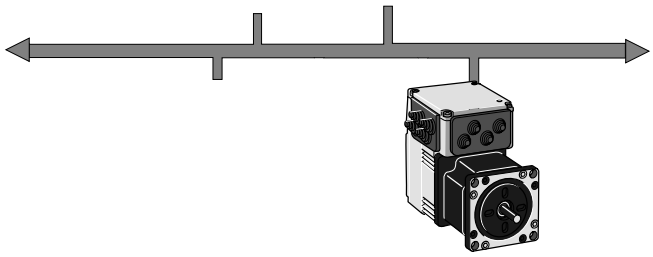
Technical documentation



Field bus protocol for the intelligent compact drive IclA IFx

CANopen DS301

Order no.: 0098441113185

Edition: -000, 05.03

BERGER LAHR

a company of Schneider Electric

Important information

These compact drives are designed for general use. They are state of the art and are designed to be as safe as possible. However, drives and drive controllers that are not specifically designed for safety functions are not approved for applications where the functioning of the drive could endanger persons. The possibility of unexpected or unbraked movements can never be totally excluded without additional safety equipment. For this reason personnel must never be in the danger zone of the drives unless additional suitable safety equipment prevents any personal danger. This applies for operating the machine during production and also for all service and maintenance work on drives and the machine. The machine design must ensure personal safety. Suitable measures for prevention of property damage are also required.

For more information see chapter 2, "Safety".

Table of contents

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Written conventions and note symbols

Instructions for use

Layout and format:

Introduction to the following instruction steps

① This is the first step.

② This is the second step.

Explanation:

Instructions consist of an introduction and the actual instruction steps.

Unless otherwise stated, the individual instruction steps must be carried in the given sequence.

If an instruction step triggers a detectable reaction from the compact drive, the response is described after the step. In this way you can check that the step was correctly completed.

List symbol

Layout and format:

Note on the contents of the list

- 1. list item
- 2. list item
  - 1. list subitem
  - 2. list subitem
- 3. list item

Explanation:

The actual list follows a note on the contents of the list. It can consist of 1 or 2 levels.

The list items are sorted alphanumerically or by priority.

User notes

User notes contain general information, not safety information.

For an explanation of the safety instructions see chapter 2, "Safety".

This shows additional information on the current subject.

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1 Introduction

1.1 Documentation and literature

Documentation

- Datasheets for IclA in the IclA Intelligent Compact Drives catalog
  Order no. 005 9941 2010 001 D
  Order no. 005 9941 2010 002 GB
- Controller manuals for IclA compact drives:
  - Intelligent Compact Drive Field Bus Stepper Motor IclA IFS6x
  Order no. 00 9844 1113 188 D
  Order no. 00 9844 1113 189 GB

Literature

- Controller Area Network
  Konrad Etschberger, Carl Hanser Verlag
  ISBN 3-446-19431-2
- CANopen
  Holger Zeltwanger, VDE Verlag
  ISBN 3-8007-2448-0

1.2 Directives and standards

CANopen Standards

CANopen documentation by the CAN in Automation (CiA) user organisation.

- ISO11898
  Controller Area Network CAN part 1...4
- EN50325
  Industrial Communication Subsystem based on ISO11898 for controller device interfaces
- CiA Draft Standard 301
  CANopen Application Layer and Communication Profile
  Version 4.02, February 2002, CAN in Automation e.V.

CAN interest group

CAN in Automation (CiA)

Am Weichselgarten 26

D-91058 Erlangen

www.can-cia.de

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2 Safety

2.1 Qualifications of personnel

Only electrical and controller technicians qualified under IEV 826-09-01 (modified) are authorized to set parameters on, commission and operate the compact drive. The electrical and controller technicians must be familiar with the contents of this manual before starting work with and on the compact drive.

The electrical and controller technicians must have sufficient training, knowledge and experience to recognize and avoid dangers.

The technicians must be familiar with the current standards, regulations and work safety regulations that must be observed while working on and with the compact drive.

2.2 Intended use

2.2.1 Ambient conditions

See the approved environmental conditions described in the data sheet.

2.2.2 Intended use

The compact drive is a variable-speed drive with permanently excited synchronous motor (stepper motor), integrated controller and power electronics. As an option the compact drive can be fitted with a gearbox and a holding brake.

Another option is a Hall sensor, which sends an index pulse and can be used for blocking detection.

The compact drive may be used for industrial applications in the system configuration described with a fixed connection only.

The environment in which the compact drive is to be installed and operated must meet degree of protection IP54 as a minimum.

The compact drive must not be commissioned and operated until it has been installed in conformity with EMC requirements. The compact drive may only be used with the cables and accessories specified by your local dealer.

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2.3 Safety instructions

2.3.1 Structure of the safety instructions

All safety instructions are structured to comply with the US standard **ANSI Z535.4**. Under this standard safety instructions are classified into four core elements. A pictogram before the text allows an initial danger classification.

The following general structure is derived from this:

Structure of the safety instructions under ANSI Z535.4

DANGER LEVEL

Description of the cause and source of the danger

Actions for avoiding the danger

Danger levels

DANGER

This indicates direct personal danger.

Can lead to serious injuries with fatal consequences if not observed.

WARNING

Indication of a recognizable danger.

Can result in serious injuries with fatal consequences and destruction of the unit or system component if not observed.

CAUTION

Indication of a danger.

If this is ignored, minor personal injury and light damage to the unit or system may be the result.

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3 Basics

3.1 CAN bus

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

Features

The CAN bus is a standardized open bus, through which devices, sensors and actuators from different manufacturers communicate with each other. Features of the CAN bus are:

- Multimaster capacity
  Every device on the field bus can send and receive data independently without having to be assigned a "supervisory" master functionality.
- Message-oriented communication
  Devices can be linked into an existing network without requiring reconfiguration of the entire system. It is not necessary to set the address of a new device in the network.
- Prioritisation of messages
  Messages with higher priority are sent first for time-critical applications.
- Residual error probability
  Various backup processes in the network reduce the probability of an undetected, faulty data transfer to less than 10^{-11}. In practice, 100%-secure transmission can be assumed.

Transmission technology

In the CAN bus multiple devices are connected via a bus cable. Every network device can send 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 and output modules
- drive controllers
- analysis devices
- sensors and actuators

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3.2 CANopen technology

3.2.1 CANopen description language

CANopen is a device and manufacturer-independent network protocol for communication over a CAN bus. Originally CANopen was implemented in industry for controlling movement sequences, but now it is used in many different areas of network communications, such as medical technology, building automation and vehicle control.

3.2.2 Communications layers

CANopen uses the CAN bus technology for data communications. CANopen is based on the ISO-OSI layer model on the data communications basic network service. Three layers secure data communications in the CAN bus:

- CAN: physical layer
- CAN: data link layer
- CANopen: application layer

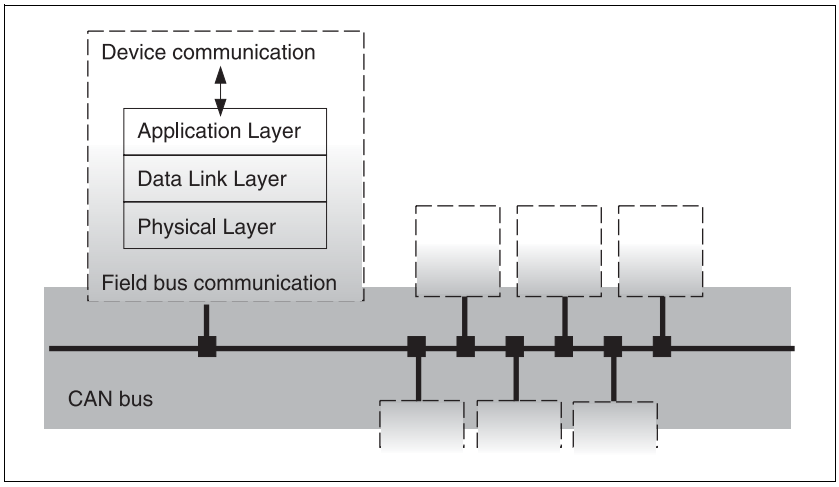

Fig. 3.1 CANopen layer model

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

Data link layer The data link layer connects the network devices. It sets the priorities of individual data packets and monitors and corrects errors.

Application layer The application layer uses communication objects (**C**ommunication **Ob**jects = COB) for data exchange among the network devices. Communication objects are elementary components for creating a CANopen application.

3.2.3 Objects

All processes under CANopen are executed via objects. Objects perform various tasks. As communication objects they transport data to the field bus, control establishment of connections or monitor the network devices. As device-specific objects they are directly connected to the device. The device functions can be used and changed via the device-specific objects.

Object directory The object directory of a device is the central connection for all objects. All objects through which the other network devices can connect to the device are listed here.

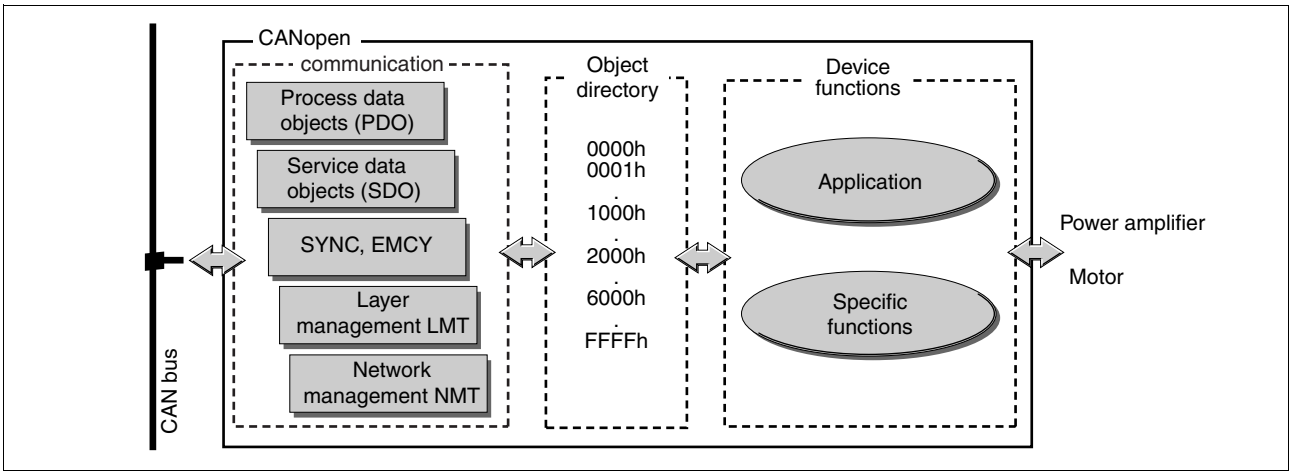

Fig. 3.2 Device model with object directory

The object directory contains objects that describe the data types and execute communications tasks and device functions under CANopen.

Object index

Every object is addressed via a 16-bit index, which is shown as a 4-digit hexadecimal number. The objects are classified in groups in the object index.

Index (hex)	Object groups	Supported by drive
0000_h	reserved	___
0001_h-$009F_h$	static and complex data types	___
$00A0_h$-$0FFF_h$	reserved	___
1000_h-$1FFF_h$	communication profile, standardised in DS 301	Yes
2000_h-$5FFF_h$	manufacturer-specific device profiles	Yes
6000_h-$9FFF_h$	standardised device profiles, e.g. in DSP 402	___
$A000_h$-$FFFF_h$	reserved	___

Table 3.1 Object index

A list of all objects that can be used for the compact drive under CANopen can be found in chapter 9, "Object directory".

Object group "data types"

The messages that move over the network as bit streams have the same meaning for sender and receiver with the data types. Data types are agreed via the objects of the data types.

Object groups of the profiles

CANopen objects carry out various tasks in field bus operation. Profiles combine the objects in accordance with their prescribed tasks.

3.2.4 CANopen profiles

Standardised profiles

Standardised profiles describe objects that can be applied to various devices without additional configuration. The Interessengemeinschaft CAN in Automation e. V. (CiA) [CAN interest group] has standardized various profiles. They include:

- the DS301 communications profile
- the DSP402 "drives and motion profile" device profile

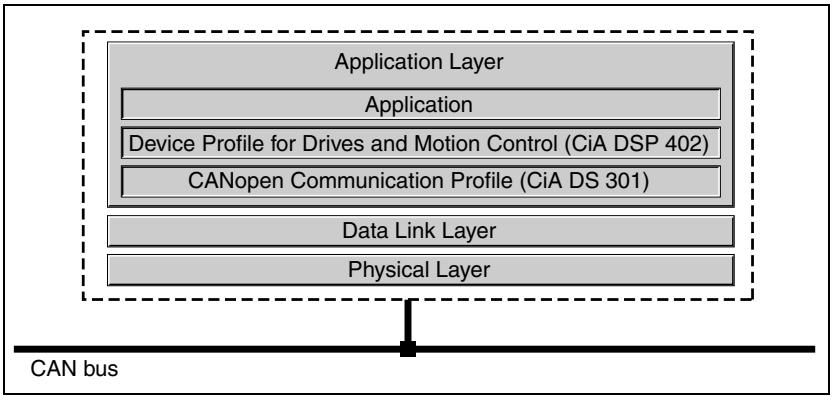

Fig. 3.3 CANopen reference model

DS-301 communications profile

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

The communications profile objects in the device carry out the tasks of data and parameter exchange with other network devices and initialise, control and monitor the device in the network. Communications profile objects are

- **P**rocess **D**ata **O**bjects (PDO)
- **S**ervice **D**ata **O**bjects (SDO)
- objects with special functions for synchronisation `SYNC` and for error reporting and response `EMCY`
- objects of network management NMT for initialisation, error monitoring and device status monitoring

Details of the communications profile objects can be found in chapter 4, "CANopen communication".

DSP402 device profile

The DSP402 device profile "drives and motion profile" describes standardised objects for positioning, monitoring and configuring drives.

The compact drive does not support DSP402.

Manufacturer-specific profiles

You can use the basic functions of a device with objects of standardised device profiles. Only manufacturer-specific device profiles offer the complete range of functions. They contain the definitions for the special functions.

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3.3 Field bus devices in the CAN bus

Different field bus devices from Berger Lahr can be operated in the same field bus segment. The CANopen bus offers a unified basis for exchanging commands and data between compact drives and other network devices.

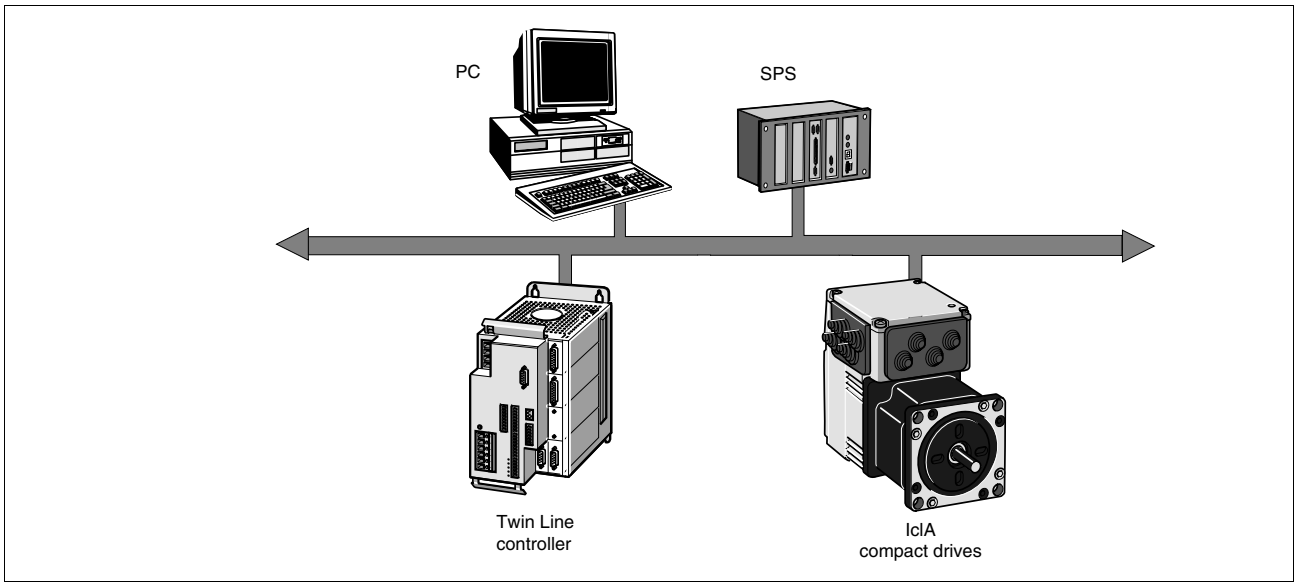

Fig. 3.4 Field bus devices in the network

3.4 Operating modes and functions in field bus operation

This manual only described the protocol for the compact drive. You can find the description of the operating modes, operating functions and all parameters in the controller manual for the compact drive in the "Operation" and "Parameters" chapters:

Operating modes

- speed mode
- point-to-point mode
- referencing

Operating functions

- definition of direction of rotation
- creating movement profile
- Quick Stop
- fast position capture

Setting options

The following settings can be made over the field bus:

- reading and writing parameters
- monitoring inputs and outputs of the 24-V signal interface
- activating diagnostics and error monitoring functions field bus mode

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4 CANopen communication

4.1 Communications profile

4.1.1 Communications objects

CANopen manages communications between the network devices with object directories and objects. With **P**rocess **D**ata **O**bjects (PDO) and **S**ervice **D**ata **O**bjects (SDO) a network device can request the object data from the object directory of another network device and – if permissible – write modified values.

You can exchange parameter values, start movement functions of specific CANopen bus devices or query status information by access to the objects of the network devices.

Every CANopen network device administers an object directory in which all objects for communication with it are listed.

Index, subindex

The objects are addressed in the object directory with a 16-bit long index.

The individual data fields of an object are specified by the subindex entries. A data field consists of one or more subindex entries.

Index and subindex are shown in hexadecimal form, shown by the appended "$_h$".

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

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

Table 4.1 Examples of index and subindex entries

Directory structure

The objects in the object directory are sorted by index values. Table 4.1, page 4-1 shows the index ranges of the object directory in accordance with the CANopen agreement.

Index range (hex)	Object groups	Supported by drive
0000_h	Reserved	___
0001_h-$001F_h$	Static data types	___
0020_h-$003F_h$	Complex data types	___
0040_h-$005F_h$	Manufacturer-specific data types	___
0060_h-$007F_h$	Status data types for the device profiles	___
0080_h-$009F_h$	Complex data types for the device profiles	___
$00A0_h$-$0FFF_h$	Reserved	___
1000_h-$1FFF_h$	Communications profile	Yes
2000_h-$5FFF_h$	Manufacturer-specific profiles	Yes
6000_h-$9FFF_h$	Standardised device profiles	___
$A000_h$-$FFFF_h$	Reserved	___

Table 4.2 Index ranges of the object directory

Object descriptions in the manual

The objects of the following object groups are described differently for CANopen programming with a compact drive.

- $1xxx_h$ objects: communications objects in this chapter
- $3xxx_h$ objects: manufacturer-specific objects, where required for controlling the compact drive.

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

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The manufacturer-specific objects are stored from index range 3000_h. To derive the CAN index from the indices given in the device documentation, it is only necessary to add 3000_h.

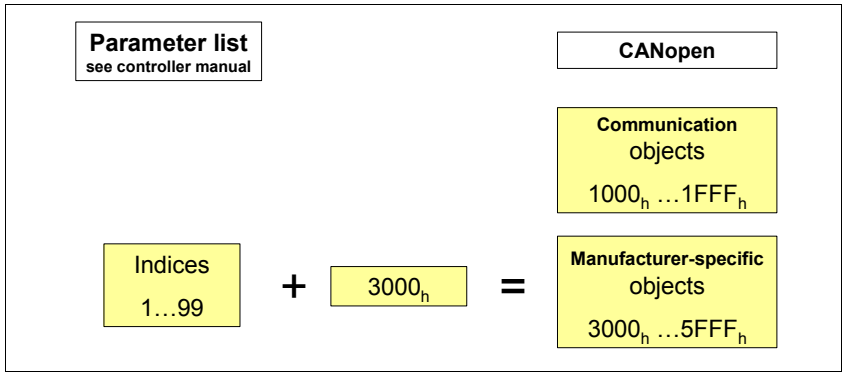

Fig. 4.1 Object groups

Example:

The control word for status change has the index 28 and the subindex 1 ⇒ in the CAN protocol access to index $301C_h$ ($3000_h + 1C_h$ [= 28_d]) and subindex 1.

Overview

The communications objects are standardised with the DS-301 CANopen communications profile. The objects can be classified into four groups according to their tasks.

- PDO (**P**rocess **D**ata **O**bjects)
  - real-time transmission of process data
- SDO (**S**ervice **D**ata **O**bjects)
  - write and read access to the object directory
- NMT (**N**etwork **M**anagemen**t**)
  - initialisation and monitoring of the network
  - error handling in the network
  - monitoring of individual network devices
- special objects for controlling CAN messages
  - object `EMCY` (**Em**ergen**cy**)
    for displaying an error of a device or its peripherals
  - object SYNC (**Sync**hronisation)
    for synchronisation of network devices

CAN message

Data are exchanged on the CAN bus as CAN messages. A CAN message transmits the communications object and a variety of management and control information.

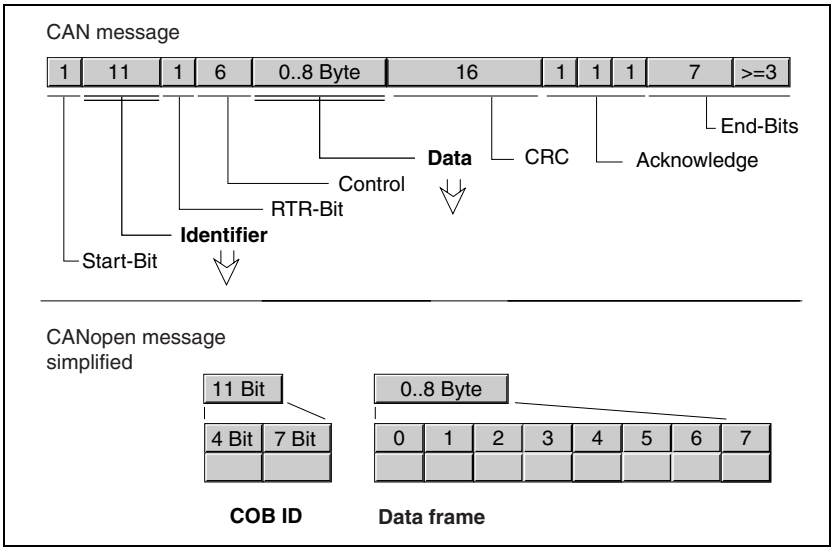

Fig. 4.2 CAN message and simplified display of CANopen message

CANopen message

The CAN message can be displayed in simplified form for work with CANopen objects and for data exchange, because most of the bits are used to ensure error-free data transmission. These bits are automatically removed from the received messages by the data link layer of the layer reference model and inserted before a message is sent.

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 maximum 8-byte data frame size of a CANopen message.

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COB-ID The COB-ID (communication object identifier) carries out two tasks for controller communications objects:

- bus arbitration: specification of transmission priorities
- identification of communications objects

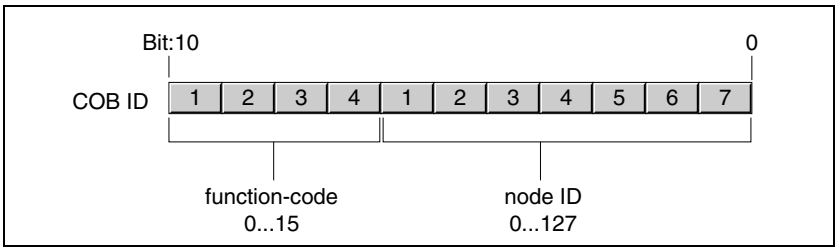

Fig. 4.3 COB-ID with function code and node address (node ID)

An 11-bit COB identifier under the CAN 2.0A specification, comprising two sections, is specified for the compact drive.

- function code, 4 bits in size
- node address (node ID), 7 bits in size

Function code The function code classifies the communications objects. Because the bits of the function code are significantly higher in the COB-ID, the function code simultaneously controls the transmission priorities. Objects with a small function code are transmitted with high priority. For example, in the case of a simultaneous bus access an object with the function code "1" is sent before an object with the function code "3".

Node address Every network device is configured before network operation. This gives it a unique 7-bit long node address between 1 and 127 ($7F_h$). The device address "0" is reserved for broadcast transmissions, in which messages are sent simultaneously to all devices.

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COB-IDs of the communications objects

The following table shows the COB-IDs of all communications objects in the factory setting. The column "Index of object parameters" shows the index of special objects, with which the communications object settings can be read or modified by SDO.

Communications object	Function code	Node address (node-id) [1...127]	COB-ID decimal (hexadecimal)	Index of object parameters
NMT Start/Stop Service	0 0 0 0	0 0 0 0 0 0 0	0	–
Object SYNC	0 0 0 1	0 0 0 0 0 0 0	128 (80_h)	1005_h....1007_h
Object EMCY	0 0 0 1	x x x x x x x	128 (80_h) + node-ID	1014_h, 1015_h
T_PDO1[1)]	0 0 1 1	x x x x x x x	384 (180_h) + node-ID	1800_h
R_PDO1[1)]	0 1 0 0	x x x x x x x	512 (200_h) + node-ID	1400_h
T_PDO2[1)]	0 1 0 1	x x x x x x x	640 (280_h) + node-ID	1801_h
R_PDO2[1)]	0 1 1 0	x x x x x x x	768 (300_h) + node-ID	1401_h
T_PDO3[1)]	0 1 1 1	x x x x x x x	896 (380_h) + node-ID	1802_h
R_PDO3[1)]	1 0 0 0	x x x x x x x	1024 (400_h) + node-ID	1402_h
T_PDO4	1 0 0 1	x x x x x x x	1152 (480_h) + node-ID	1803_h
R_PDO4	1 0 1 0	x x x x x x x	1280 (500_h) + node-ID	1403_h
T_SDO	1 0 1 1	x x x x x x x	1408 (580_h) + node-ID	–
R_SDO	1 1 0 0	x x x x x x x	1536 (600_h) + node-ID	–
NMT Error Control	1 1 1 0	x x x x x x x	1792 (700_h) + node-ID	$100E_h$
LMT Services [1)]	1 1 1 1	1 1 0 0 1 0 x	2020 ($7E4_h$), 2021 ($7E5_h$)	
NMT Identify Service [1)]	1 1 1 1	1 1 0 0 1 1 0	2022 ($7E6_h$)	
DBT Services [1)]	1 1 1 1	1 1 0 0 x x x	2023 ($7E7_h$), 2024 ($7F8_h$)	
NMT Services [1)]	1 1 1 1	1 1 0 1 0 0 x	2025 ($7E9_h$), 2026 ($7EA_h$)	

[1)] Not supported by the compact drive

Table 4.3 COB-IDs of the communications objects

Example of the selection of a COB-ID

For a compact drive with the node address 5 the COB-ID of the communications objects T_PDO4 is:
1152 + node-ID = 1152 (480_h) + 5 = 1157 (485_h).

Data frame

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

- error data frame
- remote data frame for requesting a message

The data frames are described with the relevant communications objects.

4.1.2 Communications relationships

CANopen uses three communications relationships for communications among network devices.

- master-slave
- client-server
- producer-consumer

Master-slave relationship

A master device in the network controls the message traffic. A slave device answers only when requested by the master.

The master-slave relationship is implemented with network management objects to ensure a controlled network startup and to monitor the connection of network devices.

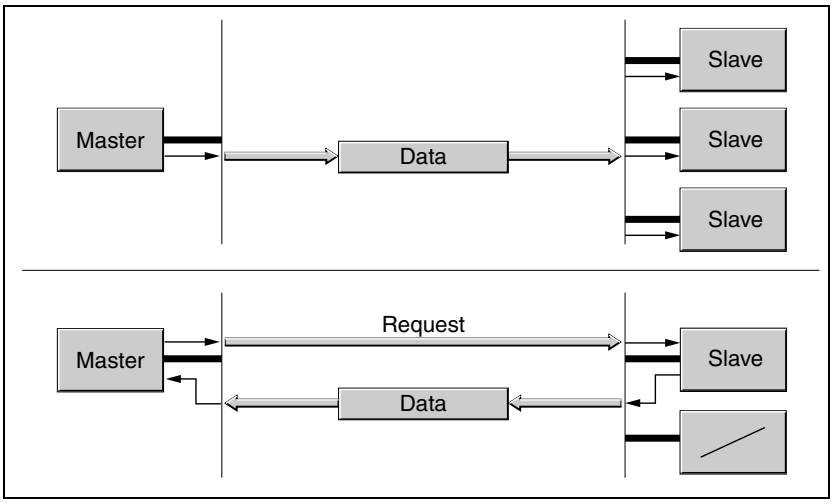

Fig. 4.4 Master-slave relationship

Messages can be exchanged unconfirmed or confirmed. When the master device sends a CANopen message that does not require response, it can be received by one, by many or by no slave devices.

To have a message confirmed, the master device requests a CANopen message from the slave, which then answers with the desired data.

Client-server relationship

A client-server relationship is always established between two network devices. The server is the network device whose objects are used during the exchange of data. The client addresses and starts the exchange of messages and waits for a confirmation from the server.

A client-server relationship is implemented with SDOs to transmit configuration data and long CANopen messages.

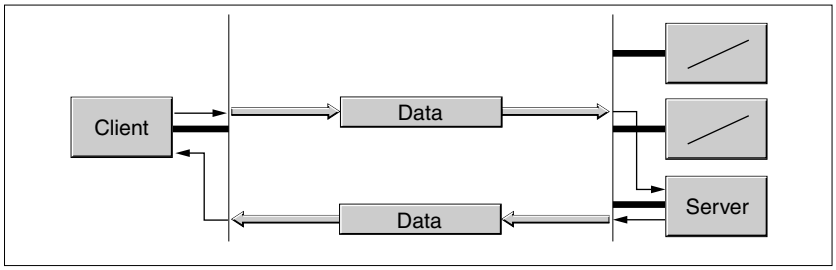

Fig. 4.5 Client-server relationship

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

Producer-consumer relationship

The producer-consumer relationship is implemented for exchanging process data messages, because this relationship allows fast data exchange without administration data.

A producer sends data, a consumer receives data.

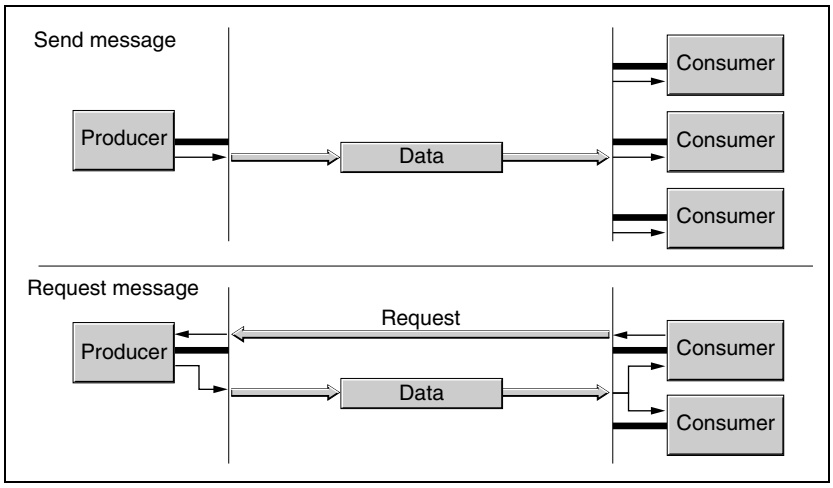

Fig. 4.6 Producer-consumer relationships

The producer sends a message that can be received by one or more consumers. The producer does not receive a receipt confirmation.

A message transmission is triggered by the following events:

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

For more information on the function of the producer-consumer relationship and on requesting messages see section 4.3, "Process data communication (PDO communication)", page 4-15.

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4.2 Service data communication (SDO communication)

4.2.1 Overview

SDO communication is based on the client-server relationship.

With SDO (SDO: **S**ervice **D**ata **O**bject) the entries of an object directory are accessed via index and subindex. The object values can be read and – if permissible – also modified.

Every network device has at least one server SDO to allow it to respond to read or write requests from another network device. A client SDO is only required to request SDO messages from the object directory of another network device or to modify data there.

With the T_SDO (T: to **t**ransmit) of a client or server SDO data are sent, with the R_SDO (R: to **r**eceive) they are received. The data length of an SDO is always 8 bytes.

SDOs have a higher COB-ID than PDOs and therefore are transmitted at lower priority on the CANopen bus.

4.2.2 SDO data exchange

An SDO transmits parameter data between two network devices. The data exchange conforms to the client-server relationship. The server is the network device to whose object directory an SDO message relates.

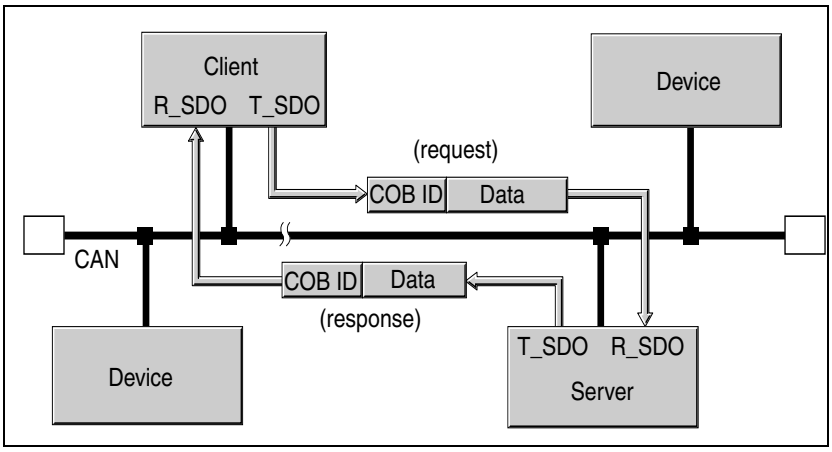

Fig. 4.7 SDO message exchange with request and response

Message types

The client-server communication is triggered by the client to send parameter values to the server or to obtain them from the server. In both cases the client starts the communication with a request and receives a response from the server.

4.2.3 SDO message

An SDO message simply consists of the COB-ID and the SDO data frame. Up to 4 bytes of data can be transmitted with the SDO data frame. Longer data strings are distributed over multiple SDO messages with a special protocol.

Larger quantities of data, such as 8-byte values of the Visible string 8 data type, must be distributed over several SDOs and transmitted in sequence in 4-byte blocks.

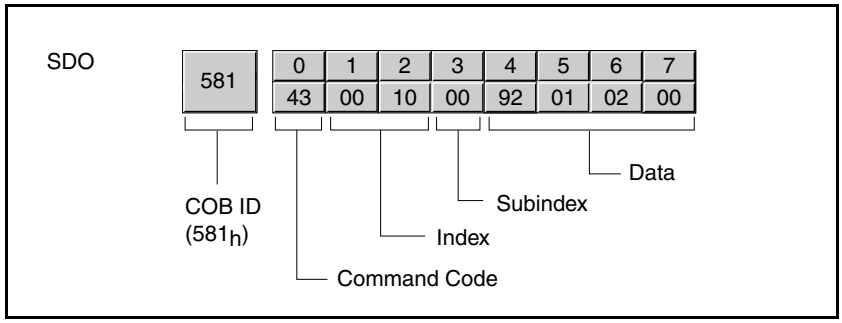

Fig. 4.8 Example of an SDO message

COB-ID and data frame

R_SDO and T_SDO have different COB-IDs, (see table 4.1, page 4-1). The data frame of an SDO messages has three components:

- Command code (CCD)
  The SDO message type and the data length of the transmitted object value are encrypted in the command code.
- Index and subindex
  Point to the SDO whose data are being transported with the SDO message. In the case of an error the faulty SDO is specified with index and subindex.
- Data
  Can have a length of up to 4 bytes.

Evaluation of numeric values

Index and data are transmitted left-aligned in Intel format. If an SDO contains numerical values over 1 byte in length, the data must be repositioned byte-by-byte before a transmission (fig. 4.9).

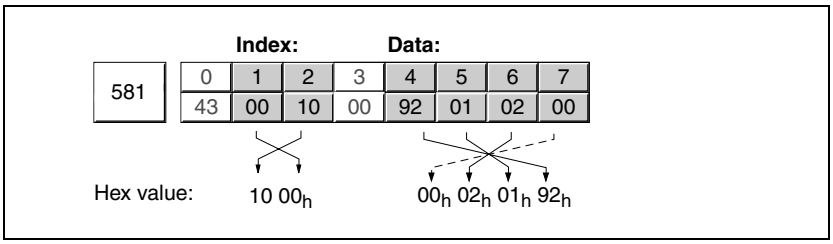

Fig. 4.9 Repositioning numeric values greater than 1 byte

4.2.4 Writing and reading SDO data

Writing object values

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

If the data have been correctly processed, the server sends a write response. The response contains the same index and subindex as the write request but not data.

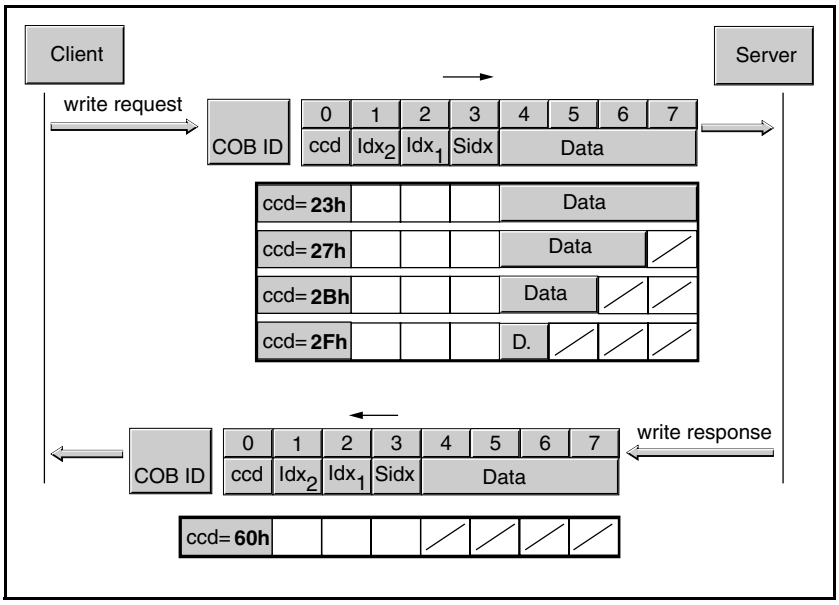

Fig. 4.10 Writing parameter values

(1) Struck-through bytes are not used; their contents are not defined.

Command code for writing object values

The following table shows the command code for writing object values. The command code depends on the message type and the transmitted data length.

Message type	Data length used				Meaning
	4 bytes	3 bytes	2 bytes	1 byte	
write request	23h	27h	2Bh	2Fh	write request
write response	60h	60h	60h	60h	write response
error response	80h	80h	80h	80h	error

Table 4.4 Command code for writing object values

Error response

If a message could not be evaluated without error, the server sends an error response.

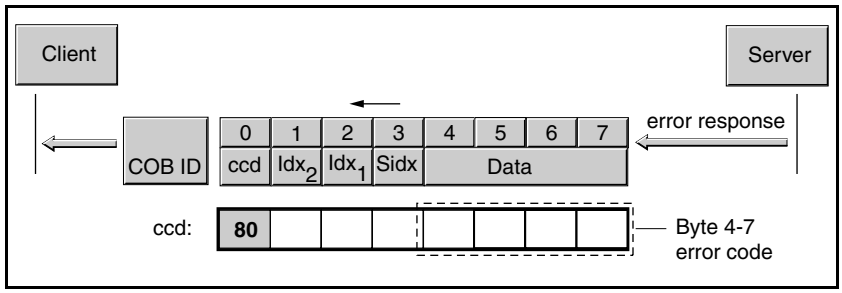

Fig. 4.11 Error response, cause of error coded in bytes 4..7 (error code)

For details on evaluating the error response see chapter 7, "Diagnosis and troubleshooting", section "SDO error message ABORT", page 7-1.

Reading object values

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

The server responds to the request with the desired data. The SDO response contains the same index and subindex. The length of the response data is specified in the command code.

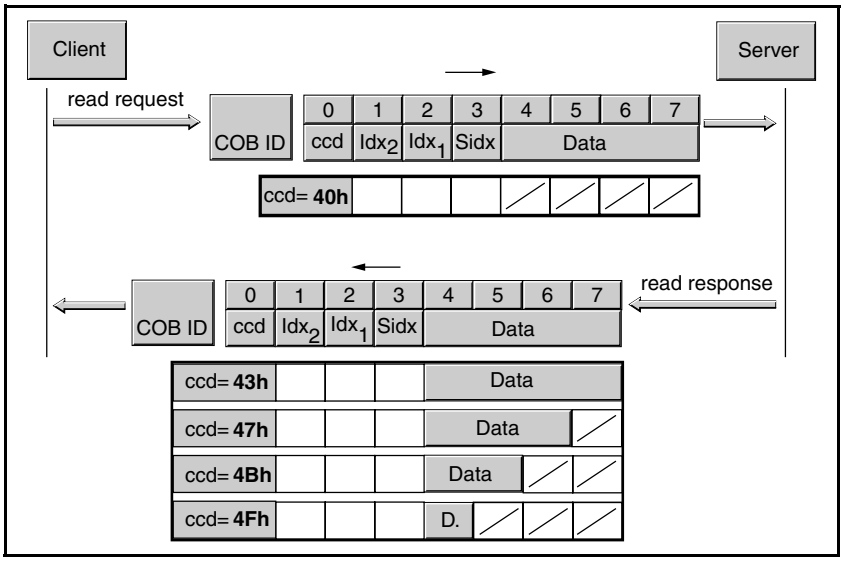

Fig. 4.12 Reading parameter value

(1) Struck-through bytes are not used; their contents are not defined.

Command code for reading object values

The following table shows the command code for reading an object value. It depends on the message type and the transmitted data length.

Message type	Data length used				Meaning
	4 bytes	3 bytes	2 bytes	1 byte	
read request	40_h	40_h	40_h	40_h	read request
read response	43_h	47_h	$4B_h$	$4F_h$	read response
error response	80_h	80_h	80_h	80_h	error response

Table 4.5 Command code for reading object values

Error response

If a message could not be evaluated without error, the server sends an error response.

For details on evaluating the error response see chapter 7, "Diagnosis and troubleshooting", section "SDO error message ABORT", page 7-1.

4.3 Process data communication (PDO communication)

This chapter describes the information flow from the point of view of the compact drive in compliance with the CiA standard DS301. The "receive" label therefore means a data flow from the master to the compact drive, while "transmit" means a data flow from the compact drive to the master.

Process **D**ata **O**bjects (PDO) are used for real-time data exchange of process data such as actual and setpoint position or the operating state of the compact drive. The transmission can be executed very fast, because it is sent without additional administration data and does not require a response from the recipient.

A PDO always is available for sending and receiving a PDO message:

- The T_PDO for sending PDO messages (T: transmit).
- The R_PDO for receiving PDO messages (R: receive).

4.3.1 PDO data exchange

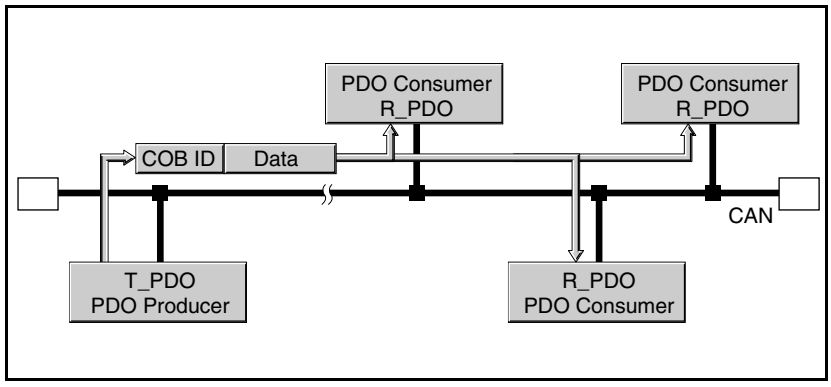

Fig. 4.13 PDO data exchange

Data exchange with PDOs conforms to the producer-consumer relationship and can be triggered in three ways:

- synchronised
- event-driven, asynchronous
- request by a consumer, asynchronous

The object SYNC controls the synchronised data processing. Synchronous PDO messages are transmitted immediately like the remaining PDO messages, but only evaluated with the next SYNC object. For example, multiple compact drives can be started simultaneously by synchnronised data exchange.

PDO messages that are called on request by a consumer or are event-driven are evaluated immediately by the network device. An emergency hold information is transmitted asynchronously so the compact drive can execute an immediate emergency stop.

The transmission type can be configured separately for every PDO via the subindex 02_h (transmission type).

Triggering message transmissions (trigger modes)

CANopen offers multiple options for transmitting the process data:

Event Driven

The "event" is a modification to the PDO data. The data are sent immediately in this mode after a modification. Note as an example that during a positioning the actual position is continuously changing and that as a result a very large number of PDOs is sent. A large number of PDOs in such circumstances can be prevented by two methods:

- A) An "inhibit timer" (object 1803h subindex 3) can be configured. The PDO will then only be transmitted after expiry of the inhibit period.
- B) The check for modifications (=event) can be restricted with a bit mask. See the "Bit mask for T_PDO4" section below for a description.

Another option for "generating" an event is to activate an event timer (object 1803h subindex 5). This counter is activated by entering a value unequal to zero. The counter sequence also represents an event, i.e. the PDO is transmitted on a value change or counter event.

Synchronised

A PDO is transmitted in relation to a SYNC object in this type of transmission. There is a detailed description in chapter 4.5, "Synchronisation", page 4-30.

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Remotely requested

Transmission of an asynchronous PDO is triggered by reception of an external request. Such a remote request is displayed by a special bit in the CAN transmission frame and has the same COB-ID (communication object identifier) as the requested communications object.

There is an overview of the various transmission types in the object directory with the PDO parameters.

Bit mask for T_PDO4

A bit mask over all bits in the T_PDO4 can be defined via the CAN.pdo4msk1 (30:9) and CAN.pdo4msk2 (30:10) objects. All bit positions that contain a zero are then no longer taken into account during checking for a modification (=event). For example, this enables only modifications to the driveStat information to be taken into account.

Name Idx:Sub dec. (hex.)	Meaning Bit assignment	Data type Value range (dec.)	Unit Default (dec.)	R/W/rem. Info
CAN.pdo4msk1 30:9 (1E:09h)	32-bit mask for process data modification part 1 32-bit mask for event-driven PDO4: This value allows bytes 1..4 to be unmasked. With event-driven transmission a message is sent at every modification to the T-PDO data. Message transmission can specified more precisely or restricted with this mask. Modifications for event-driven transmission are ignored at all bit positions at which the mask contains a 0. Exact assignment: Bit 31..24: x_end x_err x_info Bit 23..16: warn Sig_SR FltSig cos Bit 15..8: modeStat Bit 7..0: ioSignals The default value 4294967295 corresponds to 0xFFFFFFFF.	UINT32	- 4294967295	R/W/-
CAN.pdo4msk2 30:10 (1E:0Ah)	32-bit mask for process data modification part 2 32-bit mask for event-driven PDO4: Mask for bytes 5..8. For description see object pdo4msk1.	UINT32	- 0	R/W/-

Table 4.6 Parameters for the CAN bus

Example:

In this example setting the object CAN.pdo4msk2 to zero prevents modifications of the current position from triggering an event.

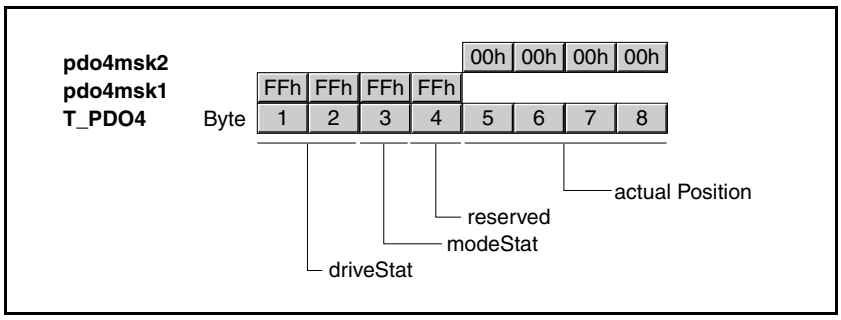

Fig. 4.14 Setting object `CAN.pdo4msk2` to zero

Requesting process data

One or more network devices with a 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.

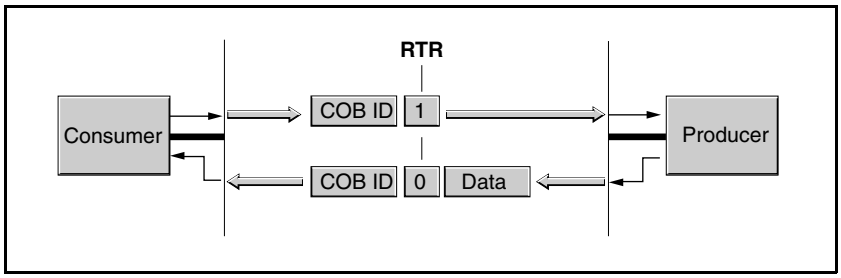

Fig. 4.15 Requesting a message with RTR = 1

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

Setting RTR request

Every PDO can be separately configured for whether it should respond to RTR requests. The identifier is enabled or disabled via subindex 01, bit 30_h of every PDO. The objects required are listed in the table on page 3-16. Subindex 02_h (transmission type) of the objects specifies the transmission type. Only if the RTR transmission is enabled for a PDO will the PDO respond to a request via the bit RTR. The subindex values for using the bit RTR are:

Objects 1403_h, 1803_h Subindex 02_h, transmission type	**Meaning**
252	RTR enabled, synchronous
253	RTR enabled, asynchronous

Table 4.7 Subindices for using the RTR bit

See the object directory for the relevant object for an overview of all values for the subindex 02_h.

The compact drive cannot request a PDO, but it can respond to the request of a PDO.

4.3.2 Dynamic and static PDO mapping

Dynamic PDO mapping

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

Static PDO mapping

In static PDO mapping all objects are mapped in accordance with a fixed, non-modifiable setting in the relevant PDO.

Properties of the IclA IFx compact drive

The IclA IFx compact drive supports 2 PDOs, the communications objects `T_PDO4` and `R_PDO4`. PDO4 is enabled for both by default.

These PDOs are statically mapped and so cannot be configured but only read. The indices for the permanently entered objects can be read from the PDO mapping object range:

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

4.3.3 Receive PDO R_PDO4 (master → compact drive)

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

- control of the compact drive status machine
  - enable or disable power amplifier
  - trigger and reset Quick-Stop
  - resetting errors
- enable operating modes
  - point-to-point mode (absolute and relative)
  - speed mode
  - reference movement
  - dimension setting
- transfer setpoint values
  - setpoint position
  - setpoint speed
  - type of reference movement

Structure of the R_PDO4:

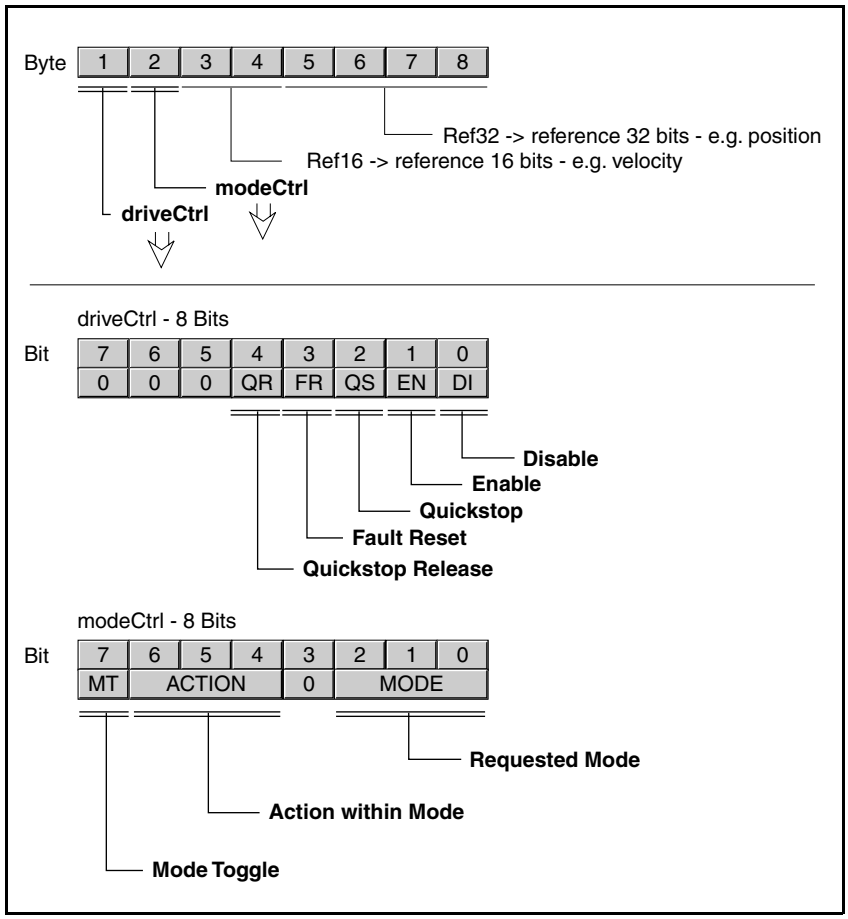

Fig. 4.16 Structure of the R_PDO4

Status machine – driveCtrl

The status machine is controlled via PDO4 or the SDO object driveCtrl, 28:1, in each case via bits 0..4.

In PDO mode these bits operate slope selectively, i.e. the relevant function is triggered with a "0 → 1" slope.

In the event of access by SDO a write access with a set bit value is sufficient; i.e. a slope change is not required.

Controlling the status machine	PDO4 Bits 0...4	SDO object driveCtrl, 28:1 Bits 0...4
Bit 0: disable amplifier	Process is run at 0 → 1 slope	Processing is run at write access if bit value =1
Bit 1: enable amplifier		
Bit 2: Quick-Stop		
Bit 3: Fault Reset		
Bit 4: Quick-Stop release		

Table 4.8 Controlling the status machine

The value "0" is a special case: if all bits 0..7 are zero during transmission, the compact drive interprets this as a disable command and the power amplifier is disabled. This is applicable both for PDO and SDO accesses.

Fault processing

If requests for controlling the status machine by the compact drive cannot be implemented, the compact drive ignores these requests. There is no error response.

Operating modes – modeCtrl

In PDO mode the operating modes are controlled via the modeCtrl object.

The master must enter the following value to trigger an operating mode or modify setpoint values:

- setpoint values in the fields "Ref16" and "Ref32"
- select mode with modeCtrl, bits 0..2 (MODE)
- select action for this mode with modeCtrl, bits 4..6 (ACTION)
- toggle modeCtrl, bit 7 (MT)

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Table 4.1, page 4-1 shows the possible modes and the associated setpoint values

Mode bits 0..2	Action bits 4..6	modeCtrl* bits 0..6	Description	Corres-ponds to object**	Setpoint value Ref16	Setpoint value Ref32
2 (Homing)	0	02h	Dimension setting	40:3	-	Dimension setting position
	1	12h	Reference movement	40:1	Type (as obj. 40:1)	-
3 (PTP)	0	03h	Absolute positioning	35:1	Setpoint speed	Setpoint position
	1	13h	Relative positioning	35:3	Setpoint speed	Setpoint position
	2	23h	Continuation of positioning	35:4	Setpoint speed	-
4 (VEL)	0	04h	Speed mode	36:1	Setpoint speed	-

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

** Column shows Index:Subindex (decimal) of the corresponding operating modes, which are described in more detail in the device documentation.

Table 4.9 Configure operating modes via `modeCtrl`

Setpoint positions are entered in increments, setpoint speeds in rpm.

In the event of simultaneous transmission of operating mode, setpoint position and setpoint speed in a PDO data consistency must be retained. As a result the compact drive only evaluates the operating mode data if `bit 7` has been toggled. Toggling means that since the last transmission a "0 → 1" or a "1 → 0" slope change was detected.

`Bit 7` is mirrored in the response PDO4 by the compact drive, so a synchronized operation is possible via the PDO4.

For more information see section 4.3.4, "Send PDO T_PDO4 (compact drive → master)", page 4-24.

Fault processing

Requests for the operating mode are triggered by toggling `bit 7`. If the requests cannot be implemented, the compact drive executes an error response as described in the section Transmit PDO4 error processing.

For more information see section 4.3.4, "Send PDO T_PDO4 (compact drive → master)", page 4-24.

4.3.4 Send PDO `T_PDO4` (compact drive → master)

In the default settings of the compact drive the send PDO is sent asynchronously event-driven; the "inhibit time" setting for the time is possible.

The compact drive supplies the following information to the master over the PDO4 channel:

- status of status machine
- errors and warnings
- active operating mode
- status of active operating mode
  - mode ended
  - fault has occurred
  - setpoint speed or setpoint position reached
  - actual position
- compact drive referenced
- acknowledgment of operating mode requests
- status of the 24V inputs or outputs

Structure of the T_PDO4:

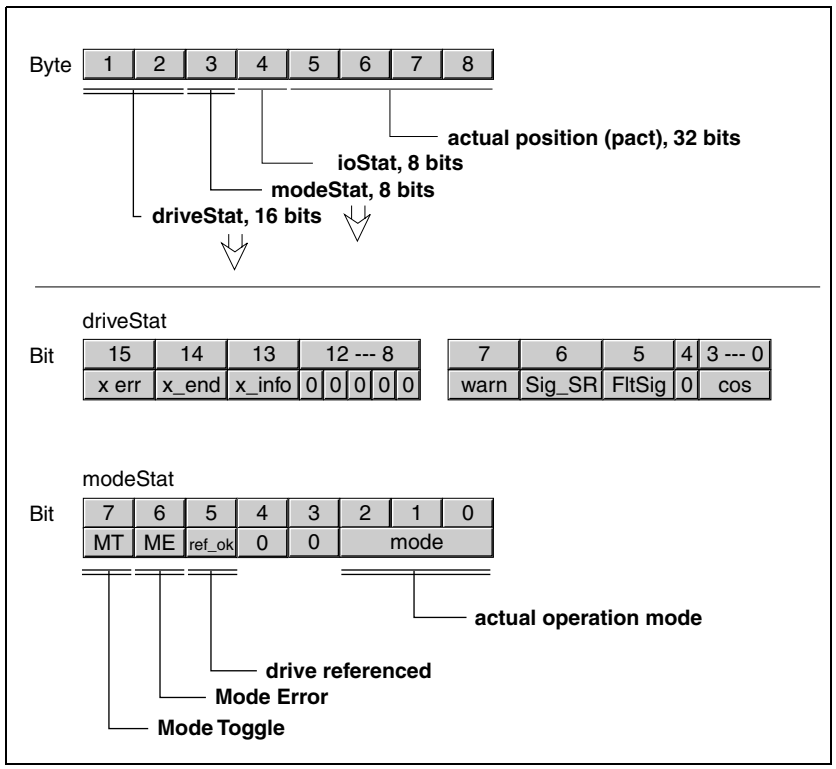

Fig. 4.17 Structure of the T_PDO4

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

Contents of information:

- status of status machine
- warning and error bits
- status of the current axis mode.

Mode `modeStat` This field corresponds to `bits 0..2` of the object `Status.xMode_act`. `Bits 6 and 7` are additional information that can be used to run a synchronised mode control via the PDO.

The field contains the following information:

Bit	Name	Description
0...2	mode	Current configured mode as with R_PDO4
5	ref_ok	Set when the compact drive has been successfully referenced by reference movement or setting dimensions.
6	ME, ModeError	Set if a request by the master device over R_PDO4 was rejected by the compact drive.
7	MT, ModeToggle	Mirrors bit 7 (Mode Toggle) by R_PDO4

Table 4.10 Mode `modeStat`

Synchronised processing can be run with `R_PDO4, bit 7` (ModeToggle – MTreq) and `T_PDO4, bit 6 and 7`. Synchronised processing means that the master device waits for responses from the compact drive and responds to them.

Example

Positioning with concluding check that it was conducted correctly.

		Master		Compact drive
Setpoint values for positioning in the fields "Ref16" and "Ref32" - set the desired mode in the mode field - toggle bit 7	R_PDO4	⇒	MTreq ≠ MTstat	⇒
If MT is toggled, then - import values - start desired mode - update status: x_end = 0 - MT mirrored by R_PDO to T_PDO	T_PDO4	⇐	MTstat = MTreq x_end = 0	⇐
If MTstat = MTreq then status is current: - check ME: 1 ⇒ request failed - to x_end = 1 wait: 1 ⇒ end of positioning				
Positioning finished: x_end = 1	T_PDO4	⇐	MTstat = MTreq x_end = 1	⇐

Table 4.11 Example: Positioning with concluding check

Special case much shorter positioning

In the case of a very short positioning, the compact drive may have already reached the setpoint position when the status is returned to the master device via the `T_PDO4`. In this case `R_PDO4, bit 7` is equal to `T_PDO4, bit 7` and `bit x_end = 1` is already set. Therefore, the case `x_end = 0` does not apply to the master device. If no error has occurred, the positioning has still been correctly carried out.

Fault processing

If the master device toggles `bit 7`, this is considered a request to the compact drive to start a mode or to modify data of the current mode. If the compact drive cannot process the request, it signals this to the master by the following actions:

- sends a `EMCY` with the corresponding error code
- sets `T_PDO4, bit 6` (ModeError)
  This bit remains set until `T_PDO4, bit 7` (ModeToggle) is toggled again.
  The master device can read the corresponding error code by an SDO read access to object `CAN.modeError, 30:11`.
- continuation of the current operating mode

The current mode is thus not influenced and there is no status change.

The reasons for a failed mode request can include the following:

- setpoint values outside the value range
- mode cannot be switched during processing
- invalid mode requested
- status machine not in status 6 (Operation Enable)

4.4 Emergency service

The emergency service reports internal device error over the CAN bus. The error message is sent to all network devices in accordance with the consumer-producer relationship with an EMCY object.

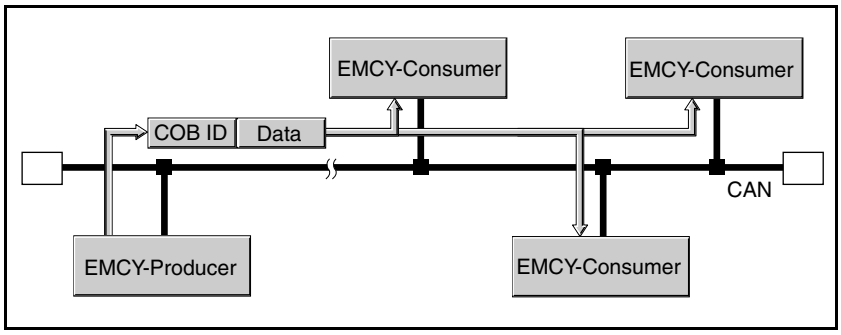

Fig. 4.18 Error message with the EMCY object

EMCY message

Causes of an EMCY message are:

- asynchronous error, error code = 1000_h
  If an internal unit error occurs, the compact drive switches to error mode in accordance with the unit status machine. The compact drive sends an EMCY message with error register and error code at the same time.
- PDO4 error with operating mode controller, error code = 8200_h
  If the request for an operating mode by PDO4 fails, the compact drive also sends an EMCY message.
- CAN communication error, error code = 8100_h

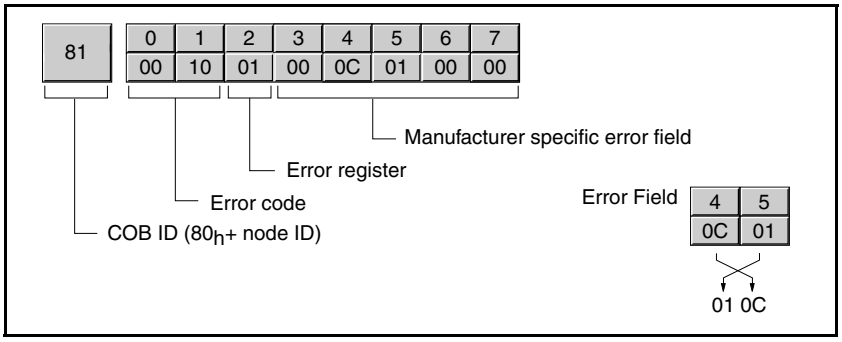

Fig. 4.19 EMCY message

(1) (1) Byte 0, 1("error code"): CANopen error code
This value in the compact drive is 1000_h, 8200_h or 8100_h depending on the cause of the error.

(2) Byte 2 ("error register"): Error register
The value is also saved in the object Error register, 1001_h.

(3) Byte 3-7 (Manufacturer Specific Error Field):
Manufacturer-specific error
Byte 3 and bytes 6,7 are always 0.
A manufacturer-specific number is stored in bytes 4,5.
A list of error numbers can found in chapter 7.2 "Error number" of the controller manual.

COB-ID The COB-ID calculates the following from the node address for every network device that supports an `EMCY` object:

COB-ID = function code of the object `EMCY`, 80_h + node-ID

4.5 Synchronisation

The synchronisation object SYNC controls synchronous message exchange between network devices, e.g. to enable multiple compact drives to be started.

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

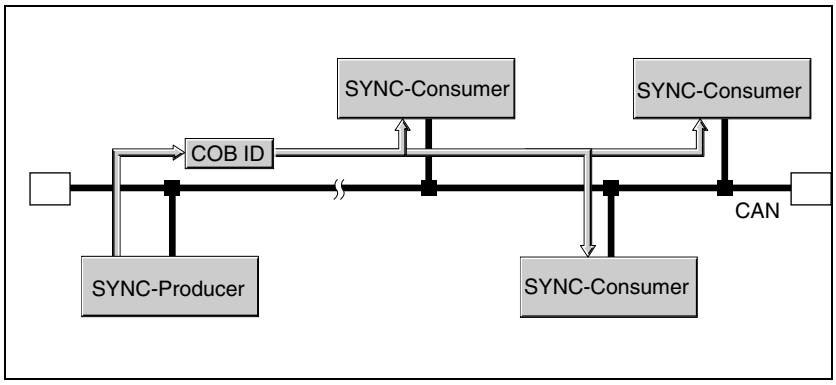

Fig. 4.20 SYNC message

4.5.1 Synchronisation periods

2 time values define the behaviour of the synchronous data transmission:

- the time cycle
- the synchronous time window

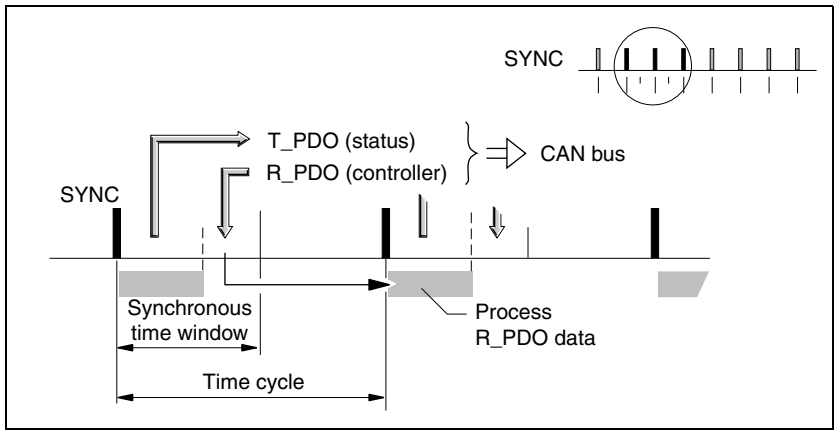

Fig. 4.21 Synchronisation periods

The time cycle shows the time gap between two 2 SYNC messages and is configured with the Communication Cycle Period, 1006_h object.

The synchronous time window apecifies the time gap in which synchronous PDO messages must be received and sent. The time window is defined by the object Synchronous Window Length, 1007_h.

4.5.2 Synchronous data transmission

From the point of view of a SYNC receiver, in one time window the status data are sent first in a T_PDO, then new control data are received via an R_PDO. However, the control data are only processed when the next SYNC message is received. The synchronisation object SYNC itself does not carry data.

Cyclic/acyclic Synchronous data transmission can be cyclic or acyclic.

You can specify whether a PDO acts in a cyclic or acyclic manner in the subindex transmission type, 02_h of the PDO parameter.

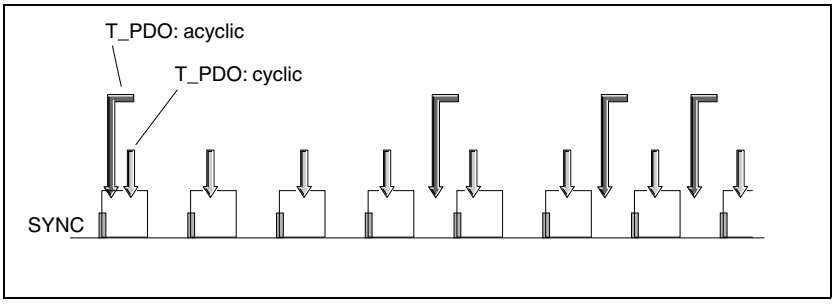

Fig. 4.22 Cyclic and acyclic transmission

In 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, the PDO message can be sent or received at any time. However, the PDO message will only be valid with the next SYNC message.

COB-ID To ensure fast transmission of the SYNC synchronisation object, it is transmitted unconfirmed and at high priority. The COB-ID of the SYNC synchronisation object is always 128 (80h) for the compact drive.

4.6 Network management objects

Network management (NMT) is a component of the CANopen communication profile.

NMT is used for the following tasks:

- connection monitoring
  - network initialisation
  - network monitoring
- monitoring network devices
  - initialisation
  - starting
  - stopping
  - status

NMT is implemented as a master-slave relationship. The NMT master device addresses individual NMT slave devices by their node address.

A message with node address "0" is addressed to all NMT slaves simultaneously.

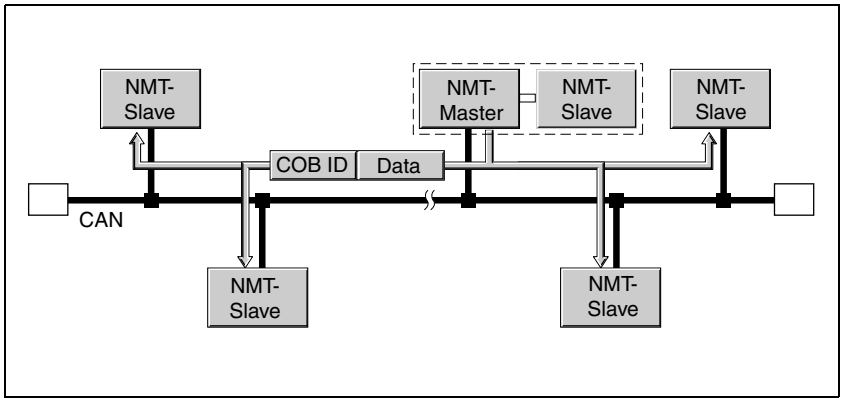

Fig. 4.23 NMT over the master-slave relationship

The compact drive can only take on the role of an NMT slave.

4.6.1 NMT services for controlling the compact drive

NMT status machine

The NMT status machine describes the behaviour of a compact drive in network operation:

- initialisation
- operating states

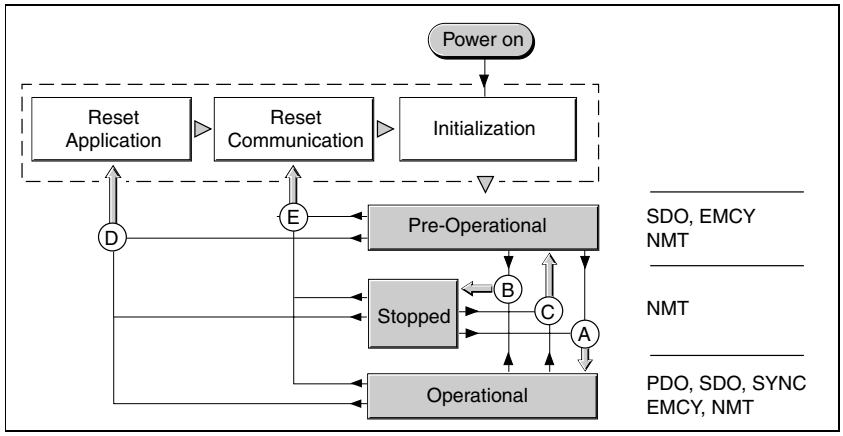

Fig. 4.24 NMT status machine

A Start Remote Node

B Stop Remote Node

C Enter Pre-Operational

D Reset Node

E Reset Communication

Initialising compact drive

After switching on the power supply, the compact drive automatically runs an initialisation phase that prepares it for CANopen operation.

During the initialisation phase the compact drive loads the non-volatile object data into RAM from the EEPROM.

At the end of the initialisation phase the compact drive switches to the Pre-operational operating status and sends the Boot Up message.

From this point an NMT master device can control the mode behaviour of a compact drive in the network with the five NMT services.

NMT services

NMT service	Transition	Meaning
Start Remote Mode	A	Switch to Operational operating status. Start standard network operation to all network devices.
Stop Remote Node	B	Switch to Stopped operating status stop compact drive communication. If connection monitoring is active, it remains switched on.
Enter Pre-Operational	C	Switch to Pre-Operational operating status. All communications objects can be set except for PDOs. The Pre-Operational operating status can be used for configuration by SDOs: - PDO mapping - start synchronisation - start connection monitoring
Reset Node	D	Switch to Reset Application operating status. Load stored device profile data and switch automatically to Pre-Operational via Reset Communication operating status
Reset Communication	E	Switch to Reset Communication operating status. Load stored communication profile data and switch automatically to Pre-Operational operating status.

Table 4.12 NMT services for controlling the compact drive

Transmission priority

The NMT services for controlling the compact drive are transmitted as messages not requiring confirmation with the COB-ID = 0. By default they receive top priority on the CAN bus.

Data frame

The data frame of an NMT messages consists of two bytes.

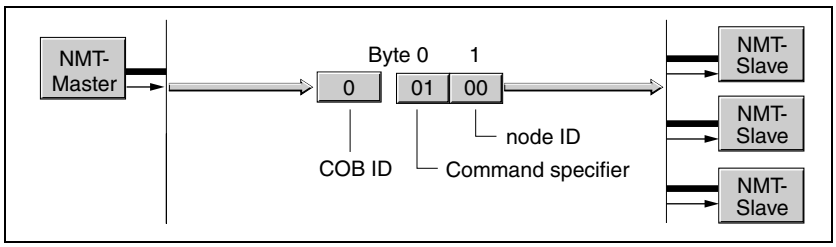

Fig. 4.25 Data frame of an NMT message

`Byte 0` (Command Specifier) specifies the NMT service in use.

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

Table 4.13 `Byte 0` (Command Specifier) of the NMT data frame

`Byte 1` addresses the recipient of the NMT message with a node address between "1" (1_h) and "127" ($7F_h$). A message with node address "0" (0_h) is directed to all NMT slaves (broadcast).

4.6.2 NMT services for connection monitoring

Connection monitoring monitors the communication status of network devices, enabling a response to the failure of a network device or a break in the network.

Connection monitoring must be disabled during the initialisation phase of a compact drive.

Monitoring node

One NMT service is available for the compact drive for monitoring the compact drive connection.

NMT service	Meaning
Monitoring node (Node guarding)	Monitoring a compact drive connection

Table 4.14 NMT services for connection monitoring

During connection monitoring with the Node guarding NMT service, the NMT master device requests an NMT status message from the compact drive at regular intervals. The status message must be sent by the compact drive within the time interval. The time interval is configured with the `Guard Time, 100C`$_h$ object.

If the NMT status message is not received by the NMT master device within the time interval, the NMT master device reports the connection error error.

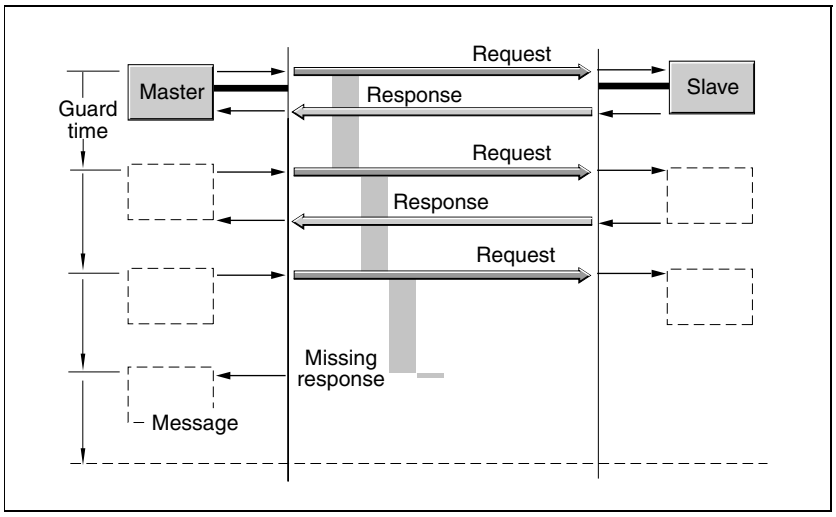

Fig. 4.26 Node guarding with time intervals and error message

The NMT master device also sends the connection error message if the compact drive operating status has changed without being initiated by the NMT master device.

COB-ID Connection monitoring is executed via the `NMT error control, 700h + node-Id` object.

Data frame The compact drive responds with a data byte on request by the NMT master device.

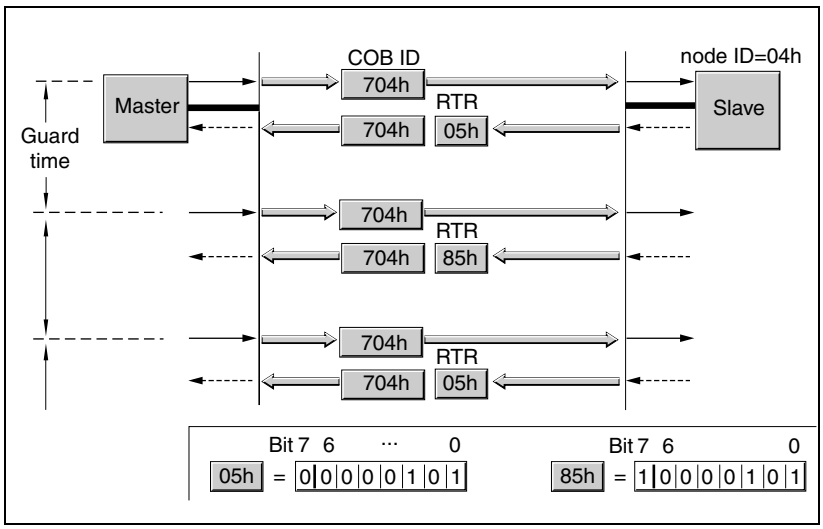

Fig. 4.27 Data frame of a compact drive NMT response

Bits 0 … 6

The `bits 0.. 6` contain the current operating status of the compact drive:

- value = 4 (04_h)
  operating status Stopped
- value = 5 (05_h)
  operating status Operational
- value = 127 ($7F_h$)
  operating status Pre-Operational

Bit 7

`Bit 7` switches between "0" and "1" on every response. The NMT master device detects when a response has been seen multiple times by `bit 7`. The NMT master device only considers the first response.

The first request when starting connection monitoring begins with bit 7 = 0.

The status of bit 7 is reset as soon as the compact drive runs through the NMT operating status reset communication.

Connection monitoring continues in NMT operating status stopped.

Boot Up message

Communication profile DS301, 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 with a boot-up message.

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

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5 Installation and setup

5.1 Installation

For information about installation, refer to the controller manual, "Installation" chapter.

Compact drives with DIP switches

Before installing the compact drive in the system, you must set the network address and the baud rate via the DIP switches in the plug housing.

For information about DIP switch settings, refer to the the controller manual, "Installation" chapter.

5.2 Commissioning field bus connection

5.2.1 Starting field bus operation

Configuration with SyCon

Instructions for using the Hilsch SyCon configuration software:

In the Node `Configuration` **do not change** the `Unit Profile` setting (value= 0)!

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

Proceed as follows to restore communication with the IclA IFX drive:

- ◯ Click `Node BootUp` button in the `Node Configuration` dialog.
- ◯ Click `Check Node Type and Profile` in the `Node BootUp` dialog to bypass this step.

Testing field bus operation

After correct configuration of the transmission data test the field bus operation.

This requires installation of a CAN configuration tool that displays CAN messages. The acknowledgment from the drive is captured by a boot-up message:

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

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

5.2.2 Troubleshooting

If the compact drive does not respond, check the following settings:

① Has the compact drive been started and the master device switched on?

② Are the cable connections mechanically and electrically sound?

③ Is the address on the compact drive correctly set? Check the DIP switch and HEX switch settings. The settings are described in the manual for the unit. Compact drives with DIP switches are set by default to the CAN address "127" ($7F_h$) and the baud rate "125 kBit/s".

④ Are the same baud rate and the same interface parameters set on the master device and compact drive?

If the compact drive still does not respond:

① Open the plug cover.

② If the compact drive is functioning correctly with the power amplifier off, the LED in the plug housing flashes constantly at 0.5 Hz (1 second on, 1 second off). If this is not the case, the compact drive has an operational error. See the controller manual for information on causes of errors and troubleshooting.

③ Compare the LED display with the information in the following table.

Error	Error class	Cause of error	Troubleshooting
LED off	–	No power supply.	Check power supply and fuses.
LED flashes at 0.5 Hz. (1 s on, 1 s off)	–	Firmware works without errors, power amplifier inactive.	Check cable connections. Check DIP switch settings.
LED flashes at 6 Hz.	4	Flash checksum wrong.	Reinstall firmware. Replace compact drive.
LED flashes at 10 Hz. Watchdog	4	Hardware error	Switch compact drive off and on again. Replace compact drive.

Refer to the controller manual for further information on the causes of errors and troubleshooting.

6 Examples for field bus operation

6.1 Overview

The program examples show practical applications for network operation of IFx compact drives. There are generally two access methods over the CANopen field bus: SDO (Service Data Objects) and PDO (Process Data Objects).

Using SDO

An SDO access is always a write or read access to one single object. The available objects are described in the controller manual and is also summarized there as a table in chapter 9, "Parameters". The use of SDO is described in this chapter with the examples of only a few objects, because this type of communication can be used for all available user objects and is always structured very similarly.

Using PDO

PDOs are recommended for positioning mode, because the information here is transferred much more effectively. Various practical examples are given for the application of PDO4, which is supported by the compact drive, and the general procedure is described.

- The PDO from the "master device" to the compact drive is labeled "R_PDO".
- The PDO from the compact drive to the "master device" is labeled "T_PDO".

Structure of the examples

When describing the PDOs, note that they are described from the point of view of the compact drive.

The following is shown:

- description of task
- initial conditions
- commands required in transmitted data frame
- response of compact drive in received data frame
- possible limitations on command execution

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You should be aware of the following to be able to reproduce the examples:

- operating concept and functional scope of the compact drive
  You will find information on this in the manual.
- field bus protocol and connection to the master controller
- functional scope of the field bus profile

Manual

The examples are designed to complement the function descriptions in the manuals. The manual describes the basic functions of the operating modes and functions.

You will also find all parameters regarding the operating modes and functions listed there.

The number format of the parameter values in a field bus command is described in table 9.2, page 9-1 of the controller manual.

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6.2 Using SDO commands

6.2.1 Writing parameters

Task The parameter (`Motion.acc, 29:26` (acceleration)) must be set to the value "10,000".

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

- index: $29 = 1D_h + 3000_h = 301D_h$
- subindex: $26 = 1A_h$
- value: $10000 = 00002710_h$

The value 23_h must be entered as CCD (Client Command Identifier), because the parameter has a 32-bit data type.

Transmitted data

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

The data type of the value to be written can be taken from the "data type" column in the parameter description of the controller manual. With the CAN protocol in use, 16-bit values and 32-bit values are transferred in the format "lowest value bit first – highest value bit last". The CCD corresponding to the data type must be entered when transferring an INT16 or UINT16 value. The value must be stored in the first two data bytes and the last two data bytes must be described with "0".

Received data

Object	COB-ID	CCD	Idx	Sdx	Data	Description
Rx $301D_h$:$1A_h$ Motion.acc	580_h+ID	60_h	$1D_h$ 30_h	$1A_h$	XX XX XX XX	The response data are meaningless.

6.2.2 Read parameter

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

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

- index: $31 = 1F_h + 3000_h = 301F_h$
- subindex $9 = 09_h$

The value "40_h" must be entered as CCD. This identifies a read request.

Transmitted data

Object	COB-ID	CCD	Idx	Sdx	Data	Description
Tx $301F_h$:09_h Status.n_actT	600_h+ID	40_h	$1F_h$ 30_h	09_h	XX XX XX XX	Reading the actual speed. The data are meaningless.

The 4 data bytes are meaningless for a read request.

Received data

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

The compact drive transmits data continuously back to the master device as 32-bit values (CCD is "43_h"). It also returns data described in the controller manual as INT16 or UINT16 data types as 32-bit values. Therefore, when reading an INT16 or UINT16 value all 4 data bytes can be evaluated. 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.

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6.2.3 Synchronous errors

If an SDO write or read command fails, the compact drive responds with an error data frame (error response). For example, an error source can be trying to read or write a non-existent object. The transmitted error number shows information on the exact cause.

Receive data with error data frame (error response)

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

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 value "80_h" is transferred to the corresponding CCD (error response). The table of error numbers can be found in chapter 7.2.1, "Synchronous errors".

6.3 Changing operating states with PDO4

The compact drive detects different operating states. The different operating states are numbered from 1 to 9. The operating states and the transition conditions are described in more detail in the controller manual, "Operation/Basics" chapter.

Table 6.1, page 6-6 shows the most important operating states:

Operating state	Name	Power amplifier	Description
4	Ready To Switch On	off	passive operating state, motor without power
6	Operation Enable	on	active operating state, motor under power
7	Quick-Stop Active	on	error state, power amplifier remains on
9	Fault	off	error state, power amplifier switched off

Table 6.1 Important operating states

Requests for switching operating states are transmitted to the compact drive in `R_PDO4` in the `driveCtrl` field. It reports the current operating state back to the master device in T_PDO4, driveStat field.

Table 6.2, page 6-6 shows the bit assignment of the `driveCtrl` field in the `R_PDO4` object:

Bit no.	Pulse value	Meaning
0	01_h	Disable
1	02_h	Enable
2	04_h	Quick-Stop
3	08_h	FaultReset
4	10_h	Quick-Stop release

Table 6.2 R_PDO4, driveCtrl, bit assignment

6.3.1 Switch power amplifier on and off

The power amplifier is switched on by the transition from operating state 4 to 6. To do this `R_PDO4` contains the two bits `Enable` and `Disable`. One must always be set to "1" and the other to "0".

Switching on the power amplifier

Condition: Compact drive is in operating state 4.

To switch on the power amplifier, a "0 → 1" slope must be generated in `driveCtrl`, `bit 1` (Enable). This can be run by clearing `bit 0` (Disable) and setting `bit 1`. The master device waits until the compact drive reports operating state 6. This may take some time (approx. 1 second), because various tests are run when the power amplifier in the compact drive is switched on.

Example

		Master		Compact drive
Disable is requested	R_PDO4	⇨	driveCtrl 01_h	⇨
Compact drive reports operating state 4	T_PDO4	⇦	driveStat $XXX4_h$	⇦
Request Enable	R_PDO4	⇨	driveCtrl 02_h	⇨
Compact drive reports operating state 5	T_PDO4	⇦	driveStat $XXX5_h$	⇦
Compact drive reports operating state 6	T_PDO4	⇦	driveStat $XXX6_h$	⇦

Table 6.3 Switching on the power amplifier

Switching off the power amplifier

Condition: Compact drive is in operating state 6 or 7.

To switch off the power amplifier, a "0 → 1" slope must be generated in `driveCtrl, bit 0` (Disable). This can be run by setting `bit 0` (Disable) and clearing `bit 1` (Enable). The compact drive then switches to operating state 4.

Example

		Master		Compact drive
Enable is requested	R_PDO4	⇨	driveCtrl 02_h	⇨
Compact drive reports operating state 6	T_PDO4	⇦	driveStat $XXX6_h$	⇦
Request Disable	R_PDO4	⇨	driveCtrl 01_h	⇨
Compact drive reports operating state 4	T_PDO4	⇦	driveStat $XXX4_h$	⇦

Table 6.4 Switching off the power amplifier

6.3.2 Triggering Quick-Stop

A current movement job can be interrupted over the field bus at any time with the Quick-Stop command. It is triggered by a "0 → 1" slope in `driveCtrl, bit 2`. The compact drive brakes at the specified emergency stop ramp by switching to operating state 7 (Quick-Stop) and comes to a standstill.

The compact drive must be placed in operating state 6 to start a new movement job. Run one of the following steps to do this:

- Fault Reset
  "0 → 1" slope in `driveCtrl, bit 3`
- Quick Stop Release
  "0 → 1" slope in `driveCtrl, bit 4`

Example:

		Master		Compact drive
Enable is requested	R_PDO4	⇨	driveCtrl 02_h	⇨
Compact drive reports operating state 6	T_PDO4	⇦	driveStat $XXX6_h$	⇦
Requesting Quick-Stop and Enable	R_PDO4	⇨	driveCtrl 06_h	⇨
Compact drive reports operating state 7	T_PDO4	⇦	driveStat $XXX7_h$	⇦
Wait until compact drive stops and system must continue				
Requesting Quick-Stop Release and Enable	R_PDO4	⇨	driveCtrl 12_h	⇨
Compact drive reports operating state 6	T_PDO4	⇦	driveStat $XXX6_h$	⇦
Resetting Quick Stop Release	R_PDO4	⇨	driveCtrl 02_h	⇨

Table 6.5 Triggering Quick-Stop

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6.3.3 Resetting errors

If an error occurs during operation, the compact drive switches to operating state 7 (Quick-Stop) or operating state 9 (Fault) depending on the error that has occurred.

After correction of the error, you can reset the error status by running a Fault Reset ("0 → 1" slope in `driveCtrl, bit 3`).

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

If the compact drive was originally in operating state 9, it will switch to operating state 4 after the Fault Reset. Then you must send a "0 → 1" slope in `driveCtrl, bit 1` (Enable) to switch on the power amplifier again.

Example:

		Master		Compact drive
Request Enable	R_PDO4	⇨	driveCtrl 02_h	⇨
Compact drive reports operating state 9 (Fault)	T_PDO4	⇦	driveStat $XXX9_h$	⇦
Correcting error				
Requesting Fault Reset	R_PDO4	⇨	driveCtrl 08_h	⇨
Compact drive reports operating state 4	T_PDO4	⇦	driveStat $XXX4_h$	⇦
Request Enable	R_PDO4	⇨	driveCtrl 02_h	⇨
Compact drive reports operating state 5	T_PDO4	⇦	driveStat $XXX5_h$	⇦
Compact drive reports operating state 6	T_PDO4	⇦	driveStatXX $XX6_h$	⇦

Table 6.6 Resetting errors

Note: In this example the master device clears the `bit 1` (Enable) during the Fault Reset to be able to run an implicit "0 → 1" slope at `bit 1`. This returns the compact drive to operating state 6.

6.4 Examples for the operating states with PDO4

R_PDO4 You can start movement commands and change them during processing with the R_PDO4.

The R_PDO4 offers three fields for use:

- modeCtrl
  start and change operating mode
- Ref16 and Ref32
  mode-independent default values

The default values of these three fields are only imported by the compact drive if modeCtrl, bit 7 (ModeToggle) has been switched.

Always proceed as follows to transfer values to the compact drive:

① Enter the desired mode and the associated default values in the modeCtrl, Ref16 or Ref32 fields.

② Switch modeCtrl, bit 7 (ModeToggle)

This is a safe way of always avoiding consistency problems within the R_PDO4.

T_PDO4 You monitor movement jobs with the T_PDO4.

The T_PDO4 offers three fields for use:

- modeStat
  for handshake purposes
- driveStat
  reports movement status and errors
- p_act
  actual position of the compact drive

ModeToggle The bit ModeToggle is in the R_PDO4 and the T_PDO4. The master device sets this bit in the R_PDO4 and the compact drive mirrors it in the T_PDO4. The procedure enables the master device to detect whether the data sent by the compact drive are current.

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Example

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

The master device may receive data from the compact drive that originate from the period before the start of the positioning movement. They also contain `x_end = 1`. The master now detects that these data are old, because the `ModeToggle` bit does not match that of the positioning job.

In general, the master device should only evaluate data in which the receive bit `ModeToggle` is identical with that which it sent last.

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

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

- operating state 6 (Operation Enable)
- compact drive has not yet been referenced (bit `ref_ok = 0`)
- `p_act = 0` (actual position)
- `R_PDO4`: `modeCtrl, bit 7 = 0` (`ModeToggle`)

6.4.1 Point-to-point mode – absolute positioning

To start an absolute positioning movement the following setting must be made in the `R_PDO4`:

① Enter the setpoint speed in `Ref16` and the target position in Ref32.

② Enter mode 03_h (point-to-point mode, absolute positioning) in the field `modeCtrl`.

③ Switch `modeCtrl, bit 7` so the data from the compact drive are imported.

Example 1:

Absolute positioning to position "100,000" ($000186A0_h$)

at a setpoint speed of 1000 rpm ($03E8_h$)

		Master					Compact drive
Trigger positioning	R_PDO4	⇨	driveCtrl 02_h	modeCtrl 83_h	Ref16 $03E8_h$	Ref32 $000186A0_h$	⇨
Positioning running x_err = 0, x_end = 0	T_PDO4	⇦	driveStat 0006_h	modeStat 83_h		p_act $XXXXXXXX_h$	⇦
Positioning finished x_err = 0, x_end = 1, x_info = 1	T_PDO4	⇦	driveStat 6006_h	modeStat 83_h		p_act $000186A0_h$	⇦

Table 6.7 Point-to-point mode, absolute positioning at constant setpoint speed

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

Example 2

As in example 1, except that the setpoint speed is changed to 2000 rpm ($07D0_h$) during the movement.

		Master					Compact drive
Trigger positioning	R_PDO4	⇨	driveCtrl 02_h	modeCtrl 83_h	Ref16 $03E8_h$	Ref32 $000186A0_h$	⇨
Positioning running x_err = 0, x_end = 0	T_PDO4	⇦	driveStat 0006_h	modeStat 83_h		p_act $XXXXXXXX_h$	⇦
Change setpoint speed	R_PDO4	⇨	driveCtrl 02_h	modeCtrl 03_h	Ref16 $07D0_h$	Ref32 $000186A0_h$	⇨
Positioning running x_err = 0, x_end = 0	T_PDO4	⇦	driveStat 0006_h	modeStat 03_h		p_act $XXXXXXXX_h$	⇦
Positioning finished xerr=0, x_end = 1, x_info = 1	T_PDO4	⇦	driveStat 6006_h	modeStat 03_h		p_act $000186A0_h$	⇦

Table 6.8 Point-to-point mode, absolute positioning with change of setpoint speed

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

6.4.2 Point-to-point mode – relative positioning

A relative positioning is conducted similarly to the absolute positioning. You only need to enter the value "13_h" (point-to-point mode, relative positioning) in the `modeCtrl` field. It is also important to ensure that multiple target positions transferred in succession are added.

Example:

Relative positioning by 100,000 ($000186A0_h$) increments at a speed of 1000 rpm ($03E8_h$)

The speed is changed to 2000 rpm ($07D0_h$) during the movement.

		Master					Compact drive
Trigger positioning	R_PDO4	⇨	driveCtrl 02_h	modeCtrl 93_h	Ref16 $03E8_h$	Ref32 $000186A0_h$	⇨
Positioning running x_err = 0, x_end = 0	T_PDO4	⇦	driveStat 0006_h	modeStat 83_h		p_act $XXXXXXXX_h$	⇦
Change setpoint speed transfer relative position "0"	R_PDO4	⇨	driveCtrl 02_h	modeCtrl 13_h	Ref16 $07D0_h$	Ref32 00000000_h	⇨
Positioning running x_err = 0, x_end = 0	T_PDO4	⇦	driveStat 0006_h	modeStat 03_h		p_act $XXXXXXXX_h$	⇦
Positioning finished x_err = 0, x_end = 1, x_info = 1	T_PDO4	⇦	driveStat 6006_h	modeStat 03_h		p_act $000186A0_h$	⇦

Table 6.9 Point-to-point mode, relative positioning with change of setpoint speed

Comments: The "positioning running" data frame can be sent multiple times; the actual position is in the `p_act` field. When the setpoint 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 Speed mode

In speed mode a setpoint speed is specified for the motor, and a movement is initiated with no defined finishing point.

You must make the following settings in the `R_PDO4` to start Speed mode or to change the setpoint speed while speed mode is running:

① Enter the setpoint speed in `Ref16` (`Ref32` is meaningless here).

② Enter operating mode 04_h (Speed Mode) in `modeCtrl`.

③ Switch `modeCtrl, bit 7` so the data are imported from the compact drive.

Example

Speed mode is started at a setpoint speed of 1000 rpm ($03E8_h$).

The setpoint speed is changed to 2000 rpm ($07D0_h$) during the movement.

Speed mode is ended by sending the setpoint speed "0" and then wait for the compact drive to come to a standstill.

	Master						Compact drive
Start speed mode at 1000 rpm	R_PDO4	⇨	driveCtrl 02_h	modeCtrl 84_h	Ref16 $03E8_h$	Ref32 $XXXXXXXX_h$	⇨
Compact drive accelerates xerr=0, xend=0, xinfo=0	T_PDO4	⇦	driveStat 0006_h	modeStat 84_h		p_act $XXXXXXXX_h$	⇦
Setpoint speed reached xerr=0, xend=0, xinfo=1	T_PDO4	⇦	driveStat 2006_h	modeStat 84_h		p_act $XXXXXXXX_h$	⇦
Change speed to 2000 rpm	R_PDO4	⇨	driveCtrl 02_h	modeCtrl 04_h	Ref16 $07D0_h$	Ref32 $XXXXXXXX_h$	⇨
Compact drive accelerates xerr=0, xend=0, xinfo=0	T_PDO4	⇦	driveStat 0006_h	modeStat 04_h		p_act $XXXXXXXX_h$	⇦
Setpoint speed reached xerr=0, xend=0, xinfo=1	T_PDO4	⇦	driveStat 2006_h	modeStat 04_h		p_act $XXXXXXXX_h$	⇦
Change speed to 0 rpm	R_PDO4	⇨	driveCtrl 02_h	modeCtrl 84_h	Ref16 0000_h	Ref32 $XXXXXXXX_h$	⇨
Compact drive decelerates xerr=0, xend=0, xinfo=0	T_PDO4	⇦	driveStat 0006_h	modeStat 84_h		p_act $XXXXXXXX_h$	⇦
Speed mode finished xerr=0, xend=1, xinfo=1	T_PDO4	⇦	driveStat 6006_h	modeStat 84_h		p_act $XXXXXXXX_h$	⇦

Table 6.10

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

6.4.4 Dimension setting

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

You must make the following settings for dimension settings in the `R_PDO4`:

1. Enter the new position in `Ref32` (`Ref16` is meaningless here).
2. Enter operating mode 02_h (referencing, dimension setting) in `modeCtrl`.
3. Switch `modeCtrl, bit 7` so the data from the compact drive are imported.

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

The motor is assigned the position "200,000" ($00030D40_h$).

	Master						Compact drive
Compact drive reports position -100,000	T_PDO4	⇦	driveStat $XXXX_h$	modeStat XX_h		p_act $FFFE7960_h$	⇦
Dimension setting to 200,000	R_PDO4	⇨	driveCtrl 02_h	modeCtrl 82_h	Ref16 $XXXX_h$	Ref32 $00030D40_h$	⇨
Position imported x_err = 0, x_end = 1, x_info = 0	T_PDO4	⇦	driveStat 4006_h	modeStat $A2_h$		p_act $00030D40_h$	⇦

Table 6.11 Dimension setting

6.4.5 Reference movement

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

Before starting a reference movement the parameters must be set appropriately to the requests by SDO write accesses. See the controller manual for more information on setting parameters and on running a reference movement.

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

1. Enter the type of reference movement in `Ref16` (`Ref32` is meaningless here).
   The types of reference movement are described in the controller manual.
2. Enter operating mode 12_h (Referencing, Reference movement) in `modeCtrl`.
3. Switch `modeCtrl, bit 7` so the data from the compact drive are imported.

Example

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

		Master					**Compact drive**
Trigger reference movement	R_PDO4	⇨	driveCtrl 02_h	modeCtrl 92_h	Ref16 0002_h	Ref32 $XXXXXXXX_h$	⇨
Reference movement running xerr=0, xend=0	T_PDO4	⇦	driveStat 0006_h	modeStat8 2_h		p_act $XXXXXXXX_h$	⇦
Referencing movement complete xerr=0, xend=1	T_PDO4	⇦	driveStat 4006_h	modeStat $A2_h$		p_act 00000000_h	⇦

Table 6.12 Reference movement

6.5 Error signalling via PDO4

6.5.1 Synchronous errors

If a request for an operating mode sent by the compact drive via R_PDO4 cannot be processed, the compact drive rejects the processing and sets in the `T_PDO4 modeStat, bit 6` (ModeError). This does not interrupt the current process. The master device can now read out the error number from the object `CAN.modeError, 30:11` with an SDO access to determine the cause of the error.

Example

The compact drive rotates in speed mode.
An attempt is made to run a dimension setting.

	Master						Compact drive
Speed mode x_end = 0	T_PDO4	⇦	driveStat 0006_h	modeStat 04_h		p_act $XXXXXXXX_h$	⇦
Request: Dimension setting to 0	R_PDO4	⇨	driveCtrl 02_h	modeCtrl 82_h	Ref16 $XXXX_h$	Ref32 00000000_h	⇨
Request rejected ModeError = 1	T_PDO4	⇦	driveStat 0006_h	modeStat $C4_h$		p_act XXXXXXXXh	⇦

Table 6.13 Synchronous error, Invalid request of an operating mode

Note: If a request for dimension setting is rejected, the compact drive continues to rotate in speed mode without change.

However, the compact drive sends an EMCY message to the master device with the corresponding error number.

6.5.2 Asynchronous errors

Asynchronous errors are triggered by the internal monitoring (e.g. temperature) or by the external monitoring (e.g. limit switch). If an asynchronous error occurs the compact drive responds by braking or by switching off the power amplifier.

Asynchronous errors are displayed as follows:

- Switch to operating state 7 (Quick-Stop) or operating state 9 (Fault).
  The switch is displayed in `T_PDO4, driveStat, bits 0..3`.
- Set `driveStat, bit 5` (fault by internal monitoring) or `driveStat, bit 6` (fault by external monitoring)
- In the event of a fault message by the internal monitoring:
  Set the bit corresponding to the fault in the `Status.FltSig_SR, 28:18` object
  In the event of a fault message by the external monitoring:
  Set the bit corresponding to the fault in the `Status.Sign_SR, 28:15` object that the bit corresponding to the fault is set
- An error number is also assigned to every error. In the case of an asynchronous error the corresponding error number can be read from the object Status.StopFault (32:7).

Example: Fault message triggered by the external monitoring; approach the positive limit switch LIMP.

	Master					**Compact drive**
Positioning running xerr=0, xend=0	T_PDO4	⇦	driveStat 0006_h	modeStat 03_h	p_act $XXXXXXXX_h$	⇦
Limit switch detected xerr=1, xend=0	T_PDO4	⇦	driveStat 8047_h	modeStat 03_h	p_act $XXXXXXXX_h$	⇦
Motor stopped xerr=1, xend=1	T_PDO4	⇦	driveStat $C047_h$	modeStat 03_h	p_act $XXXXXXXX_h$	⇦

Table 6.14 Asynchronous error, triggering an external

Note: When a limit switch is detected, the motor brakes to a standstill with the emrgency stop ramp and the bit `x_err` is set. After the motor is at a standstill bit `x_end` is set.

7 Diagnosis and troubleshooting

7.1 Field bus communication error diagnosis

For more information on troubleshooting see see chapter 5.2.2, „Troubleshooting“, page 5-2.

7.2 Error messages

The master device receives error messages over the field bus during network operation.

The following error messages are possible:

- synchronous errors
- asynchronous errors
- errors during mode type control via PDO

7.2.1 Synchronous errors

If an SDO command cannot be processed by the compact drive, the master device receives a synchronous error message directly from the compact drive.

SDO error message `ABORT`

The SDO error message `ABORT` is output as response to an error in an SDO transmission. The cause of the error is output in the "error code" in bytes 4…7.

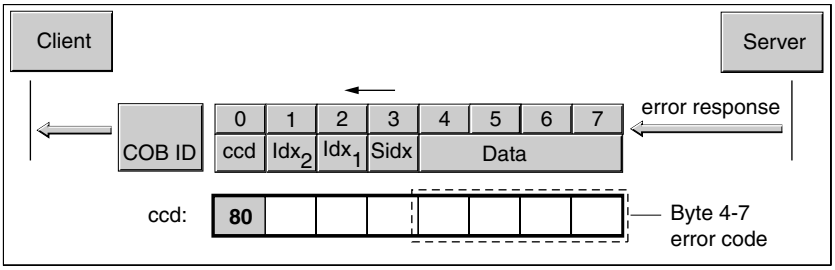

Fig. 7.1 SDO error message `ABORT`

Causes of a synchronous error

Possible causes of a synchronous error are:

- error while executing an action or control command
- parameter value outside the permissible value range
- illegal action or control command during a running process
- access to an unknown object (index/subindex)

Table 7.1, page 7-2 shows all error messages that can occur during data exchange with the compact drive.

Error code	Meaning
0504 0001_h	Command Code (ccd) not correct or unknown
0601 0002_h	No write access, because read object (ro)
0602 0000_h	Object not in object directory
0607 0010_h	Data type and parameter length do not match
0609 0011_h	Subindex not supported
0609 0030_h	Parameter value to large or too small (only relevant for write access)
0800 $xxxx_h$	Manufacturer-specific error "xxxx" corresponds to the error number of the compact drive. The error number can be found in the controller manual error number table

Table 7.1 Error codes

The byte sequence must be exchanged before evaluating according to the Intel format.

Example

Error code "0609 0011_h" is sent as "11h 00h 09h 06h".

7.2.2 Asynchronous errors

If device errors occur, the compact drive monitoring devices report an asynchronous error.

For asynchronous errors that result in a movement interruption, the compact drive sends an EMCY message.

An asynchronous error is reported via various objects:

- In T_PDO4, driveStat and in the parameter Status.driveStat, 28:2 with the following bits:
  - Bit 15, x_err
    Error status during processing:
    evaluate cause via bits 5 and 6
  - Bit 5
    Error message of an internal monitoring signal
    (e.g. overtemperature)
    The error information is enter the
    Status.FltSig_SR, 28:18 parameter bit-coded.
  - Bit 6
    Error message of an external monitoring signal
    (e.g. movement interruption by limit switch)
    The exact cause is entered in the Status.Sign_SR, 28:15 parameter bit-coded.
  - Bit 7
    Controller warning message
    (e.g. warning of overtemperature)
    The error information is entered in the Status.WarnSig, 28:10 parameter bit-coded.
- The last error cause is also saved in the parameter Status.StopFault, 32:7 as error number.
  The list of error numbers and their meaning can be found in chapter 7, "Diagnosis and troubleshooting", of the controller manuals.
- As emergency message (EMCY) with the corresponding error number. The error number is identical to that in the parameter Status.StopFault, 32:7.
  For information on the EMCY object see Kapitel 4.4, "Emergency service", Seite 4-28.

Error message

If the controller sets the `x_err` bit, it stops movement mode immediately and responds in accordance with the error class by braking or immediately switching off the power amplifier. `Bit 6` or `bit 7` is set together with `bit15, x_err`. The meaning of the error message must be determined via the corresponding parameters.

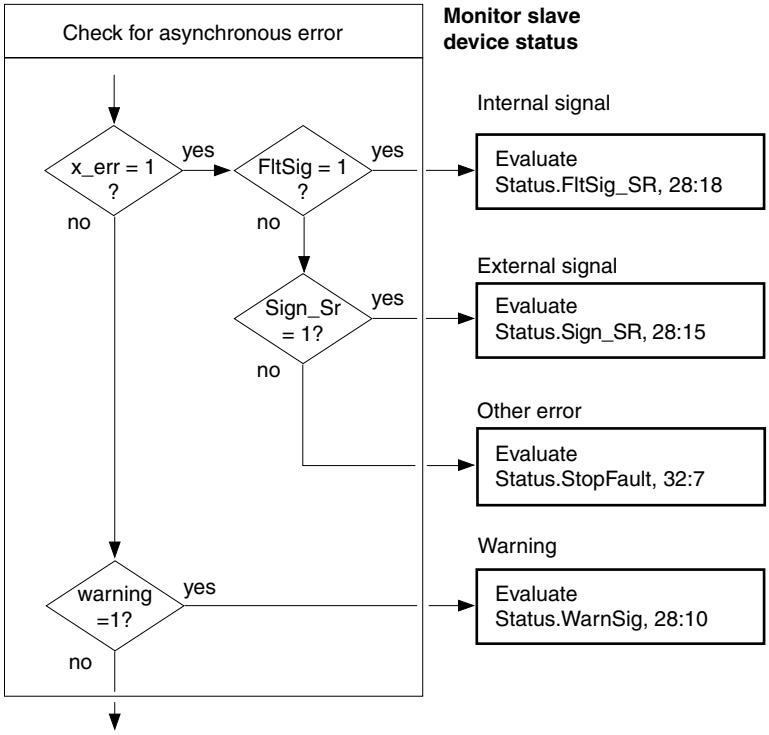

Fig. 7.2 Evaluating asynchronous errors

As a simplified procedure the master device can also simply evaluate the emergency messages and respond or visualise according to the error numbers.

For more information on parameters, error classes and troubleshooting see chapter 7, "Diagnosis and troubleshooting" in the controller manual.

7.2.3 Errors in operational control via PDOs

Movement jobs can be triggered and modified with the `R_PDO4`. If the compact drive cannot process the request, it sends the master device an `EMCY` message and sets one of the error bits in the `T_PDO4`.

For more information see chapter 4.3.4, "Send PDO T_PDO4 (compact drive → master)".

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8 Service

8.1 Service address

Contact your local dealer with any questions or problems. Your dealer will be happy to give you the name of a customer service outlet in your area.

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9 Object directory

9.1 Overview

This object list describes the protocol for the compact drive in accordance with CANopen DS301 only. The objects for controlling the operating modes, operating functions and all parameters can be found in the compact drive manual.

9.1.1 Specifications for the objects

Index This index shows the position of the object in the object directory. The index value is shown in hexadecimal.

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

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

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

Access **ro**: Read Only
Value can only be read

rw: Read Write
Value can be read and written

wo: Write Only
Value can only be written

PDO **R_PDO**: Mapping for R_PDO possible

T_PDO: Mapping for T_PDO possible

No entry: PDP mapping not possible with the object

Range of values Show the permissible range in which the object value is defined and valid.

Default value The default values can be configured with the stored factory setting.

Can be saved Yes:values can be saved in the compact drive memory and are available again after switching on.

–: Values are lost when the compact drive is switched off.

9.1.2 Objects, overview

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

Index	Subindex	Designation	Obj.code	Data type	Access
1603_h	3	3rd mapped object R_PDO4	VAR	UINT32	ro
1603_h	4	4th mapped object R_PDO4	VAR	UINT32	ro
1803_h		transmit PDO4 communication parameter	RECORD	PDO_Com	ro
1803_h	0	number of elements	VAR	UINT8	ro
1803_h	1	COB-ID used by T_PDO4	VAR	UINT32	ro
1803_h	2	transmission type T_PDO4	VAR	UINT8	rw
1803_h	3	inhibit time T_PDO4	VAR	UINT16	rw
1803_h	4	reserved T_PDO4	VAR	UINT8	rw
1803_h	5	event timer T_PDO4	VAR	UINT16	rw
$1A03_h$		transmit PDO4 mapping	RECORD	PDO_Map	ro
$1A03_h$	0	number of elements	VAR	UINT8	ro
$1A03_h$	1	1st mapped object T_PDO4	VAR	UINT32	ro
$1A03_h$	2	2nd mapped object T_PDO4	VAR	UINT32	ro
$1A03_h$	3	3rd mapped object T_PDO4	VAR	UINT32	ro
$1A03_h$	4	4th mapped object T_PDO4	VAR	UINT32	ro

9.2 Objects of the compact drive

1000h Device type

The object shows the implemented device profile and the device type.

Object description

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

Values description

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

1001h Error register

The object shows the error status of the compact drive. The detailed error cause can be determined with the manufacturer-specific object `Status.StopFault 32:7`.

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

Object description

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

Values description

Subindex	00_h, error register
Meaning	error register
Access	read-only
PDO mapping	–
Range of values	–
Default value	–
Can be saved	–

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Bit coding, subindex 00h

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

1008h Manufacturer device name

The object shows the device name (eg. "IFS ")

Object description

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

Values description

Subindex	00_h, manufacturer device name
Meaning	manufacturer name
Access	read-only
PDO mapping	–
Range of values	–
Default value	–
Can be saved	–

100Ch Guard time

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

Object description

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

Values description

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

The time span for node guarding of an NMT master device is derived from the "guard time" period multiplied by the "life time" factor, object `life time factor` ($100D_h$).

The period can be modified in the Pre-Operational NMT status.

100Dh Life time factor

The object shows the factor that combined with "guard time" period yields the time interval for node guarding of an NMT master device. Within this period the NMT slave device waits for a monitoring request by node guarding by the NMT master device.

life time = guard time * life time factor

The value "0" disables the NMT master device monitoring.

Object description

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

Values description

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

If the node guarding by the NMT master device remains off during the "life time" time interval, the Positioning controller reports an error and switches to error status.

The time factor can be modified in the Pre-Operational NMT status.

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

1015h Inhibit time emergency message

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

Object description

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

Values description

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

1018h Identity Object

The object shows information on the device. Subindex 01_h (vendor ID) contains the identification identifier of the manufacturer, subindex 02_h (product ID) shows the manufacturer-specific product code.

Values description

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

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

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

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

1403h Receive PDO4 communication parameter

The object saves settings for the fourth receive PDO R_PDO4.

Object description

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

Values description

Subindex	00_h, number of elements
Meaning	Number of subindices
Access	read-only
PDO mapping	–
Range of values	–
Default value	5
Can be saved	–

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

Subindex	02h, transmission type R_PDO4
Meaning	Transmission type
Access	read-write
PDO mapping	–
Range of values	–
Default value	254
Can be saved	–

Subindex	03_h, inhibit time R_PDO4
Meaning	Blocking period for bus access (1=100 µsec)
Access	read-write
PDO mapping	–
Range of values	0...65535
Default value	0
Can be saved	–

Subindex	04_h, compatibility entry R_PDO4
Meaning	only for compatibility purpose
Access	read-write
PDO mapping	–
Range of values	–
Default value	–
Can be saved	–

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

Bit assignment subindex 01h

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

Bit 31

An R_PDO can only be used when 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 compact drive 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 controller for evaluating R_PDO data is specified via subindex 02h. The values 241..251 are reserved.

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

If an R_PDO is transmitted synchronously (transmission type=0..252), the device evaluates the received data in accordance with the SYNC object.

- With acyclic transmission (transmission type=0) the evaluation is linked to 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 shows 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 send data with receipt of the next SYNC
- 253: updating send data with receipt of a request from a PDO consumer
- 254: updating data event-driven, the triggering event is specified manufacturer-specific

R_PDOs with the value 255 are updated immediately with receipt of the PDOs. Triggering event is the data that are sent in accordance with the definition of the device profile in the PDO.

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

A T_PDO is sent again at the earliest after expiry of the "inhibit time" time interval. The value is output as a multiple of 100 µs, but the drive rounds it out to whole milliseconds.

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

Subindex 05h The event timer time interval is only relevant for T_PDOs.

A T_PDO is sent again after expiry of the event timer time interval. The time interval is restarted simultaneously. The transmission type must be configured via subindex 02_h to the value 254 or 255.

Settings R_PDO4 is processed asynchronously and event-driven.

The byte assignment of the R_PDO4 is specified via the PDO mapping with the Receive PDO4 mapping (1603_h) object and cannot be modified. The assignment is described in chapter 4.3.3, "Receive PDO R_PDO4 (master → compact drive)".

The COB-ID of the object can be modified in the Pre-Operational NMT status.

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1603h Receive PDO4 mapping

The object shows which objects are mapped in R_PDO4 and transmitted with the PDO. When reading the object subindex 00h the number of mapped objects is given.

Object description

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

Values description

Subindex	00h, number of elements
Meaning	Number of subindices
Access	read-only
PDO mapping	–
Range of values	–
Default value	4
Can be saved	–

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

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

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

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

Bit coding from subindex 01h

Every subindex entry from subindex 01h shows the object and the byte length of the object. The object is identified via index and subindex that refers to the object directory of the device.

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

Settings

The assignment of the R_PDO4 is fixed and cannot be changed.

The assignment is described in chapter 4.3.3, "Receive PDO R_PDO4 (master → compact drive)".

1803h Transmit PDO4 communication parameter

The object saves settings for the fourth send PDO T_PDO4.

Object description

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

Values description

Subindex	00_h, number of elements
Meaning	Number of subindices
Access	read-only
PDO mapping	–
Range of values	–
Default value	5
can be saved	–

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

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

Subindex	03_h, inhibit time T_PDO4
Meaning	Blocking period for bus access (in [100 µsec]). The value is round off to whole milliseconds by the drive.
Access	read-write
PDO mapping	–
Range of values	0...65535
Default value	0
Can be saved	–

Subindex	04_h, reserved T_PDO4
Meaning	reserved (only for compatibility purpose)
Access	read-write
PDO mapping	–
Range of values	–
Default value	–
Can be saved	–

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

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

Settings

R_PDO4 is sent asynchronously and event-driven.

The byte assignment of the T_PDO4 is specified via the PDO mapping with the `Transmit PDO4 mapping` ($1A03_h$) object and cannot be modified. The assignment is described in chapter 4.3.4, "Send PDO T_PDO4 (compact drive → master)".

The COB-ID of the object can be modified in the Pre-Operational NMT status.

1A03h Transmit PDO4 mapping

The object shows which objects are mapped in T_PDO4 and transmitted with the PDO. When reading the object subindex 00h the number of mapped objects is given.

Object description

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

Values description

Subindex	00_h, number of elements
Meaning	Number of subindices
Access	read-only
PDO mapping	–
Range of values	–
Default value	4
Can be saved	–

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

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

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

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

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

Settings The PDO assignment for T_PDO4 cannot be modified. The assignment is described in chapter 4.3.4, "Send PDO T_PDO4 (compact drive → master)".

10 Glossaries

10.1 Abbreviations

Abbreviation	Meaning
CAN	**C**ontroller **A**rea **N**etwork, standardized bus system
CDD	**C**omman**d** Co**d**e, a component of an SDO message
COB	**C**ommunication **Ob**ject, basic object for transport of data in a CAN network. 2048 COBs are permissible in a CAN network and can be identified by a unique COB-ID.
COB-ID	**C**ommunication **ob**ject **id**entifier, component of the CANopen message for identification of objects and specification of bus access priorities
DS	**D**raft **s**tandard draft standard
DSP	**D**raft **s**tandard **p**roposal, proposed standard draft
PDO	**P**rocess **D**ata **O**bject, object for fast transport of data in the CAN network. They are classified into T_PDO (Transmit PDO) for sending data and R_PDO (Receive PDO) for receiving data
R_PDO	**R**eceive **P**rocess **D**ata **O**bject, process data from the master device to the drive
R_SDO	**R**eceive **S**ervice **D**ata **O**bject, configuration data from the master device to the drive
RTR	**R**emote **T**ransmission **R**equest
SDO	**S**ervice **D**ata **O**bject, object for transport of system data, including distributed over multiple SDO messages
SYNC	**Sync**hronisation object, object for synchronising devices on the network node-ID node address
T_PDO	**T**ransmit **P**rocess **D**ata **O**bject, process data from the drive to the master device
T_SDO	**T**ransmit **S**ervice **D**ata **O**bject, configuration data from the drive to the master device

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10.2 Glossary

Broadcast	Type of data transmission in the network; a device sends a message to all devices on the network
Bus arbitration	Device on the field bus for prevention of data collisions when multiple bus devices transmit simultaneously. The station that is ready to transmit and has the higher priority receives the authority. The priority is specified by the COB-ID.
CAN connection	Communications interface of the positioning drive for connection to the CAN bus
Client	First the sender, then the receiver of CAN messages in the client-server relationship starts the transmission with a transmission to the server; the reference point is the server object directory.
Consumer	Receiver of CAN messages in the producer-consumer relationship of network devices (consumer).
Default values	Factory setting, values preset on delivery from the factory
Error class	Classification of operational faults into groups corresponding to the error responses
Event timer	The sequence of an event-driven time interval triggers transmission of a PDO message Event-driven time intervals can be set in parallel to other event-driven functions such as to change the signal of a monitored device input (event timer)
Heartbeat	Heartbeat is a monitoring function with which a network device can check whether another network device is ready to send and receive (heartbeat)
Index	The index is 16-bit long value with which every object in the object directory of a device can be uniquely addressed.
Inhibit time	A minimum waiting time for repeated transmission can be set for a PDO to reduce the data transfer load on the field bus. After the first transmission the PDO is sent again only after expiry of the waiting time (inhibit time)
Master	First the sender, then the receiver of CAN messages in a master-slave relationship of network devices; the master device control the communications of the slaves (master)
Node address	Address of a device in the network; every device in the network has a unique node address
Node guarding	Node guarding is a monitoring function with which one or more network devices is regularly checked for readiness to send and receive (node guarding)
Parameter	Device data and values that can be set by the user.
Producer	Creator of CAN messages in the producer-consumer relationship of network devices (producer)
Server	First the sender, then the receiver of CAN messages in the client-server relationship responds to the request of a clients; the reference point is the server object directory (server)

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Supplement