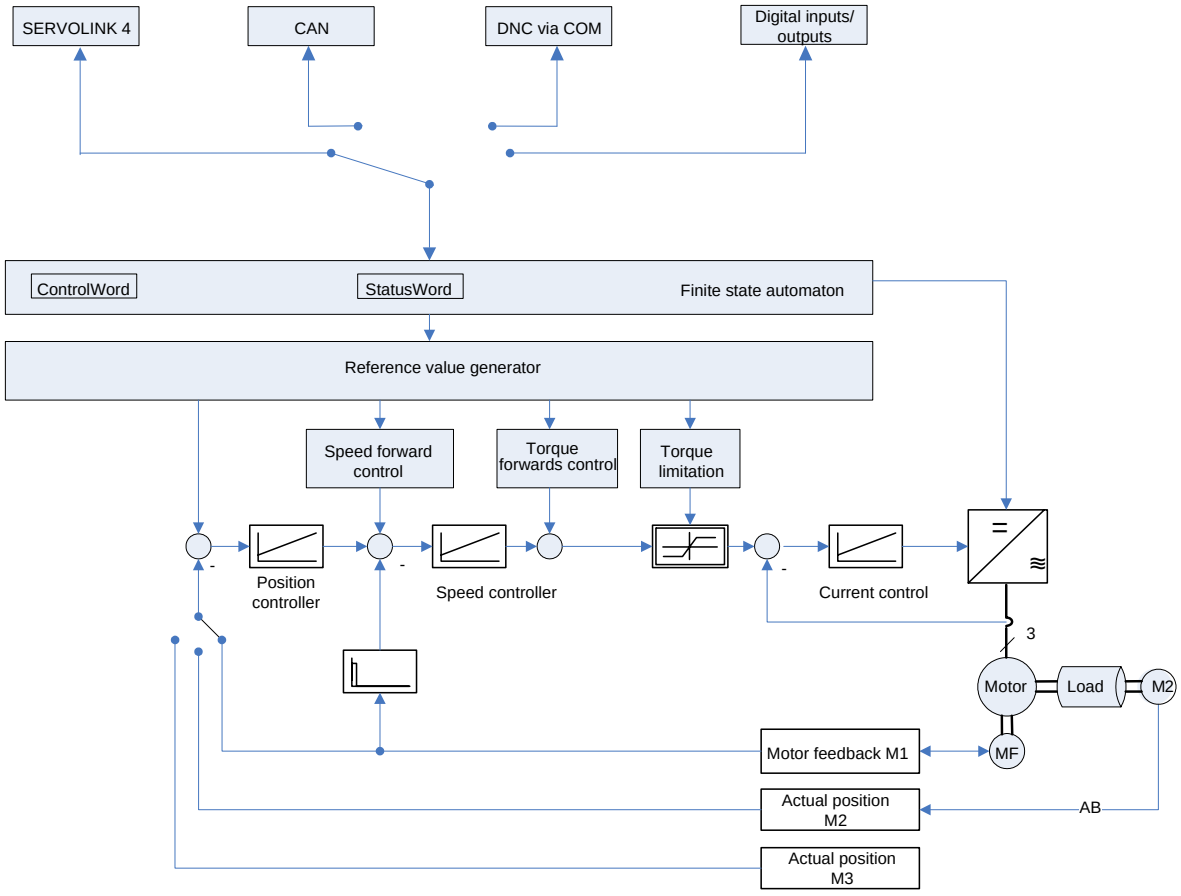
2 Finite State Automaton (FSA)

2.1 Overview

The finite state automaton is the central unit of the drive. In the finite state automaton, the system decides of which control channel reference values are to be processed and whereto actual values are to be sent.

The state of the drive is controlled via the control word. The finite state automaton provides the state of the drive via the "status word". The "Remote Mode" allows controlling the device via a bus system.

The device control comprises:
- the finite state automaton
- the individual operating modes
- the control word
- the status word.

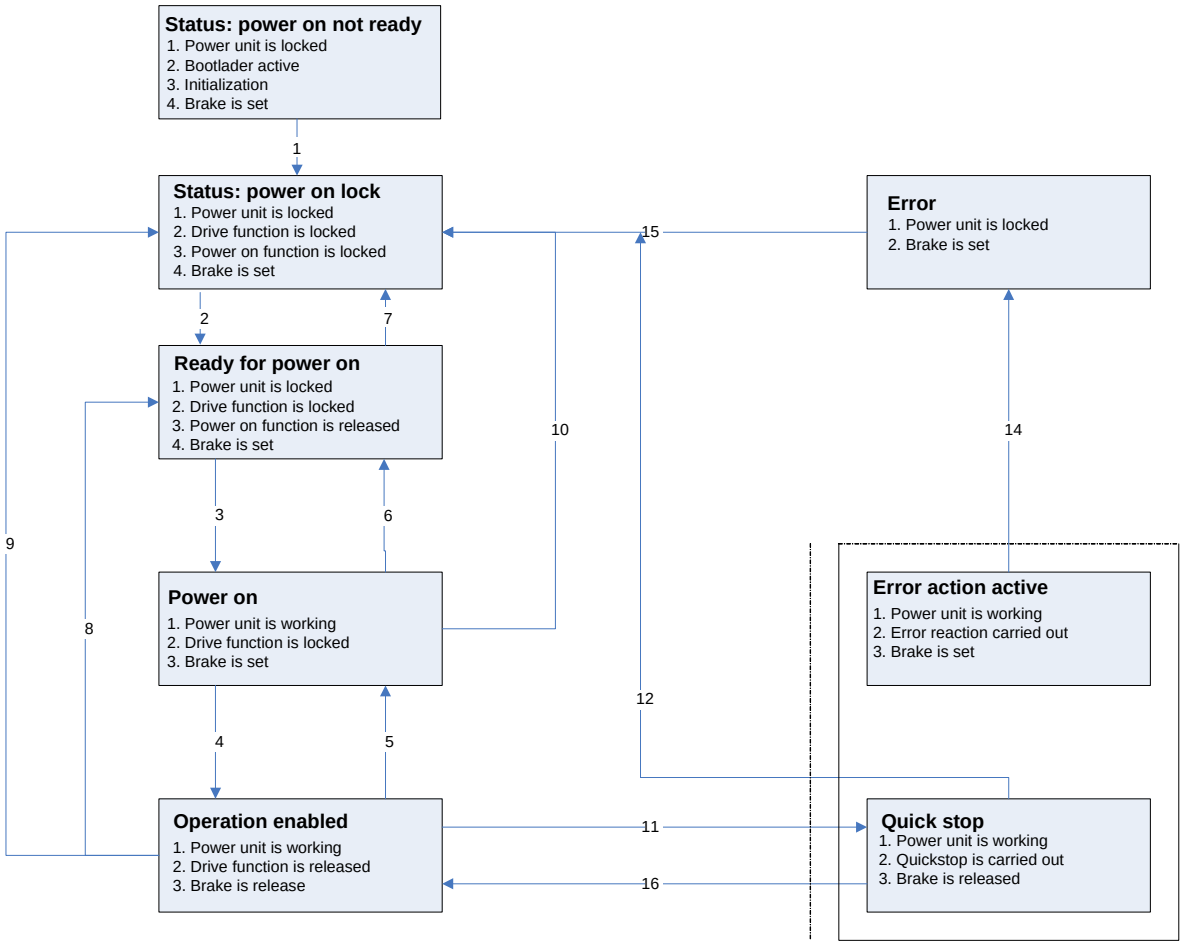


2.2 Finite State Automaton

The device status machine has the following tasks:

- Description of the status and the possible **control sequences** of the drive. The control sequences in turn depend from the status of the drive.
- Representation of the different **status of the drive** and switching of the corresponding operating modes

The following figure shows the possible **control sequences** of the drive:



2.3 States of the finite state automaton

2.3.1 "Not Ready to Switch On"

- The drive is being initialized (about 10 s).
  - Initialization
  - Self test
  - Loading the drive parameters
- Power unit is disabled.
- The drive function is disabled.
- A brake, if present, is activated.
- SERVOLINK/CAN/DNC connection is available.

2.3.2 "Switch On Disabled"

- The initialization is completed.
- No faults have been detected.
- Power unit is off.
- The drive function is disabled.
- A motor brake, if present, is active

2.3.3 "Ready to Switch On"

- No faults have been detected.
- Power supply provided.
- Power unit is off.
- The drive function is disabled.
- A motor brake, if present, is active

2.3.4 "Switched On"

- No faults have been detected.
- Power supply provided.
- Power unit is on.
- The drive function is disabled, no reference values are being processed.
- No torque transmitted to the motor.
- A motor brake, if present, is active

2.3.5 "Operation Enabled"

- No faults have been detected.
- Power supply provided.
- Power unit is on.
- The drive function is enabled, reference values are being processed.
- A motor brake, if present, is released.

2.3.6 "Quick Stop Active"

- No faults have been detected.
- Power supply provided.
- The drive function is enabled.
- The Quick Stop function is being executed
- Power unit is on, the reference values are generated by the quick stop reaction.
- A motor brake, if present, is released.

2.3.7 "Fault Reaction Active"

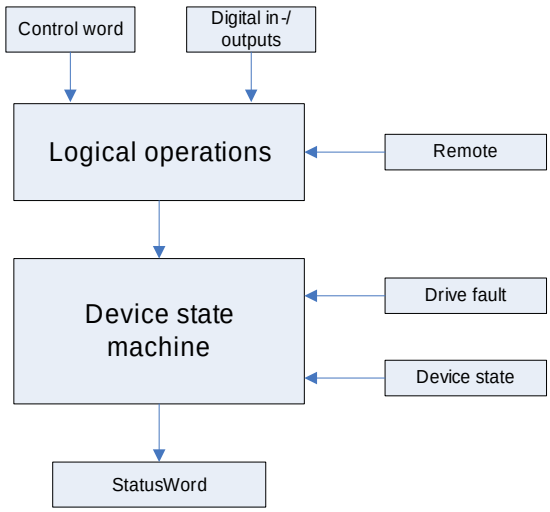
- A fault has occurred in the drive.
- Energy provided in the intermediate circuit.
- Fault reaction is being executed.
- The drive function is enabled.
- Power unit is on, the reference values are generated by the fault reaction.
- At the end of the fault reaction the system automatically changes into the state "Fault".
- A motor brake, if present, is released.

2.3.8 "Fault"

- A fault has occurred in the drive.
- The fault reaction is finished.
- Power unit is off.
- The drive function is disabled.
- The Switch On mode is disabled.
- A motor brake, if present, is active

2.4 Control Word

The device state machine is externally controlled via the status word and other external signals. During this process the access of the control word to the device state is controlled via the remote signal.



2.4.1 Control Word Object Number 68_D

Bit	Name	Description
0	Switch on	Power unit is to be switched on
1	Disable voltage	The voltage at the power unit can be switched on
2	Quick stop	The quick stop is to be activated
3	Enable operation	Enable drive function
4	Dependent on the operating mode	See chapter "Operating Modes“
5	Dependent on the operating mode	See chapter "Operating Modes“
6	Dependent on the operating mode	See chapter "Operating Modes“
7	Fault reset	Drive fault is acknowledged
8	Hold	Stop function
9		Reserved
10		Reserved
11		Reserved
12		Reserved
13		Reserved
14		Reserved
15		Reserved

Bits 0, 1, 2, 3 and 7:	The finite state automaton commands are mapped via these finite state automaton commands.
Bits 4, 5, 6:	At present, these bits are set to "0" for all bits.
Bits 8, 9, 10, 12, 13:	These control bits are reserved for future applications and must be set to "0".

2.4.2 Finite State Automaton Commands

The finite state automaton commands are mapped via the bits 0 to 3 and 7 of the control word as shown in the following table. Whether or not a finite state automaton command can be executed by the drive depends on the state of the drive.

Command	Bits of the Control Word					Transitions	Control Word
	Bit 7 Fault reset	Bit 3 Enable operation	Bit 2 Quick stop	Bit 1 Disable voltage	bit 0 Switch on		
Shutdown	0	x	1	1	0	2, 6, 8	6
Switch on	0	x	1	1	1	3	7
Disable voltage	0	x	x	0	x	7, 9, 10, 12	0
Quick stop	0	x	0	1	x	11	2
Disable operation	0	0	1	1	1	5	7
Enable operation	0	1	1	1	1	4	15
Fault reset	1	x	x	x	x	15	128

Positive edge / change from 0 to 1

x The bits labeled with X have no relevance at he corresponding position in the table.

2.4.3 Status Word Object Number 67_D

Bit	Name	Description
0	Ready to be switched on	Drive is ready to be switched on
1	Switched on	Drive is switched on
2	Enable operation	Operation enabled
3	Fault	A fault has occurred in the drive (see chapter "Fault Behavior", page 41)
4	Voltage enabled	Intermediate circuit voltage provided
5	Quick stop	Quick stop active
6	Switch on disabled	The drive can not be switched on
7	Warning message	The drive signals a warning message (see chapter "Warning Messages“, page 12 and "Fault Behavior", page 41).
8		Reserved
9	Remote	The control is realized via a bus system.
10	Target reached	Reference value was reached (see chapter "Operating Mode", page 19)
11	Limit reached	Internal limitation in the drive is active (see chapter "Operating Modes", page 19)
12	Dependent on the operating mode	See below
13	Dependent on the operating mode	See below
14		Reserved
15		Reserved

Bits 0, 1, 2, 3, 4, 5 and 6: The state of the device, i.e. the state of the device state machine is mapped

Bits 7, 10, 11, 12, 13: Additional information on the drive (dependent on the operating mode)

Operational mode	Bit 12	Bit 13
Velocity mode 1	Speed zero	Reference value for current limitation reached.
Interpolated position control	Interpolated position control active	Positional error ⟶ warning threshold

2.4.4 Device States

The states of the finite state automaton are indicated as follows via the status bits 0 to 3 and 5 to 6:

State	Bits of the status word					
	Bit 6 Switch on disabled	Bit 5 Quick stop	Bit 3 Fault	Bit 2 Enable operation	Bit 1 Switched on	bit 0 Ready to be switched on
Not ready to switch on	0	x	0	0	0	0
Switch on disabled	1	x	0	0	0	0
Ready to be switched on	0	1	0	0	0	1
Switched on	0	1	0	0	1	1
Enable operation	0	1	0	1	1	1
Quick stop	0	0	0	1	1	1
Fault reaction active	0	x	1	1	1	1
Fault	0	x	1	0	0	0

2.5 Warning Messages

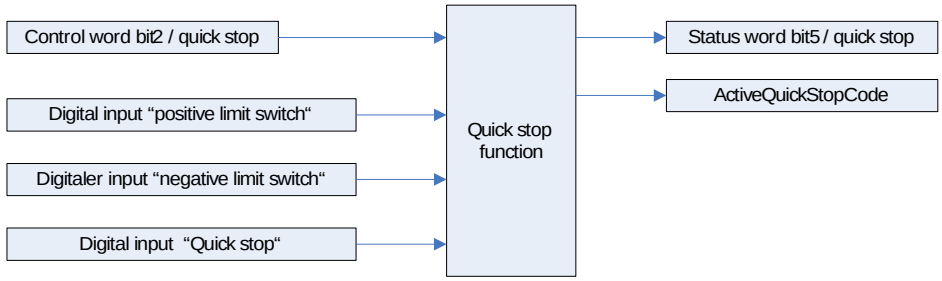
Different warning messages are generated in the drive which can be indicated via the bit 7 / warning in the status word.

All warning messages are internally mapped as coded bits in a warning register with a length of 32 bits. This warning register can directly be read-out of the drive via the object WARNING_REGISTER (index 87). Additionally it can be defined via the object WARNING_REGISTER_MASK (index 88) which warning message on the bit 7 / warning is to be mapped in the status word. Via the object WARNING_CREATES_ERROR_MASK (object number 89) it can be defined whether one or several warning messages are to indicate a drive fault. The corresponding fault reaction can be defined by the user.

A detailed list of the warning messages can be found in the chapter "Fault Behavior" (page 41).

3 Quick Stop

The quick stop function makes it possible to decelerate the drive from the operating mode "Operation enabled" into the operating mode "Quick stop". This function can be executed via the finite state automaton command "Quick stop" or directly via a digital input.



3.1 Objects for the Quick Stop Function

3.1.1 Object 71_D DEV_CTRL_QUICKSTOP_ACTUAL_CODE

The reason for the quick stop command can be read-out of the drive via the object DEV_CTRL_QUICKSTOP_ACTUAL_CODE.

Object description

Index	**$0x71_D$**
Name	DEV_CTRL_QUICKSTOP_ACTUAL_CODE
Access right	Readable if the drive parameters have been set.
Data type	U16
Unit	no

Data description

DEV_CTRL_QUICKSTOP_ACTUAL_CODE	**Reason for quick stop**
0x070D	Digital input for "SpeedEnable
0x070C	Digital input "Positive limit switch"
0x070B	Digital input "Negative limit switch"
0x0708	Software positioning error "Positive limit"
0x0707	Software positioning error "Negative limit"
0x0704	Digital input "Quick stop"
0x0703	Software function "Quick stop"

3.1.2 Object 74_D DEV_CTRL_QUICKSTOP_OPTION_CODE

The reaction to the finite state automaton command "Quick stop" can be parameterized via the object DEV_CTRL_QUICKSTOP_OPTION_CODE.

Object description

Index	**$0x74_D$**
Name	DEV_CTRL_QUICKSTOP_OPTION_CODE
Access right	Readable / writable if the drive parameters have been set.
Data type	U16
Unit	no

Data description

DEV_CTRL_QUICKSTOP_OPTION_CODE	**Quick stop reaction**
-3	Hold torque
-2	Ramp down torque
0	Switch off power unit immediately
1	Ramp down with deceleration ramp
2	Ramp down with quick stop ramp
3	Ramp down at the current limit
4	Ramp down at the voltage limit
5	Ramp down with deceleration ramp and remain in the state "Quick stop" (the command "Disable voltage" must be entered)
6	Ramp down with quick stop ramp and remain in the quick stop state (the command "Disable voltage" must be entered)
7	Ramp down at the current limit and remain in the quick stop state (the command "Disable voltage" must be entered)
8	Ramp down at the voltage limit and remain in the quick stop state (the command "Disable voltage" must be entered)

3.1.3 Object 188_D SPG_QUICKSTOP_DECELERATION_TIME_VL

The ramp of the quick stop brake can be reset in the operating mode "Velocity mode" via the object 0. The ramp time is related to a reference speed value of 100%.

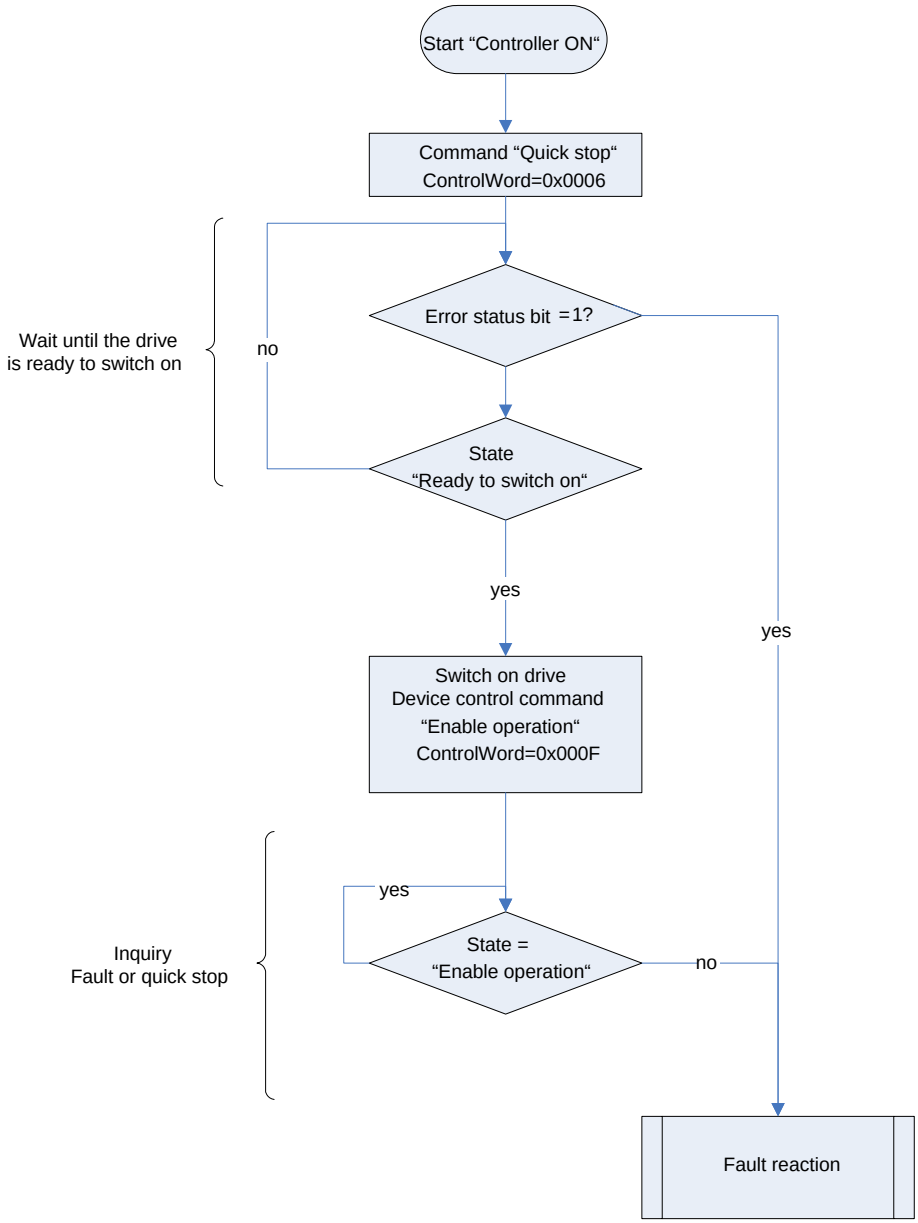
Object description

Index	**188_D**
Name	SPG_QUICKSTOP_DECELERATION_TIME_VL
Access right	Always readable and writable
Data type	U32
Unit	ms
Maximum value	10.000000 msec

4 Control Sequences

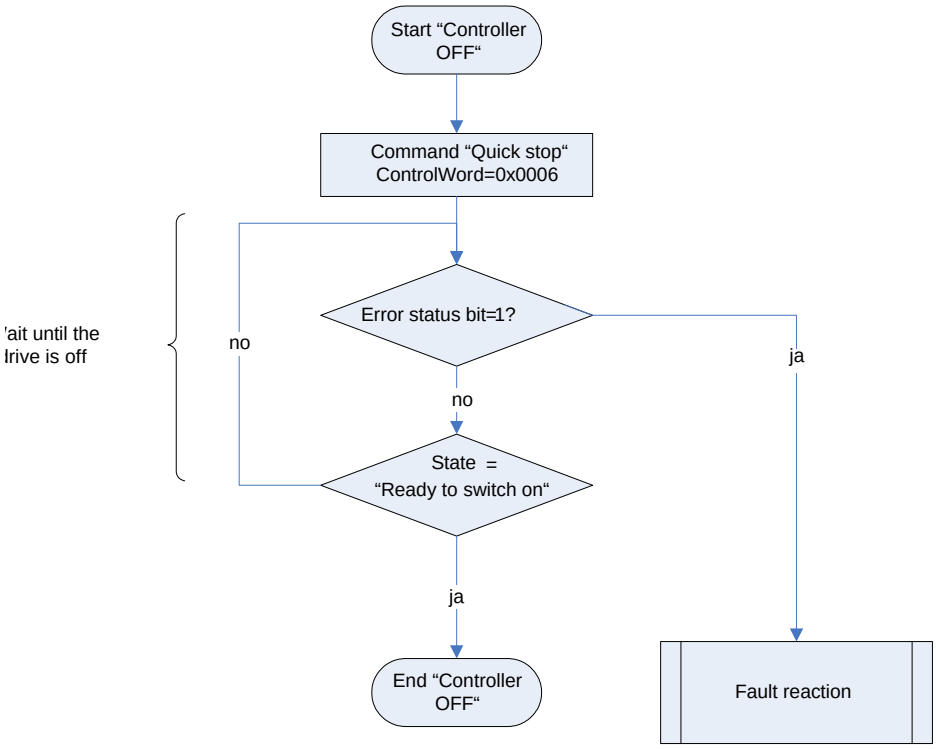
4.1 Sequence "Controller ON"

The sequence "Controller ON" is mapped via the finite state automaton commands as follows:



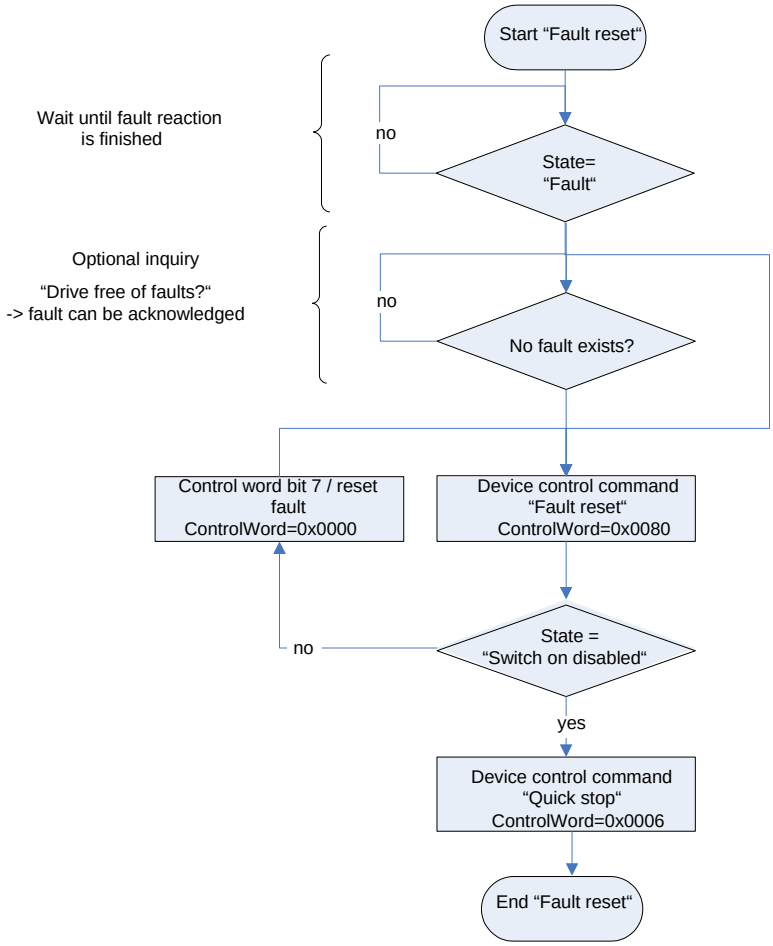
4.2 Sequence "Controller OFF"

The sequence "Controller OFF" is mapped via the finite state automaton commands as follows:



4.3 Sequence "Fault Reset"

The sequence "Fault Reset" is mapped via the finite state automaton commands as follows:



5 Operating Modes

You can change the operating modes of the drive as follows:
- via the *drivemaster2* software (configuration > drive control > operating mode)
- via accessing the corresponding objects

The objects for the selection of the operating mode are described in the following sections.

Warning
The selection of the operating mode depends on the device.

5.1 Object 76_D DEV_CTRL_MODES_OF_OPERATION

The operating mode in which the drive is to work in the device state "Operation enabled" is set via the object DEV_CTRL_MODES_OF_OPERATION. The parameter is initialized via the *drivemaster2* software.

Object description

Index	**$0x76_D$**
Name	DEV_CTRL_MODES_OF_OPERATION
Access right	Always readable / Writable if the drive parameters have been set.
Data type	U16
Unit	None

Data description

DEV_CTRL_MODES_OF_OPERATION	**Function**
0	Reserved
1	Positioning Mode → is not supported in the moment
2	Velocity mode 1
3	Profiled Velocity Mode
4	Current/torque control
5	Reserved
6	Homing Mode → is not supported in the moment
7	Interpolating position control

5.2 Object 77_D DEV_CTRL_MODES_OF_OPERATION_DISPLAY

The present operating mode of the drive can be read-out in the device state "Operation enbaled" via the object DEV_CTRL_MODES_OF_OPERATION_DISPLAY.

Object description

Index	**$0x77_D$**
Name	DEV_CTRL_MODES_OF_OPERATION_DISPLAY
Access right	Always readable
Data type	U16
Unit	None

Data description

DEV_CTRL_MODES_OF_OPERATION_ DISPLAY	**Function**
0	Reserved
1	Positioning Mode → is not supported in the moment
2	Velocity mode 1
3	Profiled Velocity Mode
4	Current/torque control
5	Reserved
6	Homing Mode → is not supported in the moment
7	Interpolating position control

5.3 Operating mode "Velocity Mode1"

5.3.1 Units of the Preset Values

In the operating mode "Velocity Mode 1" all drive data are preset, i.e. provided in the internal units.

- Motor speed: 0x3fff = maximum speed defined in the parameter file = reference value 100%. The speed values must be converted by the user.
- Motor current: 0x3fff = peak current of the output stage. The internal current values are converted in the drive when the object directory is accessed. 4 When, however, presetting the values in the cyclical channel via the SERVOLINK 4 the values must be converted by the user.

The physical units must be converted by the user under consideration of the following conversion factors which can be read-out of the drive:

- Conversion of 10 mA into internal indication
  FACTOR_CURRENT_FRAC_TO_CURRENT_NUM
  FACTOR_CURRENT_FRAC_TO_CURRENT_DENOM
- Conversion of 0.001 1/min into internal indication
  FACTOR_VELOCITY_VL_TO_VELOCITY_NUM
  FACTOR_VELOCITY_VL_TO_VELOCITY_DENOM

5.3.2 Objects in the Operating Mode "Velocity Mode 1"

5.3.2.1 Object 119_D SPG_MOTION_PROFILE_TYPE

The object SPG_MOTION_PROFILE_TYPE is used to define the course acceleration ramp and deceleration ramp.

Object description

Index	**119_D**
Name	SPG_MOTION_PROFILE_TYPE
Access right	Readable / writable if the drive parameters have been set.
Data type	U16
Unit	None

Data description

SPG_MOTION_PROFILE_TYPE	**Meaning**
1	Constant speed modification
2...0xffff	Reserved for future applications

5.3.2.2 Object 210_D SPG_TARGET_VELOCITY_VL

The object SPG_TARGET_VELOCITY_VL is used to preset the reference speed value in the operating mode "Speed Mode 1".

Object description

Index	**210_D**
Name	SPG_TARGET_VELOCITY_VL
Access right	Readable / writable if the drive parameters have been set. Only effective in the operating mode "Velocity Mode 1"
Data type	I16
Unit	Speed unit VL ≥ reference value 100 % = 0x3fff

5.3.2.3 Object 186_D SPG_VELOCITY_ACCELERATION_TIME_VL

The object SPG_VELOCITY_ACCELERATION_TIME_VL is used to define an acceleration ramp in ms in the operating mode "Velocity Mode 1" in ms. The ramp time is related to a reference speed value of 100%.

Object description

Index	**186_D**
Name	SPG_VELOCITY_ACCELERATION_TIME_VL
Access right	Always readable / always writable
Data type	U32
Unit	ms
Maximum value	10000000 msec

5.3.2.4 Object 187_D SPG_VELOCITY_DECELERATION_TIME_VL

The object SPG_VELOCITY_DECELERATION_TIME_VL is used to define a deceleration ramp in ms in the operation mode "Velocity Mode 1". The ramp time is related to a reference speed value of 100%.

Object description

Index	**187_D**
Name	SPG_VELOCITY_DECELERATION_TIME_VL
Access right	Always readable / always writable
Data type	U32
Unit	ms
Maximum value	10000000 msec

5.3.2.5 Object 188_D SPG_QUICKSTOP_DECELERATION_TIME_VL

The object SPG_QUICKSTOP_DECELERATION_TIME_VL is used to define the quick stop deceleration ramp in ms in the operating mode "Velocity Mode 1". The ramp time is related to a reference speed value of 100%.

Object description

Index	**188_D**
Name	SPG_QUICKSTOP_DECELERATION_TIME_VL
Access right	Always readable / always writable
Data type	U32
Unit	ms
Maximum value	10000000 msec

5.3.2.6 Object 189_D SPG_TORQUE_LIMIT_SLOPE_TIME

The object SPG_TORQUE_LIMIT_SLOPE_TIME is used to preset a modification ramp in the current/torque limitation of the speed controlled in ms in all operating modes. The ramp time is related to an output stage current/torque of 100%.

Object description

Index	**189_D**
Name	SPG_TORQUE_LIMIT_SLOPE_TIME
Access right	Always readable / always writable
Data type	U32
Unit	ms
Maximum value	10000000 msec

5.3.2.7 Object 209_D SPG_TARGET_TORQUE_LIMIT

The object SPG_TARGET_TORQUE_LIMIT is used to preset the torque/current limitation of the speed controller in amperes in all operating modes.

Object description

Index	**209_D**
Name	SPG_TARGET_TORQUE_LIMIT
Access right	Readable / writable if the drive parameters have been set.
Data type	I16
Unit	0,01 A (sine crest value)
Maximum value	0≤SPG_TARGET_TORQUE_LIMIT≤SPG_MAX_TORQUE

5.3.2.8 Object 176_D FACTOR_UNIT_VELOCITY_VL

The object FACTOR_UNIT_VELOCITY_VL is used to read-out the speed unit resulting from the use of the conversion factors.

Object description

Index	176_D
Name	FACTOR_UNIT_VELOCITY_VL
Access right	Readable if the drive parameters have been set.
Data type	U16
Unit	None

Data description

FACTOR_UNIT_VELOCITY_VL	Meaning
1	Speed unit = 0.001 1/min
2...0xffff	Reserved for future applications

5.3.2.9 Object 177_D FACTOR_VELOCITY_VL_TO_VELOCITY_NUM

The object FACTOR_VELOCITY_VL_TO_VELOCITY_NUM is used for conversion of the internal number format to a physical unit. The physical unit and the measuring unit is defined via the object FACTOR_UNIT_VELOCITY_VL.

Physical unit = internal measure x $\frac{Numerator}{Denominator}$

Object description

Index	177_D
Name	FACTOR_VELOCITY_VL_TO_VELOCITY_NUM
Access right	Readable if the drive parameters have been set.
Data type	I32
Unit	None
Meaning	Counter for the conversion function

5.3.2.10 Object 178_D FACTOR_VELOCITY_VL_TO_VELOCITY_DENOM

The object FACTOR_VELOCITY_VL_TO_VELOCITY_NUM is used for conversion of the internal number format to a physical unit. The physical unit and the measuring unit is defined via the object FACTOR_UNIT_VELOCITY_VL.

Physical unit = internal measure x $\frac{Numerator}{Denominator}$

Object description

Index	178_D
Name	FACTOR_VELOCITY_VL_TO_VELOCITY_DENOM
Access right	Readable if the drive parameters have been set.
Data type	I32
Unit	None
Meaning	Denominator for the conversion function

5.3.2.11 Object 181_D FACTOR_UNIT_CURRENT

The object FACTOR_UNIT_CURRENT can be used to read-out the physical unit and the measure of the current unit resulting from the use of the conversion factors.

Object description

Index	181_D
Name	FACTOR_UNIT_CURRENT
Access right	Readable if the drive parameters have been set.
Data type	U16
Unit	None

Data description

FACTOR_UNIT_CURRENT	Meaning
1	Current unit = 0.01 A (sine crest value)
2...0xffff	Reserved for future applications

5.3.2.12 Object 182_D FACTOR_CURRENT_FRAC_TO_CURRENT_NUM

The object FACTOR_CURRENT_FRAC_TO_CURRENT_NUM is used for conversion of the internal number format for currents to a physical unit. The physical unit and the measuring unit is defined via the object FACTOR_UNIT_CURRENT.

Physical unit = internal measure x $\frac{Numerator}{Denominator}$

Object description

Index	**$00B6_h$**
Name	FACTOR_CURRENT_FRAC_TO_CURRENT_NUM
Access right	Readable if the drive parameters have been set.
Data type	I32
Unit	None
Meaning	Counter for the conversion function

5.3.2.13 Object 183_D FACTOR_CURRENT_FRAC_TO_CURRENT_DENOM

The object FACTOR_CURRENT_FRAC_TO_CURRENT_DENOM is used for conversion of the internal number format for currents to a physical unit. The physical unit and the measuring unit is defined via the object FACTOR_UNIT_CURRENT.

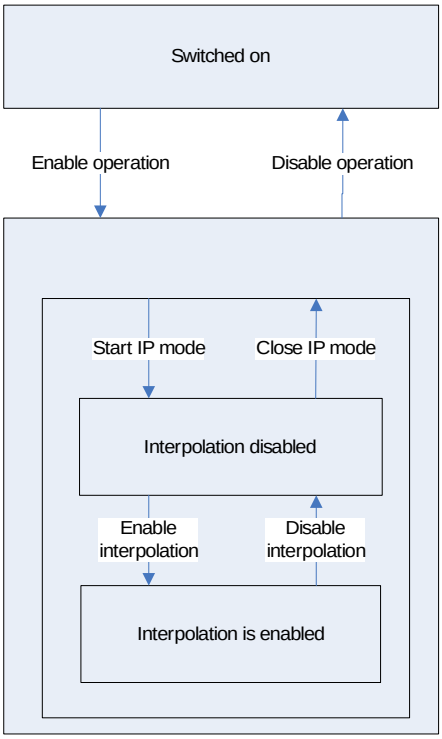
Physical unit = internal measure x $\frac{Numerator}{Denominator}$

Object description

Index	**$00B7_h$**
Name	FACTOR_CURRENT_FRAC_TO_CURRENT_DENOM
Access right	Readable if the drive parameters have been set.
Data type	I32
Unit	None
Meaning	Denominator for the conversion function

5.4 Operating Mode "Interpolated Position Mode"

5.4.1 States in the Operating Mode "Interpolated Position Mode"



Description of the States in the Operating Mode "Interpolated Position Mode"

State "Switched On"

- Interpolation data are not copied into the interpolation data buffer.
- Reference position value = actual position value
- Position control is not active.
- No tracking error monitoring.
- No monitoring of the software traveling area
- Reference speed value = 0 / drive is not moved
- Motor has no force.
- Brake is applied.

State "Interpolation disabled"

- Interpolation data are copied into the interpolation data buffer.
- Reference position value = actual position value during transition into "operation enabled" state
- Position control is active.
- Tracking error monitoring is active.
- Monitoring the software traveling area is active.
- Reference speed value = 0 / drive is not moved
- Motor has force.
- Brake is released.

State "Interpolation enabled "

- Interpolation data are copied into the interpolation data buffer and processed.
- Reference values are calculated on the basis of the interpolation data.
- Position control is active.
- Tracking error monitoring is active.
- Monitoring the software traveling area is active.
- The drive can be moved.
- Motor has force.
- Brake is released.

Transition states in the Operating Mode "Interpolated Position Mode "

Transition state "Start IP Mode"

- Switching into the state "Operation enebaled" / interpolation is disabled via the finite state automaton word and the selection of operating modes.
- Brake, if present, is released.
- A magnetic alignment is executed if necessary (synchronization of the motor).
- Reference position value is set to the actual position value.
- Position control is activated.
- Initialization of the interpolated position control.
  - Initialization of the reference value generator
  - Interpolation buffer us enabled and the master can write in it.

Transition state "Close IP Mode "

- Quit the state "Operation enabled" via the finite state automaton word and the operating mode selection.
- The operating mode "Interpolated Position Mode" is quit.
- Position control is deactivated.

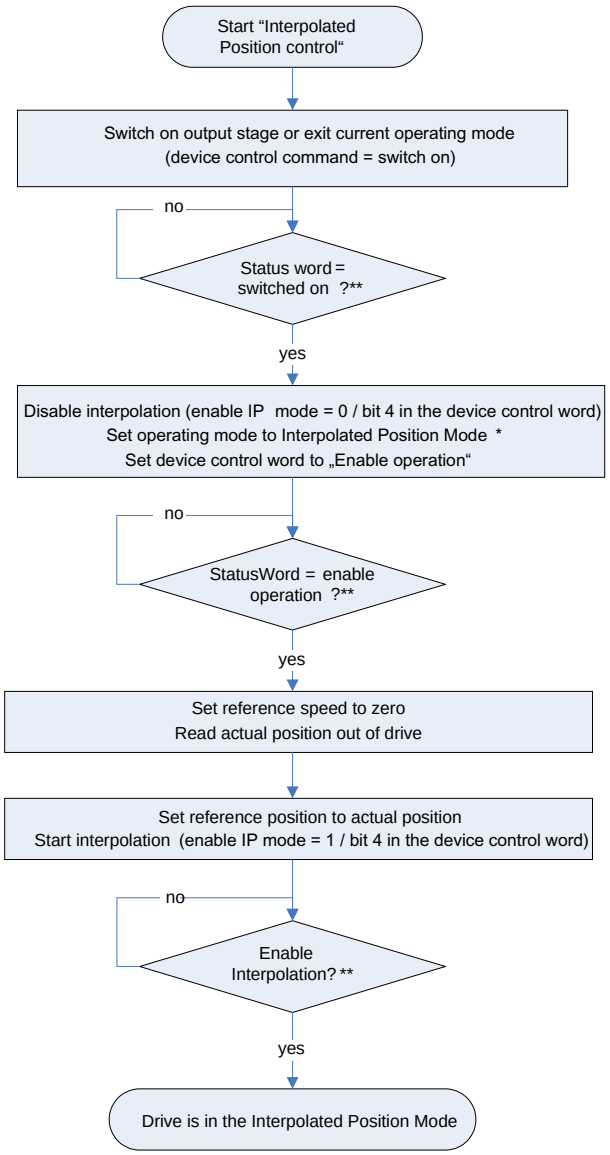
Transition State "Enable Interpolation "

- Switching into the state "Operation enabled" via the finite state automaton word (bit 4).
- The reference values are generated out of the interpolation data buffer.

State Transition "Disable Interpolation"

- Switching into the state "Operation disabled" via the finite state automaton word (bit 4).
- The reference values are not generated out of the interpolation data buffer anymore.

5.4.2 Start Operating Mode "Interpolated Position Control"



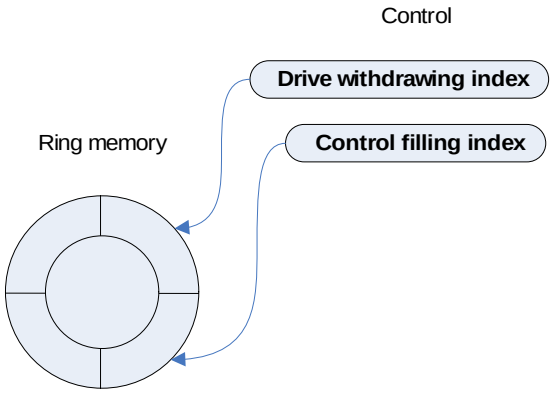
* In the moment the operating mode is firmly set to the Interpolated Position Mode and can later (during the running time) be changed via the object "ModesOfOperation"

** For clarity reasons fault inquiries were not implemented in the transitions.

5.4.3 Organization of the Interpolation Data Buffer

The interpolation data are exchanged between the control and the drive via an interpolation buffer. During this process the control organizes the buffer via the "control filling index" and a "withdrawing index" for the current drive. The control filling index is used to define the position in the ring buffer to which interpolation data are written by the control. The control indicates the drive which interpolated position is to be used for the execution.

The buffer is conceived as position buffer of 4* 48 bits, which allows the control of the filling and withdrawing position via two index counters with a width of 2 bits each.



In order to ensure that the drive can check the validity of the withdrawing index, the index must be counted incrementally. For counting the index the order 0,1,2,3 must be observed.

5.4.4 Interpolation Control Word

Bit	Name	Description
0	Actual-Index Bit 0	Defines the withdrawal position which is valid at the moment.
1	Actual-Index Bit 1	
2	Fill-Index Bit 0	Defines the withdrawal position which is valid at the moment.
3	Fill-Index Bit 1	
4		Reserved
5		Reserved
6		Reserved
7		Reserved

5.4.5 Reaction in Case of Invalid Interpolation Data

- Filling index of the drive is the same as the last filling index
  - This fault can be caused by a failure of a reference value telegram
  - The drive interpolates automatically with the last interpolation data
  - If, after a failed reference value telegram, execution can not be continued with the correct withdrawal index the fault message "interpolation fault" is generated. This fault results in a defined deceleration of the drive.

- Withdrawal index of the drive is not the same as the last or the expected withdrawal index
  - This fault is generated by incorrect control of the ring buffer and results in the fault "Interpolation fault""

- Calculated speed > V_{max}
  - This event causes the drive fault "Interpolation fault" which results in a defined switching off of the drive

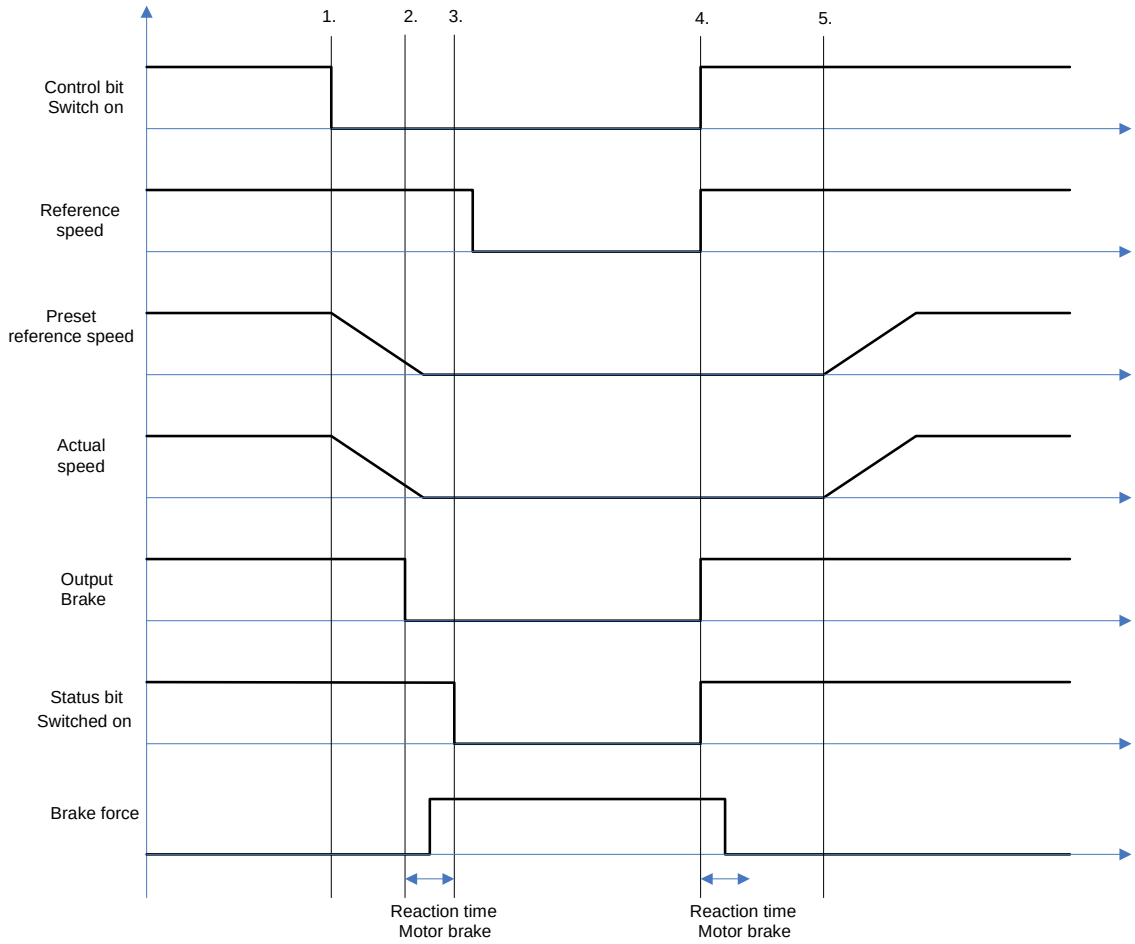
- Calculated acceleration > A_{max}
  - This event causes the drive fault "Interpolation fault" which results in a defined switching off of the drive

6 Controlling the Motor Brake

The control of a motor brake is implemented in the finite state automaton.

Warning
This type of brake control is not protected! Careful use is required to avoid injuries of the operator!

The following diagram shows how the motor brake is controlled by the drive:



[1] The command "Shutdown" (control bit "Switch on"). The drive is decelerated. The deceleration ramp can be set via the *drivemaster2*software (Object DEV_CTRL_SHUTDOWN_OPTION_CODE)

[2] After "Speed zero" was detected (message M12), the motor holding brake is activated.

[3] After the reaction time of the motor holding brake is passed, the output stage is switched off (programmable in the drivemaster2 software: Configuration>Motor>On delay motor holding brake).

[4] The command "Enable operation" activates the output stage and deactivated the motor brake at the same time. After the reaction time is passed, a "MagneticAlignment" is started, if necessary

[5] After the "MagneticAlignment" the drive can be switched into the state "Enable operation"

The reaction time for the motor holding brake is not considered for the following actions:

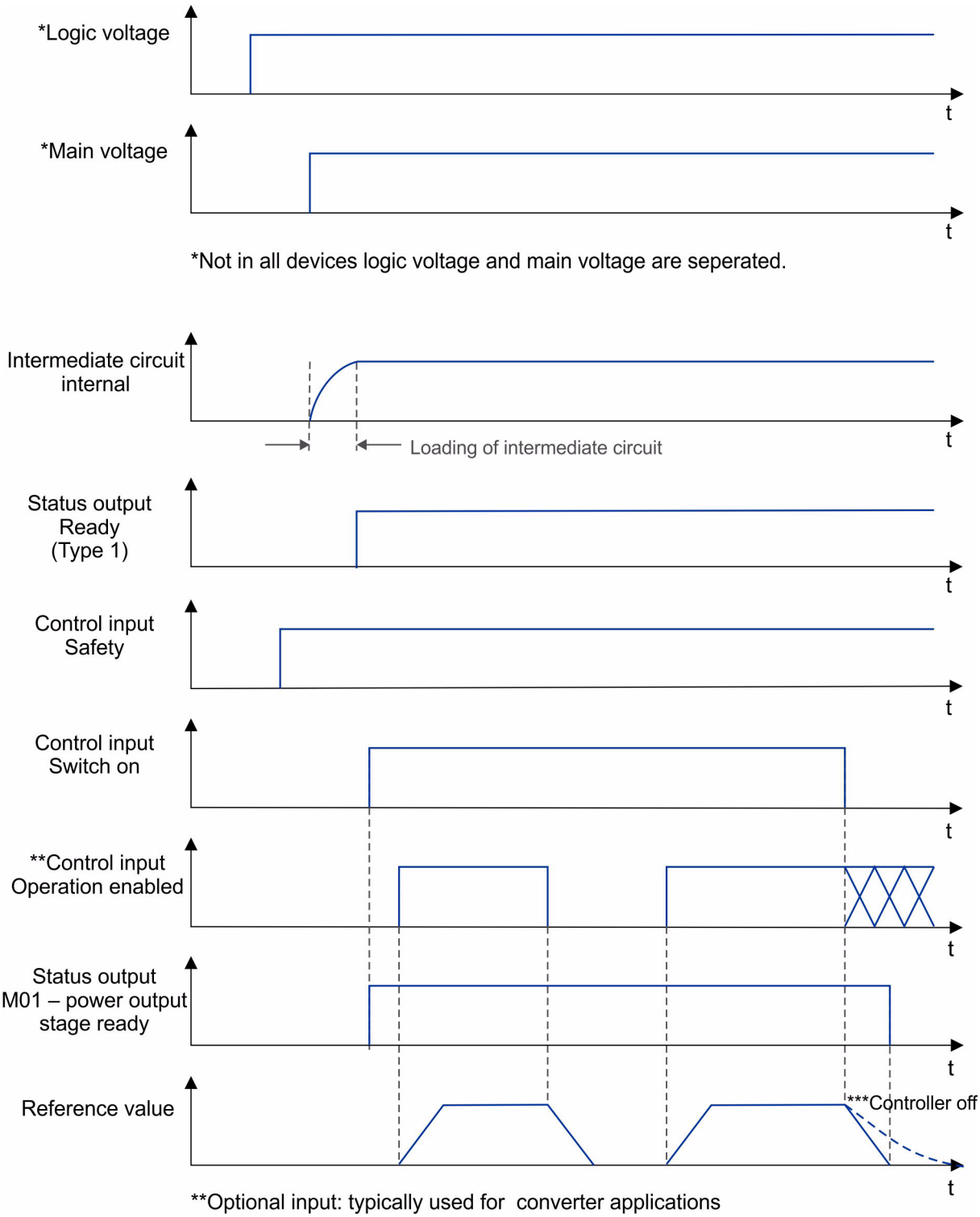
- after a drive error has occurred
- during direct control of the brake when the output stage is switched off (finite state automaton command "Switch on disabled")

7 Switch-on and Switch-off Behavior

This section describes the switch-on and switch-off behavior of an SD2 device during normal operation. In particular the following diagrams illustrate the timely relations between the individual status and control lines.

The accurate behavior depends on several other parameters (settings in the device) and on the used device type. The timing diagrams illustrate only the relations between external events and internal reactions during normal operation.

7.1 Switch-on and Switch-off during Normal Operation



*Not in all devices logic voltage and main voltage are seperated.

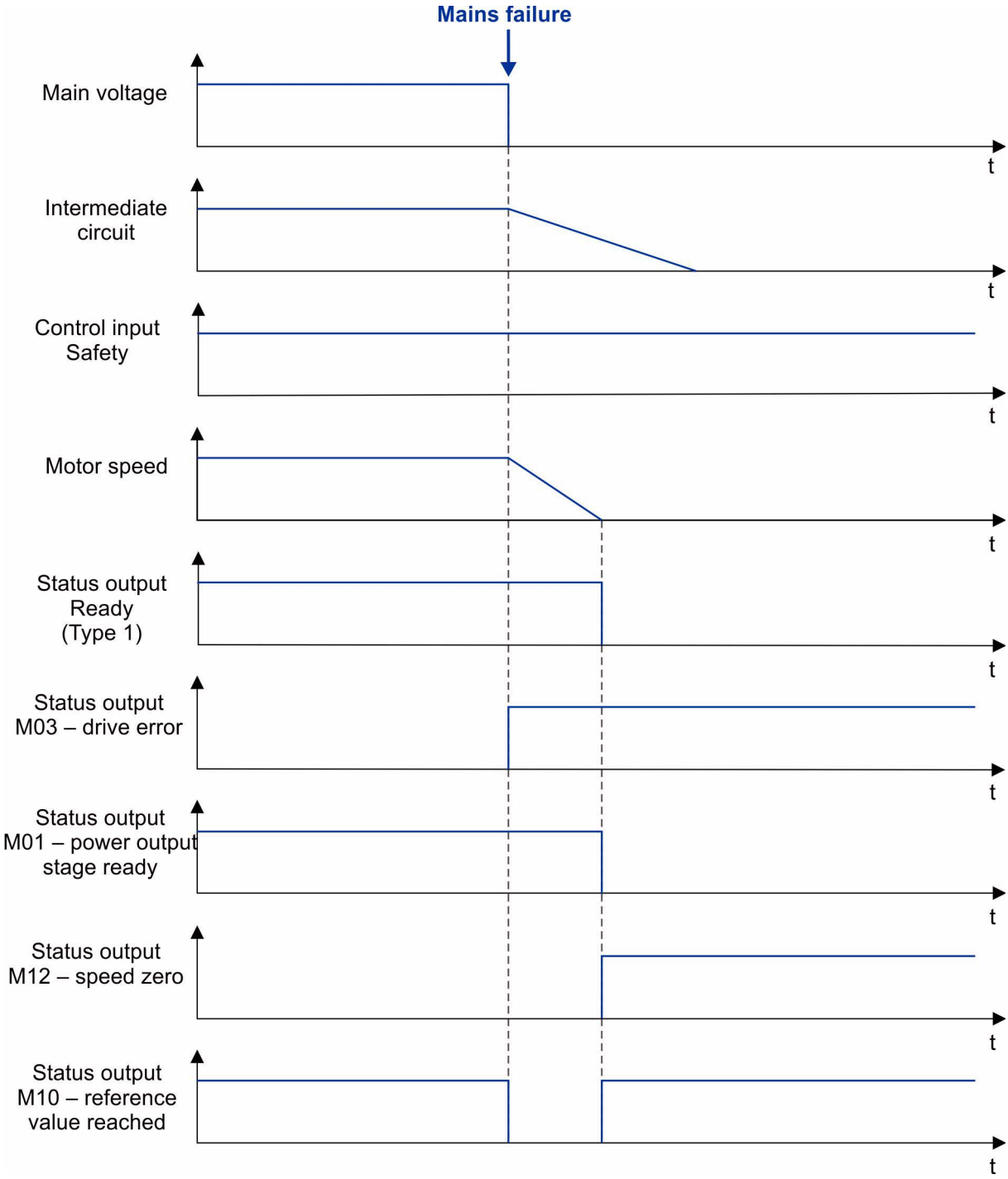
**Optional input: typically used for converter applications

***Controller off: depends on parameterization in *drivemaster2* (Behavior in case of Controller off command)

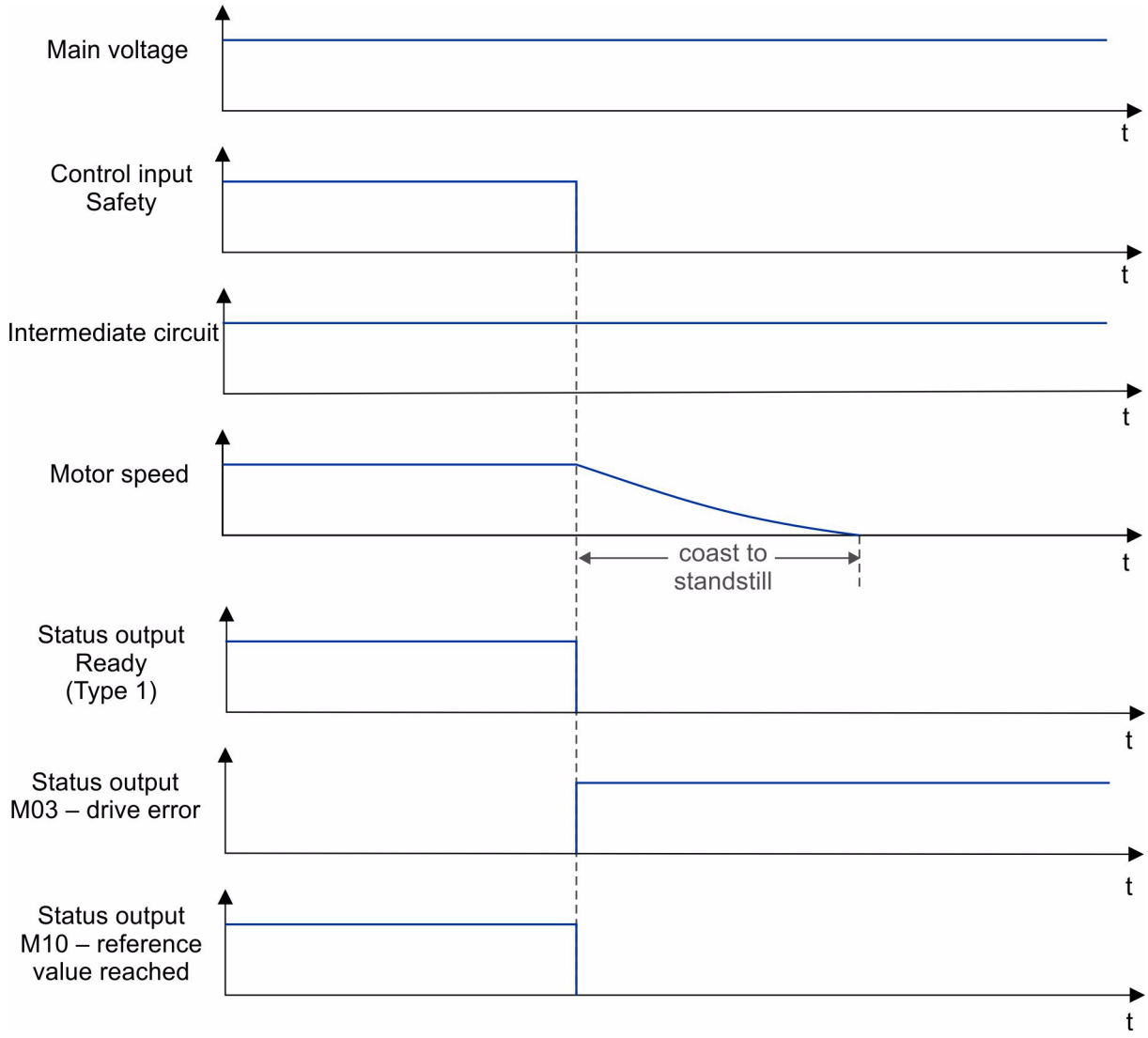
The control input "Safety" (X10/X43) is not time-related to the other illustrated signals. But the function is to be set before the control input "Switch on" and must not be used for device switch-off.

7.2 Behavior in the Event of a Mains Failure

The following timing diagram illustrates the relations of the status and control lines in the event of a mains failure.



The following diagram illustrates the behavior when the signal of the control input "Safety" is unset during normal operation.

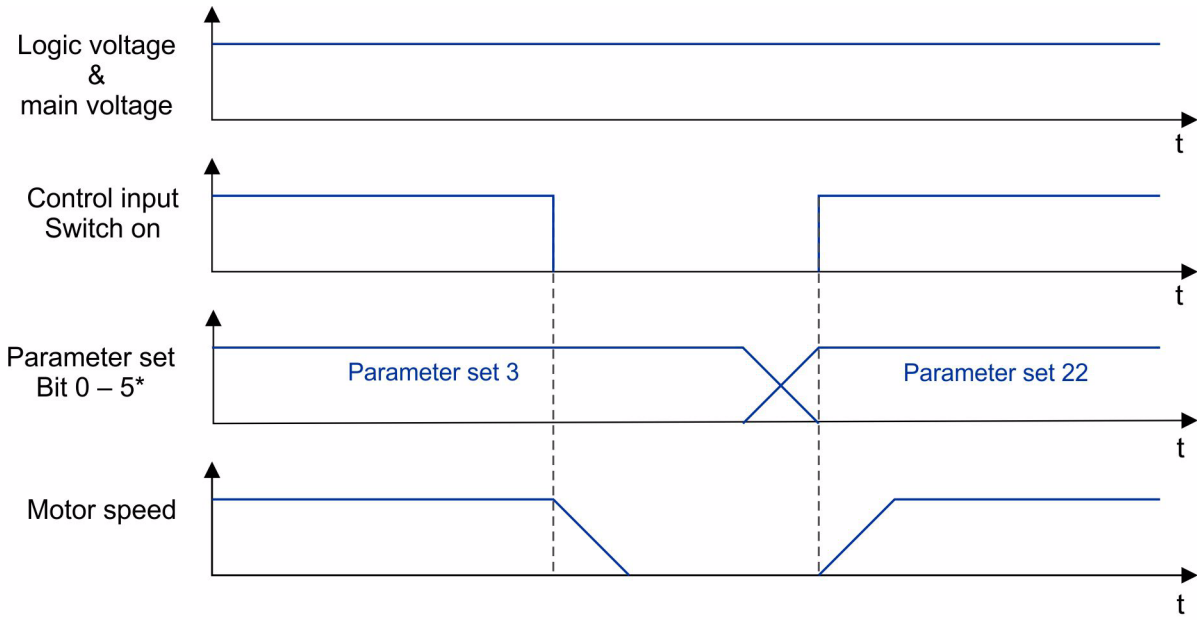


Please refer to the section “Status Display and Error Messages” on page 43 for information on other error states and reactions of the device.

7.2.1 Behavior during Parameter Set Change

The following diagram illustrates the relations when the parameter set is changed via the digital inputs. The functions of the digital inputs must be determined accordingly in the software *drivemaster2*.

The parameter set is actually switched to the new one by unsetting and setting the control input "Switch on".



*The parameter set bits depend on the number of parameter sets saved in the drive.

8 Fault Behavior

When a fault is detected in the drive, a corresponding fault reaction is immediately activated and the device control switches into the state "Fault Reaction Active". After the fault reaction has been finished the power unit is switched off and the device control automatically switches into the state "Fault".

The states "Fault Reaction active" and "Fault" are mapped as follows in the status word of the device control via bit 3:

State of the device control	Status word / DEV_CTRL_STATUS_WORD
Fault reaction active	xxxx xxxx x0xx 1111
Error	xxxx xxxx x0xx 1000

Additionally the objects

- DEV_CTRL_ERROR_CODE_ACTUAL
- DEV_CTRL_ERROR_CODE_LATCHED

allows reading-out the last fault with the highest priority.
A fault reset command can only be executed, if no there is no fault in the drive at present (object DEV_CTRL_ERROR_CODE_ACTUAL = 0x0000). The latched fault will be cleared via the fault reset command (object DEV_CTRL_ERROR_CODE_LATCHED).

The chapter "Control Sequences" (page 15 and the following) describes in detail a sequence for clearing a drive fault.

8.1 Objects for the Fault Evaluation

8.1.1 Object 69_D DEV_CTRL_ERROR_CODE_ACTUAL

The object DEV_CTRL_ERROR_CODE_ACTUAL allows reading-out the current fault code of the drive.

Object description

Index	69_D
Name	DEV_CTRL_ERROR_CODE_ACTUAL
Access right	Always readable
Data type	U32
Unit	None

8.1.2 Object 70_D DEV_CTRL_ERROR_CODE_LATCHED

The object DEV_CTRL_ERROR_CODE_LATCHED allows reading-out the reason of the fault which had caused that the drive was switched off.

Object description

Index	**70_D**
Name	DEV_CTRL_ERROR_CODE_LATCHED
Access right	Always readable
Data type	U32
Unit	None

8.2 Status Display and Error Messages

The display (LCD or 7-segment display) indicates status and error messages.

The status messages consist of up to 5 digits. All messages end with dot behind the last digit. When the first digit is 'E.', there is a permanent error.

8.2.1 List of the Operating States

Code	State
0	Ready to be switched on
1	Controller active
1.	Controller active, controller is limited / PI limit
2	Mains 'Ready for operation' not present yet
L	Boot loader active (during boot / software load)

8.2.2 List of the Error Messages of the Drive

The following messages apply to the entire SD2 drive series. According to the device type or operating mode, certain messages may not appear.

Display code (error code)	Error name	Error reaction	Possible reason
E03 (0x103)	Interpolation error (interpolated position control)	Motor is stopped by quick stop ramp and drive is disabled (controlled standstill)	▶ Incorrect reference value transmitted by control ▶ Maximum speed or maximum acceleration is parameterized too low
E05 (0x105)	Error caused by warning	Motor is stopped by quick stop ramp and drive is disabled (controlled standstill)	▶ Parameter-driven monitoring stopped the drive
E06 (0x106)	Digital Input 'External Hardware'	Motor is stopped by parameter-driven ramp and drive is disabled (controlled standstill)	▶ Digital 24 V input "External Hardware OK" is not connected to 24 V
E07 (0x107)	Error in internal hardware (FC2)	Motor is stopped by quick stop ramp and drive is disabled (controlled standstill)	▶ Overload in digital outputs
E09 (0x109)	Hiperface / Endat OEM data incorrect	No "Ready" for startup	▶ Number of motor pole pairs in Endat/ Hiperface encoder does not match the parameter set
E10 (0x10A)	drive-setup-tool heartbeat	Motor is stopped by quick stop ramp and drive is disabled (controlled standstill)	▶ drive-setup-tool was not able to communicate with the drive in the parameterized time period for monitoring
E11 (0x10B)	Communication / bus system error	Motor is stopped by parameter-driven ramp and drive is disabled (controlled standstill)	▶ Monitoring of bus communication led to switch-off

Display code (error code)	Error name	Error reaction	Possible reason
E12 (0x10C)	Mains 'Ready for operation' is missing	Motor is stopped by parameter-driven ramp and drive is disabled (controlled standstill)	▶ Mains supply has been disconnected or interrupted during the power stage was switched on.
E15 (0x10F)	Endat / Hiperface communication faulty	Motor is stopped by quick stop ramp and drive is disabled (controlled standstill)	▶ Communication of Endat/Hiperface is faulty
E17 (0x311)	FPGA power output stage shut down	Motor is stopped immediately	▶ Overload in power supply unit
E18 (0x312)	Error in spindle selection	Drive will not be switched on	▶ Spindle selection was not valid when "Controller On" was activated
E25 (0x319)	Power supply load too high	Drive is stopped by limitation of motor torque.	▶ Output power of drive is greater than rated power of power supply unit, since the dimensioning of drive and motor are not compatible.
E26 (0x31A)	Motor temperature too high	Motor is stopped by error ramp and current limitation	▶ Wrong parameters entered for the motor or wrong dimensioning of the motor
E27 (0x31B)	Ambient temperature too high	Motor is stopped by error ramp and current limitation	▶ Cooling of the device is not sufficient
E28 (0x31C)	Power output stage temperature too high	Motor is stopped by error ramp and current limitation	▶ Cooling of power stage is not sufficient (heat sink)
E29 (0x31D)	Motor load too high (Motor I^2t)	Motor is stopped by error ramp and current limitation	▶ Average motor load is too high due to mechanical problems ▶ Wrong dimensioning of the motor
E30 (0x31E)	Power output stage load too high (I^2t)	Motor is stopped by error ramp and current limitation	▶ Average load of output stage is too high due to mechanical problems ▶ Wrong dimensioning of the drive
E31 (0x31F)	Speed error or slip too high	Servo amplifier: drive is limited by current monitoring via short-circuit of the motor phases HSPWM: drive is stopped by error ramp and current limitation	▶ Motor is not able to comply with the set speed (e.g. defective motor, mechanical problems, wrong parameters)
E33 (0x521)	Power supply load monitoring -> mains voltage too high	Power supply unit will be disconnected from mains	▶ Parameterized mains voltage is not corresponding to the connected voltage ▶ Device connection is incorrect ▶ Heavy fluctuation of the power supply towards overvoltage
E34 (0x522)	Power supply load monitoring -> mains voltage too low	Power supply unit will be disconnected from mains	▶ Intermediate circuit was not pre-loaded to the minimum voltage level in the set time period; mains voltage will be connected to the short-circuited intermediate circuit
E35 (0x523)	Error in external power supply unit	Drive is immediately disabled, motor coasts to standstill	▶ Error message from external power supply unit; Power supply is switched off See error messages of the power supply unit,
E36 (0x524)	Encoder 0 monitoring	Motor is stopped by current monitoring via short-circuit of the motor phases.	▶ Connection of Encoder 0 faulty ▶ Broken cable
E37 (0x525)	Ballast circuit load (I^2t ballast resistor)	Drive is immediately disabled, motor coasts to standstill	▶ When the motor is stopped, too much energy returned by the motor. Rated power of the ballast resistor too low, ballast resistor defective or not connected
E37[1] (0x525)	DC DC converter overload	Power supply unit will be disconnected from mains	▶ Voltage converter of intermediate circuit is overloaded.

Display code (error code)	Error name	Error reaction	Possible reason
E38 (0x526)	Actual speed value greater than overspeed threshold	Motor is stopped by current monitoring via short-circuit of the motor phases.	▶ Wrong Parameters ▶ Motor connection is incorrect
E39 (0x527)	Tracking error monitoring when motor is stopped	Motor is stopped by current monitoring via short-circuit of the motor phases.	▶ Wrong Parameters ▶ Motor connection is incorrect ▶ Mechanical problems
E40 (0x528)	Motor feedback	Motor is stopped by current monitoring via short-circuit of the motor phases.	▶ Motor feedback connection faulty ▶ Broken cable
E41 (0x529)	Motor phase missing	Motor is stopped by current monitoring via short-circuit of the motor phases.	▶ Connection of motor phases faulty ▶ Broken cable
E42 (0x52A)	Overvoltage in DC link	Drive is immediately disabled, motor coasts to standstill	▶ No ballast resistor connected or ballast resistor dimensioned too small
E43 (0x52B)	Undervoltage in DC link	Drive is immediately disabled, motor coasts to standstill	▶ Intermediate circuit is not connected
E44 (0x52C)	Commutation lost	Only HSPWM: Drive is immediately disabled, motor coasts to standstill	▶ Mechanical overload ▶ Wrong parameters (flux current)
E45 (0x52D)	Short circuit in power output stage	Drive is immediately disabled, motor coasts to standstill	▶ Short circuit occurred when motor phases were connected ▶ Output stage defective
E46 (0 x52E)	Safety circuit (Safety X10)	Drive is immediately disabled, motor coasts to standstill without control	▶ Safety circuit is activated when the output stage is active. Input Save A and/or input Save B were triggered.
E47 (0x52F)	Drive parameters not activated	Power output stage can not be activated	▶ Drive start is not acknowledged by master yet (configurable by parameters in software)
E55 (0x737)	Firmware stopped by ESC	Device stops in BIOS	▶ During boot up the device received an ESC sequence at the serial interface
E56 (0x738)	Device configuration	Device stops in BIOS	▶ During boot up the device detected that hardware, firmware parameters and logic are not consistent. A clear error description is received by a parameters download
E57 (0x739)	Faulty or no firmware	Device stops in BIOS	▶ During boot up the device detected that there is no firmware or the firmware is faulty
E58 (0x73A)	FPGA Watchdog triggered	Device stops in BIOS	▶ FPGA process monitoring has been triggered. Please contact SIEB & MEYER
E59 (0x73B)	No drive parameters loaded	Device stops in BIOS	▶ Device is not parameterized (status of delivery)
E60 (0x73C)	Drive parameters incorrect	Device stops in BIOS	▶ Parameter set of the device is not valid (CRC error)
E61 (0x73D)	Logic coding missing or incorrect	Device stops in BIOS	▶ Device does not receive a valid logic
E62 (0x73E)	Error in electronic type plate	Device stops in BIOS	▶ Type plate is not programmed or incorrect. Please contact SIEB & MEYER

1. The error code E37 has two meanings for device variant 0362161xy: either the error "Ballast circuit load (I^2t ballast resistor)" or the error "DC DC converter overload" is present.

8.2.3 List of Warning Messages

Warning messages are not displayed in the device display. They can only be seen in the software *drivemaster2* via "Diagnosis→Errors and warnings".

Code	Cause of warning
W00	Digital input 'Quick stop'
W01	Digital input 'Positive limit switch'
W02	Digital input 'Negative limit switch'
W03	Mains supply not OK
W04	Power output stage load greater than parameterized threshold (I^2t)
W05	Motor load greater than parameterized threshold (I^2t)
W06	Power output stage temperature greater than parameterized threshold
W07	Motor temperature greater than parameterized threshold
W08	DC link voltage greater than parameterized threshold
W09	DC link voltage less than parameterized threshold
W10	Internal limitation / PI limit
W11	Tracking error greater than parameterized threshold
W12	Speed error greater than parameterized threshold
W13	Reserved
W14	Ambient temperature greater than parameterized threshold
W15	Ballast resistor load greater than parameterized threshold
W16	Safety circuit is active
W17	No commutation
W18	Endat / Hiperface data not valid
W19	Dirt signal encoder input 0
W20	Dirt signal encoder input 1
W21	Dirt signal encoder input 2
W22	Reserved
W23	Reserved
W24	Warning by current monitoring
W25	Reference speed less than minimum motor speed
W26	Reserved
W27	Reserved
W28	Reserved
W29	Reserved
W30	Reserved
W31	Reserved

8.2.4 Messages of the Quick Stop Functions

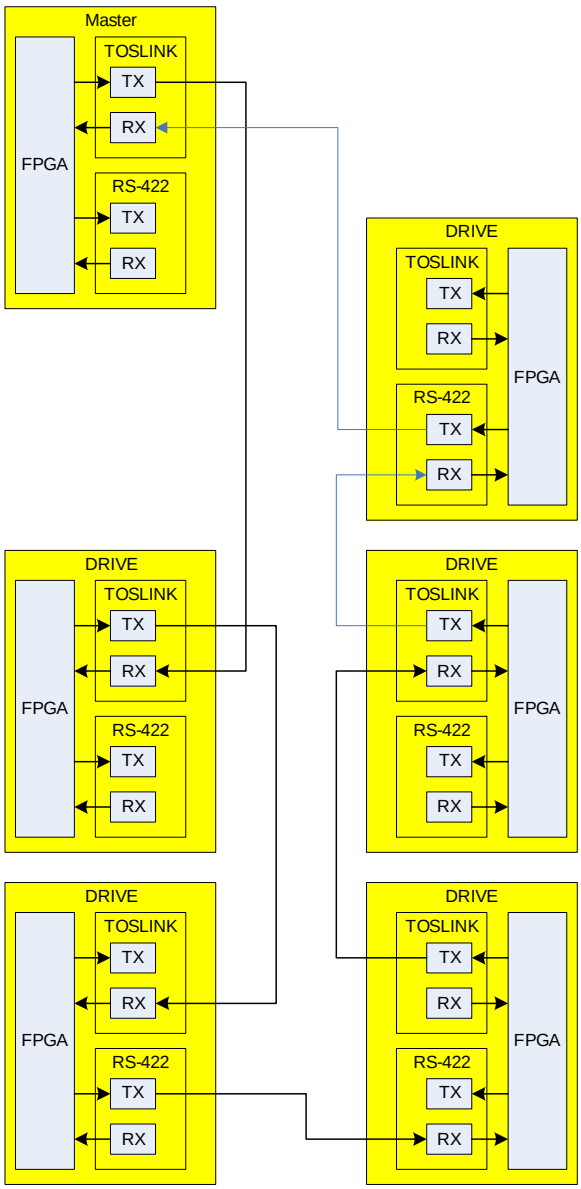
Quick stop code	Reason for quick stop
H13	Digital input "Speed Enable"
H12	Digital input "Positive limit switch"
H11	Digital input "Negative limit switch"
H08	Software positioning error "Positive limit"
H07	Software positioning error "Negative limit"
H04	Digital input "Quick stop"
H03	Software function "Quick stop"

9 SERVOLINK 4

9.1 General Information

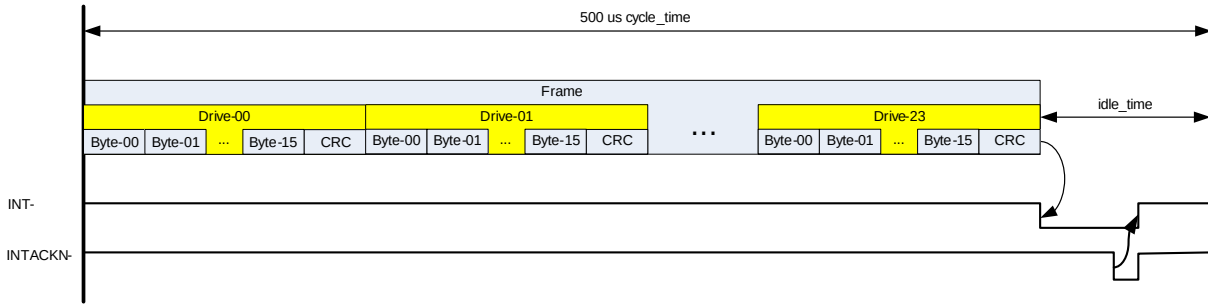
The SERVOLINK 4 is a bus system for linking servo amplifiers with a communication controller. The bus is conceived as a ring. Data transmission is serial and cyclical. The data are transmitted via optical fiber connectors (TOSLINK) and RS-422 interfaces. The servo modules are provided with both types of connectors and both connectors can be used at the same time. FPGA solutions are provided for connection at the master and slave module, the master module is additionally equipped with a PCI plug-in board (036500001) or the gateway 0362151. The interface to the controller behaves like a dual port memory (DPRAM). For every drive 16 bytes are provided for reference date and 16 bytes for actual data. The contents depend on the operating mode. The data blocks are checked with a CRC check (cyclic redundancy check). Every drive replaces the received reference data by the actual data; this ensures that the transmission time is not prolonged by the transmission of the actual values.

9.2 Structure



Mixed operation with Toslink and RS422

9.3 Transmission Format



Transmission time:

t_{bit} = 84 ns

$t_{frame} = t_{bit} * n_{drives} ((n_{bytes} + n_{delay} + 1_{CRC}) * 10_{bits}) = 84\ ns * 24 * ((16 + 2 + 1) * 10) = 380\ \mu s$

$t_{idle} = t_{cycle} - t_{frame} = 500\ \mu s - 380\ \mu s = 120\ \mu s$

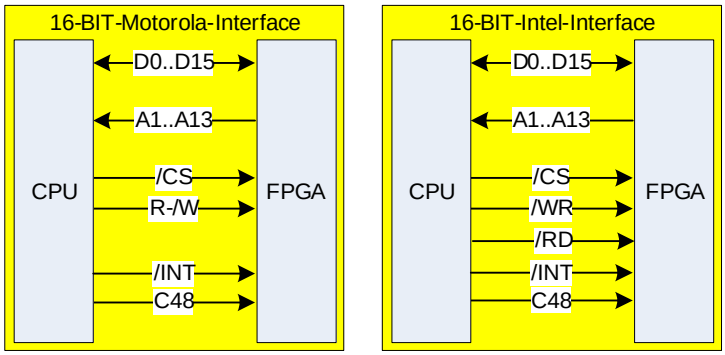
CRC:

$1 + x^1 + x^2 + x^8$

9.4 Interrupt

As a default the FPGA releases an interrupt at the end of a data frame. In the interrupt routine the actual values must be read-out and the new reference values must be written into the FPGA. If this process is not executed until the next cycle starts, zero data are automatically transmitted to the drives. The interrupt is reset by reading an address in the FPGA.

9.5 FPGA Interface



9.5.1 RAM Interface

Address	Name	Meaning
0x0000..0x017f	ACTUAL-VALUES	Actual data of the drive
0x0200..0x037f	SETPOINT-VALUES	Reference data of the drive
0x0400..0x0402	CRCSTATE	CRC status, 0xffffff → OK
0x0404	DATAEXCHANGE	Bit = 0 → idle operation Bit = 1 → data exchange
0x0406	INTACKN	Interrupt acknowledgement
0x0408	CONFIG	Configuration Bit-0 = 1 → Interrupt ON
0x040a	SELECT	Medium selection Bit-0 = 0 → RS-422 Bit-0 = 1 → TOSLINK
0x040c	DRIVEIN	Receipt position
0x040e	DRIVEOUT	Transmission position
0x0410	INTPOSITION	Interrupt position
0x0412	ZEROCNT	16 bit zero data counter
0x1000	VERSION	Version code
0x1002	TESTWORD	Test word (0xaaaa)

ACTUAL VALUES
Actual data of the drive: 24 drives x 16 bytes per drive.

SETPOINT VALUES
Reference data of the drive: 24 drives x 16 bytes per drive.

CRC-STATE
One CRC bit per drive. Bit-0 for drive-0, bit-1 for drive-1 etc.
Bit = 0 → invalid data, bit = 1 → valid data
When a new cycle is started all bits are reset to zero. The CRC bit is set after a the data package was received without faults.

DATA EXCHANGE
Bit-0 = 0 → SERVOLINK 4 is in the idle operation. Bit-0 = 1 → SERVOLINK 4 is in the transmission phase.

INTACKN
An access to this register acknowledges the interrupt. If the interrupt is not sent until the next cycle starts zero data will be sent automatically.

CONFIG
Bit-0 = 0 → interrupt locked. Bit-0 = 1 → interrupt enabled.

SELECT
Bit-0 = 0 → RS-422 interface. Bit-0 = 1 → TOSLINK interface.

DRIVE-IN-POSITION
The register indicates the drive number of the data package which is currently being received.

DRIVE-OUT-POSITION
The register indicates the drive number of the data package which is currently being sent.

INTPOSITION (programmable interrupt position)
This register is used for setting the interrupt position. The position is indicated in bit times. The position can lay between 160 and 5999. Please consider a delay of 20 µs for each module.

ZEROCNT
The counter is increased after every transmission process of a ZERO data cycle.

VERSION
Version code of the VHDL program, e.g. 0x10001

TESTWORD
Test register. The value is 0xaaaa.

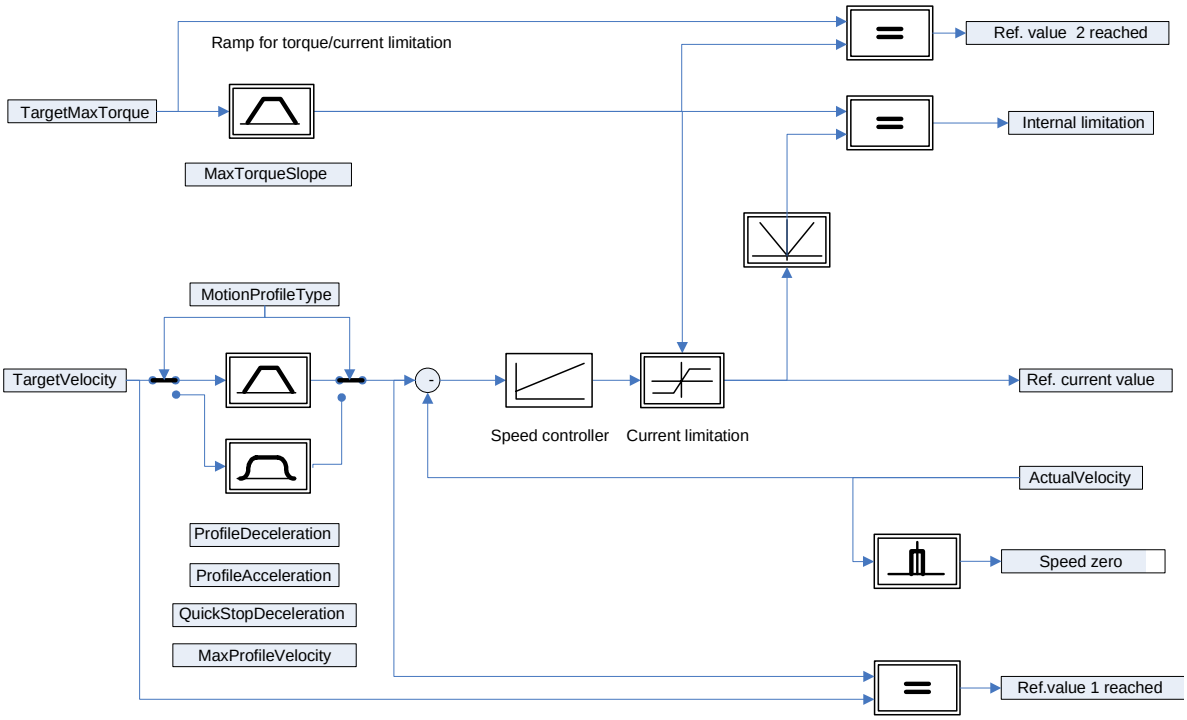
9.6 Telegrams

The SERVOLINK 4 telegrams are divided into a process data channel and a service data channel. The data in the process data are updated and transmitted in every cycle. The corresponding data are the control and the status word. The additional area is used differently in the operating modes and described in separate sections.
The service data channel serves for transmitting not time critical or larger data areas. The data transmission is serial.

9.6.1 Velocity Mode 1 (Mode 2)

The operating mode "Velocity Mode 1" offers the following features:

- Easy definition of the reference speed/velocity value
- Easy definition of the current/maximal torque limitation
- Internal ramp generation for
  - reference speed/velocity value with linear acceleration and deceleration ramp
  - reference speed/velocity value with S-curve acceleration and deceleration ramp
  - Limitation of the current / maximum torque
- Status functions for
  - Speed zero
  - Speed ramp has reached the target value
  - Speed controller is in the current/torque limitation
  - Current/torque limitation has reached the target value
  - Device state
- Quick stop function (configurable via parameter setting)
  - Deceleration with maximum torque/current
  - Deceleration with deceleration ramp (configurable via parameter setting)
  - Decelerating with defined down-ramping of the torque/current
- Device control according to the drive profile DS402
- finite state automaton and torque control are possible


Ramp for torque/current limitation
TargetMaxTorque
MaxTorqueSlope
Ref. value 2 reached
Internal limitation
MotionProfileType
TargetVelocity
Speed controller
Current limitation
Ref. current value
ActualVelocity
ProfileDeceleration
ProfileAcceleration
QuickStopDeceleration
MaxProfileVelocity
Speed zero
Ref.value 1 reached

9.6.1.1 Reference Value Telegram

The reference value telegram for controlling the drive consists of informative data of 16 bytes structured as follows:

Byte	Size	Name	Bit	Description
0	2	ControlWord	0	Switch on
			1	Enable voltage
			2	Quick stop
			3	Enable operation
			4	Reserved
			5	Reserved
			6	Reserved
			7	Fault reset
			8	Reserved
			9	Reserved
			10	Reserved
			11	Reserved
			12	Reserved
			13	Reserved
			14	Reference value telegram ID / 0
			15	Reference value telegram ID / 1
2	2	Reserved		Reserved
4	2	SPG_TARGET-VELOCITY-VL		Target velocity VL 16 bits 0x3fff = 100% = Vscaling
6	2	SPG-TARGET-TORQUE-LIMIT		Torque / current limitation 0x3fff = peak current of the amplifier Only in the drive function SERVO, otherwise reserved
8	1	Reserved		Reserved
9	7	ServiceChannel		See chapter "Service data channel", page 62

The functioning of the individual bits is explained in the chapter "Operating Modes" (page 19).

9.6.1.2 Actual Value Telegram

The actual value telegram consists of informative data of 16 bytes structured as follows:

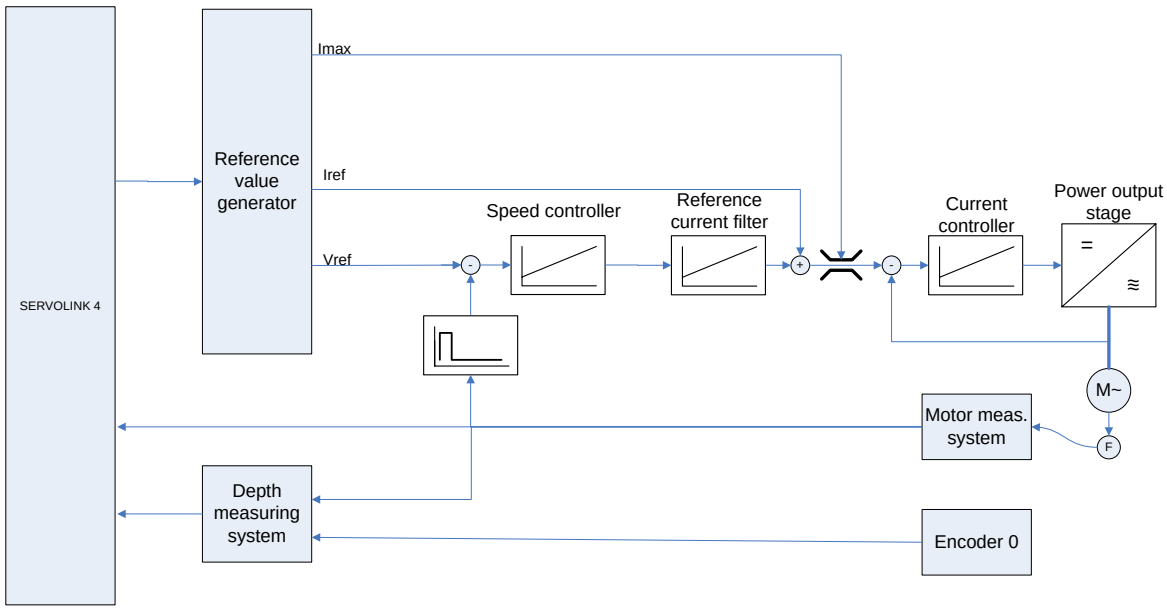
Byte	Size	Name	Bit	Description
0	2	StatusWord	0	Ready to switch on
			1	Switched on
			2	Operation enabled
			3	Fault
			4	Enable voltage
			5	Quick stop
			6	Switch on disabled
			7	Warning
			8	Reserved
			9	Remote
			10	Reference value reached
			11	Internal limit active
			12	Speed reached
			13	Max. torque reached
			14	Actual value telegram ID / 1
			15	Actual value telegram ID / 0
2	4	PCTRL_POSITION_ACTUAL_VALUE		Current position of position controller 32 bits,
6	2	VCTRL_VELOCITY_ACTUAL_VALUE		Current actual speed 0x3fff = 100% = Vscaling
8	2	ICTRL_IQ_REFERENCE		Current reference current value 0x3fff = peak current of the amplifier
10	6	ServiceData Channel		See chapter "Service data channel", page 62

The functioning of the individual bits is explained in the chapter "Operating Modes" (page 19).

9.6.2 Profiled Velocity Mode (PV, Mode 3)

The operating mode "Profiled Velocity Mode" provides the following possibilities:

- Speed value setting via SERVOLINK 4 while the positioning profile must be generated in the higher-ranking control
- The SERVOLINK-transmission rate is 2 kHz (default) or 4 kHz.
- The data rate of the reference speed values can be as a multiple of 4 kHz.
- Internal precise interpolation of the reference speed values for reducing reference value jumps resulting from the data rate of the preset values
- Direct presetting of a current feed forward value in the cyclic reference value telegram
- Automatic conversion / scaling of the position measuring systems in 100 nm
- Calculation of a current feed forward with 4 kHz in the drive amplifier
- Monitoring of the speed error in the drive amplifier
- Monitoring of the preset positioning profile concering max. velocity and max. acceleration
- Device control according to the drive profile DS402
- Additional torque / force limitation



9.6.2.1 Reference Value Telegram

The reference value telegram for controlling the drive consists of informative data of 16 bytes structured as follows:

Byte	Size	Name	Bit	Description
0	2	ControlWord	0	Switch on
			1	Enable voltage
			2	Quick stop
			3	Enable operation
			4	Reserved
			5	Reserved
			6	Reserved
			7	Fault reset
			8	Reserved
			9	Reserved
			10	Reserved
			11	Reserved
			12	Reset Delta Z function
			13	Reserved
			14	Reference value telegram ID / 0
			15	Reference value telegram ID / 1
2	2	Reserved		Reserved
4	2	SPG_TARGET-VELOCITY-VL		Target speed 32 Bit [0.1u/500µs*65536]
6	2	SPG_TARGET-TORQUE-LIMIT		Current feed forward [0x3fff = peak current of the amplifier
8	1	Reserved		Reserved
9	7	ServiceChannel		See chapter "Service data channel", page 62

The functioning of the individual bits is explained in the chapter "Operating Modes" (page 19).

9.6.2.2 Actual Value Telegram

The actual value telegram consists of informative data of 16 bytes structured as follows:

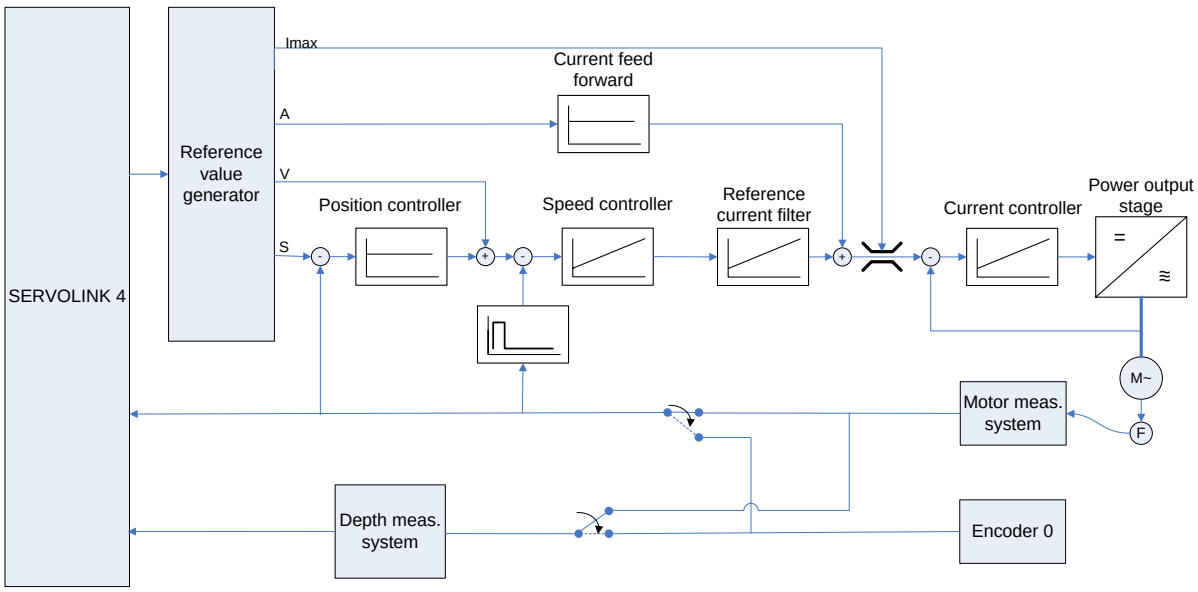
Byte	Size	Name	Bit	Description
0	2	StatusWord	0	Ready to switch on
			1	Switched on
			2	Operation enabled
			3	Fault
			4	Enable voltage
			5	Quick stop
			6	Switch on disabled
			7	Warning
			8	Status of the digital input 4 / measuring system contact
			9	Remote
			10	Reference value reached
			11	Internal limit active
			12	Speed reached
			13	Max. torque reached
			14	Actual value telegram ID / 1
			15	Actual value telegram ID / 0
2	4	PCTRL_POSITION_ACTUAL_VALUE		Current position of position controller 32 bits, resolution 0.1 µm
6	2	DELTAZ_POSITION_ACTUAL_VALUE		Current DeltaZ position 16 bits resolution 0.1 µm
8	2	ICTRL_IQ_REFERENCE		Actual current 0x3fff = peak current of the amplifier
10	6	ServiceData Channel		See chapter "Service data channel", page 62

The functioning of the individual bits is explained in the chapter "Operating Modes" (page 19).

9.6.3 Interpolated Position Mode (Mode 7)

The operating mode "Interpolated Position Control" provides the following possibilities:

- Cyclic position value setting via SERVOLINK 4 while the positioning profile must be generated in the higher-ranking control
- The SERVOLINK-transmission rate is 2 kHz (default) or 4 kHz.
- The data rate of the reference position values can be as a multiple of 4 kHz.
- Internal calculation of the reference speed values from the reference position values with precise interpolation
- The position control is done in the drive amplifier with 4 kHz.
- Automatic conversion / scaling of the position measuring systems in 100 nm
- Calculation of a current feed forward with 4 kHz in the drive amplifier
- Monitoring of the preset positioning profile concering max. velocity and max. acceleration
- Tracking error monitoring in the drive amplifier
- Device control according to the drive profile DS402
- Additional torque / force limitation



9.6.3.1 Reference Value Telegram

The reference value telegram for controlling the drive consists of informative data of 16 bytes structured as follows:

Byte	Size	Name	Bit	Description
0	2	ControlWord	0	Switch on
			1	Enable voltage
			2	Quick stop
			3	Enable operation
			4*	Enable IP mode
			5*	Reserved
			6*	Reserved
			7	Fault reset
			8*	Stop bit (always 1)
			9	Interpolating position control
			10	Velocity mode 1
			11	Profiled Velocity Mode (PV)
			12	Reset Delta Z function
			13	Reserved
			14	Reference value telegram ID / always 0
			15	Reference value telegram ID / 1
2	6	INTERPOLATION_DATA		Target position (Format 0.1µ*65536)
8	1	INTERPOLATION_CONTROLWORD		See operating mode "Interpolated position mode", page 30
9	7	ServiceData		See chapter "Service data channel", page 62

*Bit 4, 5, 6 and 8 are control bits depending on the operating mode

The functioning of the individual bits is explained in the chapter "Operating Modes" (page 19).

9.6.3.2 Actual Value Telegram

The actual value telegram consists of informative data of 16 bytes structured as follows:

Byte	Size	Name	Bit	Description
0	2	StatusWord	0	Ready to switch on
			1	Switched on
			2	Operation enabled
			3	Fault
			4	Enable voltage
			5	Quick stop
			6	Switch on disabled
			7	Warning
			8	Status of the digital input 4 / measuring system contact
			9	Remote
			10	Reference value reached
			11	Internal limit active
			12	Interpolation active
			13	Reserved
			14	Actual value telegram ID / 1
			15	Actual value telegram ID / 0
2	4	PCTRL_POSITION__ACTUAL_VALUE		Current position of position controller 32 bits, resolution 0.1 µm
6	2	DELTAZ_POSITION_ACTUAL_VALUE		Current Delta Z position, 16 bits, resolution 0.1 µm
8	2	ICTRL_IQ_REFERENCE		Current reference current value 0x3fff = peak current of the amplifier
10	6	ServiceData Channel		See chapter "Service data channel", page 62

The functioning of the individual bits is explained in the chapter "Operating Modes" (page 19).

9.7 Service Data Channel

The service data channel allows reading and writing any data object. The contents are transmitted sequentially via a cyclical data channel. Large data structures and complete programs can also be transmitted via the cyclical data channel. Contrary to the objects in the process data channel these data are not transmitted cyclically, but only if required.

9.7.1 Mapping in the Telegram

9.7.1.1 Reference Value Telegram

The reference value telegram for controlling the drive consists of informative data of 16 bytes. The bytes 9 to 15 are used for the service data channel.

Byte	Size	Name	Bit	Description
0	9	CyclicDataChannel		Prozess data channel
9	1	ServiceControl	0	ServiceValidToggle
			1	ServiceFunction bit 0
			2	ServiceFunction bit 1
			3	ServiceLastValidByteIndex bit 0
			4	ServiceLastValidByteIndex bit 1
			5	Reserved S&M
			6	Reserved S&M
			7	Reserved S&M
10	2	ServiceIndex		Object number
12	4	ServiceValue		Object value

Control bits "ValidToggle"

Comparing the bits "ServiceValidToggle" of the reference value telegram and the bit "ServiceDoneToggle" of the actual value telegram allows detection whether a service inquiry is still active or a result already exists. If the bits have the same value the result can be read-out of the actual value telegram. If the values are different, the inquiry is not yet finished. The master toggles the bit "ServiceValidToggle" during every service inquiry. The bit "ServiceDoneToggle" is adapted after the execution by the slave. Toggling the bit "ServiceValidToggle" is only allowed if it has the same value as the bit "ServiceDoneToggle. The process is shown in the diagram on page 67.

Control bits "ServiceFunction0/1"

The desired function is selected via the bits "ServiceFunction0" and "ServiceFunction1".

Value	Meaning
0	Read object
1	Set array index
2	Write object
3	Reserved

Control bits "ServiceLastValidByteIndex0/1"

The bits "ServiceLastValidByteIndex" indicate the number of valid data bytes in the last data word

Value	Meaning
0	1 byte valid
1	2 bytes valid
2	3 bytes valid
3	4 bytes valid

Index

The index describes the selected object number.

Value (write)

The object value is transmitted in the bytes 12 to 15.

Actual Value Telegram

The actual value telegram for controlling the drive consists of informative data of 16 bytes. The bytes 10 to 13 and 15 are used for the service data channel.

Byte	Size	Name	Bit	Description
0	10	CyclicDataChannel		Prozess data channel
10	4	ServiceValue		Return values
14	1	Reserved		
15	1	ServiceState	0	ServiceDoneToggle
			1	ServiceFault
			2	Reserved S&M
			3	Reserved S&M
			4	Reserved S&M
			5	Reserved S&M
			6	Reserved S&M
			7	Reserved S&M

DoneToggle

The bit "ServiceDoneToggle" acknowledges the acception of a data word (see diagram page 67).

Fault

The bit "ServiceFault" indicates the successful transmission of the object data (0 = successful, 1 = not successful). The state of the bit is valid when "ServiceValidToggle" and "ServiceDoneToggle" have the same value. During a running service inquiry (ServiceValidToggle ≠ ServiceDoneToggle) the state is not defined. If a service inquiry is processed successfully, this bit is cleared.

Value (read)

The object value is transmitted in the bytes 10 to 13.

9.7.2 Access to the Drive Objects

The master controls the access to the service data channel via the signal "ServiceValidToggle". The drive signals the status of the execution via the signal "ServiceDoneToggle"
If no service command is executed the two signals "ServiceValidToggle" and "ServiceDoneToggle" have the same level.
A new service command is started by the master by toggling the signal "ServiceValidToggle". When the execution of a service command by the drive is finished, it is signaled to the control by adapting the signal "ServiceDoneToggle".

- Reading an object:
  Reading access is controlled in the reference value telegram via "ServiceFunction = 0". The corresponding object is selected via "ServiceIndex". The result of the reading access is returned in the actual value telegram via "ServiceReturn".

- Writing an object:
  Writing access is controlled in the reference value telegram via "ServiceIndex", "ServiceData" and "ServiceFunction = 2". "ServiceIndex" is used for selecting the corresponding object and "ServiceData" includes the corresponding value. The number of valid bytes (-1) in this telegram must be set via "ServiceLastValidByteIndex".

- Object access fault:
  If the access to a drive object is faulty (index not valid, value range exceeded...) the fault is signaled in the actual value telegram is indicated via the signal "ServiceFault". Additionally the detailed fault number is returned in "ServiceReturn".

The acyclic service data channel provides informative data of max. 32 bits. For this reason only objects with a max. length of 32 bits can be written. Larger objects such as arrays require an additional mechanism. In order to write arrays the start index must first be handed over via the ServiceFunction = 1 (set array index). This is done with a reference value telegram. The drive acknowledges the telegram with a ServiceToggle and by returning the received array index in the actual value telegram. In the following reference value telegram 1 to 4 bytes can be written into the command array via the command "ServiceFunction = 2" (write object). The array index saved in the drive amplifier is increased automatically by the number of written bytes. This makes it possible that data can be written into the array by calling again the command "ServiceFunction = 2" (write object). Since only one variable is provided in the drive for saving the current array index, nested access to two arrays, e.g write array A / write array B / write array A etc., is not possible.

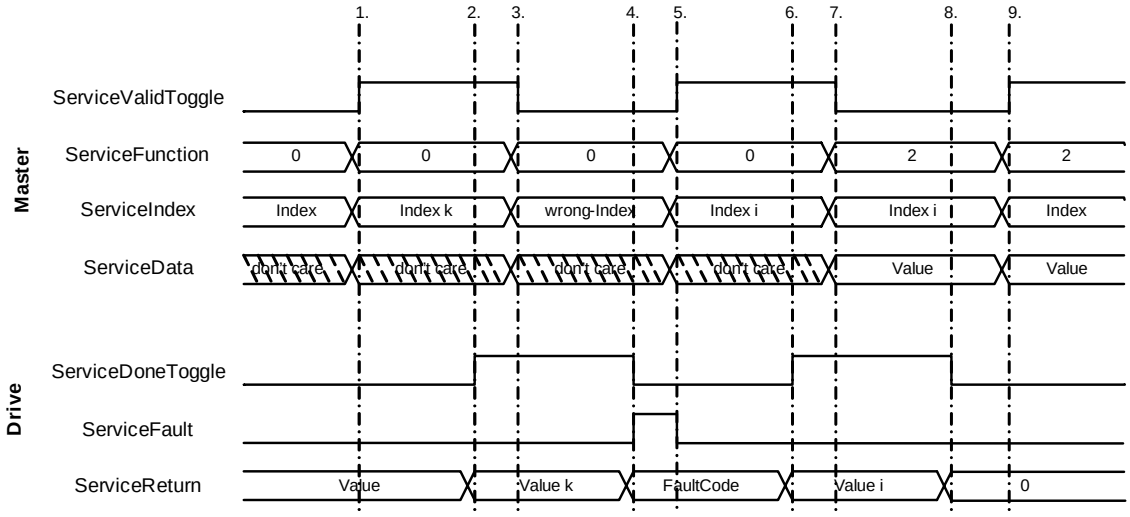
When array objects are read, the array index is transmitted in every reference value telegram. Therefore, no array index must be set. The variable saved in the drive is not increased during the read access. Therefore, the incremental writing of the array is not interrupted during the read access.

9.7.3 Overview on Access Functions

Reference Value Telegram	Byte	Read object (0)	Write object (2)	Set array index (1)
Service control	9	Service control	Service control	Service control
Service index	10	Index LOW-byte	Index LOW-byte	Not assigned
	11	Index HIGH-byte	Index HIGH-byte	Not assigned
Service value	12	Array index 0	Byte 0	Array index 0
	13	Array index 1	Byte 1	Array index 1
	14	Array index 2	Byte 2	Array index 2
	15	Array index 3	Byte 3	Array index 3

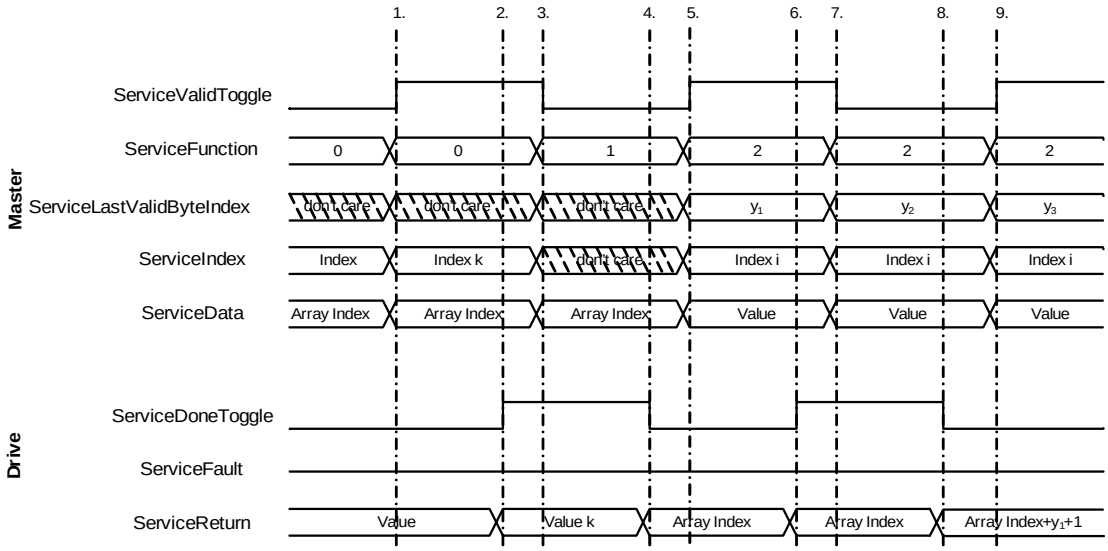
Actual Value Telegram	Byte	Read object (0)	Write object (2)	Set array index (1)
Service return	10	Byte 0 / Fault code	Array index 0 / Fault code	Array index 0
	11	Byte 1 / Fault code	Array index 1 / Fault code	Array index 1
	12	Byte 2	Array index 2	Array index 2
	13	Byte 3	Array index 3	Array index 3
Free	14	-	-	-
Service state	15	Service status	Service status	Service status

9.7.4 Reading and Writing Simple Objects



- Read-out process for the object with the index k is started
- Read-out process for the object with the index k is completed successfully
- Read-out process for the object with a wrong index is started
- Read-out process for the object with a wrong index is not completed successfully (faults have occurred)
- Read-out process for the object with the index i is started
- Read-out process for the object with the index i is completed successfully
- Write process to the object with the index i is started
- Write process to the object with the index i is completed successfully

9.7.5 Reading and Writing Array Objects



- Read-out process for the array object k at the array position "Array-Index" is started
- Read-out process for the object k is completed successfully
- Array position for the following writing process of an array is set
- Drive acknowledges and returns array index for checking
- Y_1 + bytes are written at the array position "Array Index" in the array i
- Drive acknowledges and returns current array index for checking
- Auto-incremental y_2 + 1 byte is written in the array i
- Drive acknowledges and returns current array index for checking
- Auto-incremental y_2 + 1 bytes is written in the array i

9.7.6 Access to Array/String Objects

Reference value index	Byte	Read array object	Write array object	Array object incremental writing
Service index	0	Index LOW-byte	Index LOW-byte	Index LOW-byte
	1	Index HIGH-byte	Index HIGH-byte	Index HIGH-byte
Service value	0	Array index LOW-byte	Array index LOW-byte	Data
	1	Array index HIGH-byte	Array index HIGH-byte	Data
	2	Not assigned	Data	Data
	3	Not assigned	Data	Data

Actual value index	Byte	Read array object	Write array object	Array object incremental writing
Service return	0	Data /error code	Fault code	Fault code
	1	Data /error code	Fault code	Fault code
	2	Data	Not assigned	Array index LOW-byte
	3	Data	Not assigned	Array index HIGH-byte

In order to send an array index via the service channel, the meaning of ServiceValue is adapted in the reference value telegram by using the 2 higher-ranking bytes as index pointer to a word of the array. Generally data are transmitted the same way as for objects. The result in the actual value telegram are 4 bytes, beginning with the transmitted array index. This allows reading-out an array step by step. In case of a fault during the access the ServiceFault bit is set and the error code is transmitted in the 2 higher-ranking bits of the actual value telegram.

The write and read process of an array work the same way. The process also uses the 2 higher-ranking bytes of the ServiceValue as index pointer. The 2 lower-ranking bytes include the data to be written, beginning from the indicated index. The higher-ranking bytes of the actual value telegram are used for transmitting the error code in case of ServiceFault. Since the bandwidth of the write channel only has 16 bits per telegram, the auto-incremental mode can be used. For this purpose the ServiceAutoIncrement bit must be set. When the bit is set 4 bytes can be transmitted via ServiceValue.

9.7.7 Fault Codes of the Service Data Channel

Fault code	Description
0x00	No error
0x81 or 0x01	Toggle bit is adapted
0x86 or 0x06	CRC error
0x87 or 0x07	No free memory available
0x88 or 0x08	Not allowed access to an object
0x89 or 0x09	Try to read a write-only object
0x8A or 0x0A	Try to write a read-only object
0x8B or 0x0B	Object does not exist in the object directory
0x8C or 0x0C	Reserved
0x8D or 0x0D	Reserved
0x8E or 0x0E	General incompatibility of the parameters
0x8F or 0x0F	General internal incompatibility in the device
0x90 or 0x10	Access denied due to hardware error
0x91 or 0x11	Data type not correct, length of the service parameter not correct
0x92 or 0x12	Data type not correct, length of the service parameter too high
0x93 or 0x13	Data type not correct, length of the service parameter too low
0x94 or 0x14	Subindex does not exist
0x95 or 0x15	Value range of the parameter exceeded (only during write access)
0x96 or 0x16	Value of the written parameter too high
0x97 or 0x17	Value of the written parameter too low
0x98 or 0x18	Maximum value below minimum value
0x99 or 0x19	General fault
0x9A or 0x1A	Data can not be transmitted or saved in the application
0x9B or 0x1B	Data can not be transmitted or saved in the application due to the status of the control
0x9C or 0x1C	Data can not be transmitted or saved in the application due to reset of the device
0x9D or 0x1D	Dynamic generation of the object directory not possible or no object directory existing
0x9E or 0x1E	Read access denied
0x9F or 0x1F	Write access denied