IL•1F CANopen DS301
Fieldbus interface
Fieldbus manual
V2.01, 11.2008
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.
Table of Contents

Important information ............................................. 2

Table of Contents .................................................. 3

Writing conventions and symbols ............................... 7

1 Introduction ................................................... 9

1.1 About this manual ......................................... 9

1.2 CAN-Bus ................................................... 9

1.3 Fieldbus devices networked via CAN bus ............. 10

1.4 Operating modes and functions in fieldbus mode .... 10

1.5 Documentation and literature references ............. 11

2 Before you begin - safety information...................... 13

3 Basics .......................................................... 15

3.1 CANopen technology .................................... 15

3.1.1 CANopen description language ..................... 15

3.1.2 Communication layers .............................. 15

3.1.3 Objects ............................................... 16

3.1.4 CANopen profiles ..................................... 18

3.2 Communication profile .................................. 19

3.2.1 Object dictionary .................................. 19

3.2.2 Communication objects ............................ 21

3.2.3 Communication relationships ..................... 24

3.3 Service data communication ............................ 26

3.3.1 Overview .............................................. 26

3.3.2 SDO data exchange ................................ 26

3.3.3 SDO message ........................................ 27

3.3.4 Reading and writing data .......................... 28

3.4 Process data communication ........................... 31

3.4.1 Overview .............................................. 31

3.4.2 PDO data exchange ................................ 32

3.5 Synchronization ............................................ 44

3.6 Network management services ......................... 46

3.6.1 NMT services for device control .................. 46

3.6.2 NMT services for connection monitoring .......... 48

4 Installation .................................................... 51
## Table of Contents

### 5 Commissioning
- 5.1 Commissioning the device ........................................... 53
- 5.2 Address and baud rate ............................................... 54
- 5.3 Commissioning the fieldbus network ............................ 54
  - 5.3.1 Starting fieldbus mode ........................................... 54
  - 5.3.2 Troubleshooting ..................................................... 55
- 5.4 SyCon CANopen configuration software ......................... 56
  - 5.4.1 Creating a new network ......................................... 56
  - 5.4.2 Selecting the CANopen master ................................. 56
  - 5.4.3 Setting the bus parameters .................................... 57
  - 5.4.4 Selecting and inserting nodes ................................. 58

### 6 Operation
- 6.1 Overview .............................................................. 59
- 6.2 Using SDO commands .................................................. 61
  - 6.2.1 Writing parameters ............................................... 61
  - 6.2.2 Reading a parameter .............................................. 62
  - 6.2.3 Synchronous errors ................................................ 62
- 6.3 Changing operating states with PDO4 .......................... 63
  - 6.3.1 Switching the power stage on and off ....................... 64
  - 6.3.2 Triggering a "Quick Stop" ...................................... 64
  - 6.3.3 Resetting faults ................................................... 66
- 6.4 Examples for the operating modes with PDO4 ............... 67
  - 6.4.1 Operating mode Profile Position: absolute positioning ... 68
  - 6.4.2 Operating mode Profile Position: relative positioning ... 69
  - 6.4.3 Operating mode Profile Velocity .............................. 69
  - 6.4.4 Position setting ................................................... 70
  - 6.4.5 Operating mode Homing .......................................... 71
- 6.5 Error signaling via PDO4 ............................................ 72
  - 6.5.1 Synchronous errors ............................................... 72
  - 6.5.2 Asynchronous errors ............................................. 72

### 7 Diagnostics and troubleshooting
- 7.1 Fieldbus communication error diagnostics .................. 75
- 7.2 Error diagnostics via fieldbus ..................................... 76
  - 7.2.1 Message objects .................................................. 76
  - 7.2.2 Messages on the device status ............................... 76
- 7.3 CANopen error messages ............................................ 77
  - 7.3.1 Error register .................................................... 77
  - 7.3.2 Error code table ................................................ 77
  - 7.3.3 SDO error message ABORT ..................................... 78
Table of Contents

8 Object directory .................................................. 79
  8.1 Overview .................................................... 79
  8.1.1 Specifications for the objects ......................... 79
  8.1.2 Objects, overview ...................................... 80
  8.2 Objects of the product .................................... 81

9 Glossary .......................................................... 93
  9.1 Units and conversion tables ............................... 93
    9.1.1 Length .................................................. 93
    9.1.2 Mass .................................................... 93
    9.1.3 Force .................................................. 93
    9.1.4 Power .................................................. 93
    9.1.5 Rotation ............................................... 94
    9.1.6 Torque ................................................ 94
    9.1.7 Moment of inertia .................................... 94
    9.1.8 Temperature .......................................... 94
    9.1.9 Conductor cross section .............................. 94
  9.2 Terms and Abbreviations .................................. 95

10 Index ........................................................... 97
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 mm² (AWG 14)
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 (Controller Area Network) 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
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
1.5 Documentation and literature references

*Manuals*  In addition to this fieldbus manual, the following manuals also belong 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
2 Before you begin - safety information

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

![CANopen layer model](image)

**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.
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.

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.

<table>
<thead>
<tr>
<th>Index (hex)</th>
<th>Object groups</th>
<th>Supported by the drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000h</td>
<td>Reserved</td>
<td>No</td>
</tr>
<tr>
<td>0001h-009Fh</td>
<td>Static and complex data types</td>
<td>No</td>
</tr>
<tr>
<td>00A0h-0FFFh</td>
<td>Reserved</td>
<td>No</td>
</tr>
<tr>
<td>1000h-1FFFh</td>
<td>Communication profile, standardized in DS 301</td>
<td>Yes</td>
</tr>
<tr>
<td>2000h-5FFFh</td>
<td>Manufacturer-specific device profiles</td>
<td>Yes</td>
</tr>
<tr>
<td>6000h-9FFFh</td>
<td>Standardized device profiles, e.g. in DSP 402</td>
<td>No</td>
</tr>
<tr>
<td>A000h-FFFFh</td>
<td>Reserved</td>
<td>No</td>
</tr>
</tbody>
</table>

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
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.
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

**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:

- **Process Data Objects = PDO**
- **Service Data Objects = 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

**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.
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, 1603h for mapping in R_PDO4.

<table>
<thead>
<tr>
<th>Index</th>
<th>Subindex</th>
<th>Object</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1603h</td>
<td>00h</td>
<td>Number of elements</td>
<td>Number of subindexes</td>
</tr>
<tr>
<td>1603h</td>
<td>01h</td>
<td>1st mapped object R_PDO4</td>
<td>First object for mapping in R_PDO4</td>
</tr>
<tr>
<td>1603h</td>
<td>02h</td>
<td>2nd mapped object R_PDO4</td>
<td>Second object for mapping in R_PDO4</td>
</tr>
<tr>
<td>1603h</td>
<td>03h</td>
<td>3rd mapped object R_PDO4</td>
<td>Third object for mapping in R_PDO4</td>
</tr>
</tbody>
</table>

Table 3.2 Examples of index and subindex entries
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.

<table>
<thead>
<tr>
<th>Index range (hex)</th>
<th>Object groups</th>
<th>Supported by the drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000h</td>
<td>Reserved</td>
<td>No</td>
</tr>
<tr>
<td>0001h-001Fh</td>
<td>Static data types</td>
<td>No</td>
</tr>
<tr>
<td>0020h-003Fh</td>
<td>Complex data types</td>
<td>No</td>
</tr>
<tr>
<td>0040h-005Fh</td>
<td>Manufacturer-specific data types</td>
<td>No</td>
</tr>
<tr>
<td>0060h-007Fh</td>
<td>Static data types for the device profiles</td>
<td>No</td>
</tr>
<tr>
<td>0080h-009Fh</td>
<td>Complex data types for the device profiles</td>
<td>No</td>
</tr>
<tr>
<td>00A0h-0FFFh</td>
<td>Reserved</td>
<td>No</td>
</tr>
<tr>
<td>1000h-1FFFh</td>
<td>Communication profile</td>
<td>Yes</td>
</tr>
<tr>
<td>2000h-5FFFh</td>
<td>Manufacturer-specific profiles</td>
<td>Yes</td>
</tr>
<tr>
<td>6000h-9FFFh</td>
<td>Standardized device profiles</td>
<td>No</td>
</tr>
<tr>
<td>A000h-FFFFh</td>
<td>Reserved</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 3.3 Index ranges of the object dictionary

Object descriptions in the manual

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

- 1xxxh objects: Communication objects in this chapter
- 3xxxh 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 3000h. To derive the CAN index from the indexes given in the device documentation, it is sufficient to add 3000h.

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 (3000h + 1C0h = 28d) and the subindex 1.
### 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.

![Communication objects diagram](image)

- **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
**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.

**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 (Communication Object Identifier) 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 3.5 CAN message and simplified representation of CANopen message]

[Figure 3.6 COB ID with function code and node address]
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.

<table>
<thead>
<tr>
<th>Communication object</th>
<th>Function code</th>
<th>Node address, node ID [1...127]</th>
<th>COB ID decimal (hexadecimal)</th>
<th>Index of object parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>NMT Start/Stop Service</td>
<td>0 0 0 0</td>
<td>0 0 0 0 0 0 0 0</td>
<td>0 (0h)</td>
<td>-</td>
</tr>
<tr>
<td>SYNC object</td>
<td>0 0 0 1</td>
<td>0 0 0 0 0 0 0 0</td>
<td>128 (80h)</td>
<td>1005h,...1007h</td>
</tr>
<tr>
<td>EMCY object</td>
<td>0 0 0 1</td>
<td>x x x x x x x x</td>
<td>128 (80h) + node ID</td>
<td>1014h, 1015h</td>
</tr>
<tr>
<td>T_PDO1 1)</td>
<td>0 0 1 1</td>
<td>x x x x x x x x</td>
<td>384 (180h) + node ID</td>
<td>1800h</td>
</tr>
<tr>
<td>R_PDO1 1)</td>
<td>0 1 0 0</td>
<td>x x x x x x x x</td>
<td>512 (200h) + node ID</td>
<td>1400h</td>
</tr>
<tr>
<td>T_PDO2 1)</td>
<td>0 1 0 1</td>
<td>x x x x x x x x</td>
<td>640 (280h) + node ID</td>
<td>1801h</td>
</tr>
<tr>
<td>R_PDO2 1)</td>
<td>0 1 1 0</td>
<td>x x x x x x x x</td>
<td>768 (300h) + node ID</td>
<td>1401h</td>
</tr>
<tr>
<td>T_PDO3 1)</td>
<td>0 1 1 1</td>
<td>x x x x x x x x</td>
<td>896 (380h) + node ID</td>
<td>1802h</td>
</tr>
<tr>
<td>R_PDO3 1)</td>
<td>1 0 0 0</td>
<td>x x x x x x x x</td>
<td>1024 (400h) + node ID</td>
<td>1402h</td>
</tr>
<tr>
<td>T_PDO4</td>
<td>1 0 0 1</td>
<td>x x x x x x x x</td>
<td>1152 (480h) + node ID</td>
<td>1803h</td>
</tr>
<tr>
<td>R_PDO4</td>
<td>1 0 1 0</td>
<td>x x x x x x x x</td>
<td>1280 (500h) + node ID</td>
<td>1403h</td>
</tr>
<tr>
<td>T_SDO</td>
<td>1 0 1 1</td>
<td>x x x x x x x x</td>
<td>1408 (580h) + node ID</td>
<td>-</td>
</tr>
<tr>
<td>R_SDO</td>
<td>1 1 0 0</td>
<td>x x x x x x x x</td>
<td>1536 (600h) + node ID</td>
<td>-</td>
</tr>
<tr>
<td>NMT error control</td>
<td>1 1 1 0</td>
<td>x x x x x x x x</td>
<td>1792 (700h) + node ID</td>
<td></td>
</tr>
<tr>
<td>LMT Services 1)</td>
<td>1 1 1 1</td>
<td>1 1 0 0 1 0 0</td>
<td>x 2020 (7E4h), 2021 (7E5h)</td>
<td></td>
</tr>
<tr>
<td>NMT Identify Service 1)</td>
<td>1 1 1 1</td>
<td>1 1 0 0 1 1 0</td>
<td>x 2022 (7E6h)</td>
<td></td>
</tr>
<tr>
<td>DBT Services 1)</td>
<td>1 1 1 1</td>
<td>1 1 0 0 x x x</td>
<td>x 2023 (7E7h), 2024 (7F8h)</td>
<td></td>
</tr>
<tr>
<td>NMT Services 1)</td>
<td>1 1 1 1</td>
<td>1 1 0 1 0 0 x</td>
<td>x 2025 (7E9h), 2026 (7EAh)</td>
<td></td>
</tr>
</tbody>
</table>

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 (01h) and 127 (7Fh). The device address "0" is reserved for “broadcast” transmissions which are used to send messages to all devices simultaneously.
Example  Selection of a COB ID

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

\[ 384 + \text{node ID} = 384 \text{ (180h)} + 5 = 389 \text{ (185h)}. \]

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.

![Master-slave relationships](image)

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.
**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.

![Diagram of client-server relationship](image)

**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.

![Diagram of producer-consumer relationship](image)

**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".
3 Basics

3.3 Service data communication

3.3.1 Overview

Service Data Object (SDO: Service Data Object) 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.

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.
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.

![SDO message, example](image)

**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.

![Rearranging numeric values greater than 1 byte](image)
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.

![Diagram of writing parameter values](image)

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.

<table>
<thead>
<tr>
<th>Message type</th>
<th>Data length used</th>
<th>4 bytes</th>
<th>3 bytes</th>
<th>2 bytes</th>
<th>1 byte</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Transmitting parameters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Write request</td>
<td>23&lt;sub&gt;h&lt;/sub&gt;</td>
<td>27&lt;sub&gt;h&lt;/sub&gt;</td>
<td>2B&lt;sub&gt;h&lt;/sub&gt;</td>
<td>2F&lt;sub&gt;h&lt;/sub&gt;</td>
<td></td>
</tr>
<tr>
<td>Write response</td>
<td>60&lt;sub&gt;h&lt;/sub&gt;</td>
<td>60&lt;sub&gt;h&lt;/sub&gt;</td>
<td>60&lt;sub&gt;h&lt;/sub&gt;</td>
<td>60&lt;sub&gt;h&lt;/sub&gt;</td>
<td></td>
</tr>
<tr>
<td>Error response</td>
<td>80&lt;sub&gt;h&lt;/sub&gt;</td>
<td>80&lt;sub&gt;h&lt;/sub&gt;</td>
<td>80&lt;sub&gt;h&lt;/sub&gt;</td>
<td>80&lt;sub&gt;h&lt;/sub&gt;</td>
<td></td>
</tr>
</tbody>
</table>

Table 3.5 Command code for writing parameter values
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".

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.

<table>
<thead>
<tr>
<th>Message type</th>
<th>Data length used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 bytes</td>
</tr>
<tr>
<td>read request</td>
<td>40h</td>
</tr>
<tr>
<td>Read response</td>
<td>43h</td>
</tr>
<tr>
<td>Error response</td>
<td>80h</td>
</tr>
</tbody>
</table>

Table 3.6 Command code for transmitting a read value
**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)](image-url)
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: Process Data Object) 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")
3.4.2 PDO data exchange

Data exchange with PDOs follows 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 02h (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 1803h 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 1803h 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.
**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.

<table>
<thead>
<tr>
<th>NameIdx:Sub dec. (hex.)</th>
<th>Meaning</th>
<th>Bit assignment</th>
<th>Data type</th>
<th>Unit Default (dez.)</th>
<th>R/W/ rem. Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>30:9 (1E:09h)</td>
<td>The default value 4294967295 corresponds to 0xFFFFFFFF.</td>
<td>UINT32</td>
<td>4294967295</td>
<td>R/W/-</td>
<td></td>
</tr>
<tr>
<td>30:10 (1E:0Ah)</td>
<td>See object pdo4msk1 for a description.</td>
<td>UINT32</td>
<td>0</td>
<td>R/W/-</td>
<td></td>
</tr>
</tbody>
</table>

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](Image)

Fieldbus interface
3 Basics

**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.

![Diagram showing request for message with RTR = 1]

The RTR bit (RTR: Remote Transmission Request) of a CAN message is used to detect a request. The COB ID remains the same for both messages: RTR = 0: transmission of data RTR = 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 30h of each PDO. Subindex 02h (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:

<table>
<thead>
<tr>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>252</td>
<td>RTR active, synchronous</td>
</tr>
<tr>
<td>253</td>
<td>RTR active, asynchronous</td>
</tr>
</tbody>
</table>

Table 3.8 Subindexes for using the bit

An overview of all values for the subindex 02h 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 1403h**: receive PDO4 communication parameter
- **Object 1603h**: receive PDO4 mapping
- **Object 1803h**: transmit PDO4 communication parameter
- **Object 1A03h**: transmit PDO4 mapping
3.4.2.2 Receive PDO R_PDO4 (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:**

![Diagram of R_PDO4 structure](image-url)

- **Byte 1:** Ref32 -> reference 32 bits - e.g. position
- **Byte 2:** Ref16 -> reference 16 bits - e.g. velocity
- **driveCtrl - 8 Bits**
  - Bit 7: QR (Quick Stop)
  - Bit 6: FR (Fault Reset)
  - Bit 5: QS (Quick Stop Release)
  - Bit 4: EN (Enable)
  - Bit 3: DI (Disable)
- **modeCtrl - 8 Bits**
  - Bit 7: MT (Mode Toggle)
  - Bit 6: ACTION (Requested Mode)
  - Bit 5: MODE (Action within Mode)
State machine – drivectrl

The state machine is controlled via PDO4 or the SDO object \texttt{drivectrl}, \texttt{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.

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

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.
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:

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

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 corresponding operating mode objects which are described in more detail in the device documentation.
Reference positions are entered in increments, reference speeds in [min\(^{-1}\)].

<table>
<thead>
<tr>
<th>WARNING</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNINTENDED OPERATION</td>
</tr>
<tr>
<td>• Note that any changes to the values of these parameters are executed by the drive controller immediately on receipt of the data set.</td>
</tr>
<tr>
<td>• Verify that the system is free and ready for movement before changing these parameters.</td>
</tr>
<tr>
<td><strong>Failure to follow these instructions can result in death, serious injury or equipment damage.</strong></td>
</tr>
</tbody>
</table>

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_PDO4 (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
**Structure of T_PDO4:**

![Diagram of T_PDO4 structure](image)

**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
**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:

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

### 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 $x_{\text{end}} = 1$ (end of positioning).

![Figure 3.21 Mode Toggle Handshake](image)

- (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 $x_{\text{end}} = 0$ in driveStat
- (4) Slave signals end of positioning with $x_{\text{end}} = 1$ in driveStat
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 \( x_{\text{end}} \), 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:

<table>
<thead>
<tr>
<th>Master MT</th>
<th>Slave MT</th>
<th>Slave ( x_{\text{end}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1 Slave has not yet detected command</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0 Slave has detected command, positioning running</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1 Slave signals that positioning is complete</td>
</tr>
</tbody>
</table>

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

![Diagram](image)

Figure 3.22 Mode Toggle Handshake, short movement

(1) Master starts positioning with MT = 1 in byte \( \text{modeCtrl} \)
(2+3) Slave signals that positioning is active with MT = 1 in \( \text{modeStat} \) and simultaneously with \( x_{\text{end}} = 0 \) in \( \text{driveStat} \)
(4) Slave signals end of positioning with \( x_{\text{end}} = 1 \) in \( \text{driveStat} \)
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.
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.

![Diagram](image)

**EMCY message**

Causes of an EMCY comprise:

- asynchronous errors, error code = 1000h, in 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 = 8200h, If the request for an operating mode via PDO4 fails, the product also sends an EMCY message.
- CAN communication error, error code = 8100h.

![Diagram](image)

- Bytes 0, 1 (error code): CANopen error code. This value is 1000h, 8200h, or 8100h, depending on the cause of the error.
- Byte 2: Error register. The value is also stored in the object Error register, 1001h.
- 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:

$$\text{COB ID} = \text{Function code of EMCY object, } 80h + \text{Node-ID}$$
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.

**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 transmitted. The time window is defined with the object Synchronous window length (1007h).

**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.
Cyclic and acyclic data transmission

Synchronous exchange of messages can be cyclic or acyclic.

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 (02h) of the corresponding PDO parameter, e.g. in the object 1st receive PDO parameter (1400h:02h) 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 (80h) by default. The value can be changed after initialization of the network with the object COB-ID SYNC Message (1005h).
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](image)

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](image)

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

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

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.
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.

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

<table>
<thead>
<tr>
<th>Command Specifier</th>
<th>NMT service</th>
<th>Transition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (01h)</td>
<td>Start remote node</td>
<td>A</td>
</tr>
<tr>
<td>2 (02h)</td>
<td>Stop remote node</td>
<td>B</td>
</tr>
<tr>
<td>128 (80h)</td>
<td>Enter Pre-Operational</td>
<td>C</td>
</tr>
<tr>
<td>129 (81h)</td>
<td>Reset node</td>
<td>D</td>
</tr>
<tr>
<td>130 (82h)</td>
<td>Reset communication</td>
<td>E</td>
</tr>
</tbody>
</table>

The second byte addresses the recipient of an NMT message with a node address between 1 and 127 (7Fh). 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 (700h+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 (700h) + node-Id.
After a request from the NMT master, the NMT slave responds with one data byte.

**Structure of the NMT message**

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)
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.

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
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.


⚠️ 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 with DIP 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.
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.
5 Commissioning

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 (80h)+node-Id.

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

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

See the product manual for additional information on the cause of errors and on troubleshooting.
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".
5.4.3 Setting the bus parameters

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

- Confirm your selection with "OK".
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".
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".
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.
### 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 `3000h` added to the index for the SDO access:

- Index: `29 = 1Dh + 3000h = 301Dh`
- Subindex: `26 = 1Ah`
- Value: `10000 = 00002710h`

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

**Transmit data**

<table>
<thead>
<tr>
<th>Object</th>
<th>COB ID</th>
<th>CCD</th>
<th>Idx</th>
<th>Sdx</th>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tx 301Dh:1A Motion.acc</td>
<td>600h+ID</td>
<td>23h</td>
<td>1Dh 30h</td>
<td>1Ah</td>
<td>10h 27h 00 00</td>
<td>Sets the acceleration to 10000 min⁻¹s⁻¹ = 2710h as a 32 bit value</td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>Object</th>
<th>COB ID</th>
<th>CCD</th>
<th>Idx</th>
<th>Sdx</th>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rx 301Dh:1A Motion.acc</td>
<td>580h+ID</td>
<td>60h</td>
<td>1Dh 30h</td>
<td>1Ah</td>
<td>XX XX XX XX</td>
<td>The response data does not have a meaning.</td>
</tr>
</tbody>
</table>

The response data does not have a meaning.
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 3000h added to the index for the SDO access:

- Index: 31 = 1Fh + 3000h = 301Fh
- Subindex 9 = 09h

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

**Transmit data**

<table>
<thead>
<tr>
<th>Object</th>
<th>COB ID</th>
<th>CCD</th>
<th>Idx</th>
<th>Sdx</th>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tx 301Fh:09h Status.n_act</td>
<td>600h+ID</td>
<td>40h</td>
<td>1Fh 30h</td>
<td>09h</td>
<td>XX XX XX XX</td>
<td>Reads the actual speed. The data has no significance.</td>
</tr>
</tbody>
</table>

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

**Receive data**

<table>
<thead>
<tr>
<th>Object</th>
<th>COB ID</th>
<th>CCD</th>
<th>Idx</th>
<th>Sdx</th>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rx 301Dh:09h Status.n_act</td>
<td>580h+ID</td>
<td>43h</td>
<td>1Fh 30h</td>
<td>09h</td>
<td>E8 03 00 00</td>
<td>The data 000003E8 corresponds to 1000 min⁻¹.</td>
</tr>
</tbody>
</table>

The product transmits the data as 32 bit values back to the master (CCD is "43h"). 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.

<table>
<thead>
<tr>
<th>Object</th>
<th>COB ID</th>
<th>CCD</th>
<th>Index</th>
<th>Sub</th>
<th>Data</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rx 3028h:20h</td>
<td>580h+ID</td>
<td>80h</td>
<td>28h 30h</td>
<td>00h</td>
<td>00 02 06</td>
<td>Error value 06020000h means &quot;object does not exist in object dictionary&quot;</td>
</tr>
</tbody>
</table>

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 80h. Refer to 7.3.2 "Error code table" for a table with the error numbers.
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".

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

Table 6.1 Important operating states

Requests for switching operating states are transmitted to the product in R_PDO4 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_PDO4:

<table>
<thead>
<tr>
<th>Bit no.</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>01h</td>
<td>Disable</td>
</tr>
<tr>
<td>1</td>
<td>02h</td>
<td>Enable</td>
</tr>
<tr>
<td>2</td>
<td>04h</td>
<td>Quick Stop</td>
</tr>
<tr>
<td>3</td>
<td>08h</td>
<td>Fault Reset</td>
</tr>
<tr>
<td>4</td>
<td>10h</td>
<td>Quick Stop release</td>
</tr>
</tbody>
</table>

Table 6.2 R_PDO4, drivectrl, bit assignment
6 Operation

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_PDO4. One of them must be "1", the other "0".

Enabling the power stage

Prerequisite: the product 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

| Enable is requested | ---| drivectrl 02h |
| Slave signals operating state 6 | ---| driveStat XXX6h |
| Request disable | ---| drivectrl 01h |
| Slave signals operating state 4 | ---| driveStat XXX4h |

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

| Enable is requested | ---| drivectrl 02h |
| Slave signals operating state 6 | ---| driveStat XXX6h |
| Request disable | ---| drivectrl 01h |
| Slave signals operating state 4 | ---| driveStat XXX4h |

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
### Example

<table>
<thead>
<tr>
<th>Master &lt;-- Slave</th>
<th>Action</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Enable&quot; is requested</td>
<td>---&gt;</td>
<td>drivectl 02h</td>
</tr>
<tr>
<td>Slave signals operating state 6</td>
<td>&lt;--</td>
<td>driveStat XXX6h</td>
</tr>
<tr>
<td>request &quot;Quick Stop&quot; and &quot;Enable&quot;</td>
<td>---&gt;</td>
<td>drivectl 06h</td>
</tr>
<tr>
<td>Slave signals operating state 7</td>
<td>&lt;--</td>
<td>driveStat XXX7h</td>
</tr>
<tr>
<td>Wait until the product has come to a standstill and the system is to resume operation</td>
<td>---&gt;</td>
<td></td>
</tr>
<tr>
<td>Request &quot;Quick Stop Release&quot; and &quot;Enable&quot;</td>
<td>&lt;--</td>
<td>drivectl 12h</td>
</tr>
<tr>
<td>Slave signals operating state 6</td>
<td>---&gt;</td>
<td>driveStat XXX6h</td>
</tr>
<tr>
<td>Cancel &quot;Quick Stop Release&quot;</td>
<td>&lt;--</td>
<td>drivectl 02h</td>
</tr>
</tbody>
</table>
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**

<table>
<thead>
<tr>
<th>Master &lt;-&gt; Slave</th>
<th>Master &lt;--- Slave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Request Enable</td>
<td>drivectrl 02h</td>
</tr>
<tr>
<td>Slave signals operating state 9 (Fault)</td>
<td>driveStat XXX9h</td>
</tr>
<tr>
<td>Remedy cause of error</td>
<td>drivectrl 08h</td>
</tr>
<tr>
<td>Request &quot;Fault Reset&quot;</td>
<td>driveStat XXX4h</td>
</tr>
<tr>
<td>Request &quot;Enable&quot;</td>
<td>drivectrl 02h</td>
</tr>
<tr>
<td>Slave signals operating state 5</td>
<td>driveStat XXX5h</td>
</tr>
<tr>
<td>Slave signals operating state 6</td>
<td>driveStat XXX6h</td>
</tr>
</tbody>
</table>

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.
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 R_PDO4 and the product mirrors it in the T_PDO4. 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)
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 03h (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 positioning to position 100,000 (000186A0h) at a reference speed of 1000 min⁻¹ (03E8h)

<table>
<thead>
<tr>
<th>Triggering positioning</th>
<th>Master &lt;--&gt; Slave</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_PDO4 ---&gt; drivectrl</td>
<td>modeCtrl</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Positioning running</td>
<td></td>
</tr>
<tr>
<td>x_err = 0,</td>
<td>driveStat</td>
</tr>
<tr>
<td>x_end = 0</td>
<td>modeStat</td>
</tr>
<tr>
<td>x_end = 1, x_info = 1</td>
<td></td>
</tr>
<tr>
<td>T_PDO4 &lt;--- driveStat</td>
<td>modeStat</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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 (07D0h) during the movement.

<table>
<thead>
<tr>
<th>Triggering positioning</th>
<th>Master &lt;--&gt; Slave</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_PDO4 ---&gt; drivectrl</td>
<td>modeCtrl</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Positioning running</td>
<td></td>
</tr>
<tr>
<td>x_err = 0,</td>
<td>driveStat</td>
</tr>
<tr>
<td>x_end = 0</td>
<td>modeStat</td>
</tr>
<tr>
<td>x_end = 1, x_info = 1</td>
<td></td>
</tr>
<tr>
<td>T_PDO4 &lt;--- driveStat</td>
<td>modeStat</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.
6.4.2 Operating mode Profile Position: relative positioning

Relative positioning is similar to absolute positioning. You only need to enter the value 13h (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 (000186A0h) increments at a speed of 1000 min⁻¹ (03E8h)

During the movement, the speed is to be changed to 2000 min⁻¹ (07D0h).

<table>
<thead>
<tr>
<th>Master &lt;-&gt; Slave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triggering positioning</td>
</tr>
<tr>
<td>Positioning running x_err = 0, x_end = 0</td>
</tr>
<tr>
<td>Change reference speed Transmit relative position &quot;0&quot;</td>
</tr>
<tr>
<td>Positioning running x_err = 0, x_end = 0</td>
</tr>
<tr>
<td>Positioning complete x_err = 0, x_end = 1, x_info = 1</td>
</tr>
</tbody>
</table>

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_PDO4:

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

<table>
<thead>
<tr>
<th>Master &lt;-&gt; Slave</th>
<th>Start Profile Velocity mode with 1000 min(^{-1})</th>
<th>R PDO4 --&gt;</th>
<th>driveCtrl 02(_h)</th>
<th>modeCtrl 84(_h)</th>
<th>Ref16 03E8(_h)</th>
<th>Ref32 XXXXXXXX(_h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product accelerates xerr=0, xend=0, xinfo=0</td>
<td>T PDO4 &lt;--</td>
<td>driveStat 0006(_h)</td>
<td>modeStat 84(_h)</td>
<td></td>
<td>p_act XXXXXXXX(_h)</td>
<td></td>
</tr>
<tr>
<td>Reference speed reached xerr=0, xend=0, xinfo=1</td>
<td>T PDO4 &lt;--</td>
<td>driveStat 2006(_h)</td>
<td>modeStat 84(_h)</td>
<td></td>
<td>p_act XXXXXXXX(_h)</td>
<td></td>
</tr>
<tr>
<td>Change speed to 2000 min(^{-1})</td>
<td>R PDO4 --&gt;</td>
<td>driveCtrl 02(_h)</td>
<td>modeCtrl 04(_h)</td>
<td>Ref16 07D0(_h)</td>
<td>Ref32 XXXXXXXX(_h)</td>
<td></td>
</tr>
<tr>
<td>Product accelerates xerr=0, xend=0, xinfo=0</td>
<td>T PDO4 &lt;--</td>
<td>driveStat 0006(_h)</td>
<td>modeStat 04(_h)</td>
<td></td>
<td>p_act XXXXXXXX(_h)</td>
<td></td>
</tr>
<tr>
<td>Reference speed reached xerr=0, xend=0, xinfo=1</td>
<td>T PDO4 &lt;--</td>
<td>driveStat 2006(_h)</td>
<td>modeStat 04(_h)</td>
<td></td>
<td>p_act XXXXXXXX(_h)</td>
<td></td>
</tr>
<tr>
<td>Change speed to 0 min(^{-1})</td>
<td>R PDO4 --&gt;</td>
<td>driveCtrl 02(_h)</td>
<td>modeCtrl 84(_h)</td>
<td>Ref16 0000(_h)</td>
<td>Ref32 XXXXXXXX(_h)</td>
<td></td>
</tr>
<tr>
<td>Product decelerates xerr=0, xend=0, xinfo=0</td>
<td>T PDO4 &lt;--</td>
<td>driveStat 0006(_h)</td>
<td>modeStat 84(_h)</td>
<td></td>
<td>p_act XXXXXXXX(_h)</td>
<td></td>
</tr>
<tr>
<td>Profile Vel. mode terminated xerr=0, xend=1, xinfo=1</td>
<td>T PDO4 &lt;--</td>
<td>driveStat 6006(_h)</td>
<td>modeStat 84(_h)</td>
<td></td>
<td>p_act XXXXXXXX(_h)</td>
<td></td>
</tr>
</tbody>
</table>

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\(_h\)).

<table>
<thead>
<tr>
<th>Master &lt;-&gt; Slave</th>
<th>Product signals position-100,000</th>
<th>T PDO4 &lt;--</th>
<th>driveStat XXXX(_h)</th>
<th>modeStat XX(_h)</th>
<th>p_act FFFE7960(_h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position setting to 200,000</td>
<td>R PDO4 --&gt;</td>
<td>driveCtrl 02(_h)</td>
<td>modeCtrl 82(_h)</td>
<td>Ref16 XXXX(_h)</td>
<td>Ref32 00030D40(_h)</td>
</tr>
<tr>
<td>Position taken over x_err = 0, x_end = 1, x_info = 0</td>
<td>T PDO4 &lt;--</td>
<td>driveStat 4006(_h)</td>
<td>modeStat A2(_h)</td>
<td></td>
<td>p_act 00030D40(_h)</td>
</tr>
</tbody>
</table>
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 12h "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.

<table>
<thead>
<tr>
<th>Master &lt;-&gt; Slave</th>
<th>R_PDO4</th>
<th>drivectrl</th>
<th>modeCtrl</th>
<th>Ref16</th>
<th>Ref32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trigger reference movement</td>
<td>R_PDO4</td>
<td>02h</td>
<td>92h</td>
<td>0002h</td>
<td>XXXXXXh</td>
</tr>
<tr>
<td>Reference movement running xerr=0, xend=0</td>
<td>T_PDO4</td>
<td>0006h</td>
<td>2h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference movement complete xerr=0, xend=1</td>
<td>T_PDO4</td>
<td>4006h</td>
<td>A2h</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6.7 Reference movement
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_PDO4. 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.

<table>
<thead>
<tr>
<th>Master &lt;---&gt; Slave</th>
</tr>
</thead>
<tbody>
<tr>
<td>T_PDO4</td>
</tr>
<tr>
<td>0006h</td>
</tr>
<tr>
<td>Request: Dimension setting to 0</td>
</tr>
<tr>
<td>02h</td>
</tr>
<tr>
<td>Request rejected &quot;ModeError&quot; = 1</td>
</tr>
<tr>
<td>T_PDO4</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Master --- Slave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positioning running ( x_{err} = 0 ), ( x_{end} = 0 )</td>
</tr>
<tr>
<td>Limit switch detected ( x_{err} = 1 ), ( x_{end} = 0 )</td>
</tr>
<tr>
<td>Motor stopped ( x_{err} = 1 ), ( x_{end} = 1 )</td>
</tr>
</tbody>
</table>

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.
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:

- 24Vdc 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 700h + node ID and 1 data byte with the content 00h).
- With the factory setting 127 (7Fh) 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.
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 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).
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.

<table>
<thead>
<tr>
<th>Bit</th>
<th>Message</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Generic error</td>
<td>An error has occurred</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>reserved</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>reserved</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>reserved</td>
</tr>
<tr>
<td>4</td>
<td>Communication</td>
<td>Network communication error</td>
</tr>
<tr>
<td>5</td>
<td>Device profile-specific</td>
<td>Error in execution as per device profile</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>reserved</td>
</tr>
<tr>
<td>7</td>
<td>Manufacturer-specific</td>
<td>Vendor-specific error message</td>
</tr>
</tbody>
</table>

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.
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](image)

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

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

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

Data type

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

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.
Can be saved: 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

<table>
<thead>
<tr>
<th>Index</th>
<th>Subindex</th>
<th>Designation</th>
<th>Obj. code</th>
<th>Data type</th>
<th>Access</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000h</td>
<td></td>
<td>device type</td>
<td>VAR</td>
<td>UINT32</td>
<td>ro</td>
</tr>
<tr>
<td>1001h</td>
<td></td>
<td>error register</td>
<td>VAR</td>
<td>UINT8</td>
<td>ro</td>
</tr>
<tr>
<td>1008h</td>
<td></td>
<td>manufacturer device name</td>
<td>VAR</td>
<td>String</td>
<td>ro</td>
</tr>
<tr>
<td>100Ch</td>
<td></td>
<td>guard time</td>
<td>VAR</td>
<td>UINT16</td>
<td>rw</td>
</tr>
<tr>
<td>100Dh</td>
<td></td>
<td>life time factor</td>
<td>VAR</td>
<td>UINT8</td>
<td>rw</td>
</tr>
<tr>
<td>1015h</td>
<td></td>
<td>inhibit time EMCY</td>
<td>VAR</td>
<td>UINT16</td>
<td>rw</td>
</tr>
<tr>
<td>1018h</td>
<td></td>
<td>identity object</td>
<td>RECORD</td>
<td>Identity</td>
<td>ro</td>
</tr>
<tr>
<td>1018h</td>
<td>0</td>
<td>number of elements</td>
<td>VAR</td>
<td>UINT8</td>
<td>ro</td>
</tr>
<tr>
<td>1018h</td>
<td>1</td>
<td>Vendor id</td>
<td>VAR</td>
<td>UINT32</td>
<td>ro</td>
</tr>
<tr>
<td>1018h</td>
<td>2</td>
<td>product code</td>
<td>VAR</td>
<td>UINT8</td>
<td>ro</td>
</tr>
<tr>
<td>1403h</td>
<td>0</td>
<td>number of elements</td>
<td>VAR</td>
<td>UINT8</td>
<td>ro</td>
</tr>
<tr>
<td>1403h</td>
<td>1</td>
<td>COB ID used by R_PDO4</td>
<td>VAR</td>
<td>UINT32</td>
<td>ro</td>
</tr>
<tr>
<td>1403h</td>
<td>2</td>
<td>transmission type R_PDO4</td>
<td>VAR</td>
<td>UINT8</td>
<td>rw</td>
</tr>
<tr>
<td>1403h</td>
<td>3</td>
<td>inhibit time R_PDO4</td>
<td>VAR</td>
<td>UINT16</td>
<td>rw</td>
</tr>
<tr>
<td>1403h</td>
<td>4</td>
<td>compatibility entry R_PDO4</td>
<td>VAR</td>
<td>UINT8</td>
<td>rw</td>
</tr>
<tr>
<td>1403h</td>
<td>5</td>
<td>event timer R_PDO4</td>
<td>VAR</td>
<td>UINT16</td>
<td>rw</td>
</tr>
<tr>
<td>1603h</td>
<td>0</td>
<td>number of elements</td>
<td>VAR</td>
<td>UINT8</td>
<td>ro</td>
</tr>
<tr>
<td>1603h</td>
<td>1</td>
<td>1st mapped object R_PDO4</td>
<td>VAR</td>
<td>UINT32</td>
<td>ro</td>
</tr>
<tr>
<td>1603h</td>
<td>2</td>
<td>2nd mapped object R_PDO4</td>
<td>VAR</td>
<td>UINT32</td>
<td>ro</td>
</tr>
<tr>
<td>1603h</td>
<td>3</td>
<td>3rd mapped object R_PDO4</td>
<td>VAR</td>
<td>UINT32</td>
<td>ro</td>
</tr>
<tr>
<td>1603h</td>
<td>4</td>
<td>4th mapped object R_PDO4</td>
<td>VAR</td>
<td>UINT32</td>
<td>ro</td>
</tr>
<tr>
<td>1803h</td>
<td>0</td>
<td>number of elements</td>
<td>VAR</td>
<td>UINT8</td>
<td>ro</td>
</tr>
<tr>
<td>1803h</td>
<td>1</td>
<td>COB ID used by T_PDO4</td>
<td>VAR</td>
<td>UINT32</td>
<td>ro</td>
</tr>
<tr>
<td>1803h</td>
<td>2</td>
<td>transmission type T_PDO4</td>
<td>VAR</td>
<td>UINT8</td>
<td>rw</td>
</tr>
<tr>
<td>1803h</td>
<td>3</td>
<td>inhibit time T_PDO4</td>
<td>VAR</td>
<td>UINT16</td>
<td>rw</td>
</tr>
<tr>
<td>1803h</td>
<td>4</td>
<td>reserved T_PDO4</td>
<td>VAR</td>
<td>UINT8</td>
<td>rw</td>
</tr>
<tr>
<td>1803h</td>
<td>5</td>
<td>event timer T_PDO4</td>
<td>VAR</td>
<td>UINT16</td>
<td>rw</td>
</tr>
<tr>
<td>1A03h</td>
<td>0</td>
<td>number of elements</td>
<td>VAR</td>
<td>UINT8</td>
<td>ro</td>
</tr>
<tr>
<td>1A03h</td>
<td>1</td>
<td>1st mapped object T_PDO4</td>
<td>VAR</td>
<td>UINT32</td>
<td>ro</td>
</tr>
<tr>
<td>1A03h</td>
<td>2</td>
<td>2nd mapped object T_PDO4</td>
<td>VAR</td>
<td>UINT32</td>
<td>ro</td>
</tr>
<tr>
<td>1A03h</td>
<td>3</td>
<td>3rd mapped object T_PDO4</td>
<td>VAR</td>
<td>UINT32</td>
<td>ro</td>
</tr>
<tr>
<td>1A03h</td>
<td>4</td>
<td>4th mapped object T_PDO4</td>
<td>VAR</td>
<td>UINT32</td>
<td>ro</td>
</tr>
</tbody>
</table>
8.2 Objects of the product

1000h Device type
The object specifies the device profile used as well as the device type.

<table>
<thead>
<tr>
<th>Object description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index</td>
</tr>
<tr>
<td>Object name</td>
</tr>
<tr>
<td>Object code</td>
</tr>
<tr>
<td>Data type</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Value description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subindex</td>
</tr>
<tr>
<td>Meaning</td>
</tr>
<tr>
<td>Access</td>
</tr>
<tr>
<td>PDO mapping</td>
</tr>
<tr>
<td>Value range</td>
</tr>
<tr>
<td>Default value</td>
</tr>
<tr>
<td>Can be saved</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Object description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index</td>
</tr>
<tr>
<td>Object name</td>
</tr>
<tr>
<td>Object code</td>
</tr>
<tr>
<td>Data type</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Value description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subindex</td>
</tr>
<tr>
<td>Meaning</td>
</tr>
<tr>
<td>Access</td>
</tr>
<tr>
<td>PDO mapping</td>
</tr>
<tr>
<td>Value range</td>
</tr>
<tr>
<td>Default value</td>
</tr>
<tr>
<td>Can be saved</td>
</tr>
</tbody>
</table>
Bit coding, subindex 00h

<table>
<thead>
<tr>
<th>Bit</th>
<th>Access</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>ro</td>
<td>–</td>
<td>Error! (generic error)</td>
</tr>
<tr>
<td>1</td>
<td>ro</td>
<td>–</td>
<td>Current</td>
</tr>
<tr>
<td>2</td>
<td>ro</td>
<td>–</td>
<td>Voltage</td>
</tr>
<tr>
<td>3</td>
<td>ro</td>
<td>–</td>
<td>Temperature</td>
</tr>
<tr>
<td>4</td>
<td>ro</td>
<td>–</td>
<td>Communication profile (communication error)</td>
</tr>
<tr>
<td>5</td>
<td>ro</td>
<td>–</td>
<td>Device profile (device profile error)</td>
</tr>
<tr>
<td>6</td>
<td>ro</td>
<td>–</td>
<td>Reserved</td>
</tr>
<tr>
<td>7</td>
<td>ro</td>
<td>–</td>
<td>Manufacturer-specific</td>
</tr>
</tbody>
</table>

1008h Manufacturer device name

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

Object description

<table>
<thead>
<tr>
<th>Index</th>
<th>1008h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object name</td>
<td>manufacturer device name</td>
</tr>
<tr>
<td>Object code</td>
<td>VAR</td>
</tr>
<tr>
<td>Data type</td>
<td>String</td>
</tr>
</tbody>
</table>

Value description

<table>
<thead>
<tr>
<th>Subindex</th>
<th>00h, manufacturer device name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meaning</td>
<td>Manufacturer name</td>
</tr>
<tr>
<td>Access</td>
<td>read-only</td>
</tr>
<tr>
<td>PDO mapping</td>
<td>–</td>
</tr>
<tr>
<td>Value range</td>
<td>–</td>
</tr>
<tr>
<td>Default value</td>
<td>–</td>
</tr>
<tr>
<td>Can be saved</td>
<td>–</td>
</tr>
</tbody>
</table>

100Ch Guard time

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

Object description

<table>
<thead>
<tr>
<th>Index</th>
<th>100Ch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object name</td>
<td>guard time</td>
</tr>
<tr>
<td>Object code</td>
<td>VAR</td>
</tr>
<tr>
<td>Data type</td>
<td>Unsigned16</td>
</tr>
</tbody>
</table>

Value description

<table>
<thead>
<tr>
<th>Subindex</th>
<th>00h, guard time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meaning</td>
<td>Time span for node guarding [ms]</td>
</tr>
<tr>
<td>Access</td>
<td>read-write</td>
</tr>
<tr>
<td>PDO mapping</td>
<td>–</td>
</tr>
<tr>
<td>Value range</td>
<td>0...65535</td>
</tr>
<tr>
<td>Default value</td>
<td>0</td>
</tr>
<tr>
<td>Can be saved</td>
<td>–</td>
</tr>
</tbody>
</table>
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 (100Dh).

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

<table>
<thead>
<tr>
<th>Index</th>
<th>100Dh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object name</td>
<td>life time factor</td>
</tr>
<tr>
<td>Object code</td>
<td>VAR</td>
</tr>
<tr>
<td>Data type</td>
<td>Unsigned8</td>
</tr>
</tbody>
</table>

Value description

<table>
<thead>
<tr>
<th>Subindex</th>
<th>00h, life time factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meaning</td>
<td>Time factor for the node guarding protocol</td>
</tr>
<tr>
<td>Access</td>
<td>read-write</td>
</tr>
<tr>
<td>PDO mapping</td>
<td>–</td>
</tr>
<tr>
<td>Value range</td>
<td>0...255</td>
</tr>
<tr>
<td>Default value</td>
<td>0</td>
</tr>
<tr>
<td>Can be saved</td>
<td>–</td>
</tr>
</tbody>
</table>

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 (100Ch).

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

<table>
<thead>
<tr>
<th>Index</th>
<th>1015h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object name</td>
<td>inhibit time EMCY</td>
</tr>
<tr>
<td>Object code</td>
<td>VAR</td>
</tr>
<tr>
<td>Data type</td>
<td>Unsigned16</td>
</tr>
</tbody>
</table>
### 8 Object directory

<table>
<thead>
<tr>
<th>Subindex</th>
<th>Meaning</th>
<th>Access</th>
<th>PDO mapping</th>
<th>Value range</th>
<th>Default value</th>
<th>Can be saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>00h</td>
<td>EMCY</td>
<td>–</td>
<td>–</td>
<td>0...65535</td>
<td>0</td>
<td>–</td>
</tr>
</tbody>
</table>

**Value description**

1018h  
Identity Object

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

<table>
<thead>
<tr>
<th>Index</th>
<th>Meaning</th>
<th>Access</th>
<th>PDO mapping</th>
<th>Value range</th>
<th>Default value</th>
<th>Can be saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>00h</td>
<td>number of elements</td>
<td>read-only</td>
<td>–</td>
<td>1...4</td>
<td>2</td>
<td>–</td>
</tr>
</tbody>
</table>

**Value description**

<table>
<thead>
<tr>
<th>Subindex</th>
<th>Meaning</th>
<th>Access</th>
<th>PDO mapping</th>
<th>Value range</th>
<th>Default value</th>
<th>Can be saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>01h</td>
<td>vendor id</td>
<td>read-only</td>
<td>–</td>
<td>0...4294967295</td>
<td>0x0100002E</td>
<td>–</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subindex</th>
<th>Meaning</th>
<th>Access</th>
<th>PDO mapping</th>
<th>Value range</th>
<th>Default value</th>
<th>Can be saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>02h</td>
<td>product code</td>
<td>read-only</td>
<td>–</td>
<td>0...4294967295</td>
<td>0x01</td>
<td>–</td>
</tr>
</tbody>
</table>
IL\1F CANopen DS301

8 Object directory

1403h  Receive PDO4 communication parameter
       The object stores settings for the fourth receive PDO R_PDO4.

<table>
<thead>
<tr>
<th>Object description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index</td>
</tr>
<tr>
<td>Object name</td>
</tr>
<tr>
<td>Object code</td>
</tr>
<tr>
<td>Data type</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Value description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subindex</td>
</tr>
<tr>
<td>Meaning</td>
</tr>
<tr>
<td>Access</td>
</tr>
<tr>
<td>PDO mapping</td>
</tr>
<tr>
<td>Value range</td>
</tr>
<tr>
<td>Default value</td>
</tr>
<tr>
<td>Can be saved</td>
</tr>
</tbody>
</table>

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

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

| Subindex | 03h, 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 | – |
8 Object directory

Bit assignment subindex 01h

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

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.
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 (1603h)** 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 00h, the number of mapped objects is read.

**Object description**

<table>
<thead>
<tr>
<th>Index</th>
<th>1603h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object name</td>
<td>receive PDO4 mapping</td>
</tr>
<tr>
<td>Object code</td>
<td>RECORD</td>
</tr>
<tr>
<td>Data type</td>
<td>PDO Mapping</td>
</tr>
</tbody>
</table>
### Value description

<table>
<thead>
<tr>
<th>Subindex</th>
<th>00h, number of elements</th>
<th>Meaning</th>
<th>Number of subindexes</th>
<th>Access</th>
<th>PDO mapping</th>
<th>Value range</th>
<th>Default value</th>
<th>Can be saved</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Subindex</th>
<th>01h, 1st mapped object R_PDO4</th>
<th>Meaning</th>
<th>First object for mapping in R_PDO4</th>
<th>Access</th>
<th>PDO mapping</th>
<th>Value range</th>
<th>Default value</th>
<th>Can be saved</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Subindex</th>
<th>02h, 2nd mapped object R_PDO4</th>
<th>Meaning</th>
<th>Second object for mapping in R_PDO4</th>
<th>Access</th>
<th>PDO mapping</th>
<th>Value range</th>
<th>Default value</th>
<th>Can be saved</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Subindex</th>
<th>03h, 3rd mapped object R_PDO4</th>
<th>Meaning</th>
<th>Third object for mapping in R_PDO4</th>
<th>Access</th>
<th>PDO mapping</th>
<th>Value range</th>
<th>Default value</th>
<th>Can be saved</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Subindex</th>
<th>04h, 4th mapped object R_PDO4</th>
<th>Meaning</th>
<th>Fourth object for mapping in R_PDO4</th>
<th>Access</th>
<th>PDO mapping</th>
<th>Value range</th>
<th>Default value</th>
<th>Can be saved</th>
</tr>
</thead>
</table>
**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.

<table>
<thead>
<tr>
<th>Bit</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>31..16</td>
<td>Index</td>
</tr>
<tr>
<td>15..8</td>
<td>Subindex</td>
</tr>
<tr>
<td>7..0</td>
<td>Object length in bytes</td>
</tr>
</tbody>
</table>

**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**

<table>
<thead>
<tr>
<th>Index</th>
<th>1803h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object name</td>
<td>Transmit PDO4 communication parameter</td>
</tr>
<tr>
<td>Object code</td>
<td>RECORD</td>
</tr>
<tr>
<td>Data type</td>
<td>PDO Communication Parameter</td>
</tr>
</tbody>
</table>

**Value description**

<table>
<thead>
<tr>
<th>Subindex</th>
<th>Meaning</th>
<th>Access</th>
<th>PDO mapping</th>
<th>Value range</th>
<th>Default value</th>
<th>Can be saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>00h</td>
<td>number of elements</td>
<td>read-only</td>
<td>–</td>
<td>–</td>
<td>5</td>
<td>–</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subindex</th>
<th>Meaning</th>
<th>Access</th>
<th>PDO mapping</th>
<th>Value range</th>
<th>Default value</th>
<th>Can be saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>01h</td>
<td>COB ID used by T_PDO4</td>
<td>read-only</td>
<td>–</td>
<td>–</td>
<td>0x00000480+nodeID</td>
<td>–</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subindex</th>
<th>Meaning</th>
<th>Access</th>
<th>PDO mapping</th>
<th>Value range</th>
<th>Default value</th>
<th>Can be saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>02h</td>
<td>transmission type T_PDO4</td>
<td>read-write</td>
<td>–</td>
<td>–</td>
<td>254</td>
<td>–</td>
</tr>
</tbody>
</table>
The meaning of the bit states and subindex values is described with the object `receive PDO4 communication parameter (1403h)`. 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 (1A03h)` 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 00h, the number of mapped objects is read.

Object description

<table>
<thead>
<tr>
<th>Index</th>
<th>1A03h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object name</td>
<td>transmit PDO4 mapping</td>
</tr>
<tr>
<td>Object code</td>
<td>RECORD</td>
</tr>
<tr>
<td>Data type</td>
<td>PDO Mapping</td>
</tr>
</tbody>
</table>
### Value description

<table>
<thead>
<tr>
<th>Subindex</th>
<th>Meaning</th>
<th>Access</th>
<th>PDO mapping</th>
<th>Value range</th>
<th>Default value</th>
<th>Can be saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>00h</td>
<td>Subindex 00h, number of elements</td>
<td>read-only</td>
<td>–</td>
<td>–</td>
<td>4</td>
<td>–</td>
</tr>
<tr>
<td>01h</td>
<td>Subindex 01h, 1st mapped object T_PDO4</td>
<td>read-only</td>
<td>–</td>
<td>–</td>
<td>0x301E0410</td>
<td>–</td>
</tr>
<tr>
<td>02h</td>
<td>Subindex 02h, 2nd mapped object T_PDO4</td>
<td>read-only</td>
<td>–</td>
<td>–</td>
<td>0x301E0308</td>
<td>–</td>
</tr>
</tbody>
</table>
The meaning of the bit states is described with the object receive PDO4 mapping (1603h).

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

<table>
<thead>
<tr>
<th>Subindex</th>
<th>Meaning</th>
<th>Access</th>
<th>PDO mapping</th>
<th>Value range</th>
<th>Default value</th>
<th>Can be saved</th>
</tr>
</thead>
<tbody>
<tr>
<td>03h</td>
<td>3rd mapped object T_PDO4</td>
<td>read-only</td>
<td>–</td>
<td>–</td>
<td>0x301E0708</td>
<td>–</td>
</tr>
<tr>
<td>04h</td>
<td>4th mapped object T_PDO4</td>
<td>read-only</td>
<td>–</td>
<td>–</td>
<td>0x301E0820</td>
<td>–</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th></th>
<th>in</th>
<th>ft</th>
<th>yd</th>
<th>m</th>
<th>cm</th>
<th>mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>in</td>
<td>-</td>
<td>/ 12</td>
<td>/ 36</td>
<td>* 0.0254</td>
<td>* 2.54</td>
<td>* 25.4</td>
</tr>
<tr>
<td>ft</td>
<td>* 12</td>
<td>-</td>
<td>/ 3</td>
<td>* 0.30479</td>
<td>* 30.479</td>
<td>* 304.79</td>
</tr>
<tr>
<td>yd</td>
<td>* 36</td>
<td>* 3</td>
<td>-</td>
<td>* 0.9144</td>
<td>* 91.44</td>
<td>* 914.4</td>
</tr>
<tr>
<td>m</td>
<td>/ 0.0254</td>
<td>/ 0.30479</td>
<td>/ 0.9144</td>
<td>-</td>
<td>* 100</td>
<td>* 1000</td>
</tr>
<tr>
<td>cm</td>
<td>/ 2.54</td>
<td>/ 30.479</td>
<td>/ 91.44</td>
<td>/ 100</td>
<td>-</td>
<td>* 10</td>
</tr>
<tr>
<td>mm</td>
<td>/ 25.4</td>
<td>/ 304.79</td>
<td>/ 914.4</td>
<td>/ 1000</td>
<td>/ 10</td>
<td>-</td>
</tr>
</tbody>
</table>

### 9.1.2 Mass

<table>
<thead>
<tr>
<th></th>
<th>lb</th>
<th>oz</th>
<th>slug</th>
<th>kg</th>
<th>g</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb</td>
<td>-</td>
<td>* 16</td>
<td>* 0.03108095</td>
<td>* 0.4535924</td>
<td>* 453.5924</td>
</tr>
<tr>
<td>oz</td>
<td>/ 16</td>
<td>-</td>
<td>* 1.942559*10^-3</td>
<td>* 0.02834952</td>
<td>* 28.34952</td>
</tr>
<tr>
<td>slug</td>
<td>/ 0.03108095</td>
<td>/ 1.942559*10^-3</td>
<td>-</td>
<td>* 14.5939</td>
<td>* 14593.9</td>
</tr>
<tr>
<td>kg</td>
<td>/ 0.45359237</td>
<td>/ 0.02834952</td>
<td>/ 14.5939</td>
<td>-</td>
<td>* 1000</td>
</tr>
<tr>
<td>g</td>
<td>/ 453.59237</td>
<td>/ 28.34952</td>
<td>/ 14593.9</td>
<td>/ 1000</td>
<td>-</td>
</tr>
</tbody>
</table>

### 9.1.3 Force

<table>
<thead>
<tr>
<th></th>
<th>lb</th>
<th>oz</th>
<th>p</th>
<th>dyne</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb</td>
<td>-</td>
<td>* 16</td>
<td>* 453.55358</td>
<td>* 444822.2</td>
<td>* 4.448222</td>
</tr>
<tr>
<td>oz</td>
<td>/ 16</td>
<td>-</td>
<td>* 28.349524</td>
<td>* 27801</td>
<td>* 0.27801</td>
</tr>
<tr>
<td>p</td>
<td>/ 453.55358</td>
<td>/ 28.349524</td>
<td>-</td>
<td>* 980.7</td>
<td>* 9.807*10^-3</td>
</tr>
<tr>
<td>dyne</td>
<td>/ 444822.2</td>
<td>/ 27801</td>
<td>/ 980.7</td>
<td>-</td>
<td>/ 100*10^3</td>
</tr>
<tr>
<td>N</td>
<td>/ 4.448222</td>
<td>/ 0.27801</td>
<td>/ 9.807*10^-3</td>
<td>* 100*10^3</td>
<td>-</td>
</tr>
</tbody>
</table>

### 9.1.4 Power

<table>
<thead>
<tr>
<th></th>
<th>HP</th>
<th>W</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP</td>
<td>-</td>
<td>* 746</td>
</tr>
<tr>
<td>W</td>
<td>/ 746</td>
<td>-</td>
</tr>
</tbody>
</table>
### 9.1.5 Rotation

<table>
<thead>
<tr>
<th>Unit</th>
<th>Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>min⁻¹ (RPM)</td>
<td>π / 30</td>
</tr>
<tr>
<td>rad/s</td>
<td>-</td>
</tr>
<tr>
<td>deg/s</td>
<td>/ 6</td>
</tr>
</tbody>
</table>

### 9.1.6 Torque

<table>
<thead>
<tr>
<th>Unit</th>
<th>Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb-in</td>
<td>/ 12 * 16</td>
</tr>
<tr>
<td>lb-ft</td>
<td>- / 12</td>
</tr>
<tr>
<td>oz-in</td>
<td>- / 192</td>
</tr>
<tr>
<td>Nm</td>
<td>/ 0.112985 / 1.355822 * 7.0616¹⁰⁻³</td>
</tr>
<tr>
<td>kp-m</td>
<td>/ 0.011521 / 0.138255 * 720.07¹⁰⁻⁶</td>
</tr>
<tr>
<td>kp-cm</td>
<td>/ 1.1521 / 13.8255 * 720.07¹⁰⁻⁶</td>
</tr>
<tr>
<td>dyne-cm</td>
<td>/ 1.129¹⁰⁶ / 13.558¹⁰⁶</td>
</tr>
</tbody>
</table>

### 9.1.7 Moment of inertia

<table>
<thead>
<tr>
<th>Unit</th>
<th>Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb-in²</td>
<td>- / 144</td>
</tr>
<tr>
<td>lb-ft²</td>
<td>* 144</td>
</tr>
<tr>
<td>oz-in²</td>
<td>* 0.04214</td>
</tr>
<tr>
<td>kg-m²</td>
<td>* 3417.16</td>
</tr>
<tr>
<td>kg-cm²</td>
<td>* 0.341716</td>
</tr>
<tr>
<td>kp-cm-s²</td>
<td>* 335.109</td>
</tr>
<tr>
<td>dyne-cm²</td>
<td>/ 16</td>
</tr>
</tbody>
</table>

### 9.1.8 Temperature

<table>
<thead>
<tr>
<th>Unit</th>
<th>Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>°F</td>
<td>-</td>
</tr>
<tr>
<td>°C</td>
<td>°C * 9/5 + 32</td>
</tr>
<tr>
<td>K</td>
<td>(K - 273.15) * 9/5 + 32</td>
</tr>
</tbody>
</table>

### 9.1.9 Conductor cross section

<table>
<thead>
<tr>
<th>AWG</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm²</td>
<td>42.4</td>
<td>33.6</td>
<td>26.7</td>
<td>21.2</td>
<td>16.8</td>
<td>13.3</td>
<td>10.5</td>
<td>8.4</td>
<td>6.6</td>
<td>5.3</td>
<td>4.2</td>
<td>3.3</td>
<td>2.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AWG</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
<th>23</th>
<th>24</th>
<th>25</th>
<th>26</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm²</td>
<td>2.1</td>
<td>1.7</td>
<td>1.3</td>
<td>1.0</td>
<td>0.82</td>
<td>0.65</td>
<td>0.52</td>
<td>0.41</td>
<td>0.33</td>
<td>0.26</td>
<td>0.20</td>
<td>0.16</td>
<td>0.13</td>
</tr>
</tbody>
</table>
9.2 Terms and Abbreviations

**AC**  Alternating current

**CAN** (Controller Area Network), 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** CAN in Automation, CAN interest group, standardization group for CAN and CANopen.

**COB ID** Communication Object Identifier; 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** (Electronic Data Sheet); 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.
**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.
10  Index

A
Abbreviations 95
ABORT 76, 78
Acyclic data transmission 45
Address 54
   Checking 75
Asynchronous errors 76

B
Baud rate 54
   Checking 75
Before you begin
   Safety information 13
Bit field data 22
Bit field identifier 22
Bit fields
   Data 22
   Identifier 22
Boot Up
   Message 47
Bus arbitration 22

C
CAN
   message 22
CAN 3.0A 22
CANopen
   Communication profile, NMT 46
   error messages 77
   Message 22
   Standards 11
ccd
   See command code
Checking
   Address 75
   Baud rate 75
Client-Server 25
Client-server
   SDO data exchange 26
COB ID 22
   for node guarding 48
   of communication objects 23
   SDO 27
   SYNC object 45
COB Id
   bus arbitration 22
   Identification of communication objects 22
   tasks 22
Coding
   Command code 28, 29
Command code
Read value 29
SDO 27
Write value 28
Command specifier 48
Command-code
See command code
Commissioning 53
Commissioning the device 53
Communication objects
COB IDs 23
Controlling 22
Identification 22
overview 21
Communication profile
DS301 18
Communication relationship
client - server 24
master - slave 24
producer - consumer 24
Connection error
Node guarding 50
Connection monitoring
NMT services 48
Cyclic data transmission 45

D
Data
Persistent data 47
Reading 29
SDO 27
Writing 28
Data frame 24
of the NMT device service 48
SDO 27
Data length
Flexible 31
Data transmission
Acyclic 45
Cyclic 45
Synchronous 44
Device profile
DS402 18
Diagnostics 75
Documentation and literature references 11
DS301
communication profile 18
DS402
Device profile 18

E
EMCY
object 21
Emergency object
See EMCY object
Error
Fieldbus interface

messages for CANopen 77
Response with SDO 30
Error code
table 77
Error diagnostics
Connections to for fieldbus operation 75
Function test of fieldbus 75
error register 77
Example
SDO message 27
Selection of a COB ID 24

F
Function code 23
function code
See Function code
Function test
Fieldbus 75

G
Glossary 93

H
Homing 71

I
Identification
of communication objects 22
Index
SDO 27
 Interruption of movement
Cause 77
Introduction 9

L
Layer model
Application Layer 15
Data Link Layer 15
Physical Layer 15
Life guarding 48

M
Master - Slave 24
Message 22
CANopen 22
NMT 48, 49
SDO 27
Message objects 76
EMCY(80h+ node ID) 76
Error code (603Fh) 76
error register (1001h) 76
Status word (6041h) 76
Message-oriented communication 9
Messages
Asynchronous errors 76
Error code (603Fh) 77
Error register (1001h) 77
on the device status 76
Synchronous errors 76
Mode Toggle 40
Multimaster capability 9

N
Network management
See NMT
NMT
Message 48
Network services 46
Recipient of a message 48
Services
Initialization 47
services 21, 46
for connection monitoring 48
for device control 46
State machine 46
State of slave 49
Structure of a message 49
Node address 22, 23, 48
Node guarding 48
COB ID 48
Connection error 50
Node ID 22

O
Object groups
overview 16
Operating mode
homing 71
profile velocity 69
Operation 59
Overview
communication objects 21
object groups 16

P
PDO 21, 31
Producer-consumer 32
Prioritization of messages 9
Process Data Object
see PDO
process data objects
see PDO
Producer-Consumer 25
Producer-consumer
PDO 32
SYNC 44
Profile velocity 69
Profiles
standardized 18
Vendor-specific 18

R
Real-time data exchange 31
Recipient
of an NMT message 48
Residual error probability 9
Response
to SDO error 30

S
SDO 21, 26
COB ID 27
Command code 27
Data 27
Data frame 27
Error message 76
error message 78
Error response 30
Index, Subindex 27
message 27
Message types 26
Response 29
Transmission error 78
Service Data Object
See SDO
Service data objects 21
See SDO
Services
For connection monitoring 46
For device control 46
NMT 21, 46
Specification
CAN 3.0A 22
State machine
NMT 46
Subindex
SDO 27
SYNC object 21, 44
COB ID 45
with PDO 32
Synchronization 44
Time values 44
Synchronization object
See SYNC object
Synchronous
Data transmission 44
Errors 76

T
Tasks
of the COB Id 22
Terms  95
Time values
   For synchronization  44
Troubleshooting  75

U
Units and conversion tables  93

V
Vendor-specific
   Profiles  18