SIEB & MEYER

Drive System SD2

Device Control

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1 Device Control

The device control is the central unit of the drive. Here, the system decides on the control channel providing the reference values to be processed and the destination of the actual values.

The status of the drive is determined via the *control word*. The device control returns the status 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

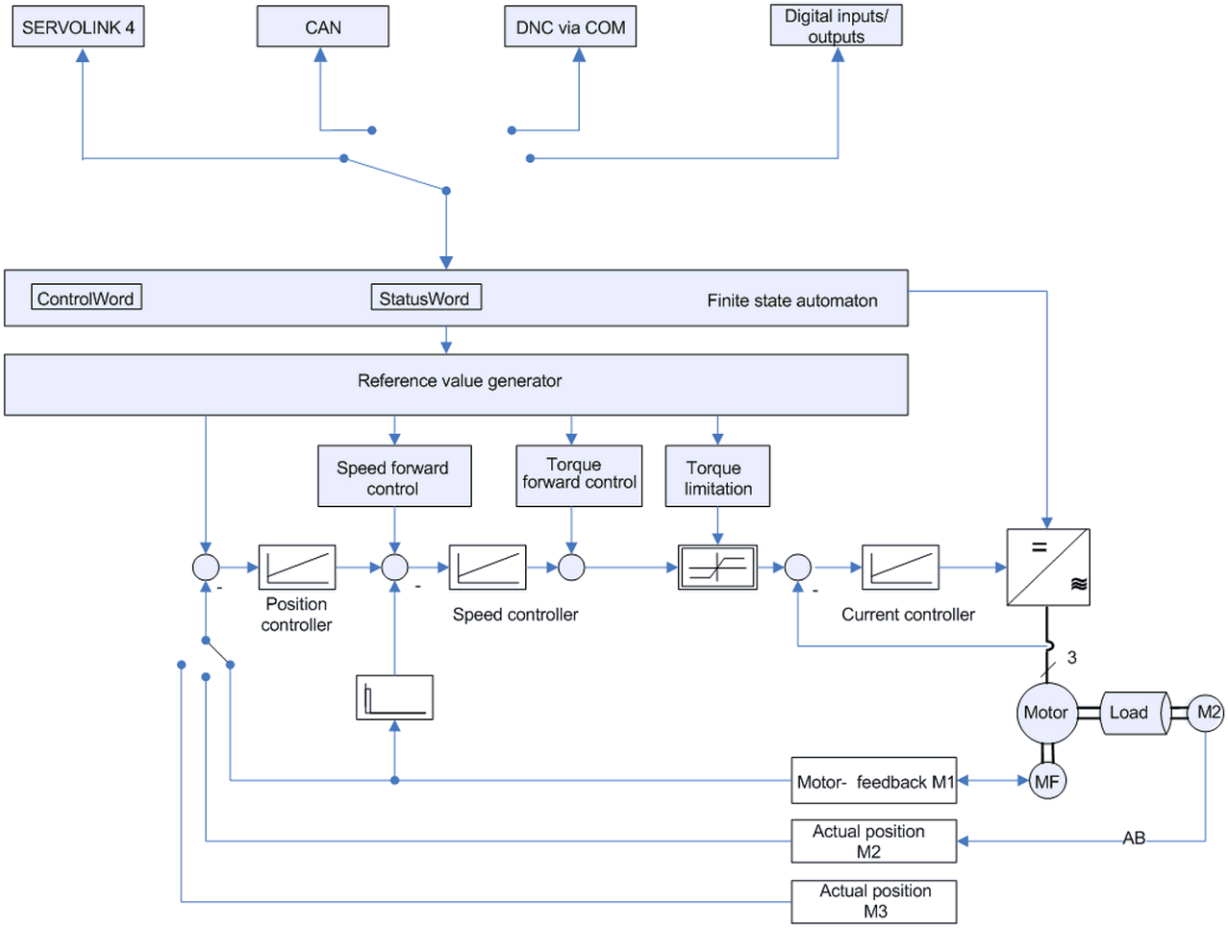


Fig. 1: Device control

1.1 Finite State Automaton

The finite state automaton has the following tasks:

- Description of the status and the possible **control sequences** of the drive. The control sequences in turn depend on the status of the drive.
- Representation of the different **states of the drives** and switching of operating states.

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

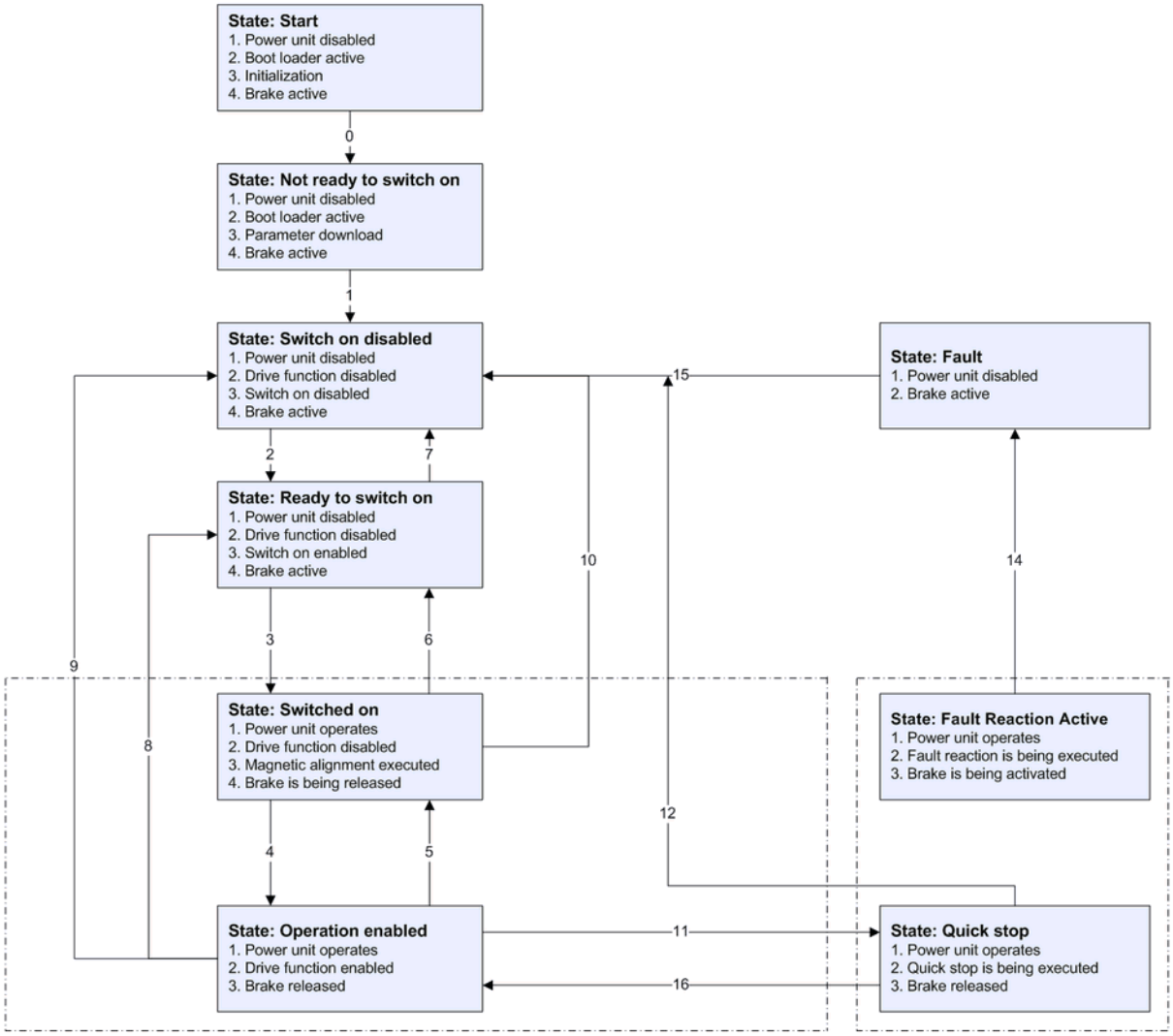


Fig. 2: Drive states and state transitions

1.2 States of the Finite State Automaton

1.2.1 Not Ready to Switch On

- Drive is booted.
  - initialization
  - self test
  - loading of the drive parameters
- Power unit disabled.
- Switch-on is disabled.
- Drive function is disabled.
- Motor holding brake, if present, is activated.
- SERVOLINK/DNC/CAN connection is available.

1.2.2 Switch On Disabled

- Booting is complete.
- No errors have been detected.
- Power unit is off.
- Switch-on is disabled.
- Drive function is disabled.
- Motor holding brake, if present, is active.

1.2.3 Ready to Switch On

- No errors have been detected.
- Power supply is provided.
- Power unit is off.
- Switch-on is enabled.
- Drive function is disabled.
- Motor holding brake, if present, is active.

1.2.4 Switched On

- No errors have been detected.
- Power supply is provided.
- Power unit is on.
- Drive function is disabled, reference values are not processed.
- Motor holding brake, if present, is being released.

1.2.5 Operation Enabled

- No errors have been detected.
- Power supply is provided.
- Power unit is on.
- Drive function is enabled, reference values are processed.
- Motor holding brake, if present, is released.

1.2.6 Quick Stop

- No errors have been detected.
- Power supply is provided.
- Drive function is enabled.
- Quick stop reaction is being executed.
- Power unit is on, reference values are generated by quick stop reaction.
- Motor holding brake, if present, is released.

1.2.7 Fault Reaction Active

- Drive error has been detected.
- Power supply is provided.
- Drive function is enabled.
- Fault reaction is being executed.
- Power unit is on, the reference values are generated by the fault reaction.

- When the fault reaction is finished, the system automatically changes into the state “Fault”.
- Motor holding brake, if present, is released.

1.2.8 Fault

- Drive error has been detected.
- Fault reaction is finished.
- Power unit is off.
- Switch-on is disabled.
- Drive function is disabled.
- Motor holding brake, if present, is active.

1.3 Control Word/Status Word

The finite state automaton is externally controlled via the control word and other external signals. During this process the access of the control word to the finite state automaton is controlled via the signal “Remote”. The device status is indicated by the status word in the actual value telegram.

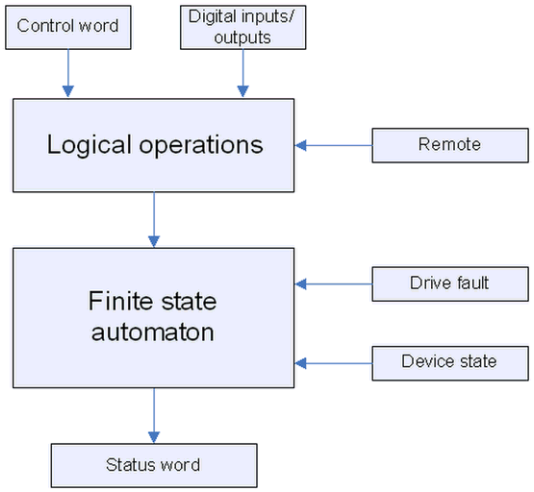


Fig. 3: Control of finite state automaton

1.3.1 Structure of the Control Word (Object 68_D)

Bit	Name	Description
0	Switch on	Power unit is to be switched on (→status: switched on).
1	Enable voltage	The voltage at the power unit can be switched on.
2	Quick stop	Quick stop is to be triggered (→status: quick stop).
3	Enable operation	Drive function is to be enabled (→status: operation enabled).
4	Mode 0	This control command depends on the current operating mode (see chapter 4 "Operating Modes", page 21).
5	Mode 1	This control command depends on the current operating mode (see chapter 4 "Operating Modes", page 21).
6	Mode 2	This control command depends on the current operating mode (see chapter 4 "Operating Modes", page 21).

Bit	Name	Description
7	Fault reset	Drive error is acknowledged. Fault reaction is to be executed (→status: fault reaction active).
8	Hold	Stop function is being executed.
9	Res.	Reserved
10	Res.	Reserved
11	Res.	Reserved
12	Res.	Reserved
13	Res.	Reserved
14	Res.	Reserved
15	Res.	Reserved

Bits 0–3 and 7: The device control commands are mapped via these bits.

Bits 4–6: At present, these bits are set to '0' for all operating modes.

Bits 8–10 and 12–13: These control bits are reserved for future applications and are to be set to '0'.

1.3.2 Device Control Commands

The device control commands are mapped by the following bit combinations of the control bits 0–3 and 7 in the control word of the reference value telegram. Whether or not a device control command can be executed by the drive depends on the status 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 Enable voltage	Bit 0 Switch on		
Shut down	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	⎍	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.

1

1.3.3 Structure of the Status Word (Object 67$_D$)

The device status is indicated by the status word in the actual value telegram.

Bit	Name	Description
0	Ready to switch on	Power output stage is ready to be switched on.
1	Switched on	Power output stage is switched on.
2	Operation enabled	Operation is enabled.
3	Fault	Error occurred in drive (see chapter 7 "Fault Behavior", page 41).
4	Voltage enabled	DC link voltage is provided.
5	Quick stop	Quick stop is executed.
6	Switch on disabled	Drive can not be switched on.
7	Warning	Drive signals a warning message (see section 1.4 "Warning messages", page 13 and chapter 7 "Fault Behavior", page 41).
8	Res.	Reserved
9	Remote	Control via bus system.
10	Target reached	Target value is reached (see chapter 4 "Operating Modes", page 21).
11	Internal limit reached	Internal limit in the drive is active (see chapter 4 "Operating Modes", page 21).
12	Operating mode	Status display depending on the current operation mode
13	Operating mode	Status display depending on the current operation mode
14	Res.	Reserved
15	Res.	Reserved

Bits 0–5 and 6: Representation of the device status or the finite state automaton

Bits 7 and 10–13: Additional information on the drive (depending on the operating mode)

Operating mode	Bit 12	Bit 13
Velocity mode 1	Speed zero	Reference value for current limitation reached
Interpolated position control	Interpolated position control active	Position error → warning threshold

1.3.4 Device States

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

Status	Bits of the status word					
	Bit 6 Switch on disabled	Bit 5 Quick stop	Bit 3 Fault	Bit 2 Operation enabled	Bit 1 Switched on	Bit 0 Ready to switch on
Not ready to switch on	0	X	0	0	0	0
Switch on disabled	1	X	0	0	0	0
Ready to switch on	0	1	0	0	0	1
Switched on	0	1	0	0	1	1
Operation enabled	0	1	0	1	1	1

Status	Bits of the status word					
	Bit 6 Switch on disabled	Bit 5 Quick stop	Bit 3 Fault	Bit 2 Operation enabled	Bit 1 Switched on	Bit 0 Ready to switch on
Quick stop	0	0	0	1	1	1
Fault reaction active	0	X	1	1	1	1
Fault	0	X	1	0	0	0

1.4 Warning messages

Different warning messages are generated in the drive. These can be indicated via bit 7 “Warning” of the status word.

Internally, all warning messages are mapped bit-coded in a warning register with a length of 32 bits each. This warning register can be read directly from the drive via the object WARNING_REGISTER (index 87). In addition, you can use the object WARNING_REGISTER_MASK (index 88) to define which warning message is to be mapped on bit 7 “Warning” in the status word. Via the object WARNING_CREATES_ERROR_MASK (index 89) you can define whether one or several warning messages signal a drive error. The corresponding fault reaction is user-defined.

A description of all warning messages is to find in section 7.2.3 "List of Warning Messages", page 47.

1

2 Quick Stop

The quick stop function allows defined deceleration of the drive from the operating status “operation enabled” to the operating status “quick stop”. This function can be executed via the device control command “quick stop” or directly via a digital input.

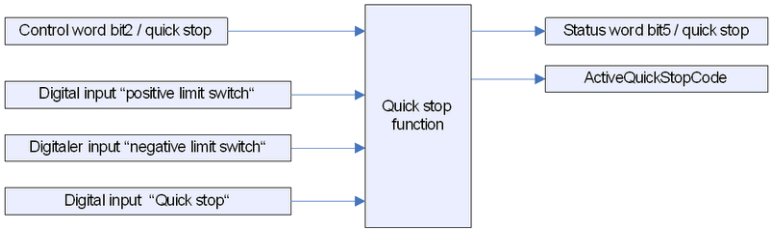


Fig. 4: Quick stop function

2.1 Objects for the Quick Stop Function

The following objects are used for cause and reaction of the quick stop. In addition, the object 188_D is available. Via this object you can determine that the quick stop ramp is defined in milliseconds in the operating mode “Velocity mode 1” (see "SPG_QUICK-STOP_DECELERATION_TIME_VL (Object 188_D)", page 24).

DEV_CTRL_QUICKSTOP_ACTUAL_CODE (Object 71_D)

Via the object DEV_CTRL_QUICKSTOP_ACTUAL_CODE you can read the cause of the quick stop command from the drive.

Object description

Object name	DEV_CTRL_QUICKSTOP_ACTUAL_CODE
Object index	71_D
Access	Readable (after the drive parameters have been set)
Data type	u16
Unit	None

Data description

Value	Cause of quick stop
0x070D	Digital input "Speed Enable"
0x070C	Digital input "Positive limit switch"
0x070B	Digital input "Negative limit switch"
0x0709	Bus system "Quick stop" (The quick stop bit is set to 0)
0x0708	Software positioning error "Positive limit"
0x0707	Software positioning error "Negative limit"
0x0704	Digital input "Quick stop"
0x0703	Software function "Quick stop"

DEV_CTRL_QUICKSTOP_OPTION_CODE (Object 74_D)

Via the object DEV_CTRL_QUICKSTOP_OPTION_CODE you can set the reaction to the device control command “quick stop”.

Object description

Object name	DEV_CTRL_QUICKSTOP_OPTION_CODE
Object index	74_D
Access	Readable/writable (after the drive parameters have been set)
Data type	u16
Unit	None

Data description

Value	Quick stop reaction
−3	Hold torque
−2	Ramp torque down
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 status “quick stop” (the command “disable voltage” is required)
6	Ramp down with quick stop ramp and remain in the status “quick stop” (the command “disable voltage” is required)
7	Ramp down at the current limit and remain in the status “quick stop” (the command “disable voltage” is required)
8	Ramp down at the voltage limit and remain in the status “quick stop” (the command “disable voltage” is required)

3 Control Sequences

3.1 Switch On Sequence

The sequence *switch on* is represented via the device control commands as follows:

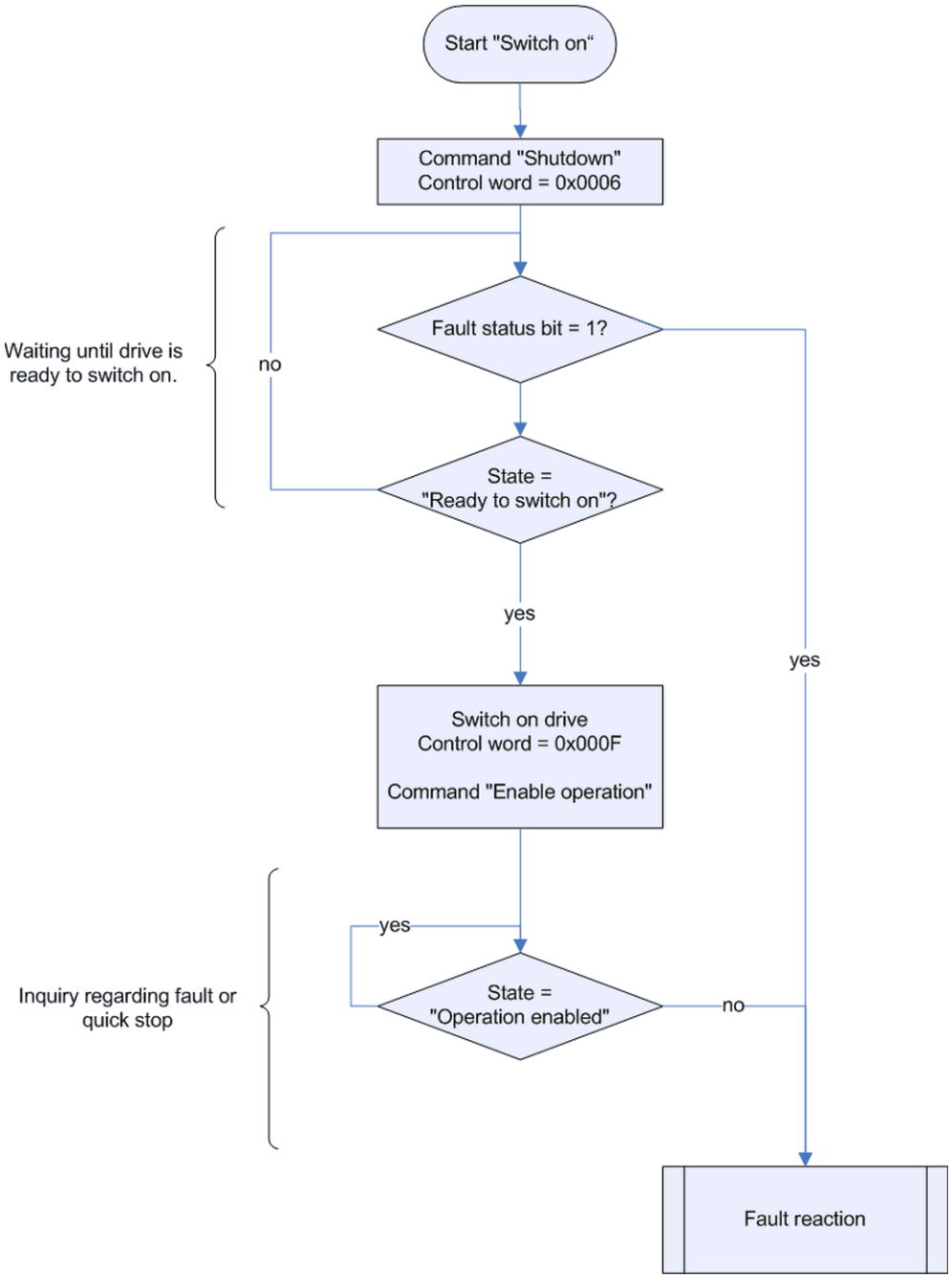


Fig. 5: Switch on

3.2 Switch Off Sequence

The sequence *switch off* is represented via the device control commands as follows:

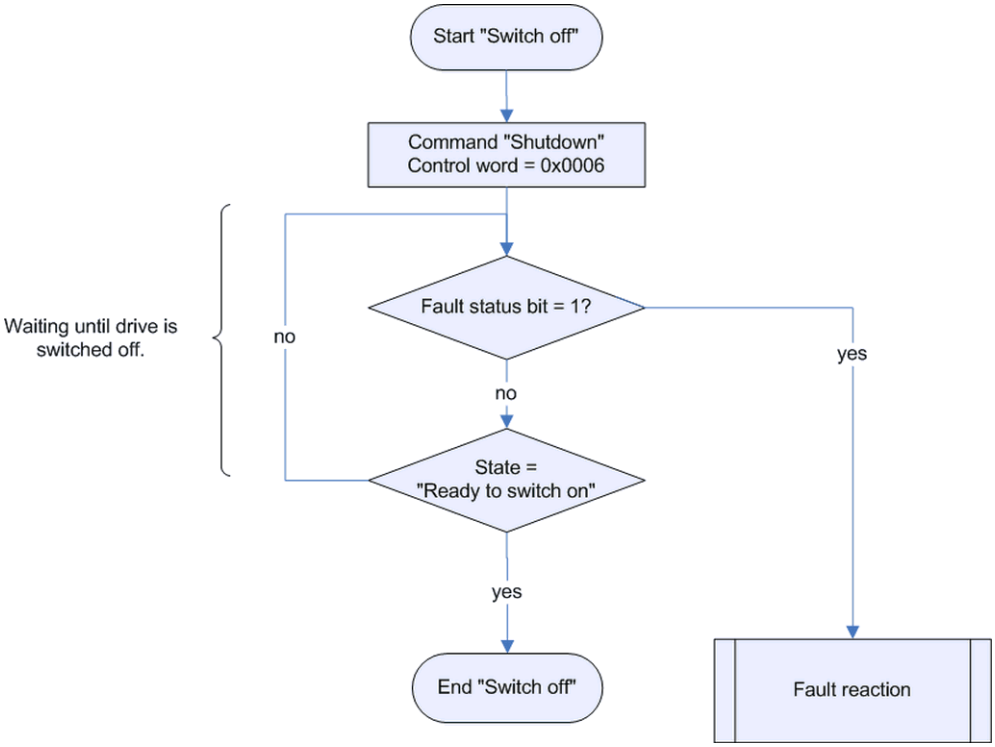


Fig. 6: Controller off

3.3 Fault Reset Sequence

The sequence *fault reset* is mapped via the device control commands as follows:

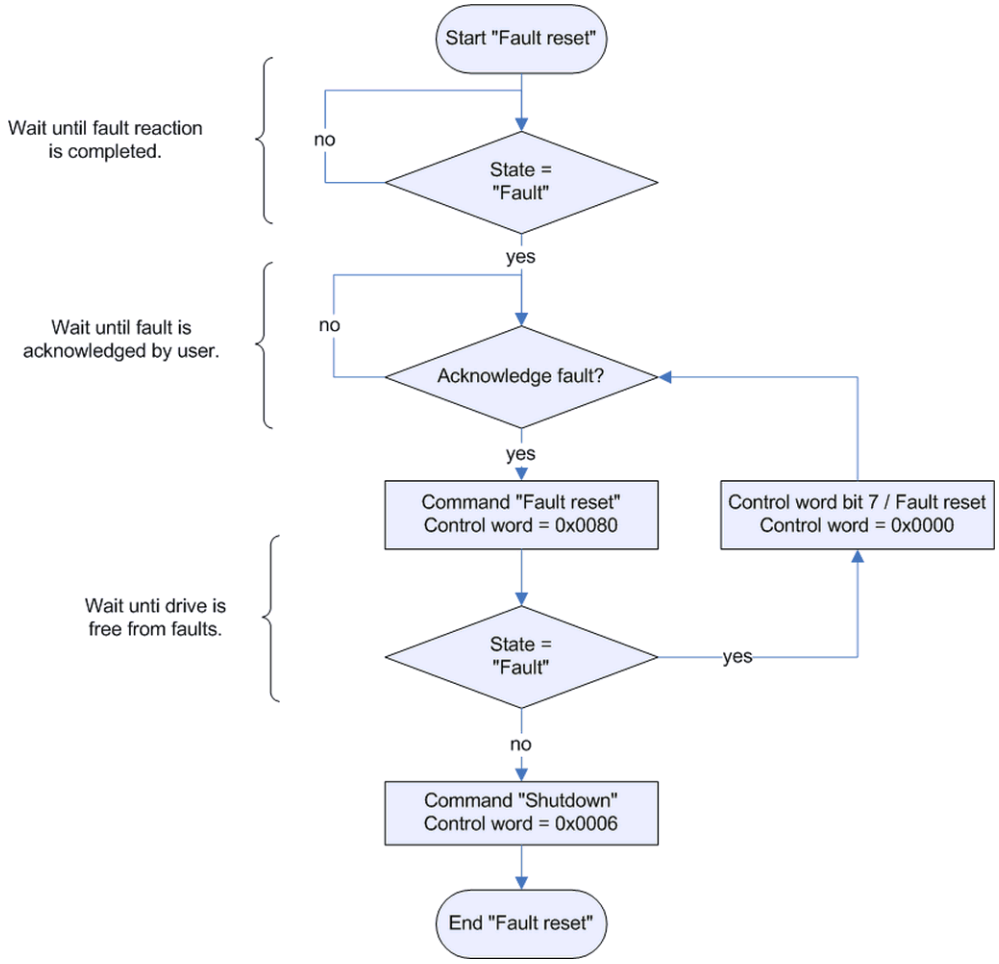


Fig. 7: Fault reset

4 Operating Modes

You can change the operating mode of your drive as follows:

- via the software *drivemaster2* (“Configuration → Drive control → Operating mode”)
- via the corresponding objects

The available operating modes depend on the used device and drive function.

4.1 Objects for the Operating Mode Selection

DEV_CTRL_MODES_OF_OPERATION (Object 76_D)

Via the object DEV_CTRL_MODES_OF_OPERATION you can set the operating mode in which the drive is to work in the device status “operation enabled”. The parameter is initialized via the software *drivemaster2*.

Object description

Object name	DEV_CTRL_MODES_OF_OPERATION
Object index	76_D
Access	Always readable Writable (after the drive parameters have been set)
Data type	u16
Unit	None

Data description

Value	Operating mode
0	Reserved
1	Positioning Mode → not yet supported
2	Velocity mode 1
3	Profiled Velocity Mode
4	Current/torque control
5	Reserved
6	Homing Mode → not yet supported
7	Interpolated position control

DEV_CTRL_MODES_OF_OPERATION_DISPLAY (Object 77_D)

Via the object DEV_CTRL_MODES_OF_OPERATION_DISPLAY you can read the current operating mode of the drive in the device status “operation enabled”.

Object description

Object name	DEV_CTRL_MODES_OF_OPERATION_DISPLAY
Object index	77_D
Access	Always readable
Data type	u16
Unit	None

Data description

Value	Operating mode
0	Reserved
1	Positioning Mode → not yet supported
2	Velocity mode 1
3	Profiled Velocity Mode
4	Current/torque control
5	Reserved
6	Homing Mode → not yet supported
7	Interpolated position control

4.2 Operating Mode “Velocity Mode 1”

4.2.1 Units of the Reference Values

In the operating mode “Velocity mode 1” all drive data are set and 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 dictionary is accessed. But when reference values are transmitted via SERVOLINK 4 in the cyclical channel, the user must convert the values himself.

To convert the values into physical units the user should use the following conversion factors which can be read from the drive:

- Conversion of 10 mA into internal unit
  - FACTOR_CURRENT_FRAC_TO_CURRENT_NUM
  - FACTOR_CURRENT_FRAC_TO_CURRENT_DENOM
- Conversion of 0.001 rpm into internal unit:
  - FACTOR_VELOCITY_VL_TO_VELOCITY_NUM
  - FACTOR_VELOCITY_VL_TO_VELOCITY_DENOM

4.2.2 Objects for Operating Mode “Velocity mode 1”

SPG_MOTION_PROFILE_TYPE (Object 119_D)

Via the object SPG_MOTION_PROFILE_TYPE you can set the courses of acceleration ramp and deceleration ramp.

Object description

Object name	SPG_MOTION_PROFILE_TYPE
Object index	119_D
Access	Readable/writable (after the drive parameters have been set)
Data type	u16
Unit	None

Data description

Value	Meaning
1	Constant speed change
2 … 0xffff	Reserved for future expansions

SPG_TARGET_VELOCITY_VL (Object 210_D)

Via the object SPG_TARGET_VELOCITY_VL you can set the reference speed value in the operating mode “Velocity mode 1”.

Object description

Object name	SPG_TARGET_VELOCITY_VL
Object index	210_D
Access	Readable/writable (after the drive parameters have been set) Only effective, when operating mode “Velocity mode 1” is active
Data type	i16
Unit	The value 0x3fff (16383) equals the drive scaling or 100 % reference value. In the software *drivemaster2* you set the drive scaling under “Parameters → Motor measurement system → Velocity scaling”.
Value range	−0x3fff … 0x3fff (equals −100 % … 100 %)

SPG_VELOCITY_ACCELERATION_TIME_VL (Object 186_D)

Via the object SPG_VELOCITY_ACCELERATION_TIME_VL you can set an acceleration ramp in milliseconds in the operating mode “Velocity mode 1”. The ramp time is related to a reference speed value of 100 %.

Object description

Object name	SPG_VELOCITY_ACCELERATION_TIME_VL
Object index	186_D
Access	Always readable/writable
Data type	u32
Unit	ms
Max. value	10,000,000 ms

SPG_VELOCITY_DECELERATION_TIME_VL (Object 187_D)

Via the object SPG_VELOCITY_DECELERATION_TIME_VL you can set a deceleration ramp in milliseconds in the operating mode “Velocity mode 1”. The ramp time is related to a reference speed value of 100 %.

Object description

Object name	SPG_VELOCITY_DECELERATION_TIME_VL
Object index	187_D
Access	Always readable/writable
Data type	u32
Unit	ms
Max. value	10,000,000 ms

SPG_QUICKSTOP_DECELERATION_TIME_VL (Object 188_D)

Via the object SPG_QUICKSTOP_DECELERATION_TIME_VL you can set the quick stomp ramp in milliseconds in the operating mode “Velocity mode 1”. The ramp time is related to a reference speed value of 100 %.

Object description

Object name	SPG_QUICKSTOP_DECELERATION_TIME_VL
Object index	188_D
Access	Always readable/writable
Data type	u32
Unit	ms
Max. value	10,000,000 ms

SPG_TORQUE_LIMIT_SLOPE_TIME (Object 189_D)

Via the object SPG_TORQUE_LIMIT_SLOPE_TIME you can set a modifying ramp for the current/torque limitation of the speed controller in milliseconds. This setting will be effective in all operating modes. The ramp time is related to an output stage current or torque of 100 %.

Object description

Object name	SPG_TORQUE_LIMIT_SLOPE_TIME
Object index	189_D
Access	Always readable/writable
Data type	u32
Unit	ms
Max. value	10,000,000 ms

SPG_TARGET_TORQUE_LIMIT (Object 209_D)

Via the object SPG_TARGET_TORQUE_LIMIT you can set the current/torque limitation of the speed controller in amperes. This setting will be effective in all operating modes.

Object description

Object name	SPG_TARGET_TORQUE_LIMIT
Object index	209_D
Access	Readable/writable (after the drive parameters have been set)
Data type	i16
Unit	0.01 A (sine peak amplitude)
Max. value	0 ≤ SPG_TARGET_TORQUE_LIMIT ≤ SPG_MAX_TORQUE

FACTOR_UNIT_VELOCITY_VL (Object 176_D)

Via the object FACTOR_UNIT_VELOCITY_VL you can read the speed unit resulting from the use of the conversion factors.

Object description

Object name	FACTOR_UNIT_VELOCITY_VL
Object index	176_D
Access	Readable (after the drive parameters have been set)
Data type	u16
Unit	None

Data description

Value	Meaning
1	Speed unit = 0.001 rpm
2 … 0xffff	Reserved for future expansions

FACTOR_VELOCITY_VL_TO_VELOCITY_NUM (Object 177_D)

Via the object FACTOR_VELOCITY_VL_TO_VELOCITY_NUM you can convert the internal number format into a physical unit. The physical unit and the range are defined by the object FACTOR_UNIT_VELOCITY_VL.

$$\text{Physical unit} = \text{internal measurement} \times \frac{\text{Numerator}}{\text{Denominator}}$$

Object description

Object name	FACTOR_VELOCITY_VL_TO_VELOCITY_NUM
Object index	177_D
Access	Readable (after the drive parameters have been set)
Data type	i32
Unit	None

Object name	FACTOR_VELOCITY_VL_TO_VELOCITY_NUM
Meaning	Numerator for the conversion function

FACTOR_VELOCITY_VL_TO_VELOCITY_DENOM (Object 178_D)

Via the object FACTOR_VELOCITY_VL_TO_VELOCITY_DENOM you can convert the internal number format into a physical unit. The physical unit and the range are defined via the object FACTOR_UNIT_VELOCITY_VL.

$$\text{Physical unit} = \text{internal measurement} \times \frac{\text{Numerator}}{\text{Denominator}}$$

Object description

Object name	FACTOR_VELOCITY_VL_TO_VELOCITY_DENOM
Object index	178_D
Access	Readable (after the drive parameters have been set)
Data type	i32
Unit	None
Meaning	Denominator for the conversion function

FACTOR_UNIT_CURRENT (Object 181_D)

Via the object FACTOR_UNIT_CURRENT you can read the physical unit and the range of the current unit resulting from the use of the conversion factors.

Object description

Object name	FACTOR_UNIT_CURRENT
Object index	181_D
Access	Readable (after the drive parameters have been set)
Data type	u16
Unit	None

Data description

Value	Meaning
1	Current unit = 0.01 A (sine peak amplitude)
2 … 0xffff	Reserved for future expansions

FACTOR_CURRENT_FRAC_TO_CURRENT_NUM (Object 182_D)

Via the object FACTOR_CURRENT_FRAC_TO_CURRENT_NUM you can convert the internal number format for currents into a physical unit. The physical unit and the range are defined via the object FACTOR_UNIT_CURRENT.

$$\text{Physical unit} = \text{internal measurement} \times \frac{\text{Numerator}}{\text{Denominator}}$$

Object description

Object name	FACTOR_CURRENT_FRAC_TO_CURRENT_NUM
Object index	182_D
Access	Readable (after the drive parameters have been set)
Data type	i32
Unit	None
Meaning	Numerator for the conversion function

FACTOR_CURRENT_FRAC_TO_CURRENT_DENOM (Object 183_D)

Via the object FACTOR_CURRENT_FRAC_TO_CURRENT_DENOM you can convert the internal number format for currents into a physical unit. The physical unit and the range are defined via the object FACTOR_UNIT_CURRENT.

$$\text{Physical unit} = \text{internal measurement} \times \frac{\text{Numerator}}{\text{Denominator}}$$

Object description

Object name	FACTOR_CURRENT_FRAC_TO_CURRENT_DENOM
Object index	183_D
Access	Readable (after the drive parameters have been set)
Data type	i32
Unit	None
Meaning	Denominator for the conversion function

4.3 Operating Mode “Interpolated Position Control”

4.3.1 States/State Transitions in Interpolated Position Control

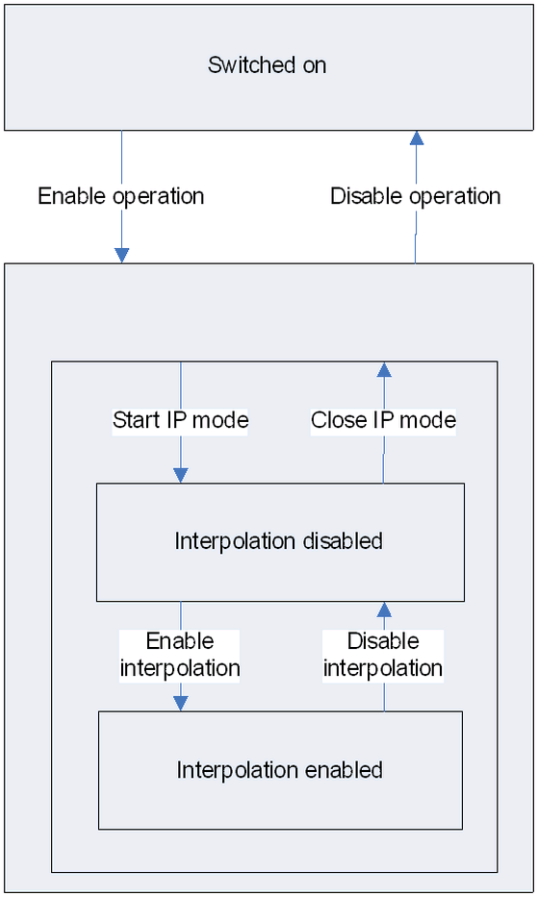


Fig. 8: Interpolated position control: states and state transitions

4.3.1.1 Description of the States

Switched On

- Interpolation data are not copied into the interpolation data buffer.
- reference position = actual position
- Position control is not active.
- Tracking error monitoring is not active.
- Monitoring of software positioning area is not active.
- Reference speed value = 0: The drive is stopped.
- Motor has no power.
- If a brake is available, it is applied.

Interpolation Disabled

- Interpolation data are copied into the interpolation data buffer.
- Reference position = actual position (during transition into “operation enabled”)
- Position control is active.

- Tracking error monitoring is active.
- Monitoring of software positioning area is active.
- Reference speed value = 0: The drive is stopped.
- Motor has power.
- If a brake is present, it is released.

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 of software positioning area is active.
- Drive can be moved.
- Motor has power.
- If a brake is present, it is released.

4.3.1.2 Description of the State Transitions

Start IP Mode

- The device switches into the status “operation enabled” / interpolation is disabled via device control word and operating mode selection.
- If a brake is present, it is being released now.
- If required, a magnetic alignment of the motor is executed.
- Reference position value is set to actual position value.
- Position control is activated.
- Initialization of interpolated position control:
  - Reference value generator is initialized.
  - Interpolation data buffer is enabled and master can write in it.

Enable Interpolation

- The device switches into the status “interpolation enabled” via the device control word (bit 4).
- Reference values are generated from the interpolation data buffer.

Disable Interpolation

- The device switches into the status “interpolation disabled” via the device control word (bit 4).
- Reference values are not generated from the interpolation data buffer anymore.

Close IP Mode

- The device quits the status “operation enabled” via the device control word and the operating mode selection.
- The device quits the operating mode “Interpolated position control”.
- Position control is deactivated.

4.3.2 Start Interpolated Position Control

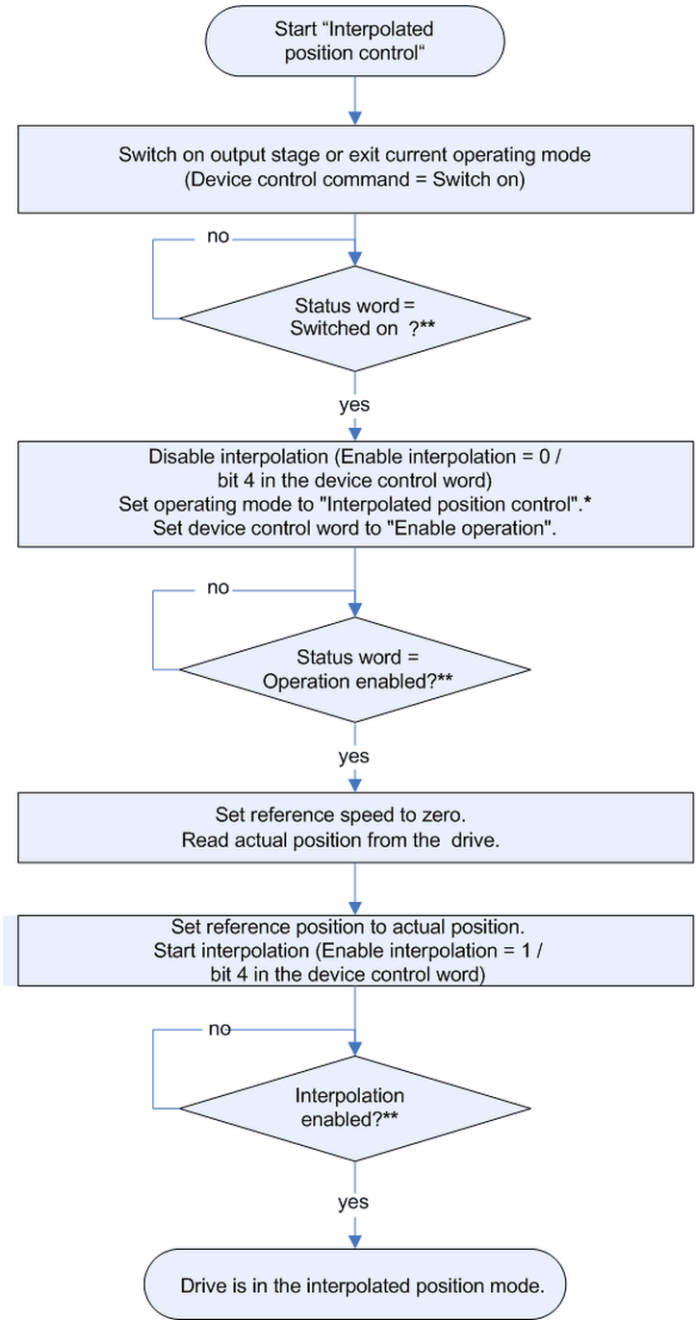


Fig. 9: Start operating mode "Interpolated position control"

* At present the operating mode is set fix to the interpolated position mode. Later (at run time) you can change it via the object 76_D (DEV_CTRL_MODES_OF_OPERATION).

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

4.3.3 Organization of the Interpolation Data Buffers

The interpolation data are exchanged between the control and the drive via an interpolation buffer. During this process the control organizes the buffer via a filling index for the control 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. Via the drive withdrawing index the control informs the drive which interpolated position is to be used for the execution.

The buffer is a 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.

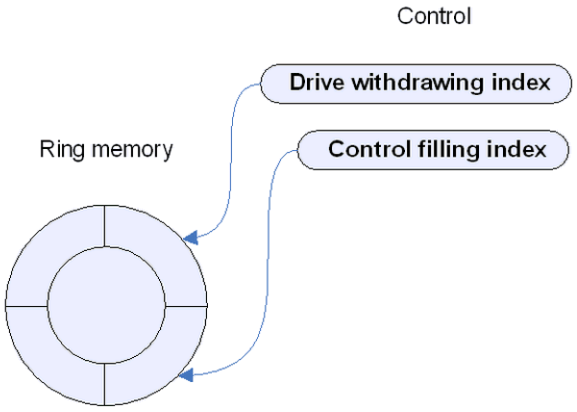


Fig. 10: Interpolation data buffer

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.

4.3.4 Interpolation Control Word

Bit	Name	Description
0	Actual-Index Bit 0	Defines the withdrawing position that is valid at the moment
1	Actual-Index Bit 1	
2	Fill-Index Bit 0	Defines the filling position that is valid at the moment
3	Fill-Index Bit 1	
4		Reserved
5		Reserved
6		Reserved
7		Reserved

4.3.5 Reaction to Invalid Interpolation Data

1. Withdrawing index of the drive is the same as the last withdrawing index.
   - This error could be caused by a failing reference value telegram.
   - The drive interpolates automatically with the last interpolation data.
   - If, after a failed reference value telegram, the execution cannot be continued with the correct withdrawing index, the error “Interpolation error (interpolated position control)” is generated. The error results in a controlled deceleration to standstill of the drive.
2. Withdrawing index of the drive is not the same as the last or the expected withdrawing index.
   - This error is generated by incorrect control of the ring buffer and triggers the error message “Interpolation error (interpolated position control)”. The error results in a controlled deceleration to standstill of the drive.
3. Calculated speed > V_{max}
   - The error message “Interpolation error (interpolated position control)” is triggered. The error results in a controlled deceleration to standstill of the drive.

4. Calculated acceleration > A_{max}
   – The error message “Interpolation error (interpolated position control)” is triggered. The error results in a controlled deceleration to standstill of the drive.

5 Control of Motor Holding Brake

The control of a motor holding brake is implemented in the device control.

WARNING

Unintended motor movement

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:

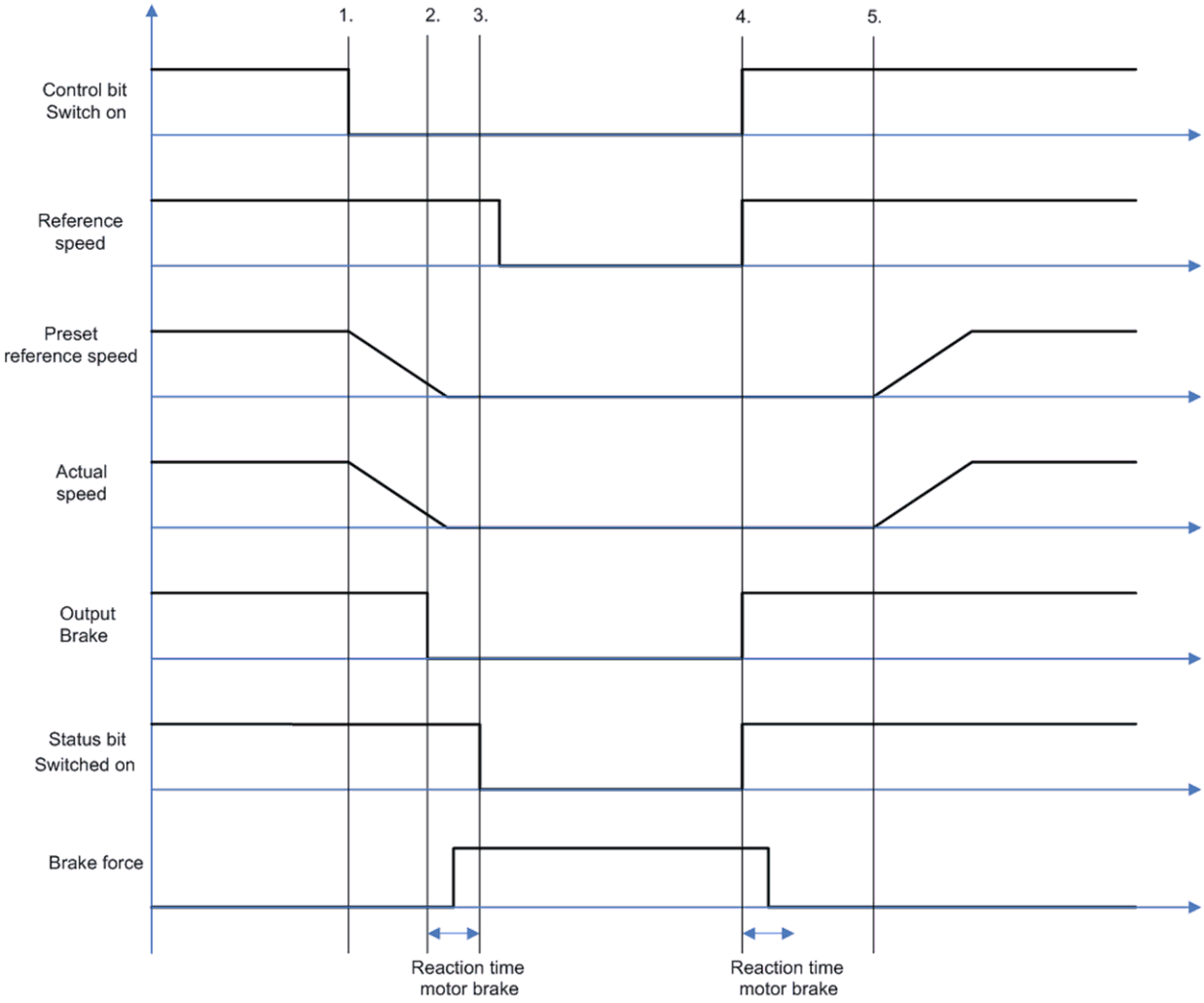


Fig. 11: Control of motor holding brake

[1] Brake
Command “Shutdown” was started (control bit “switch on”). The drive is decelerated.
The deceleration ramp can be set via the software *drivemaster2* (object DEV_CTRL_SHUTDOWN_OPTION_CODE).

[2] Speed zero detection

After detecting “Speed zero” (message M12), the motor holding brake is activated.

[3] Switch output stage off
After the reaction time of the motor holding brake the output stage is switched off (programmable in software *drivemaster2* “Configuration → Motor → On delay motor holding brake”).

[4] Switch output stage on
The device control command “enable operation” activates the output stage and also deactivates the motor holding brake. After the reaction time has passed, a magnetic alignment is started, if required.

[5] Operation enabled
After magnetic alignment the drive can switch into the status “operation enabled”.

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

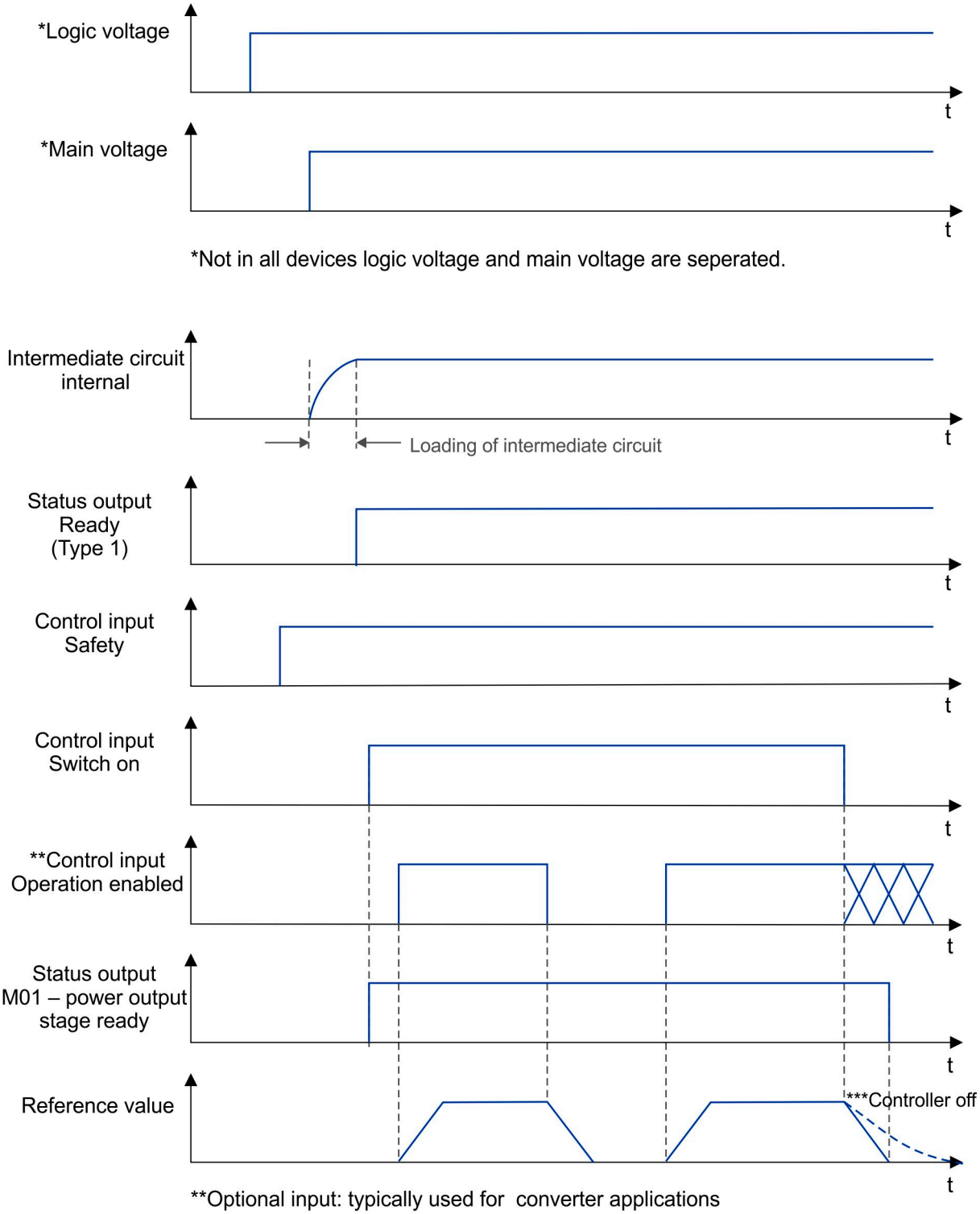
- after a drive error has occurred
- when the brake is directly controlled during switch-off of the output stage (device control command “switch on disabled”)

6 Switch-on/Switch-off Behavior of the Device

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

The exact 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.

6.1 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)

Fig. 12: Timing diagram for switch on/off

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 should not be used for device switch-off.

6.2 Fault Behavior

The following diagram illustrates the timing in the event of a mains failure:

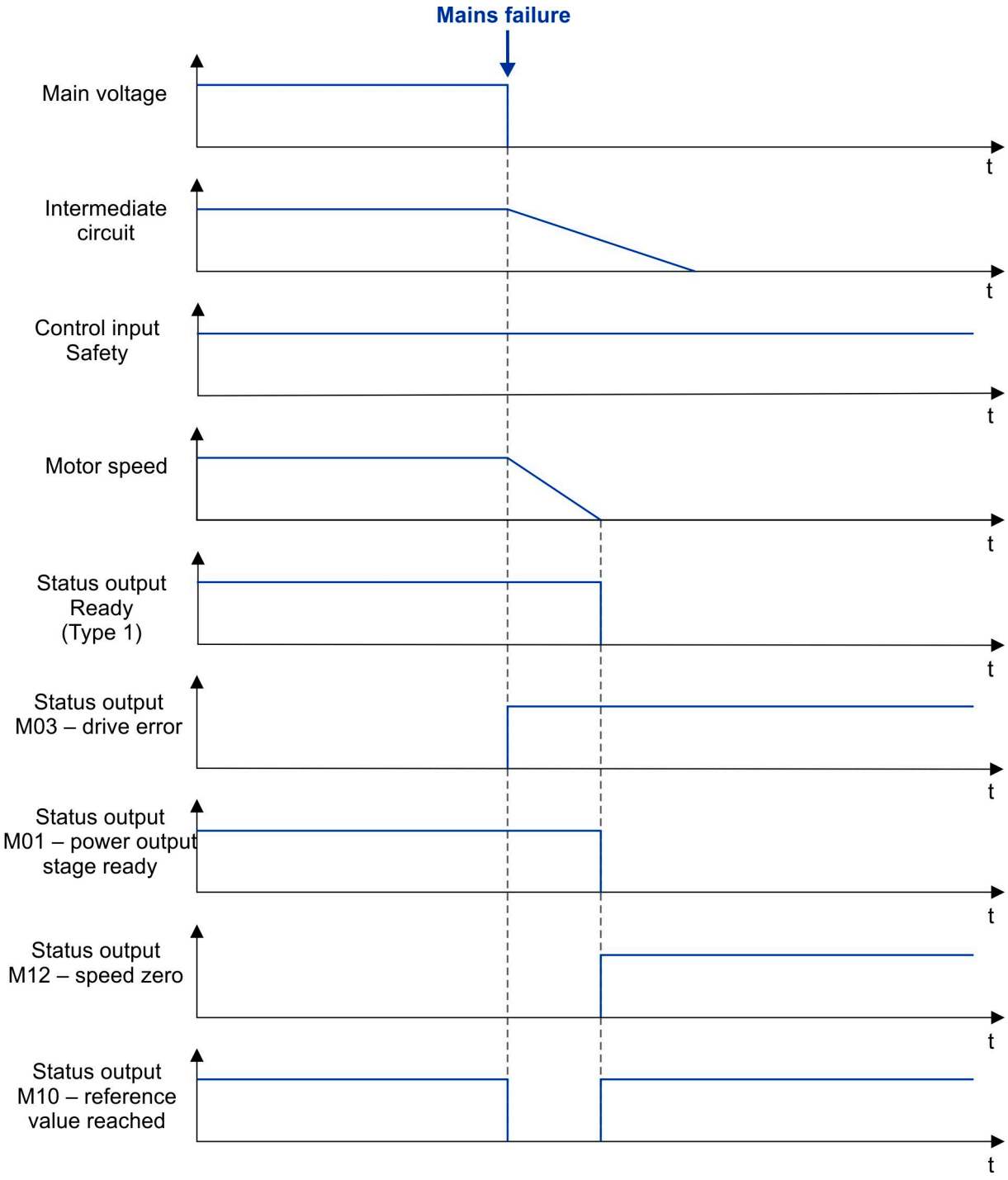


Fig. 13: Timing diagram for a mains failure

The following timing diagram illustrates the behavior when the signal of the control input “Safety” is unset:

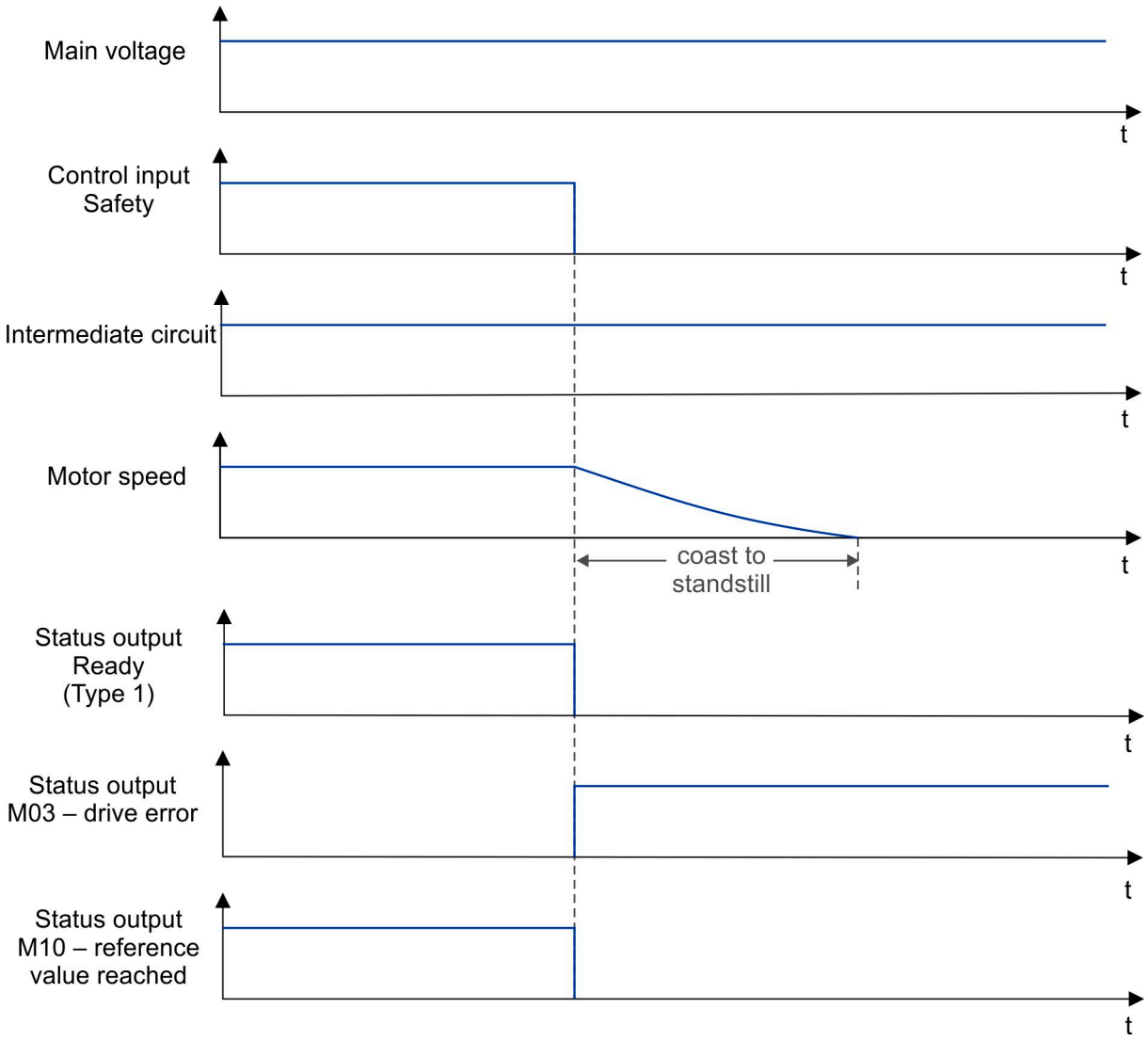


Fig. 14: Timing diagram for safety circuit

For more error states and the reactions of the device refer to section 7.2.2 "List of Drive Error Messages", page 42.

6.3 Parameter Set Change via the Digital Inputs

The following diagram shows the timing when the parameter set is switched via the digital inputs. The functions of the digital inputs must be defined accordingly in the software *drivemaster2*. Switching from one parameter set to another is actually done by unsetting and setting the control input “switch on”:

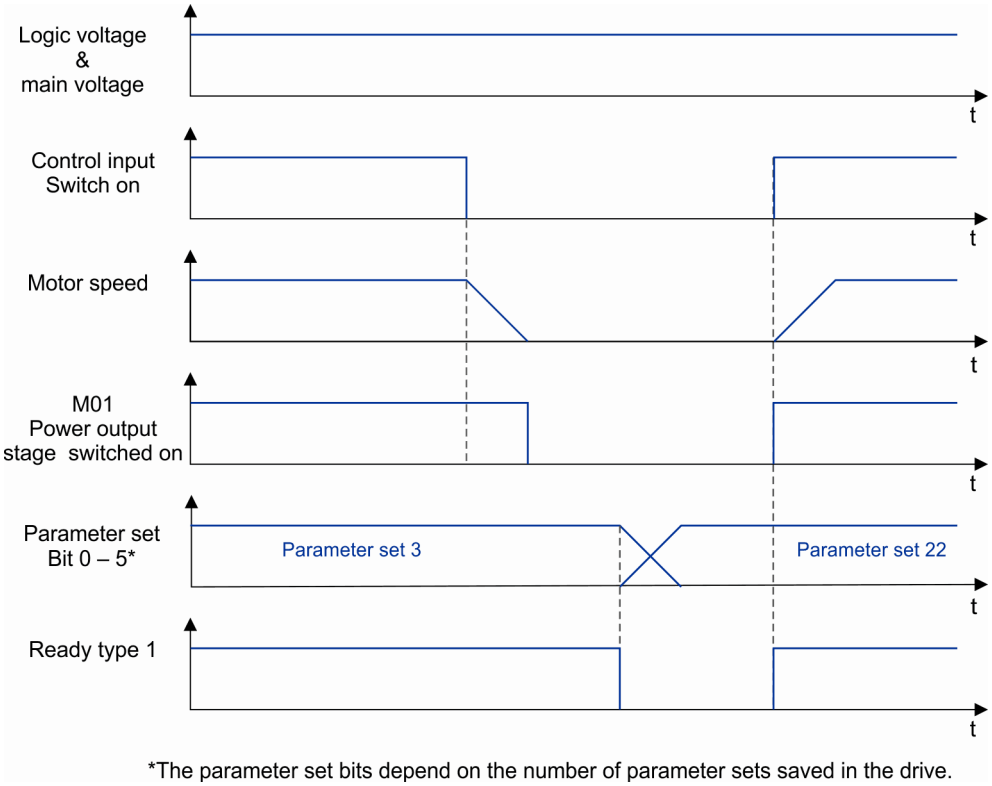


Fig. 15: Timing diagram for parameter set change (via the digital inputs)

7 Fault Behavior

When an error is detected in the drive, a corresponding fault reaction is immediately activated and the device control switches into the status “Fault reaction active”. After the fault reaction has been finished the power unit is switched off and the device control automatically switches into the status “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
Fault	xxxx xxxx x0xx 1000

In addition, the current or the last error with the highest priority can be read out via the following objects:

- DEV_CTRL_ERROR_CODE_ACTUAL
- DEV_CTRL_ERROR_CODE_LATCHED

A “Fault reset” command can only be executed, if there is no error in the drive at present (object DEV_CTRL_ERROR_CODE_ACTUAL = 0x0000). The latched error will be cleared via the “Fault reset” command (object DEV_CTRL_ERROR_CODE_LATCHED).

The chapter 3 "Control Sequences", page 17 describes a sequence for clearing a drive error in detail.

7.1 Objects for the Error Evaluation

DEV_CTRL_ERROR_CODE_ACTUAL (Object 69_D)

Via the object DEV_CTRL_ERROR_CODE_ACTUAL you can read the current error code from the drive (see section 7.2.2 "List of Drive Error Messages", page 42).

Object description

Object name	DEV_CTRL_ERROR_CODE_ACTUAL
Object index	69_D
Access	Always readable
Data type	u16
Unit	None

DEV_CTRL_ERROR_CODE_LATCHED (Object 70_D)

Via the object DEV_CTRL_ERROR_CODE_LATCHED you can read the cause of the error that had resulted in the drive switch-off (see section 7.2.2 "List of Drive Error Messages", page 42).

Object description

Object name	DEV_CTRL_ERROR_CODE_LATCHED
Object index	69_D
Access	Always readable
Data type	u16
Unit	None

DEV_CTRL_ERROR_SUBCODE_LATCHED (Object 425_D)

Via the object DEV_CTRL_ERROR_SUBCODE_LATCHED you can read the sub error code. The sub error code pinpoints the cause of the error reported in DEV_CTRL_ERRORCODE_LATCHED (seesection 7.2.2 "List of Drive Error Messages", page 42).

Object description

Object name	DEV_CTRL_ERROR_SUBCODE_LATCHED
Object index	425_D
Access	Always readable
Data type	u16
Unit	None

7.2 Status Display and Error Messages

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

A status message is made up of 1 to 5 digits. All messages end with dot behind the last digit. When the first digit is 'E.', there is a permanent error. If the cause of an error can be specified, the display indicates the actual error code followed by a hyphen and a one-digit sub error code.

Devices with older firmware do not feature the sub error code.

7.2.1 List of the Operating States

Code	Description
0	Ready to switch 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)

7.2.2 List of Drive Error Messages

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

Code	Error message		Error reaction	Possible reason	
E03 (0x103)	Interpolation error (interpolated position control)		Motor is stopped by quick stop ramp and drive is disabled (controlled standstill).	▸ Faulty motion profile of the higher-ranking control	
	1	Acceleration limit exceeded			
	2	Speed limit exceeded			
	3	Index error			
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).	Monitoring of external hardware:	
	0	Digital input		0	Digital input “External Hardware OK” is not connected to 24 V.
	1	Analog input 0: broken cable		1	Minimum current monitoring of analog input 0 has triggered.
	2	Analog input 1: broken cable		2	Minimum current monitoring of analog input 1 has triggered.
	3	Analog input 0 and 1: broken cable		3	Minimum current monitorings of analog inputs 0 and 1 have triggered.
E07 (0x107)	Error in internal hardware		Motor is stopped by quick stop ramp and drive is disabled (controlled standstill).	▸ Overload in digital outputs ▸ SD2B plus: Operating voltage not available	
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 monitoring time.	
E11 (0x10B)	Communication / bus system error ▸ [1] SERVOLINK 4 ▸ [2] DNC 8 Byte ▸ [3] CAN bus ▸ [4] EtherCAT		Motor is stopped by parameter-driven ramp and drive is disabled (controlled standstill).	Monitoring of bus communication led to switch-off:	
	1	Faulty telegram ID [1]		1	Faulty reference value telegram
	2	Zero data telegram[1]		2	Higher-ranking control not active
	3	CRC error [1]		3	Check sum error, interferences during transmission
	4	Synchronization error [1, 4]		4	Drive telegram not synchronized
	5	Configuration error [4]		5	Faulty configuration of mailbox, PDO, watchdog or synchronization
	6	NMT error [2, 3, 4]		6	Control channel of bus system was not active during switch-on (pre-operational)
	7	Addressing error [4]		7	Faulty drive address
	8	Node Guarding [3]		8	Communication node monitoring: monitoring time expired (configurable)
	9	EEPROM error [4]		9	Error in EtherCAT EEPROM

Code	Error message	Error reaction	Possible reason
	10 Heartbeat / Watchdog [2, 3, 4]		10 Heartbeat monitoring: monitoring time expired (configurable)
E12 (0x10C)	Mains 'Ready for operation' is missing	Motor is stopped by parameter-driven ramp and drive is disabled (controlled standstill).	▸ Power output stage was switched on, when mains supply was disconnected/interrupted.
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	Motor is stopped immediately.	▸ Spindle selection was not valid at “Switch on”.
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 output stage is not sufficient (heat sink).
E29 (0x31D)	Motor load too high (Motor I²t)	Motor is stopped by error ramp and current limitation.(1)	▸ Average motor load is too high due to mechanical problems. ▸ Wrong dimensioning of the motor
E30 (0x31E)	Power output stage load too high (I²t)	Motor is stopped by error ramp and current limitation.(1)	▸ Average load of output stage is too high due to mechanical problems. ▸ Wrong dimensioning of the drive
E31 (0x31F)	Speed error or slip too great	SERVO / VECTOR: Drive is limited by current monitoring via short-circuit of the motor phases. (1) 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), failure of the measuring system
E33 (0x521)	Power supply load monitoring -> mains voltage too high	Power supply unit will be disconnected from mains.	▸ Parameterized mains voltage does not match 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.	▸ DC link was not precharged to the minimum voltage level in the set time period; mains voltage will be connected to the short-circuited DC link.
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.
E36 (0x524)	Encoder 0 monitoring	Motor is stopped by current monitoring via short-circuit of the motor phases.	▸ Connection of encoder 0 is faulty. ▸ Broken cable
E37 (0x525)	Ballast circuit load (I²t ballast resistor)	Drive is immediately disabled, motor coasts to standstill.	Ballast circuit load due to:

Code	Error message		Error reaction	Possible reason	
	1	I^2t		1	Wrong dimensioning, too much energy supplied to $R_{Ballast}$, broken cable, no bridge at $R_{Ballast}$ (int./ ext.)
	2	(VCE) desaturation detection or: DC DC converter overload *(only 0362144xy)*		2	Bridge at $R_{Ballast}$ is not correct, short circuit of insulation etc. Or: internal hardware fault *(only 0362144xy)*
E37 (0x525)	DC DC converter overload *(only 0362161xy)*		Power supply unit will be disconnected from mains.	▸ Voltage converter of DC link is overloaded.	
E38 (0x526)	Actual speed value greater than overspeed threshold		Motor is stopped by current monitoring via short-circuit of the motor phases.(1)	▸ Wrong parameters ▸ Motor connection is incorrect.	
E39 (0x527)	Tracking error monitoring and motor slowdown		Motor is stopped by current monitoring via short-circuit of the motor phases.(1)	▸ 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.(1)	▸ Connection of motor feedback is faulty. ▸ Broken cable	
E41 (0x529)	Motor phase lost		Motor is stopped by current monitoring via short-circuit of the motor phases.(1)	Motor connection/configuration is faulty:	
	1	No motor connected		1	No motor connected / incorrect wiring, broken cable
	2	Wrong motor connected		2	Wrong parameters
E42 (0x52A)	Overvoltage in DC link		Drive is immediately disabled, motor coasts to standstill.	▸ No ballast resistor is connected or ballast resistor is dimensioned too small, i.e. X41/X63 not connected	
E43 (0x52B)	Undervoltage in DC link		Drive is immediately disabled, motor coasts to standstill.	▸ DC link is not connected.	
E44 (0x52C)	Commutation lost The following list of error messages includes a note for which drive function the error might appear. ▸ [1] HSBLOCK ▸ [2] FPAM ▸ [3] SVC ▸ [4] HSPWM		Drive is immediately disabled, motor coasts to standstill.	The error E44 is triggered in case of wrong current feed of the motor during operation without sensor. Possible reason: wrong parameter setting or overload of the motor. The error depends on the drive function. For details refer to the corresponding setup instructions.	
	1	EMF monitoring[1, 2, 3 4]			
	2	Flux monitoring[4]			
	3	Over current monitoring[4]			
	4	Under flux monitoring[4]			
	5	Minimum speed monitoring[1, 2, 3]			
	6	Error during alignment[1, 2]			
	7	Current limitation V/f oscillates[5]			
E45 (0x52D)	Short circuit in power output stage		Drive is immediately disabled, motor coasts to standstill.	Short circuit of the power output stage due to:	

Code	Error message		Error reaction	Possible reason	
	1	Internal short circuit		1	Faulty drive control
	2	(VCE) desaturation detection		2	Wrong parameters, output stage defective, broken cable, short circuit etc.
	3	Short to ground		3	Short to ground of a motor phase
	4	Current measuring range		4	Wrong parameters, output stage defective, broken cable, short circuit etc.
	5	Overload motor		5	Drive function V/f: incorrect parameter setting of “Flying restart”
E46 (0x52E)	1	Safety circuit (Safety X10)	Drive is immediately disabled, motor coasts to standstill without control.	1	Safety circuit STO is activated when the output stage is active; input SAFE A and/or input SAFE B were triggered.
	2	Initialization error: internal hardware of safety controller		2	Safety function SFM/SLOF: error in according hardware components of the safety controller
	3	Incorrect data/parameters in process sequence		3	Safety function SFM/SLOF: faulty PLC telegrams
	4	Error in function parameters for a functional part		4	Safety function SFM/SLOF: parameter is out of limits
	5	Timeout of monitoring functions		5	Safety function SFM/SLOF: error in according hardware components
	6	Monitoring of OSSD signals and output stage enable		6	Safety function SFM/SLOF: ▸ wrong OSSD signals ▸ defective OSSD relay ▸ defective multiplexer
	7	Monitoring of motor phases		7	Safety function SFM/SLOF: defective motor cable (broken cable)
	8	Frequency exceeded		8	Safety function SFM/SLOF: ▸ set reference speed value is too high ▸ limit value for Safe Limited Output Frequency is parameterized incorrectly ▸ OSSD signals are set incorrectly
	9	Communication error between DSP and safety controller		9	Safety function SFM/SLOF: communication between DSP and safety controller is disturbed
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 detailed error description is received by a parameter download.

Code	Error message	Error reaction	Possible reason
E57 (0x739)	Faulty or no firmware	Device stops in BIOS.	▸ During boot-up the device detected no firmware or a faulty firmware.
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.	▸ Logic programming of the device is not valid.
E62 (0x73E)	Error in electronic type plate	Device stops in BIOS.	▸ Type plate is not programmed or faulty; please contact SIEB & MEYER.

(1) For servo motors with commutation via an incremental motor measuring system the warning W17 “Unknown commutation angle ” is signaled. After a restart of the device the phasing of the motor measuring system starts automatically (magnetic alignment).

7.2.3 List of Warning Messages

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

Code	Description
W00	Digital input 'Quick stop' active
W01	Digital input 'Positive limit switch' active
W02	Digital input 'Negative limit switch' active
W03	Voltage of mains supply not OK
W04	Power output stage load greater than parameterized warning threshold W04 (power output stage I²t)
W05	Motor load greater than parameterized warning threshold W05 (motor I²t)
W06	Power output stage temperature greater than parameterized warning threshold W06
W07	Motor temperature greater than parameterized warning threshold W07
W08	DC link voltage greater than parameterized warning threshold W08
W09	DC link voltage less than parameterized warning threshold W09
W10	Speed controller in current limitation / PI limit
W11	Position/tracking error greater than parameterized warning threshold W11
W12	Speed error greater than parameterized warning threshold W12
W13	Tracking error of the current too great
W14	Ambient temperature greater than parameterized warning threshold W14
W15	Ballast resistor load greater than parameterized warning threshold W15 (ballast resistor I²t)
W16	Safety circuit is active
W17	Unknown commutation angle
W18	Hiperface / EnDat OEM data not valid
W19	Dirt signal encoder input 0
W20	Dirt signal encoder input 1
W21	Dirt signal encoder input 2
W22	Power supply unit load greater than 90% of the rated power

Code	Description
W23	Reserved
W24	Current or current rise greater than warning threshold W24 (warning current)
W25	Reference speed less than minimum motor speed
W26	Current greater than warning threshold W26 (warning overload current)
W27	Reserved
W28	Reserved
W29	Reserved
W30	Reserved
W31	Reserved

7.2.4 Message of the Quick Stop Functions

Code	Description
H01	Digital input "Switch on" waits for positive edge to switch the drive on (This function is only active when the input is set as "Switch on type 2 (with positive edge)".)
H03	Software function "Quick stop"
H04	Digital input "Quick stop"
H07	Software positioning error "Negative limit"
H08	Software positioning error "Positive limit"
H09	Bus system "Quick stop" (The quick stop bit is set to 0)
H11	Digital input "Negative limit switch"
H12	Digital input "Positive limit switch"
H13	Digital input "Speed Enable"

8 Index: Objects

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