![Nanotec PLUG & DRIVE logo]

Technical Manual N5

Fieldbus: Modbus RTU

For use with the following devices:

N5-1-5, N5-2-5

Abbildung ähnlich / similar image

Contents

1 Introduction

The *N5* is a controller for the *open loop* or *closed loop* operation of stepper motors and the *closed loop* operation of BLDC motors.

This manual describes the functions of the controller and the available operating modes. It also shows how you can address and program the controller via the communication interface.

You can find further information about the device on the Nanotec homepage **us.nanotec.com**.

1.1 Version notes

Manual version	Date	Changes	Firmware version	Hardware version
1.0.0	06/2018	First edition	FIR-v1748	W007

1.2 Copyright, marking and contact

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CE

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1.3 Intended use

The *N5 controller* is used to control stepper and BLDC motors and is designed for use under the approved **Environmental conditions**.

Any other use is considered unintended use.

ⓘ	**Note**
	Changes or modification to the controller are not permitted.

1.4 Warranty and disclaimer

Nanotec produces component parts that are used in a wide range of industrial applications. The selection and use of Nanotec products is the responsibility of the system engineer and end user. Nanotec accepts no responsibility for the integration of the products in the end system.

Under no circumstances may a Nanotec product be integrated as a safety controller in a product or construction. All products containing a component part manufactured by Nanotec must, upon delivery to the end user, be provided with corresponding warning notices and instructions for safe use and safe operation. All warning notices provided by Nanotec must be passed on directly to the end user.

Our general terms and conditions apply: **en.nanotec.com/service/general-terms-and-conditions/**.

1.5 Specialist staff

Only specialists may install, program and commission the device:

- Persons who have appropriate training and experience in work with motors and their control.
- Persons who are familiar with and understand the content of this technical manual.
- Persons who know the applicable regulations.

1.6 EU directives for product safety

The following EU directives were observed:

- RoHS directive (2011/65/EU, 2015/863/EU)
- EMC directive (2014/30/EU)

1.7 Other applicable regulations

In addition to this technical manual, the following regulations are to be observed:

- Accident-prevention regulations
- Local regulations on occupational safety

1.8 Used icons

All notices are in the same format. The degree of the hazard is divided into the following classes.

CAUTION
The CAUTION notice indicates a possibly dangerous situation.
Failure to observe the notice **may** result in moderately severe injuries.
► Describes how you can avoid the dangerous situation.

Note
• Indicates an error source or likelihood of confusion.
• Failure to observe the notice **may** result in damage to this or other devices.
• Describes how device damage can be avoided.

Tip
Shows a tip for the application or task.

1.9 Emphasis in the text

The following conventions are used in the document:

Text set in **bold** indicates cross references and hyperlinks:

- The following bits in object **6041**$_h$ (statusword) have a special function:
- A list of available system calls can be found in chapter **System calls in a NanoJ program**.

Text set in *italics* marks named objects:

- Read the *installation manual*.
- Use the *Plug & Drive Studio* software to perform the auto setup.
- For software: You can find the corresponding information in the *Operation* tab.
- For hardware: Use the *ON/OFF* switch to switch the device on.

A text set in `Courier` marks a code section or programming command:

- The line with the `od_write(0x6040, 0x00, 5 );` command has no effect.
- The NMT message is structured as follows: `000 | 81 2A`

A text in "quotation marks" marks user input:

- Start the NanoJ program by writing object 2300$_h$, bit 0 = "1".
- If a holding torque is already needed in this state, the value "1" must be written in 3212$_h$:01$_h$.

1.10 Numerical values

Numerical values are generally specified in decimal notation. The use of hexadecimal notation is indicated by a subscript *h* at the end of the number.

The objects in the object dictionary are written with index and subindex as follows:
`<Index>:<Subindex>`

Both the index as well as the subindex are specified in hexadecimal notation. If no subindex is listed, the subindex is 00$_h$.

Example: Subindex 5 of object 1003$_h$ is addressed with `1003`$_h$`:05`$_h$, subindex 00 of object 6040$_h$ with `6040`$_h$.

1.11 Bits

The numbering of individual bits in an object always begins with the LSB (bit number 0). See the following figure, which uses data type *UNSIGNED8* as an example.

	MSB							LSB	
Bit Nummer	7	6	5	4	3	2	1	0	
Bits	0	1	0	1	0	1	0	1	$\triangleq 55_{hex} \triangleq 85_{dec}$
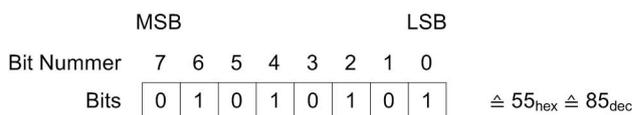
1.12 Counting direction (arrows)

In figures, the counting direction is always in the direction of an arrow. Objects `60C5`$_h$ and `60C6`$_h$ depicted as examples in the following figure are both specified as positive.
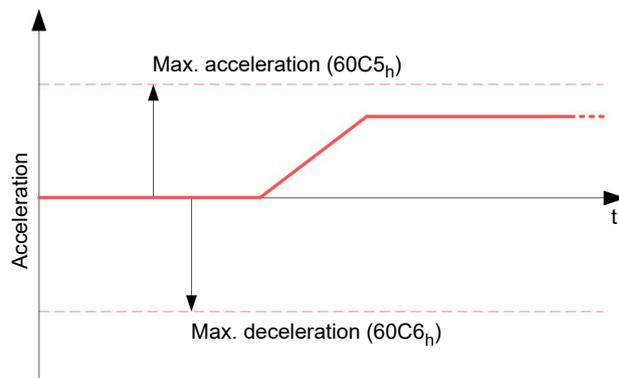
2 Safety and warning notices

> **Note**
> - Damage to the controller.
> - Changing the wiring during operation may damage the controller.
> - Only change the wiring in a de-energized state. After switching off, wait until the capacitors have discharged.

> **Note**
> - Fault of the controller due to excitation voltage of the motor.
> - Voltage peaks during operation may damage the controller.
> - Install suitable circuits (e.g., charging capacitor) that reduce voltage peaks.

> **Note**
> - There is no polarity reversal protection.
> - Polarity reversal results in a short-circuit between supply voltage and GND (earth) via the power diode.
> - Install a line protection device (fuse) in the supply line.

> **Note**
> - The device contains components that are sensitive to electrostatic discharge.
> - Improper handling can damage the device.
> - Observe the basic principles of ESD protection when handling the device.

3 Technical details and pin assignment

3.1 Environmental conditions

Environmental condition	Value
Protection class	IP20
Ambient temperature (operation)	-10 … +40°C
Air humidity (non-condensing)	0 … 95 %
Altitude of site above *sea level* (without drop in performance)	1500 m
Ambient temperature (storage)	-25 … +85°C

3.2 Dimensioned drawings
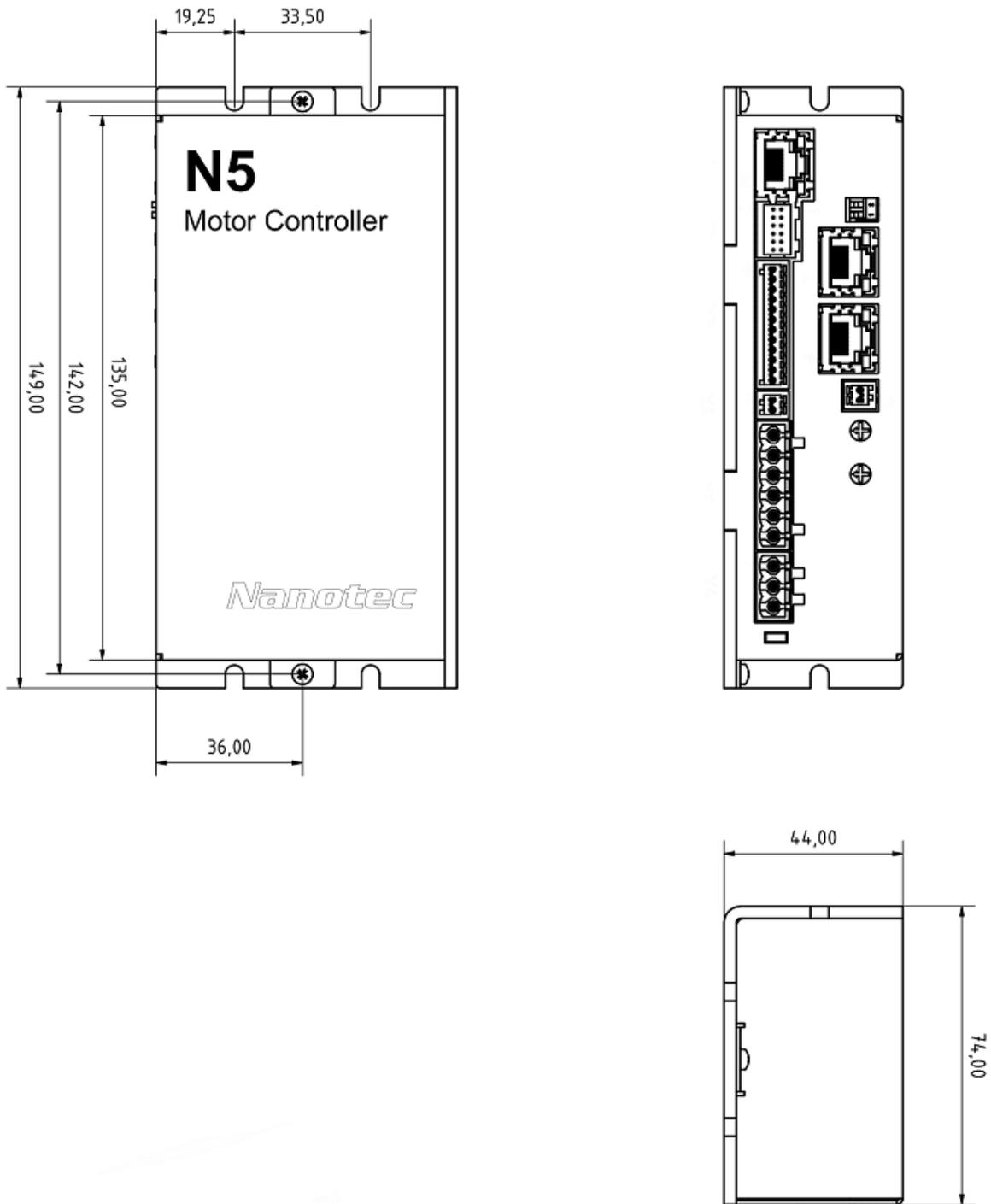
3.3 Electrical properties

Property	Description / value
Operating voltage	• 12 V -5%…72 V +4% DC for *low-current version* with designation N5-1-5 • 12 V - 48 V ±5% DC for the *high-current version* with designation N5-2-5 and up to **hardware version** w007

Property	Description / value
	• 12 V -5%…57,4 V DC for the *high-current version* with designation N5-2-5 and from **hardware version** w007b
Rated current	N5-1-5 (*low current*): 10 A$_{rms}$ N5-2-5 (*high current*): 18 A$_{rms}$
Peak current	N5-1-5 (*low current*): 10 A$_{rms}$ N5-2-5 (*high current*): 40 A$_{rms}$ for 5 seconds
Commutation	Stepper motor – open loop, stepper motor – closed loop with encoder, BLDC motor – closed loop with Hall sensor, and BLDC motor – closed loop with encoder
Operating modes	*Profile Position Mode, Profile Velocity Mode, Profile Torque Mode, Velocity Mode, Homing Mode, Interpolated Position Mode, Cyclic Sync Position Mode, Cyclic Sync Velocity Mode, Cyclic Synchronous Torque Mode, Clock-Direction Mode*
Set value setting / programming	*Modbus RTU (RS-485), Ethernet, clock-direction, analog, NanoJ program*
Interfaces	RS-485 (Modbus RTU), Ethernet
Inputs	• 4 inputs, 5 V/24 V (inputs 1 to 4) individually switchable by means of software, factory setting: 5 V • 2 inputs, wide range 5-24 V (inputs 5 and 6); • 2 analog inputs -10 to +10 V or 0–20 mA (switchable by means of software)
Outputs	2 outputs, (open drain, 0 switching, max. 24 V and 500 mA)
Encoder input	5 V or 24 V signal, differential or single-ended (switchable by means of software), max. resolution 65536 increments per revolution (16-bit)
Protection circuit	Overvoltage and undervoltage protection Overtemperature protection (> 75° Celsius on the power board) Polarity reversal protection: In the event of a polarity reversal, a short-circuit will occur between supply voltage and GND over a power diode; a line protection device (fuse) is therefore necessary in the supply line. The values of the fuse are dependent on the application and must be dimensioned • greater than the maximum current consumption of the controller • less than the maximum current of the voltage supply. If the fuse value is very close to the maximum current consumption of the controller, a medium / slow tripping characteristics should be used.

3.4 Overtemperature protection

Above a temperature of approx. 75°C on the power board (corresponds to 65–72°C outside on the back cover), the power part of the controller switches off and the error bit is set (see objects **1001**$_h$ and **1003**$_h$). After cooling down and confirming the error (see **table for the controlword**, "Fault reset"), the controller again functions normally.

The following temperature test results provide information on the temperature behavior of this controller.

Temperature tests are performed under the following conditions:

- Operating voltage: 48 V DC
- Motor current: 10 A (N5-1 *low current*)/18 A (N5-2 *high current*) rms
- Operation mode: Velocity Mode, full step, 30 rpm
- Ambient temperature: 25 °C / 45 °C
- Altitude of site: 500 m above sea level

The following graphic shows the results of the temperature tests:

N5: Controller temperature at 45° Celsius ambient temperature and 10A motor current

N5: Controller temperature at 45° Celsius ambient temperature and 18A motor current
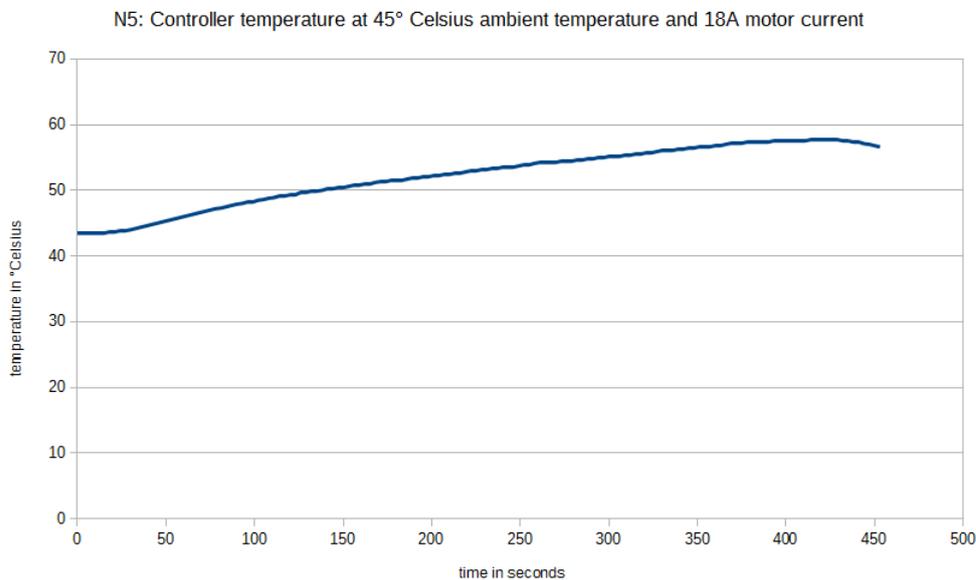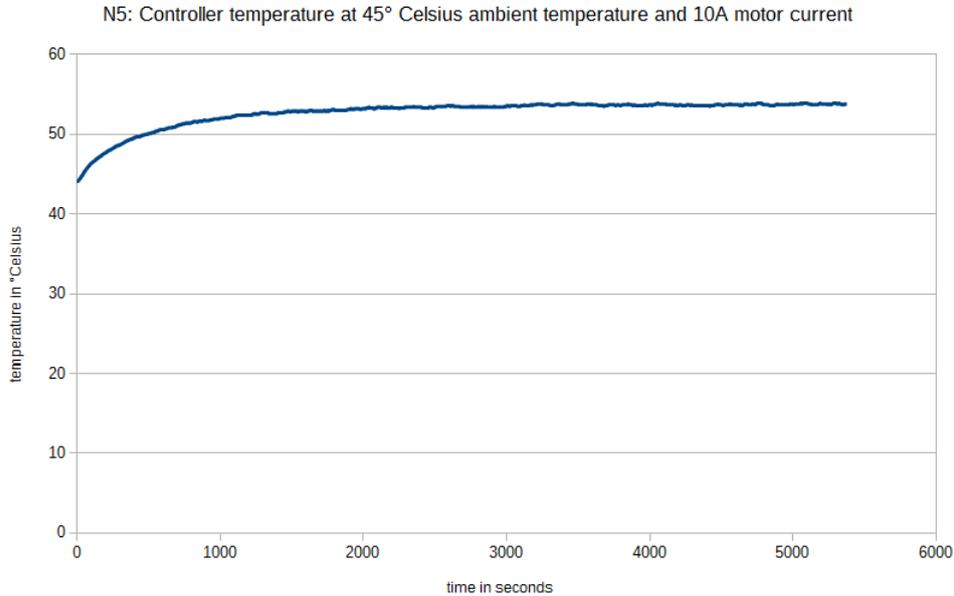
Note

Aside from the motor, the exact temperature behavior is also dependent on the flange connection and the heat transfer there as well as on the convection in the application. For this reason, we recommend always performing an endurance test in the actual environment for applications in which current level and ambient temperature pose a problem.

3.5 LED signaling

3.5.1 Power LED
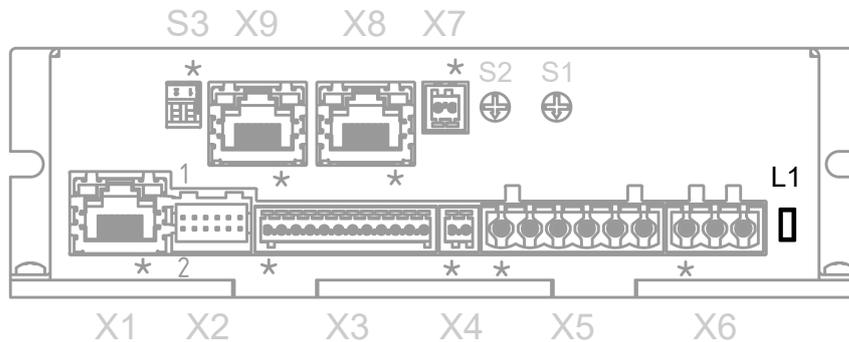
Normal operation

In normal operation, the green power LED L1 flashes briefly once per second.
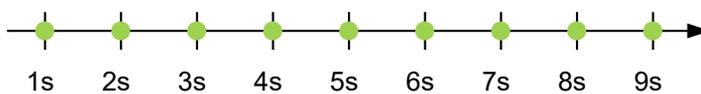
Case of an error

If an error has occurred, the LED turns red and signals an error number.In the following figure, the error number 3 is signaled.
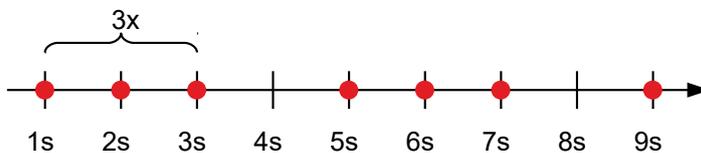
The following table shows the meaning of the error numbers.

Flash rate	Error
1	General
2	Voltage
3	Temperature
4	Overcurrent
5	Controller
6	Watchdog-Reset

ⓘ **Note**

For each error that occurs, a more precise error code is stored in object **1003**$_h$.

3.6 Pin configuration

3.6.1 Overview
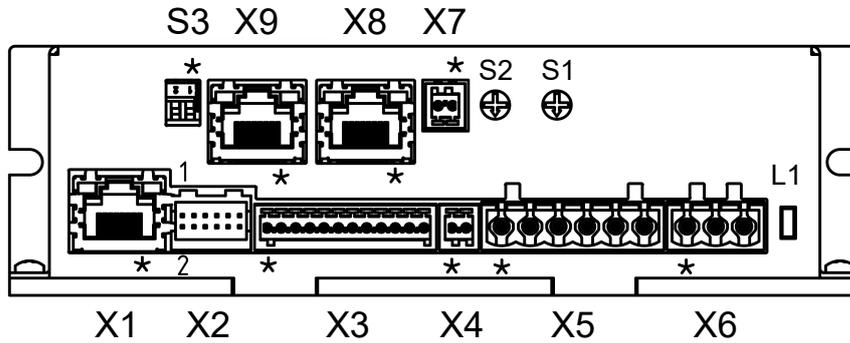
Connector	Function
X1	Ethernet
X2	Encoder and Hall sensor connection
X3	Digital/analog inputs and outputs
X4	Brake connection
X5	Motor connection
X6	Voltage supply
X7	External logic supply, input voltage +24 V DC
	Voltage supply for encoder, input voltage +24 V DC
X8	RS-485 IN
X9	RS-485 OUT
S1	Hex coding switch for Modbus address, 16s place (e.g., 0x**F** 0)
S2	Hex coding switch for Modbus address, 1s place (e.g., 0x0**F**)
S3	PIN1 150 ohm termination resistor (switch set to ON)
	PIN2 reserved
L1	Power LED

3.6.2 Connector X1 – Ethernet

Pin 1 is marked with an asterisk "*".
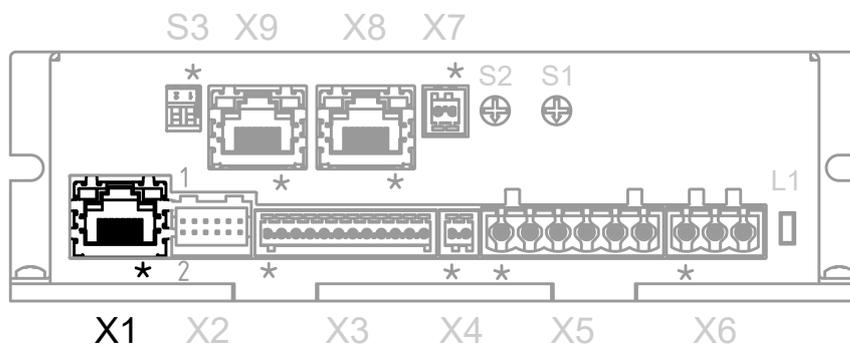
3.6.3 Connector X2 – encoder/Hall sensor

Note

Two types of encoder/Hall sensor are supported:

1. Encoder/Hall sensor with 5 V supply voltage. In this case, nothing is to be connected to connector X7; object **2059**$_h$ must be set to the value "0" (factory setting).
2. Encoder/Hall sensor with 24 V supply voltage. In this case, you must connect a voltage of 24 V DC to connector X7 (see **Connector X7 – voltage supply for encoder/Hall sensor, external logic supply**) and set object **2059**$_h$ to the value "1".

Pin 1 and Pin 2 are marked in the diagram.
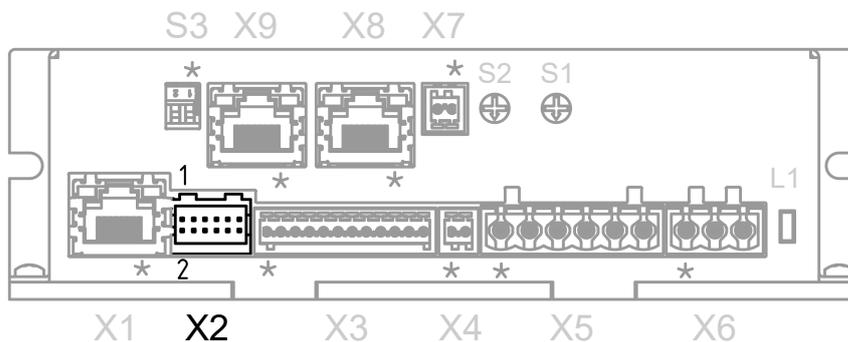
PIN	Function	Note
1	GND	
2	Vcc	+5 V DC (standard) or +24 V DC, output voltage switchable via software with object **2059**$_h$.
3	A	5/24 V signal, max. 1 MHz
4	B	5/24 V signal, max. 1 MHz
5	A\	5/24 V signal, max. 1 MHz
6	B\	5/24 V signal, max. 1 MHz
7	I	5/24 V signal
8	I\	5/24 V signal
9	Hall 1	5/24 V signal, max. 1 MHz
10	Hall 2	5/24 V signal, max. 1 MHz
11	Hall 3	5/24 V signal, max. 1 MHz
12	Shielding	Shielding

It must be ensured that the encoder reaches the switching thresholds specified below. Otherwise, an additional external circuit is necessary.

Type	Switching thresholds	
	On	Off
Single-ended 5 V	> 3.8 V	< 0.26 V
Differential 5 V	> 3.8 V	< 0.26 V
Single-ended 24 V	> 14.42 V	< 4.16 V
Differential 24 V	> 14.42 V	< 4.16 V

The internal circuit of the encoder inputs is visualised in the following image.
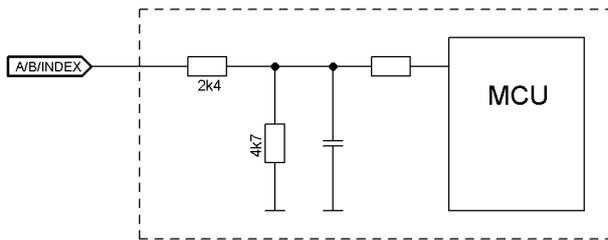
3.6.4 Connector X3 – inputs and outputs

Pin 1 is marked with an asterisk "*".
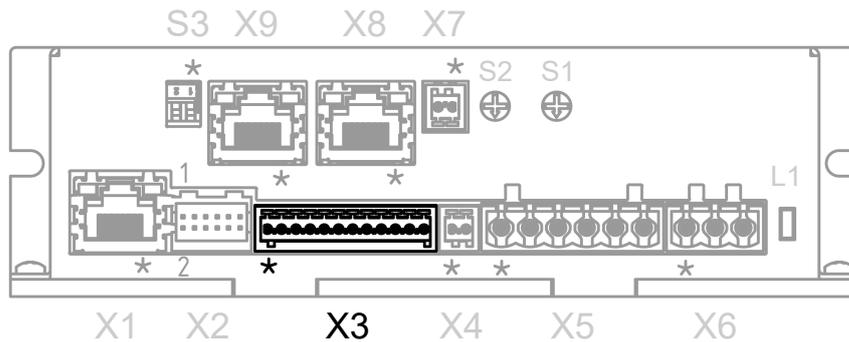
PIN	Function	Note
1	GND	
2	Input 1	Digital input, 5 V / 24 V, switchable via software with object **3240**$_h$
3	Input 2	Digital input, 5 V / 24 V, switchable via software with object **3240**$_h$
4	Input 3	Digital input, 5 V / 24 V, switchable via software with object **3240**$_h$, directional input in clock/direction mode
5	Input 4	Digital input, 5 V / 24 V, switchable via software with object **3240**$_h$, clock input in clock/direction mode
6	Input 5	Digital input, 5 V to 24 V, not switchable via software
7	Input 6	Digital input, 5 V to 24 V, not switchable via software
8	Analogue input 1	-10 V…+10 V or 0…20 mA, switchable via software with object **3221**$_h$
9	Analogue input 2	-10 V…+10 V or 0…20 mA, switchable via software with object **3221**$_h$
10	Output 1	Digital output, open drain, max. 24 V/0.5 A
11	Output 2	Digital output, open drain, max. 24 V/0.5 A
12	Shielding	Shielding

The following switching thresholds apply for inputs 1 to 4:

Max. Voltage	Switching thresholds	
	Safe switch on	Safe switch off
5 V	> 3.8 V	< 0.26 V
24 V	> 14.42 V	< 4.16 V

The following switching thresholds apply for inputs 5 and 6 (wide-range inputs from 5-24 V):

Switching thresholds	
On	Off
> 3.25 V	< approx. 2 V

Connection data	min	max
Conductor cross section solid min.	0.14 mm^2	0.5 mm^2
Conductor cross section flexible min.	0.14 mm^2	0.5 mm^2
Conductor cross section flexible, with ferrule without plastic sleeve min.	0.25 mm^2	0.5 mm^2
Conductor cross section AWG min.	26	20
Minimum AWG according to UL/CUL	28	20

3.6.5 Connector X4 – brake connection

Pin 1 is marked with an asterisk "*".
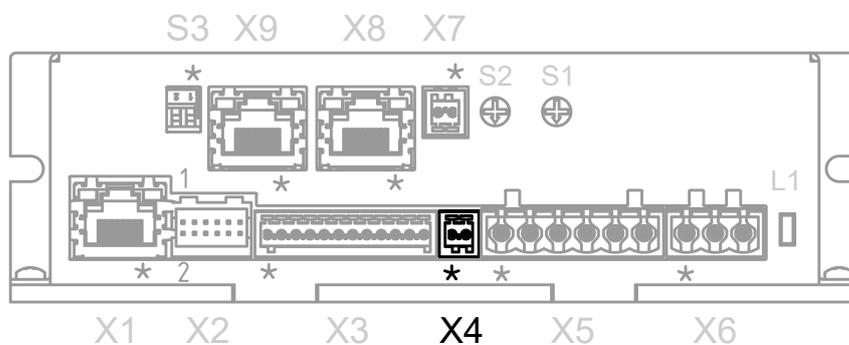
PIN	Function	Note
1	Brake +	Internally connected to +UB
2	Brake -	PWM-controlled open drain output, max. 1.5 A

Connection data	min	max
Conductor cross section solid min.	0.14 mm^2	0.5 mm^2
Conductor cross section flexible min.	0.14 mm^2	0.5 mm^2
Conductor cross section flexible, with ferrule without plastic sleeve min.	0.25 mm^2	0.5 mm^2
Conductor cross section AWG min.	26	20
Minimum AWG according to UL/CUL	28	20

3.6.6 Connector X5 – motor connection

Pin 1 is marked with an asterisk "*".
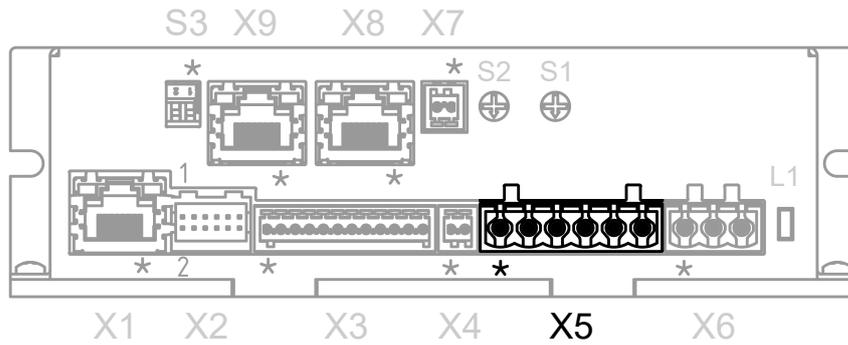
PIN	Function Stepper	Function BLDC	Note
1	Shielding	Shielding	Shielding
2	A	U	
3	A\	V	
4	B	W	
5	B\	Not used	
6	Shielding	Shielding	Shielding

Connection data	min	max
Conductor cross section solid	0.2 mm^2	2.5 mm^2
Conductor cross section flexible	0.2 mm^2	2.5 mm^2
Conductor cross section flexible, with ferrule without plastic sleeve	0.25 mm^2	2.5 mm^2
Conductor cross section flexible, with ferrule with plastic sleeve	0.25 mm^2	1.5 mm^2
Conductor cross section AWG	24	12
2 conductors with same cross section, stranded, TWIN ferrules with plastic sleeve	0.5 mm^2	1.5 mm^2
Minimum AWG according to UL/CUL	26	12

3.6.7 Connector X6 – voltage supply

Voltage source

The operating or supply voltage supplies a battery, a transformer with rectification and filtering, or a switching power supply.

Note
• EMC: For a DC power supply line longer than 30 m or when using the motor on a DC bus, additional interference-suppression and protection measures are necessary.
• An EMI filter is to be inserted in the DC supply line as close as possible to the controller/motor.
• Long data or supply lines are to be routed through ferrites.

Connections

Pin 1 is marked with an asterisk "*".

PIN	Function	Note
1	Shielding	Shielding
2	+UB	- For version N5-1 (*low current*): 12 V -5%…72 V +4% DC - For version N5-2 (*high current*) and up to **hardware version** w007: 12 V - 48 V ±5% DC - For version N5-2 (*high current*) and **hardware version** w007b and higher: 12 V -5%…57,4 V DC
3	GND	

Connection data	min	max
Conductor cross section, rigid	0.2 mm^2	2.5 mm^2
Conductor cross section, flexible	0.2 mm^2	2.5 mm^2
Conductor cross section, flexible, min. Wire-end sleeve without plastic sleeve	0.25 mm^2	2.5 mm^2
Conductor cross section, flexible, min. Wire-end sleeve min. Plastic sleeve	0.25 mm^2	1.5 mm^2
Conductor cross section, AWG	24	12
2 conductors of the same cross section, flexible, min. TWIN-AEH with plastic sleeve	0.5 mm^2	1.5 mm^2
AWG acc. to UL/CUL	26	12

Permissible operating voltage

Depending on the version, the maximum operating voltage is:

- N5-1 (*low current*): 76 V DC
- N5-2 (*high current*) and up to **hardware version** w007: 51.5 V DC
- N5-2 (*high current*) and **hardware version** w007b and higher: 58.5 V DC. With this version, you must – if desired – also enter this threshold value in **2034h Upper Voltage Warning Level**.

If the input voltage of the controller exceeds this threshold value, the motor is switched off and an error triggered. The integrated ballast circuit (25 W power) is activated above:

- N5-1 (*low current*): 75 V DC
- N5-2 (*high current*) and up to **hardware version** w007: 50.5 V DC
- N5-2 (*high current*) and **hardware version** w007b and higher: 57.5 V DC.

The minimum operating voltage is 10 V DC. If the input voltage of the controller falls below this threshold value, the motor is switched off and an error triggered.

A charging capacitor of at least 4700 µF / 50 V (approx. 1000 µF per ampere rated current) must be connected to the supply voltage to avoid exceeding the permissible operating voltage (e.g., during braking).

3.6.8 Connector X7 – voltage supply for encoder/Hall sensor, external logic supply

Functionality

The voltage supply at X7 must be connected under one of the following conditions:

1. A 24 V encoder/Hall sensor is used. In this case, a voltage of 24 V DC must be connected to X7 and bit 0 in object **2059**$_h$ set to the value "1".

2. A logic voltage supply is necessary for the controller to ensure continued access to the following functions should the power supply be lost at connector X6 (see "**Connector X6 – voltage supply**"):

   - Logical functionality of the controller
   - Controller communication
   - Encoder

> **Note**
>
> The windings of the motor are not supplied by the logic supply.

In this case, a voltage of 24 V DC must be connected to X7. With a 24 V encoder, object **2059**$_h$ must be set to the value "1". In the case of a 5 V encoder, object **2059**$_h$ is to be set to the value "0".

> **Note**
>
> Damage to the encoder due to high voltage!
>
> The encoder/Hallsensor can be damaged if the object 2059$_h$ is wrongly configured.
>
> ► Make sure that Bit 0 of the object 2059$_h$ is not set before connecting an encoder/Hallsensor with a rated voltage lower than 24 V.

Connection

Pin 1 is marked with an asterisk "*".
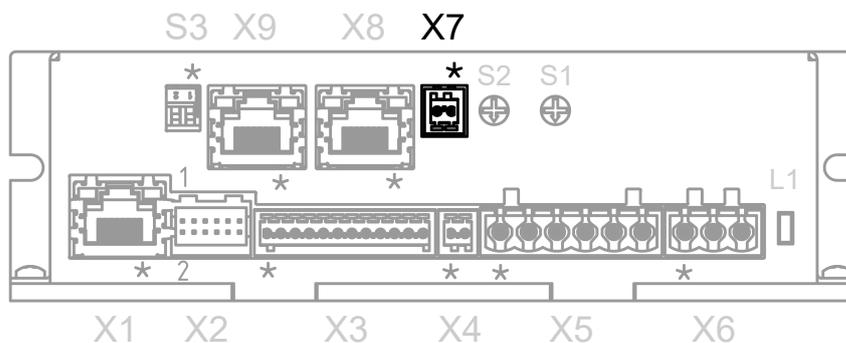
PIN	Function	Note
1	+UB Logic/encoder	+24 V DC, supply voltage for logic and encoder/Hall sensor
2	GND	

Connection data	min	max
Conductor cross section, rigid, min.	0.14 mm^2	0.5 mm^2
Conductor cross section, flexible, min.	0.14 mm^2	0.5 mm^2
Conductor cross section, flexible, min. Wire-end sleeve without plastic sleeve, min.	0.25 mm^2	0.5 mm^2

Connection data	min	max
Conductor cross section, min. AWG	26	20
Min. AWG acc. to UL/CUL	28	20

3.6.9 Connector X8 – RS-485 IN

Pin 1 is marked with an asterisk "*".
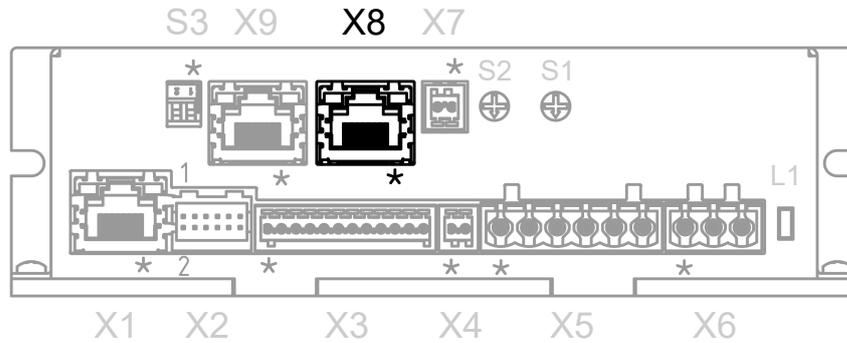
PIN	Function	Note
1	n.c.	
2	n.c.	
3	n.c.	
4	D1 (RS-485 +)	
5	D0 (RS-485 -)	
6	n.c.	
7	n.c.	
8	Common	Signal and power supply common

3.6.10 Connector X9 – RS-485 OUT

Pin 1 is marked with an asterisk "*".
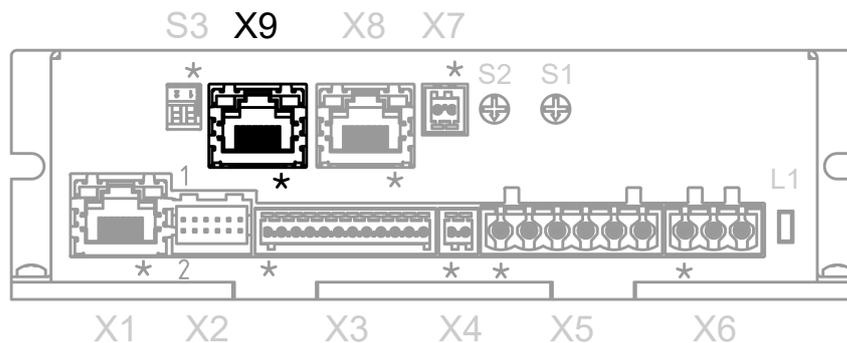
PIN	Function	Note
1	n.c.	
2	n.c.	
3	n.c.	
4	D1 (RS-485 +)	
5	D0 (RS-485 -)	

PIN	Function	Note
6	n.c.	
7	n.c.	
8	Common	Signal and power supply common

3.6.11 Switch S1 – Hex coding switch for Modbus slave address and baud rate

For setting the slave address and baud rate. See chapter **Communication settings**.

The value of this switch is multiplied by 16 and added to the value of switch S2; this switch thereby sets the 16s place.
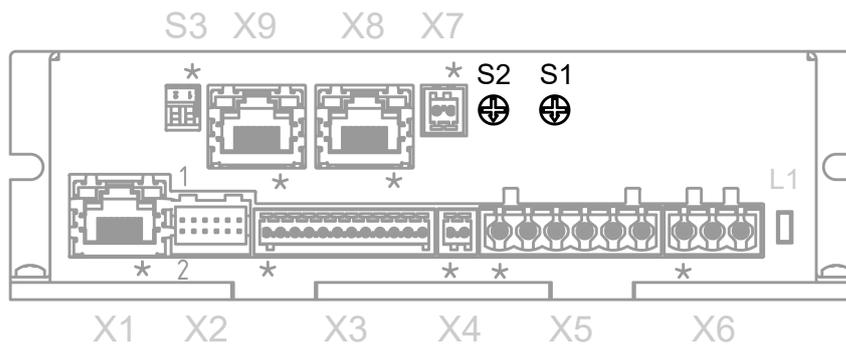
3.6.12 Switch S2 - Hex coding switch for Modbus slave address and baud rate

For setting the slave address and baud rate. See chapter **Communication settings**.

The value of this switch is added to the value of switch S1; this switch thereby sets the 1s place.
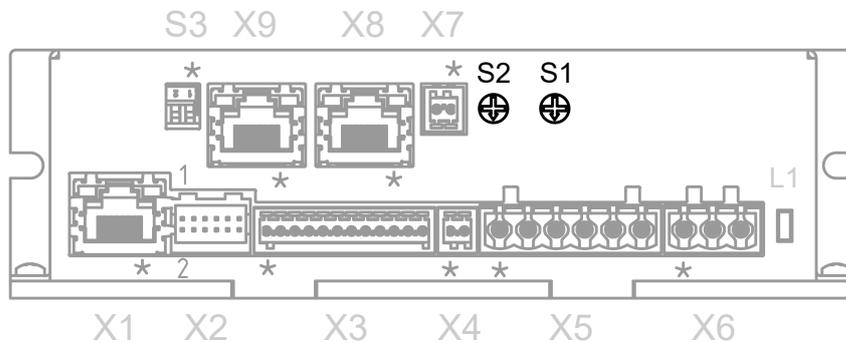
Example

Switch S1 is set to the value "1_h", switch S2 to the value "F_h"; the result is the value "$1F_h$".

3.6.13 Switch S3 – 150 ohm termination resistor

This DIP switch (PIN 1, marked with an asterisk "*") switches the termination of 150 Ω between RS-485+ and RS-485- on or off.
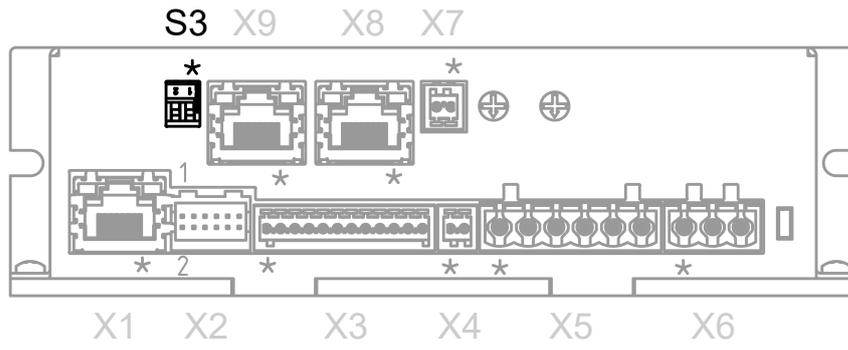
4 Commissioning

Described in this chapter is how you establish communication with the controller and set the necessary parameters to make the motor ready for operation. You can configure the controller via Ethernet or Modbus RTU.

The *Plug & Drive Studio* software offers you an option for performing the configuration and adapting the controller to the connected motor. You can find further information in document *Plug & Drive Studio: Quick Start Guide* at **us.nanotec.com**.

Observe the following note:

Note
- EMC: Current-carrying cables – particularly around supply and motor cables – produce electromagnetic alternating fields.   - These can interfere with the motor and other devices. Nanotec recommends the following measures: - Use shielded cables and earth the cable shielding on both ends over a short distance.   - Use cables with cores in twisted pairs.   - Keep power supply and motor cables as short as possible.   - Earth motor housing with large contact area over a short distance.   - Lay supply, motor and control cables separately.

4.1 Configuring the Ethernet interface

4.1.1 Overview

Interface

The controller is equipped with a 10/100 MBit Ethernet interface. In this way it can be operated with all current Ethernet components (switches, PCs) and configured via the *Plug & Drive Studio* software.

Hardware address

The controller initially has no IP address, but is instead addressed via the printed hardware address (MAC address). This address consists of 6 hexadecimal numbers in form 44-AA-E8-xx-xx-xx.

The hardware address is unique and unchangeable and is assigned during production. In general, this is only needed during a firmware update. As soon as the boot loader has ended and the actual firmware begins to operate, subsequent communication takes place via the TCP/IP protocol.

IP address

The controller needs a valid IP address. This can be obtained in the following ways:

- DHCP: A DHCP server assigns the IP address to the controller (default setting).
- AutoIP: The controller automatically determines a suitable IP address. The prerequisite here is that the communication partners are in the same physical subnet and also use AutoIP.
- Static IP address: This is defined by the user.

Which method is used depends on the network environment and is defined by the network administrator.

4.1.2 Establishing connection with the controller

Setting the IP address

Each of the connected devices (controller and communication partners) in an Ethernet network or with a point-to-point Ethernet connection requires a unique IP address. This can either be obtained automatically (DHCP) or generated (Auto-IP) or assigned statically. In the following, "communication partner" refers to a PC or laptop.

You can integrate the controller in an existing Ethernet network. To do this, you only need to establish the physical connection with a standard Ethernet cable. Provided DHCP is activated on the controller (factory setting), the controller is also automatically detected on the network and can immediately be operated via a PC located on the network.

Setting DHCP/Auto-IP

IP addresses can be obtained dynamically in a network from a DHCP server or, for example, in the case of a PC direct connection, can be automatically self-generated without DHCP by the two communication devices (e.g., PC and controller). DHCP is preset in the controller at the factory for automatically obtaining an IP address from a DHPC server or for automatic IP address generation. To establish the connection to the controller, it may only be necessary to make a few settings on the communication partner (e.g., PC or laptop). Settings using the Windows 7 operating system as an example:

1. Press the Windows Start button and select *Control Panel*.
2. Select *Network and Sharing Center*.
3. Select *Change adapter settings*.
4. A list of the available network adapters is displayed. Open the properties on the adapter to which the controller is connected (e.g., click with the right mouse button).
5. *Select Internet Protocol version 4 (TCP/IPv4)* and press the *Properties* button.
6. Select the *Obtain an IP address automatically* option.
7. Confirm acceptance of the entries with the *OK* button.
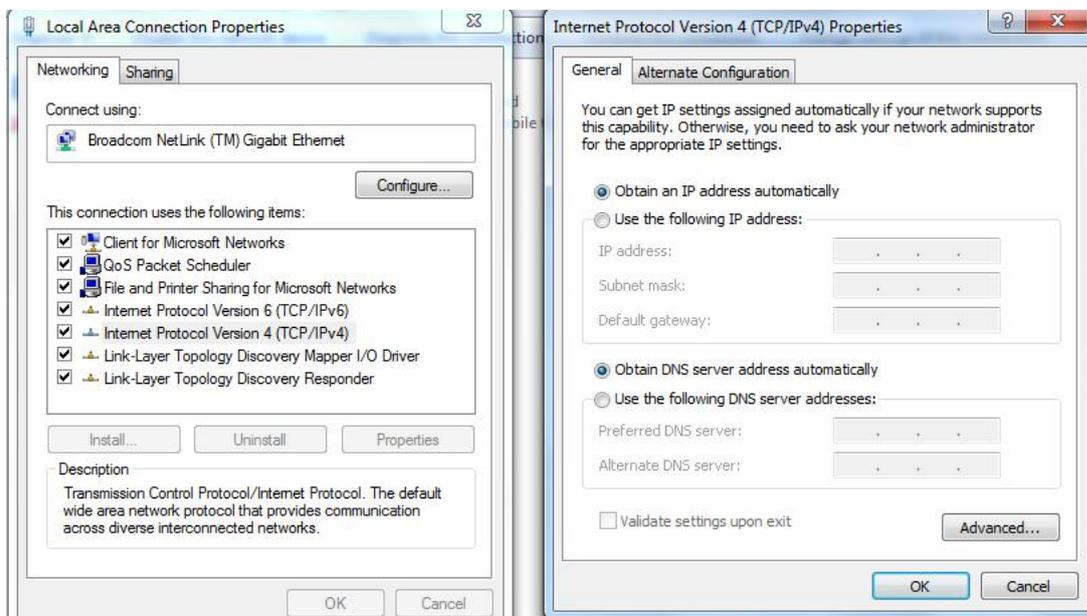
Setting a static IP address

If static addresses are to be assigned to the controller and the communication partner, just a few settings need to be performed on the controller and the communication partner.

The controller can be assigned a static IP address and network mask (each IPv4) through OD entries. The following entries are relevant in the object dictionary:

Index	Description
2010$_h$	IP configuration, bit mask with the following meaning: Bit 0: A static IP address from object **2011**$_h$ and the network mask from object **2012**$_h$ are used.
2011$_h$	Static IP address, 4 bytes in hex coding
2012$_h$	Static IP subnet mask, 4 bytes in hex coding
2013$_h$	Gateway address
2014$_h$	Active IP address, 4 bytes in hex coding
2015$_h$	Active IP subnet mask, 4 bytes in hex coding
2016$_h$	Currently used gateway address
200F$_h$	MAC address

Notes:

- If DHCP was activated and Auto-IP is not active, the controller uses the set static IP address if no address could be assigned via DHCP (e.g., because the DHCP service is temporarily unavailable).
- If both objects **2010**$_h$ and **2011**$_h$ are set to the value "0", an incorrect configuration is assumed and DHCP and Auto-IP are switched on.
- If bit 0 is set in object **2010**$_h$, the static IP address is used. DHCP and Auto-IP are not used in this case.
- If DHCP and Auto-IP are activated simultaneously, DHCP is used first to try and obtain an address. If this does not function, Auto-IP is executed.
- If only DHCP is switched on and an IP address assignment did not function, an attempt is made independent of bit 0 to connect using the entered static IP address.

A static IP address is also assigned to the communication partner. Settings using the Windows 7 operating system as an example:

1. Press the Windows Start button and select *Control Panel*.
2. Select *Network and Sharing Center*.
3. Select *Change adapter settings*.
4. A list of the available network adapters is displayed. Open the properties on the adapter with which the controller is connected (e.g., right-mouse click and select *Properties*).
5. *Select Internet Protocol version 4 (TCP/IPv4)* and press the *Properties* button.
6. Select the *Use the following IP address:* option and enter the desired IP address and network mask in the *IP address* field.
7. Confirm acceptance of the entries with the OK button.
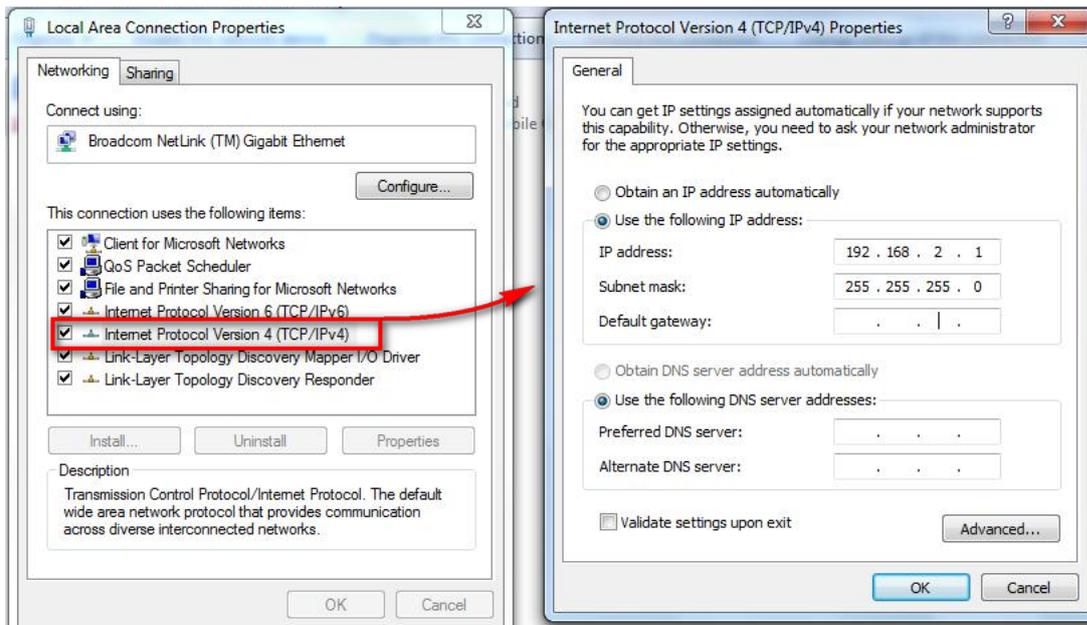
Establishing network connection

Establish a physical connection between controller and communication partner using a standard Ethernet cable. If static IP addresses were assigned to the controller and the communication partner, they can communicate directly.

If you have a DHCP server and want to find out the IP address, you can use the tool Tool *ping*. In order to do this, the NetBIOS service on the PC must be acivated and dthe MAC address known.

Example

> If you want to address the controller with the MAC address 44:AA:E8:00:02:9F, you start the tool by typing in a shell or command line:
>
> ```
> ping MAC-44AAE800029F
> ```

4.1.3 REST web services

Introduction

The protocol used by the the web server is HTTP/1.0. The architecture here is realized according to REST (Representational State Transfer) which offers the possibility to access objects/resources. The values in the object dictionary are an example of this.

The operations supported here are:

- `GET`: Request a resource
- `POST`: Add a new resource

Resource names

The name of a resource is always specified in the *URI (Uniform Resource Identifier)* notation familiar from the Internet. Via this *URI*, the controller supports access to the **object dictionary**. The identifier for this is:

- Od: Object dictionary

Example

Accessing a value in the object dictionary:

```
http://192.168.2.100/od/6040/00
```

This string is used to access entry **6040**$_h$ subindex 0 in the object dictionary.

The reply is made as a JSON string and reflects the content of this object.

Example

Accessing a value in the object dictionary:

```
GET /od/6040/00 HTTP/1.0
```

This string is used to access entry **6040**$_h$ subindex 0 in the object dictionary.

The reply is made as a JSON string and reflects the content of this object.

```
HTTP/1.0 200 OK
Server: uip/1.0
Cache-Control: no-cache, no-store, private
Content-type: application/json
"0006"
```

Writing a value in the object dictionary:

```
POST /od/6040/00 HTTP/1.0
Content-Type: application/x-www-form-urlencoded
Form item: ""000F"" = ""(Key: "000F", Value:)
```

This string is used to access entry **6040**$_h$ subindex 0 in the object dictionary.

This string is used to write the value "15(0F$_h$)" in the object **6040**$_h$ subindex 00$_h$.

The controller receives a confirmation with the status code `200 OK`:

```
HTTP/1.0 200 OK
Server: uip/1.0
```

Accessing the object dictionary

The following URIs enable access to the object dictionary:

<IP address>/od/xxxx/yy
Requests entry xxxx subindex yy from the object dictionary.

<IP address>/od/xxxx/Data
Requests entry xxxx with all subindices.

Example

Accessing a value in the object dictionary:

```
http://192.168.2.100/od/6040/00
```

This string is used to access entry **6040**$_h$ subindex 0 in the object dictionary.

The reply is made as a JSON string and reflects the content of this object.

4.2 Configuring via Modbus RTU

Described in the following chapters is how you can establish the communication.

The controller is set to slave address 1 ex works, baud rate 19200 baud, even parity, 1 stop bit.

4.2.1 Communication settings

Slave address, baud rate and parity are dependent on the position of the S1 and S2 *rotary switches* and, if applicable, on objects **2028**$_h$, **202A**$_h$, **202D**$_h$.

Configuration	Object	Value range	Factory settings
Slave address	**2028**$_h$	1 to 247	5
Baud rate	**202A**$_h$	7200 to 256000	19200
Parity	**202D**$_h$	• None: 0x00 • Even: 0x04 • Odd: 0x06	0x04 (Even)

The number of data bits is always "8" here. The number of stop bits is dependent on the parity setting:

• No parity: 2 stop bits
• "Even" or "Odd" parity: 1 stop bit

The following baud rates are supported:

• 7200
• 9600
• 14400
• 19200
• 38400
• 56000
• 57600
• 115200
• 128000
• 256000

Rotary switch

The N5 is equipped with two hex coding switches – similar to that shown in the following figure.

You can set the source for the slave address, the baud rate and the parity using the combination of numbers from both rotary switches.

The following applies here: the combination of numbers is formed using rotary switches S1 and S2, where S1 represents the higher-value byte and S2 the lower-value byte

Example

Switch S1 is set to the value "0_h", switch S2 to the value "F_h"; the result is the value "$0F_h$"="16_d".

Switch S1 is set to the value "A_h", switch S2 to the value "1_h"; the result is the value "$A1_h$"="161_d".

Number combinations of the rotary switches		Slave address	Baud rate and parity
dec	hex		
0	0	Object **2028_h**	Object **$202A_h$** or **$202D_h$**
1-247	1-F7	Number of the rotary switches	Object **$202A_h$** or **$202D_h$**
248-255	F8-FF	5	19200, even Parity

4.2.2 Establishing communication

1. Connect the *Modbus master* to the controller via the RS-485+ and RS-485- (see **Connector X8 – RS-485 IN**) cables.
2. Supply the controller with voltage.
3. Change the configuration values if necessary.
   The controller is set to slave address 1 ex works, baud rate 19200 baud, even parity, 1 stop bit.
4. To test the interface, send bytes `01 65 55 00 2E 97` to the controller (you can find a detailed description of the Modbus function codes in chapter **Modbus RTU**).
   The object dictionary is read out.

4.3 Setting the motor data

Prior to commissioning, the motor controller requires a number of values from the motor data sheet.

- Number of pole pairs: Object **2030_h**:00_h (pole pair count) The number of motor pole pairs is to be entered here. With a stepper motor, the number of pole pairs is calculated using the step angle, e.g., 1.8° = 50 pole pairs, 0.9° = 100 pole pairs (see step angle in motor data sheet).
- Setting the motor current / motor type:
  - Stepper motor only: Object **2031_h**:00_h: Rated current (bipolar) in mA (see motor data sheet)
    - Object **2031_h**:00_h: Rated current (bipolar) in mA (see motor data sheet)
    - Object **3202_h**:00_h (Motor Drive Submode Select): Defines motor type stepper motor, activates current reduction on motor standstill: 0000008h.See also chapter **Commissioning *open loop***.
  - BLDC motor only:
    - Object **2031_h**:00_h Peak current in mA (see motor data sheet)
    - Object **$203B_h$**:01_h Rated current in mA (see motor data sheet)
    - Object **$203B_h$**:02_h Maximum duration of the peak current in ms (for initial commissioning, Nanotec recommends a value of 100 ms; this value is to be adapted later to the specific application).
    - Object **3202_h**:00_h (Motor Drive Submode Select): Defines motor type BLDC: 00000041h
- Motor with encoder: Object **2059_h**:00_h (Encoder Configuration): Depending on the encoder version, one of the following values is to be entered (see motor data sheet):
  - Supply voltage 5V, differential: 00000000h
  - Supply voltage 24V, differential: 00000001h
  - Supply voltage 5V, single-ended: 00000002h
  - Supply voltage 24V, single-ended: 00000003h

- Motor with brake: Object **3202**$_h$:00$_h$ (Motor Drive Submode Select): The brake control is activated for the initial commissioning. Depending on the specific application, this configuration can be deactivated later if necessary. One of the following values is to be entered depending on the motor type:

  - Stepper motor, brake control (and **current reduction**) activated: 0000000Ch
  - BLDC motor, brake control activated: 00000044h

4.4 Connecting the motor

After setting the motor parameters, see **Setting the motor data**, connect the motor and, if applicable, the present sensors (encoders / Hall sensors).

- Connect the motor:

  - to connection X5, see **Connector X5 – motor connection**
- Connect encoders / Hall sensors:

  - to connection X2, see **Connector X2 – encoder/Hall sensor**
- Connect the brake:

  - to connection X4, see **Connector X4 – brake connection**

How the automatic brake control can be activated is described in chapter **Automatic brake control**.

4.5 Auto setup

To determine a number of parameters related to the motor and the connected sensors (encoders/Hall sensors), an auto setup is performed. **Closed Loop** operation requires a successfully completed auto setup.

Note
• Note the following prerequisites for performing the auto setup: • The motor must be load-free. • The motor must not be touched. • The motor must be able to turn freely in any direction. • No NanoJ programs may be running (object 2300$_h$:00$_h$ bit 0 = "0", see **2300h NanoJ Control**).

Tip
Execution of the auto setup requires a relatively large amount of processor computing power. During the auto setup, this may result in fieldbuses not being operated in a timely manner.

Note
The limit switches and, thus, the tolerance bands are active in this mode. For further information on the limit switches, see **Limitation of the range of motion**.

Tip
As long as the motor connected to the controller or the sensors for feedback (encoders/Hall sensors) are not changed, auto setup is only to be performed once during initial commissioning.

4.5.1 Parameter determination

Auto setup determines various parameters of the connected motor and of the present sensors by means of multiple test runs and measurement runs. To a certain extent, the type and number of parameters are dependent on the respective motor configuration.

Parameter	All motors independent of the configuration
Motor type (stepper motor or BLDC motor)	X
Winding resistance	X
Winding inductance	X
Interlinking flux	X

Parameter	Motor without encoder	Motor with encoder and index	Motor with encoder without index
Encoder resolution	-	X	---
Alignment (shifting of the electrical zero to the index.)	-	X	---

Parameter	Motor without Hall sensor	Motor with Hall sensor
Hall transitions	-	X

4.5.2 Execution

1. To preselect the *auto setup* operating mode, enter the value "-2" (="FE_h") in object $6060_h{:}00_h$. The *power state machine* must now switch to the *Operation enabled* state, see **CiA 402 Power State Machine**.
2. Start *auto setup* by setting bit 4 *OMS* in object $6040_h{:}00_h$ (controlword).

```
┌─────────────────────┐
│   Start Auto-Setup  │
└─────────────────────┘
           │
           ▼
┌─────────────────────────────┐
│     Identify motor type     │
└─────────────────────────────┘
           │
           ▼
┌─────────────────────────────────┐
│ Determine windings resistance   │
│ Determine windings inductivity   │
│ Determine magnetic flux          │
└─────────────────────────────────┘
           │
           ▼
    ◇ Encoder                  Yes   ┌──────────────────────────────┐
      and encoder-index  ─────────►  │ Determine pole pairs         │
      available? ◇                   │ Determine encoder resolution │
           │ No                      │ Determine alignment          │
           ▼                         └──────────────────────────────┘
    ◇ Hall sensor              Yes   ┌──────────────────────────────┐
      available? ◇      ─────────►   │ Measure Hall transitions     │
           │ No                      └──────────────────────────────┘
           ▼
    ◇ Encoder and/or           Yes   ┌─────────────────────────────────────┐
      Hall sensor available? ◇──►    │ Invert direction of measurement 1)  │
           │ No                      └─────────────────────────────────────┘
           ▼
┌─────────────────────┐
│   Save parameters   │
└─────────────────────┘
           │
           ▼
┌─────────────────────┐
│   End Auto-Setup    │
└─────────────────────┘
```

While the auto setup is running, the following tests and measurements are performed in succession:

1) To determine the values, the direction of the measurement method is reversed and edge detection re-evaluated.

Value 1 in bit 12 *OMS* in object $6041_h:00_h$ (statusword) indicates that the auto setup was completely executed and ended. In addition, bit 10 *TARG* in object $6041_h:00_h$ can be used to query whether (= "1") or not (= "0") an encoder index was found.
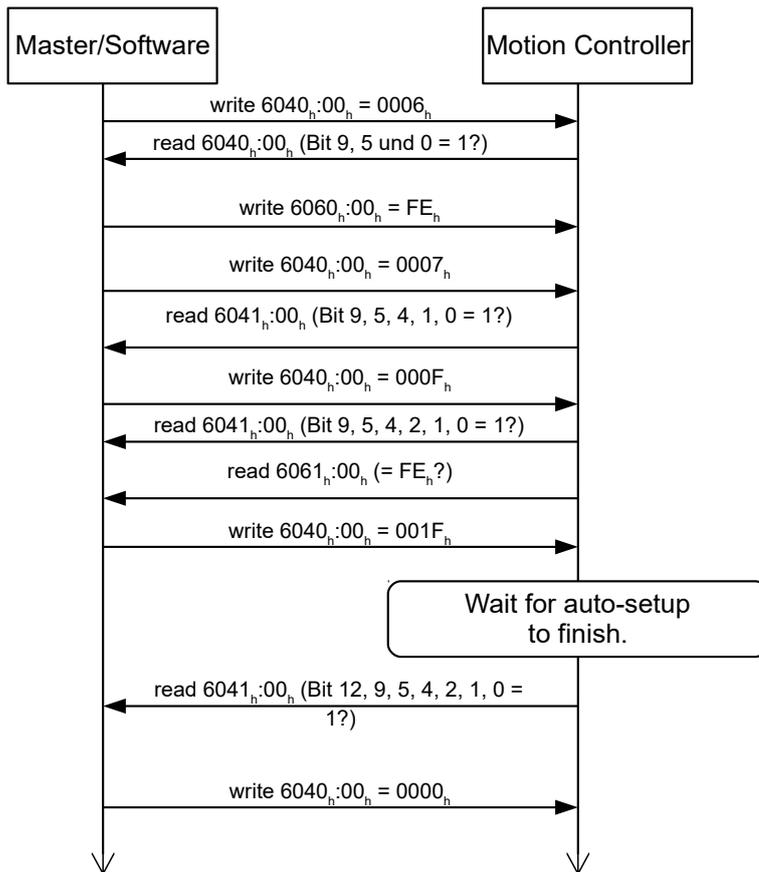
4.5.3 Parameter memory

After a successful *auto setup*, the determined parameter values are automatically taken over into the corresponding objects and stored with the storage mechanism, see **Saving objects** and **1010h Store Parameters**. Categories *Drive* $1010_h:05_h$ and *Tuning* $1010_h:06_h$ are used.

⚠️	CAUTION

Uncontrolled motor movements!

After the auto setup, the internal coordinate system is no longer valid. Unforeseen reactions can result.

► Restart the device after an auto setup. Homing alone does not suffice.

4.6 Test run

After configuring and the auto setup, a test run can be performed. As an example, the **Velocity** operating mode is used.

The values are transferred from your *Modbus master* to the controller. After every transfer, the *master* should use the status objects of the controller to ensure successful parameterization.

1. Select the *Velocity* mode by setting object **6060**$_h$ (Modes Of Operation) to the value "2".
2. Write the desired speed in **6042**$_h$.
3. Switch the *power state machine* to the *Operation enabled* state, see **CiA 402 Power State Machine**.

The following sequence starts *Velocity* mode; the motor turns at 200 rpm.

Master   **Controller**

write 6060$_h$:00$_h$ = 02$_h$

read 6061$_h$:00$_h$ (= 02$_h$?)

write 6042$_h$:00$_h$ = 00C8$_h$

write 6040$_h$:00$_h$ = 0006$_h$

read 6041$_h$:00$_h$ (Bit 9, 5 und 0 = 1?)

write 6040$_h$:00$_h$ = 0007$_h$

read 6041$_h$:00$_h$ (Bit 9, 5, 4, 1, 0 = 1?)

write 6040$_h$:00$_h$ = 000F$_h$

read 6041$_h$:00$_h$ (Bit 9, 5, 4, 2, 1, 0 = 1?)

The controller is now running in „Velocity" mode.

read 6040$_h$:00$_h$ = 0000$_h$
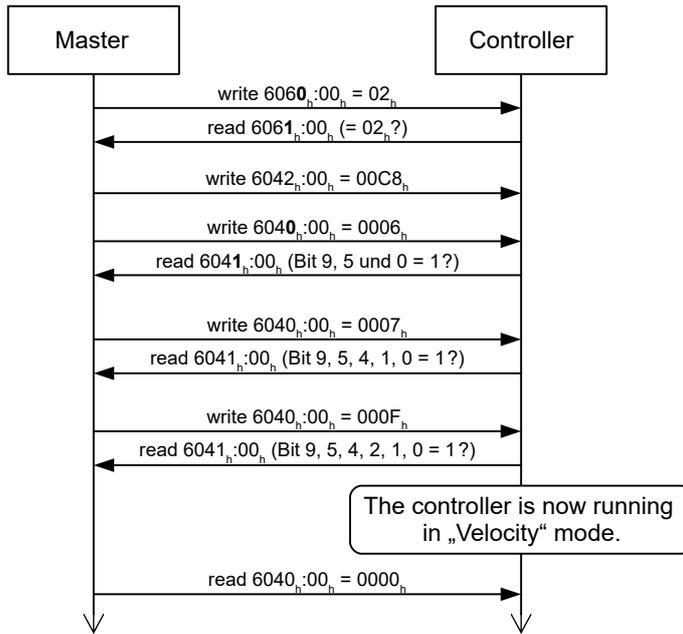
4. To stop the motor, set controlword (**6040**$_h$) to "0".

5 General concepts

5.1 Control modes

5.1.1 General

The control mode of systems without feedback is called *open loop*, the mode with feedback is called *closed loop*. In the *closed loop* control mode, it is initially irrelevant whether the fed back signals come from the motor itself or from the influenced process.

For controllers with feedback, the measured control variable (actual value) is constantly compared with a set point (set value). In the event of deviations between these values, the controller readjusts according to the specified control parameters.

Pure controllers, on the other hand, have no feedback for the value that is to be regulated. The set point (set value) is only specified.

Control mode Open Loop

Target value → Motor Controller → Motor → Process

Control mode Closed Loop

Target value → Motor Controller → Motor → Process
Actual value
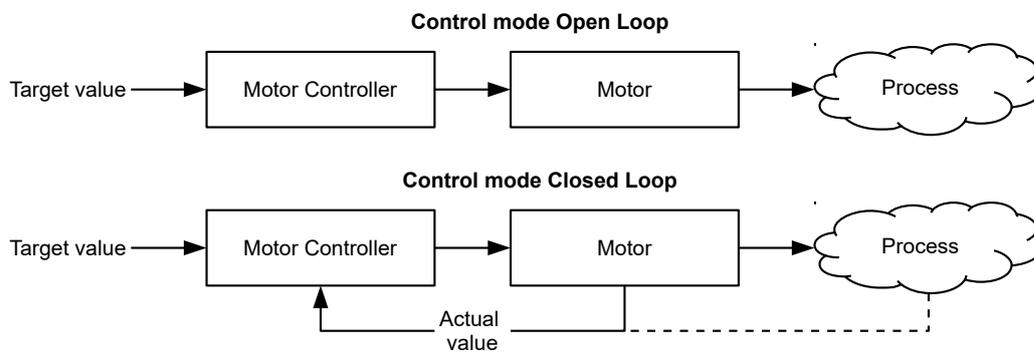
In addition to the physical feedback systems (e.g., via encoders or Hall sensors), model-based feedback systems, collectively referred to as sensorless systems, are also used. Both feedback systems can also be used in combination to further improve the control quality.

Control mode **Open-Loop** ← Motor controller → Control mode **Closed-Loop**

Physical feedback systems — Encoder/Hall

Model-based feedback systems — Sensorless
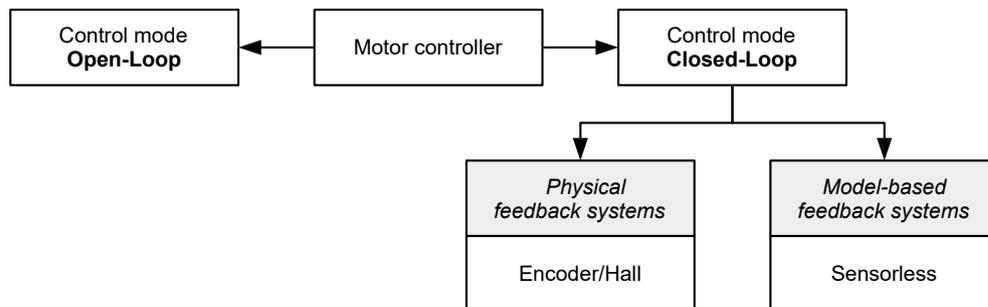
Summarized in the following are all possible combinations of control modes and feedback systems with respect to the motor technology. Support of the respective control mode and feedback is controller-specific and is described in chapters *Pin assignment* and **Operating modes**.

Control mode	Stepper motor	BLDC motor
Open Loop	yes	no
Closed Loop	yes	yes

Feedback	Stepper motor	BLDC motor
Hall	no	yes
Encoder	yes	yes

Feedback	Stepper motor	BLDC motor
Sensorless	yes	yes

Various operating modes can be used depending on the control mode. The following list contains all the types of operation that are possible in the various control modes.

Operating mode	Control mode	
	Open Loop	Closed Loop
Profile Position	yes	yes
Velocity	yes	yes
Profile Velocity	yes	yes
Profile Torque	no[1]	yes
Homing	yes[2]	yes
Interpolated Position Mode	yes[3]	yes
Cyclic Synchronous Position	yes[3]	yes
Cyclic Synchronous Velocity	yes[3]	yes
Cyclic Synchronous Torque	no[1]	yes
Clock-direction	yes	yes

1) The **Profile Torque** and **Cyclic Synchronous Torque** torque operating modes are not possible in the *open loop* control mode due to a lack of feedback.

2) Exception: Homing on block is not possible due to a lack of feedback.

3) Because ramps and speeds in operating modes **Cyclic Synchronous Position** and **Cyclic Synchronous Velocity** follow from the specified points of the master, it is not normally possible to preselect these parameters and to ascertain whether a step loss can be excluded. It is therefore not advisable to use these operating modes in combination with *open loop* control mode.

5.1.2 Open Loop

Introduction

Open loop mode is only used with stepper motors and is, by definition, a control mode without feedback. The field rotation in the stator is specified by the controller. The rotor directly follows the magnetic field rotation without step losses as long as no limit parameters, such as the maximum possible torque, are exceeded. Compared to *closed loop*, no complex internal control processes are needed in the controller. As a result, the requirements on the controller hardware and the controller logic are very low. *Open loop* mode is used primarily with price-sensitive applications and simple movement tasks.

Because, unlike *closed loop*, there is no feedback for the current rotor position, no conclusion can be drawn on the counter torque being applied to the output side of the motor shaft. To compensate for any torque fluctuations that arise on the output shaft of the motor, in *open loop* mode, the controller always supplies the maximum possible (e.g., specified by parameters) set current to the stator windings over the entire speed range. The high magnetic field strength thereby produced forces the rotor to assume the new steady state in a very short time. This torque is, however, opposite that of rotor's inertia. Under certain operating conditions, this combination is prone to resonances, comparable to a spring-mass system.

Commissioning

To use *open loop* mode, the following settings are necessary:

- In object **2030**$_h$ (Pole Pair Count), enter the number of pole pairs (see motor data sheet: for a stepper motor with 2 phases, a step angle of 1.8° corresponds to 50 pole pairs and 0.9° corresponds to 100 pole pairs).
- In object **2031**$_h$ (Max Current), enter the maximum current in mA (see motor data sheet).
- In object **3202**$_h$ (Motor Drive Submode Select), set bit 0 (CL/OL) to the value "0".
- If the clock-direction mode is to be used, then observe chapter **Clock-direction mode**.

If necessary, current reduction on motor standstill should be activated to reduce the power loss and heat build-up. To activate current reduction, the following settings are necessary:

- In object **3202**$_h$ (Motor Drive Submode Select), set bit 3 (CurRed) to "1".
- In object **2036**$_h$ (Open Loop Current Reduction Idle Time), the time in milliseconds is specified that the motor must be at a standstill before current reduction is activated.
- In object **2037**$_h$ (Open Loop Current Reduction Value/factor), the root mean square is specified to which the rated current is to be reduced if current reduction is activated in *open loop* and the motor is at a standstill.

Optimizations

Depending on the system, resonances may occur in *open loop* mode; susceptibility to resonances is particularly high at low loads. Practical experience has shown that, depending on the application, various measures are effective for largely reducing resonances:

- Reduce or increase current, see object **2031**$_h$ (Max Current). Excessive torque reserve promotes resonances.
- Reduce or increase the operating voltage, taking into account the product-specific ranges (with sufficient torque reserve). The permissible operating voltage range can be found in the product data sheet.
- Optimize the control parameters of the current controller via objects **3210**$_h$:09$_h$ (I_P) and **3210**$_h$:0A$_h$ (I_I).
- Adjustments to the acceleration, deceleration and/or target speed depending on the selected control mode:

    Profile Position operating mode

    Objects **6083**$_h$ (Profile Acceleration), **6084**$_h$ (Profile Deceleration) and **6081**$_h$ (Profile Velocity).

    Velocity operating mode

    Objects **6048**$_h$ (Velocity Acceleration), **6049**$_h$ (Velocity Deceleration) and **6042**$_h$ (Target Velocity).

    Profile Velocity operating mode

    Objects **6083**$_h$ (Profile Acceleration), **6084**$_h$ (Profile Deceleration) and **6081**$_h$ (Profile Velocity).

    Homing operating mode

    Objects **609A**$_h$ (Homing Acceleration), **6099**$_h$:01$_h$ (Speed During Search For Switch) and **6099**$_h$:02$_h$ (Speed During Search For Zero).

    Interpolated Position Mode operating mode

    The acceleration and deceleration ramps can be influenced with the higher-level controller.

    Cycle Synchronous Position operating mode

    The acceleration and deceleration ramps can be influenced via the external "position specification / time unit" targets.

    Cycle Synchronous Velocity operating mode

    The acceleration and deceleration ramps can be influenced via the external "position specification / time unit" targets.

Clock-Direction operating mode

Change of the step resolution via objects **2057**$_h$ (Clock Direction Multiplier) and **2058**$_h$ (Clock Direction Divider). Optimize acceleration / deceleration ramps by adjusting the pulse frequency to pass through the resonance range as quickly as possible.

5.1.3 Closed Loop

Introduction

The *closed loop* theory is based on the idea of a control loop. A disturbance acting on a system should be compensated for quickly and without lasting deviation to adjust the control variable back to the set point.

Closed loop using a speed control as an example:
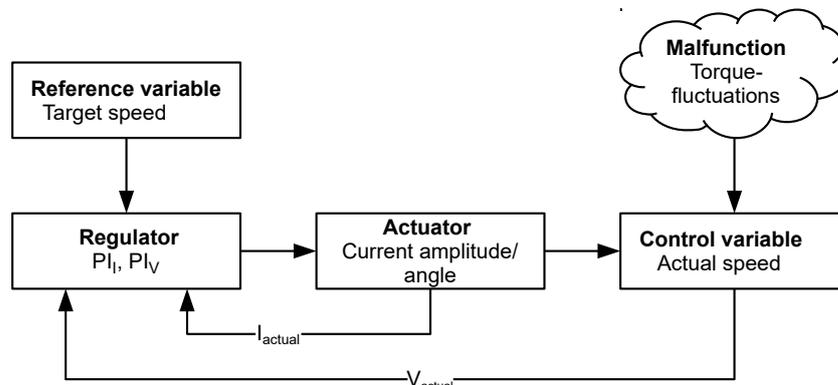
PI_I = Proportional-integral current control loop

PI_V = Proportional-integral velocity control loop

I_{actual} = Actual current

V_{actual} = Actual speed

The *closed loop* method is also referred to as "sine commutation via an encoder with field-oriented control". At the heart of *closed loop* technology is the performance-adjusted current control as well as the feedback of the actual values of the process. Using the encoder signals, the rotor orientation is recorded and sinusoidal phase currents generated in the motor windings. Vector control of the magnetic field ensures that the magnetic field of the stator is always perpendicular to that of the rotor and that the field strength corresponds precisely to the desired torque. The current thereby controlled in the windings provides a uniform motor force and results in an especially smooth-running motor that can be precisely regulated.

The feedback of the control variables necessary for *closed loop* mode can be realized with various technologies. In addition to the physical feedback with encoders or Hall sensors, it is also possible to virtually record the motor parameters through software-based model calculation. Physical variables, such as speed or back-EMF, can be reconstructed with the help of a so-called "observer" from the data of the current controller. With this sensorless technology, one has a "virtual rotary encoder", which – above a certain minimum speed – supplies the position and speed information with the same precision as a real optical or magnetic encoder.

All controllers from Nanotec that support *closed loop* mode implement a field oriented control with sine commutated current control. Thus, the stepper motors and BLDC motor are controlled in the same way as a servo motor. With *closed loop* mode, step angle errors can be compensated for during travel and load angle errors corrected within one full step.

Commissioning

An auto setup must be performed before using *closed loop* mode. The auto setup operating mode automatically determines the necessary parameters (e.g., motor data, feedback systems) that are necessary for optimum operation of the field oriented control. All information necessary for performing the auto setup can be found in chapter **Auto setup**.

Bit 0 in **3202**$_h$ must be set .

5.2 CiA 402 Power State Machine

5.2.1 State machine

CiA 402

To switch the controller to the ready state, it is necessary to run through a *state machine*. This is defined in *CANopen standard 402*. State changes are requested in object **6040**$_h$ (controlword). The actual state of the state machine can be found in object **6041**$_h$ (statusword).

Controlword

State changes are requested via object **6040**$_h$ (controlword).

State transitions

The diagram shows the possible state transitions.
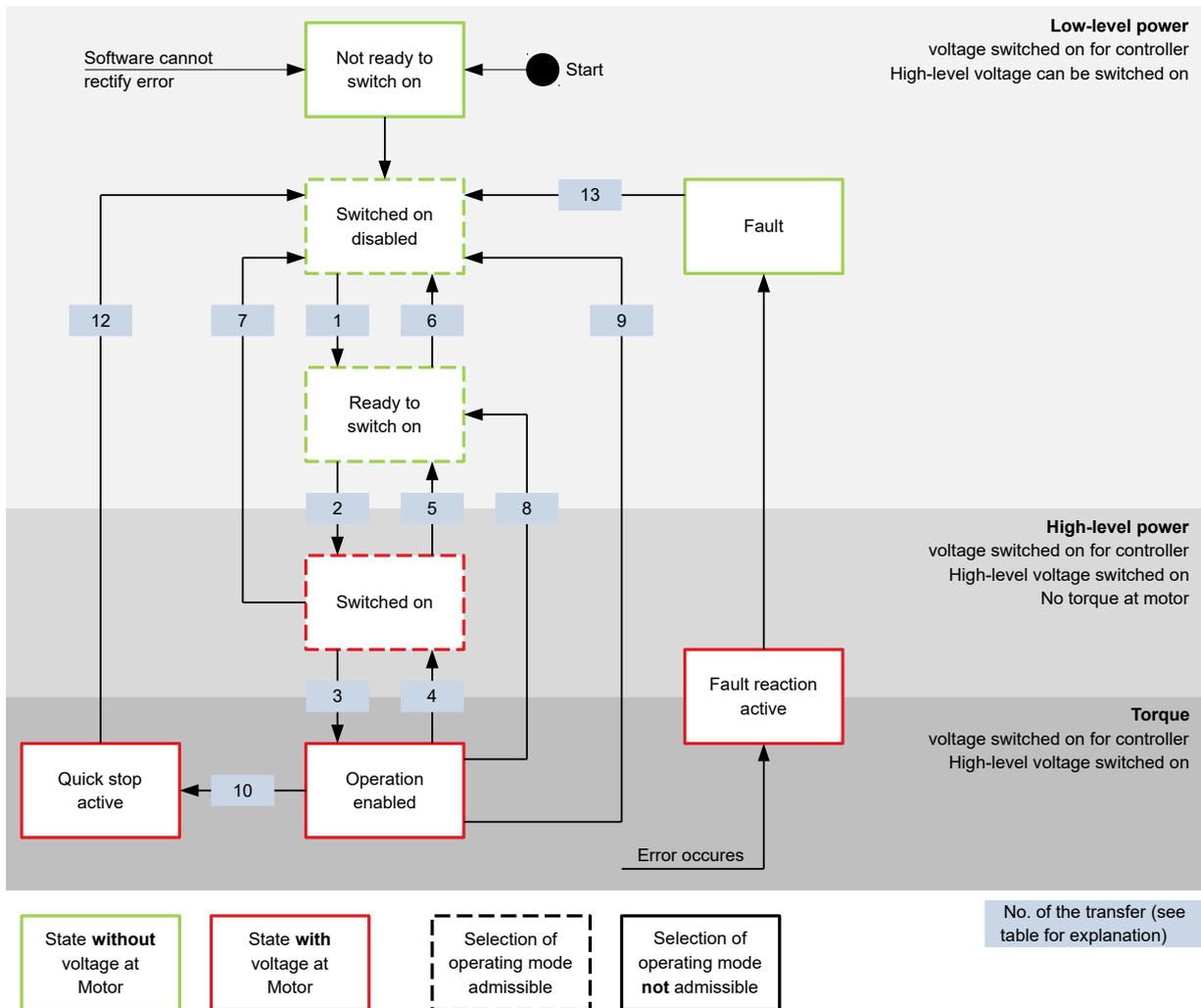
Listed in the following table are the bit combinations for the controlword that result in the corresponding state transitions. An X here corresponds to a bit state that requires no further consideration. The only exception is the resetting of the error (fault reset): the transition is only requested by the rising edge of the bit.

Command	Bit in object 6040_h					Transition
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	
Shutdown	0	X	1	1	0	1, 5, 8
Switch on	0	0	1	1	1	2
Disable voltage	0	X	X	0	X	6, 7, 9, 12
Quick stop	0	X	0	1	X	10
Disable operation	0	0	1	1	1	4
Enable operation	0	1	1	1	1	3
Fault reset	⎍	X	X	X	X	13

Statusword

Listed in the following table are the bit masks that break down the state of the controller.

Statusword (6041$_h$)	State
xxxx xxxx x0xx 0000	Not ready to switch on
xxxx xxxx x1xx 0000	Switch on disabled
xxxx xxxx x01x 0001	Ready to switch on
xxxx xxxx x01x 0011	Switched on
xxxx xxxx x01x 0111	Operation enabled
xxxx xxxx x00x 0111	Quick stop active
xxxx xxxx x0xx 1111	Fault reaction active
xxxx xxxx x0xx 1000	Fault

After switching on and successfully completing the self-test, the controller reaches the *Switch on disabled* state.

> **Note**
>
> If an unrecoverable error occurs, the controller changes to the *Not ready to switch on* state and remains there.

Operating mode

The operating mode is set in object **6060**$_h$. The actually active operating mode is displayed in **6061**$_h$.

The operating mode can be set or changed at any time.

5.2.2 Behavior upon exiting the *Operation enabled* state

Halt motion reactions

Various halt motion reactions can be programmed upon exiting the *Operation enabled* state.

The following graphic shows an overview of the halt motion reactions.

Quick stop active

Transition to the *Quick stop active* state (quick stop option):

In this case, the action stored in object **605A**$_h$ is executed (see following table).

Value in object 605A$_h$	Description
-32768 … -1	Reserved
0	Immediate stop
1	Braking with *slow down ramp* (braking deceleration depending on operating mode) and subsequent state change to *Switch on disabled*
2	Braking with *quick stop ramp* and subsequent state change to *Switch on disabled*
3 … 32767	Reserved

Ready to switch on

Transition to the *Ready to switch on* state (shutdown option):

In this case, the action stored in object **605B**$_h$ is executed (see following table).

Value in object 605B$_h$	Description
-32768 … -1	Reserved
0	Immediate stop
1	Braking with *slow down ramp* (braking deceleration depending on operating mode) and subsequent state change to *Switch on disabled*
2 … 32767	Reserved

Switched on

Transition to the *Switched on* state (disable operation option):

In this case, the action stored in object **605C**$_h$ is executed (see following table).

Value in object 605C$_h$	Description
-32768 … -1	Reserved
0	Immediate stop
1	Braking with *slow down ramp* (braking deceleration depending on operating mode) and subsequent state change to *Switch on disabled*
2 … 32767	Reserved

Halt

The bit is valid in the following modes:

- **Profile Position**
- **Velocity**
- **Profile Velocity**
- **Profile Torque**
- **Interpolated Position Mode**

When setting bit 8 in object **6040**$_h$ (controlword), the reaction stored in **605D**$_h$ is executed (see following table):

Value in object 605D$_h$	Description
-32768 … 0	Reserved
1	Braking with *slow down ramp* (braking deceleration depending on operating mode)
2	Braking with *quick stop ramp* (braking deceleration depending on operating mode)
3 … 32767	Reserved

Fault

Case of an error (fault):

If an error occurs, the motor will brake according to the value stored in object **605E**$_h$.

Value in object 605E$_h$	Description
-32768 … -1	Reserved
0	Immediate stop
1	Braking with *slow down ramp* (braking deceleration depending on operating mode)
2	Braking with *quick stop ramp* (braking deceleration depending on operating mode)
3 … 32767	Reserved

Following/slippage error

If a following or slippage error occurs, the motor is braked according to the value stored in object **3700**$_h$.

Value	Description
-32768 … -1	Reserved
0	Immediate stop
1	Braking with *slow down ramp* (braking deceleration depending on operating mode)
2	Braking with *quick stop ramp* (braking deceleration depending on operating mode)
3 … 32767	Reserved

You can deactivate error monitoring by setting object **6065**$_h$ to the value "-1" (FFFFFFFF$_h$) or object **60F8**$_h$ to the value "7FFFFFFF$_h$".

5.3 User-defined units

The controller offers you the possibility to set user-defined units. It is thereby possible to set and read out the corresponding parameters, e.g., directly in degrees [°], millimeter [mm], etc.

Depending on the mechanical circumstances, you can also define a **Gear ratio** and/or a **Feed constant**.

Factor   Units

	Encoder resolution	• Encoder increments
Encoder		
Motor	Pole pairs	• Steps • Electrical poles
Gearbox	Gear ratio	• Rad • Degree, Grade etc. • Revolutions
Linear axis	Feed constant	• Metre • Inch • Foot • dimensionless
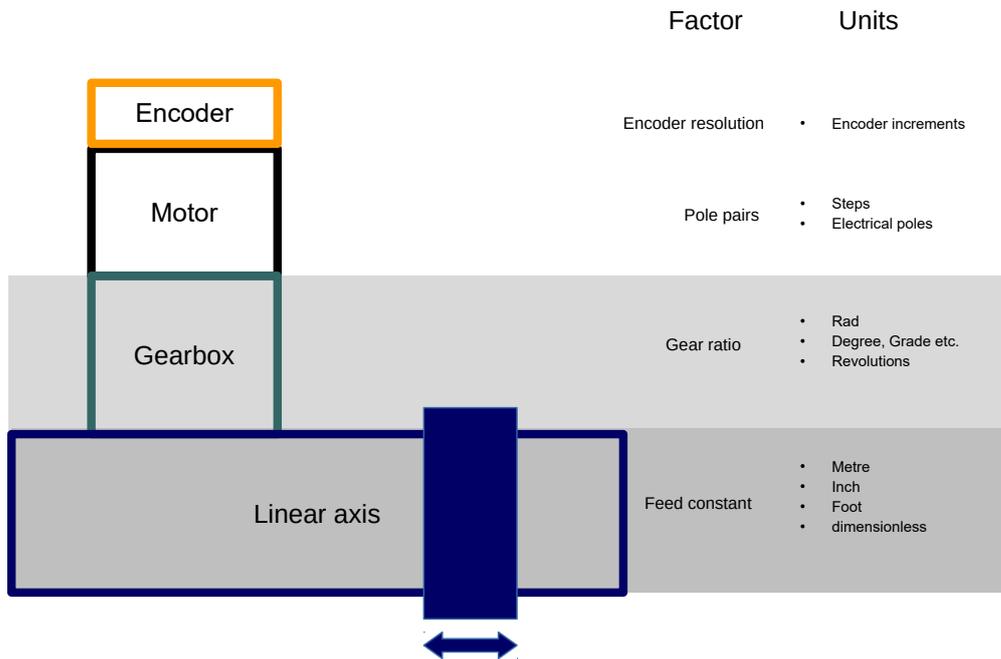
> **ℹ Note**
>
> Value changes of all objects that are described in this chapter are not immediately applied in the *Operation enabled* state of the **CiA 402 Power State Machine**. For this to happen, the *Operation enabled* state must be exited.

5.3.1 Units

Units of the international unit system (*SI*) as well as a number of specific units are supported. It is also possible to specify a power of ten as a factor.

Listed in the following table are all supported units for the position and their values for **60A8$_h$** (**Position unit**) or **60A9$_h$** (**Speed unit**). Depending on the unit that is used, **Feed constant** (**6092$_h$**) and/or **Gear ratio** (**6091$_h$**) are/is taken into account.

Name	Unit symbol	Value	6091$_h$	6092$_h$	Description
meter	m	01$_h$	yes	yes	*Meter*
inch	in	C1$_h$	yes	yes	*Inch* (=0.0254 m)
foot	ft	C2$_h$	yes	yes	*Foot* (=0.3048 m)
grade	g	40$_h$	yes	no	*Gradian* (unit of angle, 400 corresponds to 360°)
radian	rad	10$_h$	yes	no	*Radian*
degree	°	41$_h$	yes	no	*Degrees*
arcminute	'	42$_h$	yes	no	*Arcminute* (60'=1°)
arcsecond	''	43$_h$	yes	no	*Arcsecond* (60''=1')
mechanical revolution		B4$_h$	yes	no	*Revolution*

Name	Unit symbol	Value	6091_h	6092_h	Description
encoder increment		$B5_h$	no	no	*Encoder increments*
step		AC_h	no	no	*Steps.* With 2-phase stepper motors, the number of pole pairs (2030_h) multiplied by 4 is equivalent to one revolution. With 3-phase BLDC motors, the number of pole pairs (2030_h) multiplied by 6 is equivalent to one revolution.
electrical pole		$C0_h$	no	no	*Electric poles.* With a stepper motor that has, e.g., 50 pole pairs (2030_h), the unit corresponds to 1/50 of a revolution.
dimensionless		00_h	yes	yes	*Dimensionless length unit*

Listed in the following table are all supported units for the time and their values for $60A9_h$ (**Speed unit**):

Name	Unit symbol	Value	Description
second	s	03_h	*Second*
minute	min	47_h	*Minute*
hour	h	48_h	*Hour*
day	d	49_h	*Day*
year	a	$4A_h$	*Year* (=365.25 days)

Listed in the following table are the possible exponents and their values for $60A8_h$ (**Position unit**) and $60A9_h$ (**Speed unit**):

Factor	Exponent	Value
10^6	6	06_h
10^5	5	05_h
...	...	...
10^1	1	01_h
10^0	0	00_h
10^{-1}	-1	FF_h
...	..	...
10^{-5}	-5	FB_h
10^{-6}	-6	FA_h

5.3.2 Encoder resolution

The physical resolution of the used encoder/sensor is calculated from the encoder increments ($608F_h$:1_h (Encoder Increments)) per motor revolutions ($608F_h$:2_h (Motor Revolutions)):

$$\text{Position encoder resolution} = \frac{\text{Encoder Increments} (608F_h:01)}{\text{Motor Revolutions} (608F_h:02)}$$

5.3.3 Gear ratio

The gear ratio is calculated from motor revolutions (6091_h:1 (Motor Revolutions)) per axis rotation (6091_h:2 (Shaft Revolutions)) as follows:

$$\text{Gear ratio} = \frac{\text{Motor revolution } (6091_h:1)}{\text{Shaft revolution } (6091_h:2)}$$

5.3.4 Feed constant

The feed constant is calculated from the feed (6092_h:1 (Feed) per revolution of the output shaft (6092_h:2 (Shaft Revolutions) as follows:

$$\text{Feed Constant} = \frac{\text{Feed } (6092_h:01)}{\text{Shaft Revolutions } (6092_h:02)}$$

The feed constant is useful for specifying the lead screw pitch for a linear axis and is used if the unit is based on length dimensions or if it is dimensionless.

5.3.5 Calculation formulas for user units

Position unit

Object $60A8_h$ contains:

- Bits 16 to 23: The position unit (see chapter **Units**)
- Bits 24 to 31: The exponent of a power of ten (see chapter **Units**)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Factor								Unit							

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
reserved (00h)								reserved (00h)							

Example

If $60A8_h$ is written with the value "FF410000$_h$" (bits 16-23=41$_h$ and bits 24-31=FF$_h$), the unit is set to *tenths of degree* (factory setting).

With a relative target position ($607A_h$) of 3600, the motor moves exactly one mechanical revolution, if **Gear ratio** is 1:1. The **Feed constant** plays no role in this case.

Example

If $60A8_h$ is written with the value "FD010000$_h$" (bits 16-23=01$_h$ and bits 24-31=FD$_h$(=-3)), the unit is set to *millimeter*.

With a relative target position ($607A_h$) of 1, the motor moves exactly one mechanical revolution, if **Feed constant** and **Gear ratio** are 1:1.

If the **Feed constant** is set according to the lead screw pitch of a linear axis, the motor turns far enough that a feed of 1 mm is achieved.

Speed unit

Object **60A9**$_h$ contains:

- Bits 8 to 15: The time unit (see chapter **Units**)
- Bits 16 to 23: The position unit (see chapter **Units**)
- Bits 24 to 31: The exponent of a power of ten (see chapter **Units**)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Factor								Nominator (Position)							

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Denominator (Time)								reserved (00h)							

Example

If **60A9**$_h$ is written with the value "00B44700$_h$" (bits 8-15=00$_h$, bits 16-23=B4$_h$ and bits 24-31=47$_h$), the unit is set to *revolutions per minute* (factory setting).

Example

If **60A9**$_h$ is written with the value "FD010300$_h$" (bits 8-15=FD$_h$(=-3), bits 16-23=01$_h$ and bits 24-31=03$_h$), the unit is set to *millimeters per second*.

ⓘ
Note
The speed unit in **Velocity** mode is preset to *revolutions per minute*. You can only set the unit via the **604Ch VI Dimension Factor**.

Conversion factor for the speed unit

You can set an additional factor for the speed unit. Thus, a unit of, e.g., 1/3 revolutions/minute is possible. The factor n is calculated from the factor for numerator (**6096**$_h$:01$_h$) divided by the factor for denominator (**6096**$_h$:02$_h$).

$$n_{velocity} = \frac{6096_h{:}01}{6096_h{:}02}$$

Acceleration unit

The acceleration unit is **speed unit** per second.

Conversion factor for the acceleration unit

The factor n for the acceleration unit is calculated from the numerator (**6097**$_h$:01$_h$) divided by the denominator (**6097**$_h$:02$_h$).

$$n_{acceleration} = \frac{6097_h{:}01}{6097_h{:}02}$$

Jerk unit

The jerk unit is **Acceleration unit** per second.

Conversion factor for jerk

The factor n for the jerk is calculated from the numerator (**60A2$_h$:01$_h$**) divided by the denominator (**60A2$_h$:02$_h$**).

$$n_{jerk} = \frac{60A2_h:01}{60A2_h:02}$$

5.4 Limitation of the range of motion

The digital inputs can be used as limit switches, as is described in chapter **Digital inputs**, if you activate this function for the inputs. The controller also supports software limit switches.

5.4.1 Tolerance bands of the limit switches
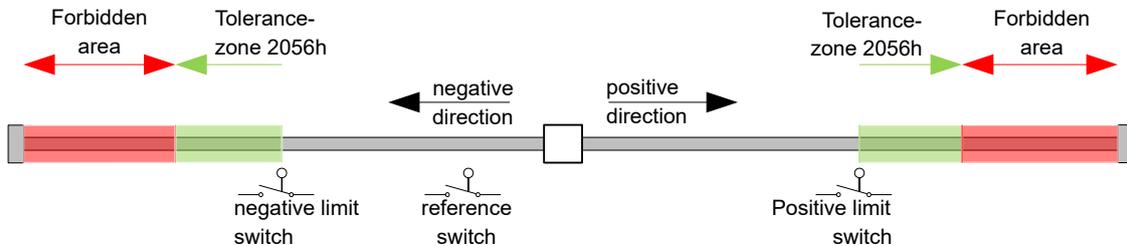
The previous figure shows the breakdown of the tolerance bands next to the limit switches:

- The tolerance zone begins immediately after the limit switch. Free movement is possible in this zone. The length of the zone can be set in object **2056$_h$**.
- If the motor moves into the forbidden range, the controller triggers an immediate stop and it switches to the *fault* state, see also **State transitions**.

5.4.2 Software limit switches

The controller takes into account software limit switches (**607D$_h$** (Software Position Limit)). Target positions (**607A$_h$**) are limited by **607D$_h$**; the absolute target position may not be larger than the limits in **607D$_h$**. If the motor is located outside of the permissible range when setting up the limit switches, only travel commands in the direction of the permissible range are accepted.

5.5 Cycle times

The controller operates with a cycle time of 1 ms. This means that data are processed every 1 ms; multiple changes to a value (e.g., value of an object or level at a digital input) within one ms cannot be detected.

The following table includes an overview of the cycle times of the various processes.

Task	Cycle time
Application	1 ms
NanoJ application	1 ms
Current controller	31.25 µs (32 kHz)

Task	Cycle time
Speed controller	250 µs (4 kHz)
Position controller	1 ms

6 Operating modes

6.1 Profile Position

6.1.1 Overview

Description

Profile Position Mode is used to move to positions relative to the last target position or to an absolute position (last reference position). During the movement, the limit values for the speed, starting acceleration/braking deceleration and jerks are taken into account.

> **Note**
>
> The limit switches and, thus, the tolerance bands are active in this mode. For further information on the limit switches, see **Limitation of the range of motion**.

Activation

To activate the mode, the value "1" must be set in object **6060**$_h$ (Modes Of Operation) (see "**CiA 402 Power State Machine**").

Controlword

The following bits in object **6040**$_h$ (controlword) have a special function:

- Bit 4 starts a travel command. This is carried out on a transition from "0" to "1". An exception occurs if changing from another operating mode to *Profile Position*: If bit 4 is already set, it does not need to be set to "0" and then back to "1" in order to start the travel command.
- Bit 5: If this bit is set to "1", a travel command triggered by bit 4 is immediately executed. If it is set to "0", the just executed travel command is completed and only then is the next travel command started.
- Bit 6: With "0", the target position (**607A**$_h$) is absolute and with "1" the target position is relative. The reference position is dependent on bits 0 and 1 of object **60F2**$_h$.
- Bit 8 (Halt): If this bit is set to "1", the motor stops. On a transition from "1" to "0", the motor accelerates with the set start ramp to the target speed. On a transition from "0" to "1", the motor brakes and comes to a standstill. The braking deceleration is dependent here on the setting of the "Halt Option Code" in object **605D**$_h$.
- Bit 9 (Change on setpoint): If this bit is set, the speed is not changed until the first target position is reached. This means that, before the first target is reached, no braking is performed, as the motor should not come to a standstill at this position.

Controlword 6040$_h$		
Bit 9	**Bit 5**	**Definition**
X	1	The new target position is moved to immediately.
0	0	Positioning is completed before moving to the next target position with the new limits.
1	0	The current target position is only passed through; afterwards, the new target position is moved to with the new values.

For further information, see figure in "**Setting travel commands**".

ⓘ

Note

Bit 9 in the controlword is ignored if the ramp speed is not met at the target point. In this case, the controller would need to reset and take a run-up to reach the preset.

Statusword

The following bits in object 6041_h (statusword) have a special function:

- Bit 10 (Target Reached): This bit is set to "1" if the last target was reached and the motor remains within a tolerance window (6067_h) for a preset time (6068_h).
- Bit 11: Limit exceeded: The demand position is above or below the limit values set in $607D_h$.
- Bit 12 (Set-point acknowledge): This bit confirms receipt of a new and valid set point. It is set and reset in sync with the "New set-point" bit in the controlword.
  There is an exception in the event that a new movement is started before another one has completed and the next movement is not to occur until after the first one has finished. In this case, the bit is reset if the command was accepted and the controller is ready to execute new travel commands. If a new travel command is sent even though this bit is still set, the newest travel command is ignored.
  The bit is not set if one of the following conditions is met:

  - The new target position can no longer be reached while adhering to all boundary conditions.
  - A target position was already traveled to and a target position was already specified. A new target position can only be specified after the current positioning has been concluded.
- Bit 13 (Following Error): This bit is set in *closed loop* mode if the following error is greater than the set limits (6065_h (Following Error Window) and 6066_h (Following Error Time Out)).

6.1.2 Setting travel commands

Travel command

In object $607A_h$ (Target Position), the new target position is specified in user units (see **User-defined units**). The travel command is then triggered by setting bit 4 in object 6040_h (controlword). If the target position is valid, the controller responds with bit 12 in object 6041_h (statusword) and begins the positioning move. As soon as the position is reached, bit 10 in the statusword is set to "1".
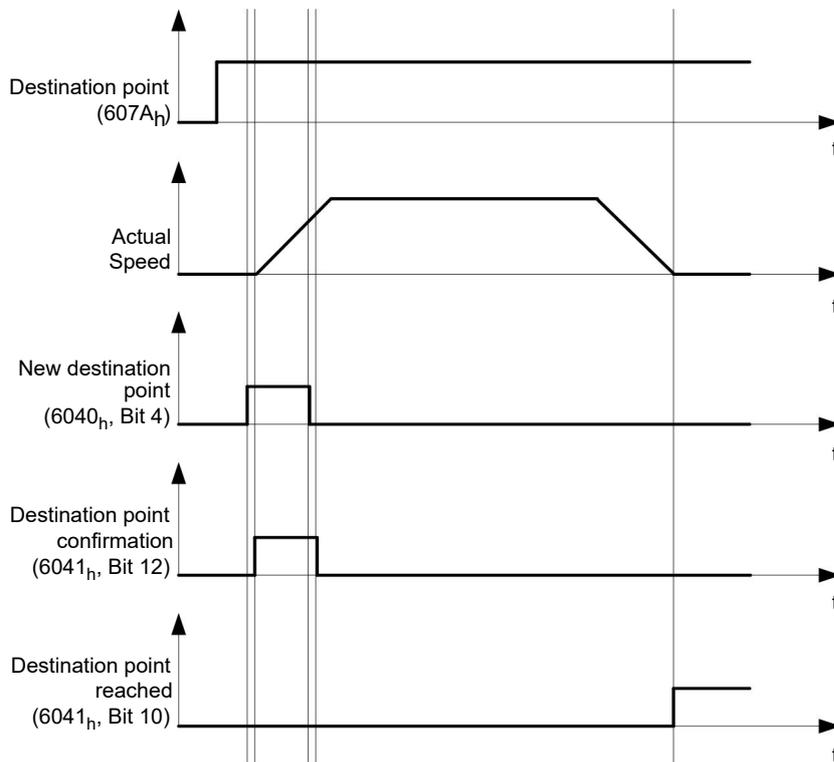
The controller can also reset bit 4 in object **6040**$_h$ (controlword) on its own. This is set with bits 4 and 5 of object **60F2**$_h$.

Other travel commands

Bit 12 in object **6041**$_h$ (statusword, set-point acknowledge) changes to "0" if another travel command can be buffered (see time 1 in the following figure). As long as a target position is being moved to, a second target position can be passed to the controller in preparation. All parameters – such as speed, acceleration, braking deceleration, etc. – can thereby be reset (time 2). If the buffer is empty, the next time can be queued up (time 3).

If the buffer is already full, a new set point is ignored (time 4). If bit 5 in object **6040**$_h$ (controlword, bit: "Change Set-Point Immediately") is set, the controller operates without the buffer; new travel commands are implemented directly (time 5).

Times
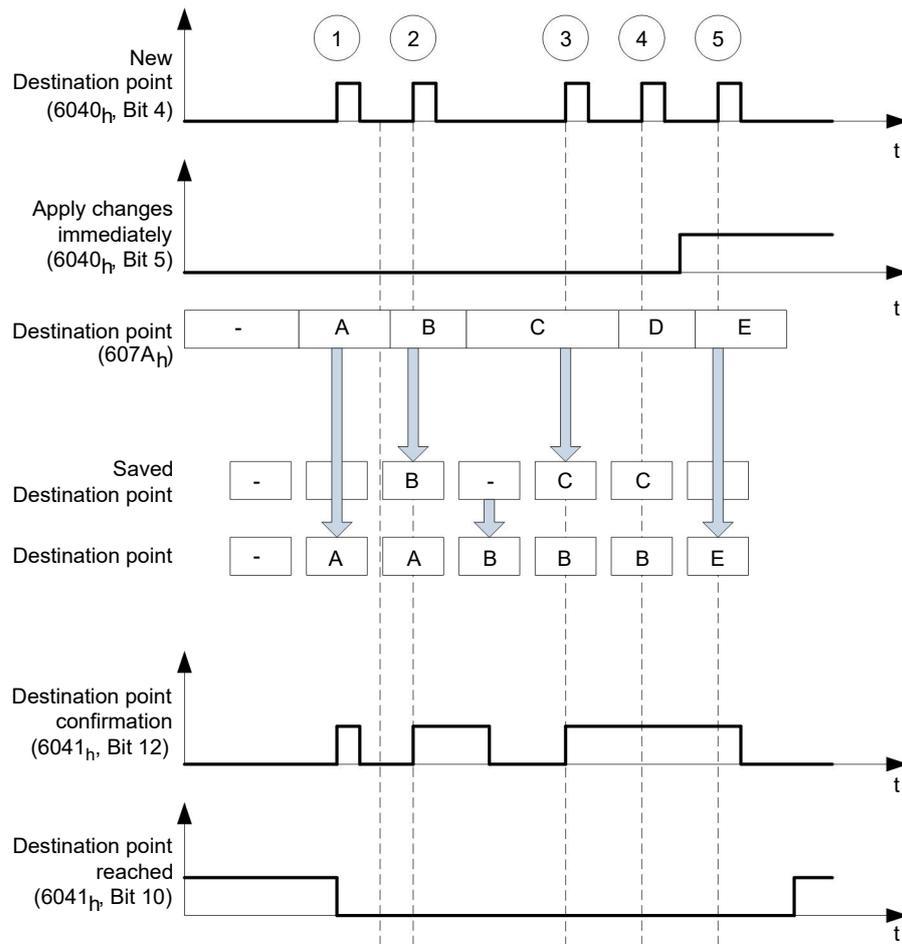
Transition procedure for second target position

The following graphic shows the transition procedure for the second target position while moving to the first target position. In this figure, bit 5 of object **6040**$_h$ (controlword) is set to "1"; the new target value is, thus, taken over immediately.
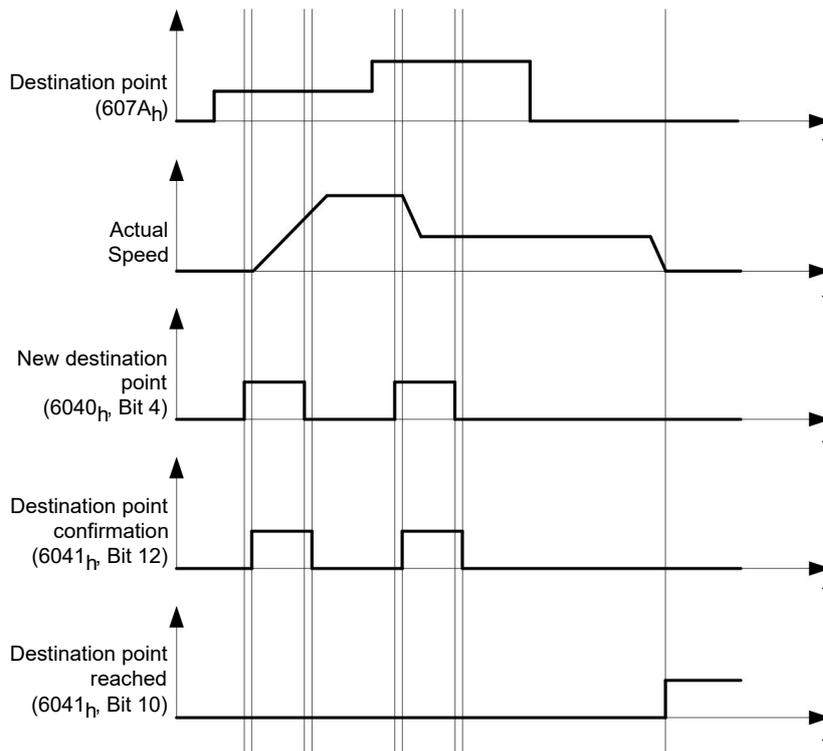
Possibilities for moving to a target position

If bit 9 in object **6040**$_h$ (controlword) is equal to "0", the current target position is first moved to completely. In this example, the final speed (**6082**$_h$) of the target position is equal to zero. If bit 9 is set to "1", the profile speed (**6081**$_h$) is maintained until the target position is reached; only then do the new boundary conditions apply.
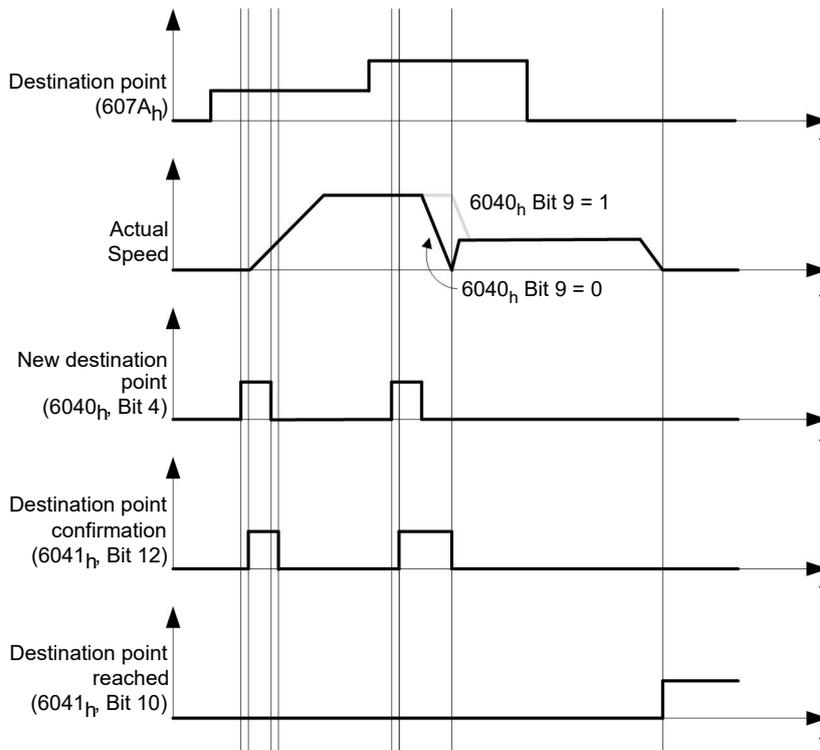
Possible combinations of travel commands

To provide a better overview of the travel commands, combinations of travel commands are listed and depicted in this chapter.

The following applies for the figures below:

- A double arrow indicates a new travel command.
- The first travel command at the start is always an absolute travel command to position 1100.
- The second movement is performed at a lower speed so as to present the graphs in a clear manner.

- Change on setpoint (6040_h:00 Bit 5 = 0)
- Move absolute (6040_h:00 Bit 6 = 0)
- Target position: 300
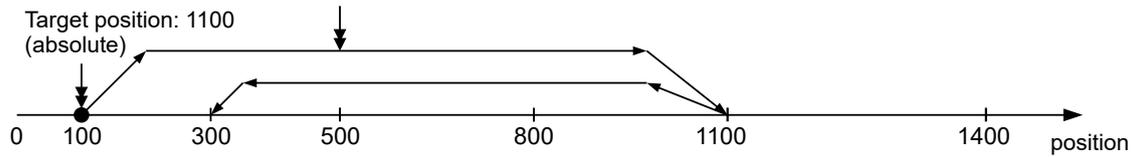
- Relative to the preceding target position ($60F2_h$:00 = 0)
- Change on setpoint (6040_h:00 Bit 5 = 0)
- Move relative (6040_h:00 Bit 6 = 1)
- Target position: 300
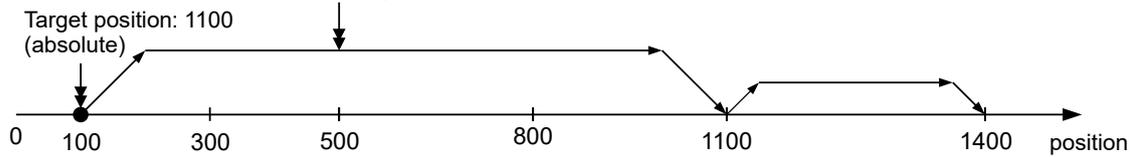
- Change set immediately (6040_h:00 Bit 5 = 1)
- Move absolute (6040_h:00 Bit 6 = 0)
- Target position: 300
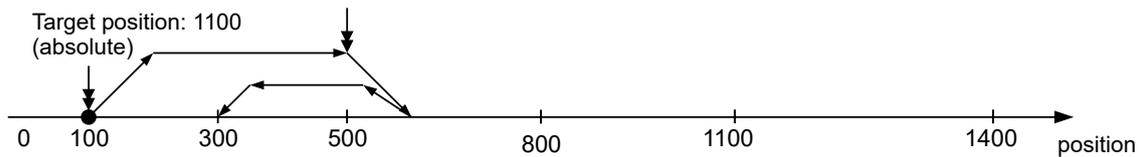
- Relative to the preceding target position ($60F2_h$:00 = 0)
- Change set immediately (6040_h:00 Bit 5 = 1)
- Move relative (6040_h:00 Bit 6 = 1)
- Target position: 300
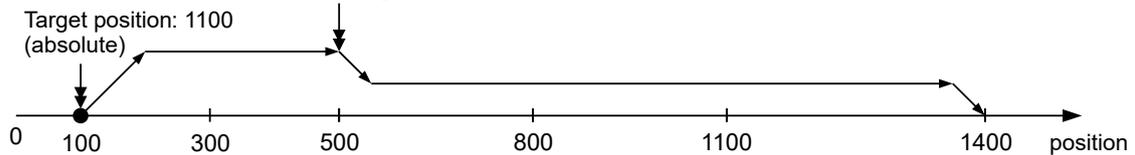
- Change on setpoint (6040_h:00 Bit 5 = 0)
- Move absolute (6040_h:00 Bit 6 = 0)
- Target position: 300

Target position: 1100
(absolute)

0   100   300   500   800   1100   1400   position
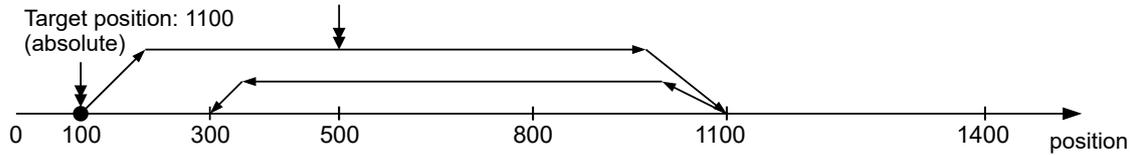
- Relative to the actual position ($60F2_h$:00 = 1)
- Change on setpoint (6040_h:00 Bit 5 = 0)
- Move relative (6040_h:00 Bit 6 = 1)
- Target position: 300
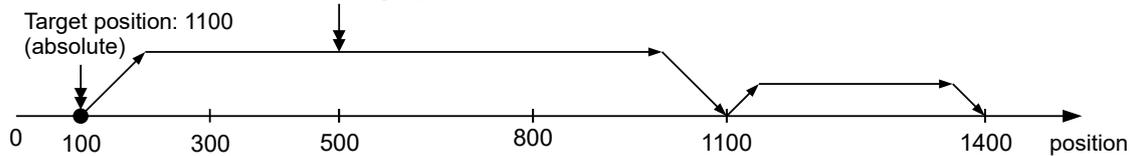
Target position: 1100
(absolute)

0   100   300   500   800   1100   1400   position

- Change set immediately (6040_h:00 Bit 5 = 1)
- Move absolute (6040_h:00 Bit 6 = 0)
- Target position: 300

Target position: 1100
(absolute)

0   100   300   500   800   1100   1400   position

6.1.3 Loss of accuracy for relative movements

When linking together relative movements, a loss of accuracy may occur if the final speed is not set to zero. The following graphic illustrates the reason.

Position

Target position

Arriving at target position

1: Sampling before arriving the target position

2: Sampling after arriving the target position

1ms

t
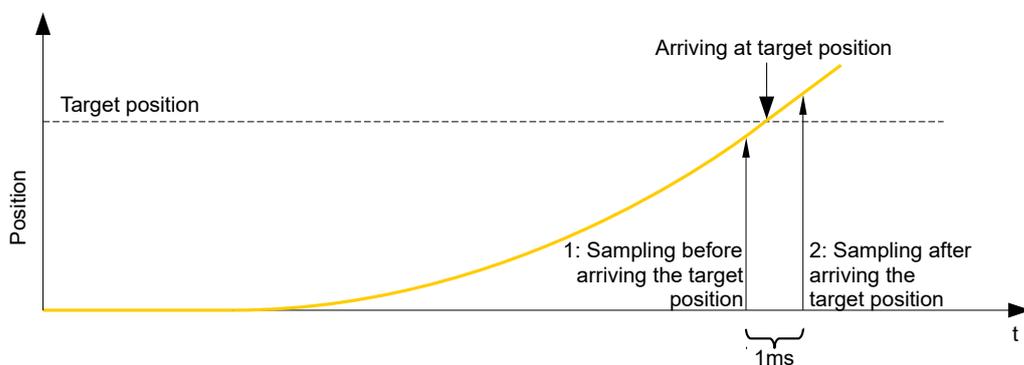
The current position is sampled once per millisecond. It is possible that the target position is reached between two samples. If the final speed is not equal to zero, then, after the target position is reached, the sample is used as an offset as the basis for the subsequent movement. As a result, the subsequent movement may go somewhat farther than expected.

6.1.4 Boundary conditions for a positioning move

Object entries

The boundary conditions for the position that has been moved to can be set in the following entries of the object dictionary:

- **607A$_h$**: (Target Position): Planned target position
- **607D$_h$**: (Software Position Limit): Definition of the limit stops (see chapter **Software limit switches**)
- **607C$_h$** (Home Offset): Specifies the difference between the zero position of the controller and the reference point of the machine in **user-defined units**. (See "**Homing**")
- **607B$_h$** (Position Range Limit): Limits of a modulo operation for replicating an endless rotation axis
- **607$_h$** (Polarity): Direction of rotation
- **6081$_h$** (Profile Velocity): Maximum speed with which the position is to be approached
- **6082$_h$** (End Velocity): Speed upon reaching the target position
- **6083$_h$** (Profile Acceleration): Desired starting acceleration
- **6084$_h$** (Profile Deceleration): Desired braking deceleration
- **6085$_h$** (Quick Stop Deceleration): Emergency-stop braking deceleration in case of the "Quick stop active" state of the "CiA 402 Power State Machine"
- **6086$_h$** (Motion Profile Type): Type of ramp to be traveled; if the value is "0", the jerk is not limited; if the value is "3", the values of 60A4$_h$:1$_h$–4$_h$ are set as limits for the jerk.
- **60C5$_h$** (Max Acceleration): The maximum acceleration that may not be exceeded when moving to the end position
- **60C6$_h$** (Max Deceleration): The maximum braking deceleration that may not be exceeded when moving to the end position
- **60A4$_h$** (Profile Jerk), subindex 01$_h$ to 04$_h$: Objects for specifying the limit values for the jerk.
- The speed is is limited by **607F$_h$** (Max Profile Velocity) and **6080$_h$** (Max Motor Speed); the smaller value is used as the limit.
- **60F2$_h$**: (Positioning Option Code): Defines the positioning behavior

Objects for the positioning move

The following graphic shows the objects involved in the boundary conditions of the positioning move.
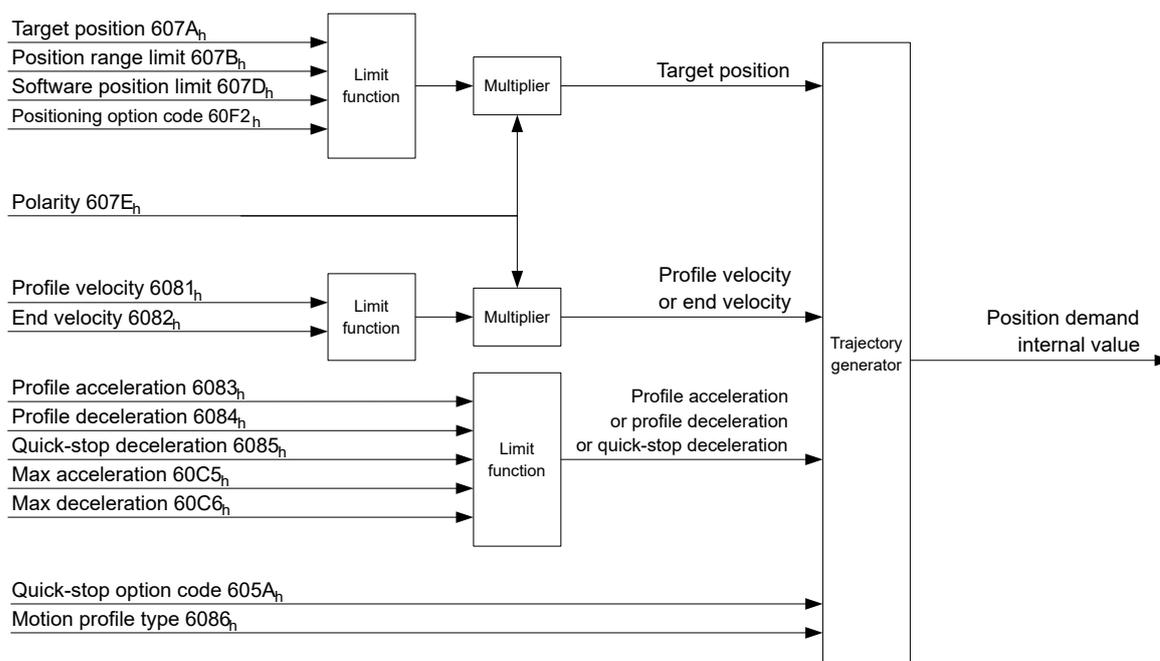
Parameters for the target position

The following graphic shows an overview of the parameters that are used for moving to a target position (figure not to scale).
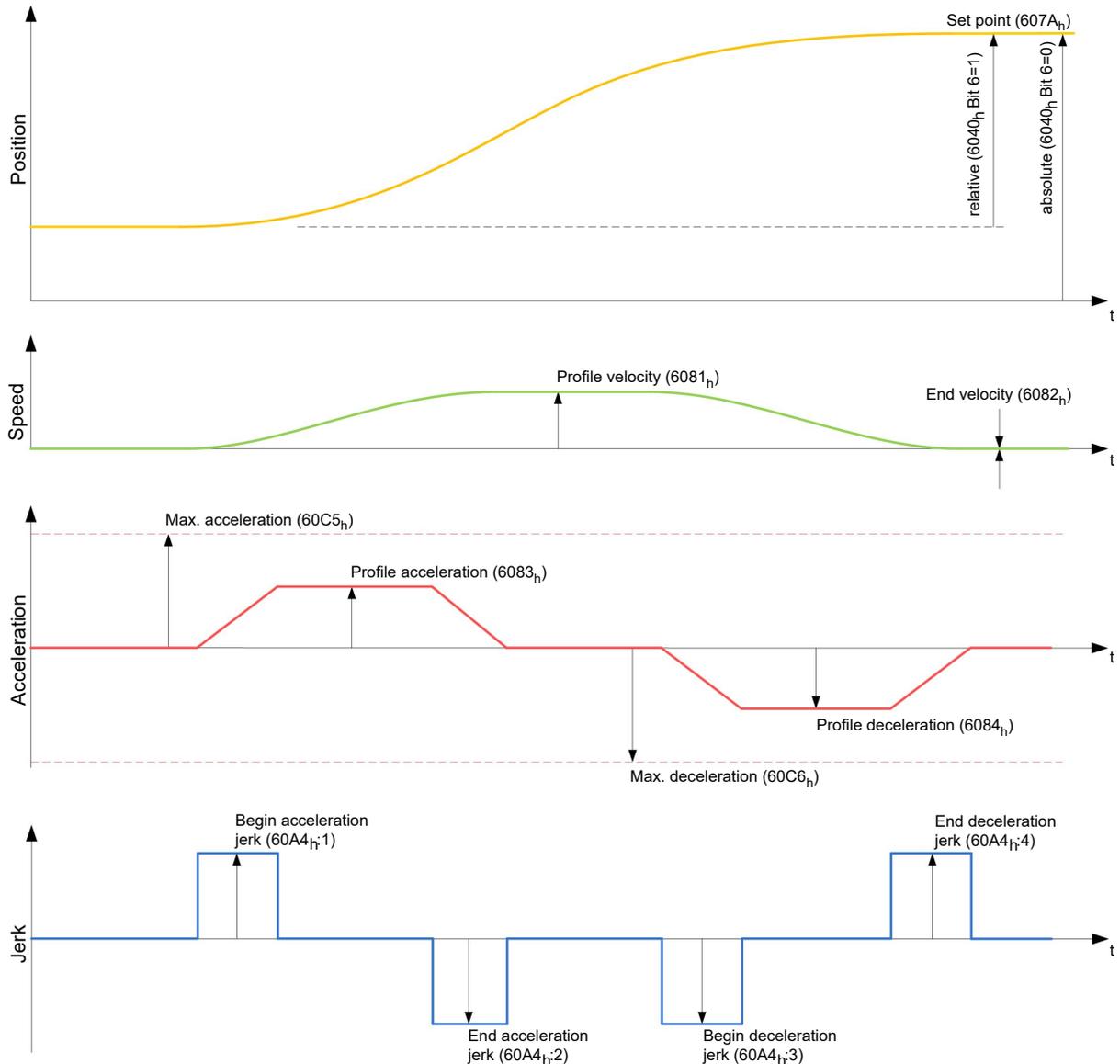
6.1.5 Jerk-limited mode and non-jerk-limited mode

Description

A distinction is made between the "jerk-limited" and "non-jerk-limited" modes.

Jerk-limited mode

Jerk-limited positioning can be achieved by setting object **6086**$_h$ to "3". The entries for the jerks in subindices :1$_h$–4$_h$ of object **60A4** thereby become valid.

Non-jerk-limited mode

A "non-jerk-limited" ramp is traveled if the entry in object **6086**$_h$ is set to "0" (default setting).

6.2 Velocity

6.2.1 Description

This mode operates the motor at a preset target speed, similar to a frequency inverter. Unlike the *Profile Velocity Mode*, this mode does not permit the selection of jerk-limited ramps.

> **Note**
>
> The limit switches and, thus, the tolerance bands are active in this mode. For further information on the limit switches, see **Limitation of the range of motion**.

6.2.2 Activation

To activate the mode, the value "2" must be set in object **6060**$_h$ (Modes Of Operation) (see "**CiA 402 Power State Machine**").

6.2.3 Controlword

The following bits in object **6040**$_h$ (controlword) have a special function:

- Bit 8 (Halt): If this bit is set to "1", the motor stops. On a transition from "1" to "0", the motor accelerates with the acceleration ramp to the target speed. On a transition from "0" to "1", the motor brakes according to the deceleration ramp and comes to a standstill.

6.2.4 Statusword

The following bits in object **6041**$_h$ (statusword) have a special function:

- Bit 11: Limit exceeded: The target speed is above or below the set limit values.

6.2.5 Object entries

The following objects are necessary for controlling this mode:

- **604C**$_h$ (Dimension Factor):
  The unit for speed values is defined here for the following objects.
  Subindex 1 contains the denominator (multiplier) and subindex 2 contains the numerator (divisor) with which the internal speed values are converted to revolutions per minute. If, for example, subindex 1 is set to the value "60" and subindex 2 is set to the value "1", the speed is specified in revolutions per second (60 revolutions per 1 minute).
- **6042**$_h$: Target Velocity.
  The target speed is set here in user-defined units.
- **6048**$_h$: Velocity Acceleration
  This object defines the acceleration. Subindex 1 contains the change in speed, subindex 2 the corresponding time in seconds. Both together are used to calculate the acceleration:

$$\text{VL velocity acceleration} = \frac{\text{Delta speed (6048}_h\text{:1)}}{\text{Delta time (6048}_h\text{:2)}}$$

- **6049**$_h$ (Velocity Deceleration):
  This object defines the deceleration (deceleration ramp). The subindices here are arranged as described in object **6048**$_h$; the change in speed is to be specified with positive sign.
- **6046**$_h$ (Velocity Min Max Amount):
  The limitations of the target speeds are specified in this object.
  The minimum speed is set in **6046**$_h$:1$_h$. If the target speed (**6042**$_h$) falls below the minimum speed, the value is limited to the minimum speed **6046**$_h$:1$_h$.
  The maximum speed is set in **6046**$_h$:2$_h$. If the target speed (**6042**$_h$) exceeds the maximum speed, the value is limited to the maximum speed **6046**$_h$:2$_h$.

- **604A**$_h$ (Velocity Quick Stop):
  This object can be used to set the quick-stop ramp. Subindices 1 and 2 are identical to those described for object **6048**$_h$.
- **6080**$_h$ (Max Motor Speed): Maximum speed

The following objects can be used to check the function:

- **6043**$_h$ (Vl Velocity Demand)
- **6044**$_h$ (Vl Velocity Actual Value)

Speeds in Velocity Mode
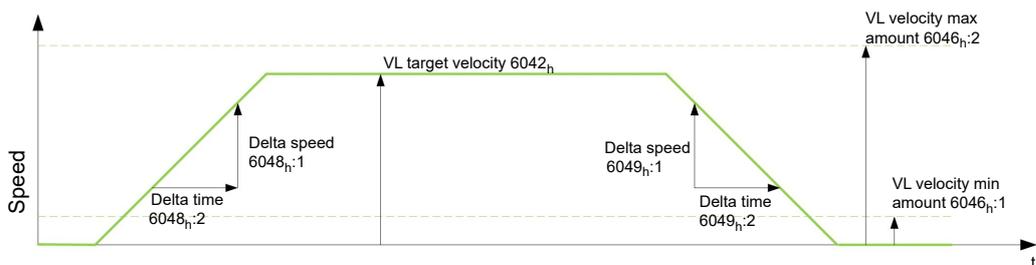
Objects for Velocity Mode

The ramp generator follows the target speed, remaining within the set speed and acceleration limits. As long as a limit is active, bit 11 in object **6041**$_h$ is set (internal limit active).
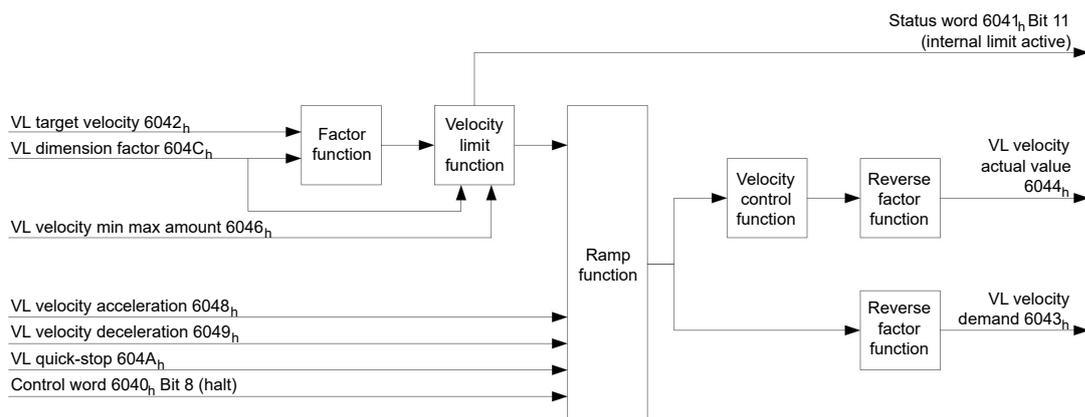
6.3 Profile Velocity

6.3.1 Description

This mode operates the motor in Velocity Mode with extended (jerk-limited) ramps. Unlike *Velocity Mode* (see "**Velocity**"), the **statusword** is used in this mode to indicate whether the target speed is reached.

ⓘ	**Note**

The limit switches and, thus, the tolerance bands are active in this mode. For further information on the limit switches, see **Limitation of the range of motion**.

6.3.2 Activation

To activate the mode, the value "3" must be set in object **6060**$_h$ (Modes Of Operation) (see "**CiA 402 Power State Machine**").

6.3.3 Controlword

The following bits in object 6040_h (controlword) have a special function:

- Bit 8 (Halt): If this bit is set to "1", the motor stops. On a transition from "1" to "0", the motor accelerates with the set start ramp to the target speed. On a transition from "0" to "1", the motor brakes and comes to a standstill.

6.3.4 Statusword

The following bits in object 6041_h (statusword) have a special function:

- Bit 10 (target speed reached; Target Reached): In combination with bit 8 in the controlword, this bit specifies whether the target speed is reached, if braking is taking place or if the motor is at a standstill (see table).

6041_h Bit 10	6040_h Bit 8	Description
0	0	Target speed not reached
0	1	Axis braking
1	0	Target speed within target window (defined in $606D_h$h and $606E_h$)
1	1	Axis speed is 0

- Bit 13 (Deviation Error): This bit is set in *closed loop* mode if the slippage error is greater than the set limits (**60F8h Max Slippage** and **203Fh Max Slippage Time Out**).

6.3.5 Object entries

The following objects are necessary for controlling this mode:

- **$606B_h$** (Velocity Demand Value):
  This object contains the output of the ramp generator, which simultaneously serves as the preset value for the speed controller.
- **$606C_h$** (Velocity Actual Value):
  Indicates the current actual speed.
- **$606D_h$** (Velocity Window):
  This value specifies by how much the actual speed may vary from the set speed for bit 10 (target speed reached; Target Reached") in object 6041_h (statusword) to be set to "1".
- **$606E_h$** (Velocity Window Time):
  This object specifies how long the actual speed and the set speed must be close to one another (see **$606D_h$** "Velocity Window") for bit 10 "Target speed reached" in object 6041_h (statusword) to be set to "1".
- **$607E_h$** (Polarity):
  If bit 6 is set to "1" here, the sign of the target speed is reversed.
- **6083_h** (Profile acceleration):
  Sets the value for the acceleration ramp in Velocity Mode.
- **6084_h** (Profile Deceleration):
  Sets the value for the deceleration ramp in Velocity Mode.
- **6085_h** (Quick Stop Deceleration):
  Sets the value for the deceleration ramp for rapid braking in Velocity Mode.
- **6086_h** (Motion Profile Type):
  The ramp type can be selected here ("0" = trapezoidal ramp, "3" = jerk-limited ramp).
- **$60FF_h$** (Target Velocity):
  Specifies the target speed that is to be reached.
- The speed is is limited by **$607F_h$** (Max Profile Velocity) and **6080_h** (Max Motor Speed); the smaller value is used as the limit.

Objects in Profile Velocity Mode
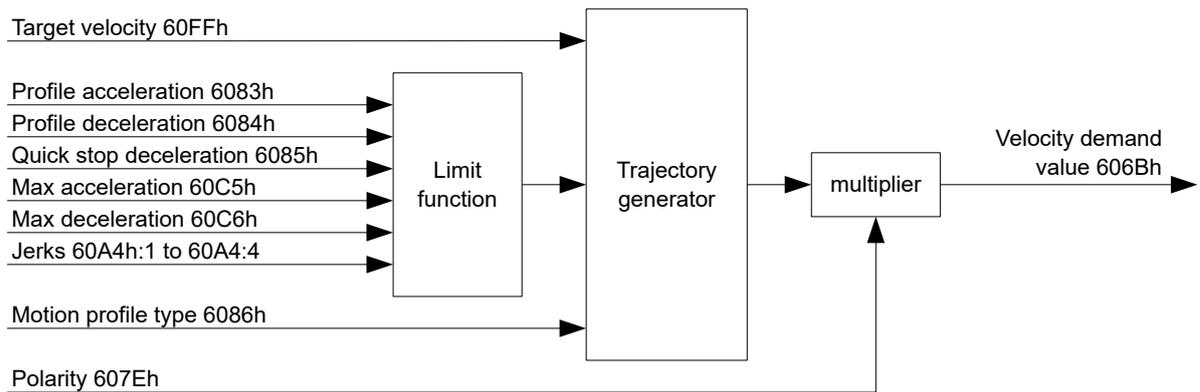
Activation

After the mode is selected in object **6060**$_h$ (Modes Of Operation) and the "Power State machine" (see "**CiA 402 Power State Machine**") is switched to *Operation enabled*, the motor is accelerated to the target speed in object **60FF**$_h$ (see following figures). The speed and acceleration values are taken into account here; for jerk-limited ramps, the jerk-limit values are also taken into account.

Limitations in the jerk-limited case

The following figure shows the adjustable limits in the jerk-limited case (**6086**$_h$ = 3).
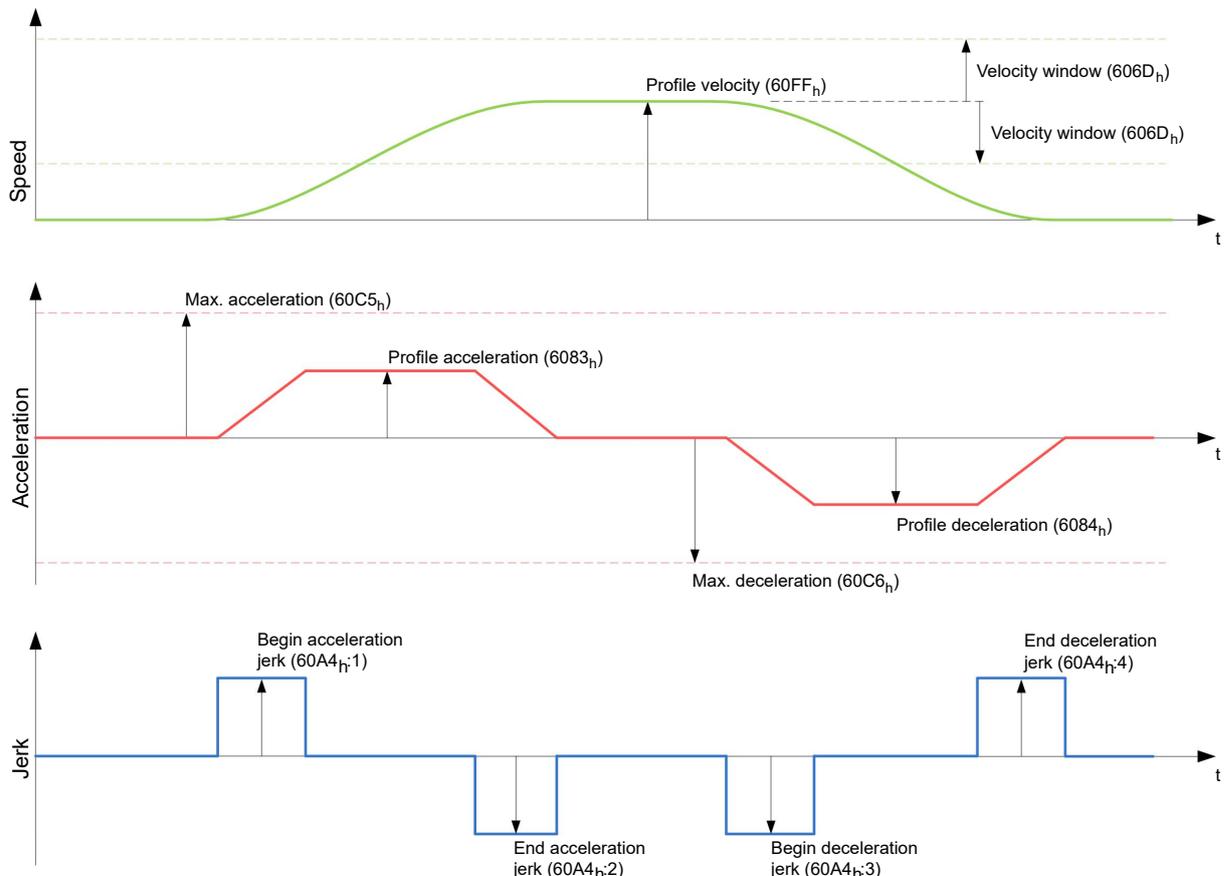
Limitations in the trapezoidal case

This figure shows the adjustable limitations for the trapezoidal case (**6086**$_h$ = 0).
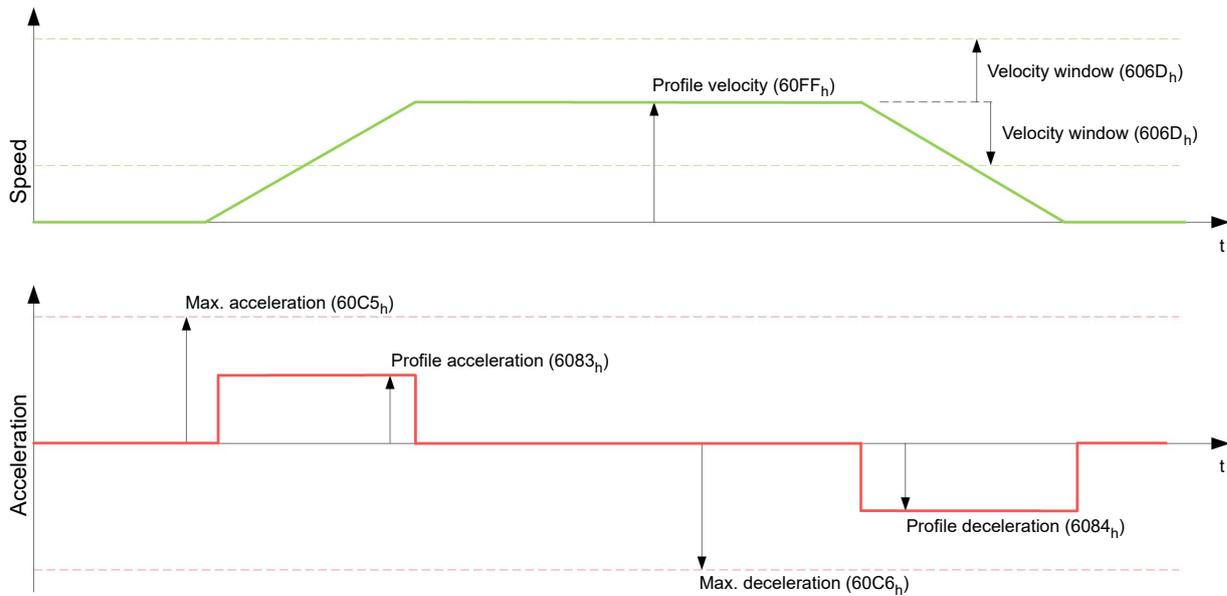
6.4 Profile Torque

6.4.1 Description

In this mode, the torque is preset as a set value and reached via a ramp function.

> ⓘ **Note**
>
> This mode only functions if **closed loop** is activated, see also **Commissioning Closed Loop**.

> ⓘ **Note**
>
> The limit switches and, thus, the tolerance bands are active in this mode. For further information on the limit switches, see **Limitation of the range of motion**.

6.4.2 Activation

To activate the mode, the value "4" must be set in object **6060**$_h$ (Modes Of Operation) (see "**CiA 402 Power State Machine**").

6.4.3 Controlword

The following bits in object **6040**$_h$ (controlword) have a special function:

- Bit 8 (Halt): If this bit is set to "1", the motor stops. If this bit is set from "1" to "0", the motor is started up according to the presets. When setting from "0" to "1", the motor is again brought to a standstill, taking the preset values into consideration.

6.4.4 Statusword

The following bits in object **6041**$_h$ (statusword) have a special function:

- Bit 10 (Target Reached): In combination with bit 8 of object **6040**$_h$ (controlword), this bit indicates whether the specified torque is reached (see following table). The target is considered having been met if the current torque (**6077h Torque Actual Value**) is within a tolerance window (**203Dh Torque Window**) for a specified time (**203Eh Torque Window Time Out**).

6040_h Bit 8	6041_h Bit 10	Description
0	0	Specified torque not reached
0	1	Specified torque reached
1	0	Axis accelerated
1	1	Axis speed is 0

- Bit 11: Limit exceeded: The target torque (6071_h) exceeds the maximum torque entered in 6072_h.

6.4.5 Object entries

All values of the following entries in the object dictionary are to be specified as a thousandth of the maximum torque, which corresponds to the rated current ($203B_h$:01_h) . This includes the objects:

- 6071_h (Target Torque):
  Target torque
- 6072_h (Max Torque):
  Maximum torque during the entire ramp (accelerate, maintain torque, decelerate)
- 6074_h (Torque Demand):
  Current output value of the ramp generator (torque) for the controller
- 6087_h (Torque Slope):
  Max. change in torque per second

> **Note**
>
> These values are not limited to 100% of the rated current ($203B_h$:01_h). Torque values greater than the rated torque (generated from the rated current) can be achieved if the maximum duration of the peak current ($203B_h$:02_h) is set (see **I2t Motor overload protection**). All torque objects are limited by the peak current.

The following objects are also needed for this operating mode:

- 3202_h Bit 5 (Motor Drive Submode Select):
  If this bit is set to "0", the drive controller is operated in the torque-limited Velocity Mode, i.e., the maximum speed can be limited in object 6080_h and the controller can operate in field weakening mode.
  If this bit is set to "1", the controller operates in the ("Real") Torque Mode; the maximum speed cannot be limited here and field weakening mode is not possible.

Objects of the ramp generator
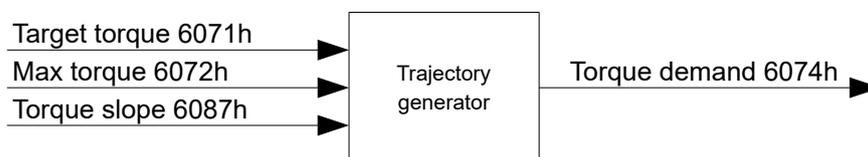
Torque curve
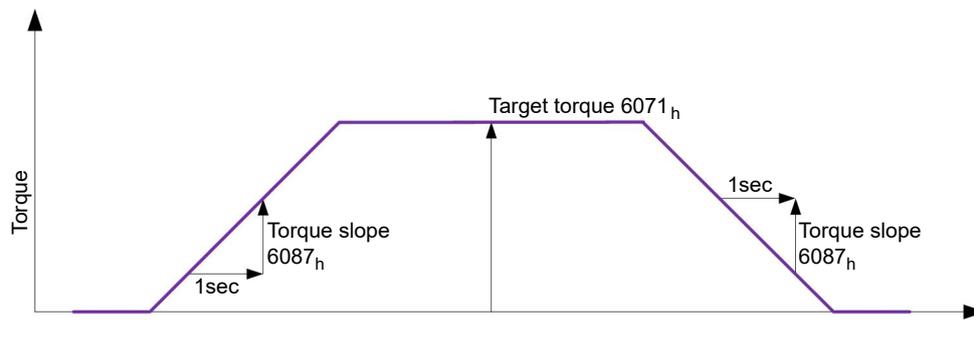
6.5 Homing

6.5.1 Overview

Description

The purpose of the homing method is to align the position zero point of the controller with an encoder index or position switch.

Activation

To activate the mode, the value "6" must be set in object **6060**$_h$ (Modes Of Operation) (see "**CiA 402 Power State Machine**").

If home switches and/or limit switches are used, these special functions must first be activated in the I/O configuration (see "**Digital inputs and outputs**").

Controlword

The following bits in object **6040**$_h$ (controlword) have a special function:

- Bit 4: If the bit is set to "1", referencing is started. This is performed until either the reference position is reached or bit 4 is reset to "0".

Statusword

The following bits in object **6041**$_h$ (statusword) have a special function:

Bit 13	Bit 12	Bit 10	Description
0	0	0	Homing is performed
0	0	1	Homing is interrupted or not started
0	1	0	Homing confirmed, but target not yet reached
0	1	1	Homing completed
1	0	0	Error during homing, motor still turning
1	0	1	Error during homing, motor at standstill

Object entries

The following objects are necessary for controlling this mode:

- **607C**$_h$ (Home Offset): Specifies the difference between the zero position of the controller and the reference point of the machine in **user-defined units**.
- **6098**$_h$ (Homing Method):
  Method to be used for referencing (see "**Homing method**")

- **6099**$_h$:01$_h$ (Speed During Search For Switch):
  Speed for the search of the switch
- **6099**$_h$:02$_h$ (Speed During Search For Zero):
  Speed for the search of the index
- **6080**$_h$ (Max Motor Speed): Maximum speed
- **609A**$_h$ (Homing Acceleration):
  Starting acceleration and braking deceleration for homing
- **2056**$_h$ (Limit Switch Tolerance Band):
  After reaching the positive or negative limit switch, the controller permits a tolerance range in which the motor can continue to run. If this tolerance range is exceeded, the motor stops and the controller switches to the "Fault" state. If limit switches can be actuated during homing, the tolerance range should be selected such that the motor does not exit the tolerance range during braking. Homing cannot otherwise be successfully performed. After homing is completed, the tolerance range can be reset to "0" if this is required by the application.
- **203A**$_h$:01$_h$ (Minimum Current For Block Detection):
  Minimum current threshold which, if exceeded, is to detect the blocking of the motor at a block.
- **203A**$_h$:02$_h$ (Period Of Blocking):
  Specifies the time in ms that the motor is to continue to run against the block after block detection.

Homing speeds

The figure shows the homing speeds using method 4 as an example:
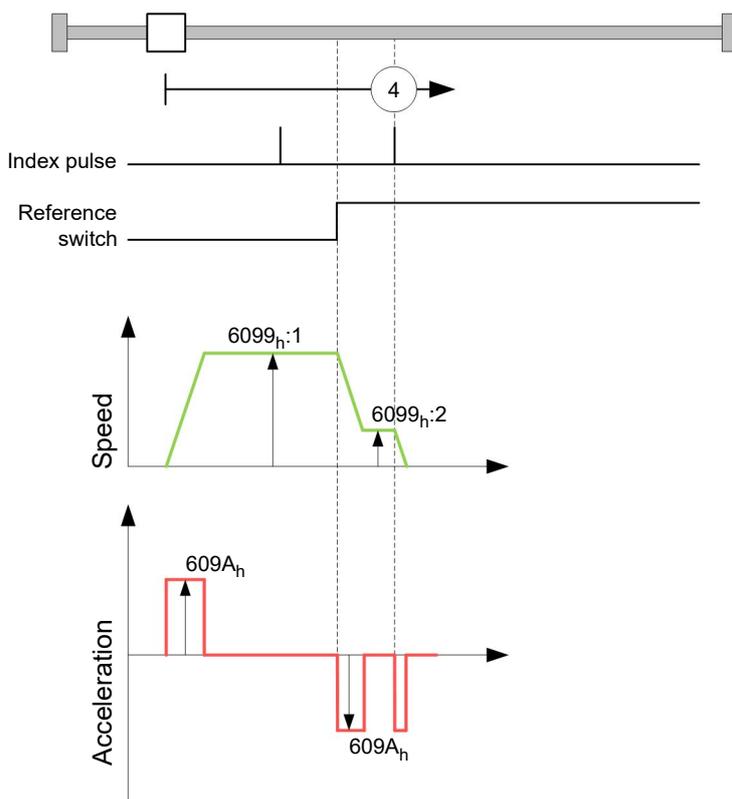
6.5.2 Homing method

Description

The homing method is written as a number in object **6098**$_h$ and decides whether, on a switch edge (rising/falling), a current threshold for block detection or an index pulse is referenced or in which direction homing starts. Methods that use the index pulse of the encoder lie in the number range 1 to 14, 33 and 34. Methods that do not use the index pulse of the encoder lie between 17 and 30, but are identical to methods 1 to 14 with respect to the travel profiles. These number are shown in circles in the

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following figures. Methods for which no limit switches are used and, instead, travel against a block is to be detected, a minus must be placed before the method number when making the call.

In the following graphics, the negative movement direction is to the left. The *limit switch* is located before the respective mechanical block; the *home switch* is located between the two limit switches. The index pulses come from the connected encoder.

For methods that use homing on block, the same figures apply as for the methods with limit switch. Because nothing is different aside from the missing limit switches, the same figures are used. For the figures here, the limit switches must be replaced with a mechanical block.

Homing on block

Homing on block currently only functions in *closed loop* mode.

"Homing on block" functions like every homing method with the difference that instead of a limit switch, a block (limit stop) is used for positioning. Two settings are to be made here:

1. Current level: In object **203A**$_h$:01, the current level is defined above which movement against the block is detected.
2. Blocking duration: In object **203A**$_h$:02, the duration during which the motor moves against the block is set.
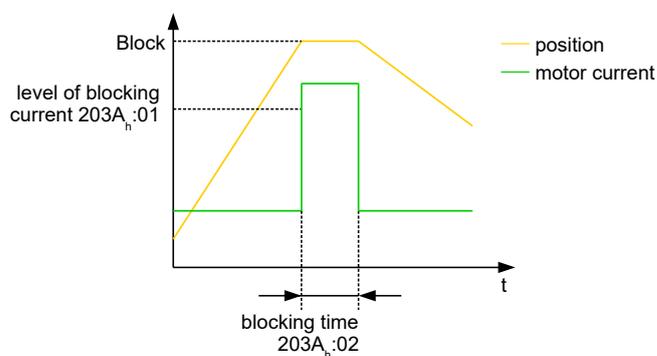
Overview of methods

Methods 1 to 14 as well as 33 and 34 use the index pulse of the encoder.

Methods 17 to 32 are identical to methods 1 to 14 with the difference that only limit or home switches are used for referencing and not the index pulse.

- Methods 1 to 14 use an index pulse.
- Methods 17 to 30 do not use an index pulse.
- Methods 33 and 34 reference only to the next index pulse.
- Method 35 references to the current position.

The following methods can be used for homing on block:

- Methods -1 to -2 and -7 to -14 contain an index pulse
- Methods -17 to -18 and -23 to -30 have no index pulse

Methods 1 and 2

Reference to limit switches and index pulse.

Method 1 references to negative limit switch and index pulse:
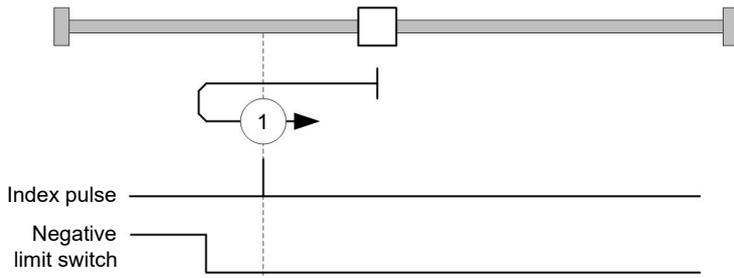
Method 2 references to positive limit switch and index pulse:
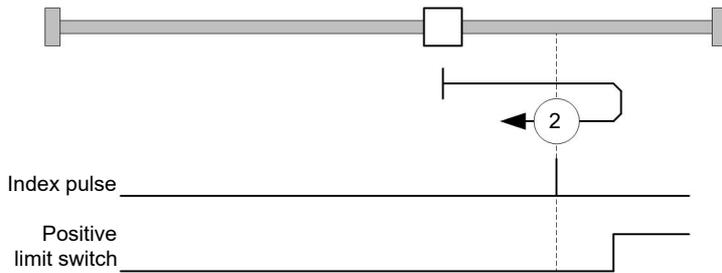
Methods 3 to 6

Reference to the switching edge of the home switch and index pulse.

With methods 3 and 4, the left switching edge of the home switch is used as reference:
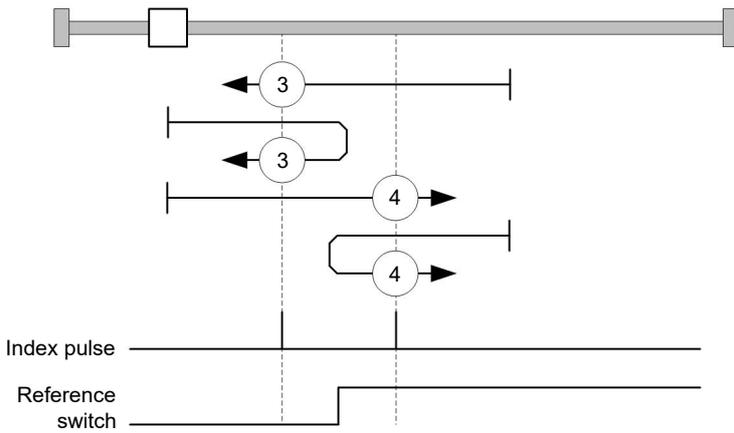
With methods 5 and 6, the right switching edge of the home switch is used as reference:
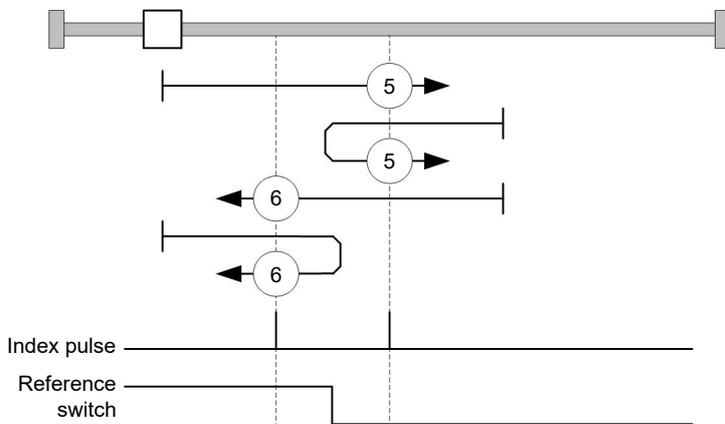
Methods 7 to 14

Reference to the home switch and index pulse (with limit switches).

With these methods, the current position relative to the home switch is not important. With method 10, for example, referencing is always performed to the index pulse to the right of the right edge of the home switch.

Methods 7 to 10 take the positive limit switch into account:
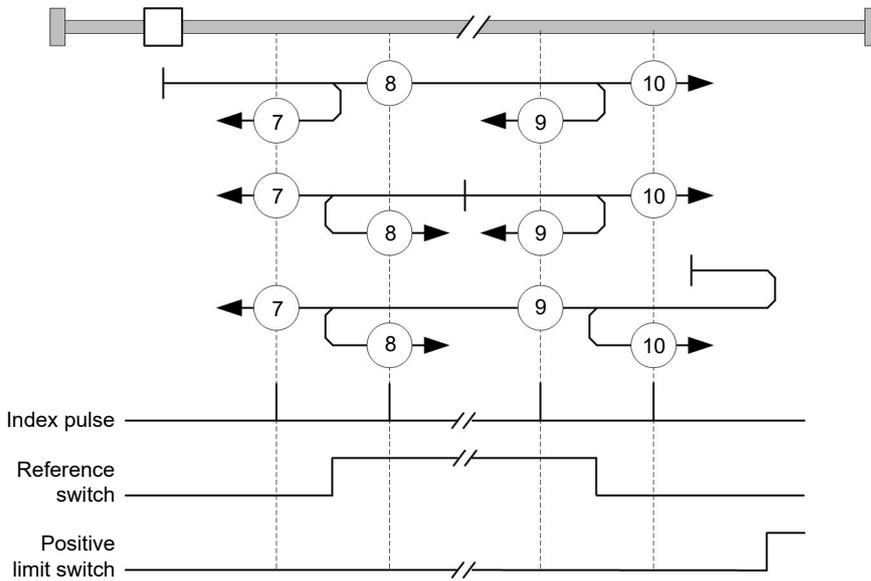
Methods 11 to 14 take the negative limit switch into account:
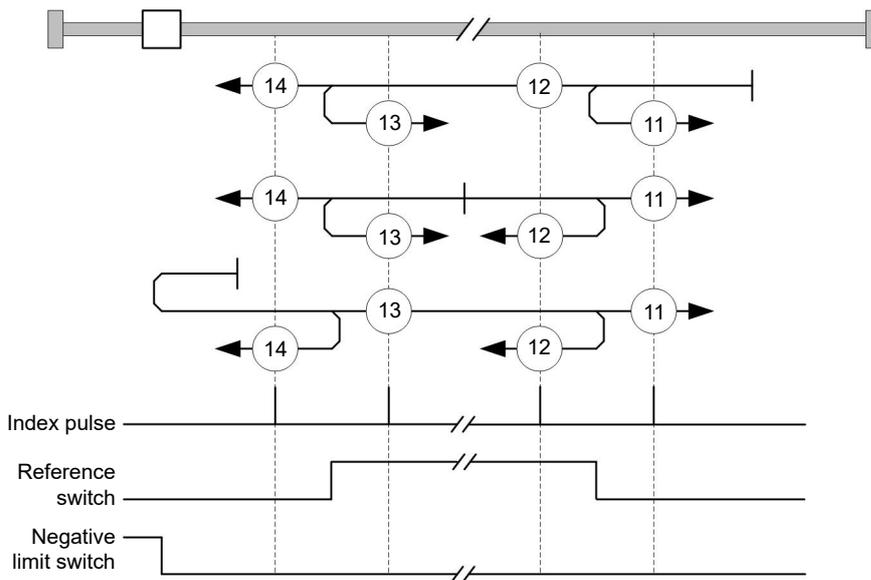
Methods 17 and 18

Reference to the limit switch without the index pulse.

Method 17 references to the negative limit switch:
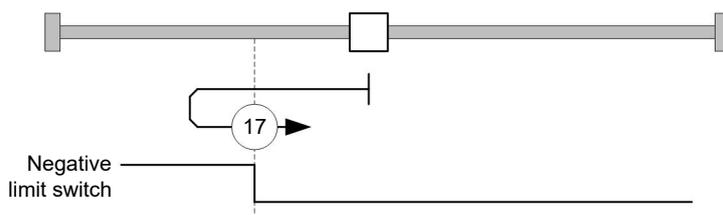
Method 18 references to the positive limit switch:
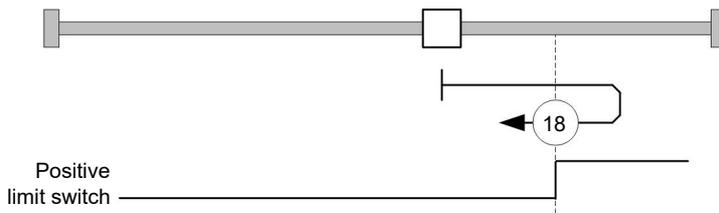
Methods 19 to 22

Reference to the switching edge of the home switch without the index pulse.

With methods 19 and 20 (equivalent to methods 3 and 4), the left switching edge of the home switch is used as reference:
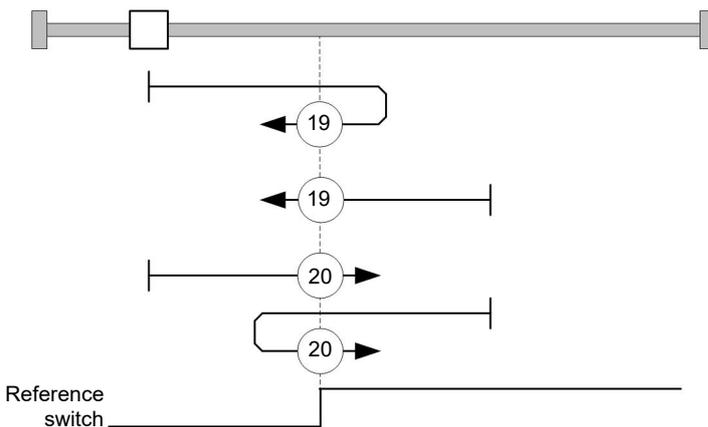
With methods 21 and 22 (equivalent to methods 5 and 6), the right switching edge of the home switch is used as reference:
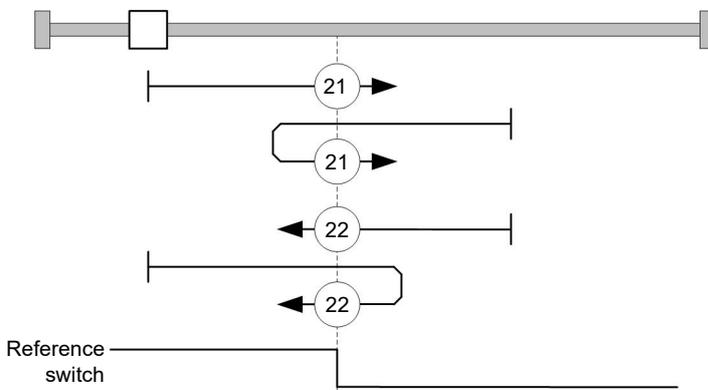
Methods 23 to 30

Reference to the home switch without the index pulse (with limit switches).

With these methods, the current position relative to the home switch is not important. With method 26, for example, referencing is always performed to the index pulse to the right of the right edge of the home switch.

Methods 23 to 26 take the positive home switch into account:
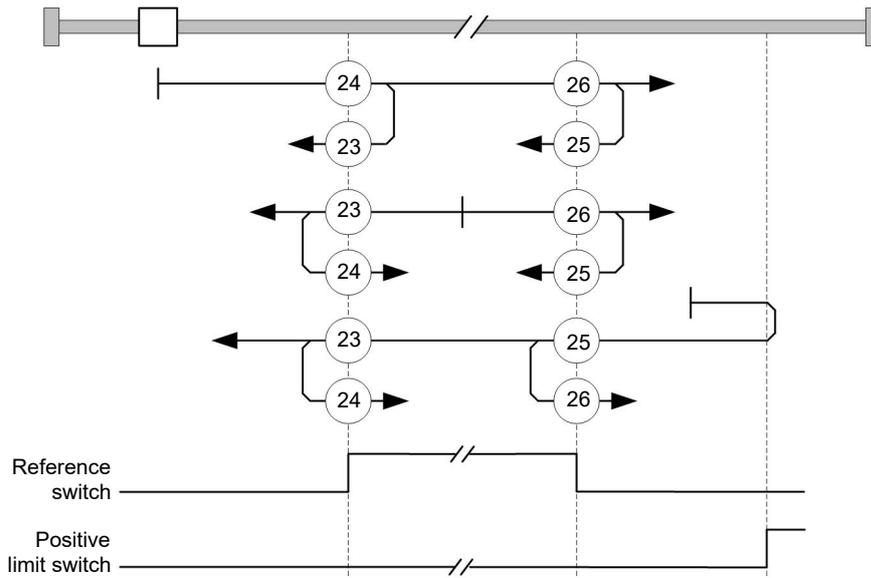
Methods 27 to 30 take the negative home switch into account:
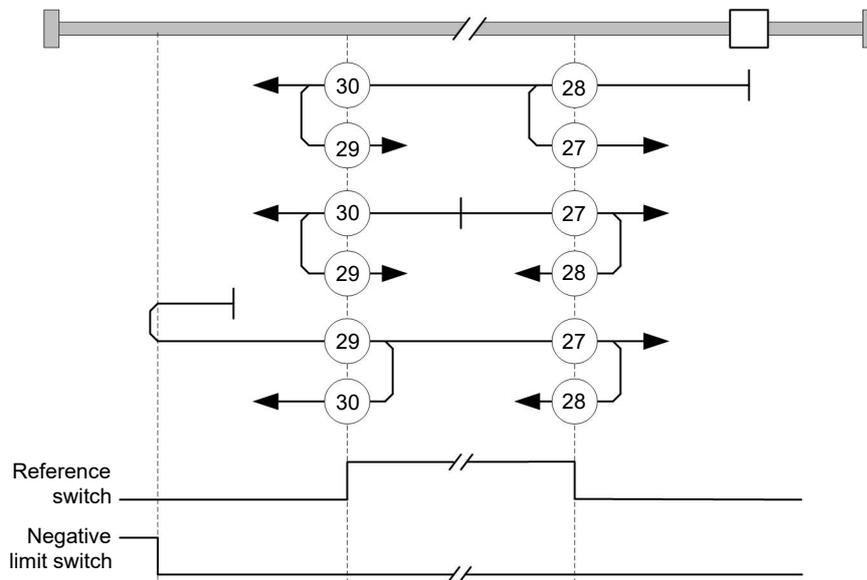
Methods 33 and 34

Reference to the next index pulse.

With these methods referencing is only performed to the respective subsequent index pulse:
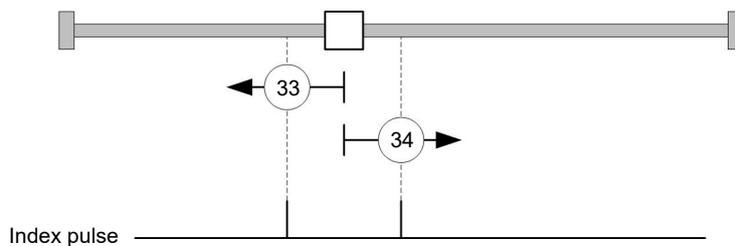
Method 35

References to the current position.

> **Note**
>
> For Homing Mode 35, it is not necessary to switch the **CiA 402 Power State Machine** to the "Operation enabled" state. When energizing the motor windings in *open loop* mode, it is thereby possible to prevent the current position from not being exactly 0 after Homing Mode 35.

6.6 Interpolated Position Mode

6.6.1 Overview

Description

Interpolated Position Mode is used to synchronize multiple axes. For this purpose, a higher-level controller performs the ramp and path calculation and passes the respective demand position, at which the axis is to be located at a certain time, to the controller. The controller interpolates between these intermediate position points.

> **Note**
>
> The limit switches and, thus, the tolerance bands are active in this mode. For further information on the limit switches, see **Limitation of the range of motion**.

Synchronization with the SYNC object

For Interpolated Position Mode, it is necessary that the controller synchronizes with the SYNC object (depending on the fieldbus). This SYNC object is to be sent by the higher-level controller in regular intervals. Synchronization occurs as soon as the controller is switched to the *Operational* NMT mode.

> **Note**
>
> Where possible, it is recommended that a time interval of the *SYNC object* be used.

6.6.2 Activation

To activate the mode, the value "7" must be set in object **6060**$_h$ (Modes Of Operation) (see "**CiA 402 Power State Machine**").

6.6.3 Controlword

The following bits in object **6040**$_h$ (controlword) have a special function:

- Bit 4 activates the interpolation when it is set to "1".
- Bit 8 (Halt): If this bit is set to "1", the motor stops. On a transition from "1" to "0", the motor accelerates with the set start ramp to the target speed. On a transition from "0" to "1", the motor brakes and comes to a standstill. The braking deceleration is dependent here on the setting of the "Halt Option Code" in object **605D**$_h$.

6.6.4 Statusword

The following bits in object **6041**$_h$ (statusword) have a special function:

- Bit 10: Target position reached: This bit is set to "1" if the target position was reached (if the halt bit in the controlword is "0") or the axis has speed 0 (if the halt bit in the last control word was "1").
- Bit 12 (IP mode active): This bit is set to "1" if interpolation is active.

6.6.5 Use

The controller follows a linearly interpolated path between the current position and the preset target position. The (next) target position must be written in record **60C1**$_h$:01$_h$.
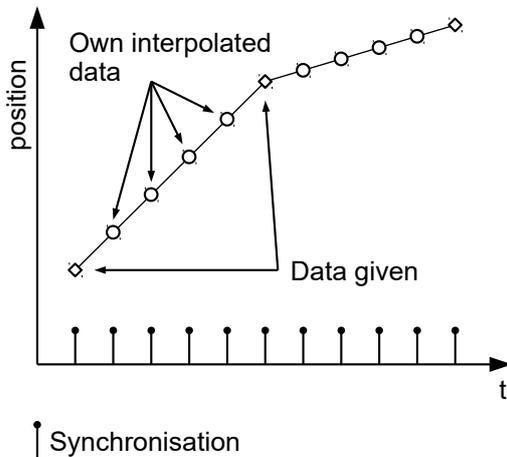
In the current implementation, only

• linear interpolation
• and a target position

are supported.

6.6.6 Setup

The following setup is necessary:

• **60C2**$_h$:01$_h$: Time between two passed target positions in ms.
• **60C4**$_h$:06$_h$: This object is to be set to "1" to be able to modify the target position in object **60C1**$_h$:01$_h$.
• **6081**$_h$ (Profile Velocity): Maximum speed with which the position is to be approached
• The speed is is limited by **607F**$_h$ (Max Profile Velocity) and **6080**$_h$ (Max Motor Speed); the smaller value is used as the limit.
• To be able to turn the motor, the *power state machine* is to be set to the *Operation enabled* state (see **CiA 402 Power State Machine**)

6.6.7 Operation

After setting up, the task of the higher-level controller is to write the target positions to object **60C1**$_h$:01$_h$ in time.

6.7 Cyclic Synchronous Position

6.7.1 Overview

Description

In this mode, the controller receives an absolute position preset via the fieldbus at fixed time intervals (referred to in the following as a *cycle*). The controller then no longer calculates any ramps, but rather only follows the presets.

The target position is transferred cyclically (via *PDO*). Bit 4 in the controlword does not need to be set (unlike the **Profile Position** mode).

> ℹ️
> | **Note** |
> |---|
> The target is absolute and, thus, independent of how often it was sent per *cycle*.

> ℹ️
> | **Note** |
> |---|
> The limit switches and, thus, the tolerance bands are active in this mode. For further information on the limit switches, see **Limitation of the range of motion**.

Activation

To activate the mode, the value "8" must be set in object **6060**$_h$ (Modes Of Operation) (see "**CiA 402 Power State Machine**").

Controlword

In this mode, the bits of controlword **6040**$_h$ have no special function.

Statusword

The following bits in object **6041**$_h$ (statusword) have a special function:

Bit	Value	Description
8	0	The controller is not in sync with the fieldbus
8	1	The controller is in sync with the fieldbus
10	0	Reserved
10	1	Reserved
12	0	Controller does not follow the target; the preset of **607A**$_h$ (Target Position) is ignored
12	1	Controller follows the target; object **607A**$_h$ (Target Position) is used as the input for position control.
13	0	No following error
13	1	Following error

Bit 11: Limit exceeded: The demand position is above or below the limit values set in **607D**$_h$.

6.7.2 Object entries

The following objects are necessary for controlling this mode:

- **607A**$_h$ (Target Position): This object must be written cyclically with the position set value.
- **607B**$_h$ (Position Range Limit): This object contains the preset for an overrun or underrun of the position specification.
- **607D**$_h$ (Software Position Limit): This object defines the limitations within which the position specification (607A$_h$) must be located.
- **6065**$_h$ (Following Error Window): This object specifies a tolerance corridor in both the positive and negative direction from the set specification. If the actual position is outside of this corridor for longer than the specified time (**6066**$_h$), a following error is reported.
- **6066**$_h$ (Following Error Time Out): This object specifies the time range in milliseconds. If the actual position is outside of the position corridor (**6065**$_h$) for longer than this time range, a following error is triggered.
- **6085**$_h$ (Quick-Stop Deceleration): This object contains the braking deceleration for the case that a quick-stop is triggered.

- **605A**$_h$ (Quick-Stop Option Code): This object contains the option that is to be executed in the event of a quick-stop.
- **6080**$_h$ (Max Motor Speed): Maximum speed
- **60C2**$_h$:01$_h$ (Interpolation Time Period): This object specifies the time of a *cycle*; a new set value must be written in **607A**$_h$ in these time intervals.
  The following applies here: cycle time = value of **60C2**$_h$:01$_h$ * 10$^{\text{value of 60C2:02}}$ seconds.
- **60C2**$_h$:02$_h$ (Interpolation Time Index): This object specifies the time basis of the cycles. Currently, only value **60C2**$_h$:02$_h$=-3 is supported; this yields a time basis of 1 millisecond.

The following objects can be read in this mode:

- **6064**$_h$ (Position Actual Value)
- **606C**$_h$ (Velocity Actual Value)
- **60F4**$_h$ (Following Error Actual Value)

6.8 Cyclic Synchronous Velocity

6.8.1 Overview

Description

In this mode, the controller passes a speed preset via the fieldbus at fixed time intervals (referred to in the following as a *cycle*). The controller then no longer calculates any ramps, but rather only follows the presets.

ℹ	**Note**
	The limit switches and, thus, the tolerance bands are active in this mode. For further information on the limit switches, see **Limitation of the range of motion**.

Activation

To activate the mode, the value "9" must be set in object **6060**$_h$ (Modes Of Operation) (see "**CiA 402 Power State Machine**").

Controlword

In this mode, the bits of controlword **6040**$_h$ have no special function.

Statusword

The following bits in object **6041**$_h$ (statusword) have a special function:

Bit	Value	Description
8	0	The controller is not in sync with the fieldbus
8	1	The controller is in sync with the fieldbus
10	0	Reserved
10	1	Reserved
12	0	Controller does not follow the target; the preset of **60FF**$_h$ (Target Velocity) is ignored
12	1	Controller follows the target; object **60FF**$_h$ (Target Velocity) is used as the input for position control.
13	0	Reserved
13	1	Reserved

6.8.2 Object entries

The following objects are necessary for controlling this mode:

- **60FF**$_h$ (Target Velocity): This object must be written cyclically with the speed set value.
- **6085**$_h$ (Quick-Stop Deceleration): This object contains the braking deceleration for the case that a quick-stop is triggered (see "**CiA 402 Power State Machine**").
- **605A**$_h$ (Quick-Stop Option Code): This object contains the option that is to be executed in the event of a quick-stop (see "**CiA 402 Power State Machine**").
- **6080**$_h$ (Max Motor Speed): Maximum speed
- **60C2**$_h$:01$_h$ (Interpolation Time Period): This object specifies the time of a *cycle*; a new set value must be written in **60FF**$_h$ in these time intervals.
  The following applies here: cycle time = value of **60C2**$_h$:01$_h$ * 10$^{\text{value of 60C2:02}}$ seconds.
- **60C2**$_h$:02$_h$ (Interpolation Time Index): This object specifies the time basis of the cycles. Currently, only value **60C2**$_h$:02$_h$=-3 is supported; this yields a time basis of 1 millisecond.

The following objects can be read in this mode:

- **606C**$_h$ (Velocity Actual Value)
- **607E**$_h$ (Polarity)

6.9 Cyclic Synchronous Torque

6.9.1 Overview

Description

In this mode, the controller passes an absolute torque preset via the fieldbus at fixed time intervals (referred to in the following as a *cycle*). The controller then no longer calculates any ramps, but rather only follows the presets.

	Note
ⓘ	This mode only functions if **closed loop** is activated, see also **Commissioning closed loop**.

	Note
ⓘ	The limit switches and, thus, the tolerance bands are active in this mode. For further information on the limit switches, see **Limitation of the range of motion**.

Activation

To activate the mode, the value "10" must be set in object **6060**$_h$ (Modes Of Operation) (see "**CiA 402 Power State Machine**").

Controlword

In this mode, the bits of controlword **6040**$_h$ have no special function.

Statusword

The following bits in object **6041**$_h$ (statusword) have a special function:

Bit	Value	Description
8	0	The controller is not in sync with the fieldbus
8	1	The controller is in sync with the fieldbus

Bit	Value	Description
10	0	Reserved
10	1	Reserved
12	0	Controller does not follow the target; the preset of 6071_h (Target Torque) is ignored
12	1	Controller follows the target; object 6071_h (Target Torque) is used as the input for position control.
13	0	Reserved
13	1	Reserved

6.9.2 Object entries

The following objects are necessary for controlling this mode:

- 6071_h (Target Torque): This object must be written cyclically with the torque set value and is to be set relative to 6072_h.
- 6072_h (Max Torque): Describes the maximum permissible torque.
- 6080_h (Max Motor Speed): Maximum speed
- $60C2_h$:01_h (Interpolation Time Period): This object specifies the time of a *cycle*; a new set value must be written in $60FF_h$ in these time intervals.
  The following applies here: cycle time = value of $60C2_h$:01_h * $10^{\text{value of 60C2:02}}$ seconds.
- $60C2_h$:02_h (Interpolation Time Index): This object specifies the time basis of the cycles. Currently, only value $60C2_h$:02_h=-3 is supported; this yields a time basis of 1 millisecond.

The following objects can be read in this mode:

- $606C_h$ (Velocity Actual Value)
- 6074_h (Torque Demand)

6.10 Clock-direction mode

6.10.1 Description

In clock-direction mode, the motor is operated via two inputs by a higher-level positioning controller with clock and direction signal. On each clock signal, the motor moves one step in the direction corresponding to the direction signal.

ⓘ
Note

The limit switches and, thus, the tolerance bands are active in this mode. For further information on the limit switches, see **Limitation of the range of motion**.

6.10.2 Activation

To activate the mode, the value "-1" (or "FFh") must be set in object 6060_h (Modes Of Operation) (see "**CiA 402 Power State Machine**").

6.10.3 General

The following data apply for every subtype of the clock-direction mode:

- The maximum frequency of the input pulse is 1 MHz; the ON pulse should not be less than 200 ns.
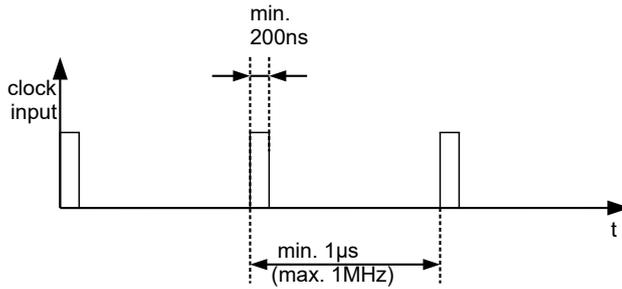
- The steps are scaled using objects 2057_h and 2058_h. The following formula applies here:

$$\text{step width per pulse} = \frac{2057_h}{2058_h}$$

The "step size per pulse" value is set to 128 (2057_h=128 and 2058_h=1) ex works, which corresponds to a quarter step per pulse. A full step is the value "512", a half step per pulse corresponds to "256", etc.

Note

For a stepper motor with 50 pole pairs, 200 full steps correspond to one mechanical revolution of the motor shaft.
In *clock-direction mode*, the BLDC motors are also handled as stepper motors by the controller. This means that for a BLDC motor with, e.g., 3 pole pairs, 12 (=4*3) full steps correspond to one revolution.

Note

If there is a change of direction, a time of at least 35 µs must elapse before the new clock signal is applied.

6.10.4 Statusword

The following bits in object 6041_h (statusword) have a special function:

- Bit 13 (Following Error): This bit is set in *closed loop* mode if the following error is greater than the set limits (6065_h (Following Error Window) and 6066_h (Following Error Time Out)).

6.10.5 Subtypes of the clock-direction mode

Clock-direction mode (TR mode)

To activate the mode, object $205B_h$ must be set to the value "0" (factory settings).

In this mode, the pulses must be preset via the clock input; the signal of the direction input specifies the direction of rotation here (see following graphic).
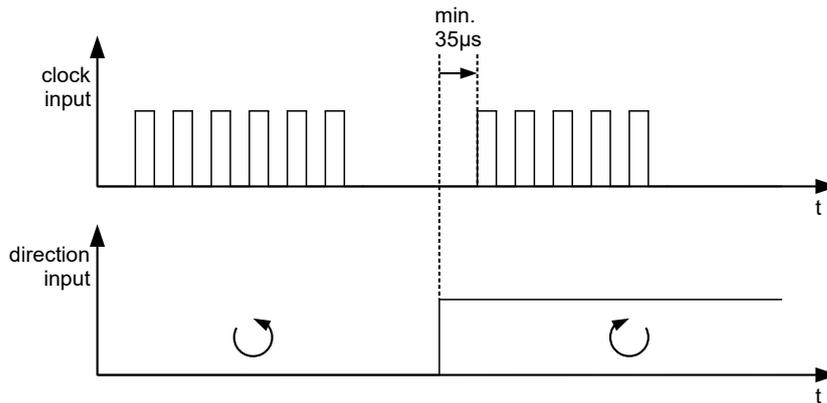
Right / left rotation mode (CW / CCW mode)

To activate the mode, object **205B**$_h$ must be set to the value "1".

In this mode, the input that is used decides the direction of rotation (see following graphic).
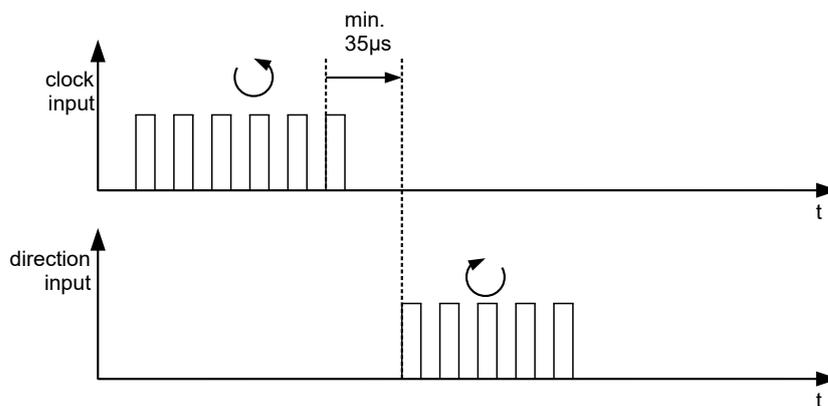
6.11 Auto setup

6.11.1 Description

To determine a number of parameters related to the motor and the connected sensors (encoders/Hall sensors), an *auto setup* is performed. **Closed Loop** operation requires a successfully completed *auto setup*. *Auto setup* is only to be performed once during commissioning as long as the motor/sensor connected to the controller is not changed. For details, see **the corresponding section in chapter Commissioning**.

> ⓘ
> **Note**
>
> The limit switches and, thus, the tolerance bands are active in this mode. For further information on the limit switches, see **Limitation of the range of motion**.

6.11.2 Activation

To activate the mode, the value "-2" (="FE$_h$") must be set in object **6060**$_h$ (Modes Of Operation) (see **CiA 402 Power State Machine**).

6.11.3 Controlword

The following bits in object **6040**$_h$ (controlword) have a special function:

- Bit 4 starts a travel command. This is carried out on a transition from "0" to "1".

6.11.4 Statusword

The following bits in object **6041**$_h$ (statusword) have a special function:

- Bit 10: Indexed: indicates whether (= "1") or not (= "0") an encoder index was found.
- Bit 12: Aligned: this bit is set to "1" after *auto setup* has concluded

7 Special functions

7.1 Digital inputs and outputs

7.1.1 Bit assignment

The software of the controller assigns each input and output two bits in the respective object (e.g., **60FDh Digital Inputs** or **60FEh Digital Outputs**):

1. The first bit corresponds to the special function of an output or input. These functions are always available on bits 0 to 15 (inclusive) of the respective object. These include the limit switches and the home switch for the digital inputs and the brake control for the outputs.
2. The second bit shows the output/input as a level; these are then available on bits 16 to 31.

Example

To manipulate the value of output 2, always use bit 17 in **60FE$_h$**.

To activate the "negative limit switch" special function of input 1, set bit 0 in **3240$_h$**:01$_h$; to query the status of the input, read bit 0 in **60FD$_h$**. Bit 16 in **60FD$_h$** also shows the status of input 1 (independent of whether or not the special function of the input was activated).

This assignment is graphically illustrated in the following drawing.

Bits of any object for controlling inputs
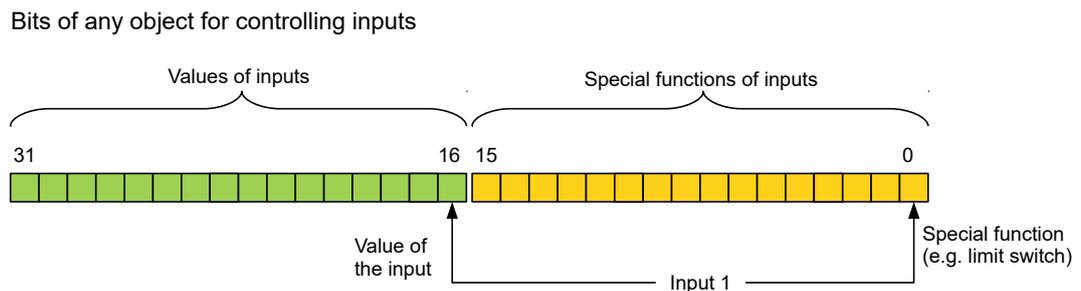
7.1.2 Digital inputs

Overview

> **Note**
>
> For digital inputs with 5 V, the length of the supply lines must not exceed 3 meters.

> **Note**
>
> The digital inputs are sampled once per millisecond. Signal changes at the input less than one millisecond in duration are not processed.

The following inputs are available:

Input	Special function	Switching threshold switchable	Differential / single-ended
1	Negative limit switch	yes, 5 V or 24 V (see 3240_h:06_h)	single-ended
2	Positive limit switch	yes, 5 V or 24 V (see 3240_h:06_h)	single-ended
3	Home switch / direction input in clock-direction mode	yes, 5 V or 24 V (see 3240_h:06_h)	single-ended
4	Clock input in clock-direction mode	yes, 5 V or 24 V (see 3240_h:06_h)	single-ended
5	None	no, 5 V to 24 V wide range input	single-ended
6	None	no, 5 V to 24 V wide range input	single-ended

Object entries

The value of an input can be manipulated using the following OD settings, whereby only the corresponding bit acts on the input here.

- **3240_h:01_h** (Special Function Enable): This bit allows special functions of an input to be switched off (value "0") or on (value "1"). If input 1 is not used as, e.g., a negative limit switch, the special function must be switched off to prevent an erroneous response to the signal generator. The object has no effect on bits 16 to 31.
  The firmware evaluates the following bits:

  - Bit 0: Negative limit switch
  - Bit 1: Positive limit switch
  - Bit 2: Home switch

  If, for example, two limit switches and one home switch are used, bits 0–2 in **3240_h:01_h** must be set to "1".
- **3240_h:02_h** (Function Inverted): This subindex switches from normally open logic (a logical high level at the input yields the value "1" in object **$60FD_h$**) to normally closed logic (the logical high level at the input yields the value "0").
  This applies for the special functions (except for the clock and direction inputs) and for the normal inputs. If the bit has the value "0", normally open logic applies; for the value "1", normally closed logic applies. Bit 0 changes the logic of input 1, bit 1 changes the logic of input 2, etc.
- **3240_h:03_h** (Force Enable): This subindex switches on the software simulation of input values if the corresponding bit is set to "1".
  In this case, the actual values are no longer used in object **3240_h:04_h**, but rather the set values for the respective input. Bit 0 corresponds to input 1 here, bit 1 to input 2, etc.
- **3240_h:04_h** (Force Value): This bit specifies the value that is to be read as the input value if the same bit was set in object **3240_h:03_h**.
- **3240_h:05_h** (Raw Value): This object contains the unmodified input value.
- **3240_h:06_h** (Input Range Select): This can be used to switch inputs – that are equipped with this function – from the switching threshold of 5 V (bit is "0") to the switching threshold of 24 V (bit is "1"). Bit 0 corresponds to input 1 here, bit 1 to input 2, etc.
- **$60FD_h$** (Digital Inputs): This object contains a summary of the inputs and the special functions.

Computation of the inputs

Computation of the input signal using the example of input 1:

The value at bit 0 of object **$60FD_h$** is interpreted by the firmware as negative limit switch; the result of the complete computation is stored in bit 16.
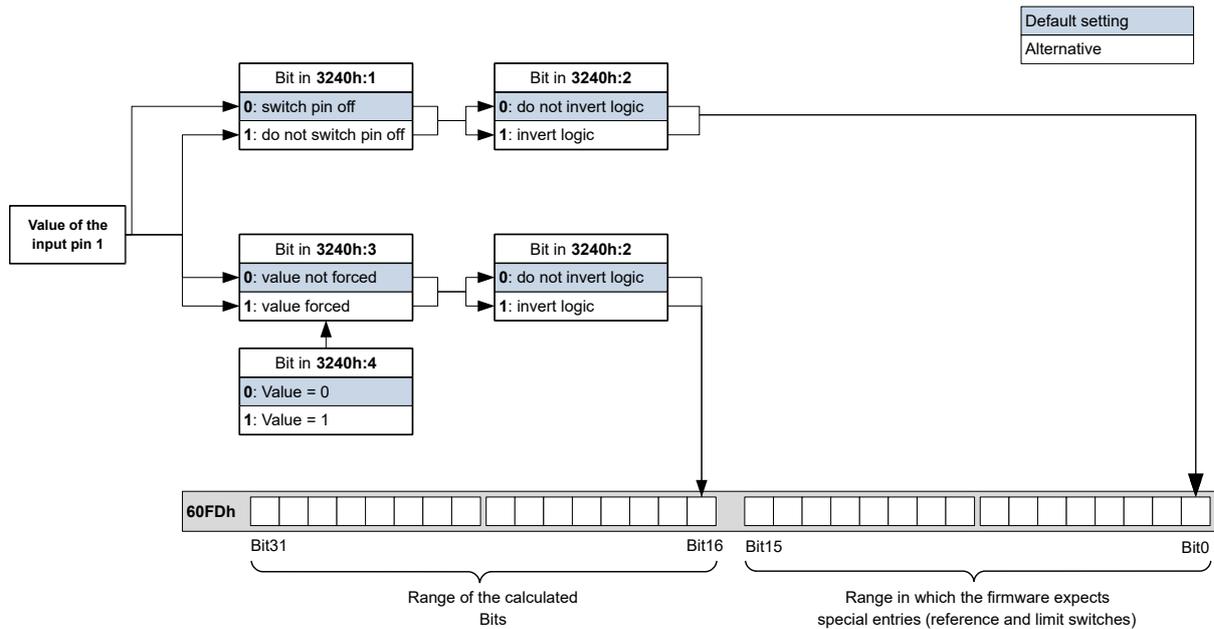
Input Routing

Principle

To perform the assignment of the inputs more flexibly, there is a mode called *Input Routing Mode*. This assigns a signal of a source to a bit in object **60FD**$_h$.
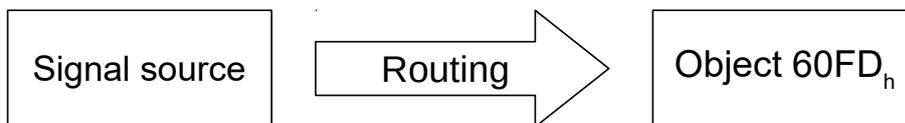
Activation

This mode is activated by setting object **3240**$_h$:**08**$_h$ (Routing Enable) to 1.

> ⓘ **Note**
>
> Entries **3240**$_h$:01$_h$ to **3240**:04$_h$ then have **no** function until Input Routing is again switched off.

> ⓘ **Note**
>
> If *Input Routing* is switched on, the initial values of **3242**$_h$ are changed and correspond to the function of the input as it was before activation of *Input Routing*. The inputs of the controller behave the same with activation of *Input Routing*. Therefore, you should not switch back and forth between the normal mode and *Input Routing*.

Routing

Object 3242$_h$ determines which signal source is routed to which bit of **60FD**$_h$. Subindex 01$_h$ of 3242$_h$ determines bit 0, subindex 02$_h$ determines bit 1, and so forth. You can find the signal sources and their numbers in the following lists.

Number		
dec	hex	Signal source
00	00	Signal is always 0
01	01	Physical input 1
02	02	Physical input 2
03	03	Physical input 3
04	04	Physical input 4
05	05	Physical input 5
06	06	Physical input 6
07	07	Physical input 7
08	08	Physical input 8
09	09	Physical input 9
10	0A	Physical input 10
11	0B	Physical input 11
12	0C	Physical input 12
13	0D	Physical input 13
14	0E	Physical input 14
15	0F	Physical input 15
16	10	Physical input 16
65	41	Hall input "U"
66	42	Hall input "V"
67	43	Hall input "W"
68	44	Encoder input "A"
69	45	Encoder input "B"
70	46	Encoder input "Index"
72	48	"Ethernet active" status

The following table describes the inverted signals of the previous table.

Number		
dec	hex	Signal source
128	80	Signal is always 1
129	81	Inverted physical input 1
130	82	Inverted physical input 2
131	83	Inverted physical input 3
132	84	Inverted physical input 4
133	85	Inverted physical input 5
134	86	Inverted physical input 6
135	87	Inverted physical input 7
136	88	Inverted physical input 8
137	89	Inverted physical input 9
138	8A	Inverted physical input 10
139	8B	Inverted physical input 11
140	8C	Inverted physical input 12
141	8D	Inverted physical input 13
142	8E	Inverted physical input 14

Number		
dec	hex	Signal source
143	8F	Inverted physical input 15
144	90	Inverted physical input 16
193	C1	Inverted Hall input "U"
194	C2	Inverted Hall input "V"
195	C3	Inverted Hall input "W"
196	C4	Inverted encoder input "A"
197	C5	Inverted encoder input "B"
198	C6	Inverted encoder input "Index"
200	C8	"Ethernet active" inverted status

Example

Input 1 is to be routed to bit 16 of object **60FD**$_h$:

The number of the signal source for input 1 is "1". The routing for bit 16 is written in 3242_h:11_h.

Hence, object 3242_h:11_h must be set to the value "1".

7.1.3 Digital outputs

Outputs

The outputs are controlled via object **60FE**$_h$. Here, output 1 corresponds to bit 16 in object **60FE**$_h$, output 2 corresponds to bit 17, etc., as with the inputs. The outputs with special functions are again entered in the firmware in the lower bits 0 to 15. The only bit assigned at the present time is bit 0, which controls the motor brake.

Wiring

Note
Always observe the maximum capacity of the output (see **Pin configuration**).

The outputs are implemented as "open drain". Hence, an external voltage supply is always necessary.

Example

The digital output signal should continue to be used. For this purpose, a circuit as shown in the following figure is to be realized.
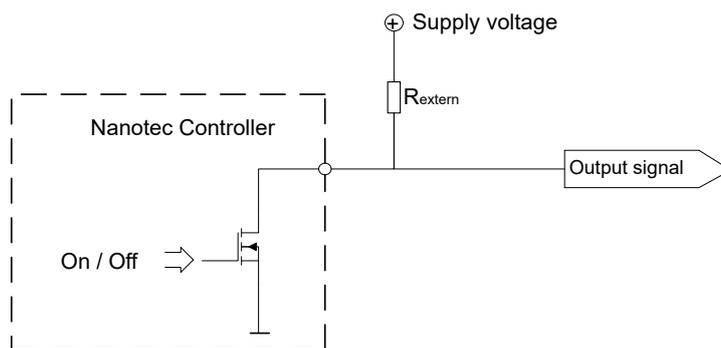
With a supply voltage of +24 V, a resistance value $R_{external}$ of 10 kΩ is recommended.

Example

A simple load is to be used with the digital output.
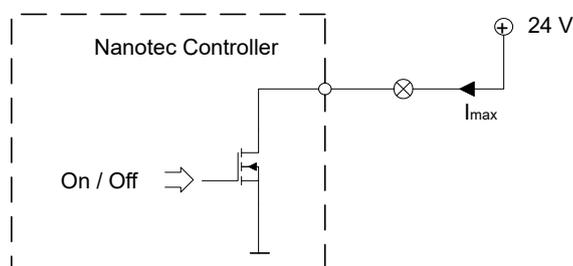
Object entries

Additional OD entries are available for manipulating the value of the outputs (see the following example for further information). As with the inputs, only the bit at the corresponding location acts on the respective output:

- **3250**$_h$:01$_h$: No function.
- **3250**$_h$:02$_h$: This is used to switch the logic from *normally open* to *normally closed*. Configured as *normally open*, the input outputs a logical high level if the bit is "1". With the *normally closed* configuration, a logical low level is output accordingly for a "1" in object **60FE**$_h$.
- **3250**$_h$:03$_h$: If a bit is set here, the output is controlled manually. The value for the output is then in object **3250**$_h$:4$_h$; this is also possible for the brake output.
- **3250**$_h$:04$_h$: The bits in this object specify the output value that is to be applied at the output if manual control of the output is activated by means of object **3250**$_h$:03$_h$.
- **3250**$_h$:05$_h$: This object has no function and is included for reasons of compatibility.

Computation of the outputs

Example for calculating the bits of the outputs:
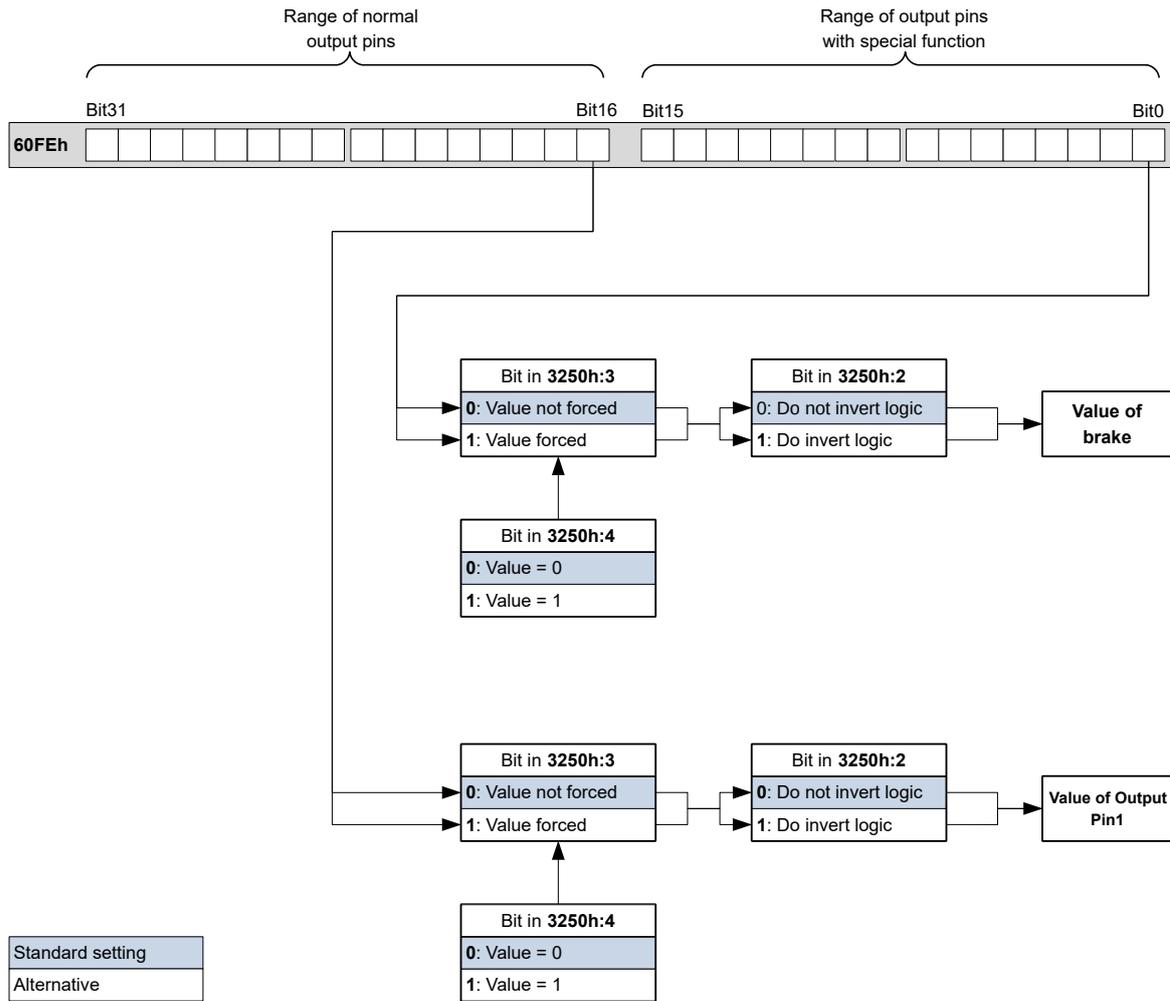
Output Routing

Principle

The "Output Routing Mode" assigns an output a signal source; a control bit in object **60FE**$_h$:01$_h$ switches the signal on or off.

The source is selected with **3252**$_h$:01 to 05 in the "high byte" (bit 15 to bit 8). The assignment of a control bit from object **60FE**$_h$:01$_h$ is performed in the "low byte" (bit 7 to bit 0) of **3252**$_h$:01$_h$ to 05 (see following figure).
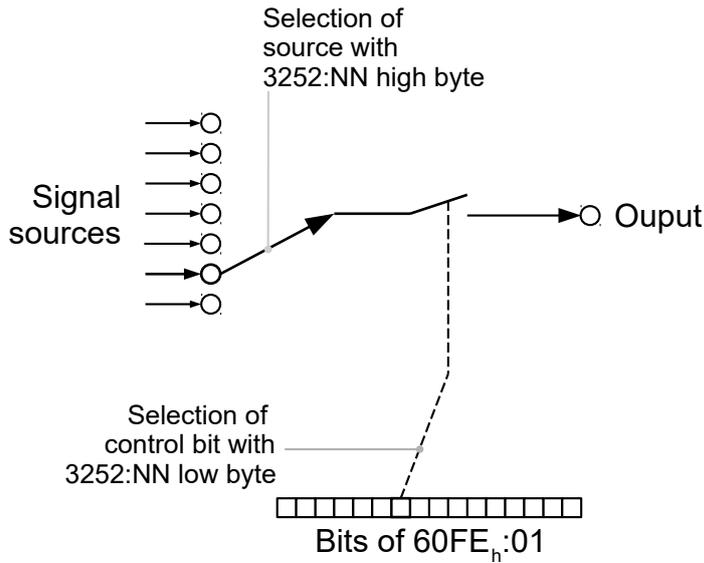
Activation

This mode is activated by setting object 3250_h:08_h (Routing Enable) to 1.

> **(i)** **Note**
>
> Entries 3250_h:01_h to 3250:04_h then have **no** function until "Output Routing" is switched off again.

Routing

The subindex of object 3252_h determines which signal source is routed to which output. The output assignments are listed in the following:

Subindex 3252_h	Output Pin
01_h	Configuration of PWM output (if available)
02_h	Configuration of output 1
03_h	Configuration of output 2 (if available)
04_h	Configuration of output 3 (if available)
05_h	Configuration of output 4 (if available)

> **(i)** **Note**
>
> The maximum output frequency of output 1 and output 2 is 10 kHz; of the PWM output it is 2 kHz. All other outputs can only produce signals up to 500 Hz.

Subindices 3252_h:01_h to 05_h are 16 bits wide, whereby the high byte selects the signal source (e.g., the PWM generator) and the low byte determines the control bit in object $60FE_h$:01.

Bit 7 of 3252_h:01_h to 05 inverts the controller from object $60FE_h$:01. Normally, value "1" in object $60FE_h$:01 switches on the signal; if bit 7 is set, the value "0" switches on the signal.

Number in 3252:01 to 05	
$00XX_h$	Output is always "1"

Number in 3252:01 to 05	
$01XX_h$	Output is always "0"
$02XX_h$	Encoder signal (6063_h) with frequency divider 1
$03XX_h$	Encoder signal (6063_h) with frequency divider 2
$04XX_h$	Encoder signal (6063_h) with frequency divider 4
$05XX_h$	Encoder signal (6063_h) with frequency divider 8
$06XX_h$	Encoder signal (6063_h) with frequency divider 16
$07XX_h$	Encoder signal (6063_h) with frequency divider 32
$08XX_h$	Encoder signal (6063_h) with frequency divider 64
$09XX_h$	Position Actual Value (6064_h) with frequency divider 1
$0AXX_h$	Position Actual Value (6064_h) with frequency divider 2
$0BXX_h$	Position Actual Value (6064_h) with frequency divider 4
$0CXX_h$	Position Actual Value (6064_h) with frequency divider 8
$0DXX_h$	Position Actual Value (6064_h) with frequency divider 16
$0EXX_h$	Position Actual Value (6064_h) with frequency divider 32
$0FXX_h$	Position Actual Value (6064_h) with frequency divider 64
$10XX_h$	PWM signal that is configured with object 2038_h:05_h and 06_h
$11XX_h$	Inverted PWM signal that is configured with object 2038_h:05_h and 06_h

Example

The encoder signal (6063_h) is to be applied to output 1 with a frequency divider 4. The output is to be controlled with bit 5 of object **60FE**:01.

- **3250_h**:08_h = 1 (activate routing)
- **3252_h**:02_h = 0405_h ($04XX_h$ + 0005_h) Dabei ist:
- $04XX_h$: Encoder signal with frequency divider 4
- 0005_h: Selection of bit 5 of **60FE**:01

The output is switched on by setting bit 5 in object **60FE**:01.

Example

The brake PWM signal is to be applied to output 2. Because the automatic brake control uses bit 0 of **60FE**:01_h, this should be used as control bit.

- **3250_h**:08_h = 1 (activate routing)
- **3252_h**:03_h = 1080_h (=$10XX_h$ + 0080_h). Where:
  - $10XX_h$: Brake PWM signal
  - 0080_h: Selection of the inverted bit 0 of object **60FE**:01

7.2 Automatic brake control

7.2.1 Description

Automatic brake control is activated if the controller is switched to the *Operation enabled* state of the **CiA 402 Power State Machine**; the brake otherwise always remains closed.

The brake output of the controller results in a PWM signal that can be adjusted with respect to frequency and duty cycle.

For information on the interaction of the brake with the motor stopping behavior, see also chapter **Power State machine – halt motion reactions**.

7.2.2 Activation and connection

The brake can be controlled either automatically or manually:

- Automatic: Setting bit 2 of object **3202**$_h$ to "1" activates the brake control.
- Manual: Setting bit 2 of object **3202**$_h$ to "0" deactivates the brake control; the brake can now be controlled with bit 0 in object **60FE**$_h$:01$_h$.

Connection

The brake output is located on connector X4 (see chapter **Connector X4 – brake connection**)

7.2.3 Brake control

The following graphic shows the states of the **CiA 402 Power State Machine** together with the states of the brake for the automatic mode.

The following steps are performed on the transition, which is marked with 1:

1. The motor current is switched on.
2. The time stored in **2038**$_h$:3$_h$ is allowed to elapse.
3. The brake releases.
4. The time stored in **2038**$_h$:4$_h$ is allowed to elapse.
5. The *Operation enabled* state is reached, the motor controller can perform travel commands.

The following steps are performed on all transitions that are marked with 2:

1. The motor is brought to a standstill.
2. The time stored in **2038**$_h$:1$_h$ is allowed to elapse.
3. The brake is activated.
4. The time stored in **2038**$_h$:2$_h$ is allowed to elapse.
5. The motor current is switched off.

7.2.4 Brake PWM

The switched-on brake generates a PWM signal at the output of the controller that can be adjusted with respect to duty cycle and frequency. If an output pin without PWM is needed, a duty cycle of 100 percent can be set.

Note
The *Brake +* pin of the brake output is connected to the voltage supply of the controller.
If the operating voltage of the brake is greater than the supply voltage of the controller, you cannot use the brake output of the controller; you must supply the brake externally.
If the supply voltage of the controller is greater than the operating voltage of the brake (and up to 48 V DC), it is recommended that the PWM controller from Nanotec with order designation *EB-BRAKE-48V* be used and the duty cycle of the controller brake output be set to "100".

Frequency

The frequency of the brake PWM can be set in object **2038**$_h$:5$_h$. The unit is Hertz; a value greater than 2000 is not possible.

Note
If the PWM signal of the brake causes interfering noise, it can be eliminated by connecting a 47 µF … 100 µF capacitor in parallel at the brake output.

Duty cycle

The duty cycle – the ratio of pulse to period duration – is set in **2038**$_h$:6$_h$. The value is a percentage and can be selected between 2 and 100. With a value of 100, the output pin is permanently switched on.

In the following figure, example duty cycles of 25 and 50 percent are shown, whereby the frequency is held constant.

Duty cycle 25%

Output voltage

2038h:6
=25

t

Duty cycle 50%

Output voltage

2038h:6=50

t
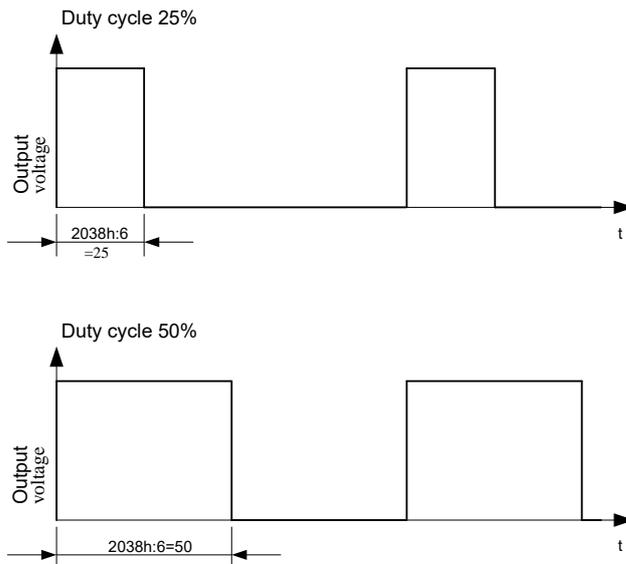
7.3 I^{2}t Motor overload protection

7.3.1 Description

> **Note**
>
> For stepper motors, only the rated current is specified, not a maximum current. No liability is therefore assumed when using I^{2}t with stepper motors.

The goal of I^{2}t motor overload protection is to protect the motor from damage and, at the same time, operate it normally up to its thermal limit.

This function is only available if the controller is in the **closed loop mode** (bit 0 of object **3202**$_h$ must be set to "1").

There is an exception: If I^{2}t is activated in *open loop* mode, the current is limited to the set rated current, even if the set maximum current is larger. This function was implemented for safety reasons so that one can switch from *closed loop* mode with very high, brief maximum current to *open loop* mode without damaging the motor.

7.3.2 Object entries

The following objects affect I^{2}t motor overload protection:

- **2031**$_h$: Peak Current – specifies the maximum current in mA.
- **203B**$_h$:1$_h$ Nominal Current – specifies the rated current in mA.
- **203B**$_h$:2$_h$ Maximum Duration Of Peak Current – specifies the maximum duration of the maximum current in ms.

The following objects indicate the current state of I^{2}t:

- **203B**$_h$:3$_h$ Threshold – specifies the limit in mAs that determines whether the maximum current or rated current is switched to.
- **203B**$_h$:4$_h$ CalcValue – specifies the calculated value that is compared with the threshold for setting the current.
- **203B**$_h$:5$_h$ LimitedCurrent – shows the momentary current value that was set by I^{2}t.
- **203B**$_h$:6$_h$ Status:
  - Value = "0": I^{2}t deactivated
  - Value = "1": I^{2}t activated

7.3.3 Activation

Closed loop must be activated, (bit 0 of object **3202**$_h$ set to "1", see also chapter **Closed Loop**). To activate the mode, the three object entries mentioned above (**2031**$_h$, **203B**$_h$:1$_h$, **203B**$_h$:2$_h$) must have been appropriately specified. This means that the maximum current must be greater than the rated current and a time value for the maximum duration of the maximum current must be entered. If these conditions are not met, the I^{2}t functionality remains deactivated.

7.3.4 Function of I^{2}t

From the specification of rated current, maximum current and maximum duration of the maximum current, an I^{2}t$_{Lim}$ is calculated.

The motor can run with maximum current until the calculated I^{2}t$_{Lim}$ is reached. The current is then immediately reduced to the rated current.

The relationships are illustrated again in the following diagram.
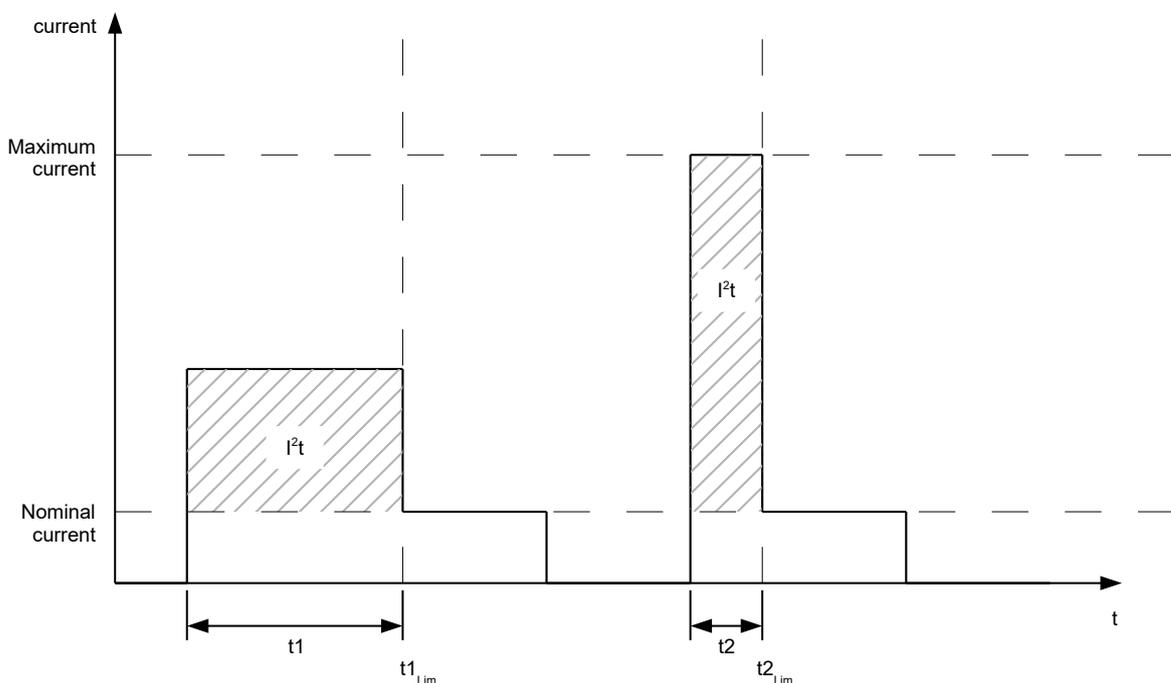
In the first section, t1, the current value is higher than the rated current. At time t1$_{Lim}$, I^{2}t$_{Lim}$ is reached and the current is limited to the rated current. A current that corresponds to the maximum current then occurs for a period of time t2. Hence, the value for I^{2}t$_{Lim}$ is reached more quickly than in time t1.

7.4 Saving objects

ⓘ	**Note**
	Improper use of the function can result in it no longer being possible to start the controller. Therefore, carefully read the entire chapter before using the function.

7.4.1 General

Many objects in the object dictionary can be saved and then automatically reloaded the next time the controller is switched on or reset. Furthermore, the saved values are also retained following a firmware update.

Only entire collections of objects (referred to in the following as *categories*) can be saved together; individual objects cannot be saved.

An object can be assigned one of the following *categories*:

- Communication: Parameters related to external interfaces, such as PDO configuration etc.
- Application: Parameters related to operating modes.
- Cutsomer: Parameters that are written and read by the customer/user only and are ignored by the controller firmware.
- Drive: Parameters related to the motor and the sensors (BLDC/Stepper, *Closed/Open Loop…*). Some are set and saved by auto setup.
- Tuning: Parameters related to motor and encoder that are set either by auto setup or that can be found in the data sheets, e.g., pole pairs and maximum current.
- Modbus RTU: Parameters related to Modbus RTU communication
- Ethernet: Parameters related to Ethernet communication

If an object is not assigned one of these *categories*, it cannot be saved, e.g., statusword and all objects whose value is dependent on the current state of the controller.

The objects in each *category* are listed below. In chapter **Description of the object dictionary**, the corresponding *category* for each object is also specified.

7.4.2 Category: communication

- **2102$_h$**: Fieldbus Module Control
- **3502$_h$**: MODBUS Rx PDO Mapping
- **3602$_h$**: MODBUS Tx PDO Mapping

7.4.3 Category: application

- **2034$_h$**: Upper Voltage Warning Level
- **2035$_h$**: Lower Voltage Warning Level
- **2036$_h$**: Open Loop Current Reduction Idle Time
- **2037$_h$**: Open Loop Current Reduction Value/factor
- **2038$_h$**: Brake Controller Timing
- **203A$_h$**: Homing On Block Configuration
- **203D$_h$**: Torque Window
- **203E$_h$**: Torque Window Time Out
- **203F$_h$**: Max Slippage Time Out
- **2056$_h$**: Limit Switch Tolerance Band
- **2057$_h$**: Clock Direction Multiplier
- **2058$_h$**: Clock Direction Divider
- **205B$_h$**: Clock Direction Or Clockwise/Counter Clockwise Mode
- **2084$_h$**: Bootup Delay
- **2300$_h$**: NanoJ Control
- **2410$_h$**: NanoJ Init Parameters
- **2800$_h$**: Bootloader And Reboot Settings
- **3210$_h$**: Motor Drive Parameter Set
- **3212$_h$**: Motor Drive Flags
- **3221$_h$**: Analogue Inputs Control
- **3240$_h$**: Digital Inputs Control
- **3242$_h$**: Digital Input Routing
- **3243$_h$**: Digital Input Homing Capture
- **3250$_h$**: Digital Outputs Control
- **3252$_h$**: Digital Output Routing
- **3321$_h$**: Analogue Input Offset
- **3322$_h$**: Analogue Input Pre-scaling

- **3700**$_h$: Deviation Error Option Code
- **4013**$_h$: HW Configuration
- **6040**$_h$: Controlword
- **6042**$_h$: Vl Target Velocity
- **6046**$_h$: Vl Velocity Min Max Amount
- **6048**$_h$: Vl Velocity Acceleration
- **6049**$_h$: Vl Velocity Deceleration
- **604A**$_h$: Vl Velocity Quick Stop
- **604C**$_h$: Vl Dimension Factor
- **605A**$_h$: Quick Stop Option Code
- **605B**$_h$: Shutdown Option Code
- **605C**$_h$: Disable Option Code
- **605D**$_h$: Halt Option Code
- **605E**$_h$: Fault Option Code
- **6060**$_h$: Modes Of Operation
- **6065**$_h$: Following Error Window
- **6066**$_h$: Following Error Time Out
- **6067**$_h$: Position Window
- **6068**$_h$: Position Window Time
- **606D**$_h$: Velocity Window
- **606E**$_h$: Velocity Window Time
- **6071**$_h$: Target Torque
- **6072**$_h$: Max Torque
- **607A**$_h$: Target Position
- **607B**$_h$: Position Range Limit
- **607C**$_h$: Home Offset
- **607D**$_h$: Software Position Limit
- **607E**$_h$: Polarity
- **607F**$_h$: Max Profile Velocity
- **6081**$_h$: Profile Velocity
- **6082**$_h$: End Velocity
- **6083**$_h$: Profile Acceleration
- **6084**$_h$: Profile Deceleration
- **6085**$_h$: Quick Stop Deceleration
- **6086**$_h$: Motion Profile Type
- **6087**$_h$: Torque Slope
- **6091**$_h$: Gear Ratio
- **6092**$_h$: Feed Constant
- **6096**$_h$: Velocity Factor
- **6097**$_h$: Acceleration Factor
- **6098**$_h$: Homing Method
- **6099**$_h$: Homing Speed
- **609A**$_h$: Homing Acceleration
- **60A2**$_h$: Jerk Factor
- **60A4**$_h$: Profile Jerk
- **60A8**$_h$: SI Unit Position
- **60A9**$_h$: SI Unit Velocity
- **60B0**$_h$: Position Offset
- **60B1**$_h$: Velocity Offset
- **60B2**$_h$: Torque Offset
- **60C1**$_h$: Interpolation Data Record
- **60C2**$_h$: Interpolation Time Period
- **60C4**$_h$: Interpolation Data Configuration

- **60C5$_h$**: Max Acceleration
- **60C6$_h$**: Max Deceleration
- **60E8$_h$**: Additional Gear Ratio - Motor Shaft Revolutions
- **60E9$_h$**: Additional Feed Constant - Feed
- **60ED$_h$**: Additional Gear Ratio - Driving Shaft Revolutions
- **60EE$_h$**: Additional Feed Constant - Driving Shaft Revolutions
- **60F2$_h$**: Positioning Option Code
- **60F8$_h$**: Max Slippage
- **60FE$_h$**: Digital Outputs
- **60FF$_h$**: Target Velocity

7.4.4 Category: customer

- **2701$_h$**: Customer Storage Area

7.4.5 Category: drive

- **3202$_h$**: Motor Drive Submode Select
- **3203$_h$**: Feedback Selection

7.4.6 Category: tuning

- **2030$_h$**: Pole Pair Count
- **2031$_h$**: Maximum Current
- **203B$_h$**: I2t Parameters
- **2059$_h$**: Encoder Configuration
- **3390$_h$**: Feedback Hall
- **33A0$_h$**: Feedback Incremental A/B/I 1
- **6075$_h$**: Motor Rated Current
- **6080$_h$**: Max Motor Speed
- **608F$_h$**: Position Encoder Resolution
- **6090$_h$**: Velocity Encoder Resolution
- **60E6$_h$**: Additional Position Encoder Resolution - Encoder Increments
- **60EB$_h$**: Additional Position Encoder Resolution - Motor Revolutions

7.4.7 Category: Modbus RTU

- **2028$_h$**: MODBUS Slave Address
- **202A$_h$**: MODBUS RTU Baudrate
- **202D$_h$**: MODBUS RTU Parity

7.4.8 Category: Ethernet

- **2010$_h$**: IP-Configuration
- **2011$_h$**: Static-IPv4-Address
- **2012$_h$**: Static-IPv4-Subnet-Mask
- **2013$_h$**: Static-IPv4-Gateway-Address

7.4.9 Starting the save process

⚠️

CAUTION

Uncontrolled motor movements!

Control may be affected while saving. Unforeseen reactions can result.

► The motor must be at a standstill before starting the saving process. The motor must not be started while saving.

ℹ️

Note

- Saving may take a few seconds. Under no circumstances may you interrupt the voltage supply while saving. The state of the saved objects is otherwise undefined.
- Always wait until the controller has signaled that the save process has been successfully completed with the value "1" in the corresponding subindex in object 1010_h.

There is a subindex in object 1010_h for each *category*. To save all objects of this *category*, the value "65766173_h" must be written in the subindex. [1] The controller signals the end of the save process by overwriting the value with a "1".

The following table shows which subindex of object 1010_h is responsible for which *category*.

Subindex	Category
01_h	All categories with the exception of 06_h (Tuning) , $0B_h$ (Modbus RTU) and $0C_h$ (Ethernet)
02_h	Communication
03_h	Application
04_h	Customer
05_h	Drive
06_h	Tuning
$0B_h$	Modbus RTU
$0C_h$	Ethernet

7.4.10 Discarding the saved data

If all objects or one *category* of saved objects is to be deleted, value "$64616F6C_h$" must be written in object 1011_h. [2] The following subindices correspond to a *category* here:

Subindex	Category
01_h	All categories (reset to factory settings) with the exception of 06_h (Tuning) , $0B_h$ (Modbus RTU) and $0C_h$ (Ethernet)
02_h	Communication
03_h	Application
04_h	Customer
05_h	Drive

---

[1] This corresponds to the decimal of 1702257011_d or the ASCII string `save`.
[2] This corresponds to the decimal of 1684107116_d or the ASCII string `load`.

Subindex	Category
06_h	Tuning
$0B_h$	Modbus RTU
$0C_h$	Ethernet

The saved objects are subsequently discarded; the change does not take effect until after the controller is restarted. You can restart the controller by entering the value "$746F6F62_h$" in 2800_h:01_h.

ℹ️
Note

- Objects of *category* 06_h (Tuning) are determined by **Auto setup** and are not reset when resetting to factory settings with subindex 01_h (thereby making it unnecessary to again perform an auto setup). You can reset these objects with subindex 06_h.
- Objects of *category* $0C_h$ (Ethernet) are not reset with subindex 01_h.

7.4.11 Verifying the configuration

Object **1020_h** can be used to verify the configuration. It acts as a modification marker similar to common text editors: as soon as a file is modified in the editor, a marker (usually an asterisk) is added.

The entries of object **1020_h** can be written with a date and time and then saved together with all other savable objects with **1010_h**:01.

The entries of **1020_h** are reset to "0" as soon as a savable object (including **1010_h**:$0x_h$, except for **1010_h**:01_h and **1020_h**) is written.

The following sequence makes verification possible:

1. An external tool or master configures the controller.
2. The tool or master sets the value in object **1020_h**.
3. The tool or master activates the saving of all objects **1010_h**:01_h = 65766173_h. The date and time in object **1020_h** are also saved.

After the controller is restarted, the master can check the value in **1020_h**:01_h and **1020**:01_h. If one of the values is "0", the object dictionary was changed after the saved values were loaded. If the date or time in **1020** does not correspond to the expected value, objects were probably saved with values other than those that were expected.

8 Modbus RTU

Modbus references: **www.modbus.org**.

- *MODBUS APPLICATION PROTOCOL SPECIFICATION V1.1b3*, Date: 26.04.2014, Version: 1.1b3
- *MODBUS over Serial Line Specification and Implementation Guide V1.02*, Date: 20.12.2006, Version: 1.02

The controller can be controlled by means of Modbus RTU. The I/O data, with, e.g., the preconfigured drive values (see **Process data objects (PDO)**), can be handled with the standard Modbus function codes. To configure your own I/O data, however, function code 2Bh (CAN Encapsulation) must be supported by the master in order for the parameters to be read and written independent of the process image.

If the master does not support this function code, the I/O image can be configured and stored using *Plug & Drive Studio*. The master can then access the data using the standard Modbus function codes.

8.1 RS-485

The "Two-Wire Modbus Interface" electrical interface is supported by the controller in accordance

with standard EIA/TIA-485 (RS-485).

8.2 Modbus Modicon notation with PLCs

Many PLCs use the Modicon addressing model. This notation is not used in the Modbus standard.

The following address notation is relevant for Nanotec controllers:

- Input register 30001 - 39999 is mapped to Modbus telegram address 0 (0_h) - 9998 ($270E_h$).
- Holding register 40001 - 49999 is mapped to Modbus telegram address 0 (0_h) - 9998 ($270E_h$).

ⓘ	**Note**
	Where Modbus addresses are mentioned in the manual, it may be necessary to implement the register addresses in the PLC in accordance with *Modicon notation*.

8.3 General

Modbus is generally big-endian based.

The only exceptions are the commands with function codes 43 ($2B_h$), 101 (65_h) and 102 (66_h), which are based on CANopen. For the data values of these commands, the little-endian format applies. The remainder of the Modbus message is, on the other hand, based on big-endian.

Example

Command $2B_h$: With this command, the value 12345678_h is written in object 0123_h (does not exist):

SA	FC	Data		CRC
05	2B	0D 01 00 01 23 01 00 00 00 00 04 **78 56 34 12**		67 35

SA

Slave address

FC

Function code

Data

Data range, decoding is dependent on the used function code

CRC

Cyclic redundancy check

8.4 Communication settings

Slave address, baud rate and parity are dependent on the position of the S1 and S2 *rotary switches* and, if applicable, on objects **2028**$_h$, **202A**$_h$, **202D**$_h$.

Configuration	Object	Value range	Factory settings
Slave address	**2028**$_h$	1 to 247	5
Baud rate	**202A**$_h$	7200 to 256000	19200
Parity	**202D**$_h$	• None: 0x00 • Even: 0x04 • Odd: 0x06	0x04 (Even)

The number of data bits is always "8" here. The number of stop bits is dependent on the parity setting:

- No parity: 2 stop bits
- "Even" or "Odd" parity: 1 stop bit

The following baud rates are supported:

- 7200
- 9600
- 14400
- 19200
- 38400
- 56000
- 57600
- 115200
- 128000
- 256000

8.4.1 Rotary switch

The N5 is equipped with two hex coding switches – similar to that shown in the following figure.

You can set the source for the slave address, the baud rate and the parity using the combination of numbers from both rotary switches.

The following applies here: the combination of numbers is formed using rotary switches S1 and S2, where S1 represents the higher-value byte and S2 the lower-value byte

Example

Switch S1 is set to the value "0_h", switch S2 to the value "F_h"; the result is the value "$0F_h$"="16_d".

Switch S1 is set to the value "A_h", switch S2 to the value "1_h"; the result is the value "$A1_h$"="161_d".

Number combinations of the rotary switches		Slave address	Baud rate and parity
dec	hex		
0	0	Object **2028**$_h$	Object **202A**$_h$ or **202D**$_h$
1-247	1-F7	Number of the rotary switches	Object **202A**$_h$ or **202D**$_h$
248-255	F8-FF	5	19200, even Parity

8.5 Function codes

The following "function codes" are supported:

	Name	Function code	Subfunction code
Data access (16-bit)	Read Holding Registers	03 (03_h)	
	Read Input Register	04 (04_h)	
	Write Single Register	06 (06_h)	
	Write Multiple Registers	22 (16_h)	
	Read/Write Multiple Registers	23 (17_h)	
Diagnosis	Clear Counters and Diagnostic Register	08 (08_h)	10 ($0A_h$)
	Return Bus Message Count	08 (08_h)	11 ($0B_h$)
	Return Bus Communication Error Count	08 (08_h)	12 ($0C_h$)
	Return Bus Exception Error Count	08 (08_h)	13 ($0D_h$)
	Return Server Message Count	08 (08_h)	14 ($0E_h$)
	Return Server No Response Count	08 (08_h)	15 ($0F_h$)
	Return Server NAK Count	08 (08_h)	16 (10_h)
	Return Server Busy Count	08 (08_h)	17 (11_h)
	Return Bus Character Overrun Count	08 (08_h)	18 (12_h)
Miscellaneous	Encapsulated Interface Transport	43 ($2B_h$)	13 ($0D_h$)
	Read complete object dictionary start	101 (65_h)	85 (55_h)
	Read complete object dictionary next	101 (65_h)	170 (AA_h)
	Read complete array or record start	102 (66_h)	85 (55_h)
	Read complete array or record next	102 (66_h)	170 (AA_h)

8.6 Function code descriptions

8.6.1 FC 3 (03_h) Read Input Registers / FC 4 (04_h) Read Holding Registers

With this function code, one 16-bit value or multiple 16-bit values can be read. This function can be applied to NanoJ objects (see **NanoJ objects**) or process data objects (min. 4-byte alignment, see **Process data objects (PDO)**).

Request		
Name	**Length**	**Value**
Slave address	1 byte	
Function code	1 byte	03_h / 04_h
Start address	2 bytes	0000_h to $FFFF_h$
Number of registers	2 bytes	1 to ($7D_h$)
CRC	2 bytes	

Response ("M" corresponds to the number of registers to be read)		
Name	**Length**	**Value**
Slave address	1 byte	
Function code	1 byte	03_h / 04_h
Number of bytes	1 byte	2 * M
Register value	2 bytes	
CRC	2 bytes	

Error		
Name	**Length**	**Value**
Slave address	1 byte	
Error code	1 byte	83_h / 84_h
Exception code	1 byte	01, 02, 03 or 04
CRC	2 bytes	

Example

Below is an example of a read request and response of register 5000 (1388_h) and of the following register (2 registers):

Request

SA	FC	Data	CRC
05	03	13 88 00 02	41 21

Response

SA	FC	Data	CRC
05	03	04 02 40 00 00	41 21

8.6.2 FC 6 (06_h) Write Single Register

This function code can be used to write a single 16-bit value. The function can be used on process data objects (see **Process data objects (PDO)**).

Request		
Name	**Length**	**Value**
Slave address	1 byte	
Function code	1 byte	06_h
Register address	2 bytes	0000_h to $FFFF_h$
Register value	2 bytes	0000_h to $FFFF_h$
CRC	2 bytes	

Response		
Name	**Length**	**Value**
Slave address	1 byte	
Function code	1 byte	06_h
Register address	2 bytes	0000_h to $FFFF_h$
Register value	2 bytes	0000_h to $FFFF_h$
CRC	2 bytes	

Error		
Name	**Length**	**Value**
Slave address	1 byte	
Error code	1 byte	86_h
Exception code	1 byte	01, 02, 03 or 04
CRC	2 bytes	

Example

Below is an example of a write request and response in register 6000 (1770_h) with the value "0001_h":

Request

SA	FC	Data	CRC
05	06	17 70 00 01	4D E1

Response

SA	FC	Data	CRC
05	06	17 70 00 01	4D E1

8.6.3 FC 16 (10_h) Write Multiple Registers

With this function code, one 16-bit value or multiple 16-bit values can be written. The function can be applied to NanoJ objects (see **Process data objects (PDO)**) or process data objects (see **NanoJ objects**).

Request ("N" is the number of registers to be written)		
Name	**Length**	**Value**
Slave address	1 byte	
Function code	1 byte	10_h
Start address	2 bytes	0000_h to $FFFF_h$
Number of registers	2 bytes	0001_h to $007B_h$
Number of bytes	1 byte	2 * N
Register value	N * 2 bytes	
CRC	2 bytes	

Response		
Name	**Length**	**Value**
Slave address	1 byte	
Function code	1 byte	10_h
Start address	2 bytes	0000_h to $FFFF_h$
Number of registers	2 bytes	0001_h to $007B_h$
CRC	2 bytes	

Error		
Name	**Length**	**Value**
Slave address	1 byte	
Error code	1 byte	90_h
Exception code	1 byte	01, 02, 03 or 04
CRC	2 bytes	

Example

Below is an example for writing values "0102_h" and "0304_h" starting with register address 6000 (1770_h), number of registers is 2, length of the data is 4:

Request

SA	FC	Data	CRC
05	10	17 70 00 02 04 01 02 03 04	AB 44

Response

SA	FC	Data	CRC
05	10	17 70 00 02	44 23

8.6.4 FC 17 (11_h) Report Server ID

This function code can be used to read the description of the type, the current status and other information about the device.

Request

Name	Length	Value
Slave address	1 byte	
Function code	1 byte	11_h
CRC	2 bytes	

Response

Name	Length	Value
Slave address	1 byte	
Function code	1 byte	03_h
Number of bytes	1 byte	01_h
Run Indicator Status	1 byte	00_h = OFF, FF_h = ON
Additional data		
CRC	2 bytes	

Error

Name	Length	Value
Slave address	1 byte	
Error code	1 byte	91_h
Exception code	1 byte	01 or 04
CRC	2 bytes	

Example

Below is an example of a request/response for ID and status:

Request

SA	FC	CRC
05	11	C2 EC

Response

SA	FC	Data	CRC
05	11	02 05 FF	0F EC

8.6.5 FC 23 (17_h) Read/Write Multiple registers

With this function code, one 16-bit value or multiple 16-bit values can be simultaneously read and written. The function can be applied to NanoJ objects (see **Process data objects (PDO)**) or process data objects (see **NanoJ objects**).

Request ("N" is the number of registers to be read):		
Name	**Length**	**Value**
Slave address	1 byte	
Function code	1 byte	17_h
Read: Start address	2 bytes	0000_h to $FFFF_h$
Read: Number of registers	2 bytes	0001_h to 0079_h
Write: Start address	2 bytes	0000_h to $FFFF_h$
Write: Number of registers	2 bytes	0001_h to 0079_h
Write: Number of bytes	1 byte	2 * N
Write: Register value	N * 2 bytes	
CRC	2 bytes	

Response ("M" corresponds to the number of bytes to be written):		
Name	**Length**	**Value**
Slave address	1 byte	
Function code	1 byte	17_h
Number of bytes	1 byte	2 * M
Registers read	M * 2 bytes	
CRC	2 bytes	

Error		
Name	**Length**	**Value**
Slave address	1 byte	
Error code	1 byte	97_h
Exception code	1 byte	01, 02, 03 or 04
CRC	2 bytes	

Example

Below is an example for reading two registers beginning with register 5000 (1388_h) and for writing two registers beginning with register 6000 (1770_h) with 4 bytes and data "0102_h" and "0304_h":

Request

SA	FC	Data	CRC
05	17	13 88 00 02 17 70 00 02 04 01 02 03 04	56 6A

Response

SA	FC	Data	CRC
05	17	04 02 40 00 00	0F EC

8.6.6 FC 8 (08$_h$) Diagnostics

Modbus function code FC08 offers numerous tests for checking the communication system between client and server or for checking various internal error states within the server.

This function uses a two-byte subfunction code in the request for defining the type of test. In a normal response, the server repeats both, the function and the subfunction code. Some diagnoses contain data of the device in the data field of the normal response.

Request:

Name	Length	Value
Function code	1 byte	08$_h$
Subfunction code	2 bytes	
Data	N x 2 bytes	

Response:

Name	Length	Value
Function code	1 byte	08$_h$
Subfunction code	2 bytes	
Data	N x 2 bytes	

Error:

Name	Length	Value
Function code	1 byte	88$_h$
Exception code	1 byte	01 or 03 or 04

FC 8.10 (08$_h$.0A$_h$) Clear Counters and Diagnostic Register

The objective of this request is to reset all counters and diagnosis registers. Counters are also reset when the controller is switched on.

Subfunction	Data range	
	Request	Response
00$_h$ 0A$_h$	00$_h$ - 00$_h$	Echo of the request data

Example

Request

SA	FC	Data	CRC
05	08	00 0A 00 00	56 6A

Response

SA	FC	Data	CRC
05	08	00 0A 00 00	C1 8D

FC 8.11 (08$_h$.0B$_h$) Return Bus Message Count

The response data range returns the number of messages detected by the communications system since the last restart, "Clear Counters and Diagnostic Register" request, or switching on of the controller.

Subfunction	Data range	
	Request	**Response**
00$_h$ 0B$_h$	00$_h$ - 00$_h$	Total Message Count

FC 8.12 (08$_h$.0C$_h$) Return Bus Communication Error Count

The response data range returns the number of CRC errors since the last restart, "Clear Counters and Diagnostic Register" request, or switching on of the controller.

Subfunction	Data range	
	Request	**Response**
00$_h$ 0C$_h$	00$_h$ - 00$_h$	CRC Error Count

Example

Request

SA	FC	Data	CRC
05	08	00 0C 00 00	21 8C

Response

SA	FC	Data	CRC
05	08	00 0C 00 00	21 8C

FC 8.13 (08$_h$.0D$_h$) Return Bus Exception Error Count

The response data range returns the number of Modbus exceptions since the last restart, "Clear Counters and Diagnostic Register" request, or switching on of the controller.

Subfunction	Data range	
	Request	**Response**
00$_h$ 0D$_h$	00$_h$ - 00$_h$	Exception Error Count

Example

Request

SA	FC	Data	CRC
05	08	00 0D 00 00	70 4C

Response

SA	FC	Data	CRC
05	08	00 0D 00 00	70 4C

FC 8.14 (08$_h$.0E$_h$) Return Server Message Count

The response data range returns the number of messages addressed to the device and the number of broadcast messages that were processed by the controller. The number of messages since the last restart, "Clear Counters and Diagnostic Register" request, or switching on of the controller are counted.

Subfunction	Data range	
	Request	**Response**
00$_h$ 0E$_h$	00$_h$ - 00$_h$	Server Message Count

Example

Request

SA	FC	Data	CRC
05	08	00 0E 00 00	80 4C

Response

SA	FC	Data	CRC
05	08	00 0E 00 00	80 4C

FC 8.15 (08$_h$.0F$_h$) Return Server No Response Count

The response data range returns the number of messages addressed to the controller for which no response was returned (neither normal response nor exception response). The number of messages since the last restart, "Clear Counters and Diagnostic Register" request, or switching on of the controller are counted.

Subfunction	Data range	
	Request	**Response**
00$_h$ 0F$_h$	00$_h$ - 00$_h$	No Response Count

Example

Request

SA	FC	Data	CRC
05	08	00 0F 00 00	D1 8C

Response

SA	FC	Data	CRC
05	08	00 0F 00 00	D1 8C

FC 8.16 (08$_h$.10$_h$) Return Server NAK Count

The response data range returns the number of messages for which a "Negative Acknowledge (NAK)" exception response was returned. The number of messages since the last restart, "Clear Counters and Diagnostic Register" request, or switching on of the controller are counted.

Subfunction	Data range	
	Request	**Response**
00$_h$ - 10$_h$	00$_h$ - 00$_h$	Server NAK Count

Example

Request

SA	FC	Data	CRC
05	08	00 10 00 00	E0 4A

Response

SA	FC	Data	CRC
05	08	00 10 00 00	E0 4A

FC 8.17 (08$_h$.11$_h$) Return Server Busy Count

The response data range returns the number of messages for which a "Server Device Busy" exception response was returned. The number of messages since the last restart, "Clear Counters and Diagnostic Register" request, or switching on of the controller are counted.

Subfunction	Data range	
	Request	**Response**
00_h - 11_h	00_h - 00_h	Server NAK Count

Example

Request

SA	FC	Data	CRC
05	08	00 11 00 00	B1 8A

Response

SA	FC	Data	CRC
05	08	00 11 00 00	B1 8A

FC 8.18 (08_h.12_h) Return Bus Character Overrun Count

The response data range returns the number of messages addressed to the controller that could not be processed due to a character overrun. The number of messages since the last restart, "Clear Counters and Diagnostic Register" request, or switching on of the controller are counted. A character overrun occurs when characters arrive at the controller faster than they can be stored or by the loss of a character due to a hardware malfunction.

Subfunction	Data range	
	Request	**Response**
00_h - 12_h	00_h - 00_h	Server Character Overrun Count

Example

Request

SA	FC	Data	CRC
05	08	00 12 00 00	41 8A

Response

SA	FC	Data	CRC
05	08	00 12 00 00	41 8A

8.6.7 FC 43 ($2B_h$) Encapsulated Interface Transport

This function facilitates simple access of the CANopen object dictionary. Further details can be found in the following documentation:

1. *MODBUS APPLICATION PROTOCOL SPECIFICATION V1.1b3*, Date: 26.04.2014, Version: 1.1b3

2. *CiA 309 Draft Standard Proposal - Access from other networks - Part 2: Modbus/TCP mapping V1.3*, Date: 30.07.2015, Version: 1.3

> **Note**
>
> For the messages of the Encapsulated Interface Transport, another byte sequence applies in part, see chapter **General**.

Definition of the request and response:

Name	Length	Example/number range
Slave address	1 byte	
Function code	1 byte	$2B_h$ (43_d)
MEI type	1 byte	$0D_h$ (13_d)
Protocol options Range	2 to 5 bytes	
Address and data range	N bytes	
CRC	2 bytes	

Protocol options Range

Name	Length	Example/number range
Protocol control	1 to 2 bytes	See description
Reserved	1 byte	Always 0
(Optional) Counter byte	1 byte	
(Optional) Network ID	1 byte	
(Optional) Encoded data	1 byte	

Protocol control:

The "Protocol control" field contains the flags that are needed for controlling the message protocols. The bytes of the "Protocol control" field are defined as follows if the "extended" flag was set (the second byte is otherwise omitted):

0		7	8		15
	Protocol control byte 1			Protocol control byte 2	
MSB		LSB	MSB		LSB
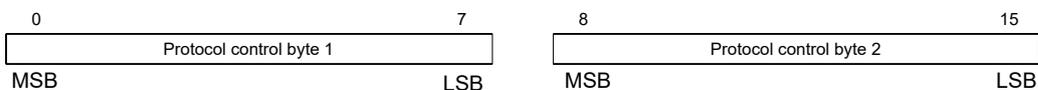
The most significant bit (MSB) is bit 0 for "protocol control" byte 1 and bit 8 for "protocol control" byte 2. The least significant bit (LSB) is bit 7 for "protocol control" byte 1 and bit 15 for "protocol control" byte 2.

Bit	Name	Description
0	"Extended" flag	This bit is used if the object dictionary data set is larger than would fit in a Modbus command. The data set then spans over multiple Modbus messages; each message contains part of the data set. "0" = No multiple message transaction or the end of the multiple message transaction. "1" = Part of a multiple message transaction.

Bit	Name	Description
1	Extended protocol control	Length of the protocol control, the value "0" indicates a length of 1 byte, the value "1" indicates a length of 2 bytes.
2	Counter byte option	This bit is set to "1" to indicate that the "counter byte" field is used in this message. If this bit is set to "0", the "counter byte" field does not exist in this message.
3 and 4	Reserved	0
5	Network ID option	Not supported, must be "0".
6	Encoded data option	Not supported, must be "0".
7	Access flag	This bit indicates the access method of the requested command. "0" = read, "1" = write.
8 to 15	Reserved	0

Address and data range

The address and data range is defined in the following table:

Name	Byte size and byte order	Example / range
Node ID	1 byte	01_h to $7F_h$
Index	1 byte, high 1 byte, low	0000_h to $FFFF_h$
Subindex	1 byte	00_h to FF_h
Start address	1 byte, high 1 byte, low	0000_h to $FFFF_h$
Number of data values	1 byte, high 1 byte, low	0000_h to $00FD_h$
Write/read data	n bytes	The data are encoded as described in chapter **General**.

Example:

To read object 6042_h:00_h (16-bit value), the following message must be sent by the master (all values are in hexadecimal notation, the slave ID of the controller is "5").

Request

Response

SA	FC	Data										CRC
05	2B	0D	00 00	01	60 42	00	00 00	00 02	00 00			60 34
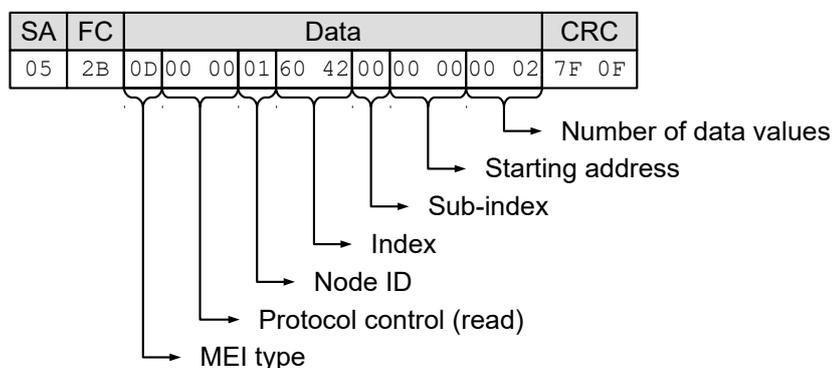
- → Data
- → Number of data values
- → Starting address
- → Sub-index
- → Index
- → Node ID
- → Protocol control (read)
- → MEI type
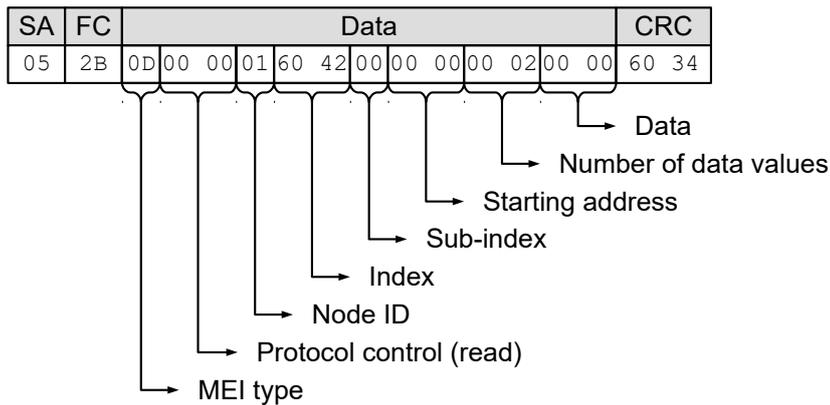
Shown as an additional example below, a sequence of Modbus messages is sent from the master to the slave to rotate the motor in "Velocity" mode:

Set 6060 = "02$_h$" (Velocity mode)

  Request

SA	FC	Data	CRC
05	2B	0D 01 00 01 60 60 00 00 00 00 01 02	C9 2F

  Response

SA	FC	Data	CRC
05	2B	0D 01 00 01 60 60 00 00 00 00 00	A9 89

Set 2031 = 203E8$_h$" (1000 mA)

  Request

SA	FC	Data	CRC
05	2B	0D 01 00 01 20 31 00 00 00 00 04 E8 03 00 00	C3 53

  Response

SA	FC	Data	CRC
05	2B	0D 01 00 01 20 31 00 00 00 00 00	E5 CC

Set 6040 = "00$_h$"

  Request

SA	FC	Data	CRC
05	2B	0D 01 00 01 60 40 00 00 00 00 02 00 00	1C 2E

Response

SA	FC	Data	CRC
05	2B	0D 01 00 01 60 40 00 00 00 00 00	AE E9

Set 6040 = "80ₕ"

Request

SA	FC	Data	CRC
05	2B	0D 01 00 01 60 40 00 00 00 00 02 80 00	7D EE

Response

SA	FC	Data	CRC
05	2B	0D 01 00 01 60 40 00 00 00 00 00	AE E9

Set 6040 = "06ₕ"

Request

SA	FC	Data	CRC
05	2B	0D 01 00 01 60 40 00 00 00 00 02 06 00	1F 8E

Response

SA	FC	Data	CRC
05	2B	0D 01 00 01 60 40 00 00 00 00 00	AE E9

Set 6040 = "07ₕ"

Request

SA	FC	Data	CRC
05	2B	0D 01 00 01 60 40 00 00 00 00 02 07 00	1E 1E

Response

SA	FC	Data	CRC
05	2B	0D 01 00 01 60 40 00 00 00 00 00	AE E9

Set 6040 = "0Fₕ"

Request

SA	FC	Data	CRC
05	2B	0D 01 00 01 60 40 00 00 00 00 02 0F 00	19 DE

Response

SA	FC	Data	CRC
05	2B	0D 01 00 01 60 40 00 00 00 00 00	AE E9

Below are two examples for reading an object:

Read 6041$_h$:00$_h$

Request

SA	FC	Data	CRC
05	2B	0D 00 00 01 60 41 00 00 00 00 02	7F 3C

Response

SA	FC	Data	CRC
05	2B	0D 00 00 01 60 41 00 00 00 00 02 37 06	B6 13

Read 6061$_h$:00$_h$

Request

SA	FC	Data	CRC
05	2B	0D 00 00 01 60 61 00 00 00 00 01	38 5D

Response

SI	FC	Data	CRC
05	2B	0D 00 00 01 60 61 00 00 00 00 01 00	5C D2

Error reaction

In the event of an error, the following error message is sent:

Name	Length	Example value
Slave address	1 byte	
Function code	1 byte	2B$_h$ +80$_h$ (171$_d$ = 43$_d$ + 128$_d$) (indicates error)
Modbus exception code	1 byte	FF$_h$ ("extended exception")
Extended exception length	2 bytes	6
MEI type	1 byte	0D$_h$
Exception code	1 byte	CE$_h$
Error code	4 bytes	CANopen error code
CRC	2 bytes	

In the event that the unsupported control option bit is set, the following error message is sent:

Name	Length	Example value
Slave address	1 byte	
Function code	1 byte	$2B_h$ +80_h (171_d = 43_d + 128_d) (indicates error)
Modbus exception code	1 byte	FF_h ("extended exception")
Extended exception length	2 bytes	2 + length of "supported protocol control"
MEI type	1 byte	$0D_h$
Exception code	1 byte	AE_h
Supported protocol control	1 or 2 bytes	See following table
CRC	2 bytes	

Bit	Name	Description
0	"Extended" flag	This bit is used if the object dictionary data set is larger than would fit in a Modbus command. The data set then spans over multiple Modbus messages; each message contains part of the data set. "0" = No multiple message transaction or the end of the multiple message transaction. "1" = Part of a multiple message transaction.
1	Extended protocol control	Length of the protocol control, the value "0" indicates a length of 1 byte, the value "1" indicates a length of 2 bytes.
2	Counter byte option	This bit is set to "1" to indicate that the "counter byte" field is used in this message. If this bit is set to "0", the "counter byte" field does not exist in this message.
3 and 4	Reserved	0
5	Network ID option	Not supported, must be "0".
6	Encoded data option	Not supported, must be "0".
7	Access flag	This bit indicates the access method of the requested command. "0" = read, "1" = write.
8 to 15	Reserved	0

The following example shows an error in the event of a faulty request. The request reads **6061**$_h$:00 with a length of 2 bytes, but the object has a size of just 1 byte:

Request

SA	FC	Data	CRC
05	2B	0D 00 00 01 60 60 00 00 00 00 02	79 8D

Response

SA	FC	Data	CRC
05	2B	FF 00 06 0D CE 12 00 07 06	AC 3C

8.6.8 FC 101 (65_h) Read complete object dictionary

This function code is used to read out the complete object dictionary.

To start or restart the reading out of the object dictionary, subfunction code 55_h must be sent. This code resets reading out of the object dictionary on object 0000_h. All subsequent object dictionary frames must then contain subfunction code AA_h. At the end, once all objects have been read out, an "Error Response" is generated with the abort code "No data available".

The format of each "read object" is as follows:

Request:

Name	Length	Value / note
Slave address	1 byte	
Function code	1 byte	65_h
Subfunction code	1 byte	55_h or AA_h
Length of the data	1 byte	00_h
CRC	2 bytes	

Response:

Name	Length	Value / note
Slave address	1 byte	65_h
Function code	1 byte	
Subfunction code	1 byte	
Length of the data	1 byte	
n times "object dictionary frame"	1 - 252 bytes	
CRC	2 bytes	

An object dictionary frame consists of the following bytes:

Name		Value / note
Index Low Byte	1 byte	
Index High Byte	1 byte	
Subindex	1 byte	
Number of bytes	1 byte	Number m of the valid data in the data field
Data byte	m-1 byte	

Example

All of the following numerical values are in hexadecimal format. The address of the slave is "5".

Start reading of the object dictionary with request:

SA	FC	Data	CRC
05	65	55 00	2F A7

The response is:

SA	FC	Data	CRC
05	65	55 CE 01 00 00 04 08 00 00 00 02 00 00 04 08 00 00 00 00 ...	EA 3A

Data length

Object dictionary frame

Object dictionary frame

01 00	00	04	08 00 00 00

Data: 00000008_h

Data length: 4 byte

Subindex: 00

Index: 0001_h
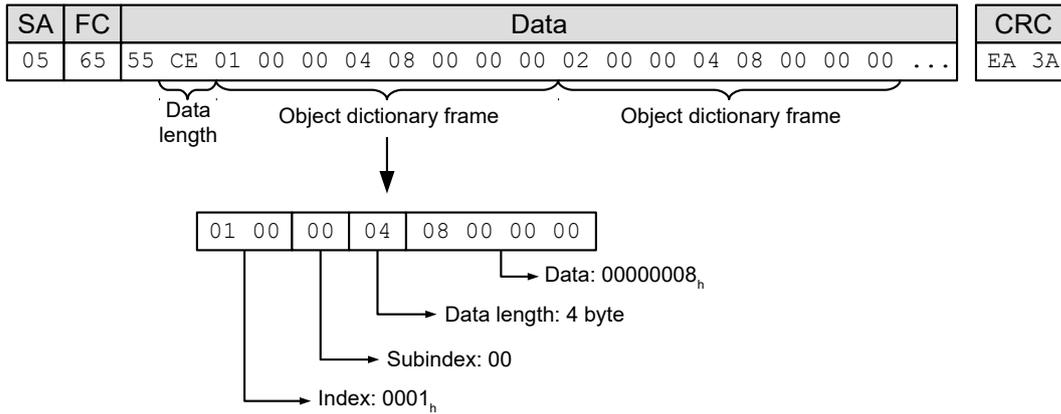
Read out the next part of the object dictionary with the request:

SA	FC	Data	CRC
05	65	AA 00	6E 57

The response is:

SA	FC	Data	CRC
05	65	AA CD 21 00 0A 02 07 00 21 00 0B 02 07 00 21 00 0C 02 ...	NN NN

Repeat reading of the object dictionary with the previous request until the response is an error:

SA	FC	Data	CRC
05	E5	0D	EA 94

Error reaction

In the event of an error, the following error message is sent:

Name	Length	Example value
Slave address	1 byte	
Function code	1 byte	$2B_h$ +80_h (171_d = 43_d + 128_d) (indicates error)
Modbus exception code	1 byte	FF_h ("extended exception")
Extended exception length	2 bytes	6
MEI type	1 byte	$0D_h$
Exception code	1 byte	CE_h
Error code	4 bytes	CANopen error code
CRC	2 bytes	

In the event that the unsupported control option bit is set, the following error message is sent:

Name	Length	Example value
Slave address	1 byte	
Function code	1 byte	$2B_h$ +80_h (171_d = 43_d + 128_d) (indicates error)

Name	Length	Example value
Modbus exception code	1 byte	FF_h ("extended exception")
Extended exception length	2 bytes	2 + length of "supported protocol control"
MEI type	1 byte	$0D_h$
Exception code	1 byte	AE_h
Supported protocol control	1 or 2 bytes	See following table
CRC	2 bytes	

Bit	Name	Description
0	"Extended" flag	This bit is used if the object dictionary data set is larger than would fit in a Modbus command. The data set then spans over multiple Modbus messages; each message contains part of the data set. "0" = No multiple message transaction or the end of the multiple message transaction. "1" = Part of a multiple message transaction.
1	Extended protocol control	Length of the protocol control, the value "0" indicates a length of 1 byte, the value "1" indicates a length of 2 bytes.
2	Counter byte option	This bit is set to "1" to indicate that the "counter byte" field is used in this message. If this bit is set to "0", the "counter byte" field does not exist in this message.
3 and 4	Reserved	0
5	Network ID option	Not supported, must be "0".
6	Encoded data option	Not supported, must be "0".
7	Access flag	This bit indicates the access method of the requested command. "0" = read, "1" = write.
8 to 15	Reserved	0

The following example shows an error in the event of a faulty request. The request reads **6061**$_h$:00 with a length of 2 bytes, but the object has a size of just 1 byte:

Request

SA	FC	Data	CRC
05	2B	0D 00 00 01 60 60 00 00 00 00 02	79 8D

Response

SA	FC	Data	CRC
05	2B	FF 00 06 0D CE 12 00 07 06	AC 3C

8.6.9 FC 102 (66_h) Read complete array or record

This function code is used to read out the complete array or record from the object dictionary.

To start or restart the reading out of the array, subfunction code 55_h must be sent. This code resets reading out on the object with subindex 00_h. All subsequent requests must then contain subfunction code AA_h. At the end, once all objects have been read out, an "Error Response" is generated.

The format of each "read object" is as follows:

Request:

Name	Length	Value / note
Slave address	1 byte	
Function code	1 byte	66_h
Subfunction code	1 byte	55_h or AA_h
Length of the data	1 byte	00_h
Index of the array to be read	2 bytes	
CRC	2 bytes	

Response:

Name	Length	Value / note
Slave address	1 byte	65_h
Function code	1 byte	
Subfunction code	1 byte	
Length of the data	1 byte	
n times object dictionary frame	1 - 252 bytes	
CRC	2 bytes	

An object dictionary frame consists of the following bytes:

Name		Value / note
Index Low Byte	1 byte	
Index High Byte	1 byte	
Subindex	1 byte	
Number of bytes	1 byte	Number m of the valid data in the data field
Data byte	m-1 byte	

Example

All of the following numerical values are in hexadecimal format; the index of the object that is to be read is 2400_h. The address of the slave is "5"$_h$.

Start reading of the array with request:

SA	FC	Data	CRC
05	66	55 00 24 00	02 8A

The response is:

SA	FC	Data	CRC
05	66	55 CD 00 24 00 01 20 00 24 01 04 06 00 00 00 00 24 00 ...	NN NN

Data length

Object dictionary frame

Object dictionary frame

| 00 24 | 00 | 01 | 20 |

Data: 20_h

Data length: 1 byte

Subindex: 00

Index: 2400_h

Error reaction

In the event of an error, the following error message is sent:

Name	Length	Example value
Slave address	1 byte	
Function code	1 byte	$2B_h +80_h$ ($171_d = 43_d + 128_d$) (indicates error)
Modbus exception code	1 byte	FF_h ("extended exception")
Extended exception length	2 bytes	6
MEI type	1 byte	$0D_h$
Exception code	1 byte	CE_h
Error code	4 bytes	CANopen error code
CRC	2 bytes	

In the event that the unsupported control option bit is set, the following error message is sent:

Name	Length	Example value
Slave address	1 byte	
Function code	1 byte	$2B_h +80_h$ ($171_d = 43_d + 128_d$) (indicates error)
Modbus exception code	1 byte	FF_h ("extended exception")
Extended exception length	2 bytes	2 + length of "supported protocol control"
MEI type	1 byte	$0D_h$
Exception code	1 byte	AE_h
Supported protocol control	1 or 2 bytes	See following table
CRC	2 bytes	

Bit	Name	Description
0	"Extended" flag	This bit is used if the object dictionary data set is larger than would fit in a Modbus command. The data set then spans over multiple Modbus messages; each message contains part of the data set. "0" = No multiple message transaction or the end of the multiple

Bit	Name	Description
		message transaction. "1" = Part of a multiple message transaction.
1	Extended protocol control	Length of the protocol control, the value "0" indicates a length of 1 byte, the value "1" indicates a length of 2 bytes.
2	Counter byte option	This bit is set to "1" to indicate that the "counter byte" field is used in this message. If this bit is set to "0", the "counter byte" field does not exist in this message.
3 and 4	Reserved	0
5	Network ID option	Not supported, must be "0".
6	Encoded data option	Not supported, must be "0".
7	Access flag	This bit indicates the access method of the requested command. "0" = read, "1" = write.
8 to 15	Reserved	0

The following example shows an error in the event of a faulty request. The request reads 6061_h:00 with a length of 2 bytes, but the object has a size of just 1 byte:

Request

SA	FC	Data	CRC
05	2B	0D 00 00 01 60 60 00 00 00 00 02	79 8D

Response

SA	FC	Data	CRC
05	2B	FF 00 06 0D CE 12 00 07 06	AC 3C

8.7 Process data objects (PDO)

As with CANopen, a process image can be configured for input and output values with Modbus. This image only contains the data values of one or more objects without additional information, such as length, index or subindex. A single message can thereby be used to read or write multiple objects at the same time.

8.7.1 Configuration

The configuration of the image is referred to as "mapping" and is written in the following objects:

- 3502_h for the Modbus Rx (master → slave) PDO mapping
- 3602_h for Modbus Tx (slave → master) PDO mapping

Both objects contain an array of 16 entries each. Subindex 00 specifies the number of valid entries here.

Objects 3502_h and 3602_h can be written with messages with Modbus function code $2B_h$.

8.7.2 Transfer

The data are written sequentially in the message without gaps and alignment.

If alignment is required (e.g., 16-bit alignment), additional "dummy objects" can be incorporated in the message. Dummy objects are only ever transferred with the data value "0". These objects are listed in the following table.

Index	Data type
0002_h	Signed integer (8 bit)
0003_h	Signed integer (16 bit)
0004_h	Signed integer (32 bit)
0005_h	Unsigned integer (8 bit)
0006_h	Unsigned integer (16 bit)
0007_h	Unsigned integer (32 bit)

Mapping is as follows:

- The PDO RX image begins at Modbus register address 6000_d (1770_h).
- The PDO TX image begins at Modbus register address 5000_d (1388_h).

Read/write access can be performed simultaneously with function code 17_h or with the 03_h, 04_h, 06_h, 10_h commands on the respective RX/TX images.

Example

The following objects are to be set in the mapping:

- 3602_h:00_h = "6_h" (6 values are mapped)
- 3602_h:01_h = "60410010_h" (object 6041_h:00_h, length 16 bits is mapped)
- 3602_h:02_h = "00050008_h" (dummy object 0005_h:00_h, length 8 bits is mapped)
- 3602_h:03_h = "60610008_h" (object 6061_h:00_h, length 8 bits is mapped)
- 3602_h:04_h = "60640020_h" (object 6064_h:00_h, length 32 bits is mapped)
- 3602_h:05_h = "60440010_h" (object 6044_h:00_h, length 16 bits is mapped)
- 3602_h:06_h = "$60FD0020_h$" (object $60FD_h$:00_h, length 32 bits is mapped)

After the mapping for object 6061_h:00_h, a dummy object is inserted so that the next object 6064_h:00_h can be aligned to 32 bit.

Rx message: The master sends the slave the following message:

SA	FC	Data	CRC
05	04	13 88 00 07	34 E2

Tx message: The slave sends following response to the master:

SA	FC	Data	CRC
05	04	0E 06 40 00 02 00 00 00 00 00 00 00 00 00 00	1C 98

60FD, 32 bit
6044, 16 bit
6064, 32 bit
6061, 8 bit
Dummy, 8 bit
6041, 16 bit
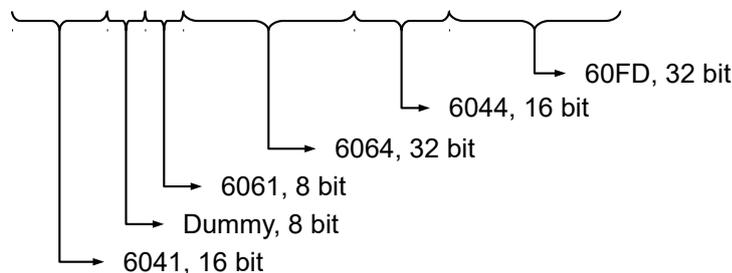
8.8 NanoJ objects

NanoJ objects 2400_h NanoJ Input and 2500_h (NanoJ Output) are, like the process image, mapped to the Modbus register:

- 2500_h with 32 x 32 bit values is mapped to the Modbus register address beginning with 2000_d ($BB8_h$) and can only be read in this way.

- **2400**$_h$ with 32 x 32 bit values is mapped to the Modbus register address beginning with 3000$_d$ (7D0$_h$) and can only be written in this way.

To access, commands with function codes 03$_h$, 04$_h$, 10$_h$ and 17$_h$ can be used. For purposes of data consistency, the restriction that the address must be 32-bit aligned and that at least 32 bits must always be written during a write operation applies.

Example

Request: The master sends the slave the following message:

SA	FC	Data	CRC
05	17	07 D0 00 08 0B B8 00 08 10 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F	41 21

Reply: The slave sends the master the following response:

SA	FC	Data	CRC
05	17	10 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00	50 9D

9 Programming with *NanoJ*

NanoJ is a programming language similar to *C* or *C++*. NanoJ is integrated in the *Plug & Drive Studio* software. You can find further information in document *Plug & Drive Studio: Quick Start Guide* at **us.nanotec.com**.

9.1 NanoJ program

A *NanoJ program* makes a protected runtime environment available within the firmware. Here, the user can create his own processes. These can then trigger functions in the controller by, for example, reading or writing entries in the object dictionary.

Through the use of protective mechanisms, a *NanoJ program* is prevented from crashing the firmware. In the worst case, the execution is interrupted with an error code stored in the object dictionary.

If the *NanoJ program* was loaded on the controller, it is automatically executed after the controller is switched on or restarted.

9.1.1 Available computing time

A *NanoJ program* receives computing time cyclically in a 1 ms clock (see following figure). Because computing time is lost through interrupts and system functions of the firmware, only approx. 30% – 50% of computing time is available to the user program (depending on operating mode and application). In this time, the user program must run through the cycle and either complete the cycle or yield the computing time by calling the `yield()` function. In the former case, the user program is restarted with the start of the next 1 ms cycle; the latter results in the program being continued on the next 1 ms cycle with the command that follows the `yield()` function.
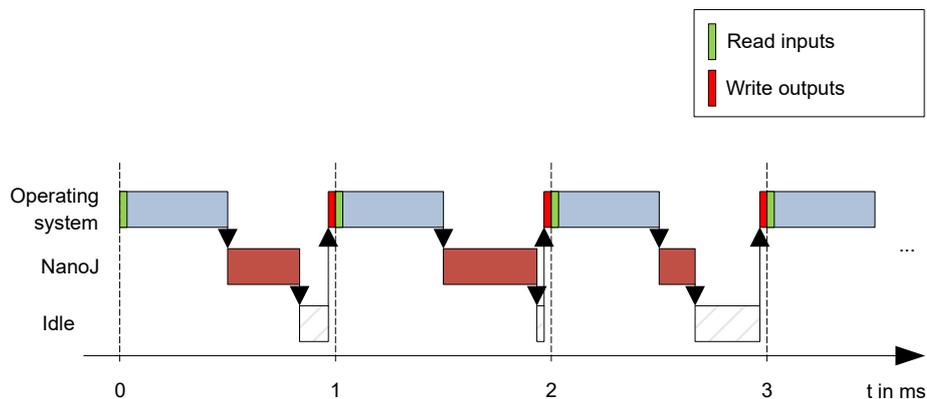
If the *NanoJ program* needs more time than was allotted, it is ended and an error code set in the object dictionary.

Tip
When developing user programs, the runtime behavior must be carefully examined, especially for more time-intensive tasks. For example, it is therefore recommended that tables be used instead of calculating a sine value using a `sin` function.

Note
If the *NanoJ program* does not yield the computing time after too long a time, it is ended by the operating system. In this case, the number 4 is entered in the statusword for object 2301_h; in the error register for object 2302_h, the number 5 (timeout) is noted, see **2301h NanoJ Status** and **2302h NanoJ Error Code**.

9.1.2 Sandbox

Using processor-specific features, a so-called *sandbox* is generated. When used in the sandbox, a user program can only access specially assigned memory areas and system resources. For example, an attempt to directly write to a processor IO register is acknowledged with an *MPU Fault* and the user program terminated with the corresponding error code in the object dictionary.

9.1.3 NanoJ program – communication possibilities

A *NanoJ program* has a number of possibilities for communicating with the controller:

- Read and write OD values using PDO mapping
- Directly read and write OD values using system calls
- Call other system calls (e.g., write debug output)

The OD values of the user program are made available in the form of variables via *PDO mapping*. Before a user program receives the 1 ms time slot, the firmware transfers the values from the object dictionary to the variables of the user program. As soon as the user program receives computing time, it can manipulate these variables as regular C variables. At the end of the time slot, the new values are then automatically copied by the firmware back to the respective OD entries.

To optimize the performance, three types of mapping are defined: input, output, and input/output (In, Out, InOut).

- *Input mappings* can only be read; they are not transferred back to the object dictionary.
- *Output mappings* can only be written.
- *Input/output mappings*, on the other hand, can both be read and written.

The set mappings can be read and checked via the GUI for objects 2310_h, 2320_h, and 2330_h. Up to 16 entries are allowed for each mapping.

Whether a variable is stored in the input, output or data range is controlled in *NanoJEasy* via the specification of the *linker section*.

9.1.4 Executing a NanoJ program

When executing a cycle, the *NanoJ program* essentially consists of the following three steps with respect to the PDO mapping:

1. Read values from the object dictionary and copy them to the input and output areas
2. Execute a user program
3. Copy values from the output and input areas back to the object dictionary

The configuration of the copy processes is based on the CANopen standard.

In addition, values of the object dictionary can be accessed via system calls. This is generally slower; mappings are therefore to be preferred. The number of mappings is limited (16 entries each in In/Out/InOut).

Tip
Nanotec recommends: Map OD entries that are used and changed frequently and use system calls to access OD entries that are used less frequently.

A list of available system calls can be found in chapter **System calls in a NanoJ program**.

Tip
Nanotec recommends accessing a given OD value either by mapping or using a system call with `od_write()`. If both are used simultaneously, the system call has no effect.

9.1.5 NanoJ program – OD entries

The *NanoJ program* is controlled and configured in object range 2300_h to 2330_h (see **2300h NanoJ Control**).

OD-Index	Name and description
2300_h	**2300h NanoJ Control**
2301_h	**2301h NanoJ Status**
2302_h	**2302h NanoJ Error Code**
2310_h	**2310h NanoJ Input Data Selection**
2320_h	**2320h NanoJ Output Data Selection**
2330_h	**2330h NanoJ In/output Data Selection**

Example:

To start the *TEST1.USR* user program, the following sequence can, for example, be used:

- Check entry **2302_h** for error code.
- If no error:
  Start the *NanoJ program* by writing object **2300_h**, bit 0 = "1".

Note
It can take up to 200 ms for the NanoJ program to start.

- Check entry **2302_h** for error code and object **2301_h**, bit 0 = "1".

To stop a running program: write entry **2300_h** with bit 0 value = "0".

9.1.6 Structure of a NanoJ program

A user program consists of at least two instructions:

- the preprocessor instruction `#include "wrapper.h"`
- the `void user(){}` function

The code to be executed can be stored in the `void user()` function.

Note
The file names of the user programs must not be longer than eight characters plus three characters in the suffix; file name `main.cpp` is permissible, file name `aLongFileName.cpp` is not permissible.

> ⓘ   **Note**
>
> In *NanoJ programs*, global variables may only be initialized within functions. It then follows:
>
> - No `new` operator
> - No constructors
> - No initialization of global variables outside of functions

Examples:

The global variable is to be initialized within the `void user()` function:

```
unsigned int i;
void user(){
 i = 1;
 i += 1;
}
```

The following assignment is not correct:

```
unsigned int i = 1;
 void user() {
 i += 1;
}
```

9.1.7 NanoJ program example

The example shows the programming of a square wave signal in object 2500_h:01_h.

```
// file main.cpp
map S32 outputReg1 as inout 0x2500:1
#include "wrapper.h"

// user program
void user()
{
  U16 counter = 0;
  while( 1 )
  {
    ++counter;

    if( counter < 100 )
     InOut.outputReg1 = 0;
    else if( counter < 200 )
      InOut.outputReg1 = 1;
    else
      counter = 0;

    // yield() 5 times (delay 5ms)
    for(U08 i = 0; i < 5; ++i )
      yield();
  }
}// eof
```

You can find other examples at **us.nanotec.com**.

9.2 Mapping in the NanoJ program

With this method, a variable in the *NanoJ program* is linked directly with an entry in the object dictionary. The creation of the mapping must be located at the start of the file here, even before the `#include "wrapper.h"` instruction. A comment is permitted above the mapping.

💡	**Tip**

Nanotec recommends:

- Use mapping if you need to access an object in the object dictionary frequently, e.g., *controlword* 6040$_h$ or *statusword* 6041$_h$.
- The `od_write()` and `od_read()` functions are better suited for accessing objects a single time, see **Accessing the object dictionary**.

9.2.1 Declaration of the mapping

The declaration of the mapping is structured as follows:

```
map <TYPE> <NAME> as <input|output|inout> <INDEX>:<SUBINDEX>
```

Where:

- ```
  <TYPE>
  ```

  The data type of the variable; U32, U16, U08, S32, S16 or S08.
- `<NAME>`
  The name of the variable as it is used in the user program.
- ```
  <input|output|inout>
  ```

  The read and write permission of a variable: a variable can be declared as an `input`, `output` or `inout`. This defines whether a variable is readable (`input`), writable (`output`) or both (`inout`) and the structure by means of which it must be addressed in the program.
- ```
  <INDEX>:<SUBINDEX>
  ```

  Index and subindex of the object to be mapped in the object dictionary.

Each declared variable is addressed in the user program via one of the three structures: *In*, *Out* or *InOut* depending on the defined write and read direction.

9.2.2 Example of mapping

Example of a mapping and the corresponding variable accesses:

```
map U16 controlWord as output 0x6040:00
map U08 statusWord as input 0x6041:00
map U08 modeOfOperation as inout 0x6060:00

#include "wrapper.h"

void user()
{
  [...]
  Out.controlWord = 1;
  U08 tmpVar = In.statusword;
  InOut.modeOfOperation = tmpVar;
  [...]
}
```

9.2.3 Possible error at `od_write()`

A possible source of errors is a write access with the `od_write()` function (see **System calls in a NanoJ program**) of an object in the object dictionary that was simultaneously created as mapping. The code listed in the following is incorrect:

```
map U16 controlWord as output 0x6040:00
#include " wrapper.h"
void user()
{
 [...]
  Out.controlWord = 1;
  [...]
  od_write(0x6040, 0x00, 5 ); // der Wert wird durch das Mapping
 überschrieben
  [...]
}
```

The line with the `od_write(0x6040, 0x00, 5 );` command has no effect. As described in the introduction, all mappings are copied to the object dictionary at the end of each millisecond.

This results in the following sequence:

1. The `od_write` function writes the value `5` in object 6040$_h$:00$_h$.
2. At the end of the 1 ms cycle, the mapping is written that also specifies object 6040$_h$:00$_h$, however, with the value `1`.
3. From the perspective of the user, the `od_write` command thus serves no purpose.

9.3 System calls in a NanoJ program

With system calls, it is possible to call up functions integrated in the firmware directly from a user program. Because direct code execution is only possible in the protected area of the sandbox, this is implemented via so-called *Cortex-Supervisor-Calls* (Svc Calls). An interrupt is triggered when the function is called. The firmware thus has the possibility of temporarily allowing code execution outside of the sandbox. Developers of user programs do not need to worry about this mechanism – for them, the system calls can be called up like normal C functions. Only the *wrapper.h* file needs to be integrated as usual.

9.3.1 Accessing the object dictionary

void **od_write** (U32 index, U32 subindex, U32 value)

This function writes the transferred value to the specified location in the object dictionary.

index	Index of the object to be written in the object dictionary
subindex	Subindex of the object to be written in the object dictionary
value	Value to be written

ⓘ | **Note** |

It is highly recommended that the processor time be passed on with `yield()` after calling a `od_write()`. The value is immediately written to the OD. For the firmware to be able to trigger actions that are dependent on this, however, it must receive computing time. This, in turn, means that the user program must either be ended or interrupted with `yield()`.

U32 **od_read** (U32 index, U32 subindex)

This function reads the value at the specified location in the object dictionary and returns it.

index	Index of the object to be read in the object dictionary
subindex	Subindex of the object to be read in the object dictionary
Output value	Content of the OD entry

> **ⓘ** **Note**
>
> Active waiting for a value in the object dictionary should always be associated with a `yield()`.

Example

```
while (od_read(2400,2) != 0) // wait until 2400:2 is set
{ yield(); }
```

9.3.2 Process control

```
void yield()
```

This function returns the processor time to the operating system. In the next time slot, the program continues at the location after the call.

```
void sleep (U32 ms)
```

This function returns the processor time to the operating system for the specified number of milliseconds. The user program is then continued at the location after the call.

| ms | Time to be waited in milliseconds |

10 Description of the object dictionary

10.1 Overview

This chapter contains a description of all objects.

You will find information here on:

- Functions
- Object descriptions ("Index")
- Value descriptions ("Subindices")
- Descriptions of bits
- Description of the object

10.2 Structure of the object description

The description of the object entries always has the same structure and usually consists of the following sections:

Function

The function of the object dictionary is briefly described in this section.

Object description

This table provides detailed information on the data type, preset values and similar. An exact description can be found in section "**Object description**"

Value description

This table is only available with the "Array" or "Record" data type and provides exact information about the sub-entries. A more exact description of the entries can be found in section "**Value description**"

Description

Here, more exact information on the individual bits of an entry is provided or any compositions explained. A more exact description can be found in section "**Description**"

10.3 Object description

The object description consists of a table that contains the following entries:

Index

Designates the object index in hexadecimal notation.

Object name

The name of the object.

Object Code

The type of object. This can be one of the following entries:

- VARIABLE: In this case, the object consists of only a variable that is indexed with subindex 0.
- ARRAY: These objects always consists of a subindex 0 – which specifies the number of sub-entries – and the sub-entries themselves, beginning with index 1. The data type within an array never changes, i.e., sub-entry 1 and all subsequent entries are always of the same data type.
- RECORD: These objects always consists of a subindex 0 – which specifies the number of sub-entries – and the sub-entries themselves, beginning with index 1. Unlike an ARRAY, the data type of the sub-entries can vary. This means that, e.g., sub-entry 1 may be of a different data type than sub-entry 2.

- VISIBLE_STRING: The object describes a character string coded in ASCII. The length of the string is specified in subindex 0; the individual characters are stored beginning in subindex 1. These character strings are **not** terminated by a null character.

Data type

The size and interpretation of the object is specified here. The following notation is used for the "VARIABLE" object code:

- A distinction is made between entries that are signed; these are designated with the prefix "SIGNED". For entries that are unsigned, the prefix "UNSIGNED" is used.
- The size of the variable in bits is placed before the prefix and can be 8, 16 or 32.

Savable

Described here is whether this object is savable and, if so, in which category.

Firmware version

The firmware version beginning with which the object is available is entered here.

Change history (ChangeLog)

Any changes to the object are noted here.

There are also the following table entries for the "VARIABLE" data type:

Access

The access restriction is entered here. The following restrictions are available:

- "read/write": The object can both be read as well as written
- "read only": The object can only be read from the object dictionary. It is not possible to set a value.

PDO mapping

Some bus systems, such as CANopen or EtherCAT, support PDO mapping. Described in this table entry is whether the object can be inserted into a mapping and, if so, into which. The following designations are available here:

- "no": The object may not be entered in a mapping.
- "TX-PDO": The object may be entered in an RX mapping.
- "RX-PDO": The object may be entered in a TX mapping.

Allowed values

In some cases, only certain values may be written in the object. If this is the case, these values are listed here. If there are no restrictions, the field is empty.

Preset value

To bring the controller to a secured state when switching on, it is necessary to preset a number of objects with values. The value that is written in the object when the controller is started is noted in this table entry.

10.4 Value description

	Note

For the sake of clarity, a number of subindices are grouped together if the entries all have the same name.

Listed in the table with the "Value description" heading are all data for sub-entries with subindex 1 or higher. The table contains the following entries:

Subindex

Number of the currently written sub-entry.

Name

Name of the sub-entry.

Data type

The size and interpretation of the sub-entry is specified here. The following notation always applies here:

- A distinction is made between entries that are signed; these are designated with the prefix "SIGNED". For entries that are unsigned, the prefix "UNSIGNED" is used.
- The size of the variable in bits is placed before the prefix and can be 8, 16 or 32.

Access

The access restriction for the sub-entry is entered here. The following restrictions are available:

- "read/write": The object can both be read as well as written
- "read only": The object can only be read from the object dictionary. It is not possible to set a value.

PDO mapping

Some bus systems, such as CANopen or EtherCAT, support PDO mapping. Described in this table entry is whether the sub-entry can be inserted into a mapping and, if so, into which. The following designations are available here:

- "no": The object may not be entered in a mapping.
- "TX-PDO": The object may be entered in an RX mapping.
- "RX-PDO": The object may be entered in a TX mapping.

Allowed values

In some cases, only certain values may be written in the sub-entry. If this is the case, these values are listed here. If there are no restrictions, the field is empty.

Preset value

To bring the controller to a secured state when switching on, it is necessary to preset a number of sub-entries with values. The value that is written in the sub-entry when the controller is started is noted in this table entry.

10.5 Description

This section may be present if use requires additional information. If individual bits of an object or sub-entry have different meaning, diagrams as shown in the following example are used.

Example: The object is 8 bits in size; bit 0 and bit 1 have different functions. Bits 2 and 3 are grouped into one function; the same applies for bits 4 to 7.

7	6	5	4	3	2	1	0
Example [4]				Example [2]		B	A

Example [4]

Description of bit 4 up to and including bit 7; these bits are logically related. The 4 in square brackets specifies the number of related bits. A list with possible values and their description is often attached at this point.

Example [2]

Description of bits 3 and 2; these bits are logically related. The 2 in square brackets specifies the number of related bits.

- Value 00_b: The description here applies if bit 2 and bit 3 are "0".
- Value 01_b: The description here applies if bit 2 is "0" and bit 3 is "1".
- Value 10_b: The description here applies if bit 2 is "1" and bit 3 is "0".
- Value 11_b: The description here applies if bit 2 and bit 3 are "1".

B

Description of bit B; no length is specified for a single bit.

A

Description of bit A; bits with a gray background are not used.

1000h Device Type

Function

Describes the controller type.

Object description

Index	1000_h
Object name	Device Type
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	00060192_h
Firmware version	FIR-v1426
Change history	

Description

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
							Motor Type [16]								

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
							Device profile number [16]								
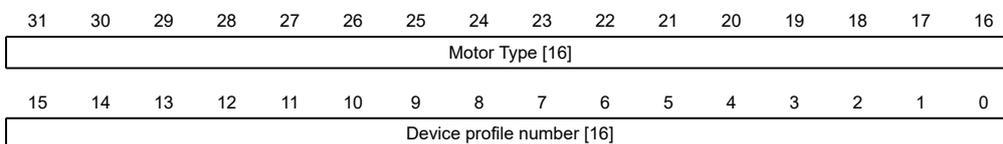
Motor Type[16]

Describes the supported motor type. The following values are possible:

- Bit 23 to bit 16: Value "1": Servo drive
- Bit 23 to bit 16: Value "2": Stepper motor

Device profile number[16]

Describes the supported CANopen standard.

Values:

0192_h or 0402_d (preset value): The CiA 402 standard is supported.

1001h Error Register

Function

Error register: The corresponding error bit is set in case of an error. If the error no longer exists, it is deleted automatically.

Object description

Index	1001_h
Object name	Error Register
Object Code	VARIABLE
Data type	UNSIGNED8
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00_h
Firmware version	FIR-v1426
Change history	

Description

7	6	5	4	3	2	1	0
MAN	RES	PROF	COM	TEMP	VOL	CUR	GEN

GEN

> General error

CUR

> Current

VOL

> Voltage

TEMP

> Temperature

COM

> Communication

PROF

> Relates to the device profile

RES

> Reserved, always "0"

MAN

> Manufacturer-specific: The motor turns in the wrong direction.

1003h Pre-defined Error Field

Function

This object contains an error stack with up to eight entries.

Object description

Index	1003$_h$
Object name	Pre-defined Error Field
Object Code	ARRAY
Data type	UNSIGNED32
Savable	no
Firmware version	FIR-v1426
Change history	

Value description

Subindex	00$_h$
Name	Number Of Errors
Data type	UNSIGNED8
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00$_h$

Subindex	01$_h$
Name	Standard Error Field
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	02$_h$
Name	Standard Error Field
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	03$_h$
Name	Standard Error Field
Data type	UNSIGNED32

Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	04$_h$
Name	Standard Error Field
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	05$_h$
Name	Standard Error Field
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	06$_h$
Name	Standard Error Field
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	07$_h$
Name	Standard Error Field
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	08$_h$
Name	Standard Error Field
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	

Preset value	00000000$_h$

Description

General function

If a new error occurs, it is entered in subindex 1. The already existing entries in subindices 1 to 7 are moved back one position. The error in subindex 7 is thereby removed.

The number of errors that have already occurred can be read from the object with subindex 0. If no error is currently entered in the error stack, it is not possible to read one of the eight subindices 1–8 and an error (abort code = 08000024$_h$) is sent in response. If a "0" is written in subindex 0, counting starts again from the beginning.

Bit description

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Error Number [8]								Error Class [8]							

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Error Code [16]															
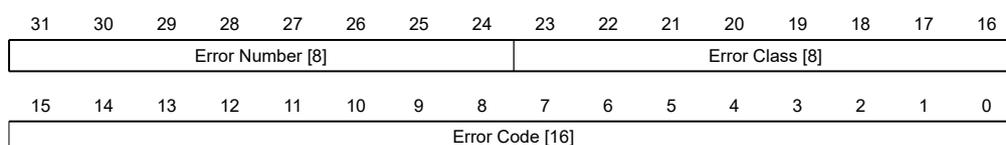
Error Number [8]

This can be used to pinpoint the cause of the error. The meaning of the number can be found in the following table.

Error number	Description
0	Watchdog-Reset
1	Input voltage too high
2	Output current too high
3	Input voltage too low
4	Error at fieldbus
5	Motor turns – in spite of active block – in the wrong direction
6	CANopen only: NMT master takes too long to send nodeguarding request
7	Encoder error due to electrical fault or defective hardware
8	Encoder error; index not found during the auto setup
9	Error in the AB track
10	Positive limit switch and tolerance zone exceeded
11	Negative limit switch and tolerance zone exceeded
12	Device temperature above 80°C
13	The values of object **6065**$_h$ (Following Error Window) and object **6066**$_h$ (Following Error Time Out) were exceeded; a fault was triggered.
14	Warning: Nonvolatile memory full; controller must be restarted for cleanup work.
15	Motor blocked
16	Warning: Nonvolatile memory damaged; controller must be restarted for cleanup work.
17	CANopen only: Slave took too long to send PDO messages.
18	Hall sensor faulty
19	CANopen only: PDO not processed due to a length error
20	CANopen only: PDO length exceeded

Error number	Description
21	Warning: Nonvolatile memory full; controller must be restarted for cleanup work.
22	Rated current must be set ($203B_h$:01_h)
23	Encoder resolution, number of pole pairs and some other values are incorrect.
24	Motor current is too high, adjust the PI parameters.
25	Internal software error, generic
26	Current too high at digital output
27	CANopen only: Unexpected sync length
28	EtherCAT only: The motor was stopped because EtherCAT switched state from OP to either SafeOP or PreOP without first stopping the motor.
30	Error in speed monitoring: slippage error too large

Error Class[8]

This byte is identical to object **1001_h**

Error Code[16]

Refer to the following table for the meaning of the bytes.

Error Code	Description
1000_h	General error
2300_h	Current at the controller output too large
3100_h	Overvoltage/undervoltage at controller input
4200_h	Temperature error within the controller
6010_h	Software reset (watchdog)
6100_h	Internal software error, generic
6320_h	Rated current must be set ($203B_h$:01_h)
7121_h	Motor blocked
7305_h	Incremental encoder or Hall sensor faulty
7600_h	Warning: Nonvolatile memory full or corrupt; restart the controller for cleanup work
8000_h	Error during fieldbus monitoring
8130_h	CANopen only: "Life Guard" error or "Heartbeat" error
8200_h	CANopen only: Slave took too long to send PDO messages.
8210_h	CANopen only: PDO was not processed due to a length error
8220_h	CANopen only: PDO length exceeded
8240_h	CANopen only: Unexpected sync length
8400_h	Error in speed monitoring: slippage error too large
8611_h	Position monitoring error: Following error too large
8612_h	Position monitoring error: Limit switch and tolerance zone exceeded
9000_h	EtherCAT only: The motor was stopped because EtherCAT switched state from OP to either SafeOP or PreOP without first stopping the motor.

1008h Manufacturer Device Name

Function

Contains the device name as character string.

Object description

Index	1008$_h$
Object name	Manufacturer Device Name
Object Code	VARIABLE
Data type	VISIBLE_STRING
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	• N5-1-5: N5-1-5 • N5-2-5: N5-2-5
Firmware version	FIR-v1426
Change history	

1009h Manufacturer Hardware Version

Function

This object contains the hardware version as character string.

Object description

Index	1009$_h$
Object name	Manufacturer Hardware Version
Object Code	VARIABLE
Data type	VISIBLE_STRING
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	0
Firmware version	FIR-v1426
Change history	

100Ah Manufacturer Software Version

Function

This object contains the software version as character string.

Object description

Index	100A$_h$
Object name	Manufacturer Software Version
Object Code	VARIABLE
Data type	VISIBLE_STRING
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	FIR-v1748-B538662
Firmware version	FIR-v1426
Change history	

1010h Store Parameters

Function

This object is used to start the saving of objects. See chapter **Saving objects**.

Object description

Index	1010$_h$
Object name	Store Parameters
Object Code	ARRAY
Data type	UNSIGNED32
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1436: "Object name" entry changed from "Store Parameter" to "Store Parameters".
	Firmware version FIR-v1436: The number of entries was changed from 3 to 4.
	Firmware version FIR-v1512: The number of entries was changed from 4 to 5.
	Firmware version FIR-v1540: The number of entries was changed from 5 to 7.
	Firmware version FIR-v1738-B501312: The number of entries was changed from 7 to 14.

Value description

Subindex	00$_h$

Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	0D$_h$

Subindex	01$_h$
Name	Save All Parameters To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	02$_h$
Name	Save Communication Parameters To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	03$_h$
Name	Save Application Parameters To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	04$_h$
Name	Save Customer Parameters To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	05$_h$
Name	Save Drive Parameters To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write

PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	06$_h$
Name	Save Tuning Parameters To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	07$_h$
Name	Save Miscellaneous Configurations To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	08$_h$
Name	Save Reserved1 Configurations To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	09$_h$
Name	Save Reserved2 Configurations To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	0A$_h$
Name	Save CANopen Configurations To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	0B$_h$
Name	Save Modbus RTU Configurations To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	0C$_h$
Name	Save Ethernet Configurations To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	0D$_h$
Name	Save Profibus Configurations To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Description

Each subindex of the object stands for a certain memory class. By reading out the entry, it is possible to determine whether (value "1") or not (value="0") this memory category can be saved.

To start the save process of a memory category, value "65766173$_h$" must be written in the corresponding subindex. This corresponds to the decimal of 1702257011$_d$ or the ASCII string `save`. As soon as the saving process is completed, the save command is again overwritten with the value "1", since saving is possible again.

For a detailed description, see chapter **Saving objects**.

1011h Restore Default Parameters

Function

This object can be used to reset all or part of the object dictionary to the default values. See chapter **Saving objects**.

Object description

Index	1011$_h$
Object name	Restore Default Parameters
Object Code	ARRAY
Data type	UNSIGNED32

Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1436: "Object Name" entry changed from "Restore Default Parameter" to "Restore Default Parameters".
	Firmware version FIR-v1436: The number of entries was changed from 2 to 4.
	Firmware version FIR-v1512: The number of entries was changed from 4 to 5.
	Firmware version FIR-v1512: "Name" entry changed from "Restore The Comm Default Parameters" to "Restore Communication Default Parameters".
	Firmware version FIR-v1512: "Name" entry changed from "Restore The Application Default Parameters" to "Restore Application Default Parameters".
	Firmware version FIR-v1540: The number of entries was changed from 5 to 7.
	Firmware version FIR-v1738-B501312: The number of entries was changed from 7 to 14.

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	$0D_h$

Subindex	01_h
Name	Restore All Default Parameters
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001_h

Subindex	02_h
Name	Restore Communication Default Parameters
Data type	UNSIGNED32
Access	read / write

PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	03$_h$
Name	Restore Application Default Parameters
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	04$_h$
Name	Restore Customer Default Parameters
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	05$_h$
Name	Restore Drive Default Parameters
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	06$_h$
Name	Restore Tuning Default Parameters
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	07$_h$
Name	Restore Miscellaneous Configurations
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	08$_h$
Name	Restore Reserved1 Configurations To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	09$_h$
Name	Restore Reserved2 Configurations To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	0A$_h$
Name	Restore CANopen Configurations To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	0B$_h$
Name	Restore Modbus RTU Configurations To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	0C$_h$
Name	Restore Ethernet Configurations To Non-volatile Memory
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	0D$_h$
Name	Restore Profibus Configurations To Non-volatile Memory
Data type	UNSIGNED32

Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001_h

Description

If the value $64616F6C_h$ (or 1684107116_d or ASCII `load`) is written in this object, part or all of the object dictionary is reset to the default values. The subindex that is used decides which range is reset.

For a detailed description, see chapter **Discarding the saved data**.

1018h Identity Object

Function

This object returns general information on the device, such as manufacturer, product code, revision and serial number.

	Tip
	Have these values ready in the event of service inquiries.

Object description

Index	1018_h
Object name	Identity Object
Object Code	RECORD
Data type	IDENTITY
Savable	no
Firmware version	FIR-v1426
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	04_h

Subindex	01_h
Name	Vendor-ID
Data type	UNSIGNED32
Access	read only

PDO mapping	no
Allowed values	
Preset value	0000026C$_h$

Subindex	02$_h$
Name	Product Code
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	• N5-1-5: 00000054$_h$ • N5-2-5: 00000055$_h$

Subindex	03$_h$
Name	Revision Number
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	06D40000$_h$

Subindex	04$_h$
Name	Serial Number
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

1020h Verify Configuration

Function

This object indicates the date and time that the configuration was stored.

A configuration tool or a master can use this object to verify the configuration after a reset and, if necessary, perform a new configuration.

The tool must set the date and time before the storage mechanism is started (see chapter **Saving objects**).

Object description

Index	1020$_h$
Object name	Verify Configuration
Object Code	ARRAY
Data type	UNSIGNED32

Savable	yes, category: verify
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1540
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02_h

Subindex	01_h
Name	Configuration Date
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000_h

Subindex	02_h
Name	Configuration Time
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000_h

Description

Subindex 01_h (configuration date) is to contain the number of days since 1 January 1984.

Subindex 02_h (configuration time) is to contain the number of milliseconds since midnight.

1F50h Program Data

Function

This object is used to program memory areas of the controller. Each entry stands for a certain memory area.

Object description

Index	1F50$_h$
Object name	Program Data
Object Code	ARRAY
Data type	DOMAIN
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1540
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	03$_h$

Subindex	01$_h$
Name	Program Data Bootloader/firmware
Data type	DOMAIN
Access	read / write
PDO mapping	no
Allowed values	
Preset value	0

Subindex	02$_h$
Name	Program Data NanoJ
Data type	DOMAIN
Access	read / write
PDO mapping	no
Allowed values	
Preset value	0

Subindex	03$_h$
Name	Program Data DataFlash
Data type	DOMAIN
Access	read / write

PDO mapping	no
Allowed values	
Preset value	0

1F51h Program Control

Function

This object is used to control the programming of memory areas of the controller. Each entry stands for a certain memory area.

Object description

Index	$1F51_h$
Object name	Program Control
Object Code	ARRAY
Data type	UNSIGNED8
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1540
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	03_h

Subindex	01_h
Name	Program Control Bootloader/firmware
Data type	UNSIGNED8
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00_h

Subindex	02_h
Name	Program Control NanoJ

Data type	UNSIGNED8
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00$_h$

Subindex	03$_h$
Name	Program Control DataFlash
Data type	UNSIGNED8
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00$_h$

1F57h Program Status

Function

This object indicates the programming status during the programming of memory areas of the controller. Each entry stands for a certain memory area.

Object description

Index	1F57$_h$
Object name	Program Status
Object Code	ARRAY
Data type	UNSIGNED32
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1540
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	03$_h$

Subindex	01h
Name	Program Status Bootloader/firmware
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000h

Subindex	02h
Name	Program Status NanoJ
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000h

Subindex	03h
Name	Program Status DataFlash
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000h

200Fh IEEE 802 MAC Address

Function

This object contains the MAC address of the controller as a character string.

Object description

Index	200Fh
Object name	IEEE 802 MAC Address
Object Code	VARIABLE
Data type	VISIBLE_STRING
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	0
Firmware version	FIR-v1748-B533384
Change history	

2010h IP-Configuration

Function

This object is used to configure the Ethernet interface.

Object description

Index	2010_h
Object name	IP-Configuration
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: Ethernet
Access	read / write
PDO mapping	no
Allowed values	
Preset value	$0000006C_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1748-B533384: "Savable" entry changed from "yes, category: communication" to "yes, category: Ethernet".

Description

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
									LLMNR	NBIOS		AUTO	DHCP		IP
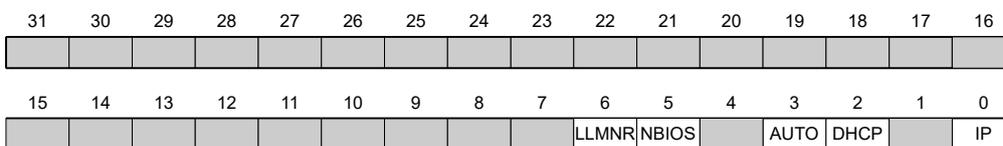
IP

Value = "1": A static IP address from object 2011_h is used and the network mask from object 2012_h is used.

UPnP

Value = "1": The UPnP (Universal Plug and Play) messages are activated

DHCP

Value = "1": IP address assignment using a DHCP server is activated

AUTO

Value = "1": IP address assignment using the AUTO-IP protocol is activated

EXT

Value = "1": The IP address was set externally by NanoFlash and applies only until the controller is restarted again.

NBIOS

Value = "1": The NetBIOS protocol is activated; this is necessary before resolving a hostname (e.g., with a ping command).

LLMNR

Value = "1": The LLMNR protocol is activated; this is necessary before resolving a hostname (e.g., with a ping command).

2011h Static-IPv4-Address

Function

Contains the static IPv4 address in the form of a 32-bit word.

Object description

Index	2011_h
Object name	Static-IPv4-Address
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: Ethernet
Access	read / write
PDO mapping	no
Allowed values	
Preset value	$C0A80792_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1450: "Object name" entry changed from "Static-IP-Address" to "Static-IPv4-Address".
	Firmware version FIR-v1748-B533384: "Savable" entry changed from "yes, category: communication" to "yes, category: Ethernet".

Description

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
IP Address Part 1 [8]								IP Address Part 2 [8]							

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IP Address Part 3 [8]								IP Address Part 4 [8]							

IP Address Part 1 [8]

Specifies the first part of the IP address

IP Address Part 2 [8]

Specifies the second part of the IP address

IP Address Part 3 [8]

Specifies the third part of the IP address

IP Address Part 4 [8]

Specifies the fourth part of the IP address

Example

Address `192.168.2.0` is first converted to hexadecimal format, resulting in the following configuration value:

192 => $C0_h$

168 => $A8_h$

2 => 02_h

0 => 0

The corresponding adjustment value is then `C0A80200`$_h$.

2012h Static-IPv4-Subnet-Mask

Function

Contains the subnet mask of the static IP address in the form of a 32-bit word.

Object description

Index	2012$_h$
Object name	Static-IPv4-Subnet-Mask
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: Ethernet
Access	read / write
PDO mapping	no
Allowed values	
Preset value	FFFFFF00$_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1450: "Object name" entry changed from "Static-IP-Subnet-Mask" to "Static-IPv4-Subnet-Mask".
	Firmware version FIR-v1748-B533384: "Savable" entry changed from "yes, category: communication" to "yes, category: Ethernet".

Description

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Subnet Mask Part 1 [8]								Subnet Mask Part 2 [8]							

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Subnet Mask Part 3 [8]								Subnet Mask Part 4 [8]							

Subnet Mask Part 1 [8]
Specifies the first part of the subnet mask

Subnet Mask Part 2 [8]
Specifies the second part of the subnet mask

Subnet Mask Part 3 [8]
Specifies the third part of the subnet mask

Subnet Mask Part 4 [8]
Specifies the fourth part of the subnet mask

Example

The class C network mask `255.255.255.0` is first converted to hexadecimal format, resulting in the following configuration value:

255 => FF$_h$

0 => 0

The corresponding adjustment value is then `FFFFFF00`$_h$.

2013h Static-IPv4-Gateway-Address

Function

Contains the static IP gateway address in the form of a 32-bit word.

Object description

Index	2013$_h$
Object name	Static-IPv4-Gateway-Address
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: Ethernet
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1446
Change history	Firmware version FIR-v1512: "Object name" entry changed from "Static-IP-Gateway-Address" to "Static-IPv4-Gateway-Address". Firmware version FIR-v1748-B533384: "Savable" entry changed from "yes, category: communication" to "yes, category: Ethernet".

Description

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
IP-Gateway-Address Part 1 [8]								IP-Gateway-Address Part Part 2 [8]							

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IP-Gateway-Address Part 3 [8]								IP-Gateway-Address Part Part 4 [8]							

IP-Gateway-Address Part 1 [8]
Specifies the first part of the IP gateway address

IP-Gateway-Address Part 2 [8]
Specifies the second part of the IP gateway address

IP-Gateway-Address Part 3 [8]
Specifies the third part of the IP gateway address

IP-Gateway-Address Part 4 [8]
Specifies the fourth part of the IP gateway address

Example

Address `192.168.2.0` is first converted to hexadecimal format, resulting in the following configuration value:

192 => C0$_h$

168 => A8$_h$

2 => 02$_h$

0 => 0

The corresponding adjustment value is then `C0A80200`$_h$.

2014h Current-IPv4-Address

Function

Contains the currently active IP address in the form of a 32-bit word.

Object description

Index	2014$_h$
Object name	Current-IPv4-Address
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1450: "Object name" entry changed from "Current-IP-Address" to "Current-IPv4-Address".

Description

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
IP Address Part 1 [8]								IP Address Part 2 [8]							

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
IP Address Part 3 [8]								IP Address Part 4 [8]							

IP Address Part 1 [8]
Specifies the first part of the IP address

IP Address Part 2 [8]
Specifies the second part of the IP address

IP Address Part 3 [8]
Specifies the third part of the IP address

IP Address Part 4 [8]
Specifies the fourth part of the IP address

Example

Address `192.168.2.0` is first converted to hexadecimal format, resulting in the following configuration value:

192 => C0$_h$

168 => A8$_h$

2 => 02$_h$

0 => 0

The corresponding adjustment value is then `C0A80200`$_h$.

2015h Current-IPv4-Subnet-Mask

Function

Contains the currently active subnet mask of the static IP address in the form of a 32-bit word.

Object description

Index	2015$_h$
Object name	Current-IPv4-Subnet-Mask
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1450: "Object name" entry changed from "Current-IP-Subnet-Mask" to "Current-IPv4-Subnet-Mask".

Description

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Subnet Mask Part 1 [8]								Subnet Mask Part 2 [8]							

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Subnet Mask Part 3 [8]								Subnet Mask Part 4 [8]							

Subnet Mask Part 1 [8]

Specifies the first part of the subnet mask

Subnet Mask Part 2 [8]

Specifies the second part of the subnet mask

Subnet Mask Part 3 [8]

Specifies the third part of the subnet mask

Subnet Mask Part 4 [8]

Specifies the fourth part of the subnet mask

Example

The class C network mask `255.255.255.0` is first converted to hexadecimal format, resulting in the following configuration value:

255 => FF$_h$

0 => 0

The corresponding adjustment value is then `FFFFFF00`$_h$.

2016h Current-IPv4-Gateway-Address

Function

This object contains the currently active gateway IP address in the form of a 32-bit word.

Object description

Index	2016$_h$
Object name	Current-IPv4-Gateway-Address
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1540
Change history	

2028h MODBUS Slave Address

Function

This object contains the slave address for Modbus. See chapter **Communication settings**.

Object description

Index	2028$_h$
Object name	MODBUS Slave Address
Object Code	VARIABLE
Data type	UNSIGNED8
Savable	yes, category: Modbus RTU
Access	read / write
PDO mapping	no
Allowed values	1-247

Preset value	05h
Firmware version	FIR-v1436
Change history	Firmware version FIR-v1748-B531667: "Savable" entry changed from "yes, category: communication" to "yes, category: Modbus RTU".

202Ah MODBUS RTU Baudrate

Function

This object contains the baud rate of the Modbus in Bd. See chapter **Communication settings**.

Object description

Index	202Ah
Object name	MODBUS RTU Baudrate
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: Modbus RTU
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00004B00h
Firmware version	FIR-v1436
Change history	Firmware version FIR-v1748-B531667: "Savable" entry changed from "yes, category: communication" to "yes, category: Modbus RTU".

202Ch MODBUS RTU Stop Bits

Function

This object contains the number of stop bits of the Modbus.

Object description

Index	202Ch
Object name	MODBUS RTU Stop Bits
Object Code	VARIABLE
Data type	UNSIGNED8
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	01h
Firmware version	FIR-v1436
Change history	Firmware version FIR-v1540: "Savable" entry changed from "yes, category: communication" to "no".

Firmware version FIR-v1540: "Access" table entry for subindex 00 changed from "read/write" to "read only".

Description

The number of stop bits is dependent on the parity, which can be set in object **202D**$_h$.

Number of stop bits	Value in object 202C$_h$
1	0
2	2

202Dh MODBUS RTU Parity

Function

For Modbus RTU, this object sets the number of parity bits and stop bits.

Object description

Index	202D$_h$
Object name	MODBUS RTU Parity
Object Code	VARIABLE
Data type	UNSIGNED8
Savable	yes, category: Modbus RTU
Access	read / write
PDO mapping	no
Allowed values	
Preset value	04$_h$
Firmware version	FIR-v1540
Change history	Firmware version FIR-v1748-B531667: "Savable" entry changed from "yes, category: communication" to "yes, category: Modbus RTU".

Description

The following values apply:

- Value "0x00": Parity None, Stop Bits 2
- Value "0x04": Parity Even, Stop Bits 1
- Value "0x06": Parity Odd, Stop Bits 1

2030h Pole Pair Count

Function

Contains the number of pole pairs of the connected motor.

Object description

Index	2030$_h$

Object name	Pole Pair Count
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: tuning
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000032$_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1540: "Savable" entry changed from "no" to "yes, category: tuning".

2031h Maximum Current

Function

If I^2t monitoring is not active, the rms current specified in the motor data sheet is entered here in mA. If Closed Loop mode is used or if I^2t monitoring is activated, the maximum current value is specified here in mA.

Within the controller, the entered value is always interpreted as the root mean square.

Object description

Index	2031$_h$
Object name	Maximum Current
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: tuning
Access	read / write
PDO mapping	no
Allowed values	
Preset value	• N5-1-5: 000003E8$_h$ • N5-2-5: 00000708$_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1614: "Savable" entry changed from "yes, category: application" to "yes, category: tuning". Firmware version FIR-v1614: "Object Name" entry changed from "Peak Current" to "Max Current".

2034h Upper Voltage Warning Level

Function

This object contains the threshold value for the "overvoltage" error in millivolts.

Object description

Index	2034$_h$
Object name	Upper Voltage Warning Level
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	• N5-1-5: 000128E0$_h$ • N5-2-5: 0000C92C$_h$
Firmware version	FIR-v1426
Change history	

Description

If the input voltage of the controller exceeds this threshold value, the motor is switched off and an error triggered. This error is reset automatically if the input voltage is less than (voltage of object 2034$_h$ minus 2 volts).

2035h Lower Voltage Warning Level

Function

This object contains the threshold value for the "Undervoltage" error in millivolts.

Object description

Index	2035$_h$
Object name	Lower Voltage Warning Level
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00002710$_h$
Firmware version	FIR-v1426
Change history	

Description

If the input voltage of the controller falls below this threshold value, the motor is switched off and an error triggered. The error is reset automatically if the input voltage exceeds the voltage of object 2035$_h$ plus 2 volts.

2036h Open Loop Current Reduction Idle Time

Function

This object describes the time in milliseconds that the motor must be at a standstill before current reduction is activated.

Object description

Index	2036_h
Object name	Open Loop Current Reduction Idle Time
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	$000003E8_h$
Firmware version	FIR-v1426
Change history	

2037h Open Loop Current Reduction Value/factor

Function

This object describes the rms current to which the motor current is to be reduced if current reduction is activated in open loop (bit 3 in 3202_h = "1") and the motor is at a standstill.

Object description

Index	2037_h
Object name	Open Loop Current Reduction Value/factor
Object Code	VARIABLE
Data type	INTEGER32
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	$FFFFFFCE_h$
Firmware version	FIR-v1426
Change history	

Description

Value of 2037_h greater than or equal to 0 and less than value 2031_h

Current is reduced to the value entered here. The value is in mA and interpreted as root mean square.

Value of 2037$_h$ in the range from -1 to -100

The entered value is interpreted as a percentage and determines the reduction of the rated current in **2037$_h$**. The value in **2031$_h$** is used for the calculation.

Example: Object **2031$_h$** has the value 4200 mA. The value -60 in **2037$_h$** reduces the current by 60% of **2031$_h$**. The result is a current reduction to a root mean square of **2031$_h$** * (**2037$_h$** + 100) / 100 = 1680 mA.

The value -100 in **2037$_h$** would, for example, mean that a current reduction is set to a root mean square of 0 mA.

	Note
ⓘ	

If the rated current is greater than 0 in **203B$_h$**:01, the smaller of **2031$_h$** and **203B$_h$**:01 is used as the rated current for calculating the current reduction.

2038h Brake Controller Timing

Function

This object contains the times for the *brake control* in milliseconds as well as the PWM frequency and the duty cycle.

Object description

Index	2038$_h$
Object name	Brake Controller Timing
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Firmware version	FIR-v1426
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	06$_h$

Subindex	01$_h$
Name	Close Brake Idle Time
Data type	UNSIGNED32
Access	read / write
PDO mapping	no

Allowed values	
Preset value	000003E8$_h$

Subindex	02$_h$
Name	Shutdown Power Idle Time
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	000003E8$_h$

Subindex	03$_h$
Name	Open Brake Delay Time
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	000003E8$_h$

Subindex	04$_h$
Name	Start Operation Delay Time
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	05$_h$
Name	PWM Frequency
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	between 0 and 2000 (7D0$_h$)
Preset value	00000000$_h$

Subindex	06$_h$
Name	PWM Duty Cycle
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	0, between 2 and 100 (64$_h$)
Preset value	00000000$_h$

Description

The subindices have the following functions:

- 01_h: Time between motor standstill and the closing of the brake.
- 02_h: Time between the closing of the brake and the switching off of the motor current.
- 03_h: Time between the switching on of the motor current and opening of the brake.
- 04_h: Time between the opening of the brake and when the *Operation enabled* state of the **CiA 402 Power State Machine** is reached.
- 05_h: Frequency of the brake PWM in hertz.
- 06_h: Duty cycle of the brake PWM in percent.

2039h Motor Currents

Function

This object contains the measured motor currents in mA.

Object description

Index	2039_h
Object name	Motor Currents
Object Code	ARRAY
Data type	INTEGER32
Savable	no
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1504: "PDO mapping" table entry for subindex 01 changed from "no" to "TX-PDO".
	Firmware version FIR-v1504: "PDO mapping" table entry for subindex 02 changed from "no" to "TX-PDO".
	Firmware version FIR-v1504: "PDO mapping" table entry for subindex 03 changed from "no" to "TX-PDO".
	Firmware version FIR-v1504: "PDO mapping" table entry for subindex 04 changed from "no" to "TX-PDO".

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	04_h

Subindex	01_h
Name	I_d
Data type	INTEGER32

Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000_h

Subindex	02_h
Name	I_q
Data type	INTEGER32
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000_h

Subindex	03_h
Name	I_a
Data type	INTEGER32
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000_h

Subindex	04_h
Name	I_b
Data type	INTEGER32
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000_h

Description

> **Note**
>
> Motor currents I_d (subindex 01_h) and I_q (subindex 02_h) are only displayed if **closed loop** was activated; the value 0 is otherwise output.

203Ah Homing On Block Configuration

Function

This object contains the parameters for *Homing on Block* (see chapter **Homing**)

Object description

Index	$203A_h$

Object name	Homing On Block Configuration
Object Code	ARRAY
Data type	INTEGER32
Savable	yes, category: application
Access	
PDO mapping	
Allowed values	
Preset value	
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1540: The number of entries was changed from 4 to 3.
	Firmware version FIR-v1540: "Name" entry changed from "Period Of Blocking" to "Block Detection time".
	Firmware version FIR-v1614: "Data Type" entry changed from "UNSIGNED32" to "INTEGER32".
	Firmware version FIR-v1614: "Savable" entry changed from "no" to "yes, category: application".
	Firmware version FIR-v1614: "Data Type" entry changed from "UNSIGNED32" to "INTEGER32".
	Firmware version FIR-v1614: "Data Type" entry changed from "UNSIGNED32" to "INTEGER32".

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02_h

Subindex	01_h
Name	Minimum Current For Block Detection
Data type	INTEGER32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	$FFFFFFBA_h$

Subindex	02_h
Name	Block Detection Time
Data type	INTEGER32
Access	read / write
PDO mapping	no

Allowed values	
Preset value	000000C8$_h$

Description

The subindices have the following function:

- 01$_h$: Specifies the current limit value above which blocking is to be detected. Positive numerical values specify the current limit in mA, negative numbers specify a percentage of object **2031**$_h$:01$_h$. Example: The value "1000" corresponds to 1000 mA (= 1 A); the value "-70" corresponds to 70% of **2031**$_h$.
- 02$_h$: Specifies the time in ms that the motor is to continue to travel against the block after block detection.

203Bh I2t Parameters

Function

This object contains the parameters for I^2t monitoring.

I^2t monitoring is activated by entering a value greater than 0 in **203B**$_h$:01 and **203B**$_h$:02 (see **I2t Motor overload protection**).

With one exception, I^2t monitoring can only be used for *closed loop* mode: If I^2t is activated in *open loop* mode, the current is reduced to the smaller of **203B**$_h$ and **2031**$_h$.

Object description

Index	203B$_h$
Object name	I2t Parameters
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: tuning
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1512: "Savable" entry changed from "no" to "yes, category: application".
	Firmware version FIR-v1512: The number of entries was changed from 7 to 8.
	Firmware version FIR-v1614: "Savable" entry changed from "yes, category: application" to "yes, category: tuning".

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	07$_h$

Subindex	01$_h$
Name	Nominal Current
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	02$_h$
Name	Maximum Duration Of Peak Current
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	03$_h$
Name	Threshold
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	04$_h$
Name	CalcValue
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	05$_h$
Name	LimitedCurrent
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	06$_h$
Name	Status
Data type	UNSIGNED32

Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000_h

Subindex	07_h
Name	ActualResistance
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000_h

Description

The subindices are divided into two groups: subindex 01_h and 02_h contain parameters for the control, subindices 03_h to 06_h are status values. The functions are as follows:

- 01_h: The rated current specified in the motor data sheet is entered here in mA. This must be smaller than the current entered in object **2031**$_h$, otherwise monitoring is not activated. The specified value is interpreted as root mean square.
- 02_h: Specifies the maximum duration of the peak current in ms.
- 03_h: Threshold, specifies the limit in mA that determines whether the maximum current or rated current is switched to.
- 04_h: CalcValue, specifies the calculated value that is compared with the threshold for setting the current.
- 05_h: LimitedCurrent, contains the momentary current as root mean square set by I^2t.
- 06_h: Current status. If the sub-entry value is "0", I^2t is deactivated; if the value is "1", I^2t is activated.

203Dh Torque Window

Function

Specifies a symmetrical range relative to the target torque within which the target is considered having been met.

If the value is set to "FFFFFFFF"$_h$, monitoring is switched off, the "Target reached" bit in object **6041**$_h$ (statusword) is never set.

Object description

Index	$203D_h$
Object name	Torque Window
Object Code	VARIABLE
Data type	UNSIGNED16
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000_h
Firmware version	FIR-v1540

Change history	Firmware version FIR-v1614: "Savable" entry changed from "no" to "yes, category: application".

203Eh Torque Window Time Out

Function

The current torque must be within the "Torque Window" (**203D**$_h$) for this time (in milliseconds) for the target torque to be considered having been met.

Object description

Index	203E$_h$
Object name	Torque Window Time Out
Object Code	VARIABLE
Data type	UNSIGNED16
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$
Firmware version	FIR-v1540
Change history	Firmware version FIR-v1614: "Savable" entry changed from "no" to "yes, category: application".
	Firmware version FIR-v1738-B501312: "Object Name" entry changed from "Torque Window Time" to "Torque Window Time Out".

203Fh Max Slippage Time Out

Function

Time in milliseconds until an excessively large slippage error in **Profile Velocity** mode results in an error message.

Object description

Index	203F$_h$
Object name	Max Slippage Time Out
Object Code	VARIABLE
Data type	UNSIGNED16
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0064$_h$
Firmware version	FIR-v1738-B501312
Change history	

Description

If the actual speed deviates so much from the set speed that the value (absolute value) of this object is exceeded, bit 13 in object **6041**$_h$ is set. The deviation must last longer than the time in object **203F**$_h$.

A reaction to the slippage error can be set in object **3700**$_h$. If a reaction is defined, an error is also entered in object **1003**$_h$.

2056h Limit Switch Tolerance Band

Function

Specifies how far a limit switch may be passed over in the positive or negative direction before the controller triggers an error.

This tolerance band is necessary, for example, to complete homing operations – in which limit switches can be actuated – error free.

Object description

Index	2056$_h$
Object name	Limit Switch Tolerance Band
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	TX-PDO
Allowed values	
Preset value	000001F4$_h$
Firmware version	FIR-v1426
Change history	

2057h Clock Direction Multiplier

Function

The clock count value in **Clock-direction mode** is multiplied by this value before it is processed further.

Object description

Index	2057$_h$
Object name	Clock Direction Multiplier
Object Code	VARIABLE
Data type	INTEGER32
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000080$_h$
Firmware version	FIR-v1426
Change history	

2058h Clock Direction Divider

Function

The clock count value in **Clock-direction mode** is divided by this value before it is processed further.

Object description

Index	2058_h
Object name	Clock Direction Divider
Object Code	VARIABLE
Data type	INTEGER32
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001_h
Firmware version	FIR-v1426
Change history	

2059h Encoder Configuration

Function

This object can be used to switch the supply voltage and the type of encoder.

Object description

Index	2059_h
Object name	Encoder Configuration
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: tuning
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000_h
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1614: "Savable" entry changed from "yes, category: application" to "yes, category: tuning".

Description

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
														TYPE	VOLT

VOLT

If this bit is set to the value "0", the supply voltage for the encoder is set to 5 V. If the bit is set to the value "1", the supply voltage is set to 24 V.

TYPE

Defines the type of encoder. For a differential encoder, the bit must have the value "0". For a single-ended encoder, the bit must be set to "1".

205Ah Absolute Sensor Boot Value (in User Units)

Function

Tip
This object only has a function when using an absolute encoder. If an absolute encoder is not used, the value is always 0.

The initial encoder position when switching on the controller (in **user-defined units**) can be read from this object.

Object description

Index	205A$_h$
Object name	Absolute Sensor Boot Value (in User Units)
Object Code	VARIABLE
Data type	INTEGER32
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1446
Change history	Firmware version FIR-v1512: "Access" table entry for subindex 00 changed from "read/write" to "read only".
	Firmware version FIR-v1738-B501312: "Object Name" entry changed from "Encoder Boot Value" to "Absolute Sensor Boot Value (in User Units)".
	Firmware version FIR-v1738-B501312: "Data type" entry changed from "UNSIGNED32" to "INTEGER32".

205Bh Clock Direction Or Clockwise/Counter Clockwise Mode

Function

This object can be used to switch the clock-direction mode (value = "0") to the **right/left rotation mode** (value = "1").

Object description

Index	205B$_h$
Object name	Clock Direction Or Clockwise/Counter Clockwise Mode
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1504
Change history	

2084h Bootup Delay

Function

Defines the period between the time that supply voltage is applied to the controller and the functional readiness of the controller in milliseconds.

Object description

Index	2084$_h$
Object name	Bootup Delay
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1426
Change history	

2101h Fieldbus Module Availability

Function

Shows the available fieldbuses.

Object description

Index	2101$_h$
Object name	Fieldbus Module Availability
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	no

Access	read only
PDO mapping	no
Allowed values	
Preset value	00010012_h
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1626: "Object Name" entry changed from "Fieldbus Module" to "Fieldbus Module Availability".

Description

Bits 0 to 15 represent the physical interface, bits 16 to 31 the used protocol (if necessary).

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
													E-IP	MTCP	MRTU

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
									SPI	E-CAT	E-NET	CAN	RS232	RS485	USB

USB

Value = "1": The USB fieldbus is available.

RS-485

Value = "1": An RS-485 interface is available.

RS-232

Value = "1": An RS-232 interface is available.

CAN

Value = "1": The CANopen fieldbus is available.

E-NET

Value = "1": An Ethernet interface is available.

E-CAT

Value = "1": An EtherCAT interface is available.

SPI

Value = "1": An SPI interface is available.

MRTU

Value = "1": The used protocol is Modbus RTU.

MTCP

Value = "1": The used protocol is Modbus TCP.

E-IP

Value = "1": The used protocol is EtherNet/IP™.

2102h Fieldbus Module Control

Function

This object can be used to activate/deactivate certain fieldbuses (physical interfaces and protocols).

Object description

Index	2102_h
Object name	Fieldbus Module Control
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: communication
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00010012_h
Firmware version	FIR-v1540
Change history	Firmware version FIR-v1626: "Savable" entry changed from "yes, category: application" to "yes, category: communication".

Description

Object 2103_h:1_h contains all physical interfaces/protocols that can be activated/deactivated. These can be switched in this object (2102_h). The current status of the activated fieldbuses is in object 2103_h:2_h.

The following distribution of the bits applies here:

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
													E-IP	MTCP	MRTU

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
									SPI	E-CAT	E-NET	CAN	RS232	RS485	USB

USB

USB interface

RS-485

RS-485 interface

RS-232

RS-232 interface

CAN

CANopen interface

E-NET

EtherNet interface

E-CAT

EtherCAT interface

SPI

SPI interface

MRTU

Modbus RTU protocol

MTCP

Modbus TCP protocol

E-IP

EtherNet/IP™ protocol

2103h Fieldbus Module Status

Function

Shows the active fieldbuses.

Object description

Index	2103_h
Object name	Fieldbus Module Status
Object Code	ARRAY
Data type	UNSIGNED32
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1540
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02_h

Subindex	01_h
Name	Fieldbus Module Disable Mask
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000012_h

Subindex	02_h
Name	Fieldbus Module Enabled

Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00010012_h

Description

Subindex 1 (Fieldbus Module Disable Mask): This subindex contains all physical interfaces and protocols that can be activated or deactivated. A value "1" means that this fieldbus can be deactivated.

Subindex 2 (Fieldbus Module Enabled): This subindex contains all currently activated physical interfaces and protocols. The value "1" means that that the fieldbus is active.

The following distribution of the bits applies for subindices 1 and 2:
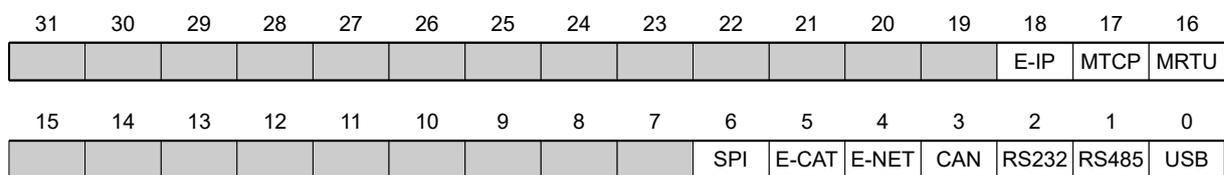
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
													E-IP	MTCP	MRTU

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
									SPI	E-CAT	E-NET	CAN	RS232	RS485	USB

USB

USB interface

RS-485

RS-485 interface

RS-232

RS-232 interface

CAN

CANopen interface

E-NET

EtherNet interface

E-CAT

EtherCAT interface

SPI

SPI interface

MRTU

Modbus RTU protocol

MTCP

Modbus TCP protocol

E-IP

EtherNet/IP™ protocol

2300h NanoJ Control

Function

Controls the execution of a NanoJ program.

Object description

Index	2300_h
Object name	NanoJ Control
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000_h
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1436: "Object Name" entry changed from "VMM Control" to "NanoJ Control".

Description

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
															ON
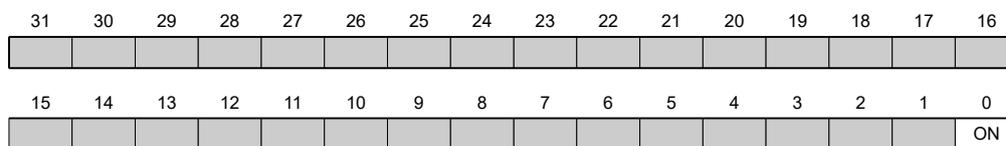
ON

Switches the NanoJ program on (value = "1") or off (value = "0").

With a rising edge in bit 0, the program is first reloaded and the variable range reset.

> ⓘ **Note**
>
> Startup of the NanoJ program can take up to 200 ms.

2301h NanoJ Status

Function

Indicates the operating state of the user program.

Object description

Index	2301_h
Object name	NanoJ Status
Object Code	VARIABLE

Data type	UNSIGNED32
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1436: "Object Name" entry changed from "VMM Status" to "NanoJ Status".

Description

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
													ERR	RES	RUN
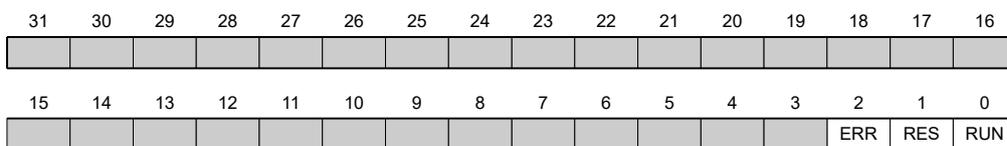
RUN

Value = "0": Program is stopped, value = "1": NanoJ program is running.

RES

Reserved.

ERR

Program was ended with an error. Cause of the error can be read from object **2302**$_h$.

2302h NanoJ Error Code

Function

Indicates which error occurred during the execution of the user program.

Object description

Index	2302$_h$
Object name	NanoJ Error Code
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1436: "Object Name" entry changed from "VMM Error Code" to "NanoJ Error Code".

Description

Error codes during program execution:

Number	Description
0000$_h$	Not an error
0001$_h$	Firmware does not (yet) support the used function
0002$_h$	Not or incorrectly initialized pointer
0003$_h$	Impermissible access to system resource
0004$_h$	Hard fault (internal error)
0005$_h$	Code executed too long without yield() or sleep()
0006$_h$	Impermissible access to system resource
0007$_h$	Too many variables on the stack
0100$_h$	Invalid NanoJ program file

Error when accessing an object:

Number	Description
1xxxxyy$_h$	Invalid mapping in the NanoJ program file: The value in "xxxx" specifies the index, the value in "yy" specifies the subindex of the object that should – but cannot – be mapped.
1000$_h$	Access of a nonexistent object in the object dictionary
1001$_h$	Write access of a write-protected entry in the OD
1002$_h$	Internal file system error

File system error codes when loading the user program:

Number	Description
10002$_h$	Internal file system error
10003$_h$	Storage medium not ready
10004$_h$	File not found
10005$_h$	Folder not found
10006$_h$	Invalid file name/folder name
10008$_h$	Access of file not possible
10009$_h$	File/directory object is invalid
1000A$_h$	Storage medium is read-only
1000B$_h$	Drive number is invalid
1000C$_h$	Working range of the drive is invalid
1000D$_h$	No valid file system on the drive
1000E$_h$	Creation of the file system failed
1000F$_h$	Access not possible within the required time
10010$_h$	Access was rejected

230Fh Uptime Seconds

Function

This object contains the operating time in seconds since the last time the controller was started.

	Note
ⓘ	This object is not stored; counting begins with "0" again after switching on.

Object description

Index	230F$_h$
Object name	Uptime Seconds
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1436
Change history	

2310h NanoJ Input Data Selection

Function

Describes the object dictionary entries that are copied to the PDO mapping input of the NanoJ program.

Object description

Index	2310$_h$
Object name	NanoJ Input Data Selection
Object Code	ARRAY
Data type	UNSIGNED32
Savable	no
Access	read / write
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1650-B472161
Change history	Firmware version FIR-v1436: "Object Name" entry changed from "VMM Input Data Selection" to "NanoJ Input Data Selection".
	Firmware version FIR-v1650-B472161: "Savable" entry changed from "yes, category: application" to "no".

Firmware version FIR-v1650-B472161: "Access" table entry for subindex 00 changed from "read/write" to "read only".

Firmware version FIR-v1650-B472161: "Access" table entry for subindex 01 changed from "read/write" to "read only".

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	10$_h$

Subindex	01$_h$ - 10$_h$
Name	Mapping #1 - #16
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Description

Each subindex (1–16) describes a different mapped object.

A mapping entry consists of four bytes, which are structured according to the following graphic.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
							Index [16]								

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
			SubIndex [8]								Length [8]				

Index [16]

This contains the index of the object to be mapped.

Subindex [8]

This contains the subindex of the object to be mapped.

Length [8]

This contains the length of the object to be mapped in units of bits.

2320h NanoJ Output Data Selection

Function

Describes the object dictionary entries that are copied into the output PDO mapping of the *NanoJ program* after it is executed.

Object description

Index	2320$_h$
Object name	NanoJ Output Data Selection
Object Code	ARRAY
Data type	UNSIGNED32
Savable	no
Access	read / write
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1650-B472161
Change history	Firmware version FIR-v1436: "Object Name" entry changed from "VMM Output Data Selection" to "NanoJ Output Data Selection".
	Firmware version FIR-v1650-B472161: "Savable" entry changed from "yes, category: application" to "no".
	Firmware version FIR-v1650-B472161: "Access" table entry for subindex 00 changed from "read/write" to "read only".
	Firmware version FIR-v1650-B472161: "Access" table entry for subindex 01 changed from "read/write" to "read only".

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	10$_h$

Subindex	01$_h$ - 10$_h$
Name	Mapping #1 - #16
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Description

Each subindex (1–16) describes a different mapped object.

A mapping entry consists of four bytes, which are structured according to the following graphic.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Index [16]															

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SubIndex [8]								Length [8]							

Index [16]

This contains the index of the object to be mapped.

Subindex [8]

This contains the subindex of the object to be mapped.

Length [8]

This contains the length of the object to be mapped in units of bits.

2330h NanoJ In/output Data Selection

Function

Describes the object dictionary entries that are first copied to the input PDO mapping of the NanoJ program and, after it is executed, are copied back to the output PDO mapping.

Object description

Index	2330_h
Object name	NanoJ In/output Data Selection
Object Code	ARRAY
Data type	UNSIGNED32
Savable	no
Access	read / write
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1650-B472161
Change history	Firmware version FIR-v1436: "Object Name" entry changed from "VMM In/output Data Selection" to "NanoJ In/output Data Selection".
	Firmware version FIR-v1650-B472161: "Savable" entry changed from "yes, category: application" to "no".
	Firmware version FIR-v1650-B472161: "Access" table entry for subindex 00 changed from "read/write" to "read only".
	Firmware version FIR-v1650-B472161: "Access" table entry for subindex 01 changed from "read/write" to "read only".

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only

PDO mapping	no
Allowed values	
Preset value	10_h

Subindex	01_h - 10_h
Name	Mapping #1 - #16
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000_h

Description

Each subindex (1–16) describes a different mapped object.

A mapping entry consists of four bytes, which are structured according to the following graphic.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Index [16]															

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
SubIndex [8]								Length [8]							

Index [16]

This contains the index of the object to be mapped.

Subindex [8]

This contains the subindex of the object to be mapped.

Length [8]

This contains the length of the object to be mapped in units of bits.

2400h NanoJ Inputs

Function

Located here is an array with 32, 32-bit integer values that is not used within the firmware and serves only for communicating with the user program via the fieldbus.

Object description

Index	2400_h
Object name	NanoJ Inputs
Object Code	ARRAY
Data type	INTEGER32
Savable	no
Firmware version	FIR-v1426
Change history	The number of entries was changed from 2 to 33.
	Firmware version FIR-v1436: "Object Name" entry changed from "VMM Inputs" to "NanoJ Inputs".

Firmware version FIR-v1436: "Name" entry changed from "VMM Input N#" to "NanoJ Input N#".

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	20_h

Subindex	01_h - 20_h
Name	NanoJ Input #1 - #32
Data type	INTEGER32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000_h

Description

Here, it is possible to pass, e.g., preset values, to the *NanoJ program*.

2410h NanoJ Init Parameters

Function

This object functions identically to object **2400**_h with the difference that this object can be stored.

Object description

Index	2410_h
Object name	NanoJ Init Parameters
Object Code	ARRAY
Data type	INTEGER32
Savable	yes, category: application
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1450
Change history	Firmware version FIR-v1450: "Data Type" entry changed from "INTEGER32" to "UNSIGNED8".

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	20$_h$

Subindex	01$_h$ - 20$_h$
Name	NanoJ Init Parameter #1 - #32
Data type	INTEGER32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$

2500h NanoJ Outputs

Function

Located here is an array with 32, 32-bit integer values that is not used within the firmware and serves only for communicating with the user program via the fieldbus.

Object description

Index	2500$_h$
Object name	NanoJ Outputs
Object Code	ARRAY
Data type	INTEGER32
Savable	no
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1436: "Object Name" entry changed from "VMM Outputs" to "NanoJ Outputs".
	Firmware version FIR-v1436: "Name" entry changed from "VMM Output N#" to "NanoJ Output N#".

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	

Preset value	20_h

Subindex	01_h - 20_h
Name	NanoJ Output #1 - #32
Data type	INTEGER32
Access	read / write
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000_h

Description

Here, the *NanoJ program* can store results which can then be read out via the fieldbus.

2600h NanoJ Debug Output

Function

This object contains debug output of a user program.

Object description

Index	2600_h
Object name	NanoJ Debug Output
Object Code	ARRAY
Data type	UNSIGNED8
Savable	no
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1436: "Object Name" entry changed from "VMM Debug Output" to "NanoJ Debug Output".

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00_h

Subindex	01_h - 40_h
Name	Value #1 - #64
Data type	UNSIGNED8
Access	read only
PDO mapping	no

Allowed values	
Preset value	00$_h$

Description

Here, the NanoJ program stores the debug output that was called up with the `VmmDebugOutputString()`, `VmmDebugOutputInt()` and similar functions.

2701h Customer Storage Area

Function

Data can be deposited and stored in this object.

Object description

Index	2701$_h$
Object name	Customer Storage Area
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: customer
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1540
Change history	Firmware version FIR-v1540: "Data Type" entry changed from "UNSIGNED32" to "UNSIGNED8".

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	FE$_h$

Subindex	01$_h$ - FE$_h$
Name	Storage #1 - #254
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

2800h Bootloader And Reboot Settings

Function

With this object, a reboot of the firmware can be triggered and the short circuiting of the motor windings in boot loader mode switched off and on.

Object description

Index	2800_h
Object name	Bootloader And Reboot Settings
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1540
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	03_h

Subindex	01_h
Name	Reboot Command
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000_h

Subindex	02_h
Name	Reboot Delay Time In Ms
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000_h

Subindex	03$_h$
Name	Bootloader HW Config
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Description

The subindices have the following function:

- 01$_h$: If the value "746F6F62$_h$" is entered here, the firmware is rebooted.
- 02$_h$: Time in milliseconds: delays the reboot of the firmware by the respective time.
- 03$_h$: Bit 0 can be used to switch short circuiting of the motor windings in boot loader mode off and on:
    - Bit 0 = 1: Short circuiting of the motor windings in boot loader mode is switched off.
    - Bit 0 = 0: Short circuiting of the motor windings in boot loader mode is switched on.

3202h Motor Drive Submode Select

Function

Controls the controller mode, such as the changeover between *closed loop* / *open loop* and whether Velocity Mode is simulated via the S-controller or functions with a real V-controller in *closed loop*.

Object description

Index	3202$_h$
Object name	Motor Drive Submode Select
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: drive
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1540: "Savable" entry changed from "yes category: application" to "yes, category: travel".
	Firmware version FIR-v1540: "Savable" entry changed from "yes category: travel" to "yes, category: movement".

Description

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
									BLDC	Torque		CurRed	Brake	VoS	CL/OL

CL/OL

Changeover between *open loop* and *closed loop*

- Value = "0": *open loop*
- Value = "1": *closed loop*

VoS

Value = "1": Simulate V-controller with an S-ramp: simulate the speed modes through continuous position changes

Brake

Value = "1": Switch on automatic brake control

CurRed (Current Reduction)

Value = "1": Current reduction activated in *open loop*

Torque

only active in operating modes **Profile Torque** and **Cyclic Synchronous Torque**

Value = "1": M-controller is active, otherwise a V-controller is superimposed: no V-controller is used in the torque modes for speed limiting, thus object **6080**$_h$ is ignored; **3210**$_h$:3 and **3210**$_h$:4 have no effect on the control.

BLDC

Value = "1": Motor type "BLDC" (brushless DC motor)

3203h Feedback Selection

Function

In this object, the sources of the presets are defined for the commutation and the speed and position control.

Object description

Index	3203$_h$
Object name	Feedback Selection
Object Code	ARRAY
Data type	UNSIGNED8
Savable	yes, category: drive
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	
Firmware version	FIR-v1748-B538662
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	03$_h$

Subindex	01$_h$
Name	1st Feedback Interface
Data type	UNSIGNED8
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00$_h$

Subindex	02$_h$
Name	2nd Feedback Interface
Data type	UNSIGNED8
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00$_h$

Subindex	03$_h$
Name	3rd Feedback Interface
Data type	UNSIGNED8
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00$_h$

Description

The subindices have the following function:

- 00$_h$: Value="1" to "n", where "n" is the number of existing feedbacks.
- n$_h$:
  Subindex n contains a bit mask for the respective feedback n. The bits have the following meaning here:

  - Bit 0: If the bit is set to "1", feedback n is used for position control.
  - Bit 1: If the bit is set to "1", feedback n is used for speed control.
  - Bit 2: If the bit is set to "1", feedback n is used for the commutation in **Closed Loop**.

  Subindex 01$_h$ always corresponds to the first (and always existing) *sensorless* feedback.

Which feedback the controller takes into account for the individual controllers (commutation, speed, position) is implicitly specified by the order of the feedbacks.

The search always begins with feedback 2 and continues in ascending order until all existing product-specific feedbacks have been queried. If a feedback is found whose parameterization is set, it is assigned to the corresponding controller and the search ended.

> **Note**
>
> If bit 0 in 3202_h is set to 0, *closed loop* is deactivated; bit 2 (commutation) then has no meaning. Bit 1 for the speed and bit 0 for the position in the respective subindicies are still used for the display of the actual position and speed values.

3204h Feedback Mapping

Function

This object contains information on the existing feedbacks.

Object description

Index	3204_h
Object name	Feedback Mapping
Object Code	ARRAY
Data type	UNSIGNED16
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	
Firmware version	FIR-v1748-B538662
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	03_h

Subindex	01_h
Name	Index Of 1st Feedback Interface
Data type	UNSIGNED16
Access	read only
PDO mapping	TX-PDO
Allowed values	

Preset value	3380$_h$

Subindex	02$_h$
Name	Index Of 2nd Feedback Interface
Data type	UNSIGNED16
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	3390$_h$

Subindex	03$_h$
Name	Index Of 3rd Feedback Interface
Data type	UNSIGNED16
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	33A0$_h$

Description

The subindices have the following function:

- 00$_h$: Value="1" to "n", where "n" is the number of existing feedbacks.
- n$_h$:
  Subindex n refers to the index of the respective object for the configuration of the corresponding feedback.
  Subindex 01$_h$ always corresponds to the first (and always existing) *sensorless* feedback.

3210h Motor Drive Parameter Set

Function

Contains the P and I components of the current, speed and position controllers for *open loop* (only current controller activated) and *closed loop*.

Object description

Index	3210$_h$
Object name	Motor Drive Parameter Set
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	
Firmware version	FIR-v1426

Change history	Firmware version FIR-v1626: "Name" entry changed from "S_P" to "Position Loop, Proportional Gain (closed loop)".
	Firmware version FIR-v1626: "Name" entry changed from "S_I" to "Position Loop, Integral Gain (closed loop)".
	Firmware version FIR-v1626: "Name" entry changed from "V_P" to "Velocity Loop, Proportional Gain (closed loop)".
	Firmware version FIR-v1626: "Name" entry changed from "V_I" to "Velocity Loop, Integral Gain (closed loop)".
	Firmware version FIR-v1626: "Name" entry changed from "Id_P" to "Flux Current Loop, Proportional Gain (closed loop)".
	Firmware version FIR-v1626: "Name" entry changed from "Id_I" to "Flux Current Loop, Integral Gain (closed loop)".
	Firmware version FIR-v1626: "Name" entry changed from "Iq_P" to "Torque Current Loop, Proportional Gain (closed loop)".
	Firmware version FIR-v1626: "Name" entry changed from "Iq_I" to "Torque Current Loop, Integral Gain (closed loop)".
	Firmware version FIR-v1626: "Name" entry changed from "I_P" to "Torque Current Loop, Proportional Gain (dspDrive – Stepper Motor, open loop)".
	Firmware version FIR-v1626: "Name" entry changed from "I_I" to "Torque Current Loop, Integral Gain (dspDrive – Stepper Motor, open loop)".
	Firmware version FIR-v1650-B472161: "Name" entry changed from "Torque Current Loop, Proportional Gain (dspDrive – Stepper Motor, open loop)" to "Torque Current Loop, Proportional Gain (open loop)".
	Firmware version FIR-v1650-B472161: "Name" entry changed from "Torque Current Loop, Integral Gain (dspDrive – Stepper Motor, open loop)" to "Torque Current Loop, Integral Gain (open loop)".
	Firmware version FIR-v1650-B472161: "Data type" entry changed from "INTEGER32" to "UNSIGNED32".
	Firmware version FIR-v1650-B472161: "Data type" entry changed from "INTEGER32" to "UNSIGNED32".
	Firmware version FIR-v1738-B501312: The number of entries was changed from 11 to 13.
	Firmware version FIR-v1738-B501312: "PDO mapping" table entry for subindex 00 to 0A changed from "no" to "RX-PDO".

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	$0C_h$

Subindex	01$_h$
Name	Position Loop, Proportional Gain (closed Loop)
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000800$_h$

Subindex	02$_h$
Name	Position Loop, Integral Gain (closed Loop)
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$

Subindex	03$_h$
Name	Velocity Loop, Proportional Gain (closed Loop)
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00002EE0$_h$

Subindex	04$_h$
Name	Velocity Loop, Integral Gain (closed Loop)
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000001E$_h$

Subindex	05$_h$
Name	Flux Current Loop, Proportional Gain (closed Loop)
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	000668A0$_h$

Subindex	06$_h$
Name	Flux Current Loop, Integral Gain (closed Loop)
Data type	UNSIGNED32

Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00002EE0$_h$

Subindex	07$_h$
Name	Torque Current Loop, Proportional Gain (closed Loop)
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	000668A0$_h$

Subindex	08$_h$
Name	Torque Current Loop, Integral Gain (closed Loop)
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00002EE0$_h$

Subindex	09$_h$
Name	Torque Current Loop, Proportional Gain (open Loop)
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0003A980$_h$

Subindex	0A$_h$
Name	Torque Current Loop, Integral Gain (open Loop)
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000AFC8$_h$

Subindex	0B$_h$
Name	Velocity Feed Forward Factor In Per Mille
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	

Preset value	000003E8$_h$

Subindex	0C$_h$
Name	Acceleration Feed Forward Factor
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$

Description

- Subindex 00$_h$: Number of entries
- Subindex 01$_h$: Proportional component of the S-controller (position)
- Subindex 02$_h$: Integral component of the S-controller (position)
- Subindex 03$_h$: Proportional component of the V-controller (speed)
- Subindex 04$_h$: Integral component of the V-controller (speed)
- Subindex 05$_h$: (Closed loop) Proportional component of the current controller of the field-forming component
- Subindex 06$_h$: (Closed loop) Integral component of the current controller of the field-forming component
- Subindex 07$_h$: (Closed loop) Proportional component of the current controller of the torque-forming component
- Subindex 08$_h$: (Closed loop) Integral component of the current controller of the torque-forming component
- Subindex 09$_h$: (Open loop) Proportional component of the current controller of the field-building component
- Subindex 0A$_h$: (Open loop) Integral component of the current controller of the field-forming component
- Subindex 0B$_h$: (Closed loop) Speed feed forward in tenths of a percent. Default is 1000 and, thus, a factor of 1.
- Subindex 0C$_h$: (Closed loop) Acceleration feed forward. Default is 0 (feed forward inactive). It applies during deceleration as well.

3212h Motor Drive Flags

Function

This object is used to specify whether or not **auto setup** is to adapt the controller parameters. The direction of the rotating field can also be changed.

ⓘ	**Note**

Changes in subindex 02$_h$ do not take effect until after the controller is restarted. Afterwards, **Auto setup** must again be performed.

Object description

Index	3212$_h$
Object name	Motor Drive Flags

Object Code	ARRAY
Data type	INTEGER8
Savable	yes, category: application
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1450
Change history	Firmware version FIR-v1512: The number of entries was changed from 2 to 3.
	Firmware version FIR-v1738-B501312: "Name" entry changed from "Enable Legacy Power Mode" to "Reserved".

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	03_h

Subindex	01_h
Name	Reserved
Data type	INTEGER8
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00_h

Subindex	02_h
Name	Override Field Inversion
Data type	INTEGER8
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00_h

Subindex	03_h
Name	Do Not Touch Controller Settings
Data type	INTEGER8
Access	read / write
PDO mapping	no

Allowed values

Preset value   00$_h$

Description

Valid values for subindex 02$_h$:

- Value = "0": Use default values of the firmware
- Value = "1": Force non-inversion of the rotating field (mathematically positive)
- Value = "-1": Force inversion of the rotating field (mathematically negative)

Valid values for subindex 03$_h$:

- Value = "0": **Auto setup** detects the motor type (stepper motor or BLDC motor) and uses the corresponding pre-configured parameter set.
- Value = "1": Perform **auto setup** with the values for the controller that were entered in object **3210**$_h$ before the auto setup; the values in **3210**$_h$ are not changed.

3220h Analog Inputs

Function

Displays the instantaneous values of the analog inputs in digits.

With object **3221**$_h$, the respective analog input can be configured as current or voltage input.

Object description

Index	3220$_h$
Object name	Analog Inputs
Object Code	ARRAY
Data type	INTEGER16
Savable	no
Firmware version	FIR-v1426
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02$_h$

Subindex	01$_h$
Name	Analogue Input 1
Data type	INTEGER16
Access	read only
PDO mapping	TX-PDO

Allowed values	
Preset value	0000$_h$

Subindex	02$_h$
Name	Analogue Input 2
Data type	INTEGER16
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	0000$_h$

Description

Formulas for converting from [digits] to the respective unit:

- Voltage input: (x digits – 512 digits) * 20 V / 1024 digits
- Current input: x digits * 20 mA / 1024 digits

3221h Analogue Inputs Control

Function

With this object, an analog input can be switched from voltage measurement to current measurement.

Object description

Index	3221$_h$
Object name	Analogue Inputs Control
Object Code	VARIABLE
Data type	INTEGER32
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1426
Change history	

Description

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
														AC2	AC1
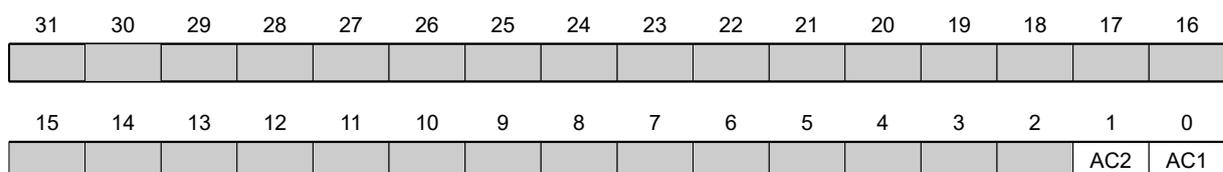
In general: If a bit is set to the value "0", the analog input measures the voltage; if the bit is set to the value "1", the current is measured.

AC1

Setting for analog input 1

AC2

Setting for analog input 2

3225h Analogue Inputs Switches

Function

This object contains the value of the rotary switch that is used to configure the address of the controller . The switch position is only read during a restart one time.

Object description

Index	3225_h
Object name	Analogue Inputs Switches
Object Code	ARRAY
Data type	UNSIGNED16
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1436
Change history	Firmware version FIR-v1436: "PDO mapping" table entry for subindex 01 changed from "RX-PDO" to "TX-PDO".

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	01_h

Subindex	01_h
Name	Analogue Input Switch1
Data type	UNSIGNED16
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	0000_h

Description

If the controller is equipped with a rotary switch, the value of the rotary switch is displayed in subindex 01_h. If the controller is equipped with two rotary switches, the value of the rotary switch is displayed in subindex 01_h, which consists of switch 1 and 2.

3240h Digital Inputs Control

Function

With this object, digital inputs can be manipulated as described in chapter **Digital inputs and outputs**.

Object description

Index	3240_h
Object name	Digital Inputs Control
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1426: Subindex 01_h: "Name" entry changed from "Special Function Disable" to "Special Function Enable"
	Firmware version FIR-v1512: The number of entries was changed from 8 to 9.

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	08_h

Subindex	01_h
Name	Special Function Enable
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000_h

Subindex	02_h
Name	Function Inverted
Data type	UNSIGNED32
Access	read / write

PDO mapping	RX-PDO
Allowed values	
Preset value	00000000h

Subindex	03h
Name	Force Enable
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000h

Subindex	04h
Name	Force Value
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000h

Subindex	05h
Name	Raw Value
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000h

Subindex	06h
Name	Input Range Select
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000h

Subindex	07h
Name	Differential Select
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000h

Subindex	08$_h$
Name	Routing Enable
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$

Description

The subindices have the following function:

- **3240**$_h$:01$_h$ (Special Function Enable): This bit allows special functions of an input to be switched off (value "0") or on (value "1"). If input 1 is not used as, e.g., a negative limit switch, the special function must be switched off to prevent an erroneous response to the signal generator. The object has no effect on bits 16 to 31.
  The firmware evaluates the following bits:

  - Bit 0: Negative limit switch
  - Bit 1: Positive limit switch
  - Bit 2: Home switch

  If, for example, two limit switches and one home switch are used, bits 0–2 in **3240**$_h$:01$_h$ must be set to "1".

- **3240**$_h$:02$_h$ (Function Inverted): This subindex switches from normally open logic (a logical high level at the input yields the value "1" in object **60FD**$_h$) to normally closed logic (the logical high level at the input yields the value "0").
  This applies for the special functions (except for the clock and direction inputs) and for the normal inputs. If the bit has the value "0", normally open logic applies; for the value "1", normally closed logic applies. Bit 0 changes the logic of input 1, bit 1 changes the logic of input 2, etc.

- **3240**$_h$:03$_h$ (Force Enable): This subindex switches on the software simulation of input values if the corresponding bit is set to "1".
  In this case, the actual values are no longer used in object **3240**$_h$:04$_h$, but rather the set values for the respective input. Bit 0 corresponds to input 1 here, bit 1 to input 2, etc.

- **3240**$_h$:04$_h$ (Force Value): This bit specifies the value that is to be read as the input value if the same bit was set in object **3240**$_h$:03$_h$.

- **3240**$_h$:05$_h$ (Raw Value): This object contains the unmodified input value.

- **3240**$_h$:06$_h$ (Input Range Select): This can be used to switch inputs – that are equipped with this function – from the switching threshold of 5 V (bit is "0") to the switching threshold of 24 V (bit is "1"). Bit 0 corresponds to input 1 here, bit 1 to input 2, etc.

3242h Digital Input Routing

Function

This object determines the source of the input routing that ends in **60FD**$_h$.

Object description

Index	3242$_h$
Object name	Digital Input Routing
Object Code	ARRAY
Data type	UNSIGNED8
Savable	yes, category: application

Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1504
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	24_h

Subindex	01_h - 24_h
Name	Input Source #1 - #36
Data type	UNSIGNED8
Access	read / write
PDO mapping	TX-PDO
Allowed values	
Preset value	00_h

Description

Subindex 01_h contains the source for bit 0 of object **60FD**. Subindex 02_h contains the source for bit 1 of object **60FD** and so on.

The number that is written in a subindex determines the source for the corresponding bit. The following table lists all possible signal sources.

Number		
dec	hex	Signal source
00	00	Signal is always 0
01	01	Physical input 1
02	02	Physical input 2
03	03	Physical input 3
04	04	Physical input 4
05	05	Physical input 5
06	06	Physical input 6
07	07	Physical input 7
08	08	Physical input 8
09	09	Physical input 9
10	0A	Physical input 10
11	0B	Physical input 11

Number		
dec	**hex**	**Signal source**
12	0C	Physical input 12
13	0D	Physical input 13
14	0E	Physical input 14
15	0F	Physical input 15
16	10	Physical input 16
65	41	Hall input "U"
66	42	Hall input "V"
67	43	Hall input "W"
68	44	Encoder input "A"
69	45	Encoder input "B"
70	46	Encoder input "Index"
72	48	"Ethernet active" status
128	80	Signal is always 1
129	81	Inverted physical input 1
130	82	Inverted physical input 2
131	83	Inverted physical input 3
132	84	Inverted physical input 4
133	85	Inverted physical input 5
134	86	Inverted physical input 6
135	87	Inverted physical input 7
136	88	Inverted physical input 8
137	89	Inverted physical input 9
138	8A	Inverted physical input 10
139	8B	Inverted physical input 11
140	8C	Inverted physical input 12
141	8D	Inverted physical input 13
142	8E	Inverted physical input 14
143	8F	Inverted physical input 15
144	90	Inverted physical input 16
193	C1	Inverted Hall input "U"
194	C2	Inverted Hall input "V"
195	C3	Inverted Hall input "W"
196	C4	Inverted encoder input "A"
197	C5	Inverted encoder input "B"
198	C6	Inverted encoder input "Index"
200	C8	"Ethernet active" inverted status

3243h Digital Input Homing Capture

Function

With this object, the encoder position can be noted automatically if a level change occurs at the digital input that is used for the home switch.

Object description

Index	3243$_h$
Object name	Digital Input Homing Capture
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1738-B501312
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	04$_h$

Subindex	01$_h$
Name	Control
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$

Subindex	02$_h$
Name	Capture Count
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$

Subindex	03$_h$
Name	Value
Data type	UNSIGNED32
Access	read / write

PDO mapping	RX-PDO
Allowed values	
Preset value	00000000_h

Subindex	04_h
Name	Sensor Raw Value
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000_h

Description

- Subindex 01_h: This is used to select the type of level change:

  - Deactivate function: Value "0"
  - With rising edge: Value "1"
  - With falling edge: Value "2"
  - Both edges: Value "3"
- Subindex 02_h: Specifies the number of the noted level changes since the time the function was started; is reset to 0 if subindex 01_h is set to 1,2 or 3
- Subindex 03_h: Encoder position of the level change (in absolute user units from **6064_h**)
- Subindex 04_h: Encoder position of the level change

3250h Digital Outputs Control

Function

This object can be used to control the digital outputs as described in chapter " **Digital inputs and outputs**".

The following applies for all subindices:

- Bits 0 to 15 control the special functions.
- Bits 16 to 31 control the level of the outputs.

Object description

Index	3250_h
Object name	Digital Outputs Control
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1426: Subindex 01_h: "Name" entry changed from "Special Function Disable" to "Special Function Enable"
	Firmware version FIR-v1446: "Name" entry changed from "Special Function Enable" to "No Function".

Firmware version FIR-v1512: The number of entries was changed from 6 to 9.

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	08$_h$

Subindex	01$_h$
Name	No Function
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$

Subindex	02$_h$
Name	Function Inverted
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$

Subindex	03$_h$
Name	Force Enable
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$

Subindex	04$_h$
Name	Force Value
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	

Preset value	00000000h

Subindex	05h
Name	Raw Value
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000h

Subindex	06h
Name	Reserved1
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000h

Subindex	07h
Name	Reserved2
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000h

Subindex	08h
Name	Routing Enable
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000h

Description

The subindices have the following function:

- 01_h: No function.
- 02_h: This subindex is used to invert the logic (from normally closed logic to normally open logic).
- 03_h: This subindex is used to force the output value if the bit has the value "1". The level of the output is defined in subindex 4_h.
- 04_h: This subindex is used to define the level to be applied to the output. The value "0" returns a logical low level at the digital output; the value "1", on the other hand, returns a logical high level.
- 05_h: The bit combination applied to the outputs is stored in this subindex.

3252h Digital Output Routing

Function

This object assigns a signal source to an output; this signal source can be controlled with **60FE**$_h$.

Object description

Index	3252$_h$
Object name	Digital Output Routing
Object Code	ARRAY
Data type	UNSIGNED16
Savable	yes, category: application
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1748-B538662
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	05$_h$

Subindex	01$_h$
Name	Output Control #1
Data type	UNSIGNED16
Access	read / write
PDO mapping	TX-PDO
Allowed values	
Preset value	1080$_h$

Subindex	02$_h$
Name	Output Control #2
Data type	UNSIGNED16
Access	read / write
PDO mapping	TX-PDO
Allowed values	
Preset value	0090$_h$

Subindex	03$_h$
Name	Output Control #3
Data type	UNSIGNED16
Access	read / write
PDO mapping	TX-PDO
Allowed values	
Preset value	0091$_h$

Subindex	04$_h$
Name	Output Control #4
Data type	UNSIGNED16
Access	read / write
PDO mapping	TX-PDO
Allowed values	
Preset value	0092$_h$

Subindex	05$_h$
Name	Output Control #5
Data type	UNSIGNED16
Access	read / write
PDO mapping	TX-PDO
Allowed values	
Preset value	0093$_h$

3320h Read Analogue Input

Function

Displays the instantaneous values of the analog inputs in user-defined units.

Object description

Index	3320$_h$
Object name	Read Analogue Input
Object Code	ARRAY
Data type	INTEGER32
Savable	no
Firmware version	FIR-v1426
Change history	

Value description

Subindex	00$_h$
Name	Number Of Analogue Inputs
Data type	UNSIGNED8

Access	read only
PDO mapping	no
Allowed values	
Preset value	02_h

Subindex	01_h
Name	Analogue Input 1
Data type	INTEGER32
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000_h

Subindex	02_h
Name	Analogue Input 2
Data type	INTEGER32
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000_h

Description

The user-defined units are made up of offset (3321_h) and pre-scaling value (3322_h). If both object entries are still set to the default values, the value in 3320_h is specified in the "ADC digits" unit.

Formula for converting from digits to the respective unit:

- Voltage input: (x digits – 512 digits) * 20 V / 1024 digits
- Current input: x digits * 20 mA / 1024 digits

The following applies for the sub-entries:

- Subindex 00_h: Number of analog inputs
- Subindex 01_h: Analog value 1
- Subindex 02_h: Analog value 2

3321h Analogue Input Offset

Function

Offset that is added to the read analog value (3320_h) before dividing by the divisor from object 3322_h.

Object description

Index	3321_h
Object name	Analogue Input Offset
Object Code	ARRAY
Data type	INTEGER32
Savable	yes, category: application

Firmware version	FIR-v1426
Change history	

Value description

Subindex	00$_h$
Name	Number Of Analogue Inputs
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02$_h$

Subindex	01$_h$
Name	Analogue Input 1
Data type	INTEGER32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	02$_h$
Name	Analogue Input 2
Data type	INTEGER32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Description

- Subindex 00$_h$: Number of offsets
- Subindex 01$_h$: Offset for analog input 1
- Subindex 02$_h$: Offset for analog input 2

3322h Analogue Input Pre-scaling

Function

Value by which the read analog value (**3320**$_h$, **3321**$_h$) is divided before it is written in object **3320**$_h$.

Object description

Index	3322$_h$
Object name	Analogue Input Pre-scaling
Object Code	ARRAY

Data type	INTEGER32
Savable	yes, category: application
Firmware version	FIR-v1426
Change history	

Value description

Subindex	00_h
Name	Number Of Analogue Inputs
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02_h

Subindex	01_h
Name	Analogue Input 1
Data type	INTEGER32
Access	read / write
PDO mapping	no
Allowed values	All values permitted except 0
Preset value	00000001_h

Subindex	02_h
Name	Analogue Input 2
Data type	INTEGER32
Access	read / write
PDO mapping	no
Allowed values	All values permitted except 0
Preset value	00000001_h

Description

The subindices contain:

- Subindex 00_h: Number of divisors
- Subindex 01_h: Divisor for analog input 1
- Subindex 02_h: Divisor for analog input 2

3390h Feedback Hall

Function

Contains configuration values for the Hall sensors. The values are determined by the **Auto setup**.

Object description

Index	3390$_h$
Object name	Feedback Hall
Object Code	ARRAY
Data type	UNSIGNED16
Savable	yes, category: tuning
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	
Firmware version	FIR-v1748-B531667
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	0C$_h$

Subindex	01$_h$
Name	1st Alignment
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$

Subindex	02$_h$
Name	2nd Alignment
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$

Subindex	03$_h$
Name	3rd Alignment
Data type	UNSIGNED16
Access	read / write

PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$

Subindex	04$_h$
Name	4th Alignment
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$

Subindex	05$_h$
Name	5th Alignment
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$

Subindex	06$_h$
Name	6th Alignment
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$

Subindex	07$_h$
Name	7th Alignment
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$

Subindex	08$_h$
Name	8th Alignment
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$

Subindex	09$_h$
Name	9th Alignment
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$

Subindex	0A$_h$
Name	10th Alignment
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$

Subindex	0B$_h$
Name	11th Alignment
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$

Subindex	0C$_h$
Name	12th Alignment
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$

33A0h Feedback Incremental A/B/I 1

Function

Contains configuration values for the first incremental encoder. The values are determined by the **Auto setup**.

Object description

Index	33A0$_h$
Object name	Feedback Incremental A/B/I 1
Object Code	ARRAY
Data type	UNSIGNED16

Savable	yes, category: tuning
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	
Firmware version	FIR-v1738-B501312
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	02$_h$

Subindex	01$_h$
Name	Configuration
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$

Subindex	02$_h$
Name	Alignment
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$

Description

The subindices have the following function:

- 00$_h$ (Configuration): The following bits have a meaning:
  - Bit 0: Value = "0": The encoder does not have an index. Value = "1": Encoder index found and is to be used.
  - Bit 15: Value = "1": The encoder is a single-turn absolute encoder.
- 01$_h$ (Alignment): This value specifies the offset between the index of the encoder and the electric field.
  The exact determination is only possible via **auto setup**. The presence of this value is necessary for *closed loop* mode with encoder.

3502h MODBUS Rx PDO Mapping

Function

The objects for RX mapping can be written in this object.

Object description

Index	3502$_h$
Object name	MODBUS Rx PDO Mapping
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: communication
Access	read / write
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1748-B538662
Change history	Firmware version FIR-v1738-B505321: "Object Name" entry changed from "MODBUS Rx PDO-Mapping" to "MODBUS Rx PDO Mapping".

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read / write
PDO mapping	no
Allowed values	
Preset value	08$_h$

Subindex	01$_h$
Name	Value #1
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	60400010$_h$

Subindex	02$_h$
Name	Value #2
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00050008$_h$

Subindex	03_h

Subindex	03$_h$
Name	Value #3
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	60600008$_h$

Subindex	04$_h$
Name	Value #4
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	32020020$_h$

Subindex	05$_h$
Name	Value #5
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	607A0020$_h$

Subindex	06$_h$
Name	Value #6
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	60810020$_h$

Subindex	07$_h$
Name	Value #7
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	60420010$_h$

Subindex	08$_h$
Name	Value #8
Data type	UNSIGNED32

Access	read / write
PDO mapping	no
Allowed values	
Preset value	60FE0120$_h$

Subindex	09$_h$
Name	Value #9
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	0A$_h$
Name	Value #10
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	0B$_h$
Name	Value #11
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	0C$_h$
Name	Value #12
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	0D$_h$
Name	Value #13
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	

Preset value	00000000$_h$

Subindex	0E$_h$
Name	Value #14
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	0F$_h$
Name	Value #15
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	10$_h$
Name	Value #16
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

3602h MODBUS Tx PDO Mapping

Function

The objects for TX mapping can be written in this object.

Object description

Index	3602$_h$
Object name	MODBUS Tx PDO Mapping
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: communication
Access	read / write
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1748-B538662

Change history	Firmware version FIR-v1738-B505321: "Object Name" entry changed from "MODBUS Tx PDO-Mapping" to "MODBUS Tx PDO Mapping".

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read / write
PDO mapping	no
Allowed values	
Preset value	06_h

Subindex	01_h
Name	Value #1
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	60410010_h

Subindex	02_h
Name	Value #2
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00050008_h

Subindex	03_h
Name	Value #3
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	60610008_h

Subindex	04_h
Name	Value #4
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	

| Preset value | 60640020_h |

Subindex	05_h
Name	Value #5
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	60440010_h

Subindex	06_h
Name	Value #6
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	60FD0020_h

Subindex	07_h
Name	Value #7
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000_h

Subindex	08_h
Name	Value #8
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000_h

Subindex	09_h
Name	Value #9
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000_h

| Subindex | 0A_h |

Name	Value #10
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	0B$_h$
Name	Value #11
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	0C$_h$
Name	Value #12
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	0D$_h$
Name	Value #13
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	0E$_h$
Name	Value #14
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	0F$_h$
Name	Value #15
Data type	UNSIGNED32
Access	read / write

PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Subindex	10$_h$
Name	Value #16
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

3700h Deviation Error Option Code

Function

The object contains the action that is to be executed if a following or slippage error is triggered.

Object description

Index	3700$_h$
Object name	Deviation Error Option Code
Object Code	VARIABLE
Data type	INTEGER16
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	FFFF$_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1738-B501312: "Object Name" entry changed from "Following Error Option Code" to "Deviation Error Option Code".

Description

Value	Description
-32768 … -2	Reserved
-1	No reaction
0	Immediate stop
1	Braking with "slow down ramp" (deceleration (deceleration ramp) depending on operating mode)
2	Braking with "quick stop ramp" (deceleration (deceleration ramp) depending on operating mode)
3 … 32767	Reserved

4012h HW Information

Function

This object contains information about the hardware.

Object description

Index	4012$_h$
Object name	HW Information
Object Code	ARRAY
Data type	UNSIGNED32
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1540
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	01$_h$

Subindex	01$_h$
Name	EEPROM Size In Bytes
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Description

Subindex 01: Contains the size of the connected EEPROM in bytes. The value "0" means that no EEPROM is connected.

4013h HW Configuration

Function

This object is used to set certain hardware configurations.

Object description

Index	4013$_h$
Object name	HW Configuration
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1540
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	01$_h$

Subindex	01$_h$
Name	HW Configuration #1
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000000$_h$

Description

Bit 0: reserved

4014h Operating Conditions

Function

This object is used to read out the current environment values for the controller.

Object description

Index	4014$_h$
Object name	Operating Conditions
Object Code	ARRAY

Data type	INTEGER32
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1540
Change history	Firmware version FIR-v1650-B472161: "Access" table entry for subindex 01 changed from "read/write" to "read only".
	Firmware version FIR-v1650-B472161: "Access" table entry for subindex 02 changed from "read/write" to "read only".
	Firmware version FIR-v1650-B472161: "Name" entry changed from "Temperature PCB [d?C]" to "Temperature PCB [Celsius * 10]".
	Firmware version FIR-v1650-B472161: "Access" table entry for subindex 03 changed from "read/write" to "read only".
	Firmware version FIR-v1738-B501312: The number of entries was changed from 4 to 6.

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	05$_h$

Subindex	01$_h$
Name	Voltage UB Power [mV]
Data type	INTEGER32
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000$_h$

Subindex	02$_h$
Name	Voltage UB Logic [mV]
Data type	INTEGER32
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000$_h$

Subindex	03h
Name	Temperature PCB [Celsius * 10]
Data type	INTEGER32
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000h

Subindex	04h
Name	Temperature Motor [Celsius * 10]
Data type	INTEGER32
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000h

Subindex	05h
Name	Temperature Microcontroller Chip [Celsius * 10]
Data type	INTEGER32
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000h

Description

The subindices contain:

- 01_h: Current voltage supply voltage in [mV]
- 02_h: Current logic voltage in [mV]
- 03_h: Current temperature of the control board in [d°C] (tenths of degree)
- 04_h: Reserves
- 05_h: Reserves

4040h Drive Serial Number

Function

This object contains the serial number of the controller.

Object description

Index	4040h
Object name	Drive Serial Number
Object Code	VARIABLE
Data type	VISIBLE_STRING
Savable	no
Access	read only

PDO mapping	no
Allowed values	
Preset value	0
Firmware version	FIR-v1450
Change history	

4041h Device Id

Function

This object contains the ID of the device.

Object description

Index	4041_h
Object name	Device Id
Object Code	VARIABLE
Data type	OCTET_STRING
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	0
Firmware version	FIR-v1540
Change history	

603Fh Error Code

Function

This object returns the error code of the last error that occurred.

It corresponds to the lower 16 bits of object 1003_h. For the description of the error codes, refer to object 1003_h.

Object description

Index	$603F_h$
Object name	Error Code
Object Code	VARIABLE
Data type	UNSIGNED16
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	0000_h
Firmware version	FIR-v1426
Change history	

Description

For the meaning of the error, see object **1003**$_h$ (Pre-defined Error Field).

6040h Controlword

Function

This object controls the **CiA 402 Power State Machine**.

Object description

Index	6040$_h$
Object name	Controlword
Object Code	VARIABLE
Data type	UNSIGNED16
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1626: "Savable" entry changed from "no" to "yes, category: application".

Description

Parts of the object are, with respect to function, dependent on the currently selected mode.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
						OMS	HALT	FR		OMS [3]		EO	QS	EV	SO

SO (Switched On)

> Value = "1": Switches to the "Switched on" state

EV (Enable Voltage)

> Value = "1": Switches to the "Enable voltage" state

QS (Quick Stop)

> Value = "0": Switches to the "Quick stop" state

EO (Enable Operation)

> Value = "1": Switches to the "Enable operation" state

OMS (Operation Mode Specific)

> Meaning is dependent on the selected operating mode

FR (Fault Reset)

> Resets an error (if possible)

HALT

> Value = "1": Triggers a halt; valid in the following modes:
>
> - **Profile Position**

- **Velocity**
- **Profile Velocity**
- **Profile Torque**
- **Interpolated Position Mode**

6041h Statusword

Function

This object returns information about the status of the **CiA 402 Power State Machine**.

Object description

Index	6041$_h$
Object name	Statusword
Object Code	VARIABLE
Data type	UNSIGNED16
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	0000$_h$
Firmware version	FIR-v1426
Change history	

Description

Parts of the object are, with respect to function, dependent on the currently selected mode. Refer to the corresponding section in chapter **Operating modes**.

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
CLA		OMS [2]		ILA	TARG	REM	SYNC	WARN	SOD	QS	VE	FAULT	OE	SO	RTSO

RTSO (Ready To Switch On)

Value = "1": Controller is in the "Ready to switch on" state

SO (Switched On)

Value = "1": Controller is in the "Switched on" state

OE (Operation Enabled)

Value = "1": Controller is in the "Operation enabled" state

FAULT

Error occurred

VE (Voltage Enabled)

Voltage applied

QS (Quick Stop)

Value = "0": Controller is in the "Quick stop" state

SOD (Switched On Disabled)

Value = "1": Controller is in the "Switched on disabled" state

WARN (Warning)

Value = "1": Warning

SYNC (synchronization)

Value = "1": Controller is in sync with the fieldbus; value = "0": Controller is not in sync with the fieldbus

REM (Remote)

Remote (value of the bit is always "1")

TARG

Target reached

ILA (Internal Limit Active)

Limit exceeded

OMS (Operation Mode Specific)

Meaning is dependent on the selected operating mode

CLA (Closed Loop Active)

Value = "1": The controller is in the *Operation enabled* state and the **Closed Loop** is activated.

Listed in the following table are the bit masks that break down the state of the controller.

Statusword (6041_h)	State
xxxx xxxx x0xx 0000	Not ready to switch on
xxxx xxxx x1xx 0000	Switch on disabled
xxxx xxxx x01x 0001	Ready to switch on
xxxx xxxx x01x 0011	Switched on
xxxx xxxx x01x 0111	Operation enabled
xxxx xxxx x00x 0111	Quick stop active
xxxx xxxx x0xx 1111	Fault reaction active
xxxx xxxx x0xx 1000	Fault

6042h VI Target Velocity

Function

Specifies the target speed in **user-defined units** for **Velocity** mode.

Object description

Index	6042_h
Object name	VI Target Velocity
Object Code	VARIABLE
Data type	INTEGER16
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO

Allowed values

Preset value	00C8$_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1626: "Savable" entry changed from "no" to "yes, category: application".

6043h VI Velocity Demand

Function

Speed specification in **user-defined units** for the controller in **Velocity** mode.

Object description

Index	6043$_h$
Object name	VI Velocity Demand
Object Code	VARIABLE
Data type	INTEGER16
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	0000$_h$
Firmware version	FIR-v1426
Change history	

6044h VI Velocity Actual Value

Function

Specifies the current actual speed in **user-defined units** in **Velocity** mode.

Object description

Index	6044$_h$
Object name	VI Velocity Actual Value
Object Code	VARIABLE
Data type	INTEGER16
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	0000$_h$
Firmware version	FIR-v1426
Change history	

6046h VI Velocity Min Max Amount

Function

This object can be used to set the minimum speed and maximum speed in **user-defined units**.

Object description

Index	6046$_h$
Object name	VI Velocity Min Max Amount
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Firmware version	FIR-v1426
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02$_h$

Subindex	01$_h$
Name	MinAmount
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$

Subindex	02$_h$
Name	MaxAmount
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00004E20$_h$

Description

Subindex 1 contains the minimum speed.

Subindex 2 contains the maximum speed.

If the value of the target speed (object **6042**_h) specified here is less than the minimum speed, the minimum speed applies and bit 11 (Internal Limit Reached) in **6041h Statusword**_h is set.

A target speed greater than the maximum speed sets the speed to the maximum speed and bit 11 (Internal Limit Reached) in **6041h Statusword**_h is set.

6048h VI Velocity Acceleration

Function

Sets the acceleration ramp in Velocity Mode (see **Velocity**).

Object description

Index	6048$_h$
Object name	VI Velocity Acceleration
Object Code	RECORD
Data type	VELOCITY_ACCELERATION_DECELERATION
Savable	yes, category: application
Firmware version	FIR-v1426
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02$_h$

Subindex	01$_h$
Name	DeltaSpeed
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	000001F4$_h$

Subindex	02$_h$
Name	DeltaTime
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0001$_h$

Description

The acceleration is specified as a fraction in user-defined units:

Speed change per change in time.

Subindex 01_h: Contains the change in speed.

Subindex 02_h: Contains the change in time.

6049h VI Velocity Deceleration

Function

Sets the deceleration (deceleration ramp) in Velocity Mode (see **Velocity**).

Object description

Index	6049_h
Object name	VI Velocity Deceleration
Object Code	RECORD
Data type	VELOCITY_ACCELERATION_DECELERATION
Savable	yes, category: application
Firmware version	FIR-v1426
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02_h

Subindex	01_h
Name	DeltaSpeed
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	$000001F4_h$

Subindex	02_h
Name	DeltaTime
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO

Allowed values	
Preset value	0001_h

Description

The deceleration is specified as a fraction in user-defined units:

Speed change per change in time.

Subindex 01_h: Contains the change in speed.

Subindex 02_h: Contains the change in time.

604Ah VI Velocity Quick Stop

Function

This object defines the deceleration (deceleration ramp) if the Quick Stop state is initiated in **Velocity Mode**.

Object description

Index	$604A_h$
Object name	VI Velocity Quick Stop
Object Code	RECORD
Data type	VELOCITY_ACCELERATION_DECELERATION
Savable	yes, category: application
Firmware version	FIR-v1426
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02_h

Subindex	01_h
Name	DeltaSpeed
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00001388_h

Subindex	02_h

Name	DeltaTime
Data type	UNSIGNED16
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0001_h

Description

The deceleration is specified as a fraction in user-defined units:

Speed change per change in time.

Subindex 01_h: Contains the change in speed.

Subindex 02_h: Contains the change in time.

604Ch VI Dimension Factor

Function

The unit for speed values is defined here for the objects associated with **Velocity Mode**.

Object description

Index	$604C_h$
Object name	VI Dimension Factor
Object Code	ARRAY
Data type	INTEGER32
Savable	yes, category: application
Firmware version	FIR-v1426
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02_h

Subindex	01_h
Name	VI Dimension Factor Numerator
Data type	INTEGER32
Access	read / write
PDO mapping	RX-PDO
Allowed values	

Preset value	00000001h

Subindex	02h
Name	VI Dimension Factor Denominator
Data type	INTEGER32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001h

Description

Subindex 1 contains the numerator (multiplier) and subindex 2 contains the denominator (divisor) with which the internal speed values are converted to revolutions per minute. If, for example, subindex 1 is set to the value "60" and subindex 2 is set to the value "1", the speed is specified in revolutions per second (60 revolutions per 1 minute).

605Ah Quick Stop Option Code

Function

The object contains the action that is to be executed on a transition of the **CiA 402 Power State Machine** to the *Quick Stop* state.

Object description

Index	605Ah
Object name	Quick Stop Option Code
Object Code	VARIABLE
Data type	INTEGER16
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	0001h
Firmware version	FIR-v1426
Change history	

Description

Value	Description
-32768 … -1	Reserved
0	Immediate stop
1	Braking with "slow down ramp" (deceleration (deceleration ramp) depending on operating mode) and subsequent state change to "Switch on disabled"
2	Braking with "quick stop ramp" and subsequent state change to "Switch on disabled"
3 … 32767	Reserved

605Bh Shutdown Option Code

Function

This object contains the action that is to be executed on a transition of the **CiA 402 Power State Machine** from the *Operation enabled* state to the *Ready to switch on* state.

Object description

Index	605B$_h$
Object name	Shutdown Option Code
Object Code	VARIABLE
Data type	INTEGER16
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	0001$_h$
Firmware version	FIR-v1426
Change history	

Description

Value	Description
-32768 … -1	Reserved
0	Immediate stop
1	Braking with "slow down ramp" (deceleration (deceleration ramp) depending on operating mode) and subsequent state change to "Switch on disabled"
2 … 32767	Reserved

605Ch Disable Option Code

Function

This object contains the action that is to be executed on a transition of the **CiA 402 Power State Machine** from the *Operation enabled* state to the *Switched on* state.

Object description

Index	605C$_h$
Object name	Disable Option Code
Object Code	VARIABLE
Data type	INTEGER16
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	0001$_h$

Firmware version	FIR-v1426
Change history	

Description

Value	Description
-32768 … -1	Reserved
0	Immediate stop
1	Braking with "slow down ramp" (deceleration (deceleration ramp) depending on operating mode) and subsequent state change to "Switch on disabled"
2 … 32767	Reserved

605Dh Halt Option Code

Function

The object contains the action that is to be executed if bit 8 (Halt) is set in controlword **6040**$_h$.

Object description

Index	605D$_h$
Object name	Halt Option Code
Object Code	VARIABLE
Data type	INTEGER16
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	0001$_h$
Firmware version	FIR-v1426
Change history	

Description

Value	Description
-32768 … 0	Reserved
1	Braking with "slow down ramp" (deceleration (deceleration ramp) depending on operating mode)
2	Braking with "quick stop ramp" (deceleration (deceleration ramp) depending on operating mode)
3 … 32767	Reserved

605Eh Fault Option Code

Function

The object contains the action specifying how the motor is to be brought to a standstill in case of an error.

Object description

Index	605E$_h$
Object name	Fault Option Code
Object Code	VARIABLE
Data type	INTEGER16
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	0002$_h$
Firmware version	FIR-v1426
Change history	

Description

Value	Description
-32768 … -1	Reserved
0	Immediate stop
1	Braking with "slow down ramp" (deceleration (deceleration ramp) depending on operating mode)
2	Braking with "quick stop ramp" (deceleration (deceleration ramp) depending on operating mode)
3 … 32767	Reserved

6060h Modes Of Operation

Function

The desired operating mode is entered in this object.

Object description

Index	6060$_h$
Object name	Modes Of Operation
Object Code	VARIABLE
Data type	INTEGER8
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	

Preset value	00ₕ
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1626: "Savable" entry changed from "no" to "yes, category: application".

Description

Mode	Description
-2	Auto setup
-1	Clock-direction mode
0	No mode change/no mode assigned
1	Profile Position Mode
2	Velocity Mode
3	Profile Velocity Mode
4	Profile Torque Mode
5	Reserved
6	Homing Mode
7	Interpolated Position Mode
8	Cyclic Synchronous Position Mode
9	Cyclic Synchronous Velocity Mode
10	Cyclic Synchronous Torque Mode

6061h Modes Of Operation Display

Function

Indicates the current operating mode. See also **6060h Modes Of Operation**.

Object description

Index	6061ₕ
Object name	Modes Of Operation Display
Object Code	VARIABLE
Data type	INTEGER8
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00ₕ
Firmware version	FIR-v1426
Change history	

6062h Position Demand Value

Function

Indicates the current demand position in **user-defined units**.

Object description

Index	6062$_h$
Object name	Position Demand Value
Object Code	VARIABLE
Data type	INTEGER32
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1426
Change history	

6063h Position Actual Internal Value

Function

Contains the current rotary encoder position in increments. Unlike objects **6062**$_h$ and **6064**$_h$, this value is not set to "0" following a **Homing** operation.

> **Note**
>
> If the encoder resolution in object **608F**$_h$ = 0, the numerical values of this object are invalid.

Object description

Index	6063$_h$
Object name	Position Actual Internal Value
Object Code	VARIABLE
Data type	INTEGER32
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1426
Change history	

6064h Position Actual Value

Function

Contains the current actual position in **user-defined units**.

Object description

Index	6064$_h$
Object name	Position Actual Value
Object Code	VARIABLE
Data type	INTEGER32
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1426
Change history	

6065h Following Error Window

Function

Defines the maximum allowed **following error** in **user-defined units** symmetrically to the **demand position**.

Object description

Index	6065$_h$
Object name	Following Error Window
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000100$_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1504: "Savable" entry changed from "no" to "yes, category: application".

Description

If the actual position deviates so much from the demand position that the value of this object is exceeded, bit 13 in object **6041**$_h$ is set. The deviation must last longer than the time in object **6066**$_h$.

If the value of the "Following Error Window" is set to "FFFFFFFF"$_h$, following error monitoring is switched off.

A reaction to the following error can be set in object **3700**h. If a reaction is defined, an error is also entered in object **1003**h.

6066h Following Error Time Out

Function

Time in milliseconds until a larger following error results in an error message.

Object description

Index	6066h
Object name	Following Error Time Out
Object Code	VARIABLE
Data type	UNSIGNED16
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0064h
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1504: "Savable" entry changed from "no" to "yes, category: application".

Description

If the actual position deviates so much from the demand position that the value of object **6065**h is exceeded, bit 13 in object **6041**h is set. The deviation must persist for longer than the time defined in this object.

A reaction to the following error can be set in object **3700**h. If a reaction is defined, an error is also entered in object **1003**h.

6067h Position Window

Function

Specifies a range symmetrical to the target position within which that target is considered having been met in modes **Profile Position** and **Interpolated Position Mode**.

Object description

Index	6067h
Object name	Position Window
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000000Ah

Firmware version	FIR-v1426
Change history	Firmware version FIR-v1504: "Savable" entry changed from "no" to "yes, category: application".

Description

If the current position deviates from the target position by less than the value of this object, bit 10 in object **6041**$_h$ is set. The condition must be satisfied for longer than the time defined in object **6066**$_h$.

If the value is set to "FFFFFFFF"$_h$, monitoring is switched off.

6068h Position Window Time

Function

The current position must be within the "Position Window" (**6067**$_h$) for this time in milliseconds for the target position to be considered having been met in the **Profile Position** and **Interpolated Position Mode** modes.

Object description

Index	6068$_h$
Object name	Position Window Time
Object Code	VARIABLE
Data type	UNSIGNED16
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0064$_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1504: "Savable" entry changed from "no" to "yes, category: application".

Description

If the current position deviates from the target position by less than the value of object **6067**$_h$, bit 10 in object **6041**$_h$ is set. The condition must be satisfied for longer than the time defined in object **6066**$_h$.

606Bh Velocity Demand Value

Function

Speed specification in **user-defined units** for the controller in **Profile Velocity Mode**.

Object description

Index	606B$_h$
Object name	Velocity Demand Value
Object Code	VARIABLE

Data type	INTEGER32
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1426
Change history	

Description

This object contains the output of the ramp generator, which simultaneously serves as the preset value for the speed controller.

606Ch Velocity Actual Value

Function

Current actual speed in **user-defined units**.

Object description

Index	606C$_h$
Object name	Velocity Actual Value
Object Code	VARIABLE
Data type	INTEGER32
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1426
Change history	

606Dh Velocity Window

Function

Specifies a symmetrical range relative to the target speed within which the target is considered having been met in the **Profile Velocity** mode.

Object description

Index	606D$_h$
Object name	Velocity Window
Object Code	VARIABLE
Data type	UNSIGNED16
Savable	yes, category: application
Access	read / write

PDO mapping	RX-PDO
Allowed values	
Preset value	$001E_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1614: "Savable" entry changed from "no" to "yes, category: application".

Description

If the current speed deviates from the set speed by less than the value of this object, bit 10 in object **6041_h** is set. The condition must be satisfied for longer than the time defined in object **6066_h** (see also **statusword in Profile Velocity Mode**).

606Eh Velocity Window Time

Function

The current speed must be within the "Velocity Window" (**$606D_h$**) for this time (in milliseconds) for the target to be considered having been met.

Object description

Index	$606E_h$
Object name	Velocity Window Time
Object Code	VARIABLE
Data type	UNSIGNED16
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000_h
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1614: "Savable" entry changed from "no" to "yes, category: application".

Description

Description

If the current speed deviates from the set speed by less than the value of object **$606D_h$**, bit 10 in object **6041_h** is set. The condition must be satisfied for longer than the time defined in object **6066** (see also **statusword in Profile Velocity Mode**).

6071h Target Torque

Function

This object contains the target torque for the **Profile Torque** and **Cyclic Synchronous Torque** modes in tenths of a percent of the rated torque.

Object description

Index	6071_h
Object name	Target Torque
Object Code	VARIABLE
Data type	INTEGER16
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000_h
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1626: "Savable" entry changed from "no" to "yes, category: application".

Description

This object is calculated as thousandths of the torque, e.g., the value "500" means "50%" of the rated torque; "1100" is equivalent to 110%. The rated torque corresponds to the rated current in object $203B_h$:01.

The target torque may not exceed the peak torque (proportional to the peak current in 2031_h).

6072h Max Torque

Function

The object describes the maximum torque for the **Profile Torque** and **Cyclic Synchronous Torque** modes in tenths of a percent of the rated torque.

Object description

Index	6072_h
Object name	Max Torque
Object Code	VARIABLE
Data type	UNSIGNED16
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000_h
Firmware version	FIR-v1426
Change history	

Description

This object is calculated as thousandths of the torque, e.g., the value "500" means "50%" of the rated torque; "1100" is equivalent to 110%. The rated torque corresponds to the rated current in object $203B_h$:01.

The target torque may not exceed the peak torque (proportional to the peak current in **2031**$_h$).

6074h Torque Demand

Function

Current torque set value requested by the ramp generator in tenths of a percent of the nominal torque for the internal controller.

Object description

Index	6074$_h$
Object name	Torque Demand
Object Code	VARIABLE
Data type	INTEGER16
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	0000$_h$
Firmware version	FIR-v1426
Change history	

Description

This object is calculated as thousandths of the torque, e.g., the value "500" means "50%" of the rated torque; "1100" is equivalent to 110%. The rated torque corresponds to the rated current in object **203B**$_h$:01.

The target torque may not exceed the peak torque (proportional to the peak current in **2031**$_h$).

6075h Motor Rated Current

Function

Contains the rated current entered in **203B**$_h$:01$_h$ in mA.

6077h Torque Actual Value

Function

This object indicates the current torque value in tenths of a percent of the rated torque for the internal controller.

Object description

Index	6077$_h$
Object name	Torque Actual Value
Object Code	VARIABLE
Data type	INTEGER16
Savable	no
Access	read only

PDO mapping	TX-PDO
Allowed values	
Preset value	0000_h
Firmware version	FIR-v1540
Change history	

Description

This object is calculated as thousandths of the torque, e.g., the value "500" means "50%" of the rated torque; "1100" is equivalent to 110%. The rated torque corresponds to the rated current in object **$203B_h$**:01.

The target torque may not exceed the peak torque (proportional to the peak current in **2031_h**).

607Ah Target Position

Function

This object specifies the target position in **user-defined units** for the **Profile Position** and **Cyclic Synchronous Position** modes.

Object description

Index	$607A_h$
Object name	Target Position
Object Code	VARIABLE
Data type	INTEGER32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	$00000FA0_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1626: "Savable" entry changed from "no" to "yes, category: application".

607Bh Position Range Limit

Function

Contains the minimum and maximum position in **user-defined units**.

Object description

Index	$607B_h$
Object name	Position Range Limit
Object Code	ARRAY
Data type	INTEGER32
Savable	yes, category: application

Firmware version	FIR-v1426
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02$_h$

Subindex	01$_h$
Name	Min Position Range Limit
Data type	INTEGER32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$

Subindex	02$_h$
Name	Max Position Range Limit
Data type	INTEGER32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$

Description

If this range is exceeded or not reached, an overflow occurs. To prevent this overflow, limit values for the target position can be set in object **607D**$_h$ ("Software Position Limit").

607Ch Home Offset

Function

Specifies the difference between the zero position of the controller and the reference point of the machine in **user-defined units**.

Object description

Index	607C$_h$
Object name	Home Offset
Object Code	VARIABLE

Data type	INTEGER32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000_h
Firmware version	FIR-v1426
Change history	

607Dh Software Position Limit

Function

Defines the limit positions relative to the reference point of the application in **user-defined units**.

Object description

Index	$607D_h$
Object name	Software Position Limit
Object Code	ARRAY
Data type	INTEGER32
Savable	yes, category: application
Firmware version	FIR-v1426
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02_h

Subindex	01_h
Name	Min Position Limit
Data type	INTEGER32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000_h

Subindex	02_h
Name	Max Position Limit

Data type	INTEGER32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000_h

Description

The absolute target position must lie within the limits set here. The Home Offset (**607C**$_h$) is not taken into account.

607Eh Polarity

Function

With this object, the direction of rotation can be reversed.

Object description

Index	$607E_h$
Object name	Polarity
Object Code	VARIABLE
Data type	UNSIGNED8
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00_h
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1738-B501312: "PDO mapping" table entry for subindex 00 changed from "no" to "RX-PDO".

Description

The following generally applies for direction reversal: If a bit is set to the value "1", reversal is activated. If the value is "0", the direction of rotation is as described in the respective mode.

7	6	5	4	3	2	1	0
POS	VEL						

VEL (Velocity)

Direction of rotation reversal in the following modes:

- **Profile Velocity Mode**
- **Cyclic Synchronous Velocity Mode**
- **Velocity Mode**

POS (Position)

Direction of rotation reversal in the following modes:

- **Profile Position Mode**
- **Cyclic Synchronous Position Mode**

Tip

You can force an inversion of the rotary field that affects all operating modes. See object $3212_h{:}02_h$.

607Fh Max Profile Velocity

Function

Specifies the maximum speed in **user-defined units** for **Profile Position**, **Interpolated Position Mode** and **Profile Velocity** modes .

Object description

Index	$607F_h$
Object name	Max Profile Velocity
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	$00030D40_h$
Firmware version	FIR-v1540
Change history	Firmware version FIR-v1738-B501312: "Object Name" entry changed from "Max profile velocity" to "Max Profile Velocity".
	Firmware version FIR-v1738-B501312: "Data type" entry changed from "INTEGER16" to "UNSIGNED32".
	Firmware version FIR-v1738-B501312: "Savable" entry changed from "no" to "yes, category: application".
	Firmware version FIR-v1738-B501312: "Access" table entry for subindex 00 changed from "read only" to "read/write".
	Firmware version FIR-v1738-B501312: "PDO mapping" table entry for subindex 00 changed from "TX-PDO" to "RX-PDO".

6080h Max Motor Speed

Function

Specifies the maximum permissible speed of the motor in **user-defined units**.

Object description

Index	6080_h
Object name	Max Motor Speed

Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: tuning
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00030D40$_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1614: "Savable" entry changed from "yes, category: application" to "yes, category: tuning".
	Firmware version FIR-v1738-B501312: "Object Name" entry changed from "Maximum Speed" to "Max Motor Speed".
	Firmware version FIR-v1738-B501312: "PDO mapping" table entry for subindex 00 changed from "no" to "RX-PDO".

6081h Profile Velocity

Function

Specifies the maximum travel speed in **user-defined units**.

Object description

Index	6081$_h$
Object name	Profile Velocity
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	000001F4$_h$
Firmware version	FIR-v1426
Change history	

6082h End Velocity

Function

Specifies the speed at the end of the traveled ramp in **user-defined units**.

Object description

Index	6082$_h$
Object name	End Velocity
Object Code	VARIABLE
Data type	UNSIGNED32

Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1426
Change history	

6083h Profile Acceleration

Function

Specifies the maximum acceleration in **user-defined units**.

Object description

Index	6083$_h$
Object name	Profile Acceleration
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	000001F4$_h$
Firmware version	FIR-v1426
Change history	

6084h Profile Deceleration

Function

Specifies the maximum deceleration (deceleration ramp) in **user-defined units**.

Object description

Index	6084$_h$
Object name	Profile Deceleration
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	000001F4$_h$
Firmware version	FIR-v1426
Change history	

6085h Quick Stop Deceleration

Function

Specifies the maximum Quick Stop Deceleration in **user-defined units**.

Object description

Index	6085$_h$
Object name	Quick Stop Deceleration
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00001388$_h$
Firmware version	FIR-v1426
Change history	

6086h Motion Profile Type

Function

Specifies the ramp type for the **Profile Position** and **Profile Velocity** modes.

Object description

Index	6086$_h$
Object name	Motion Profile Type
Object Code	VARIABLE
Data type	INTEGER16
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$
Firmware version	FIR-v1426
Change history	

Description

Value = "0": = Trapezoidal ramp

Value = "3": Ramp with limited jerk

6087h Torque Slope

Function

This object contains the slope of the torque in Torque mode.

Object description

Index	6087_h
Object name	Torque Slope
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000_h
Firmware version	FIR-v1426
Change history	

Description

This object is calculated as thousandths of the torque, e.g., the value "500" means "50%" of the rated torque; "1100" is equivalent to 110%. The rated torque corresponds to the rated current in object $203B_h$:01.

The target torque may not exceed the peak torque (proportional to the peak current in 2031_h).

608Fh Position Encoder Resolution

Function

Contains the physical resolution of the encoder/sensor that is used for position control.

Object description

Index	$608F_h$
Object name	Position Encoder Resolution
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: tuning
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1738-B501312: "Savable" entry changed from "yes, category: application" to "yes, category: tuning".
	Firmware version FIR-v1738-B501312: "PDO mapping" table entry for subindex 01 changed from "no" to "RX-PDO".
	Firmware version FIR-v1738-B501312: "PDO mapping" table entry for subindex 02 changed from "no" to "RX-PDO".

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02$_h$

Subindex	01$_h$
Name	Encoder Increments
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	000007D0$_h$

Subindex	02$_h$
Name	Motor Revolutions
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001$_h$

Description

Position Encoder Resolution = Encoder Increments (**608F**$_h$:01$_h$) / Motor Revolutions (**608F**$_h$:02$_h$)

6090h Velocity Encoder Resolution

Function

Contains the physical resolution of the encoder/sensor that is used for speed control.

Object description

Index	6090$_h$
Object name	Velocity Encoder Resolution
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: tuning
Access	read only
PDO mapping	no
Allowed values	
Preset value	

Firmware version	FIR-v1738-B501312
Change history	

Value description

Subindex	00h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02h

Subindex	01h
Name	Encoder Increments Per Second
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000h

Subindex	02h
Name	Motor Revolutions Per Second
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000h

Description

Velocity Encoder Resolution = Encoder Increments per second (6090_h:01_h) / Motor Revolutions per second (6090_h:02_h)

6091h Gear Ratio

Function

Number of motor revolutions per output shaft revolution.

Object description

Index	6091h
Object name	Gear Ratio
Object Code	ARRAY
Data type	UNSIGNED32

Savable	yes, category: application
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1738-B501312: "PDO mapping" table entry for subindex 01 changed from "no" to "RX-PDO".
	Firmware version FIR-v1738-B501312: "PDO mapping" table entry for subindex 02 changed from "no" to "RX-PDO".

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02_h

Subindex	01_h
Name	Motor Revolutions
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001_h

Subindex	02_h
Name	Shaft Revolutions
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001_h

Description

Gear Ratio = Motor Revolutions (**6091_h**:01_h) / Shaft Revolutions (**6091_h**:02_h)

6092h Feed Constant

Function

Feed in the case of a linear drive; in **user-defined units** per output shaft revolutions.

Object description

Index	6092_h

Object name	Feed Constant
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Firmware version	FIR-v1426
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02_h

Subindex	01_h
Name	Feed
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001_h

Subindex	02_h
Name	Shaft Revolutions
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001_h

Description

Feed Constant = Feed (6092_h:01_h) / Shaft Revolutions (6092_h:02_h)

6096h Velocity Factor

Function

This object contains the factor that is used for converting from user-defined speed units. See chapter **User-defined units**.

Object description

Index	6096$_h$
Object name	Velocity Factor
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1738-B501312
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02$_h$

Subindex	01$_h$
Name	Numerator
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001$_h$

Subindex	02$_h$
Name	Divisor
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001$_h$

Description

The subindices have the following functions:

- 01$_h$: Numerator of the factor
- 02$_h$: Denominator of the factor

6097h Acceleration Factor

Function

This object contains the factor that is used for converting from user-defined acceleration units. See chapter **User-defined units**.

Object description

Index	6097_h
Object name	Acceleration Factor
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1738-B501312
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02_h

Subindex	01_h
Name	Numerator
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001_h

Subindex	02_h
Name	Divisor
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001_h

Description

The subindices have the following functions:

- 01_h: Numerator of the factor
- 02_h: Denominator of the factor

6098h Homing Method

Function

This object defines the **Homing method** in **Homing** Mode.

Object description

Index	6098_h
Object name	Homing Method
Object Code	VARIABLE
Data type	INTEGER8
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	23_h
Firmware version	FIR-v1426
Change history	

6099h Homing Speed

Function

Specifies the speeds for Homing Mode (**6098_h**) in **user-defined units**.

Object description

Index	6099_h
Object name	Homing Speed
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Firmware version	FIR-v1426
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only

PDO mapping	no
Allowed values	
Preset value	02$_h$

Subindex	01$_h$
Name	Speed During Search For Switch
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000032$_h$

Subindex	02$_h$
Name	Speed During Search For Zero
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000000A$_h$

Description

The speed for the search for the switch is specified in subindex 1.

The (lower) speed for the search for the reference position is specified in subindex 2.

> **Note**
> - The speed in subindex 2 is simultaneously the initial speed when starting the acceleration ramp. If this is set too high, the motor loses steps or fails to turn at all. If the setting is too high, the index marking will be overlooked. The speed in subindex 2 should therefore be less than 1000 steps per second.
> - The speed in subindex 1 must be greater than the speed in subindex 2.

609Ah Homing Acceleration

Function

Specifies the acceleration ramp for Homing Mode in **user-defined units**.

Object description

Index	609A$_h$
Object name	Homing Acceleration
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write

PDO mapping	RX-PDO
Allowed values	
Preset value	000001F4$_h$
Firmware version	FIR-v1426
Change history	

Description

The ramp is only used when starting up. When the switch is reached, the motor immediately switches to the lower speed; when the end position is reached, it immediately stops.

60A2h Jerk Factor

Function

This object contains the factor that is used for converting from user-defined jerk units. See chapter **User-defined units**.

Object description

Index	60A2$_h$
Object name	Jerk Factor
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1738-B501312
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	02$_h$

Subindex	01$_h$
Name	Numerator
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO

Allowed values	
Preset value	00000001_h

Subindex	02_h
Name	Divisor
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001_h

Description

The subindices have the following functions:

- 01_h: Numerator of the factor
- 02_h: Denominator of the factor

60A4h Profile Jerk

Function

In the case of a ramp with limited jerk, the size of the jerk can be entered in this object. An entry with the value "0" means that the jerk is not limited.

Object description

Index	$60A4_h$
Object name	Profile Jerk
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1614: "Name" entry changed from "End Acceleration Jerk" to "Begin Deceleration Jerk".
	Firmware version FIR-v1614: "Name" entry changed from "Begin Deceleration Jerk" to "End Acceleration Jerk".

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	04_h

Subindex	01h
Name	Begin Acceleration Jerk
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	000003E8h

Subindex	02h
Name	Begin Deceleration Jerk
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	000003E8h

Subindex	03h
Name	End Acceleration Jerk
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	000003E8h

Subindex	04h
Name	End Deceleration Jerk
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	000003E8h

Description

- Subindex 01h (*Begin Acceleration Jerk*): Initial jerk during acceleration
- Subindex 02h (*Begin Deceleration Jerk*): Initial jerk during braking
- Subindex 03h (*End Acceleration Jerk*): Final jerk during acceleration
- Subindex 04h (*End Deceleration Jerk*): Final jerk during braking

60A8h SI Unit Position

Function

This object contains the position unit. See chapter **User-defined units**.

Object description

Index	60A8$_h$
Object name	SI Unit Position
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	FF410000$_h$
Firmware version	FIR-v1738-B501312
Change history	

Description

Object 60A8$_h$ contains:

- Bits 16 to 23: The position unit (see chapter **Units**)
- Bits 24 to 31: The exponent of a power of ten (see chapter **Units**)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
			Factor								Unit				

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
			reserved (00h)								reserved (00h)				
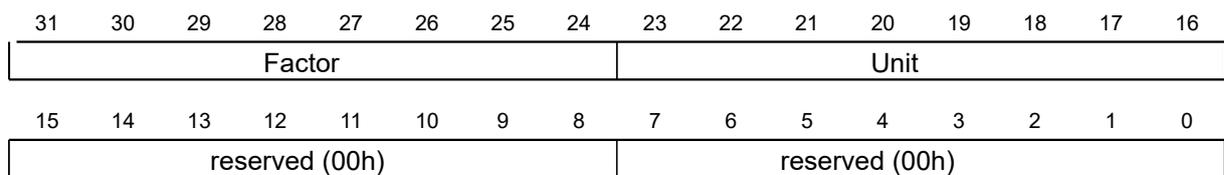
60A9h SI Unit Velocity

Function

This object contains the speed unit. See chapter **User-defined units**.

Object description

Index	60A9$_h$
Object name	SI Unit Velocity
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00B44700$_h$
Firmware version	FIR-v1738-B501312
Change history	

Description

Object 60A9$_h$ contains:

- Bits 8 to 15: The time unit (see chapter **Units**)
- Bits 16 to 23: The position unit (see chapter **Units**)
- Bits 24 to 31: The exponent of a power of ten (see chapter **Units**)

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
Factor								Nominator (Position)							

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Denominator (Time)								reserved (00h)							

60B0h Position Offset

Function

Offset for the position set value in **user-defined units**. Is taken into account in the **Cyclic Synchronous Position** and **Clock-direction mode** modes.

Object description

Index	60B0$_h$
Object name	Position Offset
Object Code	VARIABLE
Data type	INTEGER32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1738-B505321
Change history	

60B1h Velocity Offset

Function

Offset for the speed set value in **user-defined units**. Is taken into account in the **Cyclic Synchronous Position**, **Cyclic Synchronous Velocity** and **Clock-direction mode** modes.

Object description

Index	60B1$_h$
Object name	Velocity Offset
Object Code	VARIABLE
Data type	INTEGER32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO

Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1738-B505321
Change history	

60B2h Torque Offset

Function

Offset for the torque set value in tenths of a percent. Is taken into account in the **Cyclic Synchronous Position**, **Cyclic Synchronous Velocity**, **Cyclic Synchronous Torque** and **Clock-direction mode** modes.

Object description

Index	60B2$_h$
Object name	Torque Offset
Object Code	VARIABLE
Data type	INTEGER16
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0000$_h$
Firmware version	FIR-v1738-B505321
Change history	

60C1h Interpolation Data Record

Function

This object contains the demand position in **user-defined units** for the interpolation algorithm for the **Interpolated Position** operating mode.

Object description

Index	60C1$_h$
Object name	Interpolation Data Record
Object Code	ARRAY
Data type	INTEGER32
Savable	yes, category: application
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1512
Change history	Firmware version FIR-v1626: "Savable" entry changed from "no" to "yes, category: application".

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	01$_h$

Subindex	01$_h$
Name	1st Set-point
Data type	INTEGER32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$

Description

The value is taken over at the next synchronization time.

60C2h Interpolation Time Period

Function

This object contains the interpolation time.

Object description

Index	60C2$_h$
Object name	Interpolation Time Period
Object Code	RECORD
Data type	INTERPOLATION_TIME_PERIOD
Savable	yes, category: application
Access	read only
PDO mapping	no
Allowed values	
Preset value	
Firmware version	FIR-v1426
Change history	

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8

Access	read only
PDO mapping	no
Allowed values	
Preset value	02_h

Subindex	01_h
Name	Interpolation Time Period Value
Data type	UNSIGNED8
Access	read / write
PDO mapping	no
Allowed values	
Preset value	01_h

Subindex	02_h
Name	Interpolation Time Index
Data type	INTEGER8
Access	read / write
PDO mapping	no
Allowed values	
Preset value	FD_h

Description

The subindices have the following functions:

- 01_h: Interpolation time.
- 02_h: Power of ten of the interpolation time: must have the value -3 (corresponds to the time basis in milliseconds).

The following applies here: cycle time = value of **60C2**$_h$:01_h * $10^{\text{value of 60C2:02}}$ seconds.

60C4h Interpolation Data Configuration

Function

This object offers the maximum buffer size, specifies the configured buffer organization of the interpolated data and offers objects for defining the size of the record and for deleting the buffer. It is also used to store the position of other data points.

Object description

Index	$60C4_h$
Object name	Interpolation Data Configuration
Object Code	RECORD
Data type	INTERPOLATION_DATA_CONFIGURATION
Savable	yes, category: application
Access	read only
PDO mapping	no
Allowed values	

Preset value

Firmware version	FIR-v1512
Change history	Firmware version FIR-v1540: "Access" table entry for subindex 05 changed from "read/write" to "write only".
	Firmware version FIR-v1540: "Access" table entry for subindex 06 changed from "read/write" to "write only".
	Firmware version FIR-v1626: "Savable" entry changed from "no" to "yes, category: application".
	Firmware version FIR-v1650-B472161: "Access" table entry for subindex 01 changed from "read/write" to "read only".

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	06$_h$

Subindex	01$_h$
Name	MaximumBufferSize
Data type	UNSIGNED32
Access	read only
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	02$_h$
Name	ActualBufferSize
Data type	UNSIGNED32
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00000001$_h$

Subindex	03$_h$
Name	BufferOrganization
Data type	UNSIGNED8
Access	read / write
PDO mapping	no
Allowed values	
Preset value	00$_h$

Subindex	04_h
Name	BufferPosition
Data type	UNSIGNED16
Access	read / write
PDO mapping	no
Allowed values	
Preset value	0001_h

Subindex	05_h
Name	SizeOfDataRecord
Data type	UNSIGNED8
Access	write only
PDO mapping	no
Allowed values	
Preset value	04_h

Subindex	06_h
Name	BufferClear
Data type	UNSIGNED8
Access	write only
PDO mapping	no
Allowed values	
Preset value	00_h

Description

The value of subindex 01_h contains the maximum possible number of interpolated records.

The value of subindex 02_h contains the current number of interpolated records.

If subindex 03_h is "00_h", this means a FIFO buffer organization; if it is "01_h", it specifies a ring buffer organization.

The value of subindex 04_h is unitless and specifies the next free buffer entry point.

The value of subindex 05_h is specified in units of "byte". If the value "00_h" is written in subindex 06_h, it deletes the received data in the buffer, deactivates access and deletes all interpolated records. If the value "01_h" is written in subindex 06_h, it activates access to the input buffer.

60C5h Max Acceleration

Function

This object contains the maximum permissible acceleration for the **Profile Position** and **Profile Velocity** modes.

Object description

Index	$60C5_h$
Object name	Max Acceleration
Object Code	VARIABLE

Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00001388$_h$
Firmware version	FIR-v1426
Change history	

60C6h Max Deceleration

Function

This object contains the maximum permissible deceleration (deceleration ramp) for the **Profile Position** and **Profile Velocity** modes.

Object description

Index	60C6$_h$
Object name	Max Deceleration
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00001388$_h$
Firmware version	FIR-v1426
Change history	

60E4h Additional Position Actual Value

Function

Contains the current actual position of all existing feedbacks in **user-defined units**.

Object description

Index	60E4$_h$
Object name	Additional Position Actual Value
Object Code	ARRAY
Data type	UNSIGNED32
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	
Firmware version	FIR-v1738-B501312

Change history

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	03$_h$

Subindex	01$_h$ - 03$_h$
Name	Additional Position Actual Value #1 - #3
Data type	UNSIGNED32
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000$_h$

Description

The subindices have the following function:

- 00$_h$: Value="1" to "n", where "n" is the number of existing feedbacks.
- n$_h$:
  Subindex n contains the current actual position of the corresponding feedback.
  Subindex 01$_h$ always corresponds to the first (and always existing) *sensorless* feedback.

60E5h Additional Velocity Actual Value

Function

Contains the current actual speed of all existing feedbacks in **user-defined units**.

Object description

Index	60E5$_h$
Object name	Additional Velocity Actual Value
Object Code	ARRAY
Data type	UNSIGNED32
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	
Firmware version	FIR-v1738-B501312
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	03_h

Subindex	01_h - 03_h
Name	Additional Velocity Actual Value #1 - #3
Data type	UNSIGNED32
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000_h

Description

The subindices have the following function:

- 00_h: Value="1" to "n", where "n" is the number of existing feedbacks.
- n_h:
  Subindex n contains the current actual speed of the corresponding feedback.
  Subindex 01_h always corresponds to the first (and always existing) *sensorless* feedback.

60E6h Additional Position Encoder Resolution - Encoder Increments

Function

With this object and with **60EB**$_h$, the resolution of each existing feedback is calculated.

Object description

Index	$60E6_h$
Object name	Additional Position Encoder Resolution - Encoder Increments
Object Code	ARRAY
Data type	INTEGER32
Savable	yes, category: tuning
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	
Firmware version	FIR-v1748-B538662
Change history	

Value description

Subindex	00h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	03h

Subindex	01h
Name	Additional Position Encoder Resolution - Encoder Increments Feedback Interface #1
Data type	INTEGER32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00320000h

Subindex	02h
Name	Additional Position Encoder Resolution - Encoder Increments Feedback Interface #2
Data type	INTEGER32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	000000C8h

Subindex	03h
Name	Additional Position Encoder Resolution - Encoder Increments Feedback Interface #3
Data type	INTEGER32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001h

Description

The subindices have the following function:

- 00_h: Value="1" to "n", where "n" is the number of existing feedbacks.
- n_h:
  Subindex n contains the number of increments of the corresponding feedback.
  Subindex 01_h always corresponds to the first (and always existing) *sensorless* feedback.

The resolution of feedback "n" is calculated as follows:

Position Encoder Resolution = Encoder Increments ($60E6_h$:01_h) / Motor Revolutions ($60EB_h$:02_h)

60E8h Additional Gear Ratio - Motor Shaft Revolutions

Function

In this object and in **$60ED_h$**, you can set the gear ratio of each existing feedback.

Object description

Index	$60E8_h$
Object name	Additional Gear Ratio - Motor Shaft Revolutions
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	
Firmware version	FIR-v1738-B501312
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	03_h

Subindex	01_h - 03_h
Name	Additional Gear Ratio - Motor Shaft Revolutions Feedback Interface #1 - #3
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001_h

Description

The subindices have the following function:

- 00_h: Value = "n", where "n" is the number of existing feedbacks.
- n_h: Subindex "n" contains the number of motor revolutions for the corresponding feedback. Subindex 01_h always corresponds to the first (and always existing) *sensorless* feedback.

The gear ratio of feedback "n" is calculated as follows:

Gear Ratio = Motor Shaft Revolutions ($60E8_h$:n_h) / Driving Shaft Revolutions (**$60ED_h$**:n_h)

60E9h Additional Feed Constant - Feed

Function

In this object and in **$60EE_h$**, you can set a feed constant for each existing feedback.

Object description

Index	$60E9_h$
Object name	Additional Feed Constant - Feed
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	
Firmware version	FIR-v1738-B501312
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	03_h

Subindex	01_h - 03_h
Name	Additional Feed Constant - Feed Feedback Interface #1 - #3
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001_h

Description

The subindices have the following function:

- 00_h: Value = "n", where "n" is the number of existing feedbacks.
- n_h: Subindex "n" contains the feed in **user-defined units** for the corresponding feedback. Subindex 01_h always corresponds to the first (and always existing) *sensorless* feedback.

The feed constant of feedback "n" is calculated as follows:

Feed Constant = Feed ($60E9_h:n_h$) / Driving Shaft Revolutions ($60EE_h:n_h$)

60EBh Additional Position Encoder Resolution - Motor Revolutions

Function

With this object and with $60E6_h$, the resolution of each existing feedback is calculated.

Object description

Index	$60EB_h$
Object name	Additional Position Encoder Resolution - Motor Revolutions
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: tuning
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	
Firmware version	FIR-v1738-B501312
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	03_h

Subindex	01_h - 03_h
Name	Additional Position Encoder Resolution - Motor Revolutions Feedback Interface #1 - #3
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001_h

Description

The subindices have the following function:

- 00_h: Value="1" to "n", where "n" is the number of existing feedbacks.
- n_h:

Subindex n contains the number of motor revolutions of the corresponding feedback.
Subindex 01_h always corresponds to the first (and always existing) *sensorless* feedback.

The resolution of feedback "n" is calculated as follows:

Position Encoder Resolution = Encoder Increments ($60E6_h$:01_h) / Motor Revolutions ($60EB_h$:02_h)

60EDh Additional Gear Ratio - Driving Shaft Revolutions

Function

In this object and in **$60E8_h$**, you can set the gear ratio of each existing feedback.

Object description

Index	$60ED_h$
Object name	Additional Gear Ratio - Driving Shaft Revolutions
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	
Firmware version	FIR-v1738-B501312
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	03_h

Subindex	01_h - 03_h
Name	Additional Gear Ratio - Driving Shaft Revolutions Feedback Interface #1 - #3
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001_h

Description

The subindices have the following function:

- 00_h: Value = "n", where "n" is the number of existing feedbacks.
- n_h: Subindex "n" contains the number of revolutions of the output shaft for the corresponding feedback.
  Subindex 01_h always corresponds to the first (and always existing) *sensorless* feedback.

The gear ratio of feedback "n" is calculated as follows:

Gear Ratio = Motor Shaft Revolutions ($60E8_h:n_h$) / Driving Shaft Revolutions ($60ED_h:n_h$)

60EEh Additional Feed Constant - Driving Shaft Revolutions

Function

In this object and in **$60E9_h$**, you can set a feed constant for each existing feedback.

Object description

Index	$60EE_h$
Object name	Additional Feed Constant - Driving Shaft Revolutions
Object Code	ARRAY
Data type	UNSIGNED32
Savable	yes, category: application
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	
Firmware version	FIR-v1738-B501312
Change history	

Value description

Subindex	00_h
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	RX-PDO
Allowed values	
Preset value	03_h

Subindex	01_h - 03_h
Name	Additional Feed Constant - Driving Shaft Revolutions Feedback Interface #1 - #3
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000001_h

Description

The subindices have the following function:

- 00_h: Value = "n", where "n" is the number of existing feedbacks.
- n_h: Subindex "n" contains the number of revolutions of the output shaft for the corresponding feedback.
  Subindex 01_h always corresponds to the first (and always existing) *sensorless* feedback.

The feed constant of feedback "n" is calculated as follows:

Feed Constant = Feed ($60E9_h$:n_h) / Driving Shaft Revolutions ($60EE_h$:n_h)

60F2h Positioning Option Code

Function

The object describes the positioning behavior in **Profile Position** mode.

Object description

Index	$60F2_h$
Object name	Positioning Option Code
Object Code	VARIABLE
Data type	UNSIGNED16
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	0001_h
Firmware version	FIR-v1446
Change history	Firmware version FIR-v1614: "Savable" entry changed from "no" to "yes, category: application".

Description

Only the following bits are supported at the present time:

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MS	RESERVED [3]			IP OPTION [4]				RADO [2]		RRO [2]		CIO [2]		REL. OPT. [2]	

REL. OPT. (Relative Option)

These bits determine the behavior with relative rotating movement in "Profile Position" mode if bit 6 of controlword **6040_h** = "1" is set.

Bit 1	Bit 0	Definition
0	0	Position movements are executed relative to the previous (internal absolute) target position (each relative to 0 if there is no previous target position)
0	1	Position movements are executed relative to the preset value (or output) of the ramp generator.
1	0	Position movements are performed relative to the current position (object **6064_h**).

Bit 1	Bit 0	Definition
1	1	Reserved

RRO (Request-Response Option)

These bits determine the behavior when passing controlword 6040_h bit 5 ("new setpoint") – in this case, the controller releases the bit itself. This eliminates the need to externally reset the bit to "0" afterwards. After the bit is set to the value "0" by the controller, bit 12 ("setpoint acknowledgment") is also set to the value "0" in statusword 6041_h.

> **Note**
>
> These options cause the controller to modify object controlword 6040_h.

Bit 5	Bit 4	Definition
0	0	The functionality is as described under **Setting travel commands**.
0	1	The controller releases the "new setpoint" bit as soon as the current targeted movement has reached its target.
1	0	The controller releases the "new setpoint" bit as soon this is possible for the controller.
1	1	Reserved

RADO (Rotary Axis Direction Option)

These bits determine the direction of rotation in "Profile Position" mode.

Bit 7	Bit 6	Definition
0	0	Normal positioning similar to a linear axis: If one of the "Position Range Limits" – $607B_h$:01_h and 02_h – is reached or exceeded, the preset is automatically transferred to the other end of the limit. Only with this bit combination is a movement greater than the modulo value possible.
0	1	Positioning only in negative direction: If the target position is greater than the current position, the axis moves to the target position via the "Min Position Range Limit" from object $607D_h$:01_h.
1	0	Positioning only in positive direction: If the target position is less than the current position, the axis moves to the target position via the "Max Position Range Limit" from object $607D_h$:01_h.
1	1	Positioning with the shortest distance to the target position. If the difference between the current position and the target position in a 360° system is less than 180°, the axis moves in the positive direction.

60F4h Following Error Actual Value

Function

This object contains the current following error in **user-defined units**.

Object description

Index	60F4$_h$
Object name	Following Error Actual Value
Object Code	VARIABLE
Data type	INTEGER32
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1426
Change history	

60F8h Max Slippage

Function

Defines the maximum allowed slippage error in **user-defined units** symmetrically to the **set speed** in **Profile Velocity** mode.

Object description

Index	60F8$_h$
Object name	Max Slippage
Object Code	VARIABLE
Data type	INTEGER32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000190$_h$
Firmware version	FIR-v1738-B501312
Change history	

Description

If the actual speed deviates so much from the set speed that the value (absolute value) of this object is exceeded, bit 13 in object **6041**$_h$ is set. The deviation must last longer than the time in object **203F**$_h$.

If the value of 60F8$_h$ is set to "7FFFFFFF"$_h$, slippage error monitoring is switched off.

A reaction to the slippage error can be set in object **3700**$_h$. If a reaction is defined, an error is also entered in object **1003**$_h$.

60FAh Control Effort

Function

This object contains the correction speed in **user-defined units** that is fed to the speed controller by the position controller.

Object description

Index	60FA$_h$
Object name	Control Effort
Object Code	VARIABLE
Data type	INTEGER32
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1748-B531667
Change history	

Description

The position controller calculates a correction speed (in **user-defined units**) from the difference between the current position and the demand position which is then passed on to the speed controller. This correction value is dependent on the proportional component (**3210**$_h$:01$_h$) and the integral component (**3210**$_h$:02$_h$) of the position controller. See also chapter **Closed Loop**.
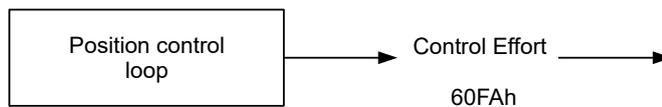
60FCh Position Demand Internal Value

Function

Indicates the current demand position in increments.

Object description

Index	60FC$_h$
Object name	Position Demand Internal Value
Object Code	VARIABLE
Data type	INTEGER32
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1738-B501312
Change history	

60FDh Digital Inputs

Function

With this object, the **digital inputs** of the motor can be read.

Object description

Index	$60FD_h$
Object name	Digital Inputs
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	00000000_h
Firmware version	FIR-v1426
Change history	

Description

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
								IN 8	IN 7	IN 6	IN 5	IN 4	IN 3	IN 2	IN 1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
													HS	PLS	NLS
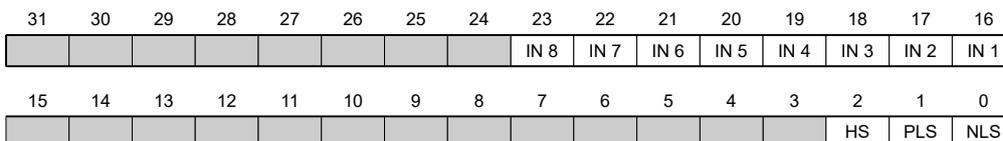
NLS (Negative Limit Switch)

 Negative limit switch

PLS (Positive Limit Switch)

 Positive limit switch

HS (Home Switch)

 Home switch

IN n (Input n)

 Input n – the number of used bits is dependent on the given controller.

60FEh Digital Outputs

Function

With this object, the **digital outputs** of the motor can be written.

Object description

Index	$60FE_h$
Object name	Digital Outputs
Object Code	ARRAY
Data type	UNSIGNED32

Savable	yes, category: application
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1626: "Savable" entry changed from "no" to "yes, category: application".

Value description

Subindex	00$_h$
Name	Highest Sub-index Supported
Data type	UNSIGNED8
Access	read only
PDO mapping	no
Allowed values	
Preset value	01$_h$

Subindex	01$_h$
Name	Digital Outputs #1
Data type	UNSIGNED32
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$

Description

To write the outputs, the entries in object **3250**$_h$, subindex 02$_h$ to 05$_h$, must also be taken into account.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16
												OUT4	OUT3	OUT2	OUT1

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
															BRK
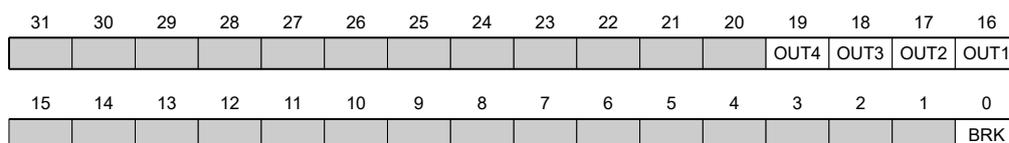
BRK (Brake)

   Bit for the brake output (if the controller supports this function).

OUT n (Output No n)

   Bit for the respective digital output; the exact number of digital outputs is dependent on the controller.

60FFh Target Velocity

Function

In this object, the target speed for the **Profile Velocity** and **Cyclic Synchronous Velocity** modes is entered in **user-defined units**.

Object description

Index	60FF$_h$
Object name	Target Velocity
Object Code	VARIABLE
Data type	INTEGER32
Savable	yes, category: application
Access	read / write
PDO mapping	RX-PDO
Allowed values	
Preset value	00000000$_h$
Firmware version	FIR-v1426
Change history	Firmware version FIR-v1626: "Savable" entry changed from "no" to "yes, category: application".

6502h Supported Drive Modes

Function

The object describes the supported operating modes in object **6060**$_h$.

Object description

Index	6502$_h$
Object name	Supported Drive Modes
Object Code	VARIABLE
Data type	UNSIGNED32
Savable	no
Access	read only
PDO mapping	TX-PDO
Allowed values	
Preset value	000003EF$_h$
Firmware version	FIR-v1426
Change history	

Description

The set bit specifies whether the respective mode is supported. If the value of the bit is "0", the mode is not supported.

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
						CST	CSV	CSP	IP	HM		TQ	PV	VL	PP

PP

Profile Position Mode

VL

    Velocity Mode

PV

    Profile Velocity Mode

TQ

    Torque Mode

HM

    Homing Mode

IP

    Interpolated Position Mode

CSP

    Cyclic Synchronous Position Mode

CSV

    Cyclic Synchronous Velocity Mode

CST

    Cyclic Synchronous Torque Mode

6503h Drive Catalogue Number

Function

Contains the device name as character string.

Object description

Index	6503_h
Object name	Drive Catalogue Number
Object Code	VARIABLE
Data type	VISIBLE_STRING
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	0
Firmware version	FIR-v1426
Change history	

6505h Http Drive Catalogue Address

Function

This object contains the manufacturer's web address as a character string.

Object description

Index	6505$_h$
Object name	Http Drive Catalogue Address
Object Code	VARIABLE
Data type	VISIBLE_STRING
Savable	no
Access	read only
PDO mapping	no
Allowed values	
Preset value	http://www.nanotec.de
Firmware version	FIR-v1426
Change history	

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11.1 Introduction

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11.2 AES

FIPS-197 compliant AES implementation

Based on XySSL: Copyright (C) 2006-2008 Christophe Devine

Copyright (C) 2009 Paul Bakker <polarssl_maintainer at polarssl dot org>

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The AES block cipher was designed by Vincent Rijmen and Joan Daemen.

http://csrc.nist.gov/encryption/aes/rijndael/Rijndael.pdf

http://csrc.nist.gov/publications/fips/fips197/fips-197.pdf

11.3 MD5

MD5C.C - RSA Data Security, Inc., MD5 message-digest algorithm

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11.5 DHCP

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11.6 CMSIS DSP Software Library

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11.7 FatFs

FatFs - FAT file system module include file R0.08 (C)ChaN, 2010

FatFs module is a generic FAT file system module for small embedded systems.

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11.8 Protothreads

Protothread class and macros for lightweight, stackless threads in C++.

This was "ported" to C++ from Adam Dunkels' protothreads C library at: http://www.sics.se/~adam/pt/

Originally ported for use by Hamilton Jet (www.hamiltonjet.co.nz) by Ben Hoyt, but stripped down for public release. See his blog entry about it for more information: http://blog.micropledge.com/2008/07/protothreads/

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This file is part of the lwIP TCP/IP stack.

Author: Adam Dunkels <adam@sics.se>