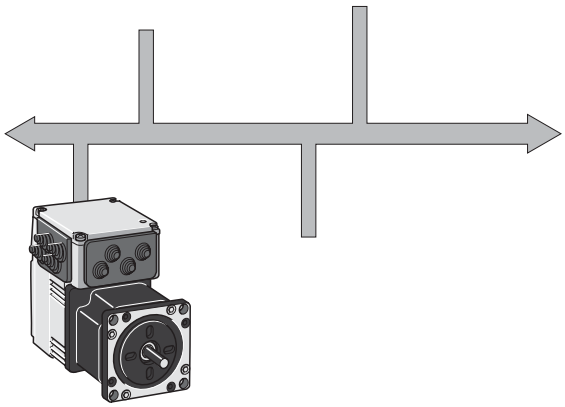
IL•1F CANopen DS301

Fieldbus interface
Fieldbus manual

V2.01, 11.2008



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Schneider Electric

Important information

This manual is part of the product.

Carefully read this manual and observe all instructions.

Keep this manual for future reference.

Hand this manual and all other pertinent product documentation over to all users of the product.

Carefully read and observe all safety instructions and the chapter "Before you begin - safety information".

Some products are not available in all countries.
For information on the availability of products, please consult the catalog.

Subject to technical modifications without notice.

All details provided are technical data which do not constitute warranted qualities.

Most of the product designations are registered trademarks of their respective owners, even if this is not explicitly indicated.

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Writing conventions and symbols

Work steps

If work steps must be performed consecutively, this sequence of steps is represented as follows:

- ■ Special prerequisites for the following work steps
- ▶ Step 1
- ◁ Specific response to this work step
- ▶ Step 2

If a response to a work step is indicated, this allows you to verify that the work step has been performed correctly.

Unless otherwise stated, the individual steps must be performed in the specified sequence.

Bulleted lists

The items in bulleted lists are sorted alphanumerically or by priority. Bulleted lists are structured as follows:

- Item 1 of bulleted list
- Item 2 of bulleted list
  - – Subitem for 2
  - – Subitem for 2
- Item 3 of bulleted list

Making work easier

Information on making work easier is highlighted by this symbol:

Sections highlighted this way provide supplementary information on making work easier.

SI units

SI units are the original values. Converted units are shown in brackets behind the original value; they may be rounded.

Example:
Minimum conductor cross section: 1.5 mm^2 (AWG 14)

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1 Introduction

1.1 About this manual

This manual describes the fieldbus specifics for products in a fieldbus network addressed via CANopen DS301.

1.2 CAN-Bus

The CAN bus (**C**ontroller **A**rea **N**etwork) was originally developed for fast, economical data transmission in the automotive industry. Today, the CAN bus is also used in industrial automation technology and has been further developed for communication at fieldbus level.

Features of the CAN bus

The CAN bus is a standardized, open bus enabling communication between devices, sensors and actuators from different manufacturers. The features of the CAN bus comprise

- Multimaster capability

  Each device in the fieldbus can transmit and receive data independently without depending on an "ordering" master functionality.

- Message-oriented communication

  Devices can be integrated into a running network without reconfiguration of the entire system. The address of a new device does not need to be specified on the network.

- Prioritization of messages

  Messages with higher priority are sent first for time-critical applications.

- Residual error probability

  Various security features in the network reduce the probability of undetected incorrect data transmission to less than 10^{-11}.

Transmission technology

In the CAN bus, multiple devices are connected via a bus cable. Each network device can transmit and receive messages. Data between network devices are transmitted serially.

Network devices

Examples of CAN bus devices are

- Automation devices, e.g. PLCs
- PCs
- Input/output modules
- Drives
- Analysis devices
- Sensors and actuators

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1.3 Fieldbus devices networked via CAN bus

Different fieldbus devices can be operated in the same fieldbus segment. The CANopen bus provides a common basis for interchanging commands and data between the product described and other network devices.

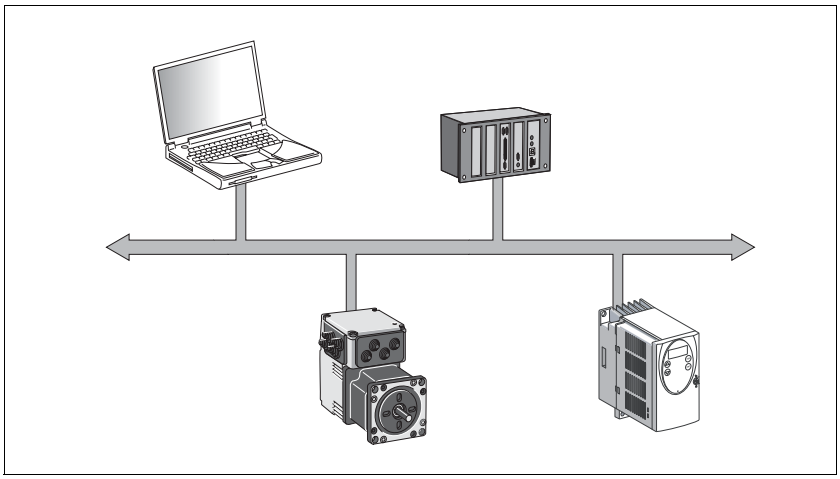

Figure 1.1 Fieldbus devices in the network

1.4 Operating modes and functions in fieldbus mode

This manual only describes the protocol for the slave. See the chapters "Operation" and "Parameters" for descriptions of the operating modes, functions and all parameters of the slave:

Operating modes

- Profile Velocity
- Profile position
- Homing
- Jog

Functions

- Definition of direction of rotation
- Motion profile generation
- Quick Stop
- Fast position capture

Settings

The following settings can be made via the fieldbus:

- Reading and writing parameters
- Monitoring the inputs and outputs of the 24 V signal interface
- Activating diagnostics and fault monitoring functions

Fieldbus mode

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1.5 Documentation and literature references

Manuals

In addition to this fieldbus manual, the following manuals also belongs to the product:

- **Product manual**, describes the technical data, installation, commissioning and all operating modes and functions.

CAN users and manufacturers organization

CiA - CAN in Automation
Am Weichselgarten 26
D-91058 Erlangen
http://www.can-cia.org/

CANopen standards

- CiA Standard 301 (DS301)
  CANopen application layer and communication profile
  V4.02, February 2002
- CiA Standard 402 (DSP402)
  Device profile for drives and motion control
  V2.0, July 2002
- ISO/DIS 11898: Controller Area Network (CAN) for high speed communication;1993
- EN 50325-4: Industrial communications subsystem based on ISO 11898 for controller device interfaces (CANopen); 2002

Literature

Controller Area Network
Konrad Etschberger, Carl Hanser Verlag
ISBN 3-446-19431-2

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2 Before you begin - safety information

The information provided in this manual supplements the product manual. Carefully read the product manual before you begin.

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3 Basics

3.1 CANopen technology

3.1.1 CANopen description language

CANopen is a device- and manufacturer-independent description language for communication via the CAN bus. CANopen provides a common basis for interchanging commands and data between CAN bus devices.

3.1.2 Communication layers

CANopen uses the CAN bus technology for data communication.

CANopen is based on the basic network services for data communication as per the ISO-OSI model model. 3 layers enable data communication via the CAN bus.

- Physical Layer
- Data Link Layer
- Application Layer

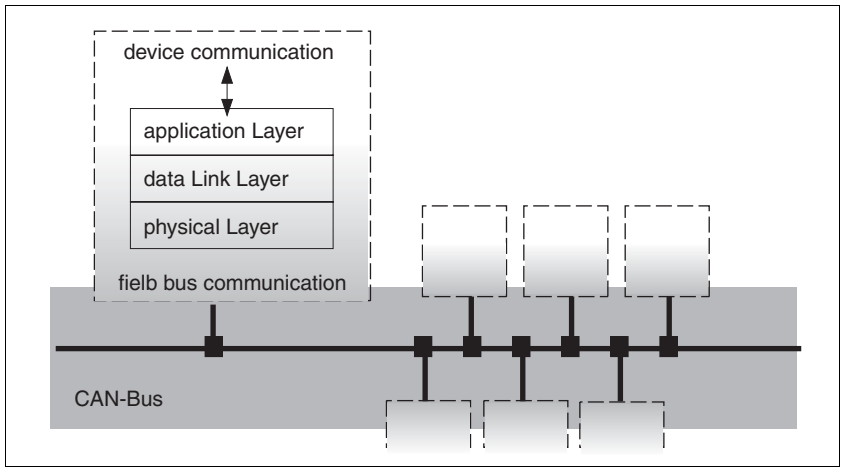

Figure 3.1 CANopen layer model

Physical Layer The physical layer defines the electrical properties of the CAN bus such as connectors, cable length and cable properties such as bit-coding and bit-timing.

Data Link Layer The data link layer connects the network devices. It assigns priorities to individual data packets and monitors and corrects errors.

Application Layer The application layer uses communication objects (COB) to exchange data between the various devices. Communication objects are elementary components for creating a CANopen application.

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3.1.3 Objects

All processes under CANopen are executed via objects. Objects carry out different tasks; they act as communication objects for data transport to the fieldbus, control the process of establishing a connection or monitor the network devices. If objects are directly linked to the device (device-specific objects), the device functions can be used and changed via these objects.

Object dictionary

The object dictionary of each network device allows for communication between the devices. Other devices find all objects with which they can communicate in this dictionary.

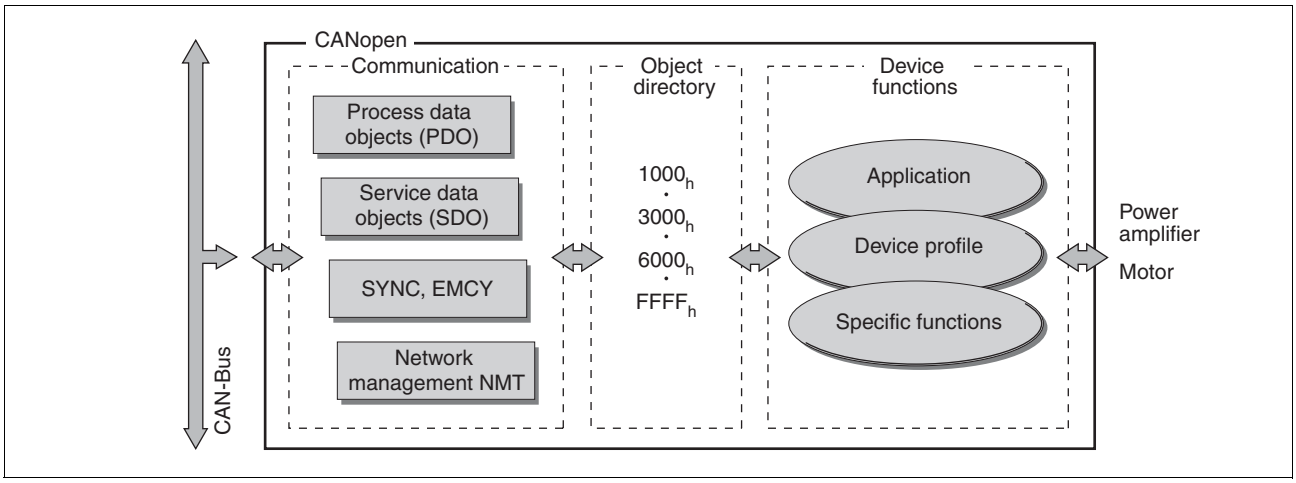

Figure 3.2 Device model with object dictionary

Objects for describing the data types and executing the communication tasks and device functions under CANopen are included in the object dictionary.

Object index

Every object is addressed by means of a 16 bit index, which is represented as a four-digit hexadecimal number. The objects are arranged in groups in the object dictionary.

Index (hex)	Object groups	Supported by the drive
0000_h	Reserved	No
0001_h-$009F_h$	Static and complex data types	No
$00A0_h$-$0FFF_h$	Reserved	No
1000_h-$1FFF_h$	Communication profile, standardized in DS 301	Yes
2000_h-$5FFF_h$	Manufacturer-specific device profiles	Yes
6000_h-$9FFF_h$	Standardized device profiles, e.g. in DSP 402	No
$A000_h$-$FFFF_h$	Reserved	No

Table 3.1 Object index

See page 79, 8.2 "Objects of the product" for a list of the CANopen objects.

Object group data types

Data types are used so that the messages that are transmitted via the network as bit streams have the same meaning for the transmitting and

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receiving devices. Data types are declared by means of the objects of the data types.

Object groups of the profiles

CANopen objects carry out various tasks in fieldbus mode. Profiles group the objects by tasks.

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3.1.4 CANopen profiles

Standardized profiles

Standardized profiles describe objects that are used with different devices without additional configuration. The users and manufacturers organization CAN in Automation has standardized various profiles. These include:

- DS301 communication profile
- DSP402 device profile

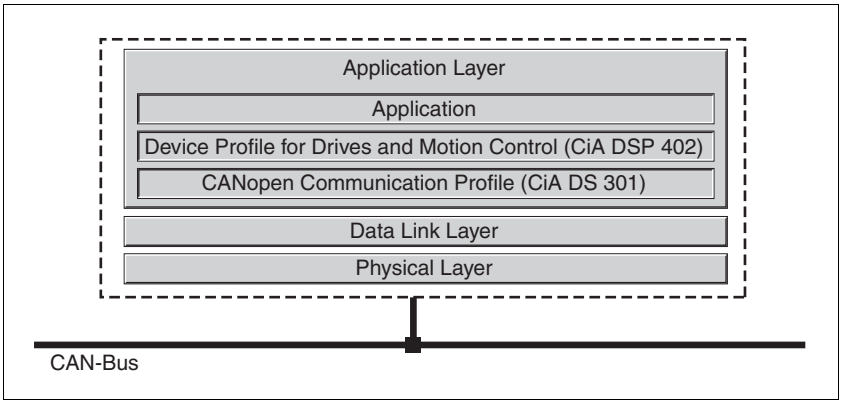

Figure 3.3 CANopen reference model

DS301 communication profile

The DS301 communication profile is the interface between device profiles and CAN bus. It was specified in 1995 under the name DS301 and defines uniform standards for common data exchange between different device types under CANopen.

The objects of the communication profile in the device carry out the tasks of data exchange and parameter exchange with other network devices and initialize, control and monitor the device in the network.

Objects of the communication profile are:

- **P**rocess **D**ata **O**bjects = PDO
- **S**ervice **D**ata **O**bjects = SDO
- Objects with special functions for synchronization SYNC and for error messages and error response EMCY
- Network management NMT objects for initialization, error monitoring and device status monitoring.

DSP402 device profile

The DSP402 device profile describes standardized objects for positioning, monitoring and settings of drives. The tasks of the objects include:

- Device monitoring and status monitoring (Device Control)
- Standardized parameterization
- Changing, monitoring and execution of operating modes

IMPORTANT: The product does not support the CiA 402 device profile.

Vendor-specific profiles

The basic functions of a device can be used with objects of standardized device profiles standardized. Only vendor-specific device profiles offer the complete range of functions. The objects with which the special functions of a device can be used under CANopen are defined in these vendor-specific device profiles.

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3.2 Communication profile

CANopen manages communication between the network devices with object dictionaries and objects. A network device can use process data objects (PDO) and service data objects (SDO) to request the object data from the object dictionary of another device and, if permissible, write back modified values.

The following can be done by accessing the objects of the network devices

- Exchange parameter values
- Start motion functions of individual CAN bus devices
- Request status information

3.2.1 Object dictionary

Each CANopen device manages an object dictionary which contains all objects for communication.

Index, subindex

The objects are addressed in the object dictionary via a 16 bit index. One or more 8 bit subindex entries for each object specify individual data fields in the object. Index and subindex are shown in hexadecimal notation with a subscript "$_h$".

The following example shows the index entries and subindex entries for the object `receive PDO4 mapping, 1603`$_h$ for mapping in `R_PDO4`.

Index	Subindex	Object	Meaning
1603_h	00_h	`Number of elements`	Number of subindexes
1603_h	01_h	`1st mapped object R_PDO4`	First object for mapping in R_PDO4
1603_h	02_h	`2nd mapped object R_PDO4`	Second object for mapping in R_PDO4
1603_h	03_h	`3rd mapped object R_PDO4`	Third object for mapping in R_PDO4

Table 3.2 Examples of index and subindex entries

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Structure of object dictionary

The objects in the object dictionary are sorted by index values. Table 3.3 shows the index ranges of the object dictionary according to the CANopen specifications.

Index range (hex)	Object groups	Supported by the drive
0000_h	Reserved	No
0001_h-$001F_h$	Static data types	No
0020_h-$003F_h$	Complex data types	No
0040_h-$005F_h$	Manufacturer-specific data types	No
0060_h-$007F_h$	Static data types for the device profiles	No
0080_h-$009F_h$	Complex data types for the device profiles	No
$00A0_h$-$0FFF_h$	Reserved	No
1000_h-$1FFF_h$	Communication profile	Yes
2000_h-$5FFF_h$	Manufacturer-specific profiles	Yes
6000_h-$9FFF_h$	Standardized device profiles	No
$A000_h$-$FFFF_h$	Reserved	No

Table 3.3 Index ranges of the object dictionary

Object descriptions inthe manual

For CANopen programming of a product, the following object groups are described in detail:

- $1xxx_h$ objects: Communication objects in this chapter
- $3xxx_h$ objects: Manufacturer-specific objects to the extent they are required for controlling the product

All operating modes and functions of the product are controlled by means of manufacturer-specific objects. These functions and objects are described in the device documentation.

The manufacturer-specific objects are stored in the index range starting at 3000_h. To derive the CAN index from the indexes given in the device documentation, it is sufficient to add 3000_h.

Example:

The control word for a state transition has the index 28 and the subindex 1. In the CAN protocol, this results in the index $301C_h$ ($3000_h + 1C_h[= 28_d]$) and the subindex 1.

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3.2.2 Communication objects

Overview The communication objects are standardized with the DS301 CANopen communication profile. The objects can be classified into 4 groups according to their tasks.

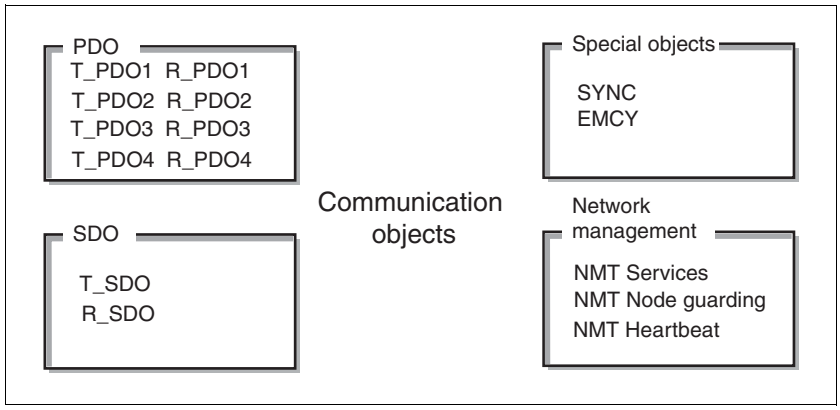

Figure 3.4 Communication objects; the following applies to the perspective of the network device: T_..: "Transmit", R_..: "Receive"

- PDOs (process data objects) for real-time transmission of process data
- SDOs (service data object) for read and write access to the object dictionary
- Objects for controlling CAN messages:
  - SYNC object (synchronization object) for synchronization of network devices
  - EMCY object (emergency object), for signaling errors of a device or its peripherals.
- Network management services:
  - NMT services for initialization and network control (NMT: network management)
  - NMT Node Guarding for monitoring the network devices
  - NMT Heartbeat for monitoring the network devices

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CAN message

Data is exchanged via the CAN bus in the form of CAN messages. A CAN message transmits the communication object and a variety of administration and control information.

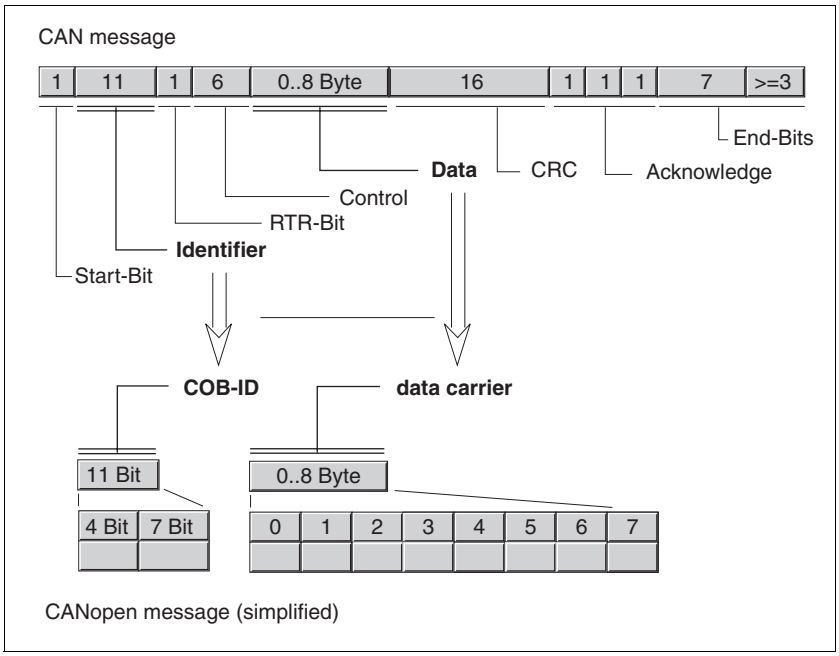

Figure 3.5 CAN message and simplified representation of CANopen message

CANopen message

For work with CANopen objects and for data exchange, the CAN message can be represented in simplified form because most of the bits are used for error correction. These bits are automatically removed from the receive message by the data link layer of the OSI model, and added to a message before it is transmitted.

The two bit fields "Identifier" and "Data" form the simplified CANopen message. The "Identifier" corresponds to the "COB ID" and the "Data" field to the data frame (maximum length 8 bytes) of a CANopen message.

COB ID

The COB ID (**C**ommunication **OB**ject **Id**entifier) has 2 tasks as far as controlling communication objects is concerned:

- Bus arbitration: Specification of transmission priorities
- Identification of communication objects

An 11 bit COB identifier as per the CAN 3.0A specification is defined for CAN communication; it comprises 2 parts

- Function code, 4 bits
- Node address (node ID), 7 bits.

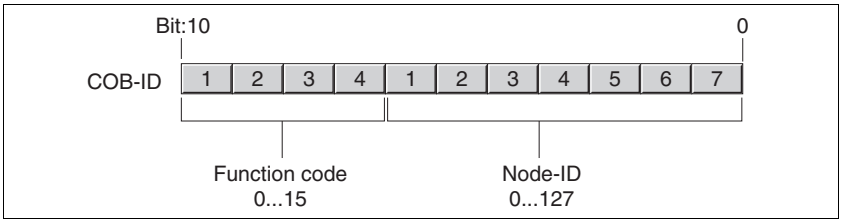

Figure 3.6 COB ID with function code and node address

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COB IDs of the communication objects

The following table shows the COB IDs of all communication objects with the factory settings. The column "Index of object parameters" shows the index of special objects with which the settings of the communication objects can be read or modified via an SDO.

Communication object	Function code	Node address, node ID [1...127]	COB ID decimal (hexadecimal)	Index of object parameters
NMT Start/Stop Service	0 0 0 0	0 0 0 0 0 0 0	0 (0_h)	-
SYNC object	0 0 0 1	0 0 0 0 0 0 0	128 (80_h)	1005_h....1007_h
EMCY object	0 0 0 1	x x x x x x x	128 (80_h) + node ID	1014_h, 1015_h
T_PDO1 1)	0 0 1 1	x x x x x x x	384 (180_h) + node ID	1800_h
R_PDO1 1)	0 1 0 0	x x x x x x x	512 (200_h) + node ID	1400_h
T_PDO2 1)	0 1 0 1	x x x x x x x	640 (280_h) + node ID	1801_h
R_PDO2 1)	0 1 1 0	x x x x x x x	768 (300_h) + node ID	1401_h
T_PDO3 1)	0 1 1 1	x x x x x x x	896 (380_h) + node ID	1802_h
R_PDO3 1)	1 0 0 0	x x x x x x x	1024 (400_h) + node ID	1402_h
T_PDO4	1 0 0 1	x x x x x x x	1152 (480_h) + node ID	1803_h
R_PDO4	1 0 1 0	x x x x x x x	1280 (500_h) + node ID	1403_h
T_SDO	1 0 1 1	x x x x x x x	1408 (580_h) + node ID	-
R_SDO	1 1 0 0	x x x x x x x	1536 (600_h) + node ID	-
NMT error control	1 1 1 0	x x x x x x x	1792 (700_h) + node ID	
LMT Services 1)	1 1 1 1	1 1 0 0 1 0 x	2020 ($7E4_h$), 2021 ($7E5_h$)	
NMT Identify Service 1)	1 1 1 1	1 1 0 0 1 1 0	2022 ($7E6_h$)	
DBT Services 1)	1 1 1 1	1 1 0 0 x x x	2023 ($7E7_h$), 2024 ($7F8_h$)	
NMT Services 1)	1 1 1 1	1 1 0 1 0 0 x	2025 ($7E9_h$), 2026 ($7EA_h$)	

1) Not supported by the device

Table 3.4 COB IDs of all communication objects

COB IDs of PDOs can be changed as required. The assignment pattern for COB IDs only specifies a basic setting.

Function code

The function code classifies the communication objects. Since the bits of the function code in the COB ID are more significant, the function code simultaneously controls the transmission priorities: Objects with a lower function code are transmitted with higher priority. For example, an object with function code "1" is transmitted prior to an object with function code "3" in the case of simultaneous bus access.

Node address

Every network device is configured before it is operated on the network. The device is assigned a 7 bit node address (node ID) between 1 (01_h) and 127 ($7F_h$). The device address "0" is reserved for "broadcast" transmissions which are used to send messages to all devices simultaneously.

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Example Selection of a COB ID

For a device with the node address 5, the COB ID of the communication object T_PDO1 is:

384+node ID = 384 (180_h) + 5 = 389 (185_h).

Data frame The data frame of the CANopen message can hold up to 8 bytes of data. In addition to the data frame for SDOs and PDOs, special frame types are specified in the CANopen profile:

- Error data frame
- Remote data frame for requesting a message

The data frames contain the respective communication objects.

3.2.3 Communication relationships

CANopen uses 3 relationships for communication between network devices:

- Master-slave relationship
- Client-server relationship
- Producer-consumer relationship

Master-slave relationship A network master controls the message traffic. A slave only responds when it is addressed by the master.

The master-slave relationship is used with network management objects for a controlled network start and to monitor the connection of devices.

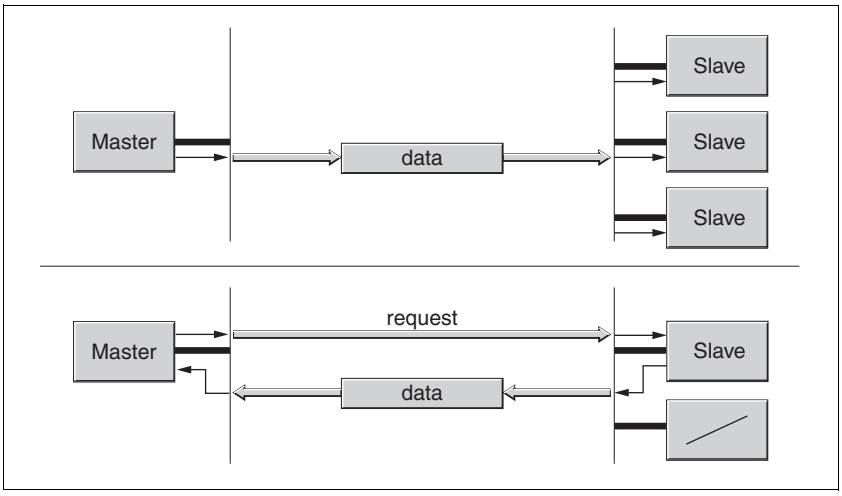

Figure 3.7 Master - slave relationships

Messages can be interchanged with and without confirmation. If the master sends an unconfirmed CAN message, it can be received by a single or by several slaves or by no slave.

To confirm the message, the master requests a message from a specific slave, which then responds with the desired data.

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Client-server relationship

A client-server relationship is established between 2 devices. The "server" is the device whose object dictionary is used during data exchange. The "client" addresses and starts the exchange of messages and waits for a confirmation from the server.

A client-server relationship with SDOs is used to send configuration data and long messages.

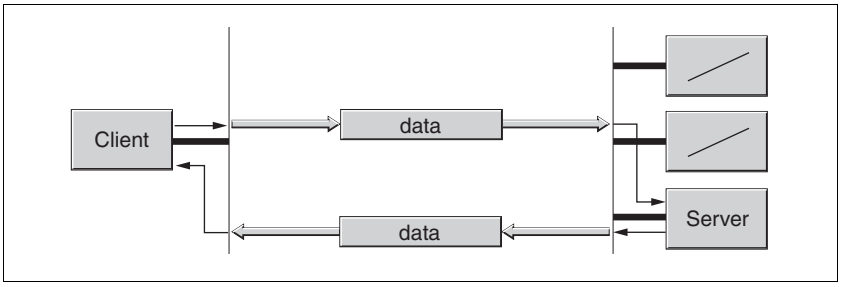

Figure 3.8 Client-server relationship

The client addresses and sends a CAN message to a server. The server evaluates the message and sends the response data as an acknowledgement.

Producer-consumer relationship

The producer-consumer relationship is used for exchanging messages with process data, because this relationship enables fast data exchange without administration data.

A "Producer" sends data, a "Consumer" receives data.

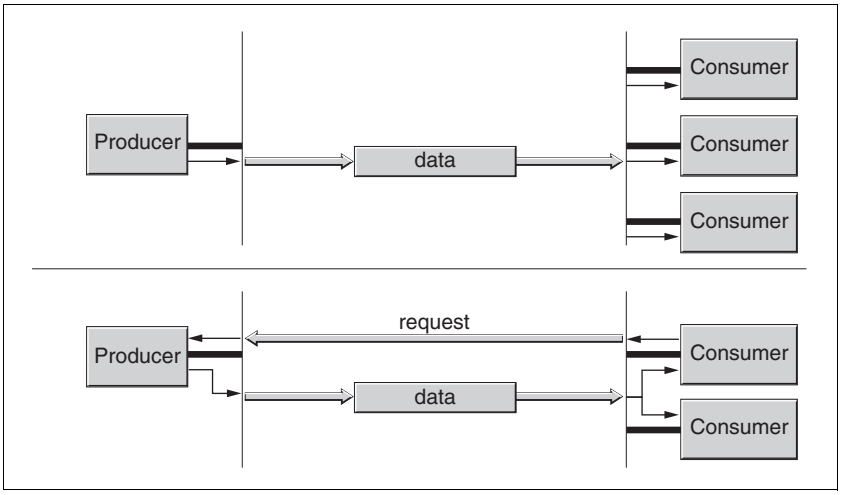

Figure 3.9 Producer-consumer relationships

The producer sends a message that can be received by one or more network devices. The producer does not receive an acknowledgement to the effect that the message was received. The message transmission can be triggered

- by an internal event, e.g. "target position reached"
- by the synchronization object SYNC
- a request of a consumer

For details on the function of the producer-consumer relationship and on requesting messages see chapter 3.4 "Process data communication".

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3.3 Service data communication

3.3.1 Overview

Service Data Object(SDO: **S**ervice **D**ata **O**bject) can be used to access the entries of an object dictionary via index and subindex. The values of the objects can be read and, if permissible, also be changed.

Every network device has at least one server SDO to be able to respond to read and write requests from a different device. A client SDO is only required to request SDO messages from the object dictionary of a different device or to change them there.

The T_SDO of an SDO client is used to send the request for data exchange; the R_SDO is used to receive. The data frame of an SDO consist of 8 bytes.

SDOs have a higher COB ID than PDOs and therefore are sent over the CAN bus at a lower priority.

3.3.2 SDO data exchange

A service data object (SDO) sends parameter data between two devices. The data exchange conforms to the client-server relationship. The server is the device to whose object dictionary an SDO message refers.

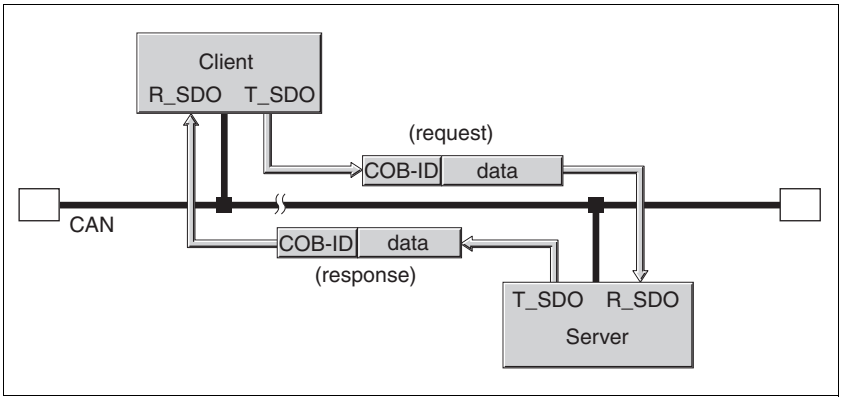

Figure 3.10 SDO message exchange with request and response

Message types Client-server communication is triggered by the client to send parameter values to the server or to get them from the server. In both cases, the client starts the communication with a request and receives a response from the server.

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3.3.3 SDO message

Put simply, an SDO message consists of the COB ID and the SDO data frame, in which up to 4 bytes of data can be sent. Longer data sequences are distributed over multiple SDO messages with a special protocol.

The device sends SDOs of up to 4 bytes data length (data). Greater amounts of data such as 8 byte values of the data type "Visible String 8" can be distributed over multiple SDOs and are transmitted successively in 7 byte blocks.

Example The following illustration shows an example of an SDO message.

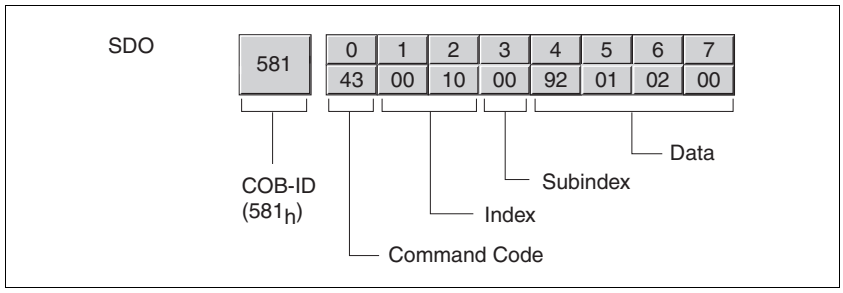

Figure 3.11 SDO message, example

COB ID and data frame R_SDO and T_SDO have different COB IDs.
The data frame of an SDO messages consists of:

- Command code (ccd) in which the SDO message type and the data length of the transmitted value are encrypted
- Index and subindex which point to the object whose data is transported with the SDO message
- Data of up to 4 bytes

Evaluation of numeric values Index and data are transmitted left-aligned in Intel format. If the SDO contains numerical values of more than 1 byte in length, the data must be rearranged byte-by-byte before and after a transmission.

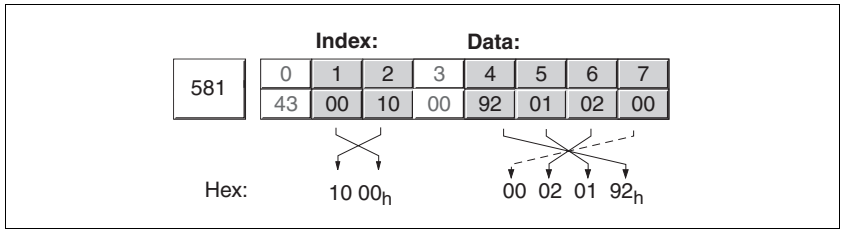

Figure 3.12 Rearranging numeric values greater than 1 byte

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3.3.4 Reading and writing data

Writing data

The client starts a write request by sending index, subindex, data length and value.

The server sends a confirmation indicating whether the data was correctly processed. The confirmation contains the same index and subindex, but no data.

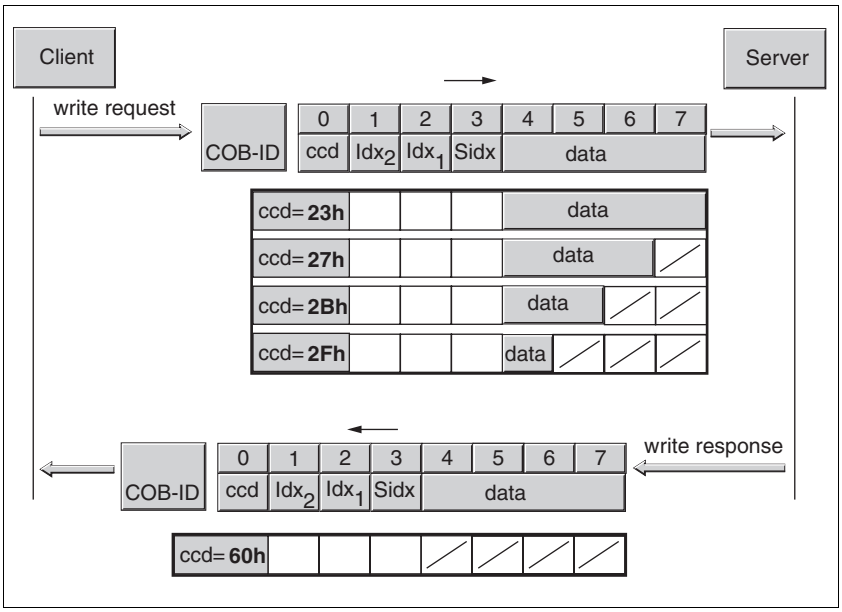

Figure 3.13 Writing parameter values

Unused bytes in the data field are shown with a slash in the graphic. The content of these data fields is not defined.

ccd coding

The table below shows the command code for writing parameter values. It depends on the message type and the transmitted data length.

Message type	Data length used				
	4 bytes	3 bytes	2 bytes	1 byte	
Write request	23_h	27_h	$2B_h$	$2F_h$	Transmitting parameters
Write response	60_h	60_h	60_h	60_h	Confirmation
Error response	80_h	80_h	80_h	80_h	Error

Table 3.5 Command code for writing parameter values

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Reading data

The client starts a read request by sending the index and subindex that point to the object or the object value whose value it wants to read.

The server confirms the request by sending the desired data. The SDO response contains the same index and subindex. The length of the response data is specified in the command code "ccd".

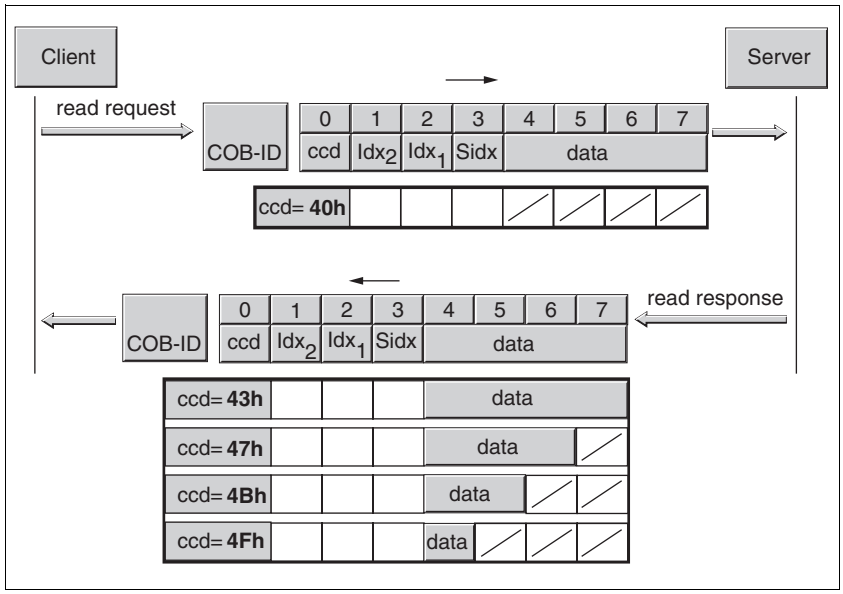

Figure 3.14 Reading a parameter value

Unused bytes in the data field are shown with a slash in the graphic. The content of these data fields is not defined.

ccd coding

The table below shows the command code for transmitting a read value. It depends on the message type and the transmitted data length.

Message type	**Data length used**				
	4 bytes	**3 bytes**	**2 bytes**	**1 byte**	
read request	40_h	40_h	40_h	40_h	Request read value
Read response	43_h	47_h	$4B_h$	$4F_h$	Return read value
Error response	80_h	80_h	80_h	80_h	Error

Table 3.6 Command code for transmitting a read value

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Error response If a message could not be evaluated without errors, the server sends an error message. For details on the evaluation of the error message see chapter 7 "Diagnostics and troubleshooting".

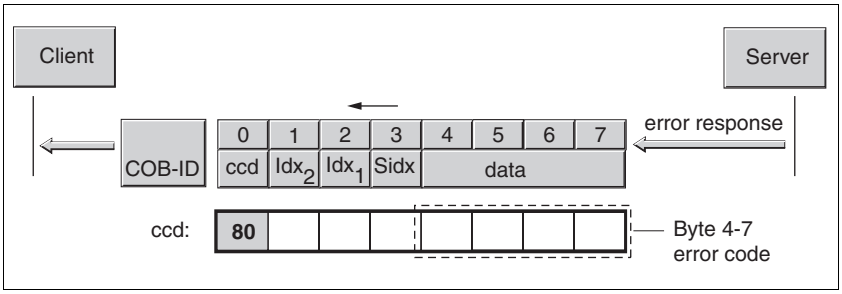

Figure 3.15 Response with error message (error response)

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3.4 Process data communication

3.4.1 Overview

This chapter describes the flow of information from the perspective of your product in compliance with CiA standard DS301. The designation "receive" relates to a flow of data from the master to the product, while "transmit" represents a flow of data from the product to the master.

Process data objects (PDO: **P**rocess **D**ata **O**bject) are used for real-time data exchange of process data such as actual and reference or operating state of the device. Transmission is very fast because the data is sent without additional administration data and a response from the recipient is not required.

The flexible data length of a PDO message also increases the data throughput. A PDO message can transmit up to 8 bytes of data. If only 2 bytes are assigned, only 2 data bytes are sent.

The length of a PDO message and the assignment of the data fields are specified by PDO mapping. For more information see chapter 3.4.2.1 "Dynamic and static PDO mapping".

PDO messages can be exchanged between devices that generate or process process data.

One PDO each is available for sending and receiving a PDO message:

- T_PDO to transmit the PDO message (T: "Transmit"),
- R_PDO to receive data (R: "Receive").

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3.4.2 PDO data exchange

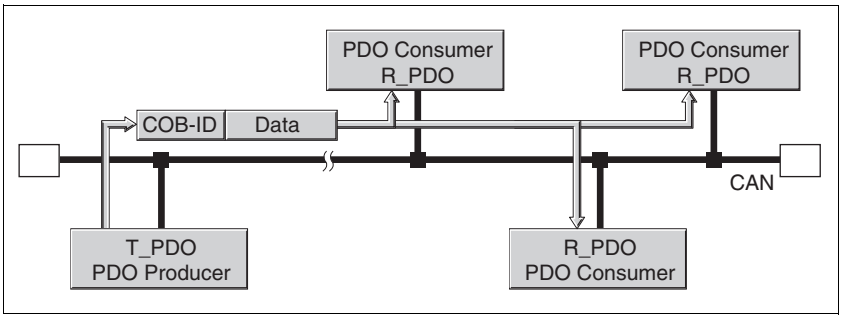

Figure 3.16 PDO data exchange

Data exchange with PDOs follows to the producer-consumer relationship and can be triggered in 3 ways

- Synchronized
- Event-driven, asynchronous
- On request of a consumer, asynchronous

The SYNC object controls synchronized data processing. Synchronous PDO messages are transmitted immediately like the standard PDO messages, but are only evaluated on the next SYNC. For example, several drives can be started simultaneously via synchronized data exchange.

The device immediately evaluates PDO messages that are called on request or in an event-driven way.

The transmission type can be specified separately for each PDO with subindex 02_h (transmission type) of the PDO communication parameter. The objects are listed in 8 "Object directory".

Event-driven

The "event" is a change of the PDO data. In this mode, the data is immediately transmitted after a change. Please note that in the case of, for example, a positioning movement, the actual position changes constantly so that a large number of PDOs is transmitted. There are two ways to avoid such a large number of PDOs:

- A) You can set an "Inhibit Timer" (object 1803_h subindex 3). The PDO is not sent until after this inhibit time has passed.
- B) By using a bit mask, you can limit the check for changes (=event). See section "Bit mask for T_PDO4" for a description.

A further possibility of "creating" an event consists of activating an "Event Timer" (object 1803_h subindex 5). You activate this counter by entering a value not equal to zero. When this counter is reached, this represents an additional event. This means that the PDO is transmitted when a value changes or when the counter event occurs.

Synchronized

In the case of this transmission mode, a PDO is transmitted in relation to a SYNC object. See 3.5 "Synchronization" for a detailed description.

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Remotely requested Transmission of an asynchronous PDO is triggered when an external request is received. Such a "Remote Request" is represented by a special bit in the CAN transmission frame; it has the same COB ID (communication object identifier) as the requested communication object.

An overview of the individual transmission types can be found in the object dictionary, PDO parameters.

Bit mask for T_PDO4 A bit mask can be defined for the objects `CAN.pdo4msk1` (30:9) and `CAN.pdo4msk2` (30:10) in T_PDO4. All bit positions containing a "zero" are then no longer considered in the checks for changes (=event). This allows you, for example, to limit checks to changes of the driveStat information.

Nameldx:Sub dec. (hex.)	MeaningBit assignment	Data type	UnitDefault (dez.)	R/W/ rem. Info
30:9 (1E:09h)	The default value 4294967295 corresponds to 0xFFFFFFFF.	UINT32	-4294967295	R/W/-
30:10 (1E:0Ah)	See object pdo4msk1 for a description.	UINT32	-0	R/W/-

Table 3.7 Parameters for the CAN bus

Example In this example, setting the object CAN.pdo4msk2 to zero keeps modifications to the current position from triggering an event.

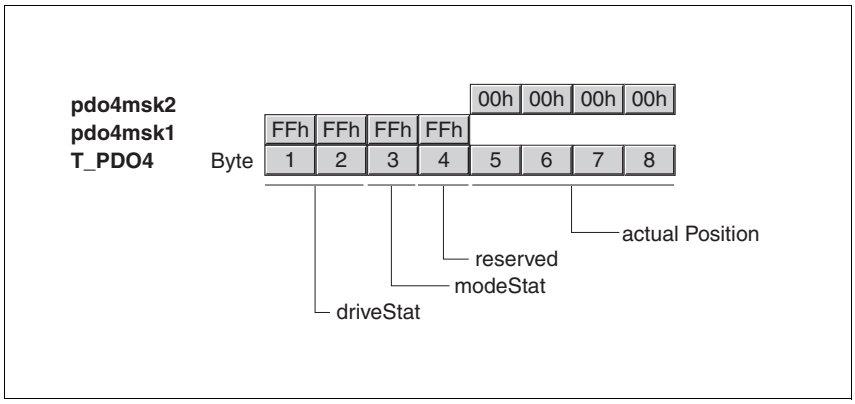

Figure 3.17 Setting the object `CAN.pdo4msk2` to zero

Requesting process data

One or more network devices with consumer function can request PDO messages from a producer. The producer is identified by the COB ID of the request and responds with the requested PDO.

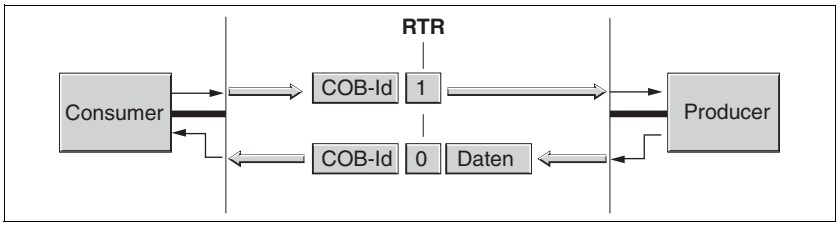

Figure 3.18 Requesting a message with RTR = 1

The RTR bit (RTR: **R**emote **T**ransmission **R**equest) of a CAN message is used to detect a request. The COB ID remains the same for both messages:RTR = 0: transmission of dataRTR = 1: request for data.

Setting RTR request

You can set for each PDO separately whether it responds to RTR requests. This is switched on or off via subindex 01, bit 30_h of each PDO. Subindex 02_h (transmission type) of the objects defines the transmission type. The PDO only responds to a request via bit RTR if RTR transmission is enabled for a PDO. The subindex values for the RTR bit are:

Objects 1403_h, 1803_h subindex 02_h, "transmission type"	**Meaning**
252	RTR active, synchronous
253	RTR active, asynchronous

Table 3.8 Subindexes for using the bit

An overview of all values for the subindex 02_h can be found in the object dictionary for the corresponding object.

The product cannot request PDOs, but it can respond to the request of PDOs.

3.4.2.1 Dynamic and static PDO mapping

Dynamic PDO mapping

The settings for PDO mapping are defined in an assigned communication object for each PDO. If the PDO mapping settings for a PDO can be changed, this is referred to as dynamic PDO mapping for the PDO. Dynamic PDO mapping enables flexible combination of different process data during operation.

Static PDO mapping

Static PDO mapping means that all objects are mapped in accordance with a fixed setting in the corresponding PDO.

Properties of the integrated drive.

The integrated drive supports 2 PDOs, the communication objects T_PDO4 and R_PDO4. These two PDO4 are enabled by default.

These PDOs are mapped statically, i.e. they cannot be configured but only read. The indexes for the permanently entered objects can be read from the PDO mapping object range:

- Object 1403_h: receive PDO4 communication parameter
- Object 1603_h: receive PDO4 mapping
- Object 1803_h: transmit PDO4 communication parameter
- Object $1A03_h$: transmit PDO4 mapping

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3.4.2.2 Receive PDO R_PD04 (master -> slave)

The master device can execute the following actions via the PDO4 channel to the slave:

- Control the state machine of the slave
  - Enable/disable the power stage of the product
  - Trigger and reset a "Quick Stop"
  - Resetting faults
- Toggle the operating modes
  - Profile Position operating mode, absolute and relative
  - Profile Velocity operating mode
  - Reference movement
  - Position setting
- Set reference values
  - Reference position
  - Reference speed
  - Type of reference movement

Structure of R_PDO4:

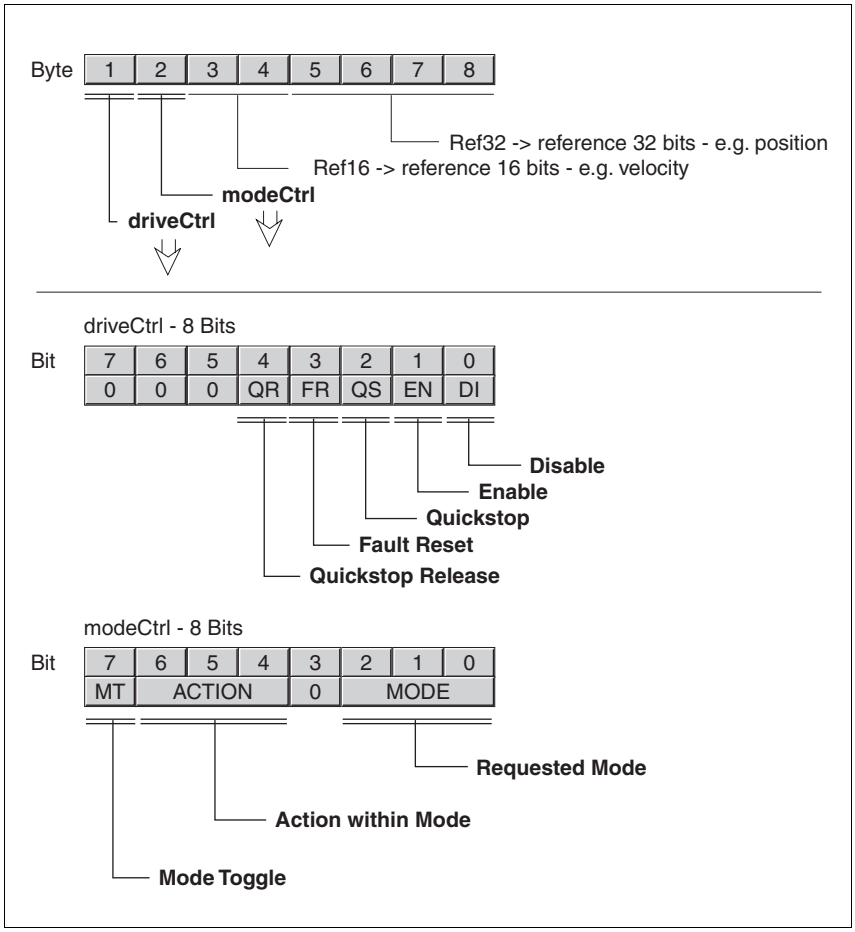

Figure 3.19 Structure of R_PDO4

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State machine – drivectrl

The state machine is controlled via PDO4 or the SDO object drivectrl, 28:1, in both cases via bits Bits 0 ... 4.

In PDO mode, a change form 0 to 1 triggers the corresponding function.

In the case of access via SDO, a write access with a set bit value is sufficient, i.e. a change of edge is not required.

Controlling the state machine	PDO4Bits 0 ... 4	SDO object drivectrl, 28:1Bits 0 ... 4
Bit 0: Power stage Disable	Triggered when 0 changes to 1	Triggered at write access if bit value = 1
Bit 1: Power stage Enable		
Bit 2: Quickstop		
Bit 3: Fault Reset		
Bit 4: Quickstop Release		

The value "0" is a special case: If during transmission all bits 0 ... 7 are "zero", the product interprets this as "Disable" command and disables the power stage. This applies to both PDO and SDO access.

Handling of errors

If requests for controlling the state machine cannot be executed by the product, the product ignores such request. There is no error response.

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Operating modes – `modeCtrl`

In PDO mode, the operating modes are controlled via object `modeCtrl`. The master must enter the following values to activate an operating mode or to change reference values:

- Reference values in fields "Ref16" and "Ref32"
- Select operating mode with `modeCtrl`, Bits 0 ... 2 (MODE)
- Select action for this operating mode with `modeCtrl`, bits 4 ... 6 (ACTION)
- Toggle `modeCtrl`, bit 7 (MT)

The following table shows the possible operating modes and the corresponding reference values:

Mode bits 0... 2	Action bits 4 ... 6	modeCtrl [1]. Bits 0 ... 6	Description	Corresponds to object [2]	Reference value Ref16	Reference value Ref32
1 (JOG)	0	01h	Jog	41:3	Start (as object 41:1)	-
2 (REF)	0	02h	Position setting	40:3	-	Position for position setting
	1	12h	Reference movement	40:1	Type (as object 40:1)	-
3 (PTP)	0	03h	Absolute positioning	35:1	Reference speed	Reference position
	1	13h	Relative positioning	35:3	Reference speed	Reference position
	2	23h	Continue positioning	35:4	Reference speed	-
4 (VEL)	0	04h	Profile Velocity	36:1	Reference speed	-

1) Column corresponds to the value to be entered in byte `modeCtrl`, but without ModeToggle (bit 7)

2) Column shows Index:Subindex (decimal) of the corressponding operating mode objects modes which are described in more detail in the device documentation.

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Reference positions are entered in increments, reference speeds in [min^{-1}].

⚠ WARNING

UNINTENDED OPERATION

- Note that any changes to the values of these parameters are executed by the drive controller immediately on receipt of the data set.
- Verify that the system is free and ready for movement before changing these parameters.

Failure to follow these instructions can result in death, serious injury or equipment damage.

If operating mode, reference position and reference speed are transmitted simultaneously in one PDO, data consistency is required. For this reason, the product evaluates the operating mode data only if bit 7 was toggled. Toggling means that a "0 -> 1" or a "1 -> 0" change of edge was detected.

Bit 7 is mirrored in the response PDO4 from the product so that synchronized operation is possible via PDO4.

Handling of errors Requests for operating mode are triggered by toggling the bit 7 . If these requests cannot be executed, the product provides an error response as described in section Transmit PDO4 - Handling of errors.

3.4.2.3 Transmit PDO T_PD04 (product to master)

With the default product settings, the transmit PDO is sent asynchronously and in an "event-driven" way; an "Inhibit Time" can be set.

The product provides the master with the following information via PDO4:

- State of state machine
- Errors and warnings
- Active operating mode
- Status of active operating mode
  - Operating mode terminated
  - Error occurred
  - Reference speed or reference position reached
  - Actual position
- Slave referenced
- Acknowledgement of operating mode requests
- Status of the 24 V inputs and outputs

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Structure of T_PDO4:

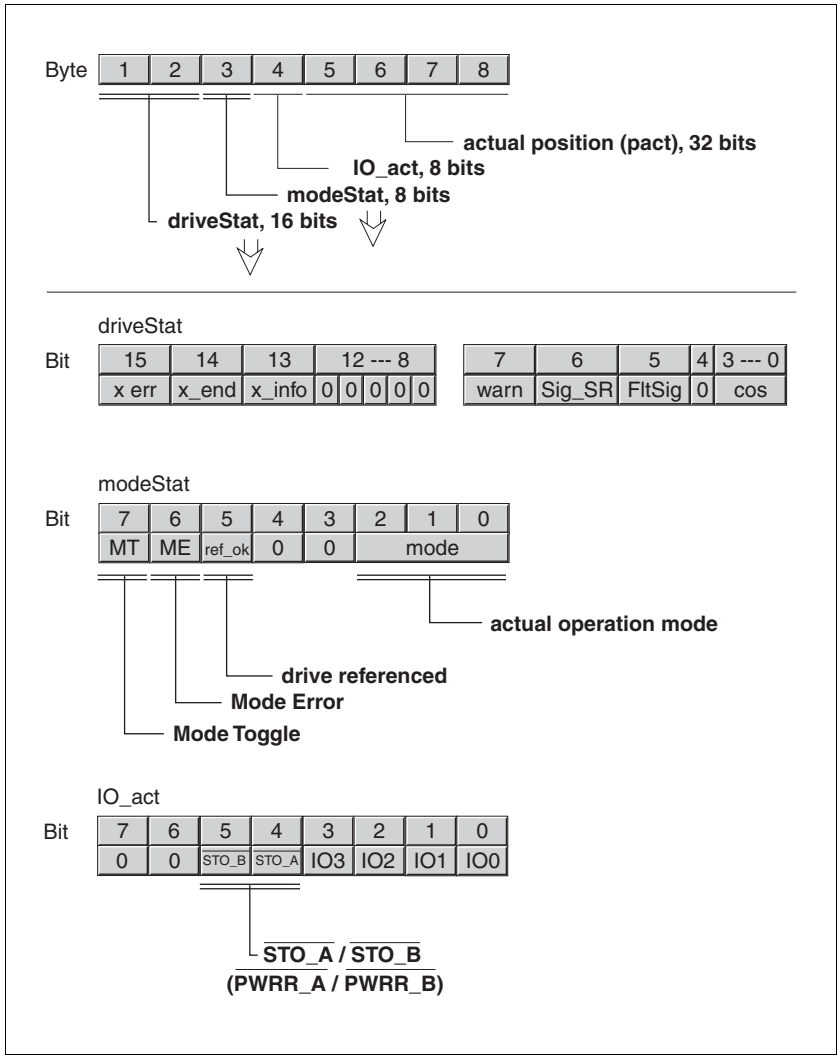

Figure 3.20 Structure of T_PDO4

Status word `driveStat`

The information in the status word `driveStat` corresponds to bits 0 ...15 of object `Status.driveStat`, 28:2.

Contents of information:

- State of state machine
- Warning and error bits
- Status of the current operating mode

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Operating mode `modeStat`

This field corresponds to bits 0 ... 2 of the object `Status.xMode_act`. Bits 6 and 7 provide additional information that can be used for synchronized operating mode control via the PDOs.

The field contains the following information:

Bit	Name	Description
0...2	mode	currently set operating mode as in R_PDO4
5	ref_ok	Is set if homing of the product by means of a reference movement or position setting was successful.
6	ME, ModeError	Set if a request of the master via R_PDO4 data was rejected by the product.
7	MT, ModeToggle	Mirrors bit 7 (Mode Toggle) of R_PDO4

3.4.2.4 Handshake with Mode Toggle Bit

Mode Toggle

Synchronized processing is possible with the transmit data `modeCtrl`, bit 7 (MT) and the receive data `modeStat`, bits 6 (ME) and 7 (MT). Synchronized processing means that the master waits for feedback messages from the slave so it can respond appropriately.

Example of positioning

The master starts a positioning movement at point in time t_0. At points in time t_1, t_2 ..., the master checks the responses from the slave. It waits for the end of the positioning movement by checking the Input Assembly for bit `x_end = 1` (end of positioning).

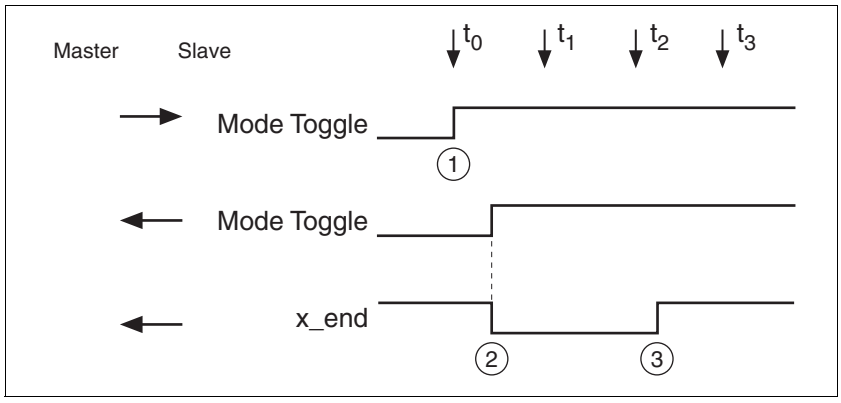

Figure 3.21 Mode Toggle Handshake

(1) Master starts positioning with MT = 1 in byte `modeCtrl`
(2) Slave signals that positioning is active with MT = 1 in `modeStat` and simultaneously with `x_end` = 0 in `driveStat`
(4) Slave signals end of positioning with `x_end` = 1 in `driveStat`

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Example of short positioning

The master starts a positioning movement that will only take a very short time. The duration is shorter than the polling cycle of the master. At point in time t_1 the movement is already complete. Using bit `x_end`, the master does not know whether the movement is already complete or has not yet been started. However, it detects this with the MT bit from the slave:

Master MT	Slave MT	Slave x_end	
1	0	1	Slave has not yet detected command
1	1	0	Slave has detected command, positioning running
1	1	1	Slave signals that positioning is complete

The master may only evaluate data in which the received MT bit is identical to the last bit transmitted by the master.

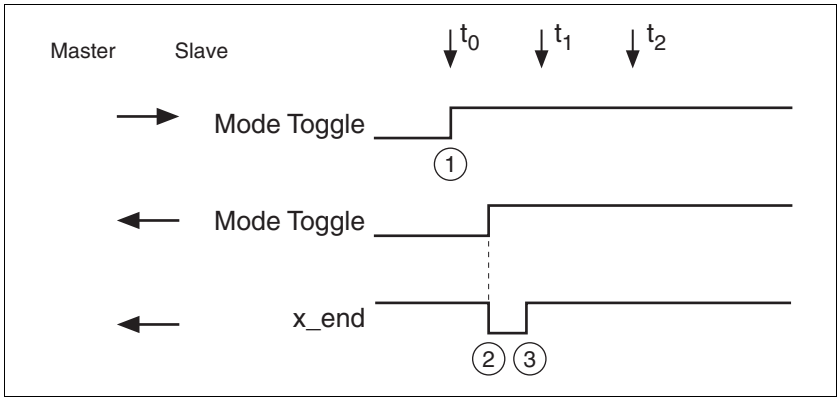

Figure 3.22 Mode Toggle Handshake, short movement

(1) Master starts positioning with MT = 1 in byte `modeCtrl`
(2+3) Slave signals that positioning is active with MT = 1 in `modeStat` and simultaneously with `x_end` = 0 in `driveStat`
(4) Slave signals end of positioning with `x_end` = 1 in `driveStat`

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Handling of errors

If the master toggles bit 7 (MT), this is interpreted by the slave as a request to start an operating mode or to change data of the current operating mode. If the request cannot be processed, the active operating mode is not changed and the slave sets bit 6 in `modeStat` (ME = `ModeError`).

The active operating mode is not changed and there is no state transition.

Bit 6 (ME) remains set until the master toggles bit 7 (MT) in `modeCtrl` again, thus triggering a new command.

The master can read the corresponding error code by a read access to parameter `ModeError`.

Possible reasons for a failure of the operating mode request:

- Reference values outside the value range
- Change of the operating mode during processing (impossible)
- Invalid operating mode requested
- The device is not in state 6 (`Operation Enable`) of the state machine.

For more information see the product manual.

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3.4.2.5 Emergency service

The Emergency Service signals internal device errors via the CAN bus. The error is sent to all network devices with an EMCY object according to the "Consumer-Producer" relationship.

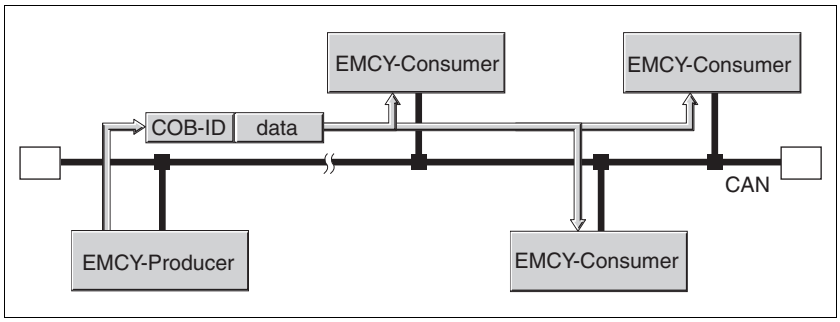

Figure 3.23 Error message with the EMCY object

EMCY message

Causes of an EMCY comprise:

- asynchronous errors, error code = 1000_hIn the case of an internal device error, the product switches to fault state in accordance with the device's state machine. At the same time, the product transmits an EMCY message with error register and error code.
- PDO4 error during operating mode control, error code = 8200_h If the request for an operating mode via PDO4 fails, the product also sends an EMCY message.
- CAN communication error, error code = 8100_h

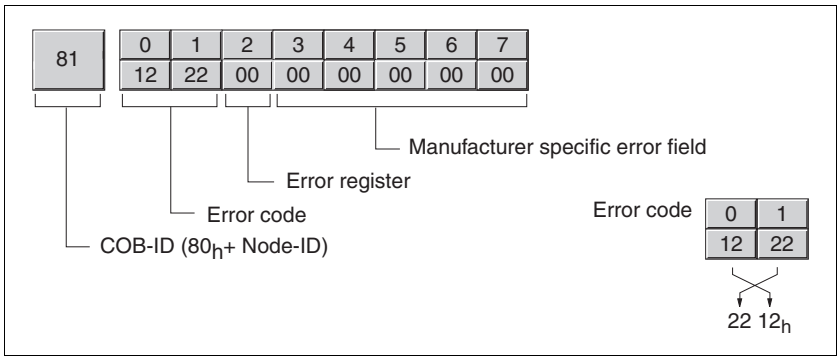

Figure 3.24 EMCY message

- Bytes 0, 1 (error code): CANopen error codeThis value is 1000, 8200_h or 8100_h, depending on the cause of the error.
- Byte 2: Error registerThe value is also stored in the object Error register, 1001_h.
- Byte 3 (Manufacturer-Specific Error Field):Manufacturer-specific error, error class

  Bytes 6 and 7 are 0. Bytes 4,5 contain a manufacturer-specific error number.See the product manual for a list of the error numbers.

COB ID

The COB ID for every device on the network supporting an EMCY object is determined on the basis of the node address:

COB ID = Function code of EMCY object, 80_h + Node-Id

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3.5 Synchronization

The synchronization object SYNC controls the synchronous exchange of messages between network devices for purposes such as the simultaneous start of multiple drives.

The data exchange conforms to the producer-consumer relationship. The SYNC object is transmitted to all devices by a network device and can be evaluated by all devices that support synchronous PDOs.

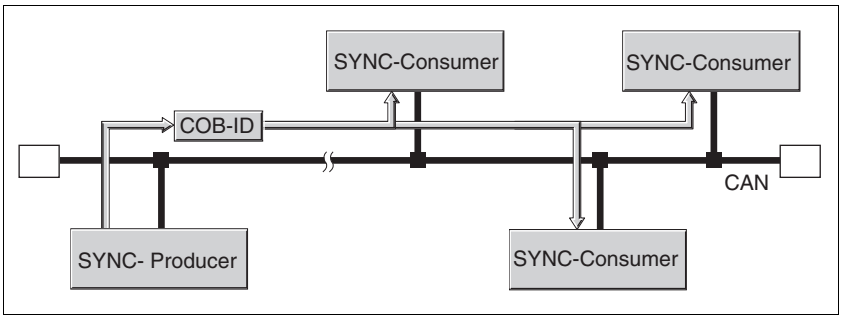

Figure 3.25 SYNC message

Time values for synchronization

Two time values define the behavior of synchronous data transmission:

- The cycle time specifies the time intervals between 2 SYNC messages. It is set with the object `Communication cycle period(1006h)`.
- The synchronous time window specifies the time span during which the synchronous PDO messages must be received and trnasmitted. The time window is defined with the object `Synchronous window length (1007h)`.

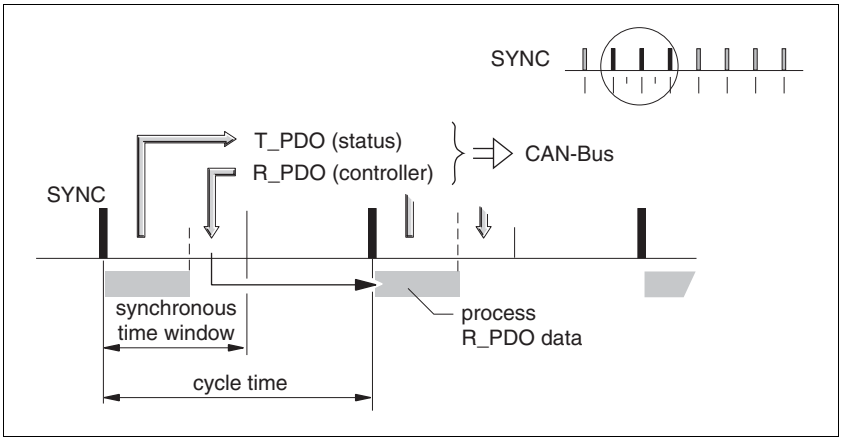

Figure 3.26 Synchronization times

Synchronous data transmission

From the perspective of a SYNC recipient, in one time window the status data is transmitted first in a T_PDO, then new control data is received via an R_PDO. However, the control data is only processed when the next SYNC message is received. The SYNC object itself does not transmit data.

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Cyclic ad acyclic data transmission

Synchronous exchange of messages can be cyclic or acyclic.

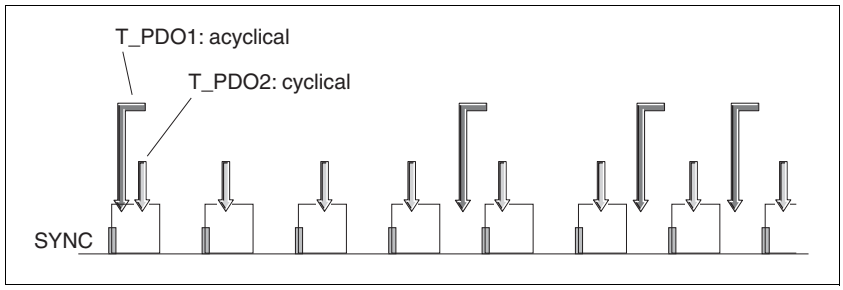

Figure 3.27 Cyclic and acyclic transmission

In the case of cyclic transmission, PDO messages are exchanged continuously in a specified cycle, e.g. with every SYNC message.

If a synchronous PDO message is transmitted acyclically, it can be transmitted or received at any time; however, it will not be valid until the next SYNC message.

Cyclic or acyclic behavior of a PDO is specified in the subindex `transmission type` (02_h) of the corresponding PDO parameter, e.g. in the object `1st receive PDO parameter` (1400_h:02_h) for R_PDO1.

COB ID, SYNC object

For fast transmission, the SYNC object is transmitted unconfirmed and with high priority.

The COB ID of the SYNC object is set to the value 128 (80_h) by default. The value can be changed after initialization of the network with the object `COB-ID SYNC Message` (1005_h) .

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3.6 Network management services

Network management (NMT) is part of the CANopen communication profile; it is used to initialize the network and the network devices and to start, stop and monitor the network devices in network mode.

NMT services are executed in a master-slave relationship. The NMT master addresses individual NMT slaves via their node address. A message with node address "0" is directed to all NMT slaves simultaneously.

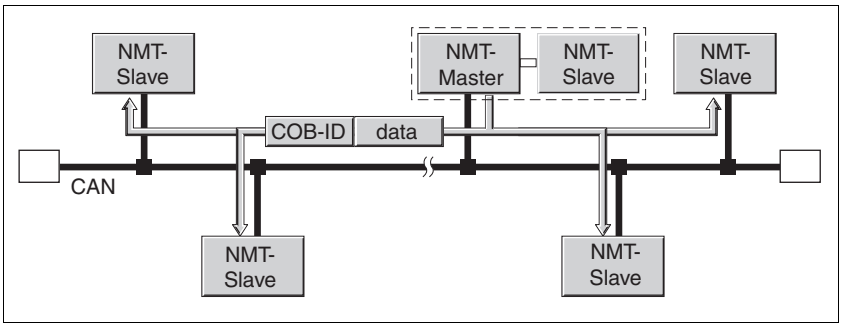

Figure 3.28 NMT services via the master-slave relationship

The device can only take on the function of an NMT slave.

NMT services NMT services can be divided into two groups:

- Services for device control, to initialize devices for CANopen communication and to control the behavior of devices in network mode
- Services:for connection monitoring

3.6.1 NMT services for device control

NMT state machine The NMT state machine describes the initialization and states of an NMT slave in mains operation.

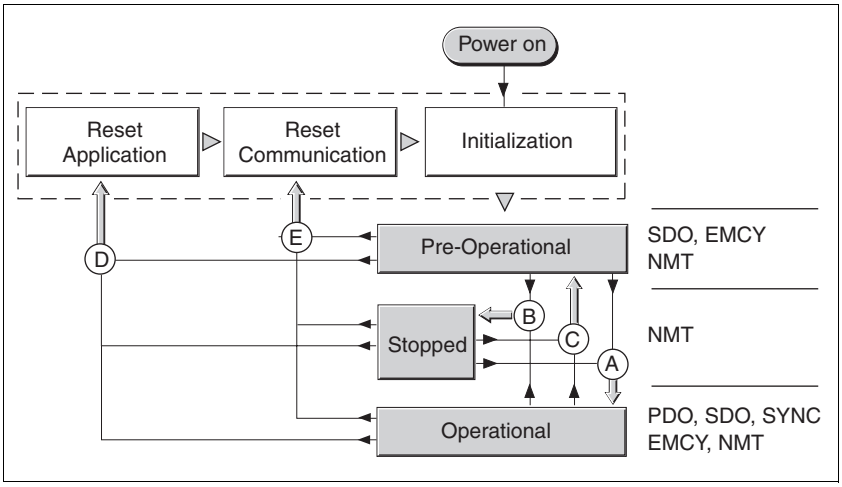

Figure 3.29 NMT state machine and available communication objects

To the right, the graphic shows all communication objects that can be used in the specific network state.

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Initialization

An NMT slave automatically runs through an initialization phase after the supply voltage is switched on (power on) to prepare it for CAN bus operation. On completion of the initialization, the slave switches to the state "Pre-operational" and sends a boot-up message. From now on, an NMT master can control the operational behavior of an NMT slave in the network via 5 NMT services, represented in the above illustration by the letters A to E.

NMT service	Transition	Meaning
Start remote node (Start network node)	A	Transition to state "Operational" Start normal network mode with all network devices
Stop remote node (Stop network node)	B	Transition to state "Stopped" Stops communication of the network device in the network. If connection monitoring is active, it remains on. If the power stage is active (state "Operation Enabled" or "QuickStop"), an error of error class 2 is triggered. The drive is stopped and switched off.
Enter Pre-Operational (Transition to "Pre-Operational")	C	Transition to "Pre-Operational" All communication objects except for PDOs can be used. The state "Pre-Operational" can be used for configuration by SDOs: - PDO mapping - Start of synchronization - Start of connection monitoring
Reset node (Reset node)	D	Transition to state "Reset application" Load stored data of the device profiles and automatically transition to "Pre-operational" via "Reset communication".
Reset communication (Reset communication data)	E	Transition to state "Reset communication" Load stored data of the communication profile and automatically switch to the state "Pre-Operational.". If the power stage is active (state "Operation Enabled" or "QuickStop"), an error of error class 2 is triggered. The drive is stopped and switched off.

Persistent data memory

When the supply voltage is switched on (power on), the device loads the saved object data from the non-volatile EEPROM for persistent data to the RAM.

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NMT message

The NMT services for device control are transmitted as unconfirmed messages with the COB ID = 0 . By default, they have the highest priority on the CAN bus.

The data frame of the NMT device service consists of 2 bytes.

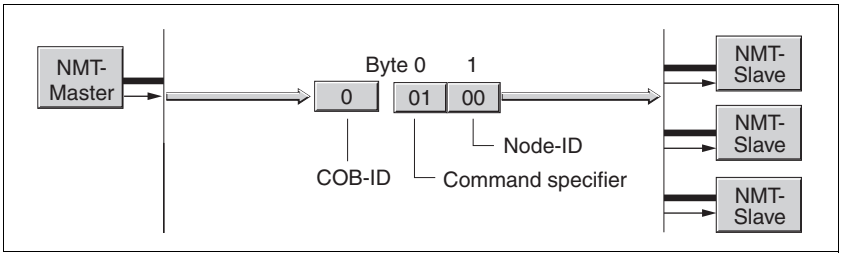

Figure 3.30 NMT message

The first byte, the "Command specifier", indicates the NMT service used.

Command Specifier	NMT service	Transition
1 (01_h)	Start remote node	A
2 (02_h)	Stop remote node	B
128 (80_h)	Enter Pre-Operational	C
129 (81_h)	Reset node	D
130 (82_h)	Reset communication	E

The second byte addresses the recipient of an NMT message with a node address between 1 and 127 ($7F_h$). A message with the node address "0" is directed to all NMT slaves.

3.6.2 NMT services for connection monitoring

Connection monitoring monitors the communication status of network devices, so a response to the failure of a device or an interruption in the network is possible.

Three NMT services for connection monitoring are available:

- "Node guarding" for monitoring the connection of an NMT slave
- "Life guarding" for monitoring the connection of an NMT master

3.6.2.1 Node/Life guarding

COB ID

Communication object `NMT error control (700`$_h$`+node-Id)` is used for connection monitoring. The COB ID for every NMT slave is determined on the basis of the node address:

COB ID = function code `NMTerror control (700`$_h$`) + node-Id`..

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Structure of the NMT message

After a request from the NMT master, the NMT slave responds with one data byte.

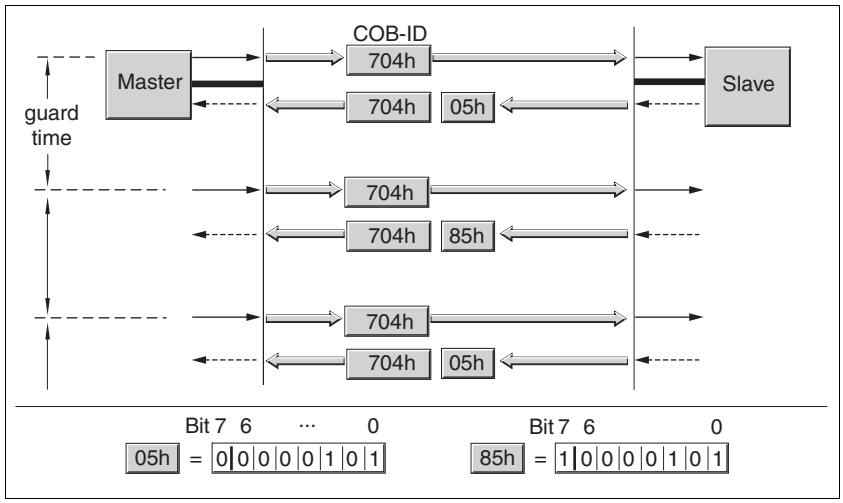

Figure 3.31 Acknowledgement of the NMT slave

Bits 0 to 6 identify the NMT state of the slave:

- 4 (04_h): "Stopped"
- 5 (05_h): "Operational"
- 127 ($7F_h$): "Pre-Operational"

After each "guard time" interval, bit 7 switches toggles between "0" and "1", so the NMT master can detect and ignore a second response within the "guard time" interval. The first request when connection monitoring is started begins with bit 7 = 0.

Connection monitoring must not be active during the initialization phase of a device. The status of bit 7 is reset as soon as the device runs though the NMT state "Reset communication".

Connection monitoring remains active in the NMT state "Stopped".

Configuration

Node/Life Guarding is configured via:

- Guard time ($100C_h$)
- Life time factor ($100D_h$)

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Connection error

The NMT master signals a connection error to the master program if:

- the slave does not respond within the "guard time" period
- the NMT state of the slave has changed without a request by the NMT master.

Figure 3.32 shows an error message after the end of the third cycle because of a missing response from an NMT slave.

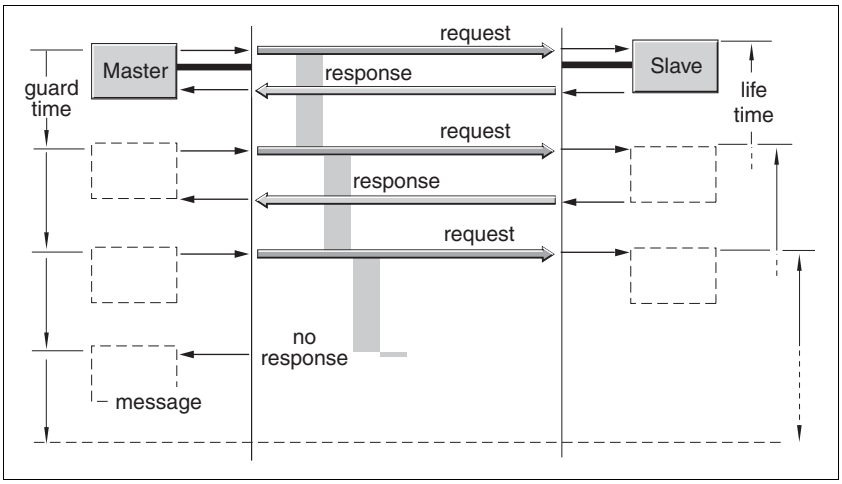

Figure 3.32 "Node Guarding" and "Life Guarding" with time intervals

Boot-up message

The communication profile DS 301, version 4.0, defines an additional task for the NMT services: sending a boot-up message.

A network device informs all other network devices that it is ready for operation using a boot-up message.

A boot-up message consists of the COB ID of the NMT object `NMT Error Control` and is transmitted without data. The default setting of the COB ID is `1792 (700h) + node-Id`

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4 Installation

⚠ WARNING

LOSS OF CONTROL

- The designer of any control scheme must consider the potential failure modes of control paths and, for certain critical functions, provide a means to achieve a safe state during and after a path failure. Examples of critical control functions are EMERGENCY STOP, overtravel stop, power outage and restart.
- Separate or redundant control paths must be provided for critical functions.
- System control paths may include communication links. Consideration must be given to the implication of unanticipated transmission delays or failures of the link.
- Observe the accident prevention regulations and local safety guidelines. [1)]
- Each implementation of the product must be individually and thoroughly tested for proper operation before being placed into service.

Failure to follow these instructions can result in death or serious injury.

1) For USA: Additional information, refer to NEMA ICS 1.1 (latest edition), Safety Guidelines for the Application, Installation, and Maintenance of Solid State Control and to NEMA ICS 7.1 (latest edition), Safety Standards for Construction and Guide for Selection, Installation for Construction and Operation of Adjustable-Speed Drive Systems.

⚠ WARNING

SIGNAL AND DEVICE INTERFERENCE

Signal interference can cause unexpected responses of device.

- Install the wiring in accordance with the EMC requirements.
- Verify compliance with the EMC requirements.

Failure to follow these instructions can result in death, serious injury or equipment damage.

For information on installation of the device and connecting the device to the fieldbus see the product manual.

Slave withDIP switches

Before installing the slave in the system, you must set the network address and the baud rate via the DIP switches in the connector housing.

See the chapter "Installation" in the product manual for information on the DIP switch settings.

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5 Commissioning

⚠ DANGER

UNINTENDED CONSEQUENCES OF EQUIPMENT OPERATION

When the system is started, the drives are usually out of the operator's view and cannot be visually monitored.

- Only start the system if there are no persons in the hazardous area.

Failure to follow these instructions will result in death or serious injury.

⚠ WARNING

UNINTENDED OPERATION

- Do not write values to reserved parameters.
- Do not write values to parameters unless you fully understand the function. For more information see the product manual.
- Run initial tests without coupled loads.
- Verify that the system is free and ready for the movement before changing parameters.
- Verify the use of the bits with fieldbus communication: bit 0 is far right (least significant). Bit 15 is far left (most significant).
- Verify the use of the word sequence with fieldbus communication.
- Do not establish a fieldbus connection unless you have fully understood all communications principles.

Failure to follow these instructions can result in death, serious injury or equipment damage.

5.1 Commissioning the device

For installation in the network, the device must first be properly installed (mechanically and electrically) and commissioned.

Commission the device as per product manual. This prepares the device for operation in the network.

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5.2 Address and baud rate

Up to 32 devices can be addressed in one CAN bus network branch and up to 127 devices in the extended network. Each device is identified by a unique address. The default node address for a device is 127.

The default baud rate is 125 kbaud.

Each device must be assigned its own node address, i.e. any given node address may be assigned only once in the network.

Setting address and baud rate

The address is set directly at the device via parameter `canAddr` and the baud rate via parameter `canBaud`.

The baud rate must be the same for all devices in the fieldbus.

5.3 Commissioning the fieldbus network

5.3.1 Starting fieldbus mode

Configuration with SyCon

Note on using the Hilscher configuration software SyCon:

Do not change the setting `Geräteprofil` (value = 0) in the `Knotenkonfiguration` dialog box!

If this value is changed, communication with the drive will no longer work. However, the setting cannot be reset to the initial value.

To restore communication with the product:

- Click the `Knoten BootUp` button in the `Knotenkonfiguration` dialog box.
- Click `Prüfe Knoten Type and Profile` in the `Knoten Aufschaltreihenfolge` dialog to skip this step.

Testing fieldbus operation

After correct configuration of the transmission data, test fieldbus operation.

This requires installation of a CAN configuration tool that displays CAN messages. The acknowledgement from the product is indicated by a boot-up message:

- Switch the power supply of the product off and on again.
- Observe the network messages shortly after switching on the device. The positioning controller sends a 1 byte boot-up message after initialization of the bus: 128 (80_h)+node-Id.

With the node address factory-set to 127 ($7F_h$), boot-up message 255 (FF_h) is transmitted via the bus. The drive can then be put into operation via NMT services.

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5.3.2 Troubleshooting

Check the following settings if the slave does not respond:

- Did you start the slave and switch on the master?
- Are all cable connections ok (electrically and mechanically)?
- Did you set the correct address at the slave? Check the DIP switch and HEX switch settings. The settings are described in the product manual. Products without DIP switches have the following default settings: CAN address 127 ($7F_h$) and baud rate 125 [kBit/s]. You can change these settings via CAN itself or by means of the PC commissioning tool via the RS 485 interface.
- Did you set the same baud rate and the same interface parameters for the master and the slave?

If the slave still does not respond:

- Open the cover of the connector housing.
- When a slave works properly with the power stage disabled, the LED in the connector housing flashes constantly at 0.5 Hz (1 second on, 1 second off). If this is not the case, the product is inoperative. See the product manual for information on errors and troubleshooting.
- Compare the behavior of LED with the information in the table below.

Error	Error class	Cause of error	Troubleshooting
LED off	–	No supply voltage.	Check supply voltage and fuses.
LED flashes at 0.5 Hz(1 s on, 1 s off)	.–	Firmware works without errors, power stage disabled.	Check cable connections. Check DIP switch settings.
LED flashes at 6 Hz.	4	Incorrect flash checksum.	Reinstall firmware. Replace slave.
LED flashes at 10 Hz. Watchdog	4	Hardware error	Switch slave off and on again. Replace slave.

See the product manual for additional information on the cause of errors and on troubleshooting.

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5.4 SyCon CANopen configuration software

The CANopen network can be configured with the "SyCon" configuration software. An additional EDS file is included in the SYCON subdirectory on the product CD.

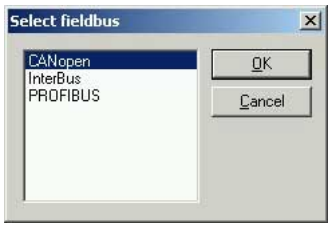
▶ Procedure:

5.4.1 Creating a new network

Create a new network via the menu item "File - New".

▶ Select CANopen as the fieldbus network.

▶ Confirm your selection with "OK".

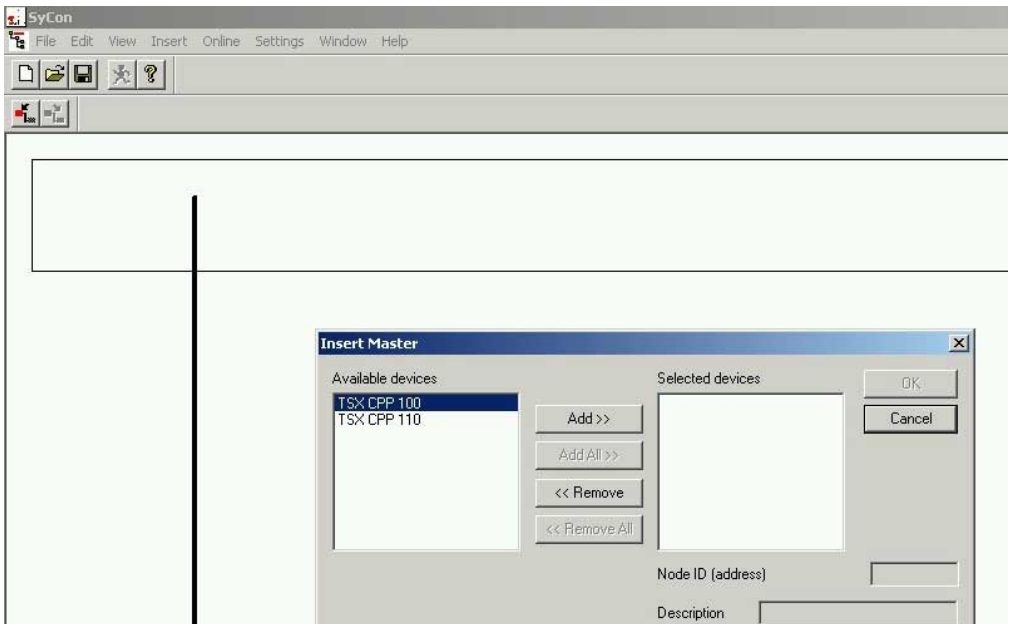


5.4.2 Selecting the CANopen master

Use the menu item "Insert - Master" to select the network master. The screenshot shows the example of a TSX CCP 110 board of a Premium PLC.

The node ID and a brief description can be entered in the appropriate fields.

▶ Confirm your selection with "OK".



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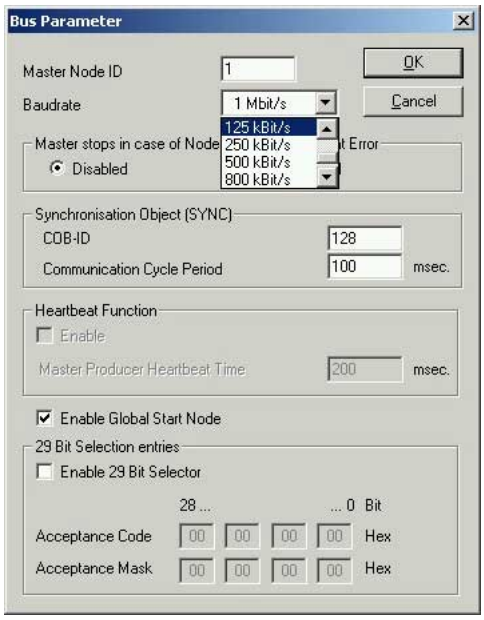
5.4.3 Setting the bus parameters

The menu item "Settings - Bus Parameter..." allows you to set the CANopen communication parameters. Please also consult the operating instructions of the SyCon configuration software.

▶ Confirm your selection with "OK".



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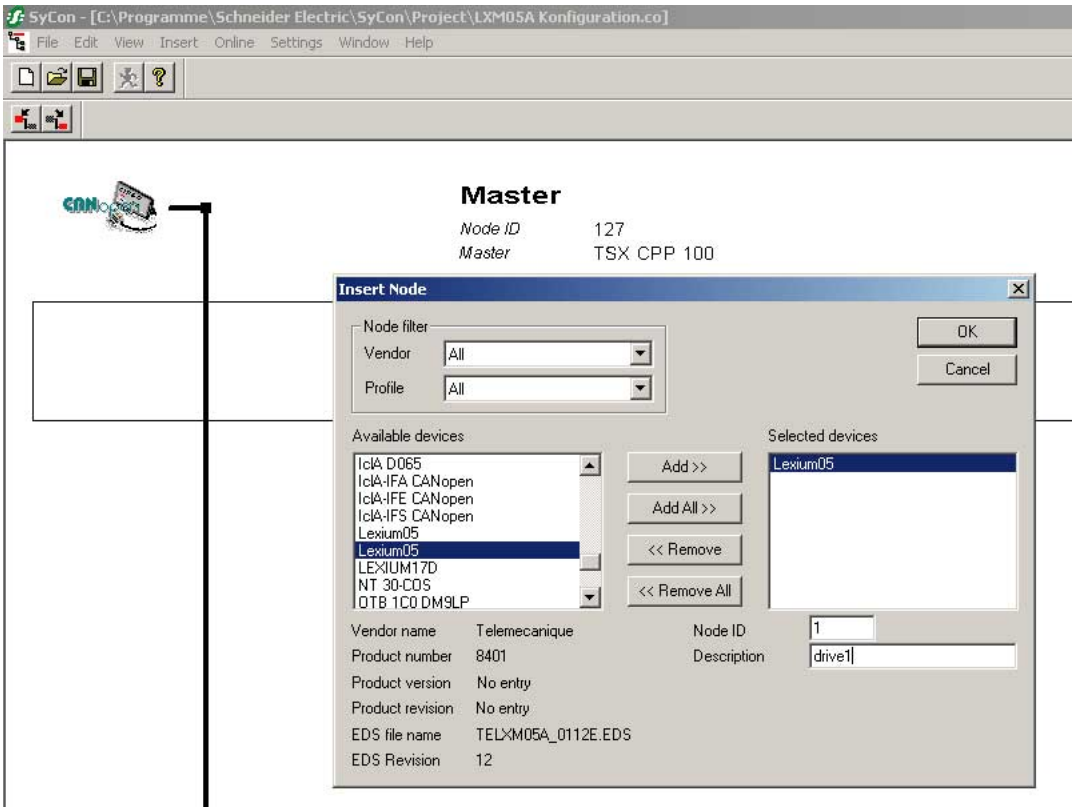
5.4.4 Selecting and inserting nodes

Use the menu item "Insert - Node" to select the network nodes. The example shows a Lexium 05.

▶ Confirm your selection with "OK".



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6 Operation

⚠ WARNING

UNINTENDED OPERATION

- Do not write values to reserved parameters.
- Do not write values to parameters unless you fully understand the function. For more information see the product manual.
- Run initial tests without coupled loads.
- Verify that the system is free and ready for the movement before changing parameters.
- Verify the use of the bits with fieldbus communication: bit 0 is far right (least significant). Bit 15 is far left (most significant).
- Verify the use of the word sequence with fieldbus communication.
- Do not establish a fieldbus connection unless you have fully understood all communications principles.

Failure to follow these instructions can result in death, serious injury or equipment damage.

6.1 Overview

The programming examples show hands-on applications for network operation. There are 2 access methods via the CANopen fieldbus: SDO "Service Data Objects" and PDO "Process Data Objects".

Using SDOs An SDO access is a write or a read access to an individual object. The available objects are described in the product manual and also summarized in a table in the chapter "Parameters". This chapter describes the use of SDOs on the basis of just a small number of objects since this type of communication can be used with all available objects and the structure is very similar in all cases.

Using PDOs PDOs are recommended for positioning mode because the information is transmitted much more efficiently. The chapter provides various hands-on examples of the application of PDO4 supported by the product and describes the general procedure.

- The PDO from the master to the product is referred to as "R_PDO".
- The PDO from the product to the master is referred to as "T_PDO".

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Structure of the examples

The PDOs are described from the perspective of the slave:

The examples describe:

- Task
- Initial conditions
- Required commands in the transmit data frame
- Response of the product in the receive data frame
- Possible restrictions for command execution.

You should be familiar with the following to be able to understand the examples:

- Operating concept and functionality of the product. For more information see the product manual.
- Fieldbus protocol and connection to the master controller
- Functionality of the fieldbus profile.

Product manual

The examples are intended to supplement the function descriptions in the product manuals. The basic function principles of the operating modes and functions are described in the product manual.

All parameters for the operating modes and functions are also listed in the product manual.

See table 9.2, page 9-1 in the device manual for a description of the number format of the parameter values in a fieldbus command.

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6.2 Using SDO commands

6.2.1 Writing parameters

Task The parameter `Motion.acc`, 29:26 (acceleration) is to be set to a value of 10,000.

Index and subindex must be converted to hexadecimal notation and the constant 3000_h added to the index for the SDO access:

- Index:29 = $1D_h$ + 3000_h = $301D_h$
- Subindex: 26 = $1A_h$
- Value:10000 = 00002710_h

The value 23_h is to be entered as a CCD (Client Command Specifier) since the parameter has a 32 bit data type.

Transmit data

Object	COB ID	CCD	Idx	Sdx	Data	Description
Tx $301D_h$:$1A_h$ Motion.acc	600_h+ID	23_h	$1D_h$ 30_h	$1A_h$	10_h 27_h 00 00	Sets the acceleration to 10000 min^{-1}*s = 2710_h as a 32 bit value

Refer to the column "Data type" in the parameter description for the data type of the value to be written. The CAN protocol used transmits 16 bit values and 32 bit values in the format "lowest value byte first – highest value byte last". When an INT16 or a UINT16 value is transmitted, the CCD corresponding to the data type must be included. The value must be stored in the first two data bytes, the last two data bytes must be "0".

Receive data

Object	COB ID	CCD	Idx	Sdx	Data	Description
Rx $301D_h$:$1A_h$ Motion.acc	580_h+ID	60_h	$1D_h$ 30_h	$1A_h$	XX XX XX XX	The response data does not have a meaning.

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6.2.2 Reading a parameter

Task The parameter `Status.n_act, 31:9` (actual speed) is to be read.

Index and subindex must be converted to hexadecimal notation and the constant 3000_h added to the index for the SDO access:

- Index:31 = $1F_h$ + 3000_h = $301F_h$
- Subindex 9 = 09_h

The value "40_h" must be entered as the CCD. This value identifies a "Read Request".

Transmit data

Object	COB ID	CCD	Idx	Sdx	Data	Description
Tx $301F_h$:09_h Status.n_actT	600_h+ID	40_h	$1F_h$ 30_h	09_h	XX XX XX XX	Reads the actual speed. The data has no significance.

The 4 data bytes have no significance for a read request.

Receive data

Object	COB ID	CCD	Idx	Sdx	Data	Description
Rx $301D_h$:09_h Status.n_act	580_h+ID	43_h	$1F_h$ 30_h	09_h	E8 03 00 00	The data 000003E8 corresponds to 1000 min^{-1}.

The product transmits the data as 32 bit values back to the master (CCD is "43_h"). It also sends back data as a 32 bit value which are described as INT16 or UINT16 data types in the product manual. When an INT16 or a UINT16 value is read, it is therefore possible to evaluate all 4 data bytes. However, for 16 bit data it is also correct to evaluate only the first two data bytes and to ignore the last two data bytes.

6.2.3 Synchronous errors

Receive data with error frame "Error Response"

If an SDO write or read command fails, the product responds with an error frame "Error Response". This may happen if, for example, you try to read or write a non-existent object. The transmitted error number provides information on the exact cause.

Object	COB ID	CCD	Index	Sub	Data	Description
Rx 3028_h:20_h	580_h+ID	80_h	28_h 30_h	20_h	00 00 02 06	Error value 06020000h means "object does not exist in object dictionary"

The example shows the response to a write or read request for a non-existent object `40:32`.

The error number of a synchronous error message is stored as a UINT16 value and the corresponding CCD (Error Response) is assigned the value 80_h. Refer to 7.3.2 "Error code table" for a table with the error numbers.

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6.3 Changing operating states with PDO4

The product operates in different operating states. The individual operating states are numbered from 1 to 9 . The operating states and the transition conditions are described in more detail in the product manual, chapters "Basics" and "Operation".

Operating state	Name	Power stage	Description
4	Ready To Switch On	off	Passive operating state, motor without current
6	Operation Enable	on	Active operating state, current available to motor
7	Quick Stop active	on	Fault state, power stage remains enabled
9	Fault	off	Fault state, power stage is disabled

Table 6.1 Important operating states

Requests for switching operating states are transmitted to the product in R_PD04 in the field `drivectrl`. The product signals the current operating state back to the master in T_PDO4, field driveStat.

Table 6.2 shows the bit assignment of the field `drivectrl` in the object R_PD04:

Bit no.	Value	Meaning
0	01_h	Disable
1	02_h	Enable
2	04_h	Quick Stop
3	08_h	Fault Reset
4	10_h	Quick Stop release

Table 6.2 R_PDO4, drivectrl, bit assignment

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6.3.1 Switching the power stage on and off

The power stage is enabled by the transition from operating state 4 to 6 . For this purpose, the two bits `Enable` and `Disable` are available in the `R_PD04`. One of them must be "1", the other "0".

Enabling the power stage

Prerequisite: the product in in operating state 4.

To enable the power stage, a "0 -> 1" edge must be generated in `drivectrl`, bit 1 (Enable). This can be done by deleting bit 0 (Disable) and setting bit 1 . The master then waits until the product signals operating state 6 . This may take a while (approx. 1 second) since various tests are run when the power stage is enabled.

Example

	Master <---> Slave	
Disable is requested	--->	drivectrl01_h
Slave signals operating state 4	<---	driveStat $XXX4_h$
Request Enable	--->	drivectrl02_h
Slave signals operating state 5	<---	driveStat $XXX5_h$
Slave signals operating state 6	<---	driveStat $XXX6_h$

Disabling the power stage

Prerequisite: Product is in operating state 6 or 7.

To disable the power stage, a "0 -> 1" edge must be generated in drivectrl, bit 0 (Disable). This can be done by setting `Bit 0` (Disable) and deleting bit 1 (Enable). The product switches to operating state 4.

Example

	Master <---> Slave	
Enable is requested	--->	drivectrl 02_h
Slave signals operating state 6	<---	driveStat $XXX6_h$
Request disable	--->	drivectrl 01_h
Slave signals operating state 4	<---	driveStat $XXX4_h$

6.3.2 Triggering a "Quick Stop"

A running motion command can be interrupted via the fieldbus at any time with the Quick Stop command. The stop is triggered by a "0 -> 1" edge in drivectrl, bit 2. After the state transition to operating state 7 (Quick Stop), the product decelerates with the set EMERGENCY STOP ramp and comes to a standstill.

In order to start a new motion command, you must first set the product to operating state 6 . To achieve this, do one of the following:

- Fault Reset"0 -> 1" edge in `drivectrl`, bit 3
- Quick Stop release"0 -> 1" edge in `drivectrl`, bit 4

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Example

	Master <---> Slave	
"Enable" is requested	--->	drivectrl 02_h
Slave signals operating state 6	<---	driveStat $XXX6_h$
request "Quick Stop" and "Enable"	--->	drivectrl 06_h
Slave signals operating state 7	<---	driveStat $XXX7_h$
Wait until the product has come to a standstill and the system is to resume operation	--->	
Request "Quick Stop Release" and "Enable"	<---	drivectrl 12_h
Slave signals operating state 6	--->	driveStat $XXX6_h$
Cancel "Quick Stop Release"	<---	drivectrl 02_h

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6.3.3 Resetting faults

If an error occurs during operation, the product switches to operating state 7 "Quick Stop" or operating state 9 "Fault", depending on the type of error.

After having remedied the cause of the fault, you can reset the error state with a Fault Reset ("0 -> 1" edge in `drivectrl`, bit 3).

If the product was originally in operating state 7, it will switch to operating state 6 after the "Fault Reset".

If the product was originally in operating state 9, it will switch to operating state 4 after the "Fault Reset". You then have to transmit a "0 -> 1" edge in `drivectrl`, bit 1 "Enable", in order to enable the power stage.

Example

	Master <---> Slave	
Request Enable	--->	drivectrl 02_h
Slave signals operating state 9 (Fault)	<---	driveStat $XXX9_h$
Remedy cause of error		
Request "Fault Reset"	--->	drivectrl 08_h
Slave signals operating state 4	<---	driveStat $XXX4_h$
Request "Enable"	--->	drivectrl 02_h
Slave signals operating state 5	<---	driveStat $XXX5_h$
Slave signals operating state 6	<---	driveStat$XXXX6_h$

Table 6.3 Disabling the power stage

Note: In this example, the master deletes the `Bit 1`"Enable" during the "Fault Reset" in order to implicitly effect a "0 -> 1" edge in `Bit 1`. This switches the product back to operating state 6.

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6.4 Examples for the operating modes with PDO4

R_PDO4 With the R_PDO4 you can start motion commands and change them while they are being processed.

R_PDO4 provides three fields for these purposes:

- `modeCtrl` Starting and changing operating modes
- "Ref16" and "Ref32" Operating mode-dependent reference values

The specified values for these three fields are not taken over by the product until `modeCtrl`, bit 7 (`ModeToggle`) changes.

Proceed as follows to assign values to the product:

▶ Enter the desired operating mode and the corresponding values in the fields `modeCtrl`, "Ref16" or "Ref32".

▶ Change `modeCtrl`, bit 7 (`ModeToggle`)

This avoids consistency problems within the R_PDO4.

T_PDO4 T_PDO4 allows you to monitor motion commands.

T_PDO4 provides three fields for this purpose:

- `modeStat` For Handshake purposes
- `driveStat` Signals motion status and errors
- `p_act`Actual position of the product

ModeToggle The bit `ModeToggle` is available in the R_PDO4 and in the T_PDO4. The master provides this bit in the and the product mirrors is in the . This procedure allows the master to detect whether the data transmitted by the slave is current.

Example The master starts a positioning movement that will only take a very short time. The master waits for the end of the positioning movement by checking T_PDO4 for bit `x_end = 1` (positioning end).

The master may receive data from the slave that still originate from a point in time before the positioning movement was started. This data also contains `x_end = 1`. The master detects that the data is obsolete because the included bit `ModeToggle` does not match that of its motion command.

The master may only evaluate data in which the received `ModeToggle` bit is identical to the last bit transmitted by the master.

Acceleration Prior to positioning, you can first set the desired acceleration with an SDO access (object `Motion.acc`, 29:26). Note that the acceleration can only be changed when the product is at a standstill.

Assumptions The examples in this chapter are based on the following assumptions:

- Operating state 6 "Operation Enable"
- Homing has not yet been performed (bit `ref_ok = 0`)
- `p_act = 0` (actual position)
- R_PDO4: `modeCtrl, Bit 7 = 0` (`ModeToggle`)

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6.4.1 Operating mode Profile Position: absolute positioning

To start an absolute positioning movement, the following settings must be made in the R_PDO4:

- ▶ Enter the reference speed in "Ref16" and the target position in "Ref32".
- ▶ Enter operating mode 03_h (Profile Position operating mode, absolute positioning) in the field `modeCtrl`.
- ▶ Change `modeCtrl`, bit 7, so the data is taken over by the product.

Example Absolute positioniing to position 100,000 ($000186A0_h$)

at a reference speed of 1000 min^{-1} ($03E8_h$)

			Master <---> Slave			
Triggering positioning	R_PDO4	--->	drivectrl 02_h	modeCtrl 83_h	Ref16 $03E8_h$	Ref32 $000186A0_h$
Positioning runningx_err = 0, x_end = 0	T_PDO4	<---	driveStat 0006_h	modeStat 83_h		p_act $XXXXXXXX_h$
Positioning completex_err = 0, x_end = 1, x_info = 1	T_PDO4	<---	driveStat 6006_h	modeStat 83_h		p_act $000186A0_h$

Table 6.4 Operating mode Profile Position, absolute positioning at constant reference speed

Note: The data frame "positioning running" can be sent several times; the current actual position is contained in the field `p_act`.

Example As the above example, but the reference speed is changed to 2000 min^{-1} ($07D0_h$) during the movement.

			Master <---> Slave			
Triggering positioning	R_PDO4	--->	drivectrl 02_h	modeCtrl 83_h	Ref16 $03E8_h$	Ref32 $000186A0_h$
Positioning runningx_err = 0, x_end = 0	T_PDO4	<---	driveStat 0006_h	modeStat 83_h		p_act $XXXXXXXX_h$
Change reference speed	R_PDO4	--->	drivectrl 02_h	modeCtrl 03_h	Ref16 $07D0_h$	Ref32 $000186A0_h$
Positioning runningx_err = 0, x_end = 0	T_PDO4	<---	driveStat 0006_h	modeStat 03_h		p_act $XXXXXXXX_h$
Positioning complete x_err=0, x_end = 1, x_info = 1	T_PDO4	<---	driveStat 6006_h	modeStat 03_h		p_act $000186A0_h$

Table 6.5 Operating mode Profile Position, absolute positioning with change of reference speed

Note: The data frame "positioning running" can be sent several times. The current actual position is contained in the field `p_act`. When the reference speed is changed, the same target position is sent because it does not change in this example.

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6.4.2 Operating mode Profile Position: relative positioning

Relative positioning is similar to absolute positioning. You only need to enter the value 13_h (operating mode Profile Positioning, relative positioning) in field `modeCtrl`. Also note that several target positions transmitted in succession are added up.

Example: Relative positioning by 100,000 ($000186A0_h$) increments at a speed of 1000 min^{-1} ($03E8_h$)

During the movement, the speed is to be changed to 2000 min^{-1} ($07D0_h$).

Master <---> Slave						
Triggering positioning	R_PDO4	--->	drivectrl 02_h	modeCtrl 93_h	Ref16 $03E8_h$	Ref32 $000186A0_h$
Positioning runningx_err = 0, x_end = 0	T_PDO4	<---	driveStat 0006_h	modeStat 83_h		p_act $XXXXXXXX_h$
Change reference speed Transmit relative postion "0"	R_PDO4	--->	drivectrl 02_h	modeCtrl 13_h	Ref16 $07D0_h$	Ref32 00000000_h
Positioning runningx_err = 0, x_end = 0	T_PDO4	<---	driveStat 0006_h	modeStat 03_h		p_act $XXXXXXXX_h$
Positioning completex_err = 0, x_end = 1, x_info = 1	T_PDO4	<---	driveStat 6006_h	modeStat 03_h		p_act $000186A0_h$

Table 6.6 Profile Position operating mode, relative positioning with change of reference speed

Note: The data frame "positioning" running can be sent several times; the current actual position is contained in the field `p_act`. When the reference speed is changed, the value "0" must be sent as the new target position because the new value is added to the previously calculated target position.

6.4.3 Operating mode Profile Velocity

In Profile Velocity operating mode, a reference speed for the motor is set and a movement without a target position is started.

To start the Profile Velocity operating mode or to change the reference speed in Profile Velocity operating mode, you must make the following settings in `R_PD04`:

- Enter the reference speed in `Ref16`t. (`Ref32` has no significance here)
- Enter the operating mode 04_h (operating mode Profile Velocity) in `modeCtrl`.
- Toggle `modeCtrl`, bit 7, so the data is taken over by the slave.

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Example The Profile Velocity operating mode is started with a reference speed of 1000 min^{-1} ($03E8_h$).

The reference speed is changed to 2000 min^{-1} ($07D0_h$) during the movement.

			Master <---> Slave			
Start Profile Velocity operating mode with 1000 min^{-1}	R_PDO4	--->	drivectrl 02_h	modeCtrl 84_h	Ref16 $03E8_h$	Ref32 $XXXXXXXX_h$
Product accelerates xerr=0, xend=0, xinfo=0	T_PDO4	<---	driveStat 0006_h	modeStat 84_h		p_act $XXXXXXXX_h$
Reference speed reached xerr=0, xend=0, xinfo=1	T_PDO4	<---	driveStat 2006_h	modeStat 84_h		p_act $XXXXXXXX_h$
Change speed to 2000 min^{-1}	R_PDO4	--->	drivectrl 02_h	modeCtrl 04_h	Ref16 $07D0_h$	Ref32 $XXXXXXXX_h$
Product accelerates xerr=0, xend=0, xinfo=0	T_PDO4	<---	driveStat 0006_h	modeStat 04_h		p_act $XXXXXXXX_h$
Reference speed reached xerr=0, xend=0, xinfo=1	T_PDO4	<---	driveStat 2006_h	modeStat 04_h		p_act $XXXXXXXX_h$
Change speed to 0 min^{-1}	R_PDO4	--->	drivectrl 02_h	modeCtrl 84_h	Ref16 0000_h	Ref32 $XXXXXXXX_h$
Product decelerates xerr=0, xend=0, xinfo=0	T_PDO4	<---	driveStat 0006_h	modeStat 84_h		p_act $XXXXXXXX_h$
Profile Vel. mode terminated xerr=0, xend=1, xinfo=1	T_PDO4	<---	driveStat 6006_h	modeStat 84_h		p_act $XXXXXXXX_h$

The Profile Velocity operating mode is terminated when the reference speed "0" is transmitted; standstill is waited for.

Note: The field `p_act` of the `T_PDO4` contains the current position of the drive in increments.

6.4.4 Position setting

During position setting, a new position is assigned to the current motor position. This only shifts the coordinate system, the motor itself does not move.

You must make the following settings for position setting in the `R_PDO4`:

- Enter the new position in `Ref32`. (`Ref16` has no significance here)
- Enter operating mode 02_h in `modeCtrl` ("Homing", "Position Setting").
- Toggle `modeCtrl`, bit 7, so the data is taken over by the slave.

Example: The motor is at position -100,000 ($FFFE7960_h$).

Position 200,000 is assigned to the motor ($00030D40_h$).

			Master <---> Slave			
Product signals position-100,000	T_PDO4	<---	driveStat $XXXX_h$	modeStat XX_h		p_act $FFFE7960_h$
Position setting to 200,000	R_PDO4	--->	drivectrl 02_h	modeCtrl 82_h	Ref16 $XXXX_h$	Ref32 $00030D40_h$
Position taken over x_err = 0, x_end = 1, x_info = 0	T_PDO4	<---	driveStat 4006_h	modeStat $A2_h$		p_act $00030D40_h$

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6.4.5 Operating mode Homing

During the reference movement a limit switch or reference switch is approached and then a new value is assigned to this position.

Before a reference movement is started, the parameters must be set by means of SDO write access to satisfy the requirements. See the product manual for detailed information on parameterization and on performing a reference movement.

To start a reference movement the following settings must be made in the `R_PDO4`:

- Enter the type of reference movement in `Ref16` (`Ref32` has no significance here).

  The available types of reference movement are described in the device manual.

- In `modeCtrl`, enter operating mode 12_h"Homing".
- Toggle `modeCtrl`, bit 7, so the data is taken over by the slave.

Example A reference movement to the negative limit switch (LIMN) is to be performed; this is reference movement type 2.

Master <---> Slave						
Trigger reference movement	R_PDO4	--->	drivectrl 02_h	modeCtrl 92_h	Ref16 0002_h	Ref32 $XXXXXXXX_h$
Reference movement runningx-err=0, xend=0	T_PDO4	<---	driveStat 0006_h	modeStat8 2_h		p_act $XXXXXXXX_h$
Reference movement complete xerr=0, xend=1	T_PDO4	<---	driveStat 4006_h	modeStat $A2_h$		p_act 00000000_h

Table 6.7 Reference movement

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6.5 Error signaling via PDO4

6.5.1 Synchronous errors

If a request for an operating mode sent via R_PDO4 cannot be processed by the product, the product rejects processing and sets `modeStat`, bit 6 ("ModeError") in the `T_PD04`. This does not interrupt the current process. To determine the cause of the error, the master can read the error number from the object `CAN.modeError`, 30:11 with an SDO access.

Example The product rotates in Profile Velocity operating mode.

			Master <---> Slave			
Profile Velocity operating modex_end = 0	T_PDO4	<---	driveStat 0006_h	modeStat 04_h		p_act $XXXXXXXX_h$
Request: Dimension setting to 0	R_PDO4	--->	drivectrl 02_h	modeCtrl 82_h	Ref16 $XXXX_h$	Ref32 00000000_h
Request rejected "ModeError" = 1	T_PDO4	<---	driveStat 0006_h	modeStat $C4_h$		p_act XXXXXXXXh

Table 6.8 Synchronous error, invalid operating mode request

NOTE: When the request for position setting is rejected, the product continues to run in Profile Velocity operating mode; there is no change.

However, the product sends an EMCY message with the corresponding error number to the master .

6.5.2 Asynchronous errors

Asynchronous errors are triggered by internal monitoring (e.g. temperature) or by external monitoring (e.g. limit switch). If an asynchronous error occurs, the product responds by braking or by disabling the power stage.

Asynchronous errors are indicated in the following way:

- Change to operating state 7 "Quick Stop" or to operating state 9 "Fault".

  The change is represented in T_PDO4, `driveStat`, bits 0 ... 3.

- Setting of `driveStat`, bit 5 (fault detected by internal monitoring) or `driveStat`, bit 6 (fault detected by internal monitoring)
- In the event of an error message by internal monitoring:

  Setting of the bit corresponding to the fault in object `Status.FltSig_SR`, 28:18.

  In the event of an error message by external monitoring:Setting of the bit corresponding to the fault in object `Status.Sign_SR`, 28:15

- In addition, an error number is assigned to each error. In the event of an asynchronous error, the corresponding error number can be read from the object `Status.StopFault` (32:7).

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Example: External monitoring triggers a fault message; positive limit switch "LIMP" was hit.

		Master <---> Slave			
Positioning running xerr=0, xend=0	T_PDO4	<---	driveStat 0006_h	modeStat 03_h	p_act $XXXXXXXX_h$
Limit switch detected xerr=1, xend=0	T_PDO4	<---	driveStat 8047_h	modeStat 03_h	p_act $XXXXXXXX_h$
Motor stopped xerr=1, xend=1	T_PDO4	<---	driveStat $C047_h$	modeStat 03_h	p_act $XXXXXXXX_h$

Table 6.9 Asynchronous error, triggering of an external

Note: When the limit switch is detected, the motor is decelerated with the EMERGENCY STOP ramp until it comes to a standstill and the bit `x_err` is set. After the motor has come to a standstill, bit `x_end` is set.

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7 Diagnostics and troubleshooting

7.1 Fieldbus communication error diagnostics

A properly operating fieldbus is essential for evaluating operating and error messages.

Connections for fieldbus mode

If the product cannot be addressed via the fieldbus, first check the connections. The product manual contains the technical data of the device and information on network and device installation. Check the following:

- $24V_{dc}$ power supply
- Power connections to the device
- Fieldbus cable and fieldbus wiring
- Network connection to the device

You can also use the commissioning software for troubleshooting.

Baud rate and address

If it is impossible to connect to a device, check the baud rate and node address.

- The baud rate must be the same for all devices in the network.
- The node address of each device must be between 1 and 127 and unique for each device.

To set the baud rate and node address see chapter 5.2 "Address and baud rate".

Fieldbus function test

After correct configuration of the transmission data, test fieldbus mode. This requires installation of a CAN configuration tool that displays CAN messages. Feedback from the product is indicated by a boot-up message:

- Switch the power supply off and on again.
- Observe the network messages after switching on. After initialization of the bus, the device sends a boot-up message (COB ID 700_h + node ID and 1 data byte with the content 00_h).
- With the factory setting 127 ($7F_h$) for the node address, the boot-up message is sent via the bus . The device can then be put into operation via NMT services.

If network operation cannot be started, the network function of the device must be checked by your local representative. Contact your local sales representative.

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7.2 Error diagnostics via fieldbus

7.2.1 Message objects

A number of objects provide information on the operating and error state:

- Object `Statusword (6041h)`
  Operating states, see product manual
- Object `EMCY (80h+ Node-ID)`
  Error message from a device with fault state and error code, see chapter 3.4.2.5 "Emergency service"
- Object `Error register (1001h)`
  Fault state
- Object `Error code (603Fh)`
  Error code of the most recent error
- Devices use the special SDO error message ABORT to signal errors in exchanging messages by SDO.

7.2.2 Messages on the device status

Synchronous and asynchronous errors are distinguished in the evaluation and handling of errors.

Synchronous errors

The device signals a synchronous error directly as a response to a message that cannot be evaluated. Possible causes comprise transmission errors or invalid data. For a list of synchronous errors see chapter 7.3.1 "Error register".

Asynchronous errors

Asynchronous errors are signaled by the monitoring units in the device as soon as a device fault occurs. An asynchronous error is signal via bit 3, "Fault", of the object `statusword (6041h)`. In the case of errors that cause a an interruption of the movement, the device transmits an EMCY message.

Asynchronous errors are also reported via bits 5..7 of the object `driveStat (2041h)`.

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7.3 CANopen error messages

CANopen error messages are signaled in the form of EMCY messages. They are evaluated via the objects `Error register (1001h)` and `Error code (603Fh)`. For information on the object EMCY see chapter 3.4.2.5 "Emergency service".

CANopen signals errors that occur during data exchange via SDO with the special SDO error message ABORT.

7.3.1 Error register

The object `Error register(1001h)` indicates the error state of a device in bit-coded form. The exact cause of error must be determined with the error code table. Bit 0 is set as soon as an error occurs.

Bit	Message	Meaning
0	Generic error	An error has occurred
1	-	reserved
2	-	reserved
3	-	reserved
4	Communication	Network communication error
5	Device profile-specific	Error in execution as per device profile
6	-	reserved
7	Manufacturer-specific	Vendor-specific error message

7.3.2 Error code table

The error code is evaluated with the object `error code (603Fh)`, an object of the DSP402 device profile, and output as a four-digit hexadecimal value. The error code indicates the cause of the last interruption of movement. See the Troubleshooting chapter of the product manual for the meaning of the error code.

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7.3.3 SDO error message ABORT

An SDO error message is generated as a response to an SDO transmission error. The cause of error is contained in `error code`, byte 4 to byte 7.

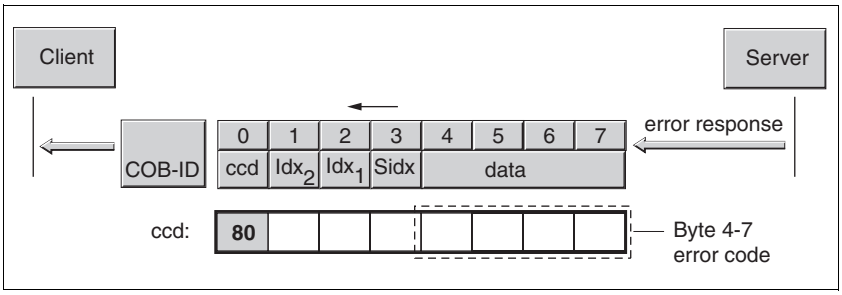

Figure 7.1 SDO error message as a response to an SDO message

The table below shows all error messages that may occur during data exchange with the product.

Error code	Meaning
0504 0000_h	Time-out during SDO transfer
0504 0001_h	Command specifier CS incorrect or unknown
0601 0000_h	Access to object impossible
0601 0001_h	No read access, because write-only object (wo)
0601 0002_h	No write access, because read object (ro)
0602 0000_h	Object does not exist in object dictionary
0604 0041_h	Object does not support PDO mapping
0604 0042_h	PDO mapping: number or length of objects exceed the byte length of the PDO
0607 0010_h	Data type and parameter length do not match
0607 0012_h	Data type does not match, parameter too long
0607 0013_h	Data type does not match, parameter too short
0609 0011_h	Subindex not supported
0609 0030_h	Value range of parameter too large (relevant only for write access)
0609 0031_h	Parameter values too great
0609 0032_h	Parameter values too small
0800 0000_h	General error
0800 0022_h	Device status keeps data from being transmitted and saved.

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8 Object directory

8.1 Overview

This object dictionary only describes the protocol for the product as per CANopen DS 301. The objects for controlling operating modes, functions and all parameters can be found in the product manual for the product.

8.1.1 Specifications for the objects

Index The index specifies the position of the object in the object dictionary. The index value is specified as a hexadecimal value.

Object code The object code specifies the data structure of the object.

Object code	Meaning	Coding
VAR	A single value, for example of the type Integer8, Unsigned32 or Visible String8.	7
ARR (ARRAY)	A data field in which every entry is of the same data type.	8
REC (RECORD)	A data field that contains entries that are a combination of single data types.	9

Data type	Value range	Data length
Boolean	0 = false, 1 = true	1 byte
INT8	-128 ..+127	1 byte
INT16	-32768 ..+32767	2 byte
INT32	-2147483648 ..+2147483647	4 byte
UINT8	0 ..255	1 byte
UINT16	0 ..65535	2 byte
UINT32	0 ..4294967295	4 byte
Visible String8	ASCII characters	8 byte
Visible String16	ASCII characters	16 byte

Access **ro**: "Read Only"value can be read only

rw: "Read Write"value can be read and written

wo: "Write Only"value can be written only

PDO **R_PDO**: mapping for R_PDO possible

T_PDO: mapping for T_PDO possible

No specification: PDP mapping not possible with the object

Value range Specifies the permissible range in which the object value is defined and valid.

Default value Load the saved factory settings to reset the product to the default values.

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Can be saved yes: values can be saved to the memory of the product and are available when the product is switched on again.

–: values are lost when the product is switched off.

8.1.2 Objects, overview

Index	Subindex	Designation	Obj. code	Data type	Access
1000_h		device type	VAR	UINT32	ro
1001_h		error register	VAR	UINT8	ro
1008_h		manufacturer device name	VAR	String	ro
$100C_h$		guard time	VAR	UINT16	rw
$100D_h$		life time factor	VAR	UINT8	rw
1015_h		inhibit time EMCY	VAR	UINT16	rw
1018_h		identity object	RECORD	Identity	ro
1018_h	0	number of elements	VAR	UINT8	ro
1018_h	1	Vendor id	VAR	UINT32	ro
1018_h	2	product code	VAR	UINT8	ro
1403_h		receive PDO4 communication parameter	RECORD	PDO_Com	ro
1403_h	0	number of elements	VAR	UINT8	ro
1403_h	1	COB ID used by R_PDO4	VAR	UINT32	ro
1403_h	2	transmission type R_PDO4	VAR	UINT8	rw
1403_h	3	inhibit time R_PDO4	VAR	UINT16	rw
1403_h	4	compatibility entry R_PDO4	VAR	UINT8	rw
1403_h	5	event timer R_PDO4	VAR	UINT16	rw
1603_h		receive PDO4 mapping	RECORD	PDO_Map	ro
1603_h	0	number of elements	VAR	UINT8	ro
1603_h	1	1st mapped object R_PDO4	VAR	UINT32	ro
1603_h	2	2nd mapped object R_PDO4	VAR	UINT32	ro
1603_h	3	3rd mapped object R_PDO4	VAR	UINT32	ro
1603_h	4	4th mapped object R_PDO4	VAR	UINT32	ro
1803_h		transmit PDO4 communication parameter	RECORD	PDO_Com	ro
1803_h	0	number of elements	VAR	UINT8	ro
1803_h	1	COB ID used by T_PDO4	VAR	UINT32	ro
1803_h	2	transmission type T_PDO4	VAR	UINT8	rw
1803_h	3	inhibit time T_PDO4	VAR	UINT16	rw
1803_h	4	reserved T_PDO4	VAR	UINT8	rw
1803_h	5	event timer T_PDO4	VAR	UINT16	rw
$1A03_h$		transmit PDO4 mapping	RECORD	PDO_Map	ro
$1A03_h$	0	number of elements	VAR	UINT8	ro
$1A03_h$	1	1st mapped object T_PDO4	VAR	UINT32	ro
$1A03_h$	2	2nd mapped object T_PDO4	VAR	UINT32	ro
$1A03_h$	3	3rd mapped object T_PDO4	VAR	UINT32	ro
$1A03_h$	4	4th mapped object T_PDO4	VAR	UINT32	ro

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8.2 Objects of the product

1000h **Device type**

The object specifies the device profile used as well as the device type.

Object description

Index	1000_h
Object name	device type
Object code	VAR
Data type	Unsigned32

Value description

Subindex	00_h, device type
Meaning	Device type and profile
Access	read-only
PDO mapping	–
Value range	–
Default value	0
Can be saved	–

1001h **Error register**

The object specifies the error state of the product. The manufacturer-specific object `Status.StopFault 32:7` provides detailed information on the cause of the error.

Errors are signaled by an EMCY message as soon as they occur.

Object description

Index	1001h
Object name	error register
Object code	VAR
Data type	Unsigned8

Value description

Subindex	00_h, error register
Meaning	error register
Access	read-only
PDO mapping	–
Value range	–
Default value	–
Can be saved	–

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Bit coding, subindex 00h

Bit	Access	Value	Meaning
0	ro	–	Error! (generic error)
1	ro	–	Current
2	ro	–	Voltage
3	ro	–	Temperature
4	ro	–	Communication profile (communication error)
5	ro	–	Device profile (device profile error)
6	ro	–	Reserved
7	ro	–	Manufacturer-specific

1008h **Manufacturer device name**

The object specifies the device name (e.g. “IFS ”)

Object description

Index	1008_h
Object name	manufacturer device name
Object code	VAR
Data type	String

Value description

Subindex	00_h, manufacturer device name
Meaning	Manufacturer name
Access	read-only
PDO mapping	–
Value range	–
Default value	–
Can be saved	–

100Ch **Guard time**

The object specifies the time span for node guarding of an NMT slave.

Object description

Index	$100C_h$
Object name	guard time
Object code	VAR
Data type	Unsigned16

Value description

Subindex	00_h, guard time
Meaning	Time span for node guarding [ms]
Access	read-write
PDO mapping	–
Value range	0...65535
Default value	0
Can be saved	–

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The time span for connection monitoring of an NMT master results from the time span "guard time" multiplied by the factor "life time", object `Life time factor` ($100D_h$).

The time span can be changed in the NMT state "Pre-Operational".

100Dh Life time factor

The object specifies the factor that, together with the time span "guard time", results in the time interval for connection monitoring of an NMT master. Within this period, the NMT slave device expects a monitoring request via node guarding from the NMT master.

life time = guard time * life time factor

The value "0" deactivates monitoring of the NMT master.

Object description

Index	$100D_h$
Object name	life time factor
Object code	VAR
Data type	Unsigned8

Value description

Subindex	00_h, life time factor
Meaning	Time factor for the node guarding protocol
Access	read-write
PDO mapping	–
Value range	0...255
Default value	0
Can be saved	–

If there is no connection monitoring through the NMT master during the time interval "life time", #Variable:device-name# signals an error and switches to error state.

The time factor can be changed in the NMT state "Pre-Operational".

The time span "guard time" is set with the object `Guard time` ($100C_h$).

1015h Inhibit time emergency message

The object specifies the waiting time for the repeated transmission of EMCY messages as a multiple of 100µs.

Object description

Index	1015_h
Object name	inhibit time EMCY
Object code	VAR
Data type	Unsigned16

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Value description

Subindex	00h, inhibit time EMCY
Meaning	Waiting time for repeated transmission of an EMCY
Access	read-write
PDO mapping	–
Value range	0...65535
Default value	0
Can be saved	–

1018h Identity Object

The object provides information on the product. Subindex 01_h (vendor Id) contains the vendor identification, subindex 02_h (product Id) contains the vendor-specific product code.

Value description

Index	1018_h
Object name	Identity Object
Object code	RECORD
Data type	Identity

Subindex	00h, number of elements
Meaning	Number of subindexes
Access	read-only
PDO mapping	–
Value range	1...4
Default value	2
Can be saved	–

Subindex	01_h, vendor id
Meaning	Vendor ID
Access	read-only
PDO mapping	–
Value range	0...4294967295
Default value	0x0100002E
Can be saved	–

Subindex	02_h, product code
Meaning	Product identification
Access	read-only
PDO mapping	–
Value range	0...4294967295
Default value	0x01
Can be saved	–

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1403h Receive PDO4 communication parameter

The object stores settings for the fourth receive PDO R_PDO4.

Object description

Index	1403_h
Object name	receive PDO4 communication parameter
Object code	RECORD
Data type	PDO Communication parameter

Value description

Subindex	00_h, number of elements
Meaning	Number of subindexes
Access	read-only
PDO mapping	–
Value range	–
Default value	5
Can be saved	–

Meaning	Identifier of the R_PDO4
Subindex	01_h, COB-ID R_PDO4
Access	read-only
PDO mapping	–
Value range	–
Default value	0x40000500+nodeID
Can be saved	–

Subindex	02_h, transmission type R_PDO4
Meaning	Transmission type
Access	read-write
PDO mapping	–
Value range	–
Default value	254
Can be saved	–

Subindex	03_h, inhibit time R_PDO4
Meaning	Delay time for repeated transmissions (1=100 µsec)
Access	read-write
PDO mapping	–
Value range	0...65535
Default value	0
Can be saved	–

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Subindex	04_h, compatibility entry R_PDO4
Meaning	For compatibility purposes only
Access	read-write
PDO mapping	–
Value range	–
Default value	–
Can be saved	–

Subindex	05_h, event timer R_PDO4
Meaning	Time setting for event triggering
Access	read-write
PDO mapping	–
Value range	–
Default value	0
Can be saved	–

Bit assignment subindex 01h

Bit	Access	Value	Meaning
31	rw	0_b	0: PDO is active 1: PDO is inactive
30	ro	0_b	0: RTR (see below) is possible 1: RTR is not permitted
29	ro	0_b	0: 11 bit identifier (CAN 2.0A) 1: 29 bit identifier (CAN 2.0B)
28-11	ro	0000_h	Only relevant if bit 29=1 is not used by the product.
10-7	rw	0100_h	Function code, bit 10-7 of the COB ID
6-0	ro	–	Node address, bit 6-0 of the COB ID

Bit 31 A R_PDO can only be used if bit 31="0".

Bit 30 RTR bit If a device supports R_PDOs with RTR (remote transmission request), it can request a PDO from a PDO producer with RTR = "0" in accordance with the producer-consumer relationship.

The product cannot request PDOs, but it can respond to the request for a PDO, see RTR bit for T_PDO1 settings (1800h).

Bit coding, subindex 02h The control for evaluating R_PDO data is specified via subindex 02h. The values 241..251 are reserved.

Transmission type	cyclic	acyclic	synchronous	asynchronous	RTR-controlled
0	–	X	X	–	–
1-240	X	–	X	–	–
252	–	–	X	–	X
253	–	–	–	X	X
254	–	–	–	X	–
255	–	–	–	X	–

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If an R_PDO is transmitted synchronously (transmission type=0..252), the product evaluates the received data depending on the SYNC object.

- In the case of acyclic transmission (transmission type=0), the evaluation depends on the SYNC object, but not the transmission of the PDO. A received PDO message is evaluated with the following SYNC.

  A value between 1 and 240 specifies the number of SYNC cycles after which a received PDO is evaluated.

The values 252 to 254 are relevant for updating T_PDOs, but not for sending them.

- 252: Updating of transmit data with receipt of the next SYNC
- 253: Updating of transmit data with receipt of a request from a PDO consumer
- 254: Updating of data in an event-controlled way, the triggering event is specified in a manufacturer-specific way

R_PDOs with the value 255 are updated immediately upon receipt of the PDOs. The triggering event is the data that is transmitted corresponding to the definition of the device profile in the PDO.

Subindex 03h The "Inhibit time" interval is only relevant for T_PDOs.

A T_PDO is retransmitted after expiration of the "Inhibit time" interval at the earliest. The value is specified as a multiple of 100 µs, however, it is rounded down to milliseconds as an integer value.

Subindex 04h The value is reserved and not used. Write or read access triggers an SDO error message.

Subindex 05h The time interval "event timer" is only relevant for T_PDOs. A T_PDO is transmitted after expiry of the time interval "event timer". At the same time, the time interval is restarted. The "transmission type" must be set to one of the values 254 or 255 via subindex 02h.

Settings R_PDO4 is processed asynchronously and in an event-controlled way.

The byte assignment of R_PDO4 is specified via PDO mapping with the object `Receive PDO4 mapping` (1603_h) and cannot be modified. The assignment is described in 3.4.2.2 "Receive PDO R_PDO4 (master -> slave)".

The COB ID of the object can be changed in the NMT state "Pre-Operational".

1603h **Receive PDO4 mapping**

The object specifies the objects mapped in R_PDO4 and transmitted with the PDO. When the object is read, subindex 00_h, the number of mapped objects is read.

Object description

Index	1603h
Object name	receive PDO4 mapping
Object code	RECORD
Data type	PDO Mapping

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Value description

Subindex	00h, number of elements
Meaning	Number of subindexes
Access	read-only
PDO mapping	–
Value range	–
Default value	4
Can be saved	–

Subindex	01_h, 1st mapped object R_PDO4
Meaning	First object for mapping in R_PDO4
Access	read-only
PDO mapping	–
Value range	–
Default value	0x301E0108
Can be saved	–

Subindex	02_h, 2nd mapped object R_PDO4
Meaning	Second object for mapping in R_PDO4
Access	read-only
PDO mapping	–
Value range	–
Default value	0x301E0208
Can be saved	–

Subindex	03_h, 3rd mapped object R_PDO4
Meaning	Third object for mapping in R_PDO4
Access	read-only
PDO mapping	–
Value range	–
Default value	0x301E0510
Can be saved	–

Subindex	04_h, 4th mapped object R_PDO4
Meaning	Fourth object for mapping in R_PDO4
Access	read-only
PDO mapping	–
Value range	–
Default value	0x301E0620
Can be saved	–

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Bit coding from subindex 01h

Every subindex entry from subindex 01h on specifies the object and the byte length of the object. The object is identified via the index and the subindex, which refer to the object dictionary of the device.

Bit	Meaning
31..16	Index
15..8	Subindex
7..0	Object length in bytes

Settings

The assignment of the R_PDO4 is preset and cannot be modified.

The assignment is described in 3.4.2.2 "Receive PDO R_PDO4 (master -> slave)".

1803h

Transmit PDO4 communication parameter

The object stores settings for the fourth transmit PDO T_PDO4.

Object description

Index	1803_h
Object name	Transmit PDO4 communication parameter
Object code	RECORD
Data type	PDO Communication Parameter

Value description

Subindex	00_h, number of elements
Meaning	Number of subindexes
Access	read-only
PDO mapping	–
Value range	–
Default value	5
Can be saved	–

Subindex	01_h, COB ID used by T_PDO4
Meaning	Identifier of the T_PDO4
Access	read-only
PDO mapping	–
Value range	–
Default value	0x00000480+nodeID
Can be saved	–

Subindex	02_h, transmission type T_PDO4
Meaning	Transmission type
Access	read-write
PDO mapping	–
Value range	–
Default value	254
Can be saved	–

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Subindex	03_h, inhibit time T_PDO4
Meaning	Delay time for repeated transmission (in [100µsec]). The value is rounded down to milliseconds as an integer value.
Access	read-write
PDO mapping	–
Value range	0...65535
Default value	0
Can be saved	–

Subindex	04_h, reserved T_PDO4
Meaning	Reserved (for compatibility purposes only)
Access	read-write
PDO mapping	–
Value range	–
Default value	–
Can be saved	–

Subindex	05h, event timer T_PDO4
Meaning	Time setting for event triggering
Access	read-write
PDO mapping	–
Value range	–
Default value	0
Can be saved	–

The meaning of the bit states and subindex values is described with the object `receive PDO4 communication parameter` (1403_h).

Settings

R_PDO4 is transmitted asynchronously and in an event-driven way.

The byte assignment of T_PDO4 is specified via PDO mapping with the object `transmit PDO4 mapping` ($1A03_h$) and cannot be modified. The assignment is described in 3.4.2.3 "Transmit PDO T_PDO4 (product to master)".

The COB ID of the object can be changed in the NMT state "Pre-Operational".

1A03h

Transmit PDO4 mapping

The object specifies the objects mapped in T_PDO4 and transmitted with the PDO. When the object is read, subindex 00_h, the number of mapped objects is read.

Object description

Index	$1A03_h$
Object name	transmit PDO4 mapping
Object code	RECORD
Data type	PDO Mapping

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Value description

Subindex	00_h, number of elements
Meaning	Number of subindexes
Access	read-only
PDO mapping	–
Value range	–
Default value	4
Can be saved	–

Subindex	01_h, 1st mapped object T_PDO4
Meaning	First object for the mapping in T_PDO4
Access	read-only
PDO mapping	–
Value range	–
Default value	0x301E0410
Can be saved	–

Subindex	02_h, 2nd mapped object T_PDO4
Meaning	Second object for the mapping in T_PDO4
Access	read-only
PDO mapping	–
Value range	–
Default value	0x301E0308
Can be saved	–

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Subindex	03_h, 3rd mapped object T_PDO4
Meaning	Third object for the mapping in T_PDO4
Access	read-only
PDO mapping	–
Value range	–
Default value	0x301E0708
Can be saved	–

Subindex	04_h, 4th mapped object T_PDO4
Meaning	Fourth object for the mapping in T_PDO4
Access	read-only
PDO mapping	–
Value range	–
Default value	0x301E0820
Can be saved	–

The meaning of the bit states is described with the object `receive PDO4 mapping` (1603_h).

Settings The PDO assignment for T_PDO4 cannot be modified. The assignement is described in 3.4.2.3 "Transmit PDO T_PDO4 (product to master)".

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9 Glossary

9.1 Units and conversion tables

The value in the specified unit (left column) is calculated for the desired unit (top row) with the formula (in the field).

Example: conversion of 5 meters [m] to yards [yd]
5 m / 0.9144 = 5.468 yd

9.1.1 Length

	in	ft	yd	m	cm	mm
in	-	/ 12	/ 36	* 0.0254	* 2.54	* 25.4
ft	* 12	-	/ 3	* 0.30479	* 30.479	* 304.79
yd	* 36	* 3	-	* 0.9144	* 91.44	* 914.4
m	/ 0.0254	/ 0.30479	/ 0.9144	-	* 100	* 1000
cm	/ 2.54	/ 30.479	/ 91.44	/ 100	-	* 10
mm	/ 25.4	/ 304.79	/ 914.4	/ 1000	/ 10	-

9.1.2 Mass

	lb	oz	slug	kg	g
lb	-	* 16	* 0.03108095	* 0.4535924	* 453.5924
oz	/ 16	-	* $1.942559*10^{-3}$	* 0.02834952	* 28.34952
slug	/ 0.03108095	/ $1.942559*10^{-3}$	-	* 14.5939	* 14593.9
kg	/ 0.45359237	/ 0.02834952	/ 14.5939	-	* 1000
g	/ 453.59237	/ 28.34952	/ 14593.9	/ 1000	-

9.1.3 Force

	lb	oz	p	dyne	N
lb	-	* 16	* 453.55358	* 444822.2	* 4.448222
oz	/ 16	-	* 28.349524	* 27801	* 0.27801
p	/ 453.55358	/ 28.349524	-	* 980.7	* $9.807*10^{-3}$
dyne	/ 444822.2	/ 27801	/ 980.7	-	/ $100*10^{3}$
N	/ 4.448222	/ 0.27801	/ $9.807*10^{-3}$	* $100*10^{3}$	-

9.1.4 Power

	HP	W
HP	-	* 746
W	/ 746	-

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9.1.5 Rotation

	min^{-1} (RPM)	**rad/s**	**deg./s**
min^{-1} (RPM)	-	* π / 30	* 6
rad/s	* 30 / π	-	* 57.295
deg./s	/ 6	/ 57.295	-

9.1.6 Torque

	lb·in	**lb·ft**	**oz·in**	**Nm**	**kp·m**	**kp·cm**	**dyne·cm**
lb·in	-	/ 12	* 16	* 0.112985	* 0.011521	* 1.1521	* $1.129*10^6$
lb·ft	* 12	-	* 192	* 1.355822	* 0.138255	* 13.8255	* $13.558*10^6$
oz·in	/ 16	/ 192	-	* $7.0616*10^{-3}$	* $720.07*10^{-6}$	* $72.007*10^{-3}$	* 70615.5
Nm	/ 0.112985	/ 1.355822	/ $7.0616*10^{-3}$	-	* 0.101972	* 10.1972	* $10*10^6$
kp·m	/ 0.011521	/ 0.138255	/ $720.07*10^{-6}$	/ 0.101972	-	* 100	* $98.066*10^6$
kp·cm	/ 1.1521	/ 13.8255	/ $72.007*10^{-3}$	/ 10.1972	/ 100	-	* $0.9806*10^6$
dyne·cm	/ $1.129*10^6$	/ $13.558*10^6$	/ 70615.5	/ $10*10^6$	/ $98.066*10^6$	/ $0.9806*10^6$	-

9.1.7 Moment of inertia

	lb·in^2	**lb·ft^2**	**kg·m^2**	**kg·cm^2**	**kp·cm·s^2**	**oz·in^2**
lb·in^2	-	/ 144	/ 3417.16	/ 0.341716	/ 335.109	* 16
lb·ft^2	* 144	-	* 0.04214	* 421.4	* 0.429711	* 2304
kg·m^2	* 3417.16	/ 0.04214	-	* $10*10^3$	* 10.1972	* 54674
kg·cm^2	* 0.341716	/ 421.4	/ $10*10^3$	-	/ 980.665	* 5.46
kp·cm·s^2	* 335.109	/ 0.429711	/ 10.1972	* 980.665	-	* 5361.74
oz·in^2	/ 16	/ 2304	/ 54674	/ 5.46	/ 5361.74	-

9.1.8 Temperature

	°F	**°C**	**K**
°F	-	(°F - 32) * 5/9	(°F - 32) * 5/9 + 273.15
°C	°C * 9/5 + 32	-	°C + 273.15
K	(K - 273.15) * 9/5 + 32	K - 273.15	-

9.1.9 Conductor cross section

AWG	1	2	3	4	5	6	7	8	9	10	11	12	13
mm^2	42.4	33.6	26.7	21.2	16.8	13.3	10.5	8.4	6.6	5.3	4.2	3.3	2.6

AWG	14	15	16	17	18	19	20	21	22	23	24	25	26
mm^2	2.1	1.7	1.3	1.0	0.82	0.65	0.52	0.41	0.33	0.26	0.20	0.16	0.13

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9.2 Terms and Abbreviations

AC	Alternating current
CAN	(**C**ontroller **A**rea **N**etwork), standardized open fieldbus as per ISO 11898, allows drives and other devices from different manufacturers to communicate.
CANopen	Device- and manufacturer-independent description language for communication via the CAN bus
CiA	**C**AN **i**n **A**utomation, CAN interest group, standardization group for CAN and CANopen.
COB ID	**C**ommunication **OB**ject **ID**entifier; uniquely identifies each communication object in a CAN network
DC	Direct current
Default value	Factory setting.
DriveCom	Specification of the DSP402 state machine was created in accordance with the DriveCom specification.
DS301	Standardizes the CANopen communication profile
DSP402	Standardizes the CANopen device profile for drives
E	Encoder
EDS	(**E**lectronic **D**ata **S**heet); contains the specific properties of a product.
Electronic gear	Calculation of a new output speed for the motor movement based on the input speed and the values of an adjustable gear ratio; calculated by the drive system.
EMC	Electromagnetic compatibility
EMCY object	Emergency Object
Encoder	Sensor for detection of the angular position of a rotating component. Installed in a motor, the encoder shows the angular position of the rotor.
Error	Discrepancy between a computed, observed or measured value or condition and the specified or theoretically correct value or condition.
Error class	Classification of errors into groups. The different error classes allow for specific responses to faults, for example by severity.
Fault	Operating state of the drive caused as a result of a discrepancy between a detected (computed, measured or signaled) value or condition and the specified or theoretically correct value or condition.
Fault reset	A function used to restore the drive to an operational state after a detected error is cleared by removing the cause of the error so that the error is no longer active (transition from operating state "Fault" to state "Operation Enable").
I/O	Inputs/outputs
Input device	A device that can be connected via the RS232 interface; either the handheld HMI device or a PC with commissioning software.
Limit switch	Switches that signal overtravel of the permissible range of travel.

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Power stage	The power stage controls the motor. The power stage generates current for controlling the motor on the basis of the positioning signals from the controller.
Heartbeat	Used for unconfirmed connection acknowledgement messages from network devices.
HMI	Human Machine Interface: hand-held operating device.
Power amplifier	See power stage
Life guarding	For monitoring the connection of an NMT master
Mapping	Assignment of object dictionary entries to PDOs
Node ID	Node address assigned to a device on the network.
NMT	Network Management (NMT), part of the CANopen communication profile; tasks include initialization of the network and devices, starting, stopping and monitoring of devices
Node guarding	Monitoring of the connection to the slave at an interface for cyclic data traffic.
Object dictionary	List of all parameters, values and functions available in the device. Each entry is uniquely referenced via index (16 bit) and subindex (8 bit).
Parameter	Device data and values that can be set by the user.
PDO	Process Data Object
Persistent	Indicates whether the value of the parameter remains in the memory after the device is switched off.
Quick Stop	Function used to enable fast deceleration of the motor via a command or in the event of an error.
R_PDO	Receive PDO
SDO	Service Data Object
SYNC object	Synchronization object
T_PDO	Transmit PDO
Warning	If the term is used outside the context of safety instructions, a warning alerts to a potential problem that was detected by a monitoring function. A warning is not an error and does not cause a transition of the operating state.

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