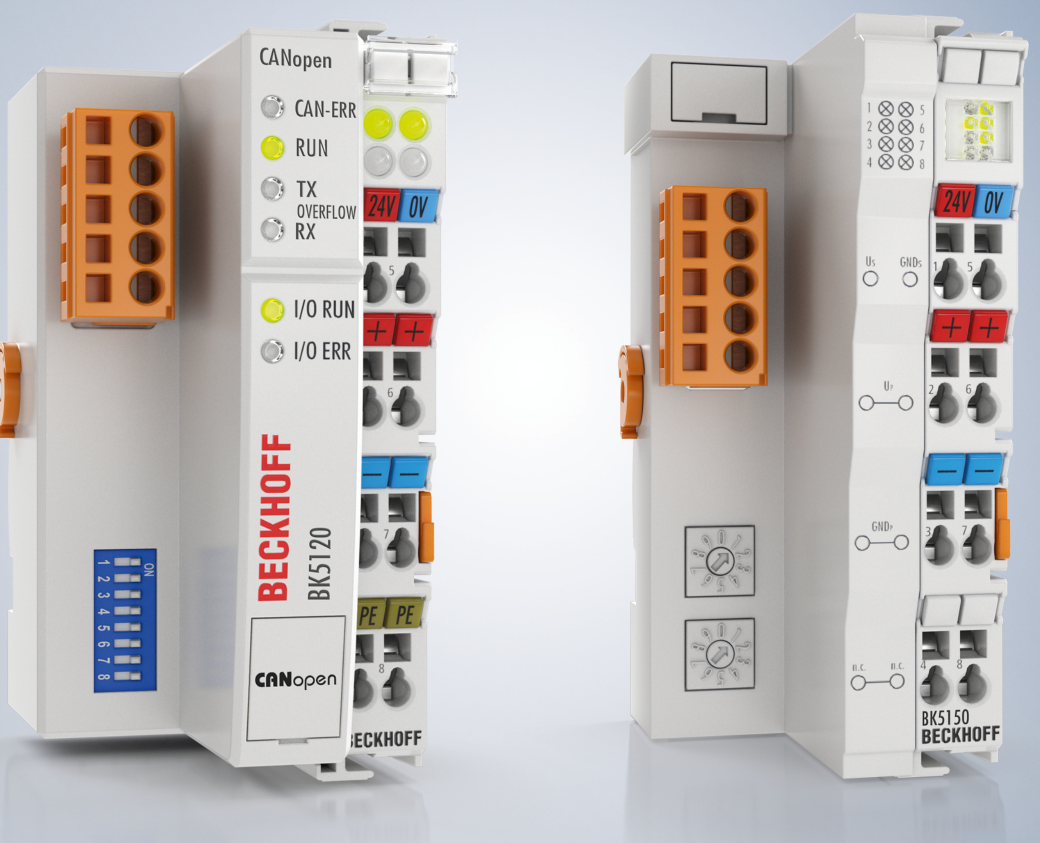
BECKHOFF New Automation Technology

Documentation | EN

BK5120, BK5150, BK5151 und LC5100

Bus Coupler for CANopen



2023-03-17 | Version: 3.3.0

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1 Foreword

1.1 Notes on the documentation

Intended audience

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards.
It is essential that the documentation and the following notes and explanations are followed when installing and commissioning these components.
It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development.

We reserve the right to revise and change the documentation at any time and without prior announcement.

No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

Trademarks

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Patent Pending

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents: EP1590927, EP1789857, EP1456722, EP2137893, DE102015105702 with corresponding applications or registrations in various other countries.

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Copyright

1.2 Safety instructions

Safety regulations

Please note the following safety instructions and explanations!
Product-specific safety instructions can be found on following pages or in the areas mounting, wiring, commissioning etc.

Exclusion of liability

All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH & Co. KG.

Personnel qualification

This description is only intended for trained specialists in control, automation and drive engineering who are familiar with the applicable national standards.

Description of instructions

In this documentation the following instructions are used.
These instructions must be read carefully and followed without fail!

⚠ DANGER

Serious risk of injury!

Failure to follow this safety instruction directly endangers the life and health of persons.

⚠ WARNING

Risk of injury!

Failure to follow this safety instruction endangers the life and health of persons.

⚠ CAUTION

Personal injuries!

Failure to follow this safety instruction can lead to injuries to persons.

NOTE

Damage to environment/equipment or data loss

Failure to follow this instruction can lead to environmental damage, equipment damage or data loss.

Tip or pointer

This symbol indicates information that contributes to better understanding.

1.3 Documentation issue status

Version	Modifications
3.3.0	• Chapter *Service Data Objects (SDO)* updated
3.2.0	• Technical data updated • Ex markings added to technical data • Chapter *Instructions for ESD protection* added • Chapter *Disposal* added • New title page
3.1	• Technical data updated • ATEX added
3.0	• Migration • Update structure
2.4	• Description of the baud rate and address settings updated.
2.3	• Documentation adapted to firmware version C6 and description of BK515x updated.
2.2.1	• Notes regarding compliance with UL requirements added.
2.2	• Documentation extended to BK515x and adjusted to firmware version C5.
2.11	• Firmware version overview complemented, LED error codes complemented.
2.1	• Documentation adjusted to firmware version C4.
2.0	• Completely revised documentation for Bus Couplers BK5120, BK5110 and LC5100 from firmware version C0.
1.1	• Extended samples for register access (objects 0x4500 and 0x4501) • Description of auto baud rate detection (from firmware version B7)
1.0	• First version for BK5120, BK5110 and LC5100

Overview of firmware versions

The firmware version is specified at the rear of the Bus Coupler (fifth and sixth digits of the production number, see sample below).

If necessary, the firmware can be updated through the serial interface (a special cable is needed) or - as from firmware status (C)1 - it may be carried out over the fieldbus using the Beckhoff CANopen FC5101 card. The firmware and update tool can be found on the internet under https://www.beckhoff.com.

Firmware	Modification, extension	Optimization
C8	• This firmware enables a higher number of objects (increased from 149 to 254) from index 0x6000 (device-specific objects, see CAN CIA DS401). ◦ 0x6000, 0x6200, 0x6401, 0x6411 (digital input bytes, digital output bytes, analog inputs, analog outputs) ◦ 0x6423, 0x6424, 0x6425 and 0x6426 (Global Interrupt Mask, Upper-, Lower- Limit, Delta). • For the delta function smaller values than 255 are possible	
C7		• Error argument in EMCY message corrected (was only relevant for firmware C6)
C6	• Changing the transmission types from asynchronous to synchronous now also works in OPERATIONAL state. • The PDO event time and the heartbeat time are now stored correctly via object 0x1010. • The automatic transition to OPERATIONAL during startup (can be activated via table 100) now also works if the baud rate is not set to a fixed value. • Upper/lower limit monitoring for analog inputs works if delta is set to 0. • The station address and baud rate can now be specified via table 100.	• The boot-up message is now generated reliably under all boundary conditions. • The receive queue no longer overruns if the startup takes too long (could only happen if many sync frames were active on the bus at the same time). • Occasional problems with the delta function (analog inputs) are fixed. • Occasional problems with the interrupt mask (0x6126) are fixed.
C5	• Optimized synchronizing of K-Bus cycle with sync telegram. • If the K-Bus cycle is not yet completed before the next SYNC telegram arrives, an emergency telegram is sent and the Tx overrun LED flashes slowly. The LED signal and EMCY are reset 10 seconds after the last occurrence of this situation. • KS2000 online mode is supported. • KL6201 (AS interface master terminal) is also supported in 38 byte mode. • KL8001 is automatically switched to CANopen-compatible data format.	• Change-over to operational is denied if K-Bus error is present. • Boot-up message is received reliably even for low baud rates. • Default mapping for node ID 64.
C4	• New: Object 0x6126 interrupt mask. Allows the data changes that lead to the transmission of event-driven TxPDOs to be selected. No change in the default behavior. • AS interface master terminal KL6201 is supported. For details see KL6201 documentation. • SDO response times to objects with PDO parameters (0x1400ff, 0x1800ff, 0x5500) shortened drastically.	• Lifetime factor of 2 no longer results in a guard error when guarding is correct. • RxPDOs of length 0 no longer cause the firmware to halt. • The boot-up message is only now sent when the coupler has reached the pre-operational state (and not when the status is still changing).

Firmware	Modification, extension	Optimization
C2		• 1 wait state introduced for RAM access. This means that C2 also runs reliably on couplers having old hardware versions.
C1	• Firmware download now also possible via CAN (object 0x5FFF was introduced for this purpose). Requires Beckhoff CANopen PCI card FC510x.	
C0	From firmware version C0 the Bus Couplers correspond to CANopen communication profile version 4.01. Main changes/extensions: • Default identifier now also for PDO3 + 4. • Firmware performance was increased significantly - this may lead to increased bus load. • The PDO event timer is now supported. • If all PDOs were configured for synchronized communication and the SYNC interval (0x1006) was parametrized, communication is now synchronized throughout with the I/O update (K-Bus) • Mapping changes (variable mapping) are only allowed according to the CANopen standard. • The LED behavior now corresponds to the new CANopen recommendation DRP303-3. • Identity object is now supported. • The guarding identifier (object 0x100E) is now read only. • Object 0x1004 (number of PDOs) is no longer used - otherwise the conformance test is not passed. • The timeout for SYNC monitoring was extended to 1.5 times the SYNC interval. • The boot-up message now uses the guarding identifier. • Heartbeat is now also supported in addition to guarding. • The firmware update is now also possible via CANopen. This requires a FC510x CANopen card. Additional notes regarding CANopen version 4 can be found in the Appendix. The Bus Coupler can be downgraded to firmware version BA at any time, if required. The firmware and a download program are available from the Beckhoff website at www.beckhoff.de A special cable is required for the download. Please contact Beckhoff support.	

Firmware	Modification, extension	Optimization
BA	• Identity object 0x1018 is now implemented. • The watchdog for the SYNC interval is now set to 1.5 times the value written in object 0x1006. • The response time was improved.	
B9	• Object 0x6424 limit value monitoring analog inputs: monitoring of upper limit for greater/equal revised (adaptation to DS401 V2.) • Shorter boot time after reset: Firmware checksum test now only after cold start.	• No change of state to “pre-operational” if the warning limit was exceeded (error was in B8). • PDO3 is now also created if 57..64 digital inputs or outputs are available.
B8	• During internal change of state from operational to pre-operational, the outputs are set to „fieldbus error“ state.	
B7	• Automatic CAN baud rate detection for DIP switch 7.8= 0.0 introduced. • Extended NODE IDs possible. • Sync time limited to 65535 ms. • New Bus Coupler IDs implemented. • Extended terminal diagnostics active. • KL1212 mapping implemented.	• Reset emergency now operational • SYNC/GUARDING Emcy is now sent • Bit timing 10 kBit CAN transfer rate adapted to CANopen standard
B4	• ERR LED flash code for guarding and sync ERROR introduced.	• Guarding error is now reset at start node.
B2	• First release	

Firmware versions that are not listed are only used for internal tests.

2 Product overview

2.1 BK5110, BK5120, LC5100 - Introduction

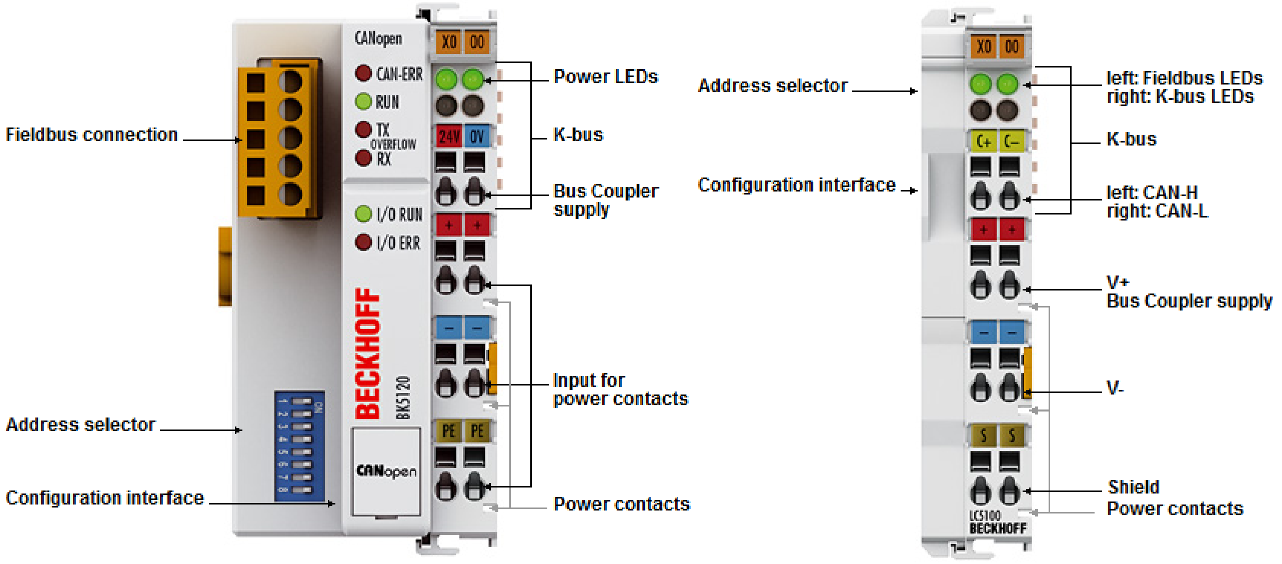

Fig. 1: BK5120, LC5100

BK5120

The BK5120 Bus Coupler connects the CAN bus system to the electronic terminal blocks, which can be extended in modular fashion. One unit consists of one Bus Coupler, any number of up to 64 terminals and one end terminal. With the K-bus extension technology, the BK5120 allows the connection of up to 255 spatially distributed Bus Terminals to one Bus Coupler.

The Bus Coupler works on the CAN protocol basis as defined in ISO 11898. In addition to network services, CANopen also determines the data allocation for automation systems applications and has established itself as an open CAN application layer. The Bus Coupler supports all types of CANopen communications and can also be used without difficulty in manufacturer-specific CAN environments due to the simple structure of this protocol definition. The firmware can be updated via the configuration interface.

Parameterizing can also be carried out using any CANopen configuration tools. For this, EDS data files are available, which describe all the setting options for the CANopen coupler. For most applications, however, no configuration is necessary, as CANopen provides practical default values for all parameters.

BK5110

The economy version BK5110 enables the particularly economical design of peripheral circuits. Up to 64 digital input and output terminals can be connected.

LC5100

The "Low Cost" Bus Coupler LC5100 is characterized by its smaller design and less expensive connection technology. All bit-oriented terminals can be connected to the "Low Cost" Bus Couplers. All digital input and output terminals - except KL15xx, KL25x2, KL2692 and KL27x1 - are supported. In addition, all system terminals with and without diagnostics can be connected.

2.2 BK5150, BK5151 - Introduction

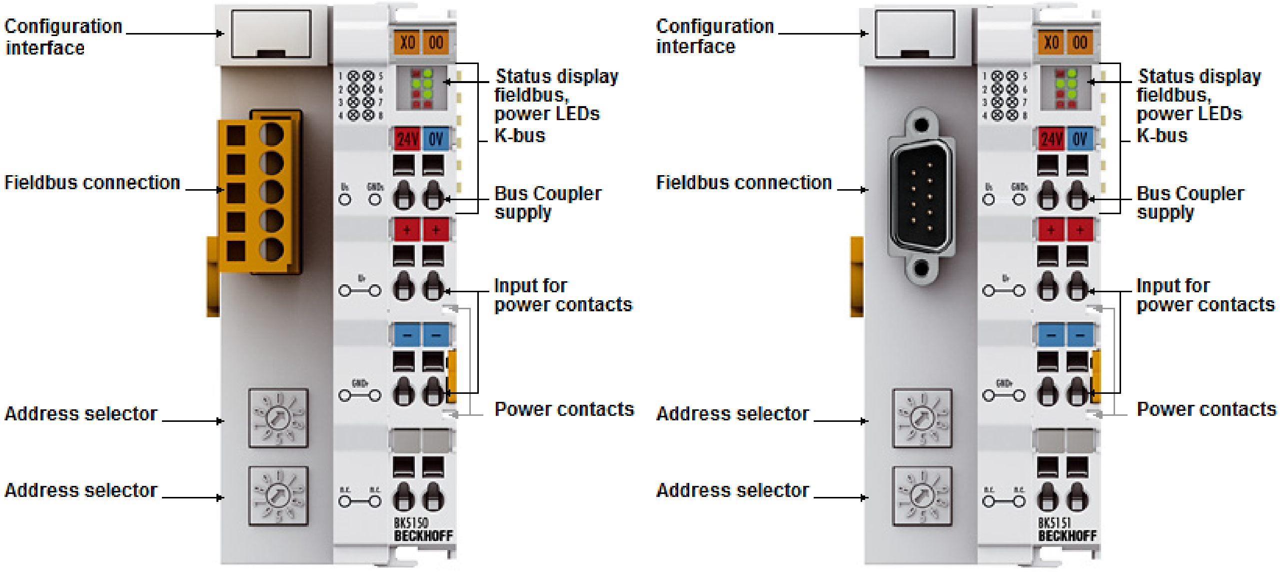

Fig. 2: BK5150, BK5151

BK5150

The Bus Coupler BK5150 for CANopen extends the Beckhoff Bus Terminal system by a cost-optimized version in a compact housing. Up to 64 Bus Terminals are supported; with the terminal bus extension, up to 255 Bus Terminals can be connected. The CANopen Bus Coupler offers automatic baud rate detection up to 1 Mbaud and two address selection switches for address assignment. A 5-pin connector for the fieldbus connection is included in the scope of supply. Optionally, the ZS1052-3000 connector with integrated terminating resistor can be connected.

BK5151

The Compact Bus Coupler BK5151 for CANopen extends the Beckhoff Bus Terminal system by a cost-optimized version in a compact housing. Up to 64 Bus Terminals are supported; with the terminal bus extension, up to 255 Bus Terminals can be connected. The CANopen Bus Coupler offers automatic baud rate detection up to 1 Mbaud and two address selection switches for address assignment. A 9-pin D-sub connector for the fieldbus connection is included in the scope of supply.

2.3 Technical data

System data

System data	CANopen						
Number of I/O points	depends on the structure						
Transmission medium	screened, twisted copper cable, 2 x signal, 1 x ground (recommended)						
Length of the cable	5,000 m	2,500 m	1,000 m	500 m	250 m	100 m	20 m
Data transfer rate	10 kbaud	20 kbaud	50 kbaud	125 kbaud, 100 kbaud	250 kbaud	500 kbaud	1,000 kbaud
Process data operating modes	synchronous, cyclical, event-driven (also with event timer), polling						
System data	I/O points						
Number of I/O points	depends on the structure						
Wiring	Cage Clamp® spring-loaded system						
Connection cross-section	0.08 mm² ... 2.5 mm², stranded, solid wire, AWG 28-14						

BK5110, BK5120, LC5100

Technical data	BK5120	BK5110	LC5100
Number of Bus Terminals	64 (255 with K-Bus extension interface KL9020 and KL9050)		
Digital peripheral signals	960 inputs/outputs	256 inputs/outputs	
Analog peripheral signals	60 inputs/outputs	not equipped	
Configuration possibility	Via the KS2000 configuration software or the controller		
Number of PDOs (CANopen)	16 Rx/16 Tx	5 Rx/5 Tx	
Additional CANopen features	life/node guarding, heartbeat, emergency object, variables mapping, store/restore		
Bus connection	1 x open style connector, 5-pole, plug included		Spring-loaded system
Power supply	24 V_{DC} (-15%/+20%)		
Input current	70 mA + (total K-bus current)/4		
	max. 500 mA	max. 200 mA	
Starting current	approx. 2.5 x continuous current		
K-bus power supply (5 V)	up to 1,750 mA	up to 500 mA	
Power contact voltage	max. 24 V_{DC}		
Power contact current load	max. 10 A		
Electrical isolation	500 V (power contact/fieldbus/supply voltage)		none between power supply/ fieldbus/power contacts
Rec. Back-up fuse	≤ 10 A		
Weight	approx. 150 g		approx. 100 g
Permissible ambient temperature (operation)	-25°C ... +60°C	0°C ... +55°C	
Permissible ambient temperature (storage)	-40°C … +85°C	-25°C … +85°C	
Permissible relative humidity	95 %, no condensation		
Vibration / shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27		
EMC immunity / emission	conforms to EN 61000-6-2 / EN 61000-6-4		
Installation position	variable		
PE for power supply	yes		
Protection class	IP20		
Approvals/markings*	CE, UKCA, cULus, EAC, GL, ATEX [▸ 34]	CE, UKCA, cULus, EAC, GL, ATEX [▸ 33]	CE, UKCA, cULus, EAC, ATEX [▸ 33]

*) Real applicable approvals/markings see type plate on the side (product marking).

Ex marking

Standard	Marking
ATEX	II 3 G Ex nA IIC T4 Gc

BK5150, BK5151

Technical data	BK5150	BK5151
Number of Bus Terminals	64 (255 with K-Bus extension interface KL9020 and KL9050)	
Digital peripheral signals	960 inputs/outputs	
Analog peripheral signals	60 inputs/outputs	
Configuration possibility	Via the KS2000 configuration software or the controller	
Number of PDOs (CANopen)	16 Rx/16 Tx	
Additional CANopen features	life/node guarding, heartbeat, emergency object, variables mapping, store/restore	
Bus connection	1 x open style connector, 5-pin, plug included	9-pin D-sub plug

Supply	BK5150	BK5151
Power supply (Us)	24 V_{DC} (-15% /+20%) Use a 4 A fuse or an NEC Class 2 power supply to meet the UL requirements!	
Input current (Us)	70 mA + (total K-bus current)/4	
	max. 320 mA	
Starting current (Us)	approx. 2.5 x continuous current	
K-bus current (5 V)	up to hardware version 09: 1000 mA from hardware version 10: 1750 mA	up to hardware version 08: 1000 mA from hardware version 09: 1750 mA
Power contact voltage (Up)	max. 24 V_{DC}	
Power contact current load (Up)	max. 10 A	
Rec. Back-up fuse (Up)	≤ 10 A	
Electrical isolation	500 V (power contact/fieldbus/supply voltage)	

⚠ CAUTION

UL-Requirements

For power supply of the Bus Coupler (Us) use a 4 A fuse or an *NEC Class 2* power supply to meet the UL requirements!

Technical data	BK5150	BK5151
Weight	approx. 100 g	
Permissible ambient temperature (operation)	-25°C ... +60°C	
Permissible ambient temperature (storage)	-40°C ... +85°C	
Permissible relative humidity	95 %, no condensation	
Vibration / shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27	
EMC immunity / emission	conforms to EN 61000-6-2 / EN 61000-6-4	
Installation position	variable	
PE for power supply	no	
Protection class	IP20	
Approvals/markings*	CE, UKCA, cULus, EAC, ATEX [▶ 34]	

*) Real applicable approvals/markings see type plate on the side (product marking).

Ex marking

Standard	Marking
ATEX	II 3 G Ex nA IIC T4 Gc

2.4 The Beckhoff Bus Terminal system

Up to 256 Bus Terminals, with 1 to 16 I/O channels per signal form

The Bus Terminal system is the universal interface between a fieldbus system and the sensor / actuator level. A unit consists of a Bus Coupler as the head station, and up to 64 electronic series terminals, the last one being an end terminal. Up to 255 Bus Terminals can be connected via the K-Bus extension. For each technical signal form, terminals are available with one, two, four or eight I/O channels, which can be mixed as required. All the terminal types have the same mechanical construction, so that difficulties of planning and design are minimized. The height and depth match the dimensions of compact terminal boxes.

Decentralized wiring of each I/O level

Fieldbus technology allows more compact forms of controller to be used. The I/O level does not have to be brought to the controller. The sensors and actuators can be wired decentrally, using minimum cable lengths. The controller can be installed at any location within the plant.

Industrial PCs as controllers

The use of an Industrial PC as the controller means that the operating and observing element can be implemented in the controller's hardware. The controller can therefore be located at an operating panel, in a control room, or at some similar place. The Bus Terminals form the decentralized input/output level of the controller in the control cabinet and the subsidiary terminal boxes. The power sector of the plant is also controlled over the bus system in addition to the sensor/actuator level. The Bus Terminal replaces the conventional series terminal as the wiring level in the control cabinet. The control cabinet can have smaller dimensions.

Bus Couplers for all usual bus systems

The Beckhoff Bus Terminal system unites the advantages of a bus system with the possibilities of the compact series terminal. Bus Terminals can be driven within all the usual bus systems, thus reducing the controller parts count. The Bus Terminals then behave like conventional connections for that bus system. All the performance features of the particular bus system are supported.

Mounting on standardized mounting rails

The installation is standardized thanks to the simple and space-saving mounting on a standardized mounting rail (EN 60715, 35 mm) and the direct wiring of actuators and sensors, without cross connections between the terminals. The consistent labelling scheme also contributes.

The small physical size and the great flexibility of the Bus Terminal system allow it to be used wherever a series terminal is also used. Every type of connection, such as analog, digital, serial or the direct connection of sensors can be implemented.

Modularity

The modular assembly of the terminal strip with Bus Terminals of various functions limits the number of unused channels to a maximum of one per function. The presence of two channels in one terminal is the optimum compromise of unused channels and the cost of each channel. The possibility of electrical isolation through potential feed terminals also helps to keep the number of unused channels low.

Display of the channel state

The integrated LEDs show the state of the channel at a location close to the sensors and actuators.

K-Bus

The K-Bus is the data path within a terminal strip. The K-Bus is led through from the Bus Coupler through all the terminals via six contacts on the terminals' side walls. The end terminal terminates the K-Bus. The user does not have to learn anything about the function of the K-Bus or about the internal workings of the terminals and the Bus Coupler. Many software tools that can be supplied make project planning, configuration and operation easy.

Potential feed terminals for isolated groups

The operating voltage is passed on to following terminals via three power contacts. You can divide the terminal strip into arbitrary isolated groups by means of potential feed terminals. The potential feed terminals play no part in the control of the terminals, and can be inserted at any locations within the terminal strip.

Up to 64 Bus Terminals can be used in a terminal block, with optional K-Bus extension for up to 256 Bus Terminals. This count does include potential feed terminals, but not the end terminal.

Bus Couplers for various fieldbus systems

Various Bus Couplers can be used to couple the electronic terminal strip quickly and easily to different fieldbus systems. It is also possible to convert to another fieldbus system at a later time. The Bus Coupler performs all the monitoring and control tasks that are necessary for operation of the connected Bus Terminals. The operation and configuration of the Bus Terminals is carried out exclusively by the Bus Coupler. Nevertheless, the parameters that have been set are stored in each Bus Terminal, and are retained in the event of voltage drop-out. Fieldbus, K-Bus and I/O level are electrically isolated.

If the exchange of data over the fieldbus is prone to errors or fails for a period of time, register contents (such as counter states) are retained, digital outputs are cleared, and analog outputs take a value that can be configured for each output when commissioning. The default setting for analog outputs is 0 V or 0 mA. Digital outputs return in the inactive state. The timeout periods for the Bus Couplers correspond to the usual settings for the fieldbus system. When converting to a different bus system it is necessary to bear in mind the need to change the timeout periods if the bus cycle time is longer.

The interfaces

A Bus Coupler has six different methods of connection. These interfaces are designed as plug connectors and as spring-loaded terminals.

2.5 CANopen - Introduction

Fig. 3: CANopenLogo

CANopen is a widely used CAN application layer, developed by the CAN-in-Automation association (CiA, http://www.can-cia.org), and which has meanwhile been adopted for international standardization.

Device Model

CANopen consists of the protocol definitions (communication profile) and of the device profiles that standardize the data contents for the various device classes. Process data objects (PDO) [▶ 54] are used for fast communication of input and output data. The CANopen device parameters and process data are stored in a structured object directory. Any data in this object directory is accessed via service data objects (SDO). There are, additionally, a few special objects (such as telegram types) for network management (NMT), synchronization, error messages and so on.

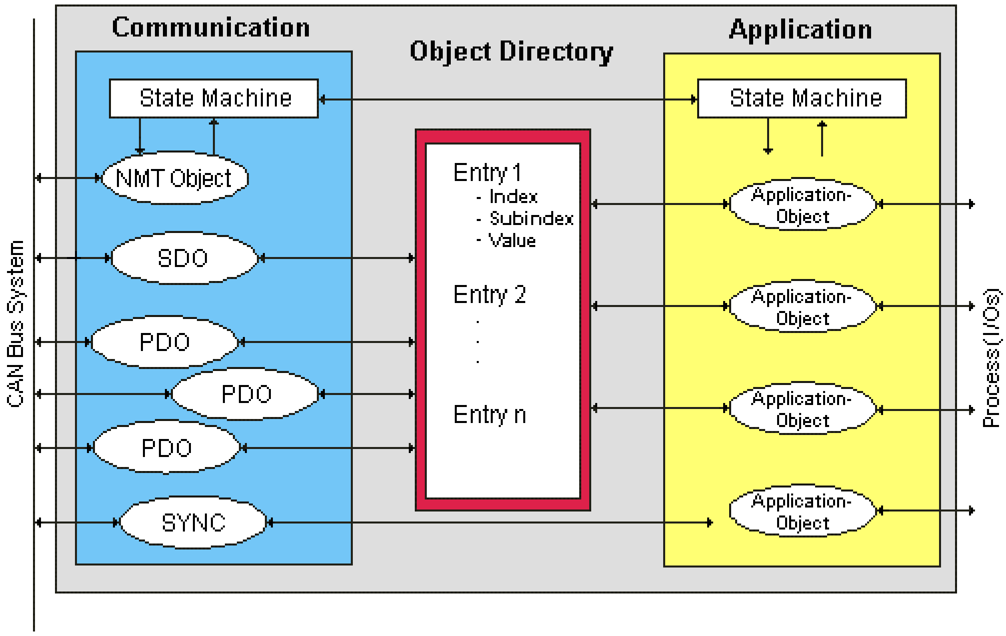

Fig. 4: CANopen Device Model

Communication Types

CANopen defines a number of communication classes for the input and output data (process data objects):

- Event driven [▶ 56]: Telegrams are sent as soon as their contents have changed. This means that the process image as a whole is not continuously transmitted, only its changes.
- Cyclic synchronous [▶ 57]: A SYNC telegram causes the modules to accept the output data that was previously received, and to send new input data.
- Requested (polled) [▶ 54]: A CAN data request telegram causes the modules to send their input data.

The desired communication type is set by the Transmission Type [▶ 54] parameter.

Device Profile

The BECKHOFF CANopen devices support all types of I/O communication, and correspond to the device profile for digital and analog input/output modules (DS401 Version 1). For reasons of backwards compatibility, the default mapping was not adapted to the DS401 V2 profile version.

Data transfer rates

Nine transmission rates from 10 kbit/s up to 1 Mbit/s are available for different bus lengths. The effective utilization of the bus bandwidth allows CANopen to achieve short system reaction times at relatively low data rates.

Topology

CAN is based on a linear topology [▸ 25]. The number of devices participating in each network is logically limited by CANopen to 128, but physically the present generation of drivers allows up to 64 nodes in one network segment. The maximum possible size of the network for any particular data rate is limited by the signal propagation delay required on the bus medium. For 1 Mbit/s, for instance, the network may extend 25 m, whereas at 50 kbit/s the network may reach up to 1000 m. At low data rates the size of the network can be increased by repeaters, which also allow the construction of tree structures.

Bus access procedures

CAN utilizes the Carrier Sense Multiple Access (CSMA) procedure, i.e. all participating devices have the same right of access to the bus and may access it as soon as it is free (multi-master bus access). The exchange of messages is thus not device-oriented but message-oriented. This means that every message is unambiguously marked with a prioritized identifier. In order to avoid collisions on the bus when messages are sent by different devices, a bit-wise bus arbitration is carried out at the start of the data transmission. The bus arbitration assigns bus bandwidth to the messages in the sequence of their priority. At the end of the arbitration phase only one bus device occupies the bus, collisions are avoided and the bandwidth is optimally exploited.

Configuration and parameterization

The TwinCAT System Manager allows all the CANopen parameters to be set conveniently. An "eds" file (an electronic data sheet) is available on the Beckhoff website (http://www.beckhoff.de) for the parameterization of Beckhoff CANopen devices using configuration tools from other manufacturers.

Certification

The Beckhoff CANopen devices have a powerful implementation of the protocol, and are certified by the CAN in Automation Association (http://www.can-cia.org).

3 Mounting and wiring

3.1 Assembly

3.1.1 Dimensions

The system of the Beckhoff Bus Terminals is characterized by low physical volume and high modularity. When planning a project it must be assumed that at least one Bus Coupler and a number of Bus Terminals will be used. The dimensions of the Bus Couplers are independent of the fieldbus system.

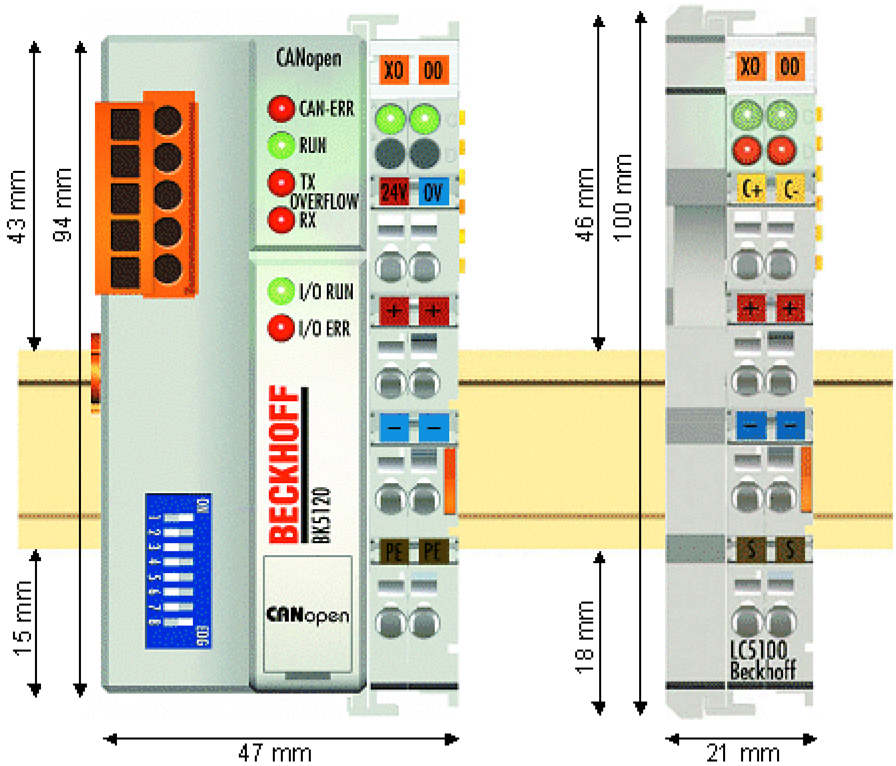

Fig. 5: Dimensions

The total width in practical cases is composed of the width of the Bus Coupler with the KL9010 Bus End Terminal and the width of the Bus Terminals in use. Depending on function, the Bus Terminals are 12 or 24 mm wide. The front wiring increases the total height of 68 mm by about 5 to 10 mm, depending on the wire thickness.

Mechanical data	BK50x0, BK5110, BK5100	BK515x	LC5100
Material	Polyamide (PA 6.6), polycarbonate		
Dimensions (W x H x D)	50 mm x 100 mm x 68 mm	44 mm x 100 mm x 68 mm	21 mm x 100 mm x 68 mm
Assembly	on 35 mm mounting rail according to EN60715 with locking mechanism		
Stackable by	double groove-tongue connection		
Labelling	Standard terminal block labelling and text slide (8 mm x 47 mm, not BK3150)		

3.1.2 Installation on mounting rails

⚠ WARNING

Risk of electric shock and damage of device!

Bring the bus terminal system into a safe, powered down state before starting installation, disassembly or wiring of the bus terminals!

Mounting

The Bus Couplers and Bus Terminals are attached to commercially available 35 mm mounting rails (DIN rail according to EN 60715) by applying slight pressure:

1. First attach the Fieldbus Coupler to the mounting rail.
2. The Bus Terminals are now attached on the right-hand side of the fieldbus Coupler. Join the components with slot and key and push the terminals against the mounting rail, until the lock clicks onto the mounting rail.
   If the terminals are clipped onto the mounting rail first and then pushed together without tongue and groove, the connection will not be operational! When correctly assembled, no significant gap should be visible between the housings.

Locking mechanism and fixing bolts

The locking mechanism of the terminals and couplers extends to the profile of the mounting rail. At the installation, the locking mechanism of the components must not come into conflict with the fixing bolts of the mounting rail. To mount the mounting rails with a height of 7.5 mm under the terminals and couplers, you should use flat mounting connections (e.g. countersunk screws or blind rivets).

Disassembly

Each terminal is secured by a lock on the mounting rail, which must be released for disassembly:

1. Carefully pull the orange-colored lug approximately 1 cm out of the terminal to be disassembled, until it protrudes loosely. The lock with the mounting rail is now released for this terminal, and the terminal can be pulled from the mounting rail without excessive force.
2. Grasp the released terminal with thumb and index finger simultaneous at the upper and lower grooved housing surfaces and pull the terminal away from the mounting rail.

Connections within a Bus Terminal block

The electric connections between the Bus Coupler and the Bus Terminals are automatically realized by joining the components:

- The six spring contacts of the K-Bus/E-Bus deal with the transfer of the data and the supply of the Bus Terminal electronics.
- The power contacts deal with the supply for the field electronics and thus represent a supply rail within the Bus Terminal block. The power contacts are supplied via terminals on the Bus Coupler.

Power contacts

During the design of a Bus Terminal block, the pin assignment of the individual Bus Terminals must be taken account of, since some types (e.g. analog Bus Terminals or digital 4-channel Bus Terminals) do not or not fully loop through the power contacts. Power Feed Terminals (KL91xx, KL92xx and EL91xx, EL92xx) interrupt the power contacts and thus represent the start of a new supply rail.

PE power contact

The power contact labelled PE can be used as a protective earth. For safety reasons this contact mates first when plugging together, and can ground short-circuit currents of up to 125 A.

NOTE

Risk of damage to the device

Note that, for reasons of electromagnetic compatibility, the PE contacts are capacitatively coupled to the mounting rail. This may lead to incorrect results during insulation testing or to damage on the terminal (e.g. disruptive discharge to the PE line during insulation testing of a consumer with a nominal voltage of 230 V). For insulation testing, disconnect the PE supply line at the Bus Coupler or the Power Feed Terminal! In order to decouple further feed points for testing, these Power Feed Terminals can be released and pulled at least 10 mm from the group of terminals.

⚠ WARNING

Risk of electric shock!

The PE power contact must not be used for other potentials!

Wiring

Up to eight connections enable the connection of solid or finely stranded cables to the Bus Terminals. The terminals are implemented in spring force technology. Connect the cables as follows:

1. Open a spring-loaded terminal by slightly pushing with a screwdriver or a rod into the square opening above the terminal.
2. The wire can now be inserted into the round terminal opening without any force.
3. The terminal closes automatically when the pressure is released, holding the wire safely and permanently.

Shielding

Analog sensors and actuators should always be connected with shielded, pair-wise twisted cables.

3.2 Disposal

Products marked with a crossed-out wheeled bin shall not be discarded with the normal waste stream. The device is considered as waste electrical and electronic equipment. The national regulations for the disposal of waste electrical and electronic equipment must be observed.

3.3 Wiring

3.3.1 Potential groups, insulation testing and PE

Potential groups

A Beckhoff Bus Terminal block usually has three different potential groups:

- The fieldbus interface is electrically isolated (except for individual Low Cost couplers) and forms the first potential group.
- Bus Coupler / Bus Terminal Controller logic, K-bus and terminal logic form a second electrically isolated potential group.
- The inputs and outputs are supplied via the power contacts and form further potential groups.

Groups of I/O terminals can be consolidated to further potential groups via potential supply terminals or separation terminals.

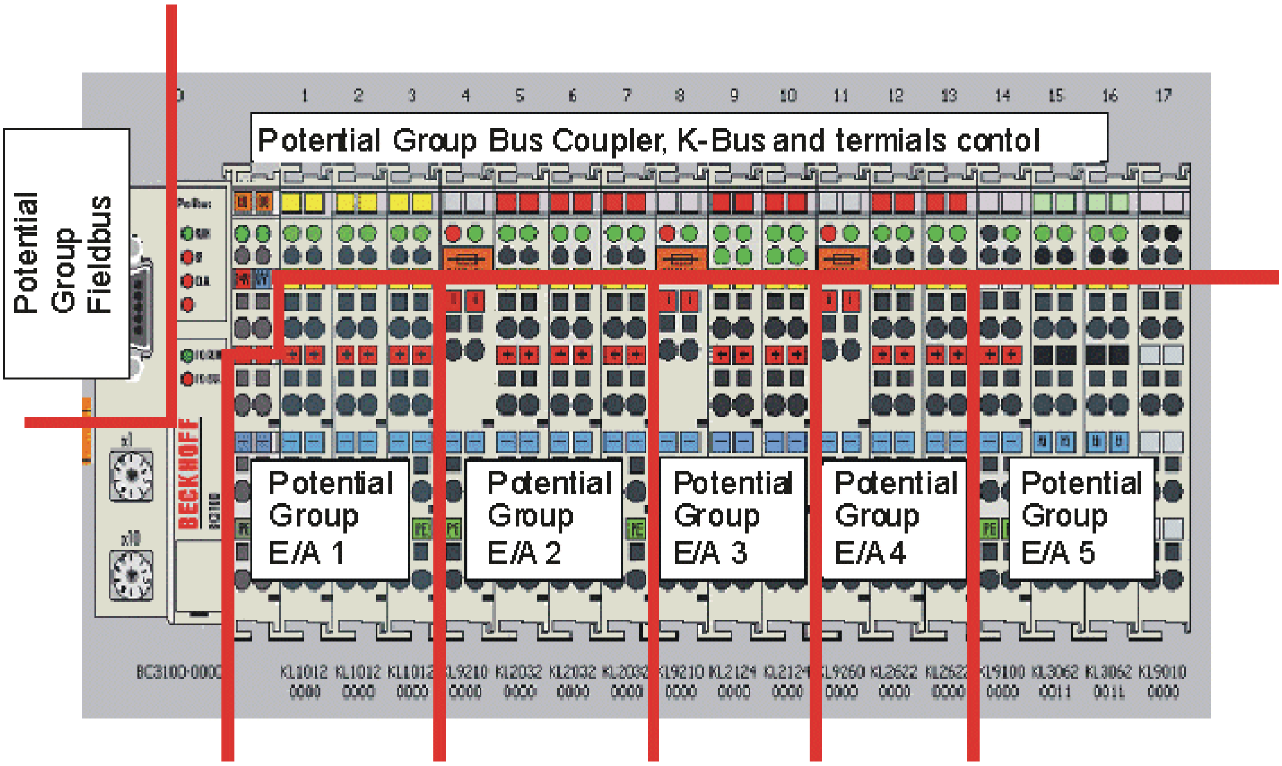

Fig. 6: Potential groups of a Bus Terminal block

Insulation testing

The connection between Bus Coupler / Bus Terminal Controller and Bus Terminals is realized automatically by latching the components. The transfer of the data and the supply voltage for the intelligent electronics in the Bus Terminals is performed by the K-bus. The supply of the field electronics is performed through the power contacts. Plugging together the power contacts creates a supply rail. Since some Bus Terminals (e.g. analog Bus Terminals or 4-channel digital Bus Terminals) are not looped through these power contacts or not completely the Bus Terminal contact assignments must be considered.

The potential feed terminals interrupt the power contacts, and represent the start of a new supply rail. The Bus Coupler / Bus Terminal Controller can also be used for supplying the power contacts.

PE power contacts

The power contact labelled PE can be used as a protective earth. For safety reasons this contact mates first when plugging together, and can ground short-circuit currents of up to 125 A.

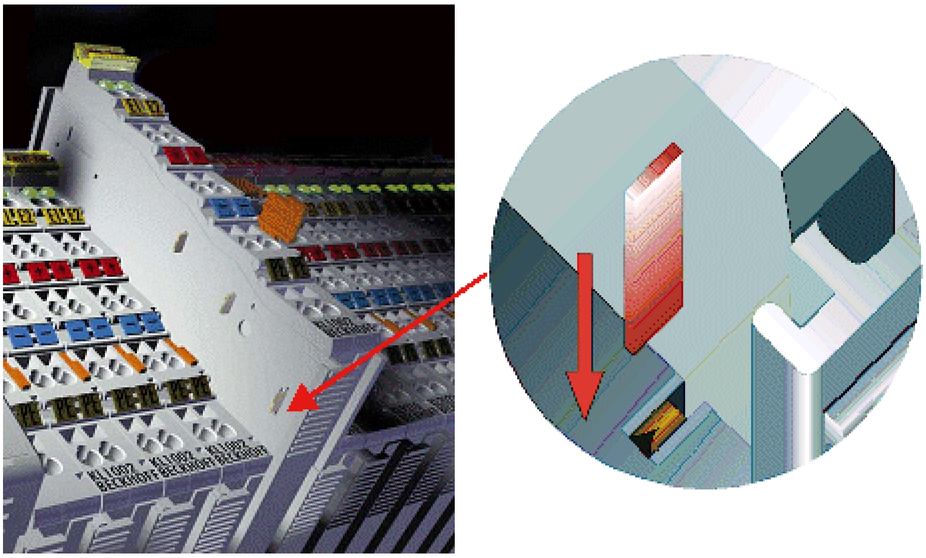

Fig. 7: Power contact on the left

It should be noted that, for reasons of electromagnetic compatibility, the PE contacts are capacitively coupled to the mounting rail. This can both lead to misleading results and to damaging the terminal during insulation testing (e.g. breakdown of the insulation from a 230 V power consuming device to the PE conductor). The PE supply line at the Bus Coupler / Bus Terminal Controller must be disconnected for an insulation test. In order to uncouple further feed locations for the purposes of testing, the feed terminals can be pulled at least 10 mm out from the connected group of other terminals. In that case, the PE conductors do not have to be disconnected.

The power contact with the label PE must not be used for other potentials.

3.3.2 Power supply

Supply of Bus Coupler / Bus Terminal Controller and Bus Terminals (Us)

⚠ WARNING

Risk of electric shock and damage of device!

Bring the bus terminal system into a safe, powered down state before starting installation, disassembly or wiring of the bus terminals!

3.3.2.1 BKxx00, BKxx10, BKxx20 and LCxxxx

The Bus Couplers / Bus Terminal Controllers require an operating voltage of 24 V_{DC}.

The connection is made by means of the upper spring-loaded terminals labelled *24 V* and *0 V*. This supply voltage is used for the electronic components of the Bus Coupler and Bus Terminal Controllers and (via the K-bus) the electronic components of the Bus Terminals. It is galvanically separated from the field level voltage.

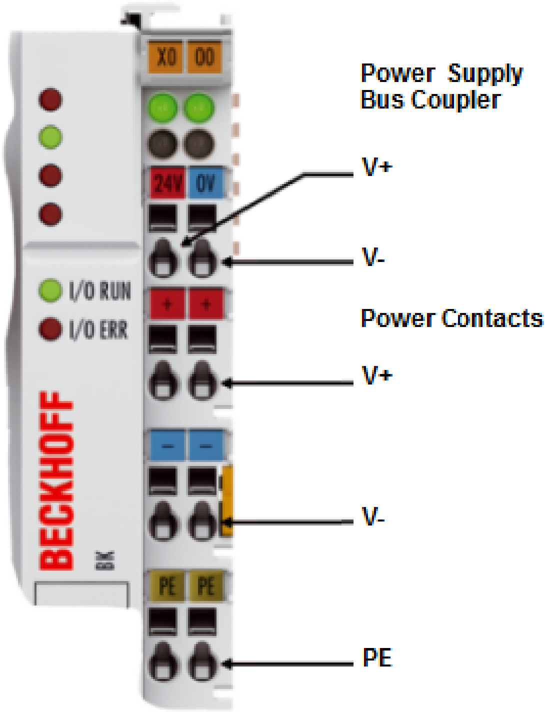

Fig. 8: Power supply connections for BKxx00, BKxx10, BKxx20 and LCxxxx

3.3.2.2 BKxx50 and BKxx51

The Bus Couplers / Bus Terminal Controllers require an operating voltage of 24 V_{DC}. Use a 4 A fuse or a Class 2 power supply to comply with the UL requirements.

The connection is made by means of the upper spring-loaded terminals labelled *Us* and *GNDs*. This supply voltage is used for the electronic components of the Bus Coupler and Bus Terminal Controllers and (via the K-bus) the electronic components of the Bus Terminals. It is galvanically separated from the field level voltage.

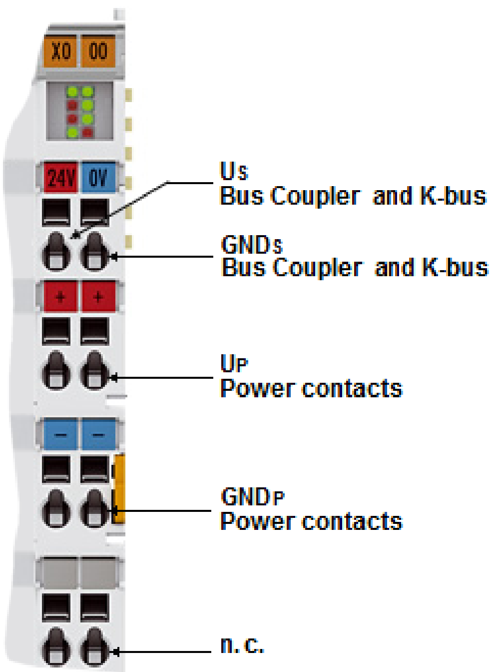

Fig. 9: Power supply connections for BKxx50 and BKxx51

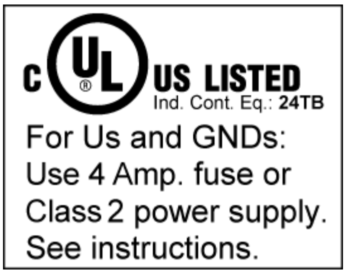

Fig. 10: UL identification

⚠ CAUTION	
c UL us	**Note the UL requirements for the power supply.** To comply with the UL requirements, the 24 V_{DC} supply voltage for Us must originate • from an isolated source protected by a fuse of max. 4A (according to UL248) or • from a voltage supply complying with NEC class 2. An NEC class 2 voltage source must not be connected in series or parallel with another NEC class 2 voltage source!

⚠ CAUTION	
c UL us	**No unlimited voltage sources!** To comply with the UL requirements, Us must not be connected with unlimited voltage sources.

3.3.2.3 Configuration and Programming Interface

The standard Bus Couplers have an RS232 interface at the bottom of the front face. The miniature plug connector can be connected to a PC using a connecting cable and the KS2000 configuration software. The interface permits the Bus Terminals to be configured, for example adjusting the amplification factors of the analog channels. The interface can also be used to change the assignments of the bus terminal data to the process image in the Bus Coupler. The functionality of the configuration interface can also be reached via the fieldbus using string communication facility.

3.3.2.4 Electrical isolation

The Bus Couplers / Bus Terminal Controllers operate with three independent potential groups. The supply voltage feeds the K-bus electronics and the K-bus itself. The supply voltage is also used to generate the operating voltage for the fieldbus interface.
Note: All the Bus Terminals are electrically isolated from the K-bus. The K-bus is thus electrically isolated from everything else.

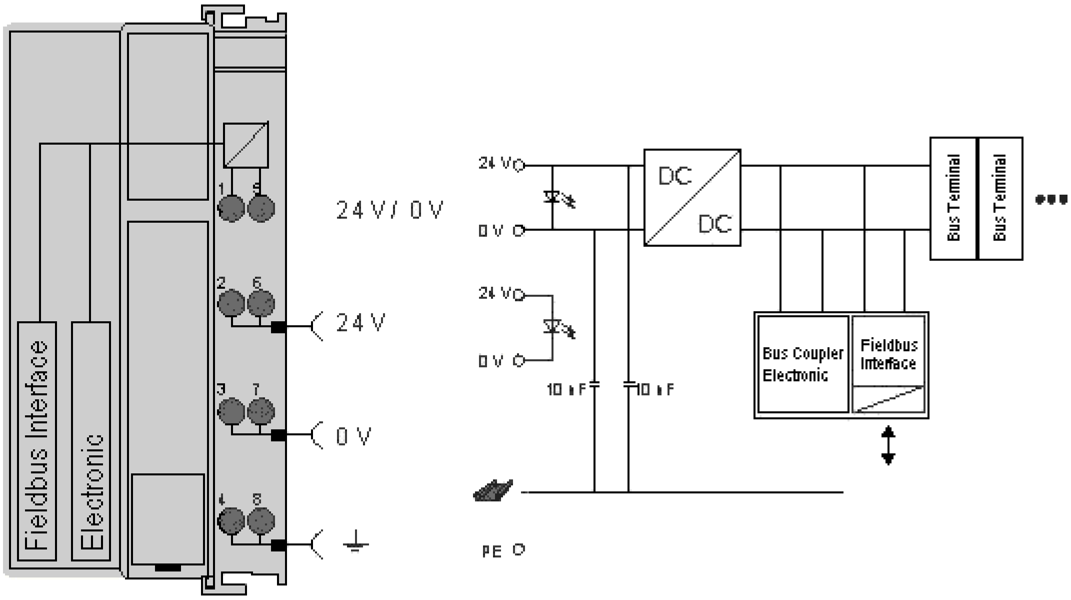

Fig. 11: Potential connection diagram of an EKxxxx

3.3.2.5 Power contacts

Power contacts supply (Up)

The bottom six connections with spring-loaded terminals can be used to feed the supply for the peripherals. The spring-loaded terminals are joined in pairs to a power contact. The power supply for the power contacts has no connection to the power supply for the Bus Couplers / Bus Terminal Controllers.

The spring-loaded terminals are designed for wires with cross-sections between 0.08 mm² and 2.5 mm².

The assignment in pairs and the electrical connection between feed terminal contacts allows the connection wires to be looped through to various terminal points. The current load from the power contact must not exceed 10 A for long periods. The current carrying capacity between two spring-loaded terminals is identical to that of the connecting wires.

Power contacts

Three spring contacts of the power contact connections can be found on the right of the Bus Coupler / Bus Terminal Controller. The spring contacts are hidden in slots so that they cannot be accidentally touched. By attaching a Bus Terminal the blade contacts on the left hand side of the Bus Terminal are connected to the spring contacts. The tongue & groove design of the top and bottom of the Bus Coupler / Bus Terminal Controller and Bus Terminals enables secure fitting of the power contacts.

3.3.3 CANopen cabling

Notes related to checking the CAN wiring can be found in the Trouble Shooting [▶ 107] section.

3.3.3.1 CAN topology

CAN is a 2-wire bus system, to which all participating devices are connected in parallel (i.e. using short drop lines). The bus must be terminated at each end with a 120 (or 121) Ohm terminating resistor to prevent reflections. This is also necessary even if the cable lengths are very short!

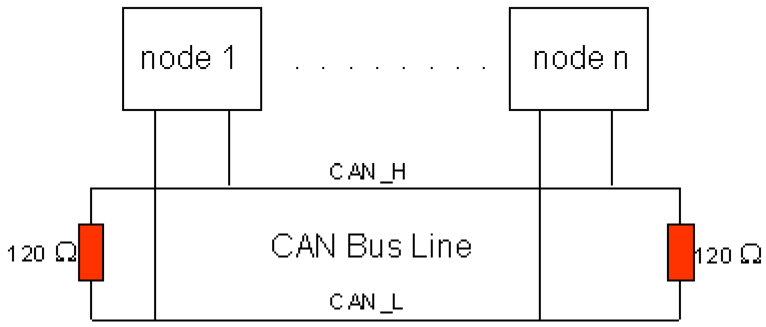

Fig. 12: Termination of the bus with a 120 Ohm termination resistor

Since the CAN signals are represented on the bus as the difference between the two levels, the CAN leads are not very sensitive to incoming interference (EMI): Both leads are affected, so the interference has very little effect on the difference.

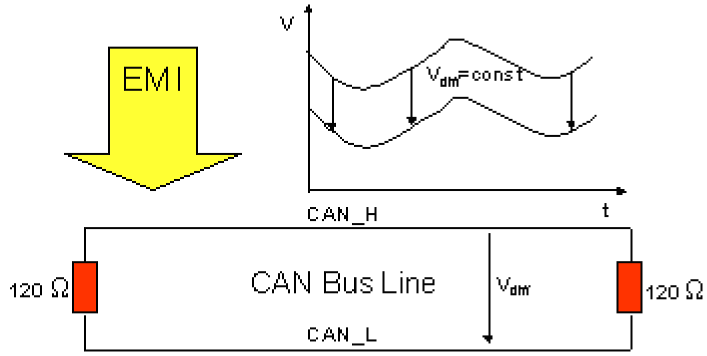

Fig. 13: Insensitivity to incoming interference

3.3.3.2 Bus length

The maximum length of a CAN bus is primarily limited by the signal propagation delay. The multi-master bus access procedure (arbitration) requires signals to reach all the nodes at effectively the same time (before the sampling within a bit period). Since the signal propagation delays in the CAN connecting equipment (transceivers, opto-couplers, CAN controllers) are almost constant, the line length must be chosen in accordance with the baud rate:

Baud rate	Bus length
1 Mbit/s	< 20 m*
500 kbit/s	< 100 m
250 kbit/s	< 250 m
125 kbit/s	< 500 m
50 kbit/s	< 1000 m
20 kbit/s	< 2500 m
10 kbit/s	< 5000 m

*) A figure of 40 m at 1 Mbit/s is often found in the CAN literature. This does not, however, apply to networks with optically isolated CAN controllers. The worst case calculation for opto-couplers yields a figure 5 m at 1 Mbit/s - in practice, however, 20 m can be reached without difficulty.

It may be necessary to use repeaters for bus lengths greater than 1000 m.

3.3.3.3 Drop lines

Drop lines must always be avoided as far as possible, since they inevitably cause reflections. The reflections caused by drop lines are not however usually critical, provided they have decayed fully before the sampling time. In the case of the bit timing settings selected in the Bus Couplers it can be assumed that this is the case, provided the following drop line lengths are not exceeded:

Baud rate	Drop line length	Total length of all drop lines
1 Mbit/s	< 1 m	< 5 m
500 kbit/s	< 5 m	< 25 m
250 kbit/s	< 10 m	< 50 m
125 kbit/s	< 20 m	< 100 m
50 kbit/s	< 50 m	< 250 m

Drop lines must not have terminating resistors.

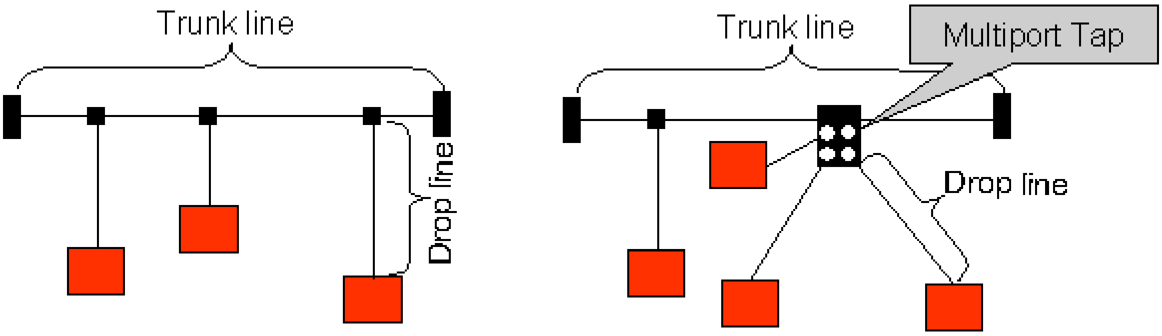

Fig. 14: Sample topology of drop lines

3.3.3.4 Star Hub (Multiport Tap)

Shorter drop line lengths must be maintained when passive distributors ("multiport taps"), such as the Beckhoff ZS5052-4500 Distributor Box. The following table indicates the maximum drop line lengths and the maximum length of the trunk line (without the drop lines):

Baud rate	Drop line length with multiport topology	Trunk line length (without drop lines)
1 Mbit/s	< 0,3 m	< 25 m
500 kbit/s	< 1,2 m	< 66 m
250 kbit/s	< 2,4 m	< 120 m
125 kbit/s	< 4,8 m	< 310 m

3.3.3.5 CAN cable

Screened twisted-pair cables (2x2) with a characteristic impedance of between 108 and 132 Ohm is recommended for the CAN wiring. If the CAN transceiver's reference potential (CAN ground) is not to be connected, the second pair of conductors can be omitted. (This is only recommended for networks of small physical size with a common power supply for all the participating devices).

ZB5100 CAN Cable

A high quality CAN cable with the following properties is included in Beckhoff's range:

- 2 x 2 x 0.25 mm² (AWG 24) twisted pairs, cable colors: red/black + white/black
- double screened
- braided screen with filler strand (can be attached directly to pin 3 of the 5-pin connection terminal)
- flexible (minimum bending radius 35 mm when bent once, 70 mm for repeated bending)

- characteristic impedance (60 kHz): 120 ohm
- conductor resistance < 80 Ohm/km
- sheath: grey PVC, outside diameter 7.3 +/- 0.4 mm
- Weight: 64 kg/km.
- printed with "Beckhoff ZB5100 CAN-BUS 2x2x0.25" and meter marking (length data every 20cm)

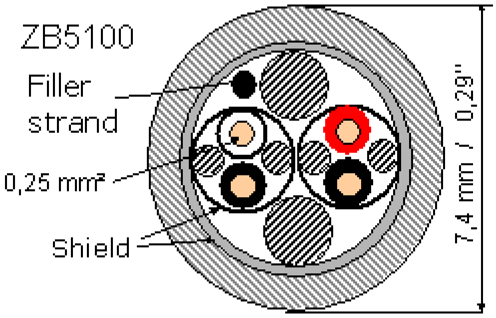

Fig. 15: Structure of CAN cable ZB5100

ZB5200 CAN/DeviceNet Cable

The ZB5200 cable material corresponds to the DeviceNet specification, and is also suitable for CANopen systems. The ready-made ZK1052-xxxx-xxxx bus cables for the Fieldbus Box modules are made from this cable material. It has the following specification:

- 2 x 2 x 0.34 mm² (AWG 22) twisted pairs
- double screened, braided screen with filler strand
- characteristic impedance (1 MHz): 126 ohm
- Conductor resistance 54 Ohm/km
- sheath: grey PVC, outside diameter 7.3 mm
- printed with "InterlinkBT DeviceNet Type 572" as well as UL and CSA ratings
- stranded wire colors correspond to the DeviceNet specification
- UL recognized AWM Type 2476 rating
- CSA AWM I/II A/B 80°C 300V FT1
- corresponds to the DeviceNet "Thin Cable" specification

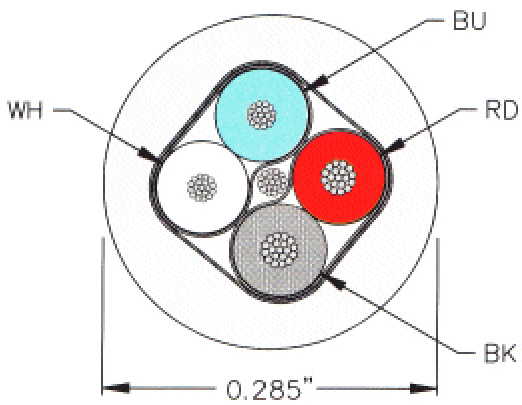

Fig. 16: Structure of CAN/DeviceNet cable ZB5200

3.3.3.6 Shielding

The screen is to be connected over the entire length of the bus cable, and only galvanically grounded at one point, in order to avoid ground loops.
The design of the screening, in which HF interference is diverted through R/C elements to the mounting rail

assumes that the rail is appropriately earthed and free from interference. If this is not the case, it is possible that HF interference will be transmitted from the mounting rail to the screen of the bus cable. In that case the screen should not be attached to the couplers - it should nevertheless still be fully connected through.

Notes related to checking the CAN wiring can be found in the Trouble Shooting [▶ 107] section.

3.3.3.7 Cable colors

Suggested method of using the Beckhoff CAN cable on Bus Terminal and Fieldbus Box:

BK51x0 pin PIN BX5100 (X510)	Pin BK5151 CX8050, CX8051, CXxxxx-B510/M510	Fieldbus Box pin	Pin FC51xx	Function	ZB5100 cable color	ZB5200 cable color
1	3	3	3	CAN Ground	**black/** (red)	**black**
2	2	5	2	CAN Low	**black**	**blue**
3	5	1	5	Shield	Filler strand	Filler strand
4	7	4	7	CAN high	**white**	**white**
5	9	2	9	not used	**(red)**	**(red)**

3.3.3.8 BK5151, FC51xx, CX with CAN interface and EL6751: D-sub, 9 pin

The CANbus cable is connected to the FC51x1, FC51x2 CANopen cards and in the case of the EL6751 CANopen master/slave terminal via 9-pin Sub-D sockets with the following pin assignment.

Pin	Assignment
2	CAN low (CAN-)
3	CAN ground (internally connected to pin 6)
6	CAN ground (internally connected to pin 3)
7	CAN high (CAN+)

The unlisted pins are not connected.
The mounting rail contact spring and the plug shield are connected together.

Note: an auxiliary voltage of up to 30 V_{DC} may be connected to pin 9. Some CAN devices use this to supply the transceiver.

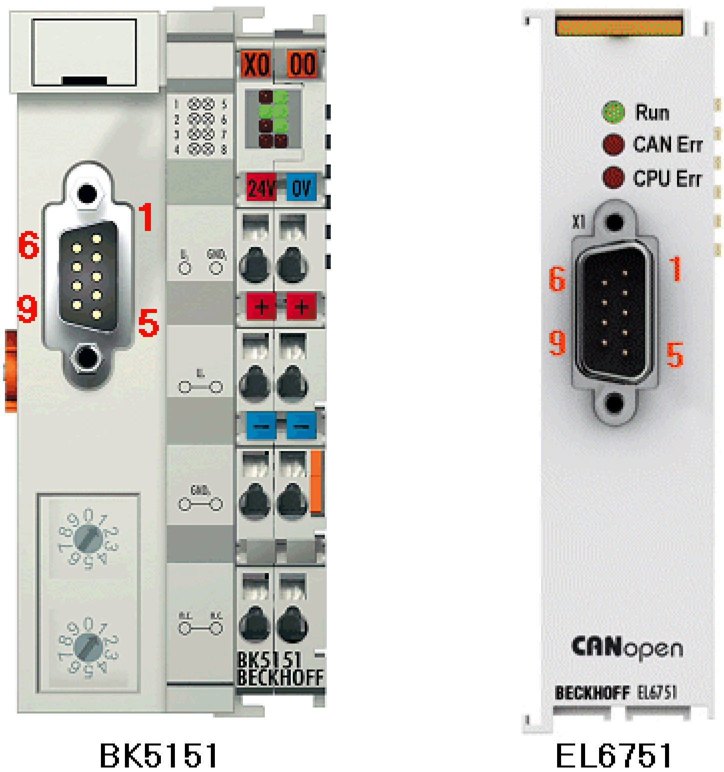

Fig. 17: BK5151, EL6751 pin assignment

FC51x2:

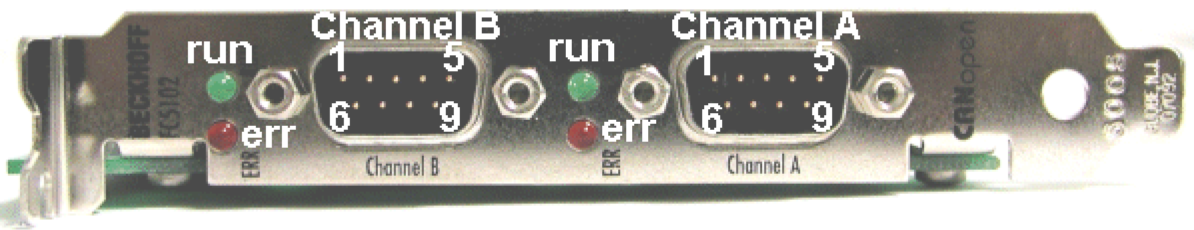

Fig. 18: FC51x2

3.3.3.9 BK51x0/BX5100: 5-pin open style connector

The BK51x0/BX5100 (X510) Bus Couplers have a recessed front surface on the left hand side with a five pin connector.
The supplied CANopen socket can be inserted here.

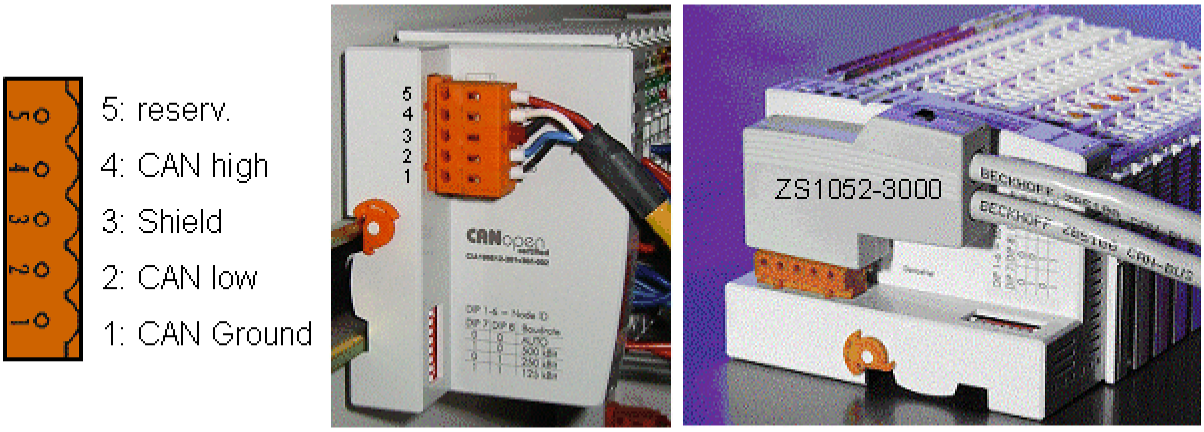

Fig. 19: BK51x0/BX5100 socket assignment

The left figure shows the socket in the BK51x0/BX5100 Bus Coupler. Pin 5 is the connection strip's top most pin. Pin 5 is not used. Pin 4 is the CAN high connection, pin 2 is the CAN low connection, and the screen is connected to pin 3 (which is connected to the mounting rail via an R/C network). CAN-GND can optionally be connected to pin 1. If all the CAN ground pins are connected, this provides a common reference potential for the CAN transceivers in the network. It is recommended that the CAN GND be connected to earth at one location, so that the common CAN reference potential is close to the supply potential. Since the CANopen BK51X0/BX5100 Bus Couplers provide full electrical isolation of the bus connection, it may in appropriate cases be possible to omit wiring up the CAN ground.

ZS1052-3000 Bus Interface Connector

The ZS1052-3000 CAN Interface Connector can be used as an alternative to the supplied connector. This makes the wiring significantly easier. There are separate terminals for incoming and outgoing leads and a large area of the screen is connected via the strain relief. The integrated terminating resistor can be switched externally. When it is switched on, the outgoing bus lead is electrically isolated - this allows rapid wiring fault location and guarantees that no more than two resistors are active in the network.

3.3.3.10 LC5100: Bus connection via spring-loaded terminals

In the low cost LC5100 Coupler, the CAN wires are connected directly to the contact points 1 (CAN-H, marked with C+) and 5 (CAN-L, marked with C-). The screen can optionally be connected to contact points 4 or 8, which are connected to the mounting rail via an R/C network.

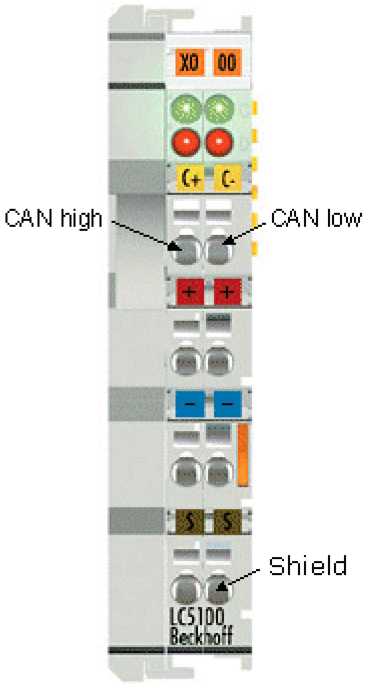

Fig. 20: LC5100

NOTE

Risk of device damage!

On account of the lack of electrical isolation, the CAN driver can be destroyed or damaged due to incorrect cabling. Always carry out the cabling in the switched-off condition.
First connect the power supply and then the CAN. Check the cabling and only then switch on the voltage.

3.3.3.11 Fieldbus Box: M12 CAN socket

The IPxxxx-B510, IL230x-B510 and IL230x-C510 Fieldbus Boxes are connected to the bus using 5-pin M12 plug-in connectors.

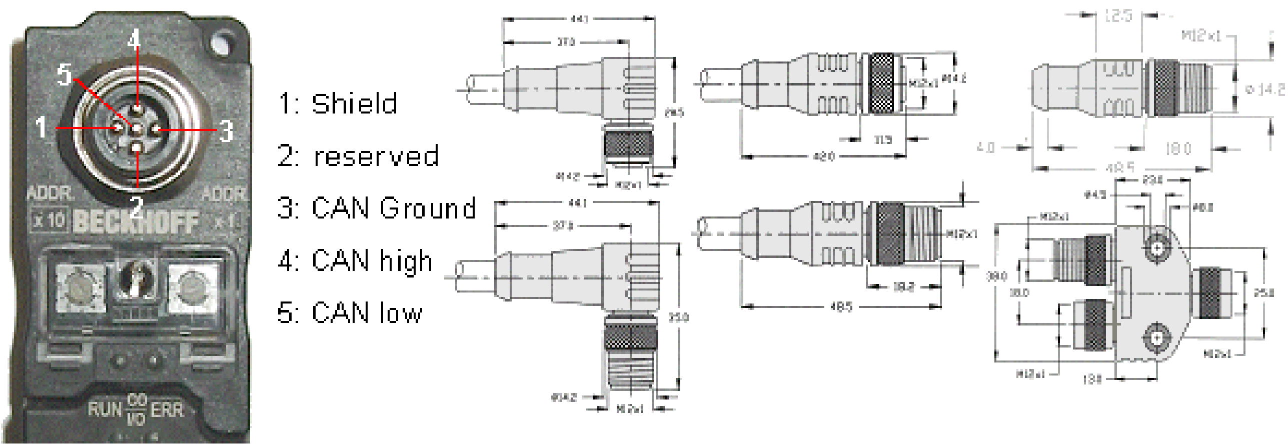

Fig. 21: Pin assignment: M12 plug, fieldbus box

Beckhoff offer plugs for field assembly, passive distributor's, terminating resistors and a wide range of pre-assembled cables for the Fieldbus Box system. Details be found in the catalogue, or under www.beckhoff.de.

3.4 ATEX - Special conditions (standard temperature range)

⚠ WARNING

Observe the special conditions for the intended use of Beckhoff fieldbus components with standard temperature range in potentially explosive areas (directive 2014/34/EU)!

- The certified components are to be installed in a suitable housing that guarantees a protection class of at least IP54 in accordance with EN 60079-15! The environmental conditions during use are thereby to be taken into account!
- For dust (only the fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9): The equipment shall be installed in a suitable enclosure providing a degree of protection of IP54 according to EN 60079-31 for group IIIA or IIIB and IP6X for group IIIC, taking into account the environmental conditions under which the equipment is used!
- If the temperatures during rated operation are higher than 70°C at the feed-in points of cables, lines or pipes, or higher than 80°C at the wire branching points, then cables must be selected whose temperature data correspond to the actual measured temperature values!
- Observe the permissible ambient temperature range of 0 to 55°C for the use of Beckhoff fieldbus components standard temperature range in potentially explosive areas!
- Measures must be taken to protect against the rated operating voltage being exceeded by more than 40% due to short-term interference voltages!
- The individual terminals may only be unplugged or removed from the Bus Terminal system if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- The connections of the certified components may only be connected or disconnected if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- The fuses of the KL92xx/EL92xx power feed terminals may only be exchanged if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- Address selectors and ID switches may only be adjusted if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!

Standards

The fundamental health and safety requirements are fulfilled by compliance with the following standards:

- EN 60079-0:2012+A11:2013
- EN 60079-15:2010
- EN 60079-31:2013 (only for certificate no. KEMA 10ATEX0075 X Issue 9)

Marking

The Beckhoff fieldbus components with standard temperature range certified according to the ATEX directive for potentially explosive areas bear one of the following markings:

II 3G KEMA 10ATEX0075 X Ex nA IIC T4 Gc Ta: 0 … +55°C

II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: 0 ... +55°C
(only for fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9)

or

II 3G KEMA 10ATEX0075 X Ex nA nC IIC T4 Gc Ta: 0 … +55°C

II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: 0 ... +55°C
(only for fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9)

3.5 ATEX - Special conditions (extended temperature range)

⚠ WARNING

Observe the special conditions for the intended use of Beckhoff fieldbus components with extended temperature range (ET) in potentially explosive areas (directive 2014/34/EU)!

- The certified components are to be installed in a suitable housing that guarantees a protection class of at least IP54 in accordance with EN 60079-15! The environmental conditions during use are thereby to be taken into account!
- For dust (only the fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9): The equipment shall be installed in a suitable enclosure providing a degree of protection of IP54 according to EN 60079-31 for group IIIA or IIIB and IP6X for group IIIC, taking into account the environmental conditions under which the equipment is used!
- If the temperatures during rated operation are higher than 70°C at the feed-in points of cables, lines or pipes, or higher than 80°C at the wire branching points, then cables must be selected whose temperature data correspond to the actual measured temperature values!
- Observe the permissible ambient temperature range of -25 to 60°C for the use of Beckhoff fieldbus components with extended temperature range (ET) in potentially explosive areas!
- Measures must be taken to protect against the rated operating voltage being exceeded by more than 40% due to short-term interference voltages!
- The individual terminals may only be unplugged or removed from the Bus Terminal system if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- The connections of the certified components may only be connected or disconnected if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- The fuses of the KL92xx/EL92xx power feed terminals may only be exchanged if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!
- Address selectors and ID switches may only be adjusted if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!

Standards

The fundamental health and safety requirements are fulfilled by compliance with the following standards:

- EN 60079-0:2012+A11:2013
- EN 60079-15:2010
- EN 60079-31:2013 (only for certificate no. KEMA 10ATEX0075 X Issue 9)

Marking

The Beckhoff fieldbus components with extended temperature range (ET) certified according to the ATEX directive for potentially explosive areas bear the following marking:

II 3G KEMA 10ATEX0075 X Ex nA IIC T4 Gc Ta: -25 … +60°C
II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: -25 ... +60°C
(only for fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9)

or

II 3G KEMA 10ATEX0075 X Ex nA nC IIC T4 Gc Ta: -25 … +60°C
II 3D KEMA 10ATEX0075 X Ex tc IIIC T135°C Dc Ta: -25 ... +60°C
(only for fieldbus components of certificate no. KEMA 10ATEX0075 X Issue 9)

3.6 Continuative documentation for ATEX and IECEx

NOTE

Continuative documentation about explosion protection according to ATEX and IECEx

Pay also attention to the continuative documentation

Ex. Protection for Terminal Systems
Notes on the use of the Beckhoff terminal systems in hazardous areas according to ATEX and IECEx,

that is available for download within the download area of your product on the Beckhoff homepage www.beckhoff.com!

4 Parametrization and commissioning

4.1 Start-up behaviour of the Bus Coupler

Immediately after being switched on, the Bus Coupler checks, in the course of a self-test, all the functions of its components and the communication on the K-bus/E-bus. The red I/O LED blinks while this is happening. After completion of the self-test, the Bus Coupler starts to test the attached Bus Terminals (the "Bus Terminal Test"), and reads in the configuration. The Bus Terminal configuration is used to generate an internal structure list, which is not accessible from outside. In case of an error, the Bus Coupler enters the *Stop* state. Once the start-up has completed without error, the Bus Coupler enters the *fieldbus start* state.

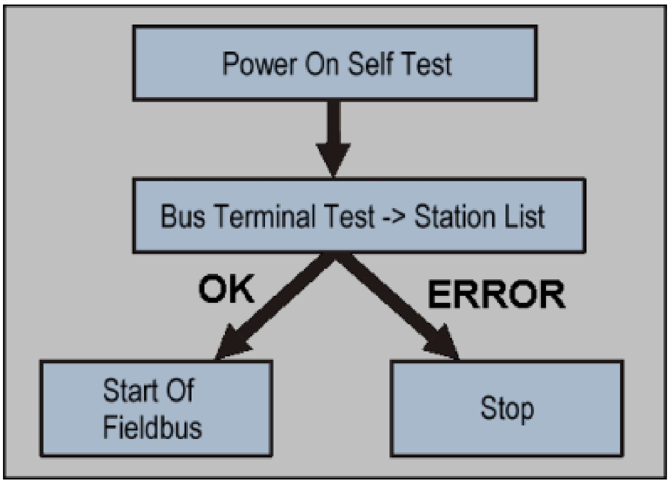

Fig. 22: Start-up behaviour of the Bus Coupler

The Bus Coupler can be made to enter the normal operating state by switching it on again once the fault has been rectified.

4.2 Address (NodeID)

BK5110, BK5120 and LC5100

Before starting the Bus Coupler, the node number (node ID) has to be set. These settings are made by means of 8 DIP switches on the coupler.

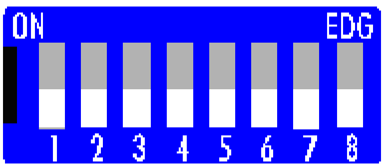

Fig. 23: DIP switch on BK5110, BK5120 and LC5100 - Setting the node ID

The coupler’s node ID is set with DIP switches 1 - 6. Switch 1 is the lowest value bit 2^0 and switch 6 the highest value bit 2^6. The bit is set when the switch is ON. The node ID can be set in the range from 0 to 63 (e.g. node ID = 14 -> switch 2, 3, 4 to ON), but the 0 is not allowed.

Each address may only occur once in the network. For changing an address the Bus Coupler must be switched off. The change in address is active as soon as the device is switched on.

BK5150 and BK5151

The node number (node ID) must be set via two rotary selection switches. The default setting is 11. All addresses from 0 to 63 are permitted. Each address may only occur once in the network. For changing an address the Bus Coupler must be switched off. The switches can be set to the required position using a screwdriver. Ensure that the switches engage correctly. The lower switch is the 10-multiplier, the upper switch is the 1-multiplier. The changed address is active as soon as the Bus Coupler is switched on again.

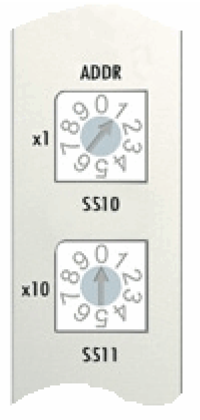

Fig. 24: Rotary selection switch on BK5150 and BK5151 - Setting the node ID

Sample

You want to set address 34.

- Set the lower rotary selection switch S511 to 3
- Set the upper rotary selection switch S510 to 4

4.3 Baud rate

Before starting the Bus Coupler, its baud rate has to be set.

BK5110, BK5120 and LC5100

This setting is made by means of the DIP switch on the coupler.

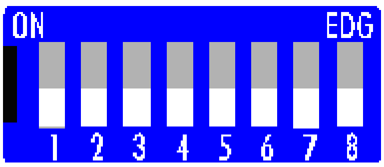

Fig. 25: DIP switch on BK5110, BK5120 and LC5100 - Setting the baud rate

The baud rate is set with switches 7 and 8.

The following table shows the possible baud rate settings.

Baud rate	DIP7	DIP8
Auto	0	0
500 kbit/s	1	0
250 kbit/s	0	1
125 kbit/s	1	1

BK5150 and BK5151

These Bus Couplers have no switch for the baud rate. Their default setting is auto baud rate.

Auto-Baud-Rate

Switch setting (0/0) activates the auto baud rate function (from firmware version B7). In order for automatic baud rate detection to function, it is necessary for a number of valid telegrams to be present on the bus at the desired baud rate. The RUN and CAN ERR LEDs blink in rapid alternation while the baud rate search is in progress. As soon as a baud rate has been detected and adopted, the Fieldbus Box begins initialization.

A software reset does not lead to a new baud rate search. The previously active baud rate is maintained.

Bit Timing

The following baud rates and entries in the bit-timing register are supported by the Beckhoff CANopen devices:

Baud-rate [kbaud]	BTR0	BTR1	Sampling Point
1000	0x00	0x14	75%
800	0x00	0x16	80%
500	0x00	0x1C	87%
250	0x01	0x1C	87%
125	0x03	0x1C	87%
100	0x04	0x1C	87%
50	0x09	0x1C	87%
20	0x18	0x1C	87%
10	0x31	0x1C	87%

The bit-timing register settings given (BTR0, BTR1) apply, e.g. for the Philips 82C200, SJA1000, Intel 80C527, Siemens 80C167 and other CAN controllers. They are optimized for the maximum bus length.

4.4 Configuration

4.4.1 Configuration overview

The Beckhoff CANopen bus components offer a wide range of configuration and setting facilities. The effort required for configuration remains, however, minimal, because sensible default values exist for all the parameters. These presettings mean that the requirements of the majority of applications are met without any difficulty.

The following list provides a summary of the devices' most important configuration options.

Node address

It is necessary for this to be set in every case, and done in such a way that no node addresses [▶ 36] are assigned more than once.

Baud rate [▶ 37]

Automatic baud rate function means that no manual configuration is required. A facility for manual setting has therefore been omitted from the Fieldbus Box modules.

PDO Parameters

PDO Identifier [▶ 55]

The CANopen default identifier allocation provides identifiers for up to 4 receive process data objects (RxPDOs) and for 4 transmit process data objects (TxPDOs). This means that CAN identifiers exist for the data from, for instance, 64 digital input/outputs and 12 analog input/outputs. If there is more than one input/output, their data is, by default, mapped into PDOs 5 to 16 (see Default Mapping for details). Identifiers for

PDOs 5 to 11 can easily be enabled by writing to object 0x5500 [▶ 71]. If more than 11 PDOs are required, or if the default identifier allocation [▶ 66] does not satisfy the requirements of the application, then the identifiers can be set individually (see objects 0x1400ff [▶ 71] and 0x1800ff [▶ 71]).

PDO Communication type [▶ 56]

The communication technique for each process data object can be set individually: event-driven (default), polled or synchronized.

PDO Mapping [▶ 59]

The data associated with the inputs and outputs is assigned (through the default mapping) to the process data objects when the module starts up. This assignment (mapping) can be modified if required (see objects 0x1600ff [▶ 71] and 0x1A00ff [▶ 71]).

Heartbeat/Guarding [▶ 53]

The modules respond to guarding requests without the need for special configuration. If the modules are to send status information on their own initiative (heartbeat), or if the modules are required to react to the absence of the request telegrams or of the master heartbeat, then the corresponding parameters do need to be set (guarding: object 0x100C [▶ 71] ff.; heartbeat: object 0x1016 [▶ 71] ff.)

The list of all the parameters accessible via CAN is located in the object directory.

Reachability of the objects and registers

The objects in the object directory can be reached by SDO access, but not generally through the KS2000 [▶ 39] configuration software. On the other hand, all the registers that can be configured with KS2000 can also be reached using SDO access to the object directory (objects 0x4500 [▶ 71] and 0x4501 [▶ 71]) - even though this does not offer the same convenience as the KS2000 software.

4.4.2 Configuration Files

The parameters and possible settings of CANopen devices are listed in the configuration files (electronic data sheets, or eds files). These eds files can be read by configuration tools. The structure and syntax of eds files is defined in CiA DSP 306. A tool can be downloaded from the website maintained by the CAN in Automation Association (http://www.can-cia.de) with which the eds files can be checked for consistency with the standard.

The eds files for the Beckhoff CANopen bus components are available on the BECKHOFF site (http://www.beckhoff.de) and on the Beckhoff product CDs.

4.4.3 KS2000 - Introduction

The KS2000 configuration software permits configuration, commissioning and parameterization of bus couplers, of the affiliated bus terminals and of Fieldbus Box Modules. The connection between bus coupler / Fieldbus Box Module and the PC is established by means of the serial configuration cable or the fieldbus.

Fig. 26: KS2000 configuration software

Configuration

You can configure the Fieldbus stations with the Configuration Software KS2000 offline. That means, setting up a terminal station with all settings on the couplers and terminals resp. the Fieldbus Box Modules can be prepared before the commissioning phase. Later on, this configuration can be transferred to the terminal station in the commissioning phase by means of a download. For documentation purposes, you are provided with the breakdown of the terminal station, a parts list of modules used and a list of the parameters you have modified. After an upload, existing fieldbus stations are at your disposal for further editing.

Parameterization

KS2000 offers simple access to the parameters of a fieldbus station: specific high-level dialogs are available for all bus couplers, all intelligent bus terminals and Fieldbus Box modules with the aid of which settings can be modified easily. Alternatively, you have full access to all internal registers of the bus couplers and intelligent terminals. Refer to the register description for the meanings of the registers.

Commissioning

The KS2000 software facilitates commissioning of machine components or their fieldbus stations: Configured settings can be transferred to the fieldbus modules by means of a download. After a *login* to the terminal station, it is possible to define settings in couplers, terminals and Fieldbus Box modules directly *online*. The same high-level dialogs and register access are available for this purpose as in the configuration phase.

The KS2000 offers access to the process images of the bus couplers and Fieldbus Box modules.

- Thus, the coupler's input and output images can be observed by monitoring.
- Process values can be specified in the output image for commissioning of the output modules.

All possibilities in the *online mode* can be used in parallel with the actual fieldbus mode of the terminal station. The fieldbus protocol always has the higher priority in this case.

4.4.4 Configuration via TwinCAT

The TwinCAT automation software is a complete automation solution for PC-compatible computers. TwinCAT turns any compatible PC into a real-time controller, an IEC 61,131-3 Multi-PLC, NC positioning system, the corresponding programming environment and user interface. TwinCAT supports several different CANopen PC cards. Beckhoff recommends the CANopen PCI master card FC5101, which can also be obtained as a two-channel version (FC5102).

System Manager

The TwinCAT system is used for configuring the FC510x CANopen master card. The System Manager provides a representation of the number of programs of the TwinCat PLC systems, the configuration of the axis control and of the connected I/O channels as a structure, and organizes the mapping of the data traffic.

Fig. 27: TwinCAT System Manager

For applications without TwinCAT PLC or NC, the TwinCAT System Manager configures the programming interfaces for a wide range of application programs:

- ActiveX control (ADS-OCX) for e.g. Visual Basic, Visual C++, Delphi, etc.
- DLL interface (ADS-DLL) for e.g. Visual C++ projects
- Script interface (ADS script DLL) for e.g. VBScript, JScript, etc.

The TwinCAT system manager has the following properties:

- Bit-wise connection between server process images and I/O channels
- Standard data formats such as arrays and structures
- User defined data formats
- Continuous variable linking
- Drag and Drop
- Import and export at all levels

Procedure when configuring the CANopen input/output modules

1. The corresponding CANopen master PC card is selected first, and inserted into the I/O configuration.

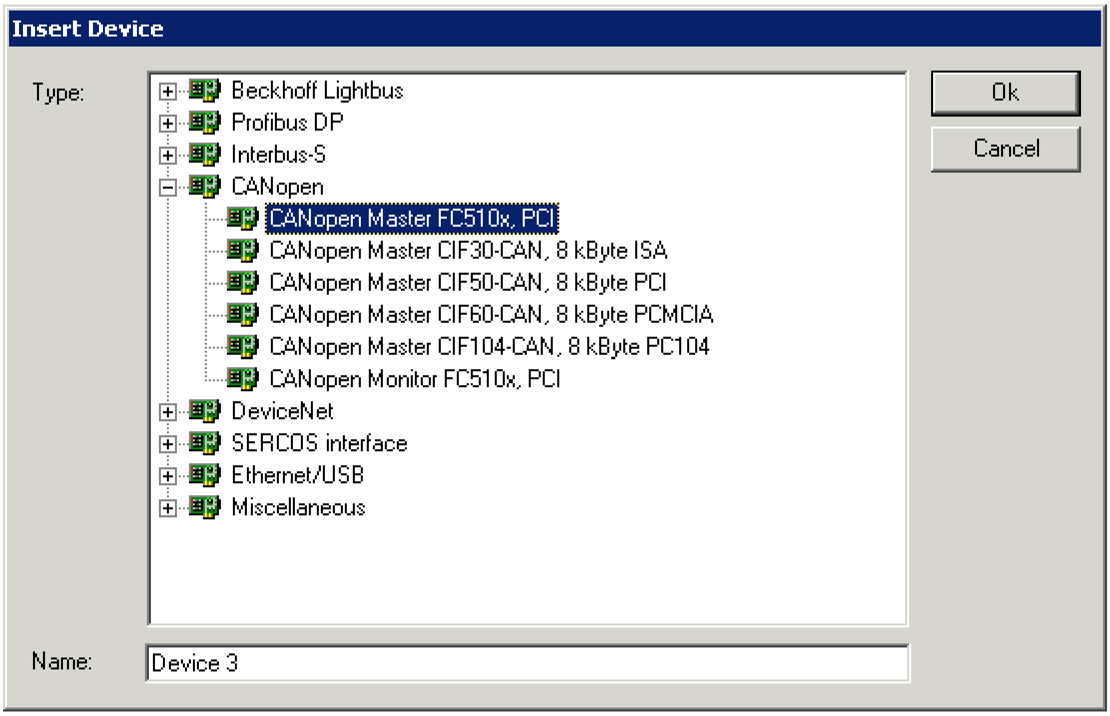

Fig. 28: TwinCAT - selecting the CANopen master PC card

2. The baud rate and, if appropriate, the master node ID (for the heartbeat protocol) are now set.

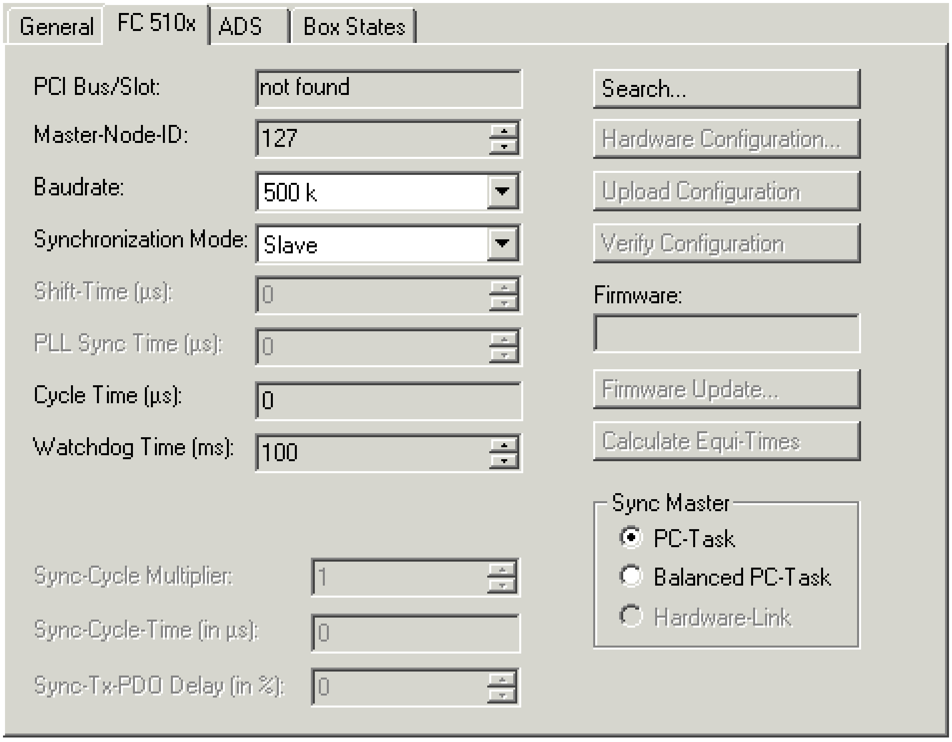

Fig. 29: TwinCAT - setting the baud rate and the master node ID, if required

3. Following the master card, the bus nodes are then inserted:

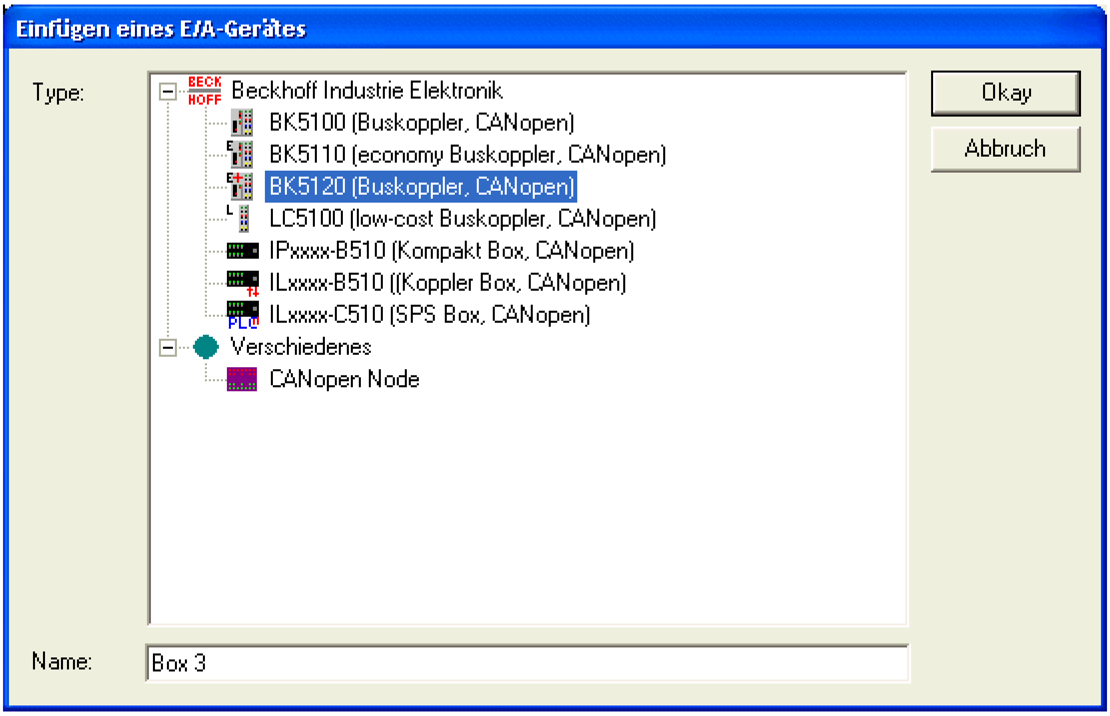

Fig. 30: TwinCAT - adding the bus nodes

4. The appropriate Bus Terminals or I/O versions and extension boxes are now appended at the CANopen Bus Coupler, Compact or Coupler Box.

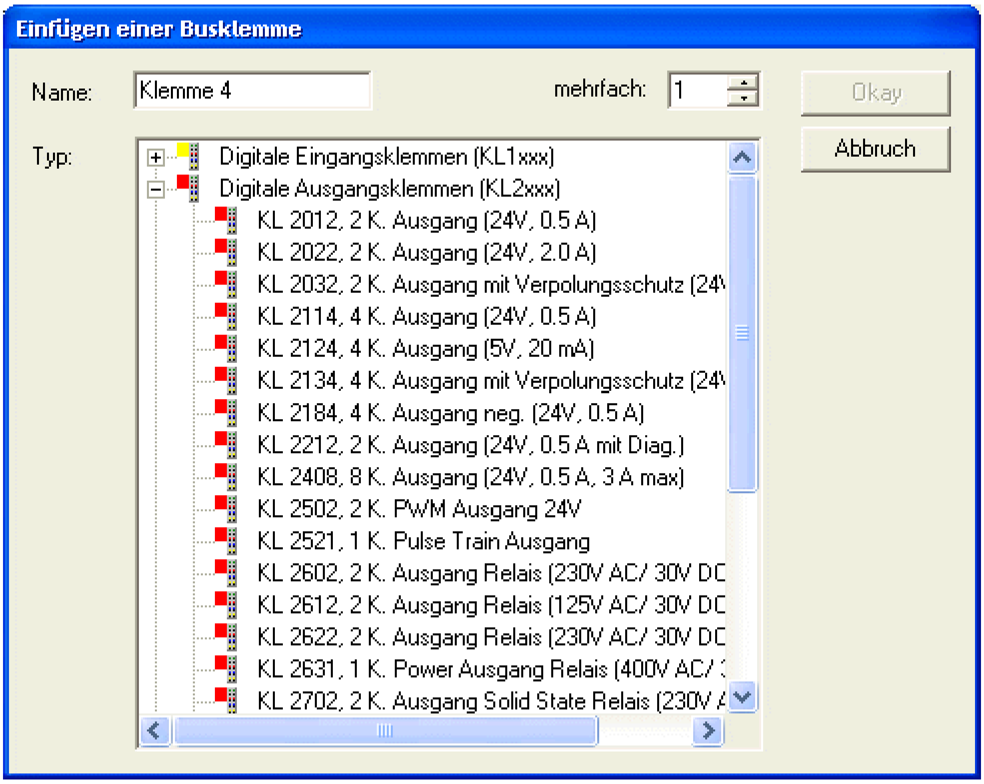

Fig. 31: TwinCAT - adding Bus Terminals or extension boxes

5. The communication properties for these bus nodes are now configured:

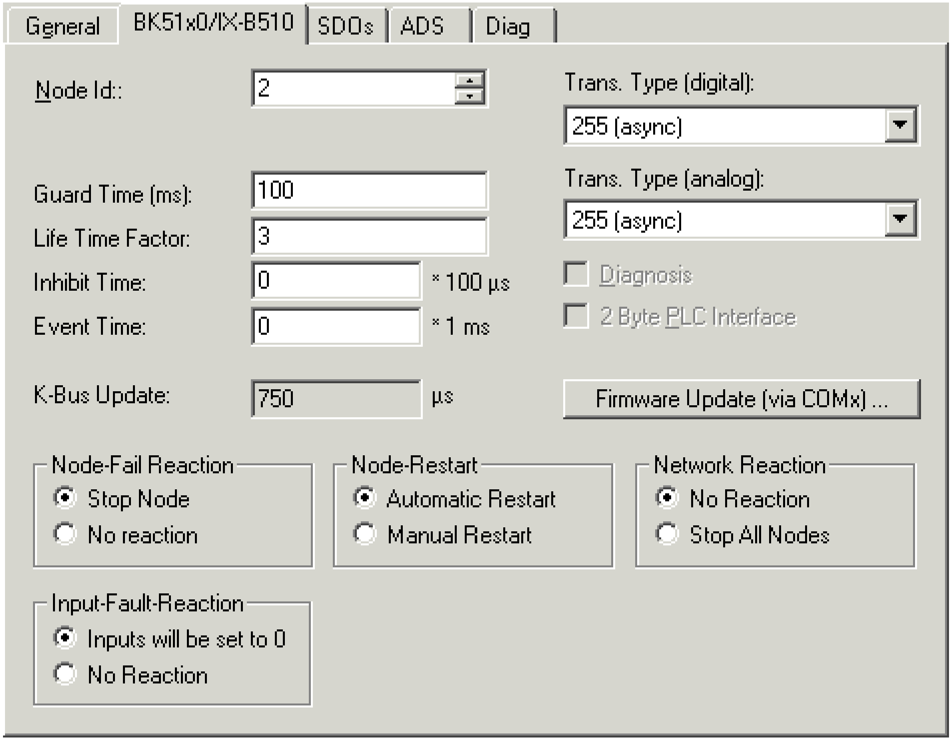

Fig. 32: TwinCAT - Bus node configuration

Node Id

Sets the node ID of the CAN bus device (between 1 and 63 (BK51x0) and/or 1 and 99 (IPxxxx-B510)). This value must comply with the value set at the Bus Coupler and/or at the compact box.

Guard time

Cycle time for the node monitoring (node guarding). In the case of the FC5101 this time is used as the producer heartbeat time.

Life time factor

Guard time multiplied produces the watchdog time for the monitoring of the master by the coupler (life guarding). Life guarding is deactivated if the lifetime factor is set to zero. The watchdog time is used as the consumer heartbeat time in bus nodes that support heartbeat.

Inhibit Time

Displays the minimum send interval for PDOs (telegrams) with analog and special signals. If more than digital 64 signals are present, these are also provided with this Inhibit Time.

Event Time

The event time for PDOs 1 and 2 (Rx + Tx) of this node is set here.

K-Bus Update

Calculates the anticipated duration of a complete update of the K-Bus (according to type and number of connected terminals).

Trans.Type

Indicates the transmission type [▸ 56] for digital or analog input telegrams. 254 & 255 relate to event-driven transmission, 1...240 are synchronous transmission types. For further details see also BK51X0 manual.

Firmware Update

Enables the updating of the coupler firmware via the serial interface (requires KS2000 software package interface cable).

Diagnostic Inputs

FC510x: Each CANopen fieldbus node contains one diagnostic input byte (Node State), which signals the status of the current slave during the running time and can be linked, e.g. with the PLC. In addition a signal is sent via the "Diag Flag" bit informing as to whether the card contains new Diagnostic Information. This can then be read via ADS READ.

CIF30-CAN: Each CANopen fieldbus box node contains one diagnostic input byte (Box State), which signals the status of the current slave during the running time and can be linked, e.g. with the PLC. In addition there is a further bit ”DataExchange", which indicates whether the node is exchanging data.

The *SDOs* tab

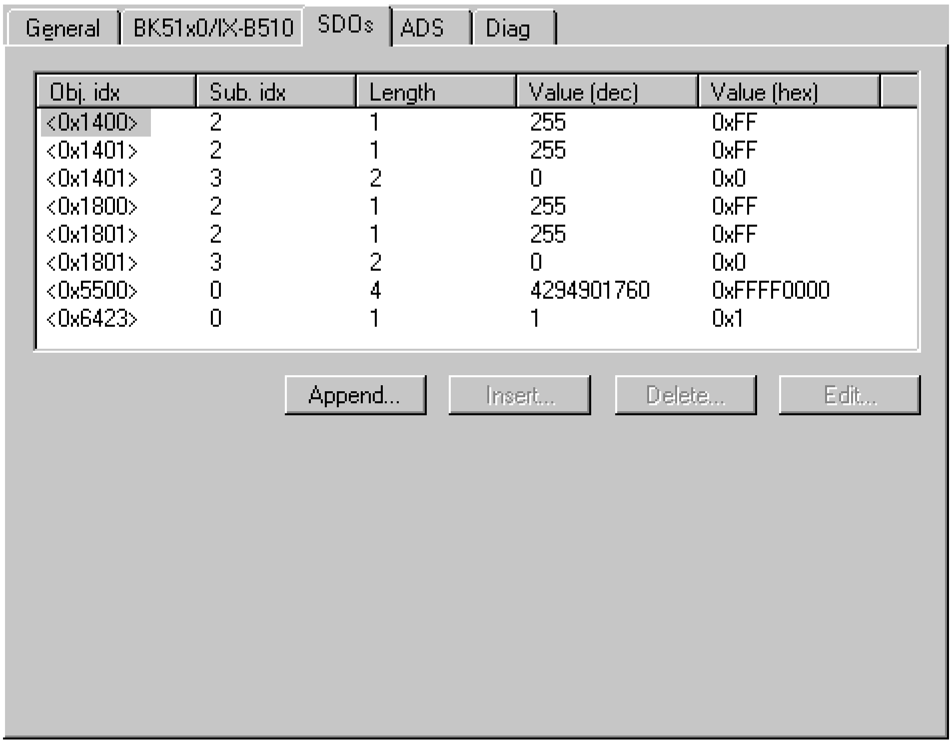

Fig. 33: The *SDOs* tab

SDO inputs sent to the node at StartUp are displayed/managed on this page. Inputs with an object index in straight brackets are automatically created on the basis of the updated terminal configuration. Other inputs can be managed using *Add, Insert, Delete* and *Edit*.

The *ADS* tab

In order to be able to read and write SDO objects during the running time (e.g. from the PLC), the node (Bus Coupler) can be allocated an ADS port (CIFx0-CAN). The FC510x provides an ADS port at all times for every node since the diagnostic information is transported via ADS. These ports can be used to read and write SDO objects using ADS read requests and/or write requests.

The ADS IndexGroup contains the CANopen object index and the ADS IndexOffset contains the CANopen Sub-Index.

CANopen Emergency Object

Some CANopen status data and emergency objects received from a node can be read by any TwinCAT program via ADS and/or signaled to any TwinCAT program. The data structures and addresses distinguish between the FC510x and the CIFx0-CAN.

Further documentation

More information on the configuration of CANopen bus nodes and master cards under TwinCAT can be found in the TwinCAT documentation or in the manual for the relevant master card.

4.4.5 Configuration with third party controllers

CANopen interfaces are available for a large number of programmable logic controllers (PLCs), embedded controllers and Industrial PCs. The range of configuration tools for these CANopen interfaces is large: it ranges from the simple "CAN layer 2 interface" in which the user has to set up each individual CAN object himself, and therefore must, so to speak, recreate CANopen, up to convenient configuration tools with drag-and-drop functionality.

In the present handbook, all the required CAN objects are deliberately described right down to the bit representation on the CAN bus. This means that the BECKHOFF CANopen devices can also be addressed directly from a simple CAN interface. In this respect, the Quick start for experienced users [▸ 111] section may be particularly helpful.

The eds files [▸ 39] are available for download for the purposes of configuration using general CANopen configuration tools. With these tools it is usually sufficient to recreate the default mapping of the input/output modules.

For more precise details of the configuration, it is necessary to consult the manuals provided by the software manufacturer concerned.

5 Automatic PDO Mapping

BK51x0, IL23x0-B510

PDO1 and PDO2 are occupied, as described, with digital and analog process data. For each further PDO the CANopen node uses the procedure shown in the flow diagram below and assigns process data to the PDOs in the following order:

1. Digital I/Os (if more than 64 are present)
2. 1-bytes special terminals
3. Analog I/Os
4. 2-bytes special terminals
5. 3-bytes special terminals
   …
6. 10. 8-bytes special terminals

Data types are not mixed! A new PDO is taken for each new data type (sample see below).

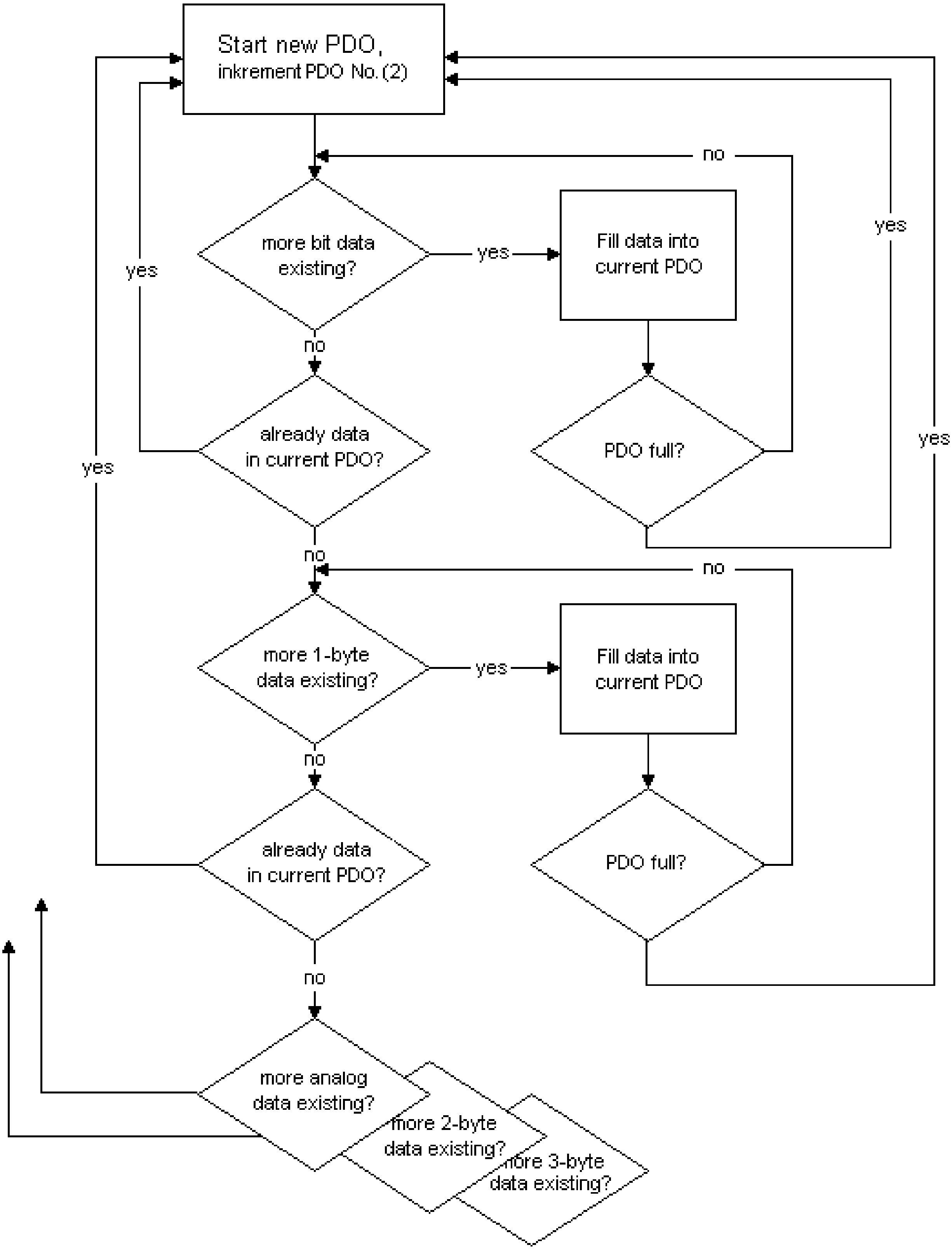

Fig. 34: Automatic PDO Mapping

Sample

A BK5120 (CANopen Coupler) has:

- 78 digital inputs and 48 digital outputs
- 6 analog inputs and 4 analog outputs
- a KL5001 (SSI encoder interface: 4 byte inputs by default)

- a KL6001 (serial interface: 4 byte inputs and 4 byte outputs by default)
- a KL5111 (incremental encoder interface) (6-byte inputs and 6-byte outputs)
- a KL6201 AS-i master terminal with default setting (22-byte process data interface)

PDO	Data content (Mapping)	Object directory	PDO	Data content (Mapping)	Object directory
RxPDO1	5-byte digital outputs 1...48	0x6200, SI 1...5	TxPDO1	8-byte digital inputs 1...64	0x6000, SI 1..8
RxPDO2	8-byte analog outputs 1..4	0x6411, SI 1...4	TxPDO2	4-byte analog inputs 1...4	0x6401, SI 1...4
RxPDO3	4-byte serial interface	0x2900, SI 1	TxPDO3	2-byte digital inputs 65...78	0x6000, SI 9...10
RxPDO4	6-byte encoder outputs	0x2D00, SI 1	TxPDO4	analog inputs 5 and 6	0x6401, SI 5...6
RxPDO5	8-byte ASI master 1: parameter data block	0x3100, SI 1	TxPDO5	8 bytes: 4-byte SSI and 4-byte serial interface	0x2800, SI 1...2
RxPDO6	8-byte ASI master 1: Process data block outputs ASI slave 1...15	0x3100, SI 2	TxPDO6	6 bytes encoder input	0x2C00, SI 1
RxPDO7	8-byte ASI master 1: Process data block outputs ASI slave 16...31	0x3100, SI 3	TxPDO7	8-byte ASI master 1: parameter data block	0x3000, SI 1
			TxPDO8	8-byte ASI master 1: Process data block inputs ASI slave 1...15	0x3000, SI 2
			TxPDO9	8-byte ASI master 1: Process data block inputs ASI slave 16...31	0x3000, SI 3

6 CANopen Communication

6.1 Protocol Description

6.1.1 Network Management

Simple Boot-Up

CANopen allows the distributed network to boot in a very simple way. After initialization, the modules are automatically in the *Pre-Operational* state. In this state it is already possible to access the object directory using service data objects (SDOs) with default identifiers, so that the modules can be configured. Since default settings exist for all the entries in the object directory, it is in most cases possible to omit any explicit configuration.

Only one CAN message is then required to start the module: Start_Remote_Node: Identifier *0*, two data bytes: 0x01, 0x00. It switches the node into the *Operational* state.

Network Status

The states and the state transitions involved as CANopen boots up can be seen from the state diagram:

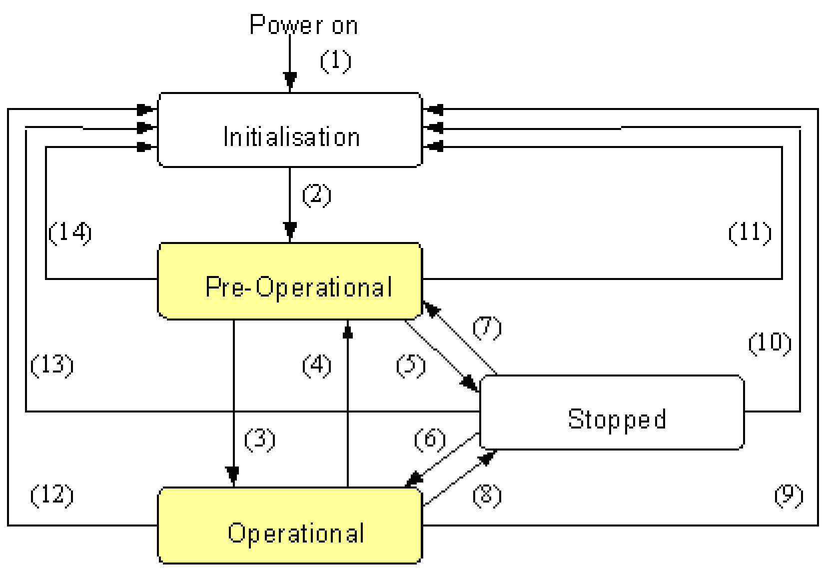

Fig. 35: CANopen bootup state diagram

Pre-Operational

After initialization the Bus Coupler goes automatically (i.e. without the need for any external command) into the *Pre-Operational* state. In this state it can be configured, since the service data objects (SDOs) are already active. The process data objects, on the other hand, are still locked.

Operational

In the *Operational* state the process data objects are also active.

If external influences (such as a CAN error, or absence of output voltage) or internal influences (such as a K-Bus error) mean that it is no longer possible for the Bus Coupler to set outputs, to read inputs or to communicate, it attempts to send an appropriate emergency message, goes into the error state, and thus returns to the *Pre-Operational* state. In this way the NMT status machine in the network master can also immediately detect fatal errors.

Stopped

In the *Stopped* state (formerly: *Prepared*) data communication with the Coupler is no longer possible - only NMT messages are received. The outputs go into the fault state.

State Transitions

The network management messages have a very simple structure: CAN identifier *0*, with two bytes of data content. The first data byte contains what is known as the command specifier (cs), and the second data byte contains the node address, the node address *0* applying to all nodes (broadcast).

11 bit identifier	2 byte user data							
0x00	cs	Node ID						

The following table gives an overview of all the CANopen state transitions and the associated commands (command specifier in the NMT master telegram):

Status transition	Command Specifier cs	Explanation
(1)	-	The initialization state is reached automatically at power-up
(2)	-	After initialization the pre-operational state is reached automatically - this involves sending the boot-up message.
(3), (6)	cs = 1 = 0x01	Start_Remote_Node. Starts the module, enables outputs, starts transmission of PDOs.
(4), (7)	cs = 128 = 0x80	Enter_Pre-Operational. Stops PDO transmission, SDO still active.
(5), (8)	cs = 2 = 0x02	Stop_Remote_Node. Outputs go into the fault state, SDO and PDO switched off.
(9), (10), (11)	cs = 129 = 0x81	Reset_Node. Carries out a reset. All objects are reset to their power-on defaults.
(12), (13), (14)	cs = 130 = 0x82	Reset_Communication. Carries out a reset of the communication functions. Objects 0x1000 - 0x1FFF are reset to their power-on defaults.

Sample 1

The following telegram puts all the modules in the network into the error state (outputs in a safe state):

11 bit identifier	2 byte of user data							
0x00	0x02	0x00						

Sample 2

The following telegram resets node 17:

11 bit identifier	2 byte of user data							
0x00	0x81	0x11						

Boot-up message

After the initialization phase and the self-test the Bus Coupler sends the boot-up message, which is a CAN message with a data byte (0) on the identifier of the guarding or heartbeat message: CAN-ID = 0x700 + node ID. In this way temporary failure of a module during operation (e.g. due to a voltage drop), or a module that is switched on at a later stage, can be reliably detected, even without Node Guarding. The sender can be determined from the message identifier (see default identifier allocation).

It is also possible, with the aid of the boot-up message, to recognize the nodes present in the network at start-up with a simple CAN monitor, without having to make write access to the bus (such as a scan of the network by reading out parameter 0x1000).

Finally, the boot-up message communicates the end of the initialization phase; the Bus Coupler signals that it can now be configured or started.

Firmware version BA

Up to firmware version BA the emergency identifier was used for the boot up message.

Format of the Boot-up message

11 bit identifier	1 byte of user data						
0x700 (=1792)+ node ID	0x00						

Node Monitoring

Heartbeat and guarding mechanisms are available to monitor failures in the CANopen network. These are of particular importance for CANopen, since modules do not regularly speak in the event-driven mode of operation. In the case of "guarding", the devices are cyclically interrogated about their status by means of a data request telegram (remote frame), whereas with "heartbeat" the nodes transmit their status on their own initiative.

Guarding: Node Guarding and Life Guarding

Node Guarding is used to monitor the non-central peripheral modules, while they themselves can use Life Guarding to detect the failure of the guarding master. Guarding involves the master sending remote frames (remote transmit requests) to the guarding identifier of the slaves that are to be monitored. These reply with the guarding message. This contains the slave’s status code and a toggle bit that has to change after every message. If either the status or the toggle bit do not agree with that expected by the NMT master, or if there is no answer at all, the master assumes that there is a slave fault.

Guarding procedure

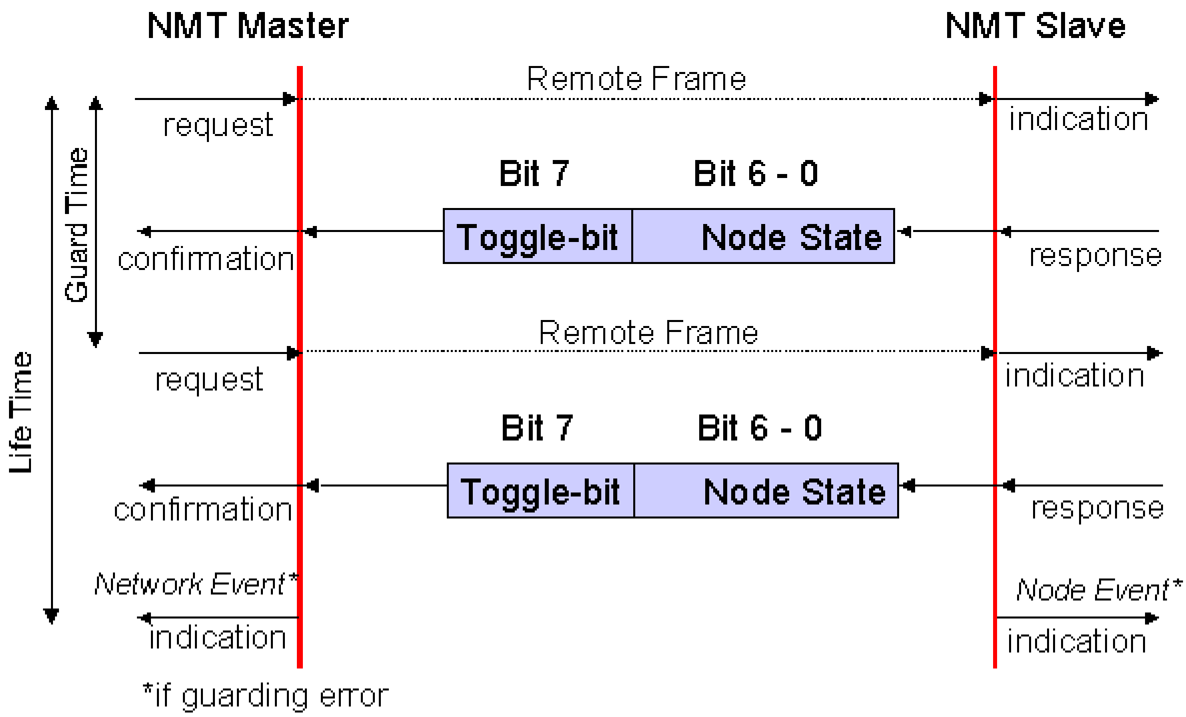

Fig. 36: Schematic diagram: "Guarding procedure"

Protocol

The toggle bit (t) transmitted in the first guarding telegram has the value *0*. After this, the bit must change (toggle) in every guarding telegram so that the loss of a telegram can be detected. The node uses the remaining seven bits to transmit its network status (s):

s	Status
4 = 0x04	Stopped (previously: Prepared)
5 = 0x05	Operational
127 = 0x7F	Pre-Operational

Sample

The guarding message for node 27 (0x1B) must be requested by a remote frame having identifier 0x71B (1819_{dec}). If the node is *Operational*, the first data byte of the answer message alternates between 0x05 and 0x85, whereas in the *Pre-Operational* state it alternates between 0x7F and 0xFF.

Guard time and life time factor

If the master requests the guard messages in a strict cycle, the slave can detect the failure of the master. In this case, if the slave fails to receive a message request from the master within the set *Node Life Time* (a guarding error), it assumes that the master has failed (the watchdog function). It then puts its outputs into the error state, sends an emergency telegram, and returns to the pre-operational state. After a guarding time-out the procedure can be re-started by transmitting a guarding telegram again.

The node life time is calculated from the guard time (object 0x100C) and life time factor (object 0x100D) parameters:

Life time = guard time x life time factor

If either of these two parameters is "0" (the default setting), the master will not be monitored (no life guarding).

Heartbeat: Node Monitoring without Remote Frame

In the heart beat procedure, each node transmits its status message cyclically on its own initiative. There is therefore no need to use remote frames, and the bus is less heavily loaded than under the guarding procedure.

The master also regularly transmits its heartbeat telegram, so that the slaves are also able to detect failure of the master.

Heartbeat procedure

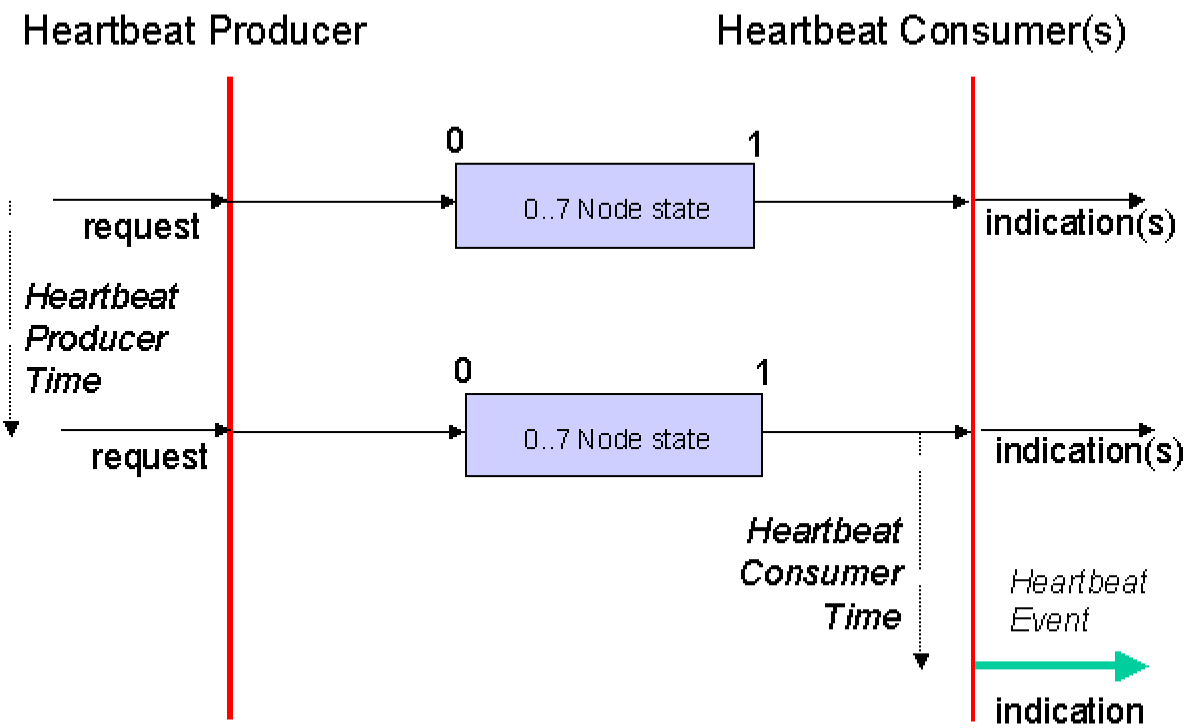

Fig. 37: Schematic diagram: "Heartbeat procedure"

Protocol

The toggle bit is not used in the heart beat procedure. The nodes send their status cyclically (s). See Guarding [▶ 53].

6.1.2 Process Data Objects (PDO)

Introduction

In many fieldbus systems the entire process image is continuously transferred - usually in a more or less cyclic manner. CANopen is not limited to this communication principle, since the multi-master bus access protocol allows CAN to offer other methods. Under CANopen the process data is not transferred in a master/ slave procedure, but follows instead the producer-consumer model. In this model, a bus node transmits its data, as a producer, on its own accord. This might, for example, be triggered by an event. All the other nodes listen, and use the identifier to decide whether they are interested in this telegram, and handle it accordingly. These are the consumers.

The process data in CANopen is divided into segments with a maximum of 8 bytes. These segments are known as process data objects (PDOs). The PDOs each correspond to a CAN telegram, whose specific CAN identifier is used to allocate them and to determine their priority. Receive PDOs (RxPDOs) and transmit PDOs (TxPDOs) are distinguished, the name being chosen from the point of view of the device: an input/ output module sends its input data with TxPDOs and receives its output data in the RxPDOs. **This naming convention is retained in the TwinCAT System Manager.**

Communication parameters

The PDOs can be given different communication parameters according to the requirements of the application. Like all the CANopen parameters, these are also available in the device's object directory, and can be accessed by means of the service data objects. The parameters for the receive PDOs are at index 0x1400 (RxPDO1) onwards. There can be up to 512 RxPDOs (ranging up to index 0x15FF). In the same way, the entries for the transmit PDOs are located from index 0x1800 (TxPDO1) to 0x19FF (TxPDO512).

The Beckhoff Bus Couplers or Fieldbus Coupler Box modules make 16 RxPDO and TxPDOs available for the exchange of process data (although the figure for Economy and LowCost BK5110 and LC5100 Couplers and the Fieldbus Boxes is 5 PDOs each, since these devices manage a lower quantity of process data). The FC510x CANopen master card supports up to 192 transmit and 192 receive PDOs for each channel - although this is restricted by the size of the DPRAM. The EL6751 CANopen terminal dynamically organizes the process image; i.e. the process data are written in succession, enabling a higher data transmission rate. Up to 32 TxPDOs and 32 RxPDOs can be handled in slave mode.

For each existing process data object there is an associated communication parameter object. The TwinCAT System Manager automatically assigns the set parameters to the relevant object directory entries. These entries and their significance for the communication of process data are explained below.

PDO Identifier

The most important communication parameter in a PDO is the CAN identifier (also known as the communication object identifier, or COB-ID). It is used to identify the data, and determines their priority for bus access. For each CAN data telegram there may only be one sender node (producer), although all messages sent in the CAN broadcast procedure can be received, as described, by any number of nodes (consumers). Thus a node can make its input information available to a number of bus devices at the same time - even without transferring them through a logical bus master. The identifier is located in sub-index 1 of the communication parameter set. It is coded as a 32-bit value in which the least significant 11 bits (bits 0...10) contain the identifier itself. The data width of the object of 32 bits also allows 29-bit identifiers in accordance with CAN 2.0B to be entered, although the default identifiers always refer to the more usual 11-bit versions. Generally speaking, CANopen is economical it its use of the available identifiers, so that the use of the 29-bit versions remains limited to unusual applications. It is therefore also not supported by a Beckhoff's CANopen devices. The highest bit (bit 31) can be used to activate the process data object or to turn it off.

A complete identifier list is provided in the appendix.

PDO linking

In the system of default identifiers, all the nodes (here: slaves) communicate with one central station (the master), since slave nodes do not listen by default to the transmit identifier of any other slave node.

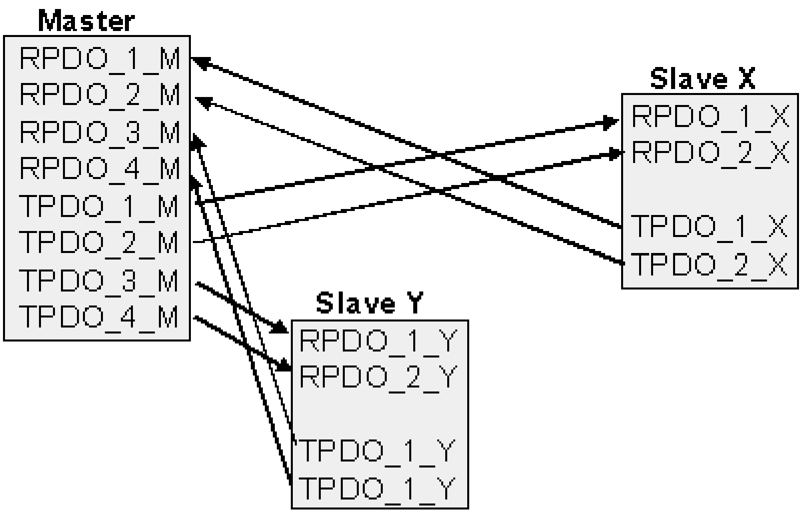

Fig. 38: Default identifier allocation: Master/Slave

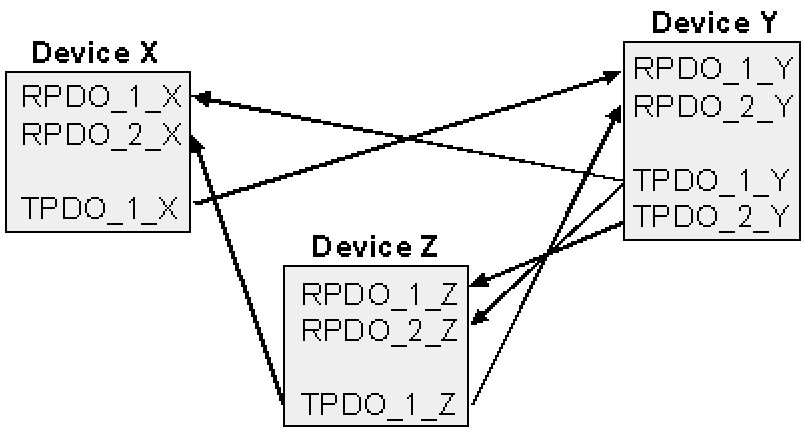

Fig. 39: PDO linking: Peer to Peer

If the consumer-producer model of CANopen PDOs is to be used for direct data exchange between nodes (without a master), the identifier allocation must be appropriately adapted, so that the TxPDO identifier of the producer agrees with the RxPDO identifier of the consumer: This procedure is known as PDO linking. It permits, for sample, easy construction of electronic drives in which several slave axes simultaneously listen to the actual value in the master axis TxPDO.

PDO Communication Types: Overview

CANopen offers a number of possible ways to transmit process data (see also: Notes on PDO Parameterization [▶ 61]).

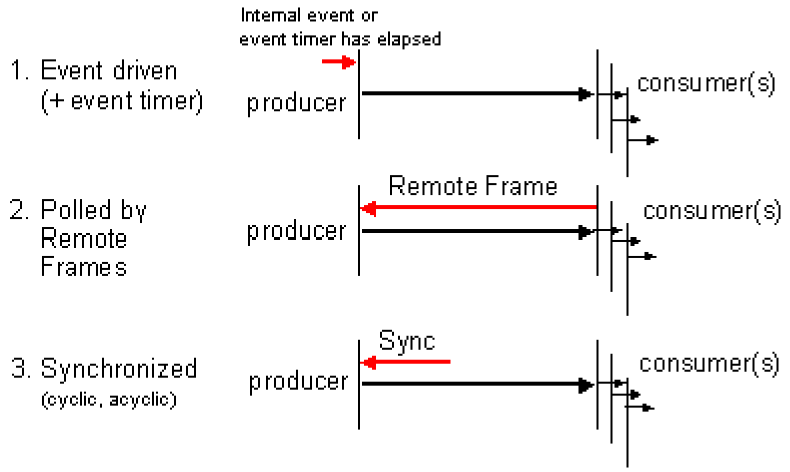

Fig. 40: Diagram: CAN process data transmission

Event driven

The "event" is the alteration of an input value, the data being transmitted immediately after this change. The event-driven flow can make optimal use of the bus bandwidth, since instead of the whole process image it is only the changes in it that are transmitted. A short reaction time is achieved at the same time, since when an input value changes it is not necessary to wait for the next interrogation from a master.

As from CANopen Version 4 it is possible to combine the event driven type of communication with a cyclic update. Even if an event has not just occurred, event driven TxPDOs are sent after the event timer has elapsed. If an event does occur, the event timer is reset. For RxPDOs the event timer is used as a watchdog in order to monitor the arrival of event driven PDOs . If a PDO does not arrive within a set period of time, the bus node adopts the error state.

Polled

The PDOs can also be polled by data request telegrams (remote frames). In this way it is possible to get the input process image of event-driven inputs onto the bus, even when they do not change, for instance through a monitoring or diagnostic device brought into the network while it is running. The time behavior of remote frame and response telegrams depends on what CAN controller is in use. Components with full integrated message filtering ("FullCAN") usually answer a data request telegram immediately, transmitting data that is waiting in the appropriate transmit buffer - it is the responsibility of the application to see that the data there is continuously updated. CAN controllers with simple message filtering (BasicCAN) on the other hand pass the request on to the application which can now compose the telegram with the latest data. This does take longer, but does mean that the data is up-to-date. Beckhoff use CAN controllers following the principle of Basic CAN.

Since this device behavior is usually not transparent to the user, and because there are CAN controllers still in use that do not support remote frames at all, polled communication can only with reservation be recommended for operative running.

Synchronized

It is not only for drive applications that it is worthwhile to synchronize the determination of the input information and the setting the outputs. For this purpose CANopen provides the SYNC object, a CAN telegram of high priority but containing no user data, whose reception is used by the synchronized nodes as a trigger for reading the inputs or for setting the outputs.

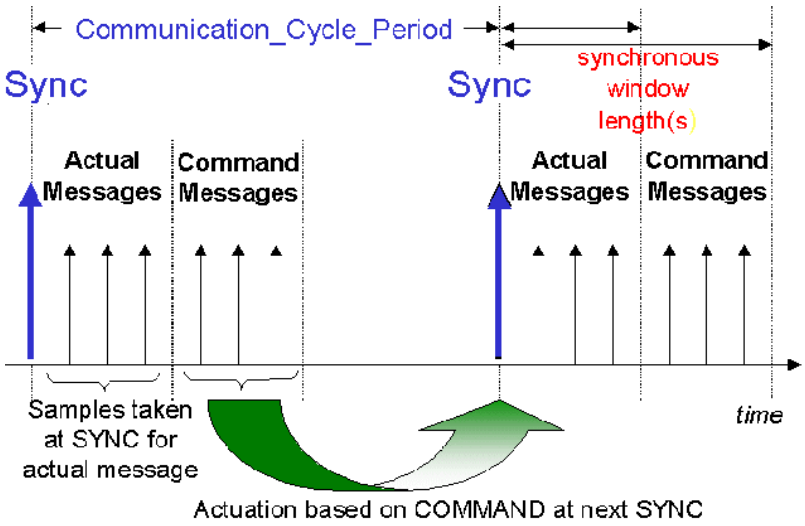

Fig. 41: Diagram: CAN "SYNC" telegram

PDO transmission types: Parameterization

The PDO transmission type parameter specifies how the transmission of the PDO is triggered, or how received PDOs are handled.

Transmission type	Cyclical	Acyclical	Synchronous	Asynchronous	Only RTR
0		X	X		
1-240	X		X		
241-251	- reserved -				
252			X		X
253				X	X
254, 255				X	

The type of transmission is parameterized for RxPDOs in the objects at 0x1400ff, sub-index 2, and for TxPDOs in the objects at 0x1800ff, sub-index 2.

Acyclic Synchronous

PDOs of transmission type 0 function synchronously, but not cyclically. An RxPDO is only evaluated after the next SYNC telegram has been received. In this way, for instance, axis groups can be given new target positions one after another, but these positions only become valid at the next SYNC - without the need to be constantly outputting reference points. A device whose TxPDO is configured for transmission type 0 acquires its input data when it receives the SYNC (synchronous process image) and then transmits it if the data correspond to an event (such as a change in input) having occurred. Transmission type 0 thus combines transmission for reasons that are event driven with a time for transmission (and, as far as possible, sampling) and processing given by the reception of "SYNC".

Cyclic Synchronous

In transmission types 1-240 the PDO is transmitted cyclically: after every ”nth" SYNC (n = 1...240). Since transmission types can be combined on a device as well as in the network, it is possible, for example, for a fast cycle to be agreed for digital inputs (n = 1), whereas the data for analog inputs is transmitted in a slower cycle (e.g. n = 10). RxPDOs do not generally distinguish between transmission types 0...240: a PDO that has been received is set to valid when the next SYNC is received. The cycle time (SYNC rate) can be monitored (object 0x1006), so that if the SYNC fails the device reacts in accordance with the definition in the device profile, and switches, for sample, its outputs into the error state.

The FC510x card / EL6751 terminal fully support the synchronous communication method: transmitting the SYNC telegram is coupled to the linked task, so that new input data is available every time the task begins. If a synchronous PDO does not arrive, this is detected and reported to the application.

Only RTR

Transmission types 252 and 253 apply to process data objects that are transmitted exclusively on request by a remote frame. 252 is synchronous: when the SYNC is received the process data is acquired. It is only transmitted on request. 253 is asynchronous. The data here is acquired continuously, and transmitted on request. This type of transmission is not generally recommended, because fetching input data from some CAN controllers is only partially supported. Because, furthermore, the CAN controllers sometimes answer remote frames automatically (without first requesting up-to-date input data), there are circumstances in which it is questionable whether the polled data is up-to-date. Transmission types 252 and 253 are for this reason not supported by the Beckhoff PC cards / terminals.

Asynchronous

The transmission types 254 + 255 are asynchronous, but may also be event-driven. In transmission type 254, the event is specific to the manufacturer, whereas for type 255 it is defined in the device profile. In the simplest case, the event is the change of an input value - this means that every change in the value is transmitted. The asynchronous transmission type can be coupled with the event timer, thus also providing input data when no event has just occurred.

Inhibit time

The ”inhibit time" parameter can be used to implement a ”transmit filter" that does not increase the reaction time for relatively new input alterations, but is active for changes that follow immediately afterwards. The inhibit time (transmit delay time) specifies the minimum length of time that must be allowed to elapse between the transmission of two of the same telegrams. If the inhibit time is used, the maximum bus loading can be determined, so that the worst case latency can then be found.

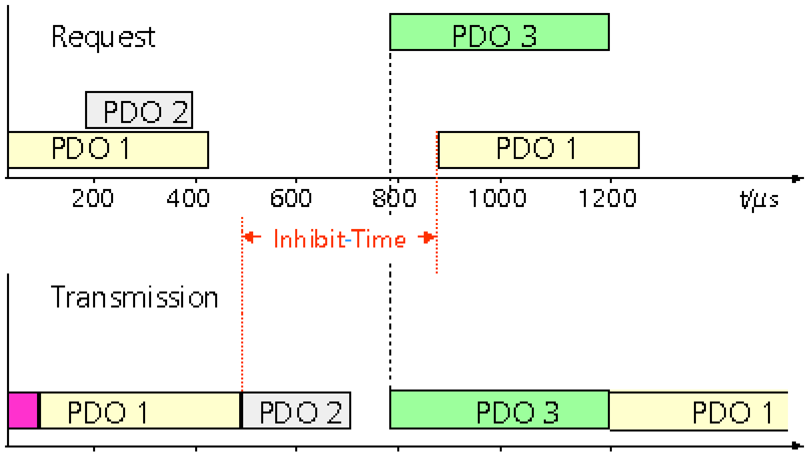

Fig. 42: Timing diagram: "Inhibit time"

Although the Beckhoff FC510x PC cards / EL6751 terminal can parameterize the inhibit time on slave devices, they do not themselves support it. The transmitted PDOs become automatically spread out (transmit delay) as a result of the selected PLC cycle time - and there is little value in having the PLC run faster than the bus bandwidth permits. The bus loading, furthermore, can be significantly affected by the synchronous communication.

Event Timer

An event timer for transmit PDOs can be specified by sub-index 5 in the communication parameters. Expiry of this timer is treated as an additional event for the corresponding PDO, so that the PDO will then be transmitted. If the application event occurs during a timer period, it will also be transmitted, and the timer is reset.

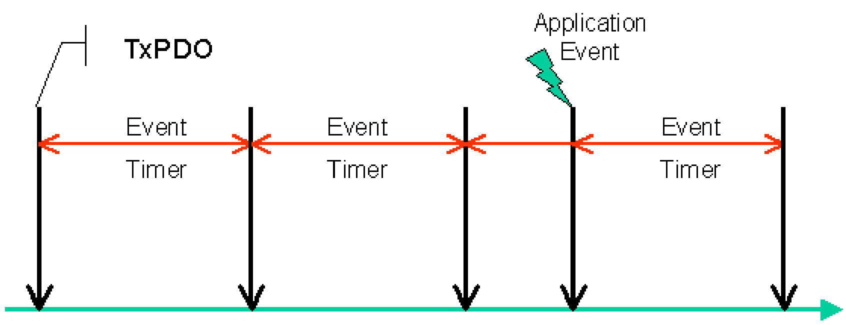

Fig. 43: Time representation of the event timer

In the case of receive PDOs, the timer is used to set a watchdog interval for the PDO: the application is informed if no corresponding PDO has been received within the set period. The FC510x / EL6751 can in this way monitor each individual PDO.

Notes on PDO Parameterization [▶ 61]

PDO Mapping

PDO mapping refers to mapping of the application objects (real time data) from the object directory to the process data objects. The CANopen device profile provide a default mapping for every device type, and this is appropriate for most applications. Thus the default mapping for digital I/O simply represents the inputs and outputs in their physical sequence in the transmit and receive process data objects.

The default PDOs for drives contain 2 bytes each of a control and status word and a set or actual value for the relevant axis.

The current mapping can be read by means of corresponding entries in the object directory. These are known as the mapping tables. The first location in the mapping table (sub-index 0) contains the number of mapped objects that are listed after it. The tables are located in the object directory at index 0x1600ff for the RxPDOs and at 0x1A00ff for the TxPDOs.

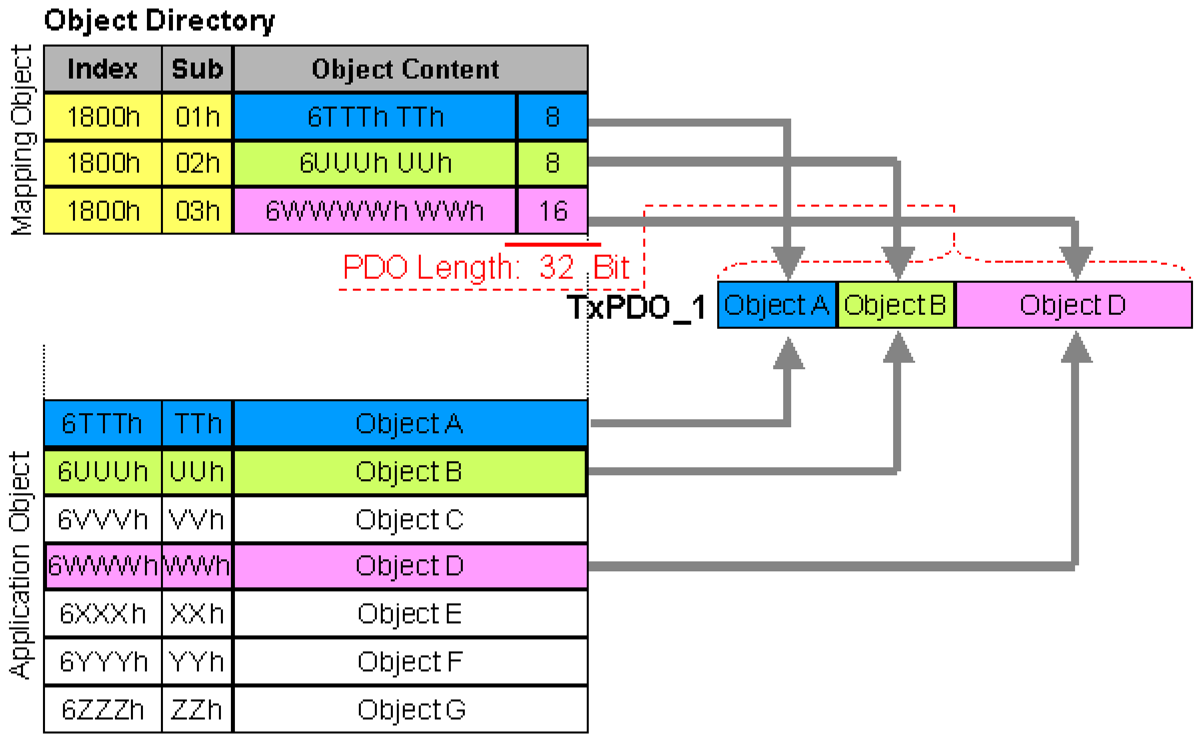

Fig. 44: Mapping representation

Digital and analog input/output modules: Read out the I/O number

The current number of digital and analog inputs and outputs can be determined or verified by reading out the corresponding application objects in the object directory:

Parameter	Object directory address
Number of digital input bytes	Index 0x6000, sub-index 0
Number of digital output bytes	Index 0x6200, sub-index 0
Number of analog inputs	Index 0x6401, sub-index 0
Number of analog outputs	Index 0x6411, sub-index 0

Variable mapping

As a rule, the default mapping of the process data objects already satisfies the requirements. For special types of application the mapping can nevertheless be altered: the Beckhoff CANopen Bus Couplers, for instance, thus support variable mapping, in which the application objects (input and output data) can be freely allocated to the PDOs. The mapping tables must be configured for this: as from Version 4 of CANopen, only the following procedure is permitted, and must be followed precisely:

1. First delete the PDO (set 0x1400ff, or 0x1800ff, sub-index 1, bit 31 to "1")
2. Set sub-index 0 in the mapping parameters (0x1600ff or 0x1A00ff) to "0"
3. Change mapping entries (0x1600ff or 0x1A00ff, SI 1..8)
4. Set sub-index 0 in the mapping parameters to the valid value. The device then checks the entries for consistency.
5. Create PDO by entering the identifier (0x1400ff or 0x1800ff, sub-index 1).

Dummy Mapping

A further feature of CANopen is the mapping of placeholders, or dummy entries. The data type entries stored in the object directory, which do not themselves have data, are used as placeholders. If such entries are contained in the mapping table, the corresponding data from the device is not evaluated. In this way, for instance, a number of drives can be supplied with new set values using a single CAN telegram, or outputs on a number of nodes can be set simultaneously, even in event-driven mode.

6.1.3 PDO Parameterization

Even though the majority of CANopen networks operate satisfactorily with the default settings, i.e. with the minimum of configuration effort, it is wise at least to check whether the existing bus loading is reasonable: 80% bus loading may be acceptable for a network operating purely in cyclic synchronous modes, but for a network with event-driven traffic this value would generally be too high, as there is hardly any bandwidth available for additional events.

Consider the Requirements of the Application

The communication of the process data must be optimized in the light of application requirements which are likely to be to some extent in conflict. These include

- Little work on parameterization - useable default values are optimal
- Guaranteed reaction time for specific events
- Cycle time for regulation processes over the bus
- Safety reserves for bus malfunctions (enough bandwidth for the repetition of messages)
- Maximum baud rate - depends on the maximum bus length
- Desired communication paths - who is speaking with whom

The determining factor often turns out to be the available bus bandwidth (bus load).

Baud rate

We generally begin by choosing the highest baud rate that the bus will permit. It should be borne in mind that serial bus systems are fundamentally more sensitive to interference as the baud rate is increased. The following rule therefore applies: just as fast as necessary. 1000 kbit/s are not usually necessary, and only to be unreservedly recommended on networks within a control cabinet where there is no electrical isolation between the bus nodes. Experience also tends to show that estimates of the length of bus cable laid are often over-optimistic - the length actually laid tends to be longer.

Determine the Communication Type

Once the baud rate has been chosen it is appropriate to specify the PDO communication type(s). These have different advantages and disadvantages:

- Cyclic synchronous communication provides an accurately predictable bus loading, and therefore a defined time behavior - you could say that the standard case is the worst case. It is easy to configure: The SYNC rate parameter sets the bus loading globally. The process images are synchronized: Inputs are read at the same time, output data is set valid simultaneously, although the quality of the synchronization depends on the implementation. The BECKHOFF FC510x PC cards / EL6751 CANopen terminal are capable of synchronizing the CANopen bus system with the cycles of the application program (PLC or NC).

  The guaranteed reaction time under cyclic synchronous communication is always at least as long as the cycle time, and the bus bandwidth is not exploited optimally, since old data, i.e. data that has not changed, is continuously transmitted. It is however possible to optimize the network through the selection of different SYNC multiples (transmission types 1...240), so that data that changes slowly is transmitted less often than, for instance, time-critical inputs. It must, however, be borne in mind that input states that last for a time that is shorter than the cycle time will not necessarily be communicated. If it is necessary for such conditions to be registered, the associated PDOs for asynchronous communication should be provided.
- Event-driven asynchronous communication is optimal from the point of view of reaction time and the exploitation of bus bandwidth - it can be described as "pure CAN". Your choice must, however, also take account of the fact that it is not impossible for a large number of events to occur simultaneously, leading to corresponding delays before a PDO with a relatively low priority can be sent. Proper network planning therefore necessitates a worst-case analysis. Through the use of, for instance, inhibit time [▶ 54], it is also necessary to prevent a constantly changing input with a high PDO priority from blocking the bus (technically known as a "babbling idiot"). It is for this reason that event driving is switched off by

default in the device profile of analog inputs, and must be turned on specifically. Time windows for the transmit PDOs can be set using progress timers: the telegram is not sent again before the inhibit time [▸ 54] has elapsed, and not later than the time required for the progress timer to complete.

- The communication type is parameterized by means of the transmission type [▸ 54].

It is also possible to combine the two PDO principles. It can, for instance, be helpful to exchange the set and actual values of an axis controller synchronously, while limit switches, or motor temperatures with limit values are monitored with event-driven PDOs. This combines the advantages of the two principles: synchronicity for the axis communication and short reaction times for limit switches. In spite of being event-driven, the distributed limit value monitoring avoids a constant addition to the bus load from the analog temperature value.

In this sample it can also be of value to deliberately manipulate the identifier allocation, in order to optimize bus access by means of priority allocation: the highest priority is given to the PDO with the limit switch data, and the lowest to that with the temperature values.

Optimization of bus access latency time through modification of the identifier allocation is not, however, normally required. On the other hand the identifiers must be altered if masterless communication is to be made possible (PDO linking [▸ 54]). In this sample it would be possible for one RxPDO for each axis to be allocated the same identifier as the limit switch TxPDO, so that alterations of the input value can be received without delay.

Determining the Bus Loading

It is always worth determining the bus loading. But what bus loading values are permitted, or indeed sensible? It is first necessary to distinguish a short burst of telegrams in which a number of CAN messages follow one another immediately - a temporary 100% bus loading. This is only a problem if the sequence of receive interrupts that it caused at the CAN nodes cannot be handled. This would constitute a data overflow (or CAN queue overrun). This can occur at very high baud rates (> 500 kbit/s) at nodes with software telegram filtering and relatively slow or heavily loaded microcontrollers if, for instance, a series of remote frames (which do not contain data bytes, and are therefore very short) follow each other closely on the bus (at 1 Mbit/s this can generate an interrupt every 40 µs; for example, an NMT master might transmit all its guarding requests in an unbroken sequence). This can be avoided through skilled implementation, and the user should be able to assume that the device suppliers have taken the necessary trouble. A burst condition is entirely normal immediately after the SYNC telegram, for instance: triggered by the SYNC, all the nodes that are operating synchronously try to send their data at almost the same time. A large number of arbitration processes take place, and the telegrams are sorted in order of priority for transmission on the bus. This is not usually critical, since these telegrams do contain some data bytes, and the telegrams trigger a sequence of receive interrupts at the CAN nodes which is indeed rapid, but is nevertheless manageable.

Bus loading most often refers to the value averaged over several primary cycles, that is the mean value over 100-500 ms. CAN, and therefore CANopen, is indeed capable of managing a bus loading of close to 100% over long periods, but this implies that no bandwidth is available for any repetitions that may be necessitated by interference, for asynchronous error messages, parameterization and so on. Clearly, the dominant type of communication will have a large influence on the appropriate level of bus loading: a network with entirely cyclic synchronous operation is always in any case near to the worst case state, and can therefore be operated with values in the 70-80% range. The figure is very hard to state for an entirely event-driven network: an estimate must be made of how many events additional to the current state of the system might occur, and of how long the resulting burst might last - in other words, for how long the lowest priority message will be delayed. If this value is acceptable to the application, then the current bus loading is acceptable. As a rule of thumb it can usually be assumed that an event-driven network running with a base loading of 30-40% has enough reserve for worst-case scenarios, but this assumption does not obviate the need for a careful analysis if delays could have critical results for the plant.

The BECKHOFF FC510x CANopen master cards / EL6751 CANopen master terminal display the bus load via the System Manager. This variable can also be processed in the PLC, or can be displayed in the visualization system.

The amount data in the process data objects is of course as relevant as the communication parameters: the PDO mapping. [▸ 59]

6.1.4 Service Data Objects (SDO)

The parameters listed in the object directory are read and written by means of service data objects. These SDOs are *Multiplexed Domains*, i.e. data structures of any size that have a multiplexer (address). The multiplexer consists of a 16-bit index and an 8-bit sub-index that address the corresponding entries in the object directory.

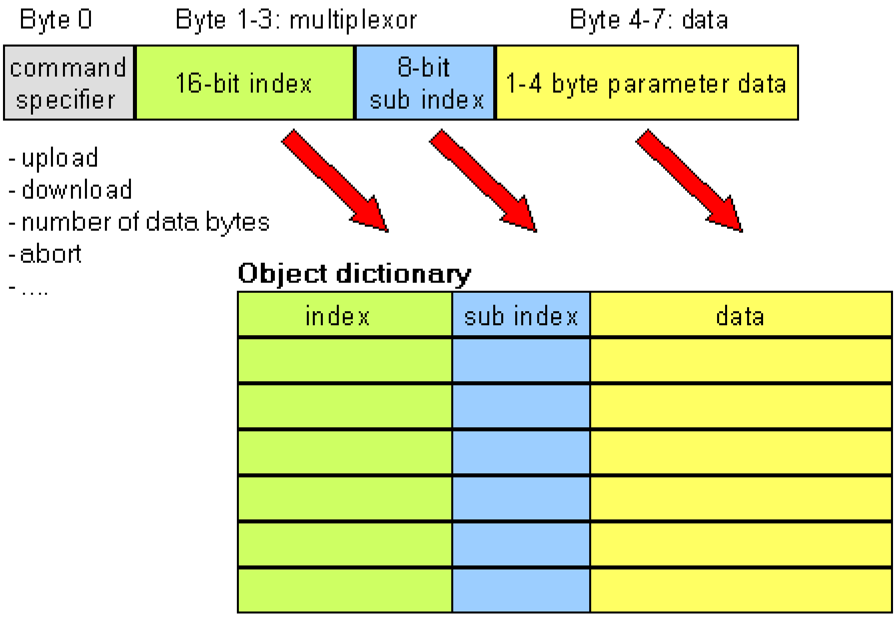

Fig. 45: SDO protocol: access to the object directory

The CANopen Bus Couplers are servers for the SDO, which means that at the request of a client (e.g. of the IPC or the PLC) they make data available (upload), or they receive data from the client (download). This involves a handshake between the client and the server.

When the size of the parameter to be transferred is not more than 4 bytes, a single handshake is sufficient (one telegram pair): For a download, the client sends the data together with its index and sub-index, and the server confirms reception. For an upload, the client requests the data by transmitting the index and sub-index of the desired parameter, and the server sends the parameter (including index and sub-index) in its answer telegram.

The same pair of identifiers is used for both upload and download. The telegrams, which are always 8 bytes long, encode the various services in the first data byte. All parameters with the exception of objects 1008h, 1009h and 100Ah (device name, hardware and software versions) are only at most 4 bytes long, so this description is restricted to transmission in expedited transfer.

Protocol

The structure of the SDO telegrams is described below.

Client -> Server, Upload Request

11 bit identifier	8 byte user data							
0x600 (=1536$_{dec}$) + node ID	0x40	Index0	Index1	SubIdx	0x00	0x00	0x00	0x00

Parameter	Explanation
Index0	Index low byte (Unsigned16, LSB)
Index1	Index high byte (Unsigned16, MSB)
SubIdx	Sub-index (Unsigned8)

Client -> Server, Upload Response

11 bit identifier	8 byte user data							
0x580 (=1408$_{dec}$) + node ID	0x4x	Index0	Index1	SubIdx	Data0	Data1	Data2	Data3

Parameter	Explanation
Index0	Index low byte (Unsigned16, LSB)
Index1	Index high byte (Unsigned16, MSB)
SubIdx	Sub-index (Unsigned8)
Data0	Data low low byte (LLSB)
Data3	Data high high byte (MMSB)

Parameters whose data type is Unsigned8 are transmitted in byte D0, parameters whose type is Unsigned16 use D0 and D1.

The number of valid data bytes is coded as follows in the first CAN data byte (0x4x):

Number of parameter bytes	1	2	3	4
First CAN data byte	0x4F	0x4B	0x47	0x43

Client -> Server, Download Request

11 bit identifier	8 byte user data							
0x600 (=1536$_{dec}$) + node ID	0x22	Index0	Index1	SubIdx	Data0	Data1	Data2	Data3

Parameter	Explanation
Index0	Index low byte (Unsigned16, LSB)
Index1	Index high byte (Unsigned16, MSB)
SubIdx	Sub-index (Unsigned8)
Data0	Data low low byte (LLSB)
Data3	Data high high byte (MMSB)

It is optionally possible to give the number of valid parameter data bytes in the first CAN data byte

Number of parameter bytes	1	2	3	4
First CAN data byte	0x2F	0x2B	0x27	0x23

This is, however, not generally necessary, since only the less significant data bytes up to the length of the object directory entry that is to be written are evaluated. A download of data up to 4 bytes in length can therefore always be achieved in BECKHOFF bus nodes with 22 h in the first CAN data byte.

Client -> Server, Download Response

11 bit identifier	8 byte user data							
0x580 (=1408$_{dec}$) + node ID	0x60	Index0	Index1	SubIdx	0x00	0x00	0x00	0x00

Parameter	Explanation
Index0	Index low byte (Unsigned16, LSB)
Index1	Index high byte (Unsigned16, MSB)
SubIdx	Sub-index (Unsigned8)

Breakdown of Parameter Communication

Parameter communication is interrupted if it is faulty. The client or server send an SDO telegram with the following structure for this purpose:

11 bit identifier	8 byte user data							
0x580 (client) or 0x600 (server) + node ID	0x80	Index0	Index1	SubIdx	Error0	Error1	Error2	Error3

Parameter	Explanation
Index0	Index low byte (Unsigned16, LSB)
Index1	Index high byte (Unsigned16, MSB)
SubIdx	Sub-index (Unsigned8)
Error0	SDO error code low low byte (LLSB)
Error3	SDO error code high high byte (MMSB)

List of SDO error codes (reason for abortion of the SDO transfer):

SDO error code	Explanation
0x05 03 00 00	Toggle bit not changed
0x05 04 00 01	SDO command specifier invalid or unknown
0x06 01 00 00	Access to this object is not supported
0x06 01 00 02	Attempt to write to a Read_Only parameter
0x06 02 00 00	The object is not found in the object directory
0x06 04 00 41	The object cannot be mapped into the PDO
0x06 04 00 42	The number and/or length of mapped objects would exceed the PDO length
0x06 04 00 43	General parameter incompatibility
0x06 04 00 47	General internal error in device
0x06 06 00 00	Access interrupted due to hardware error
0x06 07 00 10	Data type or parameter length do not agree or are unknown
0x06 07 00 12	Data type does not agree, parameter length too great
0x06 07 00 13	Data type does not agree, parameter length too short
0x06 09 00 11	Sub-index not present
0x06 09 00 30	General value range error
0x06 09 00 31	Value range error: parameter value too great
0x06 09 00 32	Value range error: parameter value too small
0x06 0A 00 23	Resource not available
0x08 00 00 00	General error
0x08 00 00 21	Access not possible due to local application
0x08 00 00 22	Access not possible due to current device status

Further, manufacturer-specific error codes have been introduced for register communication (index 0x4500, 0x4501):

SDO error code	Explanation
0x06 02 00 11	Invalid table: Table or channel not present
0x06 02 00 10	Invalid register: table not present
0x06 01 00 22	Write protection still set
0x06 07 00 43	Incorrect number of function arguments
0x06 01 00 21	Function still active, try again later
0x05 04 00 40	General routing error
0x06 06 00 21	Error accessing BC table
0x06 09 00 10	General error communicating with terminal
0x05 04 00 47	Time-out communicating with terminal

6.1.5 Identifier Allocation

Default identifier

CANopen provides default identifiers for the most important communication objects, and these are derived from the 7-bit node address (the node ID) and a 4-bit function code in accordance with the following scheme:

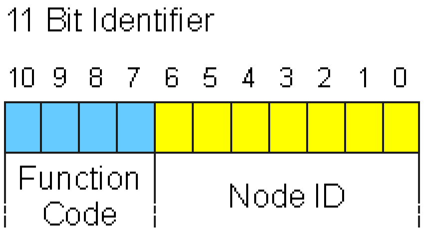

Fig. 46: Scheme CANopen default identifier

For broadcast objects the node ID is set to *0*. This gives rise to the following default identifiers:

Broadcast objects

Object	Function	Function code	Resulting COB ID		Object for communication Parameter / mapping
			hex	dec	
NMT	Boot-Up	0	0x00	0	- / -
SYNC	Synchronization	1	0x80	128	0x1005 [▶ 71]+0x1006 [▶ 71] / -

Peer-to-peer objects

Object	Function	Function code	Resulting COB ID		Object for communication Parameter / mapping
			hex	dec	
Emergency	Status / error	1	0x81 - 0xFF	129 - 255	- / -
PDO1 (tx)	dig. inputs	11	0x181 - 0x1FF	385 - 511	0x1800 [▶ 71] / 0x1A00 [▶ 71]
PDO1 (rx)	digital outputs	100	0x201 - 0x27F	513 - 639	0x1400 [▶ 71] / 0x1600 [▶ 71]
PDO2 (tx)	analog inputs	101	0x281 - 0x2FF	641 - 767	0x1801 [▶ 71] / 0x1A01 [▶ 71]
PDO2 (rx)	analog outputs	110	0x301 - 0x37F	769 - 895	0x1401 [▶ 71] / 0x1601 [▶ 71]
PDO3 (tx)	analog inputs*	111	0x381 - 0x3FF	897 - 1,023	0x1802 [▶ 71] / 0x1A02 [▶ 71]
PDO3 (rx)	analog outputs*	1000	0x401 - 0x47F	1025 - 1151	0x1402 [▶ 71] / 0x1602 [▶ 71]
PDO4 (tx)	analog inputs*	1001	0x481 - 0x4FF	1153 - 1279	0x1803 [▶ 71] / 0x1A03 [▶ 71]
PDO4 (rx)	analog outputs*	1010	0x501 - 0x57F	1281 - 1407	0x1403 [▶ 71] / 0x1603 [▶ 71]
SDO (tx)	Parameter	1011	0x581 - 0x5FF	1409 - 1535	- / -
SDO (rx)	Parameter	1100	0x601 - 0x67F	1537 - 1663	- / -
Guarding	Life/node guarding, Heartbeat, Boot-up message	1110	0x701 - 0x77F	1793 - 1919	(0x100C [▶ 71], 0x100D [▶ 71], 0x100E [▶ 71], 0x1016 [▶ 71], 0x1017 [▶ 71])

*) The Beckhoff Default Mapping [▶ 47] applies to PDO3 and PDO4. In most configurations, PDOs 3+4 contain data related to analog inputs and outputs, but there can also be "excess" data from digital I/Os, or data from special terminals. Details may be found in the section covering PDO Mapping [▶ 54].

Up until version 3 of the CANopen specification, default identifiers were assigned to 2 PDOs at a time. The Beckhoff Bus Couplers up to firmware status BA correspond to this issue of the specification. After firmware status C0 (CANopen version 4), default identifiers are provided for up to 4 PDOs.

Manufacture-Specific Default Identifiers for Additional PDOs

Identifiers are not assigned to the additional PDOs that are filled by the Beckhoff Bus Couplers in accordance with the standard scheme. The user must enter an identifier for these PDOs in the object directory. It is easier to activate the occupied PDOs by means of object 0x5500 [▶ 71].

This entry in the object directory extends the default identifier allocation up to 11 PDOs. This creates the following identifiers:

Object	Function code	Resulting COB ID (hex)	Resulting COB ID (dec)
PDO5 (tx)	1101	0x681 - 0x6BF	1665 - 1727
PDO5 (rx)	1111	0x781 - 0x7BF	1921- 1983
PDO6 (tx)	111	0x1C1 - 0x1FF	449 - 511
PDO6 (rx)	1001	0x241 - 0x27F	577 - 639
PDO7 (tx)	1011	0x2C1 - 0x2FF	705 - 767
PDO7 (rx)	1101	0x341 - 0x37F	833 - 895
PDO8 (tx)	1111	0x3C1- 0x3FF	961 - 1023
PDO8 (rx)	10001	0x441 - 0x47F	1089 - 1151
PDO9 (tx)	10011	0x4C1 - 0x4FF	1217 - 1279
PDO9 (rx)	10101	0x541 - 0x57F	1345 - 1407
PDO10 (tx)	10111	0x5C1 - 0x5FF	1473 - 1535
PDO10 (rx)	11001	0x641 - 0x67F	1601- 1663
PDO11 (tx)	11011	0x6C1 - 0x6FF	1729 - 1791
PDO11 (rx)	11101	0x741 - 0x77F	1857 - 1919

NOTE

Index 0x5500

Index 0x5500 must not be used if Bus Couplers with more than 5 PDOs are present in networks with node numbers greater than 64, otherwise identifier overlaps can occur.

7 Description of parameters

7.1 CANopen object directory

7.1.1 Object directory structure

All the CANopen objects relevant for the Bus Coupler are entered into the CANopen object directory. The object directory is divided into three different regions:

1. communication-specific profile region (index 0x1000 – 0x1FFF).
   This contains the description of all the parameters specific to communication.
2. manufacturer-specific profile region (index 0x2000 – 0x5FFF).
   Contains the description of the manufacturer-specific entries.
3. standardized device profile region (0x6000 – 0x9FFF).
   Contains the objects for a device profile according to DS-401.

Every entry in the object directory is identified by a 16 bit index. If an object consists of several components (e.g. object type array or record), the components are identified by an 8-bit sub-index. The object name describes the function of an object, while the data type attribute specifies the data type of the entry. The access attribute specifies whether an entry may only be read, only written, or may be both read and written.

Communication-specific region

All the parameters and objects necessary for the CANopen Bus Coupler's communication are in this region of the object directory. The region from 0x1000 to 0x1018 contains various general communication-specific parameters (e.g. the device name).

The communication parameters (e.g. identifiers) for the receive PDOs are located in the region from 0x1400 to 0x140F (plus sub-index). The mapping parameters of the receive PDOs are in the region from 0x1600 to 0x160F (plus sub-index). The mapping parameters contain the cross-references to the application objects that are mapped into the PDOs and the data width of the corresponding object (see also the section dealing with PDO Mapping).

The communication and mapping parameters for the transmit PDOs are located in the regions from 0x1800 to 0x180F and from 0x1A00 to 0x1A0F.

Manufacturer-specific region

This region contains entries that are specific to BECKHOFF, e.g.:

- data objects for special terminals
- objects for register communication providing access to all the Bus Couplers' and Bus Terminals' internal registers
- objects for simplified configuration of the PDOs

Standardized device profile region

The standardized device profile region supports the device profile of CANopen DS-401, Version 1. Functions are available for analog inputs that can adapt communication in the event-driven operating mode to the requirements of the application and to minimize the loading of the bus:

- Limit value monitoring
- Delta function
- activation/deactivation of event-driven mode

7.1.2 Object list

Reachability of the objects and registers

The objects in the object directory can be reached by SDO access, but not generally through the KS2000 configuration software. On the other hand, all the registers that can be configured with KS2000 can also be reached using SDO access to the object directory (objects 0x4500 and 0x4501) - even though this does not offer the same convenience as the KS2000 software.

Parameter	Index	BK5120 / BK515x	BK5110	LC5100	BX5100 / BC5150	CX8051 / B510
Device type [▸ 71]	0x1000	x	x	x		x
Error register [▸ 71]	0x1001	x	x	x	x	x *
Error store [▸ 71]	0x1003	x	x	x		x *
Sync Identifier [▸ 72]	0x1005	x	x	x	x	x
Sync Interval [▸ 72]	0x1006	x	x	x	x	x
Device name [▸ 72]	0x1008	x	x	x	x	x *
Hardware version [▸ 73]	0x1009	x	x	x		x *
Software version [▸ 73]	0x100A	x	x	x	x	x *
Node number [▸ 73]	0x100B	x	x	x		
Guard time [▸ 73]	0x100C	x	x	x	x	x
Life time factor [▸ 73]	0x100D	x	x	x	x	x
Guarding identifier [▸ 73]	0x100E	x	x	x		
Save parameters [▸ 74]	0x1010	x	x	x		
Load default values [▸ 74]	0x1011	x	x	x		
Emergency identifier [▸ 74]	0x1014	x	x	x		
Consumer heartbeat time [▸ 75]	0x1016	x	x	x	x	x
Producer heartbeat time [▸ 75]	0x1017	x	x	x	x	x
Device identifier (identity object) [▸ 75]	0x1018	x	x	x	x	x *
Server SDO parameters [▸ 76]	0x1200	x	x	x		
Communication parameters for the 1st - 5th RxPDOs [▸ 76]	0x1400 - 0x1404	x	x	x	x	x
Communication parameters for the 6th – 16th RxPDOs [▸ 78]	0x1405 - 0x140F	x			x	x
Communication parameters for the 17th – 32nd RxPDOs [▸ 78]	0x1410 - 0x141F				x only BX5100	x
Mapping 1st -5th RxPDO [▸ 79]	0x1600 - 0x1604	x	x	x	x	x
Mapping 6th –16th RxPDO [▸ 80]	0x1605 - 0x160F	x			x	x
Mapping 17th –32nd RxPDO [▸ 80]	0x1610 - 0x161F				x only BX5100	x
Communication parameters for the 1st-5th TxPDOs [▸ 80]	0x1800 - 0x1804	x	x	x	x	x
Communication parameters for the 6th-16th TxPDOs [▸ 82]	0x1805 - 0x180F	x			x	x
Communication parameters for the 17th -32nd TxPDOs [▸ 82]	0x1810 - 0x181F				x only BX5100	x
Mapping 1st –5th TxPDO [▸ 83]	0x1A00 - 0x1A04	x	x	x	x	x
Mapping 6th –16th TxPDO [▸ 84]	0x1A05 - 0x1A0F	x			x	x
Mapping 17th –32nd TxPDO [▸ 84]	0x1A10 - 0x1A1F				x only BX5100	x
Flag area %MB0-511 [▸ 71]	0x2F00				x	
Flag area %MB511-1023 [▸ 71]	0x2F01				x	
Flag area %MB1024-1535 [▸ 71]	0x2F02				x	
Flag area %MB1536-2047 [▸ 71]	0x2F03				x	
Flag area %MB2048-2559 [▸ 71]	0x2F04				x	
Flag area %MB2560-3071 [▸ 71]	0x2F05				x	
Flag area %MB3072-3584 [▸ 71]	0x2F06				x	
Flag area %MB3585-4095 [▸ 71]	0x2F07				x	

Parameter	Index	BK5120 / BK515x	BK5110	LC5100	BX5100 / BC5150	CX8051 / B510
3-byte special terminals, input data [▸ 85]	0x2600	x				
3-byte special terminals, output data [▸ 85]	0x2700	x				
4-byte special terminals, input data [▸ 85]	0x2800	x				
4-byte special terminals, output data [▸ 85]	0x2900	x				
5-byte special terminals, input data [▸ 86]	0x2A00	x				
5-byte special terminals, output data [▸ 86]	0x2B00	x				
6-byte special terminals, input data [▸ 86]	0x2C00	x				
6-byte special terminals, output data [▸ 86]	0x2D00	x				
8-byte special terminals, input data [▸ 87]	0x3000	x				
8-byte special terminals, output data [▸ 87]	0x3100	x				
Bus node register communication [▸ 87]	0x4500	x	x	x		
Bus Terminal / Extension Box register communication [▸ 91]	0x4501	x	x	x		
Activate PDOs [▸ 93]	0x5500	x	x	x		
NetId [▸ 71]	0x5FFE				x	
Digital inputs [▸ 95]	0x6000	x	x	x		
Interrupt mask [▸ 95]	0x6126	x	x	x		
Digital outputs [▸ 96]	0x6200	x	x	x		
Analog inputs [▸ 97]	0x6401	x				
Analog outputs [▸ 97]	0x6411	x				
Event control analog inputs [▸ 97]	0x6423	x				
Upper limit value analog inputs [▸ 97]	0x6424	x				
Lower limit value analog inputs [▸ 98]	0x6425	x				
Delta function for analog inputs [▸ 98]	0x6426	x				

* When an ADS server is registered, these objects are relayed to the PLC via ADS notification and have to be answered there.

7.1.3 Objects and Data

Device type

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1000	0	Device type	Unsigned32	ro	N	0x00000000	Statement of device type

The 32 bit value is divided into two 16 bit fields:

MSB	LSB
Additional information	Device profile number
0000 0000 0000 wxyz	0x191 (401_{dec})

The *additional information* contains data related to the signal type of the I/O device:
z=1 signifies digital inputs,
Y=1 signifies digital outputs,
x=1 signifies analog inputs,
w=1 signifies analog outputs,
A BK5120 with digital and analog inputs, but with no outputs, thus returns 0x00 05 01 91.

Special terminals (such as serial interfaces, PWM outputs, incremental encoder inputs) are not considered. A Coupler that, e.g. only has KL6001 serial interface terminals plugged in, thus returns 0x00 00 01 91.

The device type supplies only a rough classification of the device. The terminal identifier register of the Bus Coupler can be read for detailed identification of the Bus Couplers and the attached terminals (for details see Register communication index 0x4500 [▶ 87]).

Error register

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1001	0	Error register	Unsigned8	ro	N	0x00	Error register

The 8 bit value is coded as follows:

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
ManSpec.	reserved	reserved	Comm.	reserved	reserved	reserved	Generic

ManSpec. Manufacturer-specific error, specified more precisely in object 1003.

Comm. Communication error (CAN overrun)

Generic An error that is not more precisely specified has occurred (the flag is set at every error message)

Error store

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1003	0x00	Predefined error field (Error store)	Unsigned8	rw	N	0x00	Object 0x1003h contains a description of the error that has occurred in the device - sub-index 0 has the number of error states stored.
	1	Actual error	Unsigned32	ro	N	none	Last error state to have occurred
	...	...	...	--	...	...	...
	10	Standard error field	Unsigned32	ro	N	none	A maximum of 10 error states are stored.

The 32 bit value in the error store is divided into two 16 bit fields:

MSB	LSB
Additional code	Error Code

The additional code contains the error trigger (see emergency object [▸ 104]) and thereby a detailed error description.

New errors are always saved at sub-index 1, all the other sub-indices being appropriately incremented. The whole error store is cleared by writing a 0 to sub-index 0.

If there has not been an error since power up, then object 0x1003 only consists of sub-index 0 with a 0 entered into it. The error store is cleared by a reset or a power cycle.

As is usual in CANopen, the LSB is transferred first, followed by the MSB.

Sync Identifier

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1005	0	COB-ID Sync Message	Unsigned32	rw	N	0x80000080	Identifier of the SYNC message

The bottom 11 bits of the 32 bit value contain the identifier (0x80=128_{dec}). Bit 30 indicates whether the device sends the SYNC telegram (1) or not (0). The CANopen I/O devices receive the SYNC telegram, and accordingly bit 30=0. For reasons of backwards compatibility, bit 31 has no significance.

Sync Interval

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1006	0	Communication cycle period	Unsigned32	rw	N	0x00000000	Length of the SYNC interval in µs.

If a value other than zero is entered here, the bus node will go into the fault state if, during synchronous PDO operation, no SYNC telegram is received within the watchdog time. The watchdog time corresponds here to 1,5 times the communication cycle period that has been set - the planned SYNC interval can therefore be entered.

The I/O update is carried out at the Beckhoff CANopen bus nodes immediately after reception of the SYNC telegram, provided the following conditions are satisfied:

- Firmware status C0 or above (CANopen Version 4.01 or higher).
- All PDOs that have data are set to synchronous communication (0...240).
- The sync interval has been entered in object 0x1006 and (sync interval x lowest PDO transmission type) is less than 90 ms.

The modules are then synchronized throughout.

Device name

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1008	0	Manufacturer Device Name	Visible String	ro	N	BK51x0, LC5100, IPxxxx-B510 or ILxxxx-B510	Device name of the bus node

Since the returned value is longer than 4 bytes, the segmented SDO protocol is used for transmission.

Hardware version

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1009	0	Manufacturer hardware-version	Visible String	ro	N	-	Hardware version number of the bus node

Since the returned value is longer than 4 bytes, the segmented SDO protocol is used for transmission.

Software version

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x100A	0	Manufacturer software-version	Visible String	ro	N	-	Software version number of the bus node

Since the returned value is longer than 4 bytes, the segmented SDO protocol is used for transmission.

Node number

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x100B	0	Node ID	Unsigned32	ro	N	none	Set node number

The node number is supported for reasons of compatibility.

Guard time

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x100C	0	Guard time [ms]	Unsigned16	rw	N	0	Interval between two guard telegrams. Is set by the NMT master or configuration tool.

Life time factor

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x100D	0	Life time factor	Unsigned8	rw	N	0	Life time factor x guard time = life time (watchdog for life guarding)

If a guarding telegram is not received within the life time, the node enters the error state. If the life time factor and/or guard time = 0, the node does not carry out any life guarding, but can itself be monitored by the master (node guarding).

Guarding identifier

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x100E	0	COB-ID guarding protocol	Unsigned32	ro	N	0x000007xy, xy = NodeID	Identifier of the guarding protocol

The guarding identifier is supported for reasons of compatibility. Changing the guarding identifier has no longer been permitted since version 4 of CANopen.

Save parameters

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1010	0	Store Parameter	Unsigned8	ro	N	1	Number of store options
	1	store all parameters	Unsigned32	rw	N	1	Stores all (storable) parameters

By writing the string *save* in ASCII code (hexadecimal 0x65766173) to sub-index 1, the current parameters are placed into non-volatile storage. (The byte sequence on the bus including the SDO protocol: 0x23 0x10 0x10 0x01 0x73 0x61 0x76 0x65).

The storage process takes about 3 seconds, and is confirmed, if successful, by the corresponding TxSDO (0x60 in the first byte). Since the Bus Coupler is unable to send or receive any CAN telegrams during the storage process, saving is only possible when the node is in the pre-operational state. It is recommended that the entire network is placed into the pre-operational state before such storage. This avoids a buffer overflow.

Data saved includes:

- The terminals currently inserted (the number of each terminal category)
- All PDO parameters (identifier, transmission type, inhibit time, mapping)

Identifier

The stored identifiers apply afterwards, not the default identifiers derived from the node addresses. Changes to the DIP switch setting no longer affects the PDOs!

- All SYNC parameters
- All guarding parameters
- Limit values, delta values and interrupt enable for analog inputs

Parameters directly stored in the terminals by way of register communication are immediately stored there in non-volatile form.

Load default values

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1011	0	Restore Parameter	Unsigned8	ro	N	4	Number of reset options
	1	Restore all parameters	Unsigned32	rw	N	1	Resets all parameters to their default values
	4	Set manufacturer Defaults	Unsigned32	rw	N	1	Resets all coupler parameters to manufacturer's settings (including registers)

Writing the string *load* in ASCII code (hexadecimal 0x64616F6C) into sub-index 1 resets all parameters to default values (as initially supplied) **at the next boot (reset)**.

(The byte sequence on the bus including the SDO protocol: 0x23 0x11 0x10 0x01 0x6C 0x6F 0x61 0x64).

This makes the default identifiers for the PDOs active again.

Emergency identifier

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1014	0	COB-ID Emergency	Unsigned32	rw	N	0x00000080, + NodeID	Identifier of the emergency telegram

The bottom 11 bits of the 32 bit value contain the identifier (0x80=128dec). The MSBit can be used to set whether the device sends (1) the emergency telegram or not (0).

Alternatively, the bus node's diagnostic function can also be switched off using the *Device diagnostics* bit in the K-Bus configuration (see object 0x4500).

Consumer heartbeat time

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1016	0	Number of elements	Unsigned8	ro	N	2	The consumer heartbeat time describes the expected heartbeat cycle time and the node ID of the monitored node
	1	Consumer heartbeat time	Unsigned32	rw	N	0	Watchdog time in ms and node ID of the monitored node

The 32-bit value is used as follows:

MSB		LSB
Bit 31...24	Bit 23...16	Bit 15...0
Reserved (0)	Node ID (unsigned8)	Heartbeat time in ms (unsigned16)

The monitored identifier can be obtained from the node ID by means of the default identifier allocation: Guard-ID = 0x700 + Node-ID.

As is usual in CANopen, the LSB is transferred first, followed by the MSB.

Producer heartbeat time

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1017	0	Producer heartbeat time	Unsigned16	rw	N	0	Interval in ms between two transmitted heartbeat telegrams

Device identifier (identity object)

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1018	0	Identity Object: Number of elements	Unsigned8	ro	N	4	The identity object contains general information about the type and version of the device.
	1	Vendor ID	Unsigned32	ro	N	0x00000002	Manufacturer identifier. Beckhoff has vendor ID 2
	2	Product Code	Unsigned32	ro	N	Depends on the product	Device identifier
	3	Revision Number	Unsigned32	ro	N	-	Version number
	4	Serial Number	Unsigned32	ro	N	-	Date of manufacture Low word, high byte: calendar week (dec), low word, low byte: calendar year

Product	Product Code
BK5120	0x11400
BK5110	0x113F6
LC5100	0x113EC
IPwxyz-B510	0x2wxyz
IL2301-B510	0x2008FD

Server SDO parameters

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1200	0	Number of elements	Unsigned8	ro	N	2	Communication parameters of the server SDO. Sub-index 0: number of following parameters
	1	COB-ID Client ->Server	Unsigned32	ro	N	0x000006xy, xy=Node-ID	COB-ID RxSDO (Client -> Server)
	2	COB-ID Server ->Client	Unsigned32	ro	N	0x00000580 + Node-ID	COB-ID TxSDO (Client -> Server)

This is contained in the object directory for reasons of backwards compatibility.

Communication parameters for the 1st RxPDO

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1400	0	Number of elements	Unsigned8	ro	N	5	Communication parameters for the first receive PDO. Sub-index 0: number of following parameters
	1	COB-ID	Unsigned32	rw	N	0x000002xy, xy=Node-ID	COB-ID (Communication Object Identifier) RxPDO1
	2	Transmission Type	Unsigned8	rw	N	255	Transmission type of the PDO
	3	Inhibit Time	Unsigned16	rw	N	0	Present for reasons of backwards compatibility, but not used in the RxPDO.
	4	CMS Priority Group	Unsigned8	rw	N	-	Present for reasons of backwards compatibility, but not used.
	5	Event Timer	Unsigned16	rw	N	0	Event-Timer. Watchdog time defined for monitoring reception of the PDO.

Sub-index 1 (COB-ID): The bottom 11 bits of the 32 bit value (bits 0-10) contain the CAN identifier. The MSB (bit 31) indicates whether the PDO exists currently (0) or not (1). Bit 30 indicates whether an RTR access to this PDO is permissible (0) or not (1). Changing the identifier (bits 0-10) is not allowed while the object exists (bit 31=0). Sub-index 2 contains the type of the transmission (see introduction to PDOs).

Communication parameters for the 2nd RxPDO

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1401	0	Number of elements	Unsigned8	ro	N	5	Communication parameter for the second receive PDO.
	1	COB-ID	Unsigned32	rw	N	0x000003xy, xy=Node-ID	COB-ID (Communication Object Identifier) RxPDO2
	2	Transmission Type	Unsigned8	rw	N	255	Transmission type of the PDO
	3	Inhibit Time	Unsigned16	rw	N	0	Present for reasons of backwards compatibility, but not used in the RxPDO.
	4	CMS Priority Group	Unsigned8	rw	N	-	Present for reasons of backwards compatibility, but not used.
	5	Event Timer	Unsigned16	rw	N	0	Event-Timer. Watchdog time defined for monitoring reception of the PDO.

Communication parameters for the 3rd RxPDO

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1402	0	Number of elements	Unsigned8	ro	N	5	Communication parameter for the third receive PDO.
	1	COB-ID	Unsigned32	rw	N	0x000004xy, xy=Node-ID	COB-ID (Communication Object Identifier) RxPDO3
	2	Transmission Type	Unsigned8	rw	N	255	Transmission type of the PDO
	3	Inhibit Time	Unsigned16	rw	N	0	Present for reasons of backwards compatibility, but not used in the RxPDO.
	4	CMS Priority Group	Unsigned8	rw	N	-	Present for reasons of backwards compatibility, but not used.
	5	Event Timer	Unsigned16	rw	N	0	Event-Timer. Watchdog time defined for monitoring reception of the PDO.

Communication parameters for the 4th RxPDO

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1403	0	Number of elements	Unsigned8	ro	N	5	Communication parameters for the fourth receive PDO.
	1	COB-ID	Unsigned32	rw	N	0x000005xy, xy=Node-ID	COB-ID (Communication Object Identifier) RxPDO4
	2	Transmission Type	Unsigned8	rw	N	255	Transmission type of the PDO
	3	Inhibit Time	Unsigned16	rw	N	0	Present for reasons of backwards compatibility, but not used in the RxPDO.
	4	CMS Priority Group	Unsigned8	rw	N	-	Present for reasons of backwards compatibility, but not used.
	5	Event Timer	Unsigned16	rw	N	0	Event-Timer. Watchdog time defined for monitoring reception of the PDO.

Communication parameters for the 5th – 16th RxPDOs

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1404 - 0x140F (depending on the device type)	0	Number of elements	Unsigned8	ro	N	5	Communication parameter for the 5th to 16th receive PDOs.
	1	COB-ID	Unsigned32	rw	N	0x8000000	COB-ID (Communication Object Identifier) RxPDO5...16
	2	Transmission Type	Unsigned8	rw	N	255	Transmission type of the PDO
	3	Inhibit Time	Unsigned16	rw	N	0	Present for reasons of backwards compatibility, but not used in the RxPDO.
	4	CMS Priority Group	Unsigned8	rw	N	-	Present for reasons of backwards compatibility, but not used.
	5	Event Timer	Unsigned16	rw	N	0	Event-Timer. Watchdog time defined for monitoring reception of the PDO.

The number of RxPDOs for each bus node type can be found in the technical data.

Mapping parameters for the 1st RxPDO

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1600	0	Number of elements	Unsigned8	rw	N	Depending on type and fittings	Mapping parameter of the first receive PDO; sub-index 0: number of mapped objects.
	1	1st mapped object	Unsigned32	rw	N	0x62000108	1st mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)
	2	2nd mapped object	Unsigned32	rw	N	0x62000208	2nd mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)
	...	...	...	...	...	...	...
	8	8th mapped object	Unsigned32	rw	N	0x62000808	8th mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)

The first receive PDO (RxPDO1) is provided by default for digital output data. Depending on the number of outputs inserted, the necessary length of the PDO is automatically determined, and the corresponding objects are mapped. Since the digital outputs are organized in bytes, the length of the PDO in bytes can be found directly at sub-index 0.

Changes to the mapping

The following sequence must be observed in order to change the mapping (specified as from CANopen, version 4):

1. Delete PDO (set bit 31 in the identifier entry (sub-index 1) of the communication parameters to 1)
2. Deactivate mapping (set sub-index 0 of the mapping entry to 0)
3. Change mapping entries (sub-indices 1...8)
4. Activate mapping (set sub-index 0 of the mapping entry to the correct number of mapped objects)
5. Create PDO (set bit 31 in the identifier entry (sub-index 1) of the communication parameters to 0)

Mapping parameters for the 2nd RxPDO

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1601	0	Number of elements	Unsigned8	rw	N	Depending on type and fittings	Mapping parameter of the second receive PDO; sub-index 0: number of mapped objects.
	1	1st mapped object	Unsigned32	rw	N	0x64110110	1st mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)
	2	2nd mapped object	Unsigned32	rw	N	0x64110210	2nd mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)
	...	...	...	...	...	...	...
	8	8th mapped object	Unsigned32	rw	N	0x00000000	8th mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)

The second receive PDO (RxPDO2) is provided by default for analog outputs. Depending on the number of outputs inserted, the necessary length of the PDO is automatically determined, and the corresponding objects are mapped. Since the analog outputs are organized in words, the length of the PDO in bytes can be found directly at sub-index 0.

A specific sequence must be observed in order to change the mapping (see object index 0x1600).

Mapping parameters for the 3rd-16th RxPDO

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1602-0x160F (depending on the device type)	0	Number of elements	Unsigned8	rw	N	Depending on type and fittings	Mapping parameters for the third to sixteenth receive PDOs; sub-index 0: number of mapped objects.
	1	1st mapped object	Unsigned32	rw	N	0x00000000 (see text)	1st mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)
	2	2nd mapped object	Unsigned32	rw	N	0x00000000 (see text)	2nd mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)
	...	...	...	...	...	...	...
	8	8th mapped object	Unsigned32	rw	N	0x00000000 (see text)	8th mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)

The 3rd to 16th receive PDOs (RxPDO3ff) are automatically given a default mapping by the bus node depending on the attached terminals (or depending on the extension modules). The procedure is described in the section on PDO Mapping.

A specific sequence must be observed in order to change the mapping (see object index 0x1600).

Beckhoff default mapping

DS401 V2 specifies analog input and/or output data as the default mapping for PDOs 3+4. This corresponds to Beckhoff's default mapping when less than 65 digital inputs or outputs are present. In order to ensure backwards compatibility, the Beckhoff default mapping is retained - the mapping behavior of the devices therefore corresponds to DS401 V1, where in all other respects they accord with DS401 V2.

Communication parameters for the 1st TxPDO

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1800	0	Number of elements	Unsigned8	ro	N	5	Communication parameters for the first transmit PDO. Sub-index 0: number of following parameters
	1	COB-ID	Unsigned32	rw	N	0x00000180 + Node-ID	COB-ID (Communication Object Identifier) TxPDO1
	2	Transmission Type	Unsigned8	rw	N	255	Transmission type of the PDO
	3	Inhibit Time	Unsigned16	rw	N	0	Repetition delay [value x 100 µs]
	4	CMS Priority Group	Unsigned8	rw	N	-	Present for reasons of backwards compatibility, but not used.
	5	Event Timer	Unsigned16	rw	N	0	Event-Timer

Sub-index 1 (COB-ID): The lower 11 bits of the 32 bit value (bits 0-10) contain the CAN identifier, while the MSBit (bit 31) indicates whether the PDO exists (0) or not (1). Bit 30 indicates whether RTR access to this PDO is permitted (0) or not (1). Changing the identifier (bits 0-10) is not allowed while the object exists (bit 31=0). Sub-index 2 contains the type of transmission, sub-index 3 the repetition delay between two PDOs of the same type, while sub-index 5 contains the event timer. Sub-index 4 is retained for reasons of compatibility, but is not used. (See also Introduction to PDOs.)

Communication parameters for the 2nd TxPDO

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1801	0	Number of elements	Unsigned8	ro	N	5	Communication parameters for the second transmit PDO. Sub-index 0: number of following parameters
	1	COB-ID	Unsigned32	rw	N	0x00000280 + Node-ID	COB-ID (Communication Object Identifier) TxPDO1
	2	Transmission Type	Unsigned8	rw	N	255	Transmission type of the PDO
	3	Inhibit Time	Unsigned16	rw	N	0	Repetition delay [value x 100 µs]
	4	CMS Priority Group	Unsigned8	rw	N	-	Present for reasons of backwards compatibility, but not used.
	5	Event Timer	Unsigned16	rw	N	0	Event-Timer

The second transmit PDO is provided by default for analog inputs, and is configured for event-driven transmission (transmission type 255). Event-driven mode must first be activated (see object 0x6423 [▶ 97]), otherwise the inputs can only be interrogated (polled) by remote transmission request (RTR).

Communication parameters for the 3rd TxPDO

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1802	0	Number of elements	Unsigned8	ro	N	5	Communication parameters for the third transmit PDO. Sub-index 0: number of following parameters
	1	COB-ID	Unsigned32	rw	N	0x00000380 + Node-ID	COB-ID (Communication Object Identifier) TxPDO1
	2	Transmission Type	Unsigned8	rw	N	255	Transmission type of the PDO
	3	Inhibit Time	Unsigned16	rw	N	0	Repetition delay [value x 100 µs]
	4	CMS Priority Group	Unsigned8	rw	N	-	Present for reasons of backwards compatibility, but not used.
	5	Event Timer	Unsigned16	rw	N	0	Event-Timer

The third transmit PDO contains analog input data as a rule (see Mapping [▶ 47]). It is configured for event-driven transmission (transmission type 255). Event-driven mode must first be activated (see object 0x6423 [▶ 97]), otherwise the inputs can only be interrogated (polled) by remote transmission request (RTR).

Communication parameters for the 4th TxPDO

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1803	0	Number of elements	Unsigned8	ro	N	5	Communication parameters for the fourth transmit PDO. Sub-index 0: number of following parameters
	1	COB-ID	Unsigned32	rw	N	0x00000480 + Node-ID	COB-ID (Communication Object Identifier) TxPDO1
	2	Transmission Type	Unsigned8	rw	N	255	Transmission type of the PDO
	3	Inhibit Time	Unsigned16	rw	N	0	Repetition delay [value x 100 µs]
	4	CMS Priority Group	Unsigned8	rw	N	-	Present for reasons of backwards compatibility, but not used.
	5	Event Timer	Unsigned16	rw	N	0	Event-Timer

The fourth transmit PDO contains analog input data as a rule (see Mapping [▶ 47]). It is configured for event-driven transmission (transmission type 255). Event-driven mode must first be activated (see object 0x6423 [▶ 97]), otherwise the inputs can only be interrogated (polled) by remote transmission request (RTR).

Communication parameters for the 5th-16th TxPDOs

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1804-0x180F (depending on the device type)	0	Number of elements	Unsigned8	ro	N	5	Communication parameters for the 5th to 16th transmit PDOs. Sub-index 0: number of following parameters
	1	COB-ID	Unsigned32	rw	N	0x0000000	COB-ID (Communication Object Identifier) TxPDO1
	2	Transmission Type	Unsigned8	rw	N	255	Transmission type of the PDO
	3	Inhibit Time	Unsigned16	rw	N	0	Repetition delay [value x 100 µs]
	4	CMS Priority Group	Unsigned8	rw	N	-	Present for reasons of backwards compatibility, but not used.
	5	Event Timer	Unsigned16	rw	N	0	Event-Timer

Mapping 1st TxPDO

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1A00	0	Number of elements	Unsigned8	rw	N	Depending on type and fittings	Mapping parameter of the first transmit PDO; sub-index 0: number of mapped objects.
	1	1st mapped object	Unsigned32	rw	N	0x60000108	1st mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)
	2	2nd mapped object	Unsigned32	rw	N	0x60000208	2nd mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)
	...	...	...	...	...	...	...
	8	8th mapped object	Unsigned32	rw	N	0x60000808	8th mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)

The first transmit PDO (TxPDO1) is provided by default for digital input data. Depending on the number of inputs inserted, the necessary length of the PDO is automatically determined, and the corresponding objects are mapped. Since the digital inputs are organized in bytes, the length of the PDO in bytes can be found directly at sub-index 0.

A specific sequence must be observed in order to change the mapping (see object index 0x1600 [▸ 79]).

Mapping 2nd TxPDO

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1A01	0	Number of elements	Unsigned8	rw	N	Depending on type and fittings	Mapping parameter of the second transmit PDO; sub-index 0: number of mapped objects.
	1	1st mapped object	Unsigned32	rw	N	0x64010110	1st mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)
	2	2nd mapped object	Unsigned32	rw	N	0x64010210	2nd mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)
	...	...	...	...	...	...	...
	8	8th mapped object	Unsigned32	rw	N		8th mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)

The second transmit PDO (TxPDO2) is provided by default for analog input data. Depending on the number of inputs inserted, the necessary length of the PDO is automatically determined, and the corresponding objects are mapped. Since the analog inputs are organized in words, the length of the PDO in bytes can be found directly at sub-index 0.

A specific sequence must be observed in order to change the mapping (see object index 0x1600 [▸ 79]).

Mapping 3rd –16th TxPDO

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x1A02 - 0x1A0F (depending on the device type)	0	Number of elements	Unsigned8	rw	N	Depending on type and fittings	Mapping parameters for the third to sixteenth transmit PDOs; sub-index 0: number of mapped objects.
	1	1st mapped object	Unsigned32	rw	N	0x00000000 (see text)	1st mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)
	2	2nd mapped object	Unsigned32	rw	N	0x00000000 (see text)	2nd mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)
	...	...	...	...	...	...	...
	8	8th mapped object	Unsigned32	rw	N	0x00000000 (see text)	8th mapped application object (2 byte index, 1 byte subindex, 1 byte bit width)

The 3rd to 16th transmit PDOs (TxPDO3ff) are automatically given a default mapping by the bus node depending on the attached terminals (or depending on the extension modules). The procedure is described in the section on PDO Mapping [▸ 47].

A specific sequence must be observed in order to change the mapping (see object index 0x1600 [▸ 79]).

Beckhoff Default Mapping

DS401 V2 specifies analog input and/or output data as the default mapping for PDOs 3+4. This corresponds to Beckhoff's default mapping when less than 65 digital inputs or outputs are present. In order to ensure backwards compatibility, the Beckhoff default mapping is retained - the mapping behavior of the devices therefore corresponds to DS401 V1, where in all other respects they accord with DS401 V2.

For the sake of completeness, the following object entries are also contained in the object directory (and therefore also in the eds files):

Index	Meaning
0x2000	Digital inputs (function identical to object 0x6000)
0x2100	Digital outputs (function identical with object 0x6200)
0x2200	1-byte special terminals, inputs (at present no terminals corresponding to this type are included in the product range)
0x2300	1-byte special terminals, outputs (at present no terminals corresponding to this type are included in the product range)
0x2400	2-byte special terminals, inputs (at present no terminals corresponding to this type are included in the product range)
0x2500	2-byte special terminals, outputs (at present no terminals corresponding to this type are included in the product range)
0x2E00	7-byte special terminals, inputs (at present no terminals corresponding to this type are included in the product range)
0x2F00	7-byte special terminals, outputs (at present no terminals corresponding to this type are included in the product range)

3-byte special terminals, input data

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x2600	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of available 3-byte special channels, inputs
	1	1st input block	Unsigned24	ro	Y	0x000000	1st input channel
	...	...	...	...	...	...	...
	0X80	128th input block	Unsigned24	ro	Y	0x000000	128th input channel

Sample of special terminals with 3-byte input data (in the default setting): KL2502 (PWM outputs, 2 x 3 bytes)

3-byte special terminals, output data

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x2700	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of available 3-byte special channels, outputs
	1	1st output block	Unsigned24	rww	Y	0x000000	1st output channel
	...	...	...	...	...	...	...
	0X80	128th output block	Unsigned24	rww	Y	0x000000	128th output channel

Sample of special terminals with 3-byte output data (in the default setting): KL2502 (PWM outputs, 2 x 3 bytes)

4-byte special terminals, input data

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x2800	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of available 4-byte special channels, inputs
	1	1st input block	Unsigned32	ro	Y	0x00000000	1st input channel
	...	...	...	...	...	...	...
	0X80	128th input block	Unsigned32	ro	Y	0x00000000	128th input channel

Samples of special terminals with 4-byte input data (in the default setting): KL5001, KL6001, KL6021, KL6051

4-byte special terminals, output data

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x2900	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of available 4-byte special channels, outputs
	1	1st output block	Unsigned32	rww	Y	0x00000000	1st output channel
	...	...	...	...	...	...	...
	0X80	128th output block	Unsigned32	rww	Y	0x00000000	128th output channel

Samples of special terminals with 4-byte output data (in the default setting): KL5001, KL6001, KL6021, KL6051

5-byte special terminals, input data

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x2A00	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of available 5-byte special channels, inputs
	1	1st input block	Unsigned40	ro	Y	0x0000000000	1st input channel
	...	...	...	...	...	...	...
	0X40	64th input block	Unsigned40	ro	Y	0x0000000000	64th input channel

Sample of special terminals with 5-byte input data (in the default setting): KL1501

5-byte special terminals, output data

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x2B00	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of available 5-byte special channels, outputs
	1	1st output block	Unsigned40	rww	Y	0x0000000000	1st output channel
	...	...	...	...	...	...	...
	0X40	64th output block	Unsigned40	rww	Y	0x0000000000	64th output channel

Sample of special terminals with 5-byte output data (in the default setting): KL1501

6-byte special terminals, input data

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x2C00	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of available 6-byte special channels, inputs
	1	1st input block	Unsigned48	ro	Y	0x0000000000	1st input channel
	...	...	...	...	...	...	...
	0X40	64th input block	Unsigned48	ro	Y	0x0000000000	64th input channel

Sample of special terminals with 6-byte input data (in the default setting): KL5051, KL5101, KL5111

6-byte special terminals, output data

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x2D00	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of available 6-byte special channels, outputs
	1	1st output block	Unsigned48	rww	Y	0x0000000000	1st output channel
	...	...	...	...	...	...	...
	0X40	64th output block	Unsigned48	rww	Y	0x0000000000	64th output channel

Sample of special terminals with 6-byte output data (in the default setting): KL5051, KL5101, KL5111

8-byte special terminals, input data

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x3000	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of available 6-byte special channels, inputs
	1	1st input block	Unsigned64	ro	Y	0x0000000000	1st input channel
	...	...	...	...	...	...	...
	0x40	64th input block	Unsigned64	ro	Y	0x0000000000	64th input channel

Sample for special terminals with 8-byte input data: KL5101 (with word alignment, not according to the default setting)

8-byte special terminals, output data

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x3100-	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of available 6-byte special channels, outputs
	1	1st output block	Unsigned64	rww	Y	0x0000000000	1st output channel
	...	...	...	...	...	...	...
	0X40	64th output block	Unsigned64	rww	Y	0x0000000000	64th output channel

Sample for special terminals with 8-byte output data: KL5101 (with word alignment, not according to the default setting)

Bus node register communication

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x4500	0	Register Access	Unsigned32	rw	N	none	Access to internal bus node registers

The 32 bit value is composed as follows:

MSB			LSB
Access (bit 7) + table number (bit 6...0)	Register number	High byte register value	Low byte register value
[0..1] + [0...0x7F]	[0...0xFF]	[0...0xFF]	[0...0xFF]

As is usual in CANopen, the LSB is transferred first, followed by the MSB.

Accessing index 0x4500 allows any registers in the bus station to be written or read. The channel number and the register are addressed here with a 32 bit data word.

Reading the register value

The coupler must first be informed of which register is to be read. This requires an SDO write access to the appropriate index/sub-index combination, with:
- table number (access bit = 0) in byte 3
- register address in byte 2 of the data value 32 bit.

Bytes 1 and 0 are not evaluated if the access bit (MSB of byte 3) equals 0. The register value can then be read with the same combination of index and sub-index.

After the writing of the register address to be read, the coupler sets the access bit to 1 until the correct value is available. Thus an SDO read access must check that the table number lies in the range from 0...0x7F.

An access error during register communication is indicated by the corresponding return value in the SDO protocol (see the SDO section, Breakdown of parameter communication).

A sample of reading register values

It is necessary to determine which baud rate index has been assigned to switch setting 1,1 (DIP 7,8). (See the section covering *Network addresses and baud rates*). To do this, the value in table 100, register 3, must be read. This means that the following SDO telegrams must be sent:

Write access (download request) to index 4500, subindex 0 with data value 32 bit 0x64 03 00 00.

Id=0x600+Node-ID DLC=8; Data=23 00 45 00 00 00 03 64

Then a read access (upload request) to the same index/sub-index. The data value sent here is irrelevant (00 is used here).

Id=0x600+Node-ID DLC=8; Data=23 00 45 00 00 00 03 64

The coupler responds with the upload response telegram:

Id=0x580+Node-ID DLC=8; Data=43 00 45 00 04 00 03 64

This tells us that the value contained in this register is 4, and this baud rate index corresponds to 125 kbit/s (the default value).

Writing register values

SDO write access to the corresponding combination of index and sub-index with:
- table number + 0x80 (access bit = 1) in byte 3
- register address in byte 2
- high byte register value in byte 1
- low byte register value in byte 0 of the 32-bit data value.

Remove coupler write protection

Before the registers of the Bus Coupler can be written, the write protection must first be removed. In order to do this, the following values must be written in the given sequence to the corresponding registers:

Step	Tables	Register	Value	Corresponding SDO download value (0x4500/0)
1.	99	2	45054 (0xAFFE)	0xE3 02 AF FE (0xE3=0x63(=99)+0x80)
2.	99	1	1 (0x0001)	0xE3 01 00 01
3.	99	0	257 (0x0101)	0xE3 00 01 01

Remove coupler write protection (CAN representation)

In order to remove the coupler write protection, the following SDO telegrams (download requests) must thus be sent to the coupler:

Id=0x600+Node-ID DLC=8; Data=23 00 45 00 FE AF 02 E3

Id=0x600+Node-ID DLC=8; Data=23 00 45 00 01 00 01 E3

Id=0x600+Node-ID DLC=8; Data=23 00 45 00 01 01 00 E3

A sample of writing register values

After the write protection has been removed, the baud rate index for DIP switch setting 1,1 is to be set to the value 7. This will assign a baud rate of 20 kbaud to this switch setting.

This requires the value 7 to be written into table 100, register 3. This is done with an SDO write access (download request) to index 0x4500, sub-index 0 with the 32 bit value E4 03 00 07 (0xE4 = 0x64+0x80):

Id=0x600+Node-ID DLC=8; Data=23 00 45 00 07 00 03 E4

Identify terminals

The identifier of the coupler (or of the bus station) and of the attached Bus Terminals can be read from the Bus Coupler's table 9. Register 0 then contains the identifier of the Bus Coupler itself, register 1 the identifier of the first terminal and register n the identification of the n^{th} terminal:

Table number	Register number	Description	Value range
9	0	Bus station identifier	0 - 65535
9	1-255	Identifier of the extension module/bus terminal	0 - 65535

The Bus Coupler description in register number 0 contains 5120 = 0x1400 for the BK5120, 5110 = 0x13F6 for the BK5110 and 5100 = 0x13EC for the LC5100. For the Fieldbus Box modules, register 0 contains the ID 510dec = 0x1FE or 518dec = 0x206.

In the case of analog and special terminals, the terminal identifier (dec) is contained in the extension module identifier or the terminal description.
Sample: if a KL3042 is plugged in as the third terminal, then register 3 contains the value 3042_{dec} (0x0BE2).

The following bit identifier is used for digital terminals:

MSB								LSB							
1	s6	s5	s4	s3	s2	s1	s0	0	0	0	0	0	0	a	e

s6...s1: data width in bits; a=1: output terminal; e=1: Input terminal

This ID leads to the following terminal descriptions:

Identifier terminals	Meaning
0x8201	2 bit digital input terminal, e.g. KL1002, KL1052, Kl9110, KL9260
0x8202	2 bit digital output terminal, e.g. KL2034, KL2612, KL2702
0x8401	4 bit digital input terminal, e.g. KL1104, KL1124, KL1194
0x8402	4 bit digital output terminal, e.g. KL2124, KL2134, KL2184
0x8403	4 bit digital in/output terminal, e.g. KL2212

and the following ID for extension box modules:

Identifier extension box modules	Meaning
0x000A	4 bit input and 4 bit output module
0x0011	8 bit input and 8 bit output module
0x0014	8 bit digital input module
0x0015	8 bit digital output module

General coupler configuration (table 0)

Table 0 of the Bus Coupler contains the data for the general coupler configuration. It is not, as a general rule, necessary to change this; however, for special applications it is possible to change the settings using the KS2000 configuration software, or through direct access via register communication. The write protection must first be removed in order to do this (see above).

The relevant register entries are described below:

K-Bus configuration

Table 0, register 2 contains the K-bus configuration and is coded as follows (default value: 0x0006):

MSB								LSB							
0	0	0	0	0	0	0	0	0	0	0	0	0	D	G	A

A: Auto-reset

If there is a K-Bus error, attempts are made cyclically to start the K-Bus up again through a reset. If emergency telegrams and guarding are not evaluated, activation of auto-reset can lead to output and input information being lost without that loss being noticed.

0: No auto-reset (default)

1: Auto-reset active

G: Device diagnostics

Message (via emergency), e.g. that
- a current input is open circuit (with diagnostics)
- 10 V exceeded at 1-10V input terminal

0: Device diagnostics switched off

1: Device diagnostics active (default)

D: Diagnostic data

show digital terminals into the process image (e.g. KL2212). This flag is only evaluated when device diagnostics is active (see above).

0: Do not display

1: Display (default)

Process image description

Table 0, register 3 contains the process image description and is coded as follows (default value: 0x0903):

MSB								LSB							
0	0	0	0	k1	k0	f1	f0	0	0	a	0	d	k	1	1

k0...k1: Reaction to K-bus errors

0,2: Inputs remain unchanged (default = 2);

1: Set inputs to 0 (TxPDO with zeros is sent)

f0...f1: Reaction to fieldbus error

0: Stop the K-Bus cycles, watchdog in the terminals triggers, fault output values become active. The old output values are initially set during a restart.

1: Set outputs to 0, then stop the K-Bus cycles (default). 2: Outputs remain unchanged.

a: Word alignment of analog and special terminals

0: no alignment (default)

1: Map data to word boundaries (process data always starts on an even address in the PDO)

d: Data format for complex terminals (analog and special terminals)

0: Intel format (default)

1: Motorola format

k: Evaluation of complex terminals (analog and special terminals)

0: only user data (default)

1: Full evaluation (note: Analog channels then need 3 input and 3 output bytes; instead of 2 input bytes, e.g. Instead of 4 channels per PDO, one Rx and one TxPDO is required for 2 channels)

Bus Terminal / Extension Box register communication

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x4501	0	Access Terminal Register	Unsigned8	ro	N	none	Index 0x4501 allows access to all the registers in the bus terminal or extension module. Sub-index 0 contains the number of attached bus terminals.
	1	Access Reg. Terminal 1	Unsigned32	rw	N	none	Access to bus terminal or extension module register 1
	...	...	...	...	...	...	...
	0XFE	Access Reg. Terminal 254	Unsigned32	rw	N	none	Access to bus terminal or extension module register 254

The 32 bit value is composed as follows:

MSB			LSB
Access (bit 7) + channel number (bits 6...0)	Register number	High byte register value	Low byte register value
[0..1] + [0...0x7F]	[0...0xFF]	[0...0xFF]	[0...0xFF]

As is usual in CANopen, the LSB is transferred first, followed by the MSB.

Accessing index 0x4501 allows the user registers in the bus terminal or extension module to be written or read. The modules have a set of registers for each input or output channel. The modules are addressed by means of the sub-index; the channel number and register are addressed in the 32-bit data value. Channel number 0 corresponds here to the first channel, 1 to the second channel, and so forth.

Reading the register value

The coupler must first be informed of which register is to be read. This requires an SDO write access to the appropriate index/sub-index combination, with:
- channel number (access bit = 0) in byte 3
- register address in byte 2 of the data value 32 bit.

Bytes 1 and 0 are not evaluated if the access bit (MSB of byte 3) equals 0. The register value can then be read with the same combination of index and sub-index.

After the writing of the register address to be read, the coupler sets the access bit to 1 until the correct value is available. Thus an SDO read access must check that the table number lies in the range from 0...0x7F.

An access error during register communication is indicated by the corresponding return value in the SDO protocol (see the SDO section, Breakdown of parameter communication).

A sample of reading register values

The thermocouple type to which the second input channel of a KL3202 Thermocouple Input Terminal has been set is to be determined. This requires feature register 32 to be read. The terminal is located in the fifth slot, next to the Bus Coupler. This means that the following SDO telegrams must be sent:

Write access (download request) to index 4501, sub-index 5 with 32 bit data value 01 20 00 00 (0x01 = 2nd channel, 0x20 = register 32)
Id=0x600+Node-ID DLC=8; Data=23 00 45 00 00 00 03 64

Then a read access (upload request) to the same index/sub-index. The data value sent here is irrelevant (0x00 is used here).
Id=0x600+Node-ID DLC=8; Data=23 00 45 00 00 00 03 64

The coupler responds with the upload response telegram:
Id=0x580+Node-ID DLC=8; Data=43 00 45 00 04 00 03 64

This means that the feature register contains the value 31 06. The upper 4 bits indicate the thermocouple type. Their value here is 3, which means that PT500 is the type that has been set for this channel (see the KL3202 documentation).

Writing register values

SDO write access to the corresponding combination of index and sub-index with:

- channel number + 0x80 (access bit = 1) in byte 3
- register address in byte 2
- high byte register value in byte 1
- low byte register value in byte 0 of the 32-bit data value.

NOTE

Please note write protection

If the write protection is not removed (as a result, for instance, of a faulty codeword), then although a write access to the terminal register will be confirmed (SDO download response), the value is not in fact entered into the register. It is therefore recommended that the value is read back after writing and compared.

Remove terminal write protection

Before the user registers in the Bus Terminal (register 32-xx, depending on terminal type or extension module) can be written to, it is first necessary for write protection to be removed. The following codeword is written for this purpose into register 31 of the channel concerned:

Write protection	Channel	Register	Value	Corresponding SDO download value (0x4500/0)
	1,2, 3 or 4	31 (0x1F)	4661 (0x1235)	8y 1F 12 35 (y = channel number)

Remove terminal write protection (CAN representation)

In order to remove the terminal's write protection, the following SDO telegram must thus be sent to the coupler:

Id=600 + Node-ID DLC=8; Data=23 01 45 xx 35 12 1F 8y

where xx is the terminal's slot, and y indicates the channel.

A sample of removing write protection

Suppose that a KL3202 Thermocouple Input Terminal is inserted into slot 5 of a BK5120 that has node address 3, then the write protection for the first channel can be removed as follows:

Id=0x603 DLC=8; Data=23 01 45 05 35 12 1F 80

The following telegram is sent for the second channel:

Id=0x603 DLC=8; Data=23 01 45 05 35 12 1F 80

A sample of writing register values

The type of thermocouple attached to the second channel of the KL3202 Terminal in slot 5 is now to be changed to PT1000. For this purpose, the value 2 must be written into the upper 4 bits (the upper nibble) of the feature register. It is assumed to that the default values are to be supplied for all the other bits in the feature register. Once the write protection has been removed, SDO write access (download request) is used to write the following 32 bit value into index 0x4501, sub-index 05: 81 20 21 06 (0x81=01+0x80; 0x20=32;0x2106 = register value).

The corresponding telegram on the bus looks like this:

Id=0x600+Node-ID DLC=8; Data=23 00 45 00 00 00 03 64

Activate PDOs

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x5500	0	Activate PDO Defaults	Unsigned32	rw	N	0x00000000	sets PDO communication parameters for PDOs 2...11

CANopen defines default identifiers for 4 transmit (Tx) and receive (Rx) PDOs, all other PDOs being initially deactivated after the nodes have started up. Index 0x5500 can activate all the PDOs that, in accordance with the terminals inserted, are filled with process data (manufacturer-specific default mapping). A manufacturer-specific default identifier allocation is carried out here for PDO5…11, while the transmission type and a uniform inhibit time is set for PDO2…11. PDOs that do not have process data (and which are thus superfluous in the present configuration) are not activated.

Pre-Operational

This object can only be written in the pre-operational state!

The 32-bit value is used as follows:

MSB			LSB
Transmission Type RxPDOs	Transmission Type TxPDOs	High byte inhibit time	Low byte inhibit time

As is usual in CANopen, the LSB is transferred first, followed by the MSB.

Sample

Activate PDOs for bus node number 1, set inhibit time to 10ms (=100 x 100µs), set transmission type for TxPDOs to 255, and set transmission type for RxPDOs to 1. The following telegram must be sent:
Id=0x601 DLC=8; Data=23 00 55 00 64 00 FF 01

The node responds with the following telegram:
Id=0x601 DLC=8; Data=60 00 55 00 00 00 00 00

Identifiers used

The default identifier allocation for the additional PDOs leaves the pre-defined regions for guarding, SDOs etc. free, assumes a maximum of 64 nodes in the network with PDO6 as the next node, and proceeds according to the following scheme:

Object	Function code	Resulting COB ID (hex)	Resulting COB ID (dec)
TxPDO5	1101	0x681 - 0x6BF	1665 - 1727
RxPDO5	1111	0x781 - 0x7BF	1921 - 1983
TxPDO6	00111	0x1C1 - 0x1FF	449 - 511
RxPDO6	01001	0x241 - 0x27F	577 - 639
TxDPO7	01011	0x2C1 - 0x2FF	705 - 767
RxPDO7	01101	0x341 - 0x37F	833 - 895
TxPDO8	01111	0x3C1 - 0x3FF	961 - 1023
RxPDO8	10001	0x441 - 0x47F	1089 - 1151
TxPDO9	10011	0x4C1 - 0x4FF	1217 - 1279
RxPDO9	10101	0x541 - 0x57F	1345 - 1407
TxDPO10	10111	0x5C1 - 0x5FF	1473 - 1535
RxPDO10	11001	0x641 - 0x67F	1601 - 1663
TxPDO11	11011	0x6C1 - 0x6FF	1729 - 1791
RxPDO11	11101	0x741 - 0x77F	1857 - 1919

NOTE

Index 0x5500

Ensure that index 0x5500 is not used if Bus Couplers with more than 5 PDOs are present in networks with node addresses > 64, otherwise identification overlaps can occur. In that case, the PDO identifiers must be set individually.

For the sake of clarity, the default identifiers defined according to CANopen are also listed here:

Object	Function code	Resulting COB ID (hex)	Resulting COB ID (dec)
Emergency	0001	0x81 - 0xBF [0xFF]	129 - 191 [255]
TxPDO1	0011	0x181 - 0x1BF [0x1FF]	385 - 447 [511]
RxPDO1	0100	0x201 - 0x23F [0x27F]	513 - 575 [639]
TxPDO2	0101	0x281 - 0x2BF [0x2FF]	641 - 676 [767]
RxPDO2	0110	0x301 - 0x33F [0x37F]	769 - 831 [895]
TxDPO3	0111	0x381 - 0x3BF [0x3FF]	897 - 959 [1023]
RxPDO3	1000	0x401 - 0x43F [0x47F]	1025 - 1087 [1151]
TxPDO4	1001	0x481 - 0x4BF [0x4FF]	1153 - 1215 [1279]
RxPDO4	1010	0x501 - 0x53F [0x57F]	1281- 1343 [1407]
SDO (Tx)	1011	0x581 - 0x5BF [0x5FF]	1409 - 1471 [1535]
SDO (Rx)	1100	0x601 - 0x63F [0x67F]	1537 - 1599 [1663]
Guarding / Heartbeat°/ Bootup	1110	0x701 - 0x73F [0x77F]	1793 - 1855 [1919]

The identifiers that result from the DIP switch settings on the coupler are given, as are the identifier regions for the node addresses 64...127 (not settable in Bus Couplers BK5110, BK5120 and LC5100) in square brackets. Addresses 1 to 99 can be set for the Fieldbus Box modules and the Bus Coupler BK515x.

The appendix [▶ 113] contains a tabular summary of all the identifiers.

Digital inputs

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x6000	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of available digital 8-bit input data blocks
	1	1st input block	Unsigned8	ro	Y	0x00	1st input channel
	...	...	...	...	...	...	...
	0XFE	254th input block	Unsigned8	ro	Y	0x00	254th input channel

Interrupt mask

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x6126	0	Number of elements	Unsigned8	ro	N	Depending on type	The number of 32-bit interrupt masks = 2 x the number of TxDPOs
	1	IR-Mask0 TxPDO1	Unsigned32	rw	N	0xFFFFFFFF	IR mask bytes 0...3 TxPDO1
	2	IR-Mask1 TxPDO1	Unsigned32	rw	N	0xFFFFFFFF	IR-mask bytes 4...7 TxPDO1
	3	IR-Mask0 TxPDO2	Unsigned32	rw	N	0xFFFFFFFF	IR-mask bytes 0...3 TxPDO2
	...	...	...	...	...	...	...
	0x20	IR-Mask1 TxPDO16	Unsigned32	rw	N	0xFFFFFFFF	IR-mask bytes 4...7 TxPDO16

By default, every change in the value in an event-driven PDO causes a telegram to be sent. The interrupt mask makes it possible to determine which data changes are evaluated for this purpose. By clearing the appropriate ranges within the PDOs they are masked out for event-driving purposes (interrupt control). The interrupt mask does not just govern all the PDOs with digital inputs, but all the TxPDOs that are present. If the TxPDOs are shorter than 8 bytes, then the superfluous part of the IR mask is not evaluated.

The interrupt mask only has an effect on TxPDOs with transmission types 254 and 255. It is not stored in the device (not even through object 0x1010). Changes to the mask at runtime (when the status is operational) are possible, and are evaluated starting from the next change of input data.

The interrupt mask for TxPDOs with analog input data is not evaluated if either limit values (0x6424, 0x6425) or the delta function (0x6426) have been activated for the inputs.

This entry has been implemented in firmware C3 and above.

Sample for assignment of data

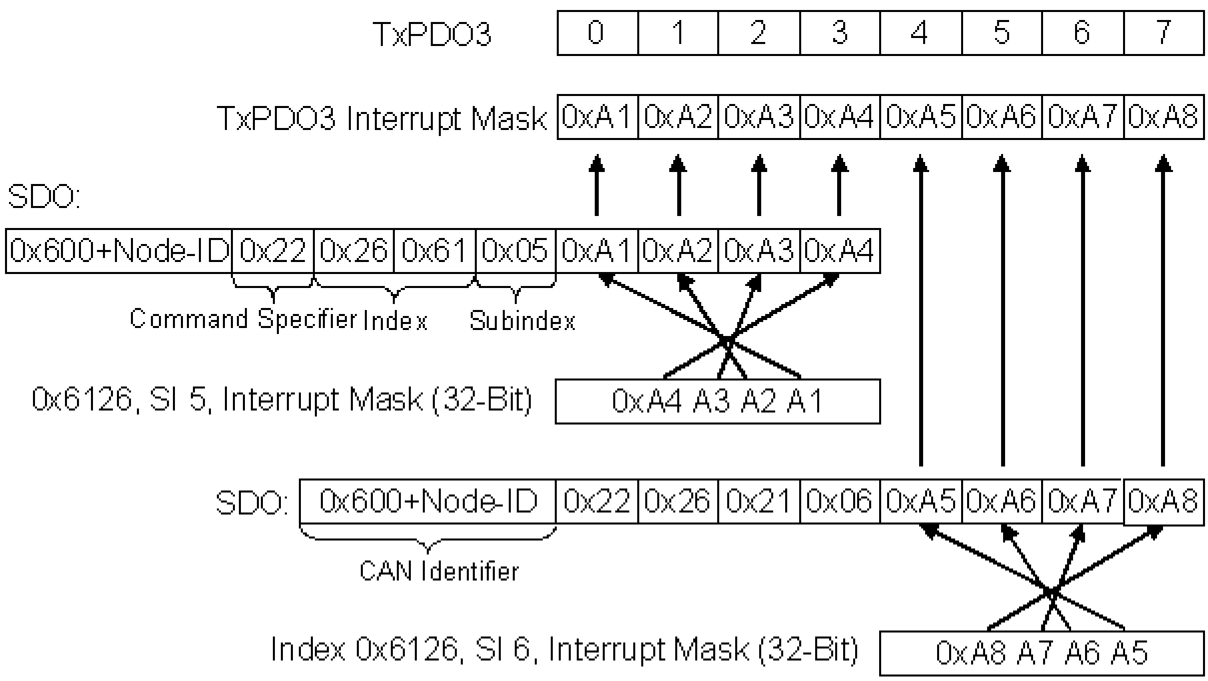

Fig. 47: Sample for assignment of data

Application sample

The value contained in a fast counter input is only to be transmitted when bits in the status word (the latch input, for instance) have changed. This requires the 32 bit counter value to be masked out (zeroed) in the interrupt mask. The status is located in byte 0, while the counter value is, by default, contained in bytes or 1..4 of the corresponding PDOs (TxPDO3 in this sample, because < 65 digital and < 5 analog inputs are present).
This means that index 0x6126, sub-index5 must receive the value 0x0000 00FF and that sub-index6 must have 0xFFFF FF00 written into it.

The corresponding SDOs therefore appear as follows:

11 bit identifier	**8 byte of user data**							
0x600+ node ID	0x22	0x26	0x61	0x05	0xFF	0x00	0x00	0x00
11 bit identifier	8 byte of user data							
0x600+ node ID	0x22	0x26	0x61	0x06	0x00	0xFF	0xFF	0xFF

Digital outputs

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x6200	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of available digital 8-bit output data blocks
	1	1st input block	Unsigned8	rw	Y	0x00	1st output channel
	...	...	...	...	...	...	...
	0XFE	254th input block	Unsigned8	rw	Y	0x00	254th output channel

Analog inputs

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x6401	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of analog input channels available
	1	1st input	Unsigned16	ro	Y	0x0000	1st input channel
	...	...	...	...	...	...	...
	0XFE	254th input	Unsigned16	ro	Y	0x0000	254th input channel

The analog signals are displayed left aligned. The representation in the process image is therefore independent of the actual resolution. Detailed information on the data format can be found at the relevant signal type.

Analog outputs

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x6411	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of analog output channels available
	1	1st input block	Unsigned16	rw	Y	0x0000	1st output channel
	...	...	...	...	...	...	...
	0XFE	254th input block	Unsigned16	rw	Y	0x0000	254th output channel

The analog signals are displayed left aligned. The representation in the process image is therefore independent of the actual resolution. Detailed information on the data format can be found at the relevant signal type.

Event driven analog inputs

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x6423	0	Global Interrupt Enable	Boolean	rw	N	FALSE (0)	Activates the event-driven transmission of PDOs with analog inputs.

Although, in accordance with CANopen, the analog inputs in TxPDO 2..4 are by default set to transmission type 255 (event driven), the event (the alteration of an input value) is suppressed by the event control in object 0x6423, in order to prevent the bus from being swamped with analog signals. It is recommended that the flow of data associated with the analog PDOs is controlled either through synchronous communication or through using the event timer. In event-driven operation, the transmission behavior of the analog PDOs can be parameterized before activation by setting the inhibit time (object 0x1800ff, sub-index 3) and/or limit value monitoring (objects 0x6424 + 0x6425) and/or delta function (object 0x6426).

Upper limit value analog inputs

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x6424	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of analog input channels available
	1	upper limit 1st input	Unsigned16	rw	Y	0x0000	Upper limit value for 1st input channel
	...	...	...	...	...	...	...
	0XFE	upper limit 254. input	Unsigned16	rw	Y	0x0000	Upper limit value for 254th input channel

Values different from 0 activate the upper limit value for this channel. A PDO is then transmitted if this limit value is exceeded. In addition, the event driven mode must be activated (object 0x6423). The data format corresponds to that of the analog inputs.

Lower limit value analog inputs

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x6425	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of analog input channels available
	1	lower limit 1st input	Unsigned16	rw	Y	0x0000	Lower limit value for 1st input channel
	...	...	...	...	...	...	...
	0XFE	lower limit 254. input	Unsigned16	rw	Y	0x0000	Lower limit value for 254th input channel

Values different from 0 activate the lower limit value for this channel. A PDO is then transmitted if the value falls below this limit value. In addition, the event driven mode must be activated (object 0x6423). The data format corresponds to that of the analog inputs.

Delta function for analog inputs

Index	Subindex	Name	Type	Attrb.	Map.	Default value	Meaning
0x6426	0	Number of elements	Unsigned8	ro	N	Depending on type and fittings	Number of analog input channels available
	1	delta value 1st input	Unsigned16	rw	Y	0x0000	Delta value for the 1st input channel
	...	...	...	...	...	...	...
	0XFE	delta value 254th input	Unsigned16	rw	Y	0x0000	Delta value for the 254th input channel

Values different from 0 activate the delta function for this channel. A PDO is then transmitted if the value has changed by more than the delta value since the last transmission. In addition, the event driven mode must be activated (object 0x6423). The data format corresponds to that of the analog inputs (delta value: can only have positive values).

7.2 Register description

The KS2000 configuration software can be used to change the settings of the CANopen coupler. This is possible from firmware version C6 of the Bus Coupler. The KS2000 configuration software shows the current firmware version of your Bus Coupler.

Register write protection

In order to be able to change the settings, you first have to deactivate the register write protection via the KS2000 configuration software.

Meaning of the entries in table 100

Table 100, offset	Description	Default (BK5150)
000	baud rate at DIP switches 7,8 "00"	0 (see table 2 -> 1 M/Auto)
001	baud rate at DIP switches 7,8 "10"	2 (see table 2 -> 500 k)
002	baud rate at DIP switches 7,8 "01"	4 (see table 2 -> 250 k)
003	baud rate at DIP switches 7,8 "11"	5 (see table 2 -> 125 k)
004	reserved	0x8809
005	Mode	0x0001
006	reserved	reserved
007	reserved	reserved
008	reserved	reserved
009	Setting a fixed node ID; DIP switches 1 to 6 are disabled	0
010	Setting a fixed baud rate; DIP switches 7 and 8 are disabled	0
011-018	baud rate at DIP switches 7,8 "00"	reserved

value in register 5	Mode
Bit 0	"TRUE" auto-baud switched on
Bit 8	The node ID can be set up to 127 (DIP 8 for baud rate, DIP 0-7 for node ID)
Bit 15	The coupler automatically switches to operational mode (only with fixed baud rate)

Setting a fixed baud rate, based on the BK5120 as a sample

A fixed baud rate can be stored in register 10 of table 100. Valid values are 0 to 3. The baud rate specified in register 0, 1, 2 or 3 is then used.

Sample for 50 kBaud

- Disable the write protection.
- Open table 100.
- Write 0x0007 in offset 0 (see table 2).
- Write 0x8000 in offset 10.
- Restart the coupler.
  The fixed baud rate of 50 kbaud is now set.

NOTE

Setting the MSB disables DIP switches 7 and 8

The DIP switches 7 and 8 no longer have a function if the MSB is set (MSB stands for most significant bit. For a word like register 10: hexadecimal 0x8000 or binary 2x1000_0000).

Deactivation of auto baud detection for IPxxxx-B510 and IL23xx-B510

For BK515x, IPxxxx-B510 and IL23xx-B510 bit 0 from register 5, table 100 must be set to „FALSE“; deactivation of auto baud detection.

permissible baud rates (table 2)

value in register 10	Baudrate
0x0000	1 MBaud/Auto
0x0001	800 kbaud
0x0002	500 kbaud
0x0003	400 kbaud
0x0004	250 kbaud
0x0005	125 kbaud
0x0006	100 kbaud
0x0007	50 kbaud
0x0008	20 kbaud
0x0009	10 kbaud
0x8xxx	Set baud rate active
0x0xxx	DIP switch active

Setting a fixed node ID

A fixed node ID can be stored in register 9 of table 100. Valid values are 1 to 63.

NOTE

Setting the MSB disables DIP switches 1 to 6

The DIP switches 1 to 6 no longer have a function if the MSB is set (MSB stands for most significant bit. For a word like register 9: hexadecimal 0x8000 or binary 2x1000_0000).

8 Diagnostics and error handling

8.1 LEDs

Overview

The Bus Coupler has two groups of LEDs for the display of status. The upper group (BK51x0) or left hand group (LC5100) indicates the state of the fieldbus.

On the upper right hand side of the BK51x0 bus coupler are two more green LEDs that indicate the supply voltage. The left hand LED indicates the presence of the 24 V supply for the Bus Coupler. The right hand LED indicates the presence of the supply to the power contacts. The two K-Bus LEDs (I/O RUN, I/O ERR) are located under the fieldbus LEDs. These indicate the operational state of the Bus Terminals and the connection to these Bus Terminals.

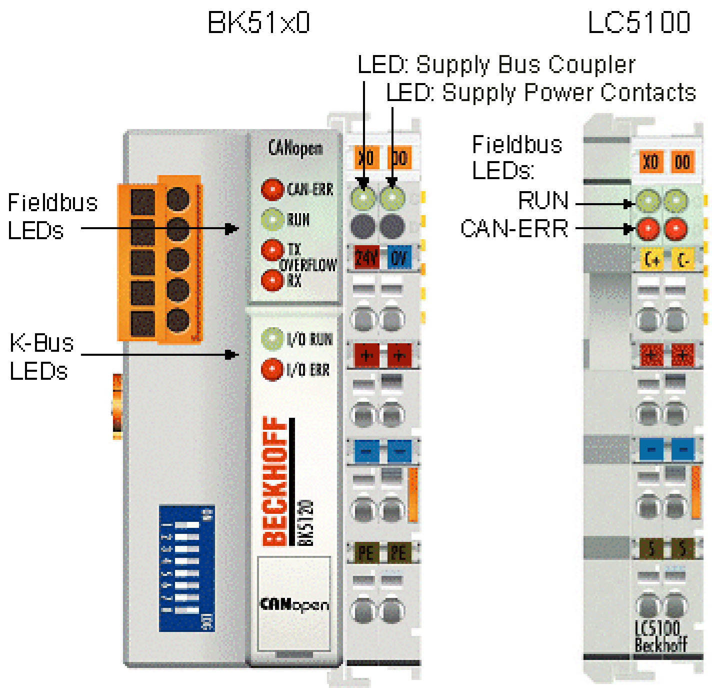

Fig. 48: BK51x0, LC5100 - LEDs

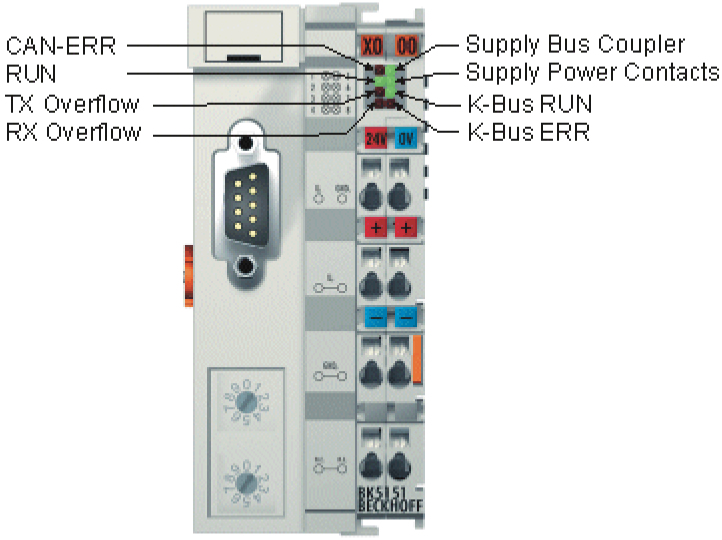

Fig. 49: BK5151 - LEDs

Fieldbus LEDs

The upper four LEDs (or the two LEDs on the left) indicate the operating state of the CANopen communication. The CAN-ERR LED here provides an indication of the physical state of the bus as well as of protocol errors. The RUN LED indicates the CANopen status of the bus node. The overflow LEDs come on in the event of a send or receive buffer overflow.

The behavior of the LEDs accords with CANopen recommendation DRP303-3 from CAN in Automation.

CAN-ERR blink code

CAN ERR	Meaning
off	CAN bus **has no errors**
fast flashing (approx. 50 ms on, approx. 50 ms off; alternating with RUN LED)	Automatic baud rate detection **has not yet found a valid baud rate.** Not enough telegrams on the bus yet.
1 x blinking (approx. 200 ms on, 1 s off)	**CAN warning limit exceeded.** There are too many error frames on the bus. Please check the wiring (e.g. termination resistors, screens, conductor length, stubs). Other possible causes for exceeding the warning limit: there are no other participating devices in the network (occurs, for instance, when the first node is started).
2 x blinking (each approx. 200ms on, 200ms off, followed by a 1s pause)	The **guarding or heartbeat monitor** has asserted, because either guarding telegrams or heartbeat telegrams are no longer being received. Precondition for guarding monitoring: guard time and life time factors are > 0. Precondition for heartbeat monitoring: Consumer Heartbeat >0). The Bus Coupler is pre-operational (PDOs switched off), and the outputs are in the error state.
3 x blinking (each approx. 200ms on, 200ms off, followed by a 1s pause)	A **synchronization error** has occurred. No sync telegrams were received from the Bus Coupler during the set monitoring time (object 0x1006 x 1.5). The bus node is pre-operational (PDOs switched off), and the outputs are in the error state.
4 x blinking (each approx. 200ms on, 200ms off, followed by a 1s pause)	**Event timer error**: The Bus Coupler has not received an RxPDO within the set event time (0x1400ff sub-index 5). The bus node is pre-operational (PDOs switched off), and the outputs are in the error state.
on	CAN communication ceased due to serious CAN errors (**bus off**). Coupler must be restarted.

RUN blink code

RUN	Meaning
off	Firmware status < C0: Bus node is in *stopped* **state**. No communication is possible with SDO or PDO.
fast flashing (approx. 50 ms on, approx. 50 ms off; alternating with CAN ERR LED)	Automatic baud rate detection **has not yet found a valid baud rate.** Not enough telegrams on the bus yet.
1 x flashing (approx. 200 ms on, 1 s off)	Bus node is in *stopped* **state**. No communication is possible with SDO or PDO.
alternating flashing (approx. 200 ms on, 200 ms off)	Bus node is in **state** *pre-operational*. The node was not yet started.
on	Bus node is in *Operational* **state**.

Tx overflow blink code

Tx Overflow	Meaning
on	A *transmit queue overflow* has occurred. The bus coupler could not send its messages. Cause: e.g. excessive bus load. A bus coupler reset must be carried out.
Blinking cyclically (approx. 200 ms on, 200 ms off)	Logical Tx queue overflow: SYNC interval too short. The coupler could not deliver all the TxPDOs before the following SYNC telegram. The TxPDOs are then, for instance, delivered in every second SYNC interval. Remedy: Lengthen the SYNC interval or raise the transmission type. In some cases it may be appropriate to reduce the I/O count at this bus station (e.g. by moving I/Os to the neighboring station) Notice: The logical Tx queue overflow is signaled for approx. 10 sec and then reset. If it keeps recurring, signaling is maintained.

Rx overflow blink code

Rx Overflow	Meaning
on	A *receive queue overflow* has occurred. The Bus Coupler loses messages. Cause: e.g. bursts of short telegrams. A bus coupler reset must be carried out.
Blinking cyclically (approx. 200 ms on, 200 ms off)	A *receive queue overflow* has occurred. The Bus Coupler has lost messages, but the overflow condition is no longer current. Cause: e.g. bursts of short telegrams, perhaps during a status transition (e.g. very short SYNC interval during transition after operational). Signaling is reset during a Bus Coupler reset.

K-bus LEDs (local errors)

Two LEDs, the K-bus LEDs, indicate the operational state of the Bus Terminals and the connection to these Bus Terminals. The green LED (I/O RUN) lights up in order to indicate fault-free operation. The red LED (I/O ERR) flashes with two different frequencies in order to indicate an error. The errors are displayed in the blink code in the following way:

Flashing Code

fast blinking	Start of the error code
First slow sequence	Error code
Second slow sequence	Error argument (error location)

Error type

Error code	Error code argument	Description	Remedy
Persistent, continuous flashing		general K-bus error	- Check terminal strip
1 pulse	0	EEPROM checksum error	- Set manufacturer's setting with the KS2000 software - Connect fewer terminals; too many entries in the table for the programmed configuration - Software update required for the coupler
	1	Inline code buffer overflow	
	2	Unknown data type	
2 pulses	0	Programmed configuration incorrect table entry / Bus Coupler	- Check programmed configuration for correctness - Incorrect table entry / Bus Coupler
	(n>0)	Incorrect table comparison (terminal n)	
3 pulses	0	K-bus command error	- No terminal connected; attach terminals. - One of the terminals is defective; halve the number of terminals attached and check whether the error is still present with the remaining terminals. Repeat until the defective terminal is located.
4 pulses	0 n	K-Bus data error, break behind Bus Terminal n	Check whether the n+1 terminal is correctly connected; replace if necessary. - Check whether the end terminal 9010 is connected.
5 pulses	n	K-Bus error during register communication with Terminal	Replace terminal n.
7 pulses	n	BK5110 or LC5110: unsupported terminal detected at location n	only use digital terminals or Bus Coupler BK5120

Error code	Error code argument	Description	Remedy
9 pulses	0 n	Checksum error in program flash memory Terminal n is not consistent with the configuration that existed during creation of the boot project	- Set manufacturer's setting with the KS2000 - Set manufacturer's setting with the KS2000, which will delete the boot project
13 pulses	0	Runtime K-bus command error	- One of the terminals is defective; halve the number of terminals attached and check whether the error is still present with the remaining terminals. Repeat until the defective terminal is located.
14 pulses	n	Terminal n has the wrong format	- Start the coupler again, and if the error occurs again then exchange the terminal
15 pulses	n	Number of terminals is no longer correct	- Start the coupler again, and if the error occurs again after this, use the KS2000 software to set manufacturer's settings
16 pulses	n	Length of the K-bus data (bit length) is no longer correct. n = bit length after booting	- Start the coupler again, and if the error occurs again after this, use the KS2000 software to set manufacturer's settings
17 pulses	n	Number of terminals is no longer correct. n = number of terminals after booting	- Start the coupler again, and if the error occurs again after this, use the KS2000 software to set manufacturer's settings
18 pulses	n	The terminal description is no longer correct after reset (n=terminal number).	- Start the coupler again, and if the error occurs again after this, use the KS2000 software to set manufacturer's settings

Error location

The number of pulses indicates the position of the last Bus Terminal before the fault. Passive Bus Terminals, such as a power feed terminal, are not included in the count.

8.2 Emergency Object

In order to be able to inform other participating devices on the CANopen bus about internal device errors or CAN bus errors, CANopen Bus Couplers can make use of the emergency object. It has a high priority, and provides valuable information about the state of the device and of the network.

NOTE

Evaluate the emergency objects!

It is strongly recommended that emergency objects are evaluated - they provide a valuable source of information.

Structure of the emergency message

The emergency object is always 8 bytes long; it contains first the 2-byte error code, then the 1-byte error register, and finally the additional code of 5 bytes. This is divided into a 2-byte bit field and a 3-byte parameter field:

11 bit identifier	8 byte user data							
0x80 (128_{dec}) + node ID	EC0	EC1	EReg	Bit field0: Comm	Bit field1: DevErr	EMCY trigger	Info0	Info1

Legend

Parameter	Explanation	
EC0	Error Code Low-Byte. 0x00 or 0x30*	
EC1	Error Code High Byte. 0X50 = Device Error, 0x81 = Communication Error, 0x00 = Error Reset	
EReg	Error Register. 0x81 = Device Error, 0x91 = Communication error	
Bit field 0: Comm	Bit field communication error:	
	0x01	Guarding delayed or failed
	0x02	Sync delayed or failed
	0x04	Incorrect PDO length parameterized
	0x08	Event timer timeout: RxPDO not received in time
	0x10	Receive Queue Overrun
	0x20	Transmit Queue Overrun
	0x40	CAN bus OFF
	0x80	CAN warning limit exceeded
Bit field 1: DevErr	Bit field device error:	
	0x01	Terminal error
	0x02	K-bus error / IP-Link error
	0x03	-
	0x04	EEPROM error
	0x10	Unsupported terminal plugged in (BK5110, LC5100)
	0x80	Altered HW configuration.

*) If EC0 has the value 0x30, then only the first four bytes of the Emcy telegram and possibly the Emcy trigger byte are to be evaluated. The data of DevErr and Info0 and Info1 have then no meaning and are to be ignored.

Parameter	Explanation	
EMCY trigger	The *emergency trigger* byte contains the code for the particular error that has triggered the emergency telegram. If an error has been rectified, an emergency telegram with the error code 0x0000 is sent, and the emergency trigger contains the description of the error that has been corrected. Errors that are still current are signaled here in the bit fields. Once the Bus Coupler is free of errors, it sends an emergency telegram containing zeros everywhere other than in the emergency trigger.	
	0x01	CAN warning limit exceeded (too many error frames)
	0x02	CAN bus OFF state has been reached. Since the coupler can no longer send an emergency telegram, an emergency telegram with trigger 0x40 is sent when the bus leaves the "off" state (a new CAN controller initialization).
	0x03	Transmit queue overrun: CAN messages are being lost
	0x04	Receive Queue Overrun: Receive queue overrun: CAN messages are being lost
	0x06	Incorrect PDO length parameterized (check mapping). Info 0: parameterized (expected) PDO length in bytes Info 1: current PDO length (results from the added lengths of the mapped objects)
	0x07	Sync delayed (time-out after communication cycle period, index 0x1006) or failed
	0x08	Guarding or heartbeat delayed (timeout following guard time x lifetime factor, or following consumer heartbeat time) or failed.
	0x09	Altered HW configuration. The inserted terminals or the composition of the extension modules has been changed since the last save.
	0x0A	Event timer timeout: RxPDO not received in time
	0x0B	Logical Tx queue overrun: SYNC interval too short. The coupler could not deliver all the TxPDOs before the following SYNC telegram. The TxPDOs are then, for instance, delivered in every second SYNC interval. Remedy: Lengthen the SYNC interval or raise the transmission type. In some cases it may be appropriate to reduce the I/O count at this bus station (e.g. by moving I/Os to the neighboring station)
	0x0C	Unsupported terminal plugged in (BK5110 or LC5100) Info 1: terminal number (1...64)
	0x0E	EEPROM error; an error occurred when saving the configuration in the EEPROM
	0x0F	K-bus error Info 0: Error type: 0x03: command error (no terminal number), 0x04: Interruption in the K-Bus or in IP-Link 0x05: Error in register communication 0x0B: Timeout in extension box 0x0C: More than 120 modules in the IP-Link ring 0x0D: K-Bus command error, or IP-Link: Unknown extension box 0x0E: Alignment error 0x0F: Number of terminals changed 0x10: K-Bus reset: Bit length of K-Bus changed 0x11: K-Bus reset: Number of terminals changed 0x12: K-Bus reset: Type of a terminal changed Info 1: terminal number (1...64)
	0x10	Terminal error Info 0: terminal number (1...64) Info 1: general diagnostic status code for the terminal: Bit 0,1: Channel number (00: Channel 1; 01: Channel 2; 10: Channel 3; 11: Channel 4) Bit 2...6: reserved Bit 7: Error (=1: occurred; =0: corrected). See the status register of the terminal or of the extension module for more detailed information about the type of error.
Info 0, Info 1	Contains additional error information; its meaning depends on the emergency trigger (see above)	

Sample of emergency behavior

1. The CAN error counter in a Bus Coupler has exceeded the warning limit (too many error frames). It sends an emergency telegram with the identifier 0x80 + node address (default setting) with the following contents:
   00 81 91 80 00 01 00 00
   The first three bytes (0x00 81 91) identify a communication error, while the bit field 0 (0x80) indicates that the *CAN Warning Limit has been exceeded*. The EMCY trigger (0x01) shows that the emergency was triggered as a result of exceeding the warning limit.
2. Immediately afterwards a cable goes open circuit on the second channel of the 4-20 mA analog input terminal plugged into the tenth location. The Bus Coupler sends another emergency telegram with the following contents:
   00 50 91 80 01 10 0A 82
   The first two bytes (0x00 50) identify a hardware error. Bits 0 (generic error), 4 (communication) and 7 (manufacturer-specific) are set in the error register (0x91). Bit 7 is set in bit field 0 (0x80), showing that the CAN warning limit continues to be exceeded. Bit 0 is set in bit field 1 (0x01), indicating a terminal error. The EMCY trigger (0x10) indicates that it is this terminal error that has triggered the emergency telegram. Finally, Info0 (0x0A) indicates the terminal number (10) while Info1 (0x82) shows in bit1 and bit7 that channel2 has an error.
3. If the error counter now falls below the warning limit again, the coupler sends the following emergency telegram:
   00 00 81 00 01 01 0A 82
   The error code (00 00) in the first two bytes shows that an error has been reset. The error register (0x81) continues to show the device error, because the cable is still broken. Bit field0 (0x00) shows that the communication error is no longer present. According to bit field 1 (0x01) the terminal error continues to be present. The EMCY trigger (0x01) indicates that the reason for the transmission was the resetting of the CAN warning limit. Info 0 and Info 1 continue to show the terminal's diagnostics status code.
4. Once the broken cable has been repaired this error is also reset, and the coupler sends the following emergency telegram:
   00 00 00 00 00 00 00 00

8.3 CANopen Trouble Shooting

Error Frames

One sign of errors in the CAN wiring, the address assignment or the setting of the baud rate is an increased number of error frames: the diagnostic LEDs then show *Warning Limit exceeded* or *Bus-off state entered*.

Error Frames

Warning limit exceeded, passive error or bus-off state are indicated first of all at those nodes that have detected the most errors. These nodes are not necessarily the cause for the occurrence of error frames!
If, for instance, one node contributes unusually heavily to the bus traffic (e.g. because it is the only one with analog inputs, the data for which triggers event-driven PDOs at a high rate), then the probability of its telegrams being damaged increases. Its error counter will, correspondingly, be the first to reach a critical level.

Node ID / Setting the Baud Rate

Care must be taken to ensure that node addresses are not assigned twice: there may only be one sender for each CAN data telegram.

Test 1

Check node addresses. If the CAN communication functions at least some of the time, and if all the devices support the boot up message, then the address assignment can also be examined by recording the boot up messages after the devices are switched on. This will not, however, recognize node addresses that have been swapped.

Test 2

Check that the same baud rate has been set everywhere. For special devices, if the bit timing parameters are accessible, do they agree with the CANopen definitions (sampling time, SJW, oscillator).

Testing the CAN wiring

These tests should not be carried out if the network is active: No communication should take place during the tests. The following tests should be carried out in the stated sequence, because some of the tests assume that the previous test was successful. Not all the tests are generally necessary.

Network terminator and signal leads

The nodes should be switched off or the CAN cable unplugged for this test, because the results of the measurements can otherwise be distorted by the active CAN transceiver.

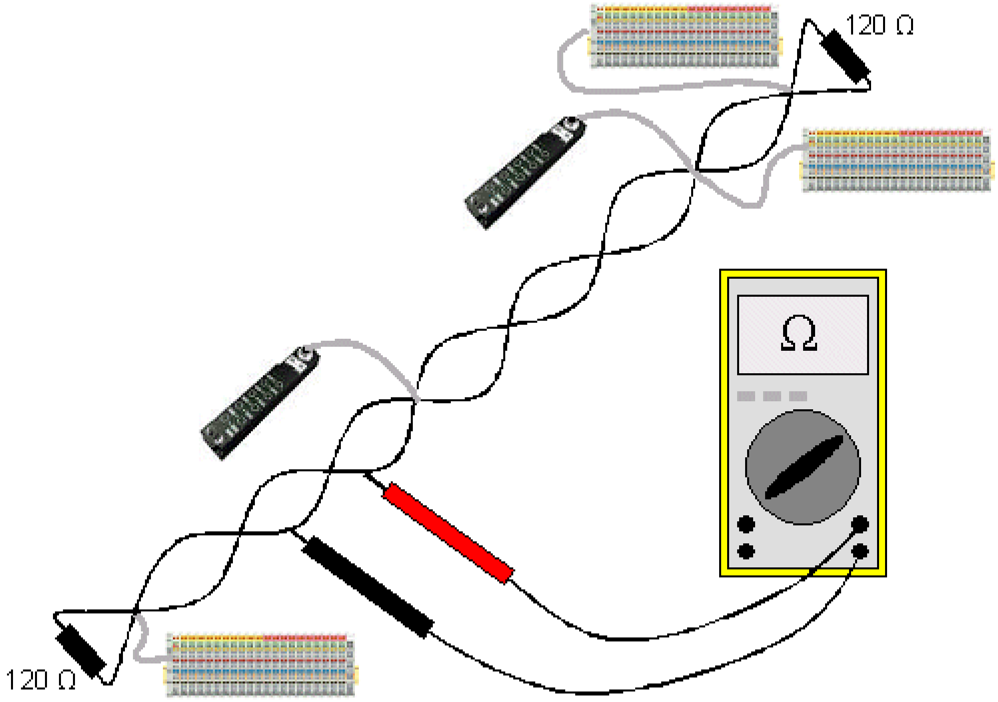

Fig. 50: Wiring diagram for test setup

Test 3

Determine the resistance between CAN high and CAN low - at each device, if necessary.

If the measured value is greater than 65 Ohms, it indicates the absence of a terminating resistor or a break in a signal lead. If the measured value is less than 50 Ohms, look for a short circuit between the CAN lines, more than the correct number of terminating resistors, or faulty transceivers.

Test 4

Check for a short circuit between the CAN ground and the signal leads, or between the screen and signal leads.

Test 5

Remove the earth connection from the CAN ground and screen. Check for a short circuit between the CAN ground and screen.

Topology

The possible cable length in CAN networks depends heavily on the selected baud rate. CAN will tolerate short drop lines - although this again depends on the baud rate. The maximum permitted drop line length should not be exceeded. The length of cable that has been installed is often underestimated - estimates can even be a factor of 10 less than the actual length. The following test is therefore recommended:

Test 6

Measure the lengths of the drop lines and the total bus lengths (do not just make rough estimates!) and compare them with the topology rules for the relevant baud rate.

Screening and earthing

The power supply and the screen should be carefully earthed at the power supply unit, once only and with low resistance. At all connecting points, branches and so forth the screen of the CAN cable (and possibly the CAN GND) must also be connected, as well as the signal leads. In the Beckhoff IP20 Bus Couplers, the screen is grounded for high frequencies via an R/C element.

Test 7

Use a DC ammeter (16 amp max.) to measure the current between the power supply ground and the shield at the end of the network most remote from the power supply unit. An equalization current should be present. If there is no current, then either the screen is not connected all the way through, or the power supply unit is not properly earthed. If the power supply unit is somewhere in the middle of the network, the measurement should be performed at both ends. When appropriate, this test can also be carried out at the ends of the drop line.

Test 8

Interrupt the screen at a number of locations and measure the connection current. If current is flowing, the screen is earthed at more than one place, creating a ground loop.

Potential differences

The screen must be connected all the way through for this test, and must not be carrying any current - this has previously been tested.

Test 9

Measure and record the voltage between the screen and the power supply ground at each node. The maximum potential difference between any two devices should be less than 5 volts.

Detect and localize faults

The "low-tech approach" usually works best: disconnect parts of the network, and observe when the fault disappears.

However, this does not work well for problems such as excessive potential differences, ground loops, EMC or signal distortion, since the reduction in the size of the network often solves the problem without the "missing" piece being the cause. The bus load also changes as the network is reduced in size, which can mean that external interference "hits" CAN telegrams less often.

Diagnosis with an oscilloscope is not usually successful: even when they are in good condition, CAN signals can look really chaotic. It may be possible to trigger on error frames using a storage oscilloscope - this type of diagnosis, however, is only possible for expert technicians.

Protocol problems

In rare cases, protocol problems (e.g. faulty or incomplete CANopen implementation, unfavorable timing at boot up, etc.) can be the cause of faults. In this case it is necessary to trace the bus traffic for evaluation by a CANopen experts - the Beckhoff support team can help here.

A free channel on a Beckhoff FC5102 CANopen PCI card is appropriate for such a trace - Beckhoff make the necessary trace software available on the internet. Alternatively, it is of course possible to use a normal commercial CAN analysis tool.

Protocol problems can be avoided if devices that have not been conformance tested are not used. The official CANopen Conformance Test (and the appropriate certificate) can be obtained from the CAN in Automation Association (https://www.can-cia.org).

9 Appendix

9.1 Quick Start for Experienced Users

Target group

This brief introduction is intended for users who are already familiar with CAN. It clarifies the CAN messages that are required in order to work with Beckhoff CANopen input/output groups in the initial configuration (default settings).

It remains necessary to read and use the full documentation.

Hardware configuration

The DIP switches must be used to set a consistent transmission rate and differing node addresses (node ID) on the Bus Couplers. The switch assignments are printed on the modules. It should be noted that CANopen uses address ”0" to address all modules (broadcast), so that this cannot be set as the address of a particular module.

Starting the modules

CANopen allows the modules to be started with a single network management [▸ 50] telegram:

11 bit identifier	2 byte user data							
0x00	0x01	0x00						

The first data byte here contains the start command (Start_Remote_Node), while the second data byte contains the node address (here: 0, which addresses all nodes).

The inputs and outputs are enabled after the modules have been started. In the default setting the modules communicate in event-driven mode, so that changes at the digital inputs are immediately transmitted and outputs are immediately set in accordance with received telegrams containing output data.

CAN identifier

The CAN identifiers for the input and output data are derived from the node address (1-63):

Data type	Default CAN identifier
digital inputs 1...64	0x180 (=384$_{dec}$) + node address
digital outputs 1...64	0x200 (=512$_{dec}$) + node address
analog inputs 1...4	0x280 (=640$_{dec}$) + node address
analog outputs 1...4	0x300 (=768$_{dec}$) + node address
analog inputs 5...8*	0x380 (=896$_{dec}$) + node address
analog outputs 5...8*	0x400 (=1024$_{dec}$) + node address
analog inputs 9...12*	0x480 (=1152$_{dec}$) + node address
analog outputs 9...12*	0x500 (=1280$_{dec}$) + node address

* If more than 64 digital inputs or outputs are present, the range is offset accordingly (see section Default mapping).

Digital inputs

The CAN messages with digital input data are composed as follows:

11 bit identifier	1-8 bytes of user data (depending on the number of input terminals or extension modules)							
0x180(=384$_{dec}$) + node ID	I0	I1	I2	I3	I4	I5	I6	I7

E0: Input bytes on input terminals (or Fieldbus Box modules), from left to right.

Digital outputs

The CAN messages with digital output data have the following structure:

11 bit identifier	1-8 bytes of user data (depending on the number of output terminals or extension modules)							
0x200(=512$_{dec}$) + node ID	A0	A1	A2	A3	A4	A5	A6	A7

O0: Output bytes on output terminals (or Fieldbus Box modules), from left to right.

Analog inputs

CAN messages with analog input data look like this:

11 bit identifier	4-8 bytes of user data (depending on the number of analog inputs)							
0x280(640$_{dec}$) + node ID	I0.0	I0.1	I1.0	I1.1	I2.0	I2.1	I3.0	I3.1

I x.0...I x.1: analog input x. The data format is described in detail in the object directory at object 0x6401 [▶ 97].

The transmission behavior of analog inputs

To avoid "swamping" the bus with constantly changing analog input values, the analog CANopen input modules do not generate any data telegrams in the default state. The analog data can be read out by means of a remote access (Remote Transmit Request, a CAN message with no data and with the RTR bit set) to the analog input telegrams. Alternatively, of course, the module can be re-configured in such a way that an alteration of the input value does trigger the sending of a telegram. For this purpose a value > 0 is written into index 0x6423 [▶ 97] of the object directory. The corresponding SDO telegram looks like this:

11 bit identifier	8 byte user data							
0x600(=768$_{dec}$) + node ID	0x22	0x23	0x64	0x00	0x01	0x00	0x00	0x00

It is recommended that event control (where every change in the LSB is considered an event, resulting in the corresponding telegram being transmitted) is not used for the transmission of input data, but that either cyclic, synchronous transmission or the event timer is used to send the data. If event control is indeed used, then the quantity of data should be reduced by setting a delta value (object directory index 0x6426 [▶ 98]), limit values (0x6424 [▶ 97]+0x6425 [▶ 98]) or an inhibit time (no new data transmission until the inhibit time has elapsed, 0x1801ff [▶ 80]). Further information on parameter communication can be found in section Service data: SDO [▶ 63].

Analog outputs

CAN messages with analog output data look like this:

11 bit identifier	4-8 bytes of user data (depending on the number of analog outputs)							
0x300(=768$_{dec}$) + node ID	O0.0	O0.1	O1.0	O1.1	O2.0	O2.1	O3.0	O3.1

O x.0...O x.1: analog output x. The data format is described in detail in the object directory at object 0x6411 [▶ 97].

Default identifier

The appendix contains a tabular summary of all the default identifiers. The CAN messages displayed on a CAN monitor can quickly and easily be identified with the help of that overview.

Stopping the modules

If necessary, the process data communication from the modules can be stopped with the following telegram:

11 bit identifier	2 byte user data							
0x00	0x80	0xYZ						

0xXX: node address; 0xYZ=0x00 addresses all the modules

Guarding

The telegrams described above are themselves adequate for many applications. Since, however, the modules operate in event-driven mode by default (no cyclical data exchange), the failure of a module is not necessarily detected. A remedy for this is provided here through monitoring the modules by cyclically polling their status, a process known as node guarding.

For this purpose a status telegram is requested cyclically by means of remote transmit request (RTR):

11 bit identifier	No user data in the request telegram (RTR)
0x700(=1792$_{dec}$) + node ID	(RTR bit set in the header)

The modules answer with a telegram that includes a status byte.

11 bit identifier	1 byte user data							
0x700(=1792$_{dec}$) + node ID	0xYZ							

0xYZ: Status byte:
bits 6...0 contain the node status (0x7F=127: pre-operational, 0x05=operational; 0x04= stopped or prepared).
Bit 7 = toggle bit (inverts with every transmission).

So that the Bus Coupler can detect failure of the network master (watchdog function), the guard time [▶ 73] (object 0x100C) and the life time factor [▶ 73] (object 0x100D) must be set to have value different from 0. (response time in the event of a fault: Guard Time X Life Time Factor).

Heartbeat

As an alternative to guarding, the module can also be monitored by means of what is called the heartbeat. This involves a status telegram (the heartbeat) being issued cyclically by the node. Data request telegrams (remote frames) are not required.

In order to activate the heartbeat telegram, the producer heartbeat time [▶ 75] must be set. This is done with the following SDO [▶ 63] telegram:

11 bit identifier	8 byte user data							
0x600(=768$_{dec}$) + node ID	0x22	0x17	0x10	0x00	0xcd	0xab	0x00	0x00

where 0xabcd is the desired heartbeat cycle time, expressed in milliseconds.

With the telegrams that have now been described you are in a position to start and stop the modules, read inputs, write outputs and to monitor the modules. Do not neglect to read the manual with attention. Only by doing so you can properly use the many features of the Beckhoff CANopen Bus Coupler.

9.2 CAN Identifier List

The list provided here should assist in identifying and assigning CANopen messages. All the identifiers allocated by the CANopen default identifier allocation are listed, as well as the manufacturer-specific default identifiers issued by Beckhoff via object 0x5500 (only to be used in networks with node addresses less than 64).

The following values serve as guide values and entry points for the comprehensive identifier table:

Decimal: 400 [▶ 113] 500 [▶ 113] 600 [▶ 113] 700 [▶ 113] 800 [▶ 113] 900 [▶ 113] 1000 [▶ 113] 1100 [▶ 113] 1200 [▶ 113] 1300 [▶ 113] 1400 [▶ 113] 1500 [▶ 113] 1600 [▶ 113] 1700 [▶ 113] 1800 [▶ 113] 1900 [▶ 113]

Hexadecimal: 0x181 [▸ 113] 0x1C1 [▸ 113] 0x201 [▸ 113] 0x301 [▸ 113] 0x401 [▸ 113] 0x501 [▸ 113] 0x601 [▸ 113] 0x701 [▸ 113]

The identifier distribution via object 0x5500 follows this pattern:

Object	Resulting COB ID (dec)	Resulting COB ID (hex)
Emergency	129 to 191 [255]	0x81 to 0xBF [0xFF]
TxPDO1 [▸ 113]	385 to 447 [511]	0x181 to 0x1BF [0x1FF]
RxPDO1 [▸ 113]	513 to 575 [639]	0x201 to 0x23F [0x27F]
TxPDO2 [▸ 113]	641 to 676 [767]	0x281 to 0x2BF [0x2FF]
RxPDO2 [▸ 113]	769 to 831 [895]	0x301 to 0x33F [0x37F]
TxDPO3 [▸ 113]	897 to 959 [1023]	0x381 to 0x3BF [0x3FF]
RxPDO3 [▸ 113]	1025 to 1087 [1151]	0x401 to 0x43F [0x47F]
TxPDO4 [▸ 113]	1153 to 1215 [1279]	0x481 to 0x4BF [0x4FF]
RxPDO4 [▸ 113]	1281 to 1343 [1407]	0x501 to 0x53F [0x57F]
TxPDO5 [▸ 113]	1665 to 1727	0x681 to 0x6BF
RxPDO5 [▸ 113]	1921 to 1983	0x781 to 0x7BF
TxPDO6 [▸ 113]	449 to 511	0x1C1 to 0x1FF
RxPDO6 [▸ 113]	577 to 639	0x241 to 0x27F
TxDPO7 [▸ 113]	705 to 767	0x2C1 to 0x2FF
RxPDO7 [▸ 113]	833 to 895	0x341 to 0x37F
TxPDO8 [▸ 113]	961 to 1023	0x3C1 to 0x3FF
RxPDO8 [▸ 113]	1089 to 1151	0x441 to 0x47F
TxPDO9 [▸ 113]	1217 to 1279	0x4C1 to 0x4FF
RxPDO9 [▸ 113]	1345 to 1407	0x541 to 0x57F
TxDPO10 [▸ 113]	1473 to 1535	0x5C1 to 0x5FF
RxPDO10 [▸ 113]	1601 to 1663	0x641 to 0x67F
TxPDO11 [▸ 113]	1729 to 1791	0x6C1 to 0x6FF
RxPDO11 [▸ 113]	1857 to 1919	0x741 to 0x77F
SDO (Tx) [▸ 113]	1409 to 1471 [1535]	0x581 to 0x5BF [0x5FF]
SDO (Rx) [▸ 113]	1537 to 1599 [1663]	0x601 to 0x63F [0x67F]
Guarding / Heartbeat / Bootup [▸ 113]	1793 to 1855 [1919]	0x701 to 0x73F [0x77F]

Identifier List

Identifiers marked with * are given manufacturer-specific assignments on the Bus Couplers after writing index 0x5500

dec	hex	Telegram type	dec	hex	Telegram type	dec	hex	Telegram type
0	0x00	NMT	874	0x36A	RxPDO7*, Nd.42	1430	0x596	SDO Tx Nd.22
128	0x80	SYNC	875	0x36B	RxPDO7*, Nd.43	1431	0x597	SDO Tx Nd.23
129	0x81	EMCY Nd.1	876	0x36C	RxPDO7*, Nd.44	1432	0x598	SDO Tx Nd.24
130	0x82	EMCY Nd.2	877	0x36D	RxPDO7*, Nd.45	1433	0x599	SDO Tx Nd.25
131	0x83	EMCY Nd.3	878	0x36E	RxPDO7*, Nd.46	1434	0x59A	SDO Tx Nd.26
132	0x84	EMCY Nd.4	879	0x36F	RxPDO7*, Nd.47	1435	0x59B	SDO Tx Nd.27
133	0x85	EMCY Nd.5	880	0x370	RxPDO7*, Nd.48	1436	0x59C	SDO Tx Nd.28
134	0x86	EMCY Nd.6	881	0x371	RxPDO7*, Nd.49	1437	0x59D	SDO Tx Nd.29
135	0x87	EMCY Nd.7	882	0x372	RxPDO7*, Nd.50	1438	0x59E	SDO Tx Nd.30
136	0x88	EMCY Nd.8	883	0x373	RxPDO7*, Nd.51	1439	0x59F	SDO Tx Nd.31
137	0x89	EMCY Nd.9	884	0x374	RxPDO7*, Nd.52	1440	0x5A0	SDO Tx Nd.32
138	0x8A	EMCY Nd.10	885	0x375	RxPDO7*, Nd.53	1441	0x5A1	SDO Tx Nd.33
139	0x8B	EMCY Nd.11	886	0x376	RxPDO7*, Nd.54	1442	0x5A2	SDO Tx Nd.34
140	0x8C	EMCY Nd.12	887	0x377	RxPDO7*, Nd.55	1443	0x5A3	SDO Tx Nd.35
141	0x8D	EMCY Nd.13	888	0x378	RxPDO7*, Nd.56	1444	0x5A4	SDO Tx Nd.36
142	0x8E	EMCY Nd.14	889	0x379	RxPDO7*, Nd.57	1445	0x5A5	SDO Tx Nd.37
143	0x8F	EMCY Nd.15	890	0x37A	RxPDO7*, Nd.58	1446	0x5A6	SDO Tx Nd.38
144	0x90	EMCY Nd.16	891	0x37B	RxPDO7*, Nd.59	1447	0x5A7	SDO Tx Nd.39
145	0x91	EMCY Nd.17	892	0x37C	RxPDO7*, Nd.60	1448	0x5A8	SDO Tx Nd.40
146	0x92	EMCY Nd.18	893	0x37D	RxPDO7*, Nd.61	1449	0x5A9	SDO Tx Nd.41
147	0x93	EMCY Nd.19	894	0x37E	RxPDO7*, Nd.62	1450	0x5AA	SDO Tx Nd.42
148	0x94	EMCY Nd.20	895	0x37F	RxPDO7*, Nd.63	1451	0x5AB	SDO Tx Nd.43
149	0x95	EMCY Nd.21	897	0x381	TxPDO3*, Nd.1	1452	0x5AC	SDO Tx Nd.44
150	0x96	EMCY Nd.22	898	0x382	TxPDO3*, Nd.2	1453	0x5AD	SDO Tx Nd.45
151	0x97	EMCY Nd.23	899	0x383	TxPDO3*, Nd.3	1454	0x5AE	SDO Tx Nd.46
152	0x98	EMCY nd. 24	900	0x384	TxPDO3*, Nd.4	1455	0x5AF	SDO Tx Nd.47
153	0x99	EMCY Nd.25	901	0x385	TxPDO3*, Nd.5	1456	0x5B0	SDO Tx Nd.48
154	0x9A	EMCY Nd.26	902	0x386	TxPDO3*, Nd.6	1457	0x5B1	SDO Tx Nd.49
155	0x9B	EMCY Nd.27	903	0x387	TxPDO3*, Nd.7	1458	0x5B2	SDO Tx Nd.50
156	0x9C	EMCY Nd.28	904	0x388	TxPDO3*, Nd.8	1459	0x5B3	SDO Tx Nd.51
157	0x9D	EMCY Nd.29	905	0x389	TxPDO3*, Nd.9	1460	0x5B4	SDO Tx Nd.52
158	0x9E	EMCY Nd.30	906	0x38A	TxPDO3*, Nd.10	1461	0x5B5	SDO Tx Nd.53
159	0x9F	EMCY Nd.31	907	0x38B	TxPDO3*, Nd.11	1462	0x5B6	SDO Tx Nd.54
160	0xA0	EMCY Nd.32	908	0x38C	TxPDO3*, Nd.12	1463	0x5B7	SDO Tx Nd.55
161	0xA1	EMCY Nd.33	909	0x38D	TxPDO3*, Nd.13	1464	0x5B8	SDO Tx Nd.56
162	0xA2	EMCY Nd.34	910	0x38E	TxPDO3*, Nd.14	1465	0x5B9	SDO Tx Nd.57
163	0xA3	EMCY Nd.35	911	0x38F	TxPDO3*, Nd.15	1466	0x5BA	SDO Tx Nd.58
164	0xA4	EMCY Nd.36	912	0x390	TxPDO3*, Nd.16	1467	0x5BB	SDO Tx Nd.59
165	0xA5	EMCY Nd.37	913	0x391	TxPDO3*, Nd.17	1468	0x5BC	SDO Tx Nd.60
166	0xA6	EMCY Nd.38	914	0x392	TxPDO3*, Nd.18	1469	0x5BD	SDO Tx Nd.61
167	0xA7	EMCY Nd.39	915	0x393	TxPDO3*, Nd.19	1470	0x5BE	SDO Tx Nd.62
168	0xA8	EMCY Nd.40	916	0x394	TxPDO3*, Nd.20	1471	0x5BF	SDO Tx Nd.63
169	0xA9	EMCY Nd.41	917	0x395	TxPDO3*, Nd.21	1473	0x5C1	TxPDO10*, Nd.1
170	0xAA	EMCY Nd.42	918	0x396	TxPDO3*, Nd.22	1474	0x5C2	TxPDO10*, Nd.2
171	0xAB	EMCY Nd.43	919	0x397	TxPDO3*, Nd.23	1475	0x5C3	TxPDO10*, Nd.3
172	0xAC	EMCY Nd.44	920	0x398	TxPDO3*, Nd.24	1476	0x5C4	TxPDO10*, Nd.4
173	0xAD	EMCY Nd.45	921	0x399	TxPDO3*, Nd.25	1477	0x5C5	TxPDO10*, Nd.5
174	0xAE	EMCY Nd.46	922	0x39A	TxPDO3*, Nd.26	1478	0x5C6	TxPDO10*, Nd.6
175	0xAF	EMCY Nd.47	923	0x39B	TxPDO3*, Nd.27	1479	0x5C7	TxPDO10*, Nd.7
176	0xB0	EMCY Nd.48	924	0x39C	TxPDO3*, Nd.28	1480	0x5C8	TxPDO10*, Nd.8
177	0xB1	EMCY Nd.49	925	0x39D	TxPDO3*, Nd.29	1481	0x5C9	TxPDO10*, Nd.9
178	0xB2	EMCY Nd.50	926	0x39E	TxPDO3*, Nd.30	1482	0x5CA	TxPDO10*, Nd.10
179	0xB3	EMCY Nd.51	927	0x39F	TxPDO3*, Nd.31	1483	0x5CB	TxPDO10*, Nd.11
180	0xB4	EMCY Nd.52	928	0x3A0	TxPDO3*, Nd.32	1484	0x5CC	TxPDO10*, Nd.12
181	0xB5	EMCY Nd.53	929	0x3A1	TxPDO3*, Nd.33	1485	0x5CD	TxPDO10*, Nd.13
182	0xB6	EMCY Nd.54	930	0x3A2	TxPDO3*, Nd.34	1486	0x5CE	TxPDO10*, Nd.14
183	0xB7	EMCY Nd.55	931	0x3A3	TxPDO3*, Nd.35	1487	0x5CF	TxPDO10*, Nd.15
184	0xB8	EMCY Nd.56	932	0x3A4	TxPDO3*, Nd.36	1488	0x5D0	TxPDO10*, Nd.16

dec	hex	Telegram type	dec	hex	Telegram type	dec	hex	Telegram type
185	0xB9	EMCY Nd.57	933	0x3A5	TxPDO3*, Nd.37	1489	0x5D1	TxPDO10*, Nd.17
186	0xBA	EMCY nd. 58	934	0x3A6	TxPDO3*, Nd.38	1490	0x5D2	TxPDO10*, Nd.18
187	0xBB	EMCY Nd.59	935	0x3A7	TxPDO3*, Nd.39	1491	0x5D3	TxPDO10*, Nd.19
188	0xBC	EMCY Nd.60	936	0x3A8	TxPDO3*, Nd.40	1492	0x5D4	TxPDO10*, Nd.20
189	0xBD	EMCY Nd.61	937	0x3A9	TxPDO3*, Nd.41	1493	0x5D5	TxPDO10*, Nd.21
190	0xBE	EMCY Nd.62	938	0x3AA	TxPDO3*, Nd.42	1494	0x5D6	TxPDO10*, Nd.22
191	0xBF	EMCY Nd.63	939	0x3AB	TxPDO3*, Nd.43	1495	0x5D7	TxPDO10*, Nd.23
385	0x181	TxPDO1, DI, Nd.1	940	0x3AC	TxPDO3*, Nd.44	1496	0x5D8	TxPDO10*, Nd.24
386	0x182	TxPDO1, DI, Nd.2	941	0x3AD	TxPDO3*, Nd.45	1497	0x5D9	TxPDO10*, Nd.25
387	0x183	TxPDO1, DI, Nd.3	942	0x3AE	TxPDO3*, Nd.46	1498	0x5DA	TxPDO10*, Nd.26
388	0x184	TxPDO1, DI, Nd.4	943	0x3AF	TxPDO3*, Nd.47	1499	0x5DB	TxPDO10*, Nd.27
389	0x185	TxPDO1, DI, Nd.5	944	0x3B0	TxPDO3*, Nd.48	1500	0x5DC	TxPDO10*, Nd.28
390	0x186	TxPDO1, DI, Nd.6	945	0x3B1	TxPDO3*, Nd.49	1501	0xDE	TxPDO10*, Nd.29
391	0x187	TxPDO1, DI, Nd.7	946	0x3B2	TxPDO3*, Nd.50	1502	0x5DE	TxPDO10*, Nd.30
392	0x188	TxPDO1, DI, Nd.8	947	0x3B3	TxPDO3*, Nd.51	1503	0x5DF	TxPDO10*, Nd.31
393	0x189	TxPDO1, DI, Nd.9	948	0x3B4	TxPDO3*, Nd.52	1504	0x5E0	TxPDO10*, Nd.32
394	0x18A	TxPDO1, DI, Nd.10	949	0x3B5	TxPDO3*, Nd.53	1505	0x5E1	TxPDO10*, Nd.33
395	0x18B	TxPDO1, DI, Nd.11	950	0x3B6	TxPDO3*, Nd.54	1506	0x5E2	TxPDO10*, Nd.34
396	0x18C	TxPDO1, DI, Nd.12	951	0x3B7	TxPDO3*, Nd.55	1507	0x5E3	TxPDO10*, Nd.35
397	0x18D	TxPDO1, DI, Nd.13	952	0x3B8	TxPDO3*, Nd.56	1508	0x5E4	TxPDO10*, Nd.36
398	0x18E	TxPDO1, DI, Nd.14	953	0x3B9	TxPDO3*, Nd.57	1509	0x5E5	TxPDO10*, Nd.37
399	0x18F	TxPDO1, DI, Nd.15	954	0x3BA	TxPDO3*, Nd.58	1510	0x5E6	TxPDO10*, Nd.38
400	0x190	TxPDO1, DI, Nd.16	955	0x3BB	TxPDO3*, Nd.59	1511	0x5E7	TxPDO10*, Nd.39
401	0x191	TxPDO1, DI, Nd.17	956	0x3BC	TxPDO3*, Nd.60	1512	0x5E8	TxPDO10*, Nd.40
402	0x192	TxPDO1, DI, Nd.18	957	0x3BD	TxPDO3*, Nd.61	1513	0x5E9	TxPDO10*, Nd.41
403	0x193	TxPDO1, DI, Nd.19	958	0x3BE	TxPDO3*, Nd.62	1514	0x5EA	TxPDO10*, Nd.42
404	0x194	TxPDO1, DI, Nd.20	959	0x3BF	TxPDO3*, Nd.63	1515	0x5EB	TxPDO10*, Nd.43
405	0x195	TxPDO1, DI, Nd.21	961	0x3C1	TxPDO8*, Nd.1	1516	0x5EC	TxPDO10*, Nd.44
406	0x196	TxPDO1, DI, Nd.22	962	0x3C2	TxPDO8*, Nd.2	1517	0x5ED	TxPDO10*, Nd.45
407	0x197	TxPDO1, DI, Nd.23	963	0x3C3	TxPDO8*, Nd.3	1518	0x5EE	TxPDO10*, Nd.46
408	0x198	TxPDO1, DI, Nd.24	964	0x3C4	TxPDO8*, Nd.4	1519	0x5EF	TxPDO10*, Nd.47
409	0x199	TxPDO1, DI, Nd.25	965	0x3C5	TxPDO8*, Nd.5	1520	0x5F0	TxPDO10*, Nd.48
410	0x19A	TxPDO1, DI, Nd.26	966	0x3C6	TxPDO8*, Nd.6	1521	0x5F1	TxPDO10*, Nd.49
411	0x19B	TxPDO1, DI, Nd.27	967	0x3C7	TxPDO8*, Nd.7	1522	0x5F2	TxPDO10*, Nd.50
412	0x19C	TxPDO1, DI, Nd.28	968	0x3C8	TxPDO8*, Nd.8	1523	0x5F3	TxPDO10*, Nd.51
413	0x19D	TxPDO1, DI, Nd.29	969	0x3C9	TxPDO8*, Nd.9	1524	0x5F4	TxPDO10*, Nd.52
414	0x19E	TxPDO1, DI, Nd.30	970	0x3CA	TxPDO8*, Nd.10	1525	0x5F5	TxPDO10*, Nd.53
415	0x19F	TxPDO1, DI, Nd.31	971	0x3CB	TxPDO8*, Nd.11	1526	0x5F6	TxPDO10*, Nd.54
416	0x1A0	TxPDO1, DI, Nd.32	972	0x3CC	TxPDO8*, Nd.12	1527	0x5F7	TxPDO10*, Nd.55
417	0x1A1	TxPDO1, DI, Nd.33	973	0x3CD	TxPDO8*, Nd.13	1528	0x5F8	TxPDO10*, Nd.56
418	0x1A2	TxPDO1, DI, nd. 34	974	0x3CE	TxPDO8*, Nd.14	1529	0x5F9	TxPDO10*, Nd.57
419	0x1A3	TxPDO1, DI, Nd.35	975	0x3CF	TxPDO8*, Nd.15	1530	0x5FA	TxPDO10*, Nd.58
420	0x1A4	TxPDO1, DI, Nd.36	976	0x3D0	TxPDO8*, Nd.16	1531	0x5FB	TxPDO10*, Nd.59
421	0x1A5	TxPDO1, DI, Nd.37	977	0x3D1	TxPDO8*, Nd.17	1532	0x5FC	TxPDO10*, Nd.60
422	0x1A6	TxPDO1, DI, Nd.38	978	0x3D2	TxPDO8*, Nd.18	1533	0x5FD	TxPDO10*, Nd.61
423	0x1A7	TxPDO1, DI, Nd.39	979	0x3D3	TxPDO8*, Nd.19	1534	0x5FE	TxPDO10*, Nd.62
424	0x1A8	TxPDO1, DI, Nd.40	980	0x3D4	TxPDO8*, Nd.20	1535	0x5FF	TxPDO10*, Nd.63
425	0x1A9	TxPDO1, DI, Nd.41	981	0x3D5	TxPDO8*, Nd.21	1537	0x601	SDO Rx Nd.1
426	0x1AA	TxPDO1, DI, Nd.42	982	0x3D6	TxPDO8*, Nd.22	1538	0x602	SDO Rx Nd.2
427	0x1AB	TxPDO1, DI, Nd.43	983	0x3D7	TxPDO8*, Nd.23	1539	0x603	SDO Rx Nd.3
428	0x1AC	TxPDO1, DI, Nd.44	984	0x3D8	TxPDO8*, Nd.24	1540	0x604	SDO Rx Nd.4
429	0x1AD	TxPDO1, DI, Nd.45	985	0x3D9	TxPDO8*, Nd.25	1541	0x605	SDO Rx Nd.5
430	0x1AE	TxPDO1, DI, Nd.46	986	0x3DA	TxPDO8*, Nd.26	1542	0x606	SDO Rx Nd.6
431	0x1AF	TxPDO1, DI, Nd.47	987	0x3DB	TxPDO8*, Nd.27	1543	0x607	SDO Rx Nd.7
432	0x1B0	TxPDO1, DI, Nd.48	988	0x3DC	TxPDO8*, Nd.28	1544	0x608	SDO Rx Nd.8
433	0x1B1	TxPDO1, DI, Nd.49	989	0x3DD	TxPDO8*, Nd.29	1545	0x609	SDO Rx Nd.9
434	0x1B2	TxPDO1, DI, Nd.50	990	0x3DE	TxPDO8*, Nd.30	1546	0x60A	SDO Rx Nd.10
435	0x1B3	TxPDO1, DI, Nd.51	991	0x3DF	TxPDO8*, Nd.31	1547	0x60B	SDO Rx Nd.11

dec	hex	Telegram type	dec	hex	Telegram type	dec	hex	Telegram type
436	0x1B4	TxPDO1, DI, Nd.52	992	0x3E0	TxPDO8*, Nd.32	1548	0x60C	SDO Rx Nd.12
437	0x1B5	TxPDO1, DI, Nd.53	993	0x3E1	TxPDO8*, Nd.33	1549	0x60D	SDO Rx Nd.13
438	0x1B6	TxPDO1, DI, Nd.54	994	0x3E2	TxPDO8*, Nd.34	1550	0x60E	SDO Rx Nd.14
439	0x1B7	TxPDO1, DI, Nd.55	995	0x3E3	TxPDO8*, Nd.35	1551	0x60F	SDO Rx Nd.15
440	0x1B8	TxPDO1, DI, Nd.56	996	0x3E4	TxPDO8*, Nd.36	1552	0x610	SDO Rx Nd.16
441	0x1B9	TxPDO1, DI, Nd.57	997	0x3E5	TxPDO8*, Nd.37	1553	0x611	SDO Rx Nd.17
442	0x1BA	TxPDO1, DI, Nd.58	998	0x3E6	TxPDO8*, Nd.38	1554	0x612	SDO Rx Nd.18
443	0x1BB	TxPDO1, DI, Nd.59	999	0x3E7	TxPDO8*, Nd.39	1555	0x613	SDO Rx Nd.19
444	0x1BC	TxPDO1, DI, Nd.60	1000	0x3E8	TxPDO8*, Nd.40	1556	0x614	SDO Rx Nd.20
445	0x1BD	TxPDO1, DI, Nd.61	1001	0x3E9	TxPDO8*, Nd.41	1557	0x615	SDO Rx Nd.21
446	0x1BE	TxPDO1, DI, Nd.62	1002	0x3EA	TxPDO8*, Nd.42	1558	0x616	SDO Rx Nd.22
447	0x1BF	TxPDO1, DI, Nd.63	1003	0x3EB	TxPDO8*, Nd.43	1559	0x617	SDO Rx Nd.23
449	0x1C1	TxPDO6*, Nd.1	1004	0x3EC	TxPDO8*, Nd.44	1560	0x618	SDO Rx Nd.24
450	0x1C2	TxPDO6*, Nd.2	1005	0x3ED	TxPDO8*, Nd.45	1561	0x619	SDO Rx Nd.25
451	0x1C3	TxPDO6*, Nd.3	1006	0x3EE	TxPDO8*, Nd.46	1562	0x61A	SDO Rx Nd.26
452	0x1C4	TxPDO6*, Nd.4	1007	0x3EF	TxPDO8*, Nd.47	1563	0x61B	SDO Rx Nd.27
453	0x1C5	TxPDO6*, Nd.5	1008	0x3F0	TxPDO8*, Nd.48	1564	0x61C	SDO Rx Nd.28
454	0x1C6	TxPDO6*, Nd.6	1009	0x3F1	TxPDO8*, Nd.49	1565	0x61D	SDO Rx Nd.29
455	0x1C7	TxPDO6*, Nd.7	1010	0x3F2	TxPDO8*, Nd.50	1566	0x61E	SDO Rx Nd.30
456	0x1C8	TxPDO6*, Nd.8	1011	0x3F3	TxPDO8*, Nd.51	1567	0x61F	SDO Rx Nd.31
457	0x1C9	TxPDO6*, Nd.9	1012	0x3F4	TxPDO8*, Nd.52	1568	0x620	SDO Rx Nd.32
458	0x1CA	TxPDO6*, Nd.10	1013	0x3F5	TxPDO8*, Nd.53	1569	0x621	SDO Rx Nd.33
459	0x1CB	TxPDO6*, Nd.11	1014	0x3F6	TxPDO8*, Nd.54	1570	0x622	SDO Rx Nd.34
460	0x1CC	TxPDO6*, Nd.12	1015	0x3F7	TxPDO8*, Nd.55	1571	0x623	SDO Rx Nd.35
461	0x1CD	TxPDO6*, Nd.13	1016	0x3F8	TxPDO8*, Nd.56	1572	0x624	SDO Rx Nd.36
462	0x1CE	TxPDO6*, Nd.14	1017	0x3F9	TxPDO8*, Nd.57	1573	0x625	SDO Rx Nd.37
463	0x1CF	TxPDO6*, Nd.15	1018	0x3FA	TxPDO8*, Nd.58	1574	0x626	SDO Rx Nd.38
464	0x1D0	TxPDO6*, Nd.16	1019	0x3FB	TxPDO8*, Nd.59	1575	0x627	SDO Rx Nd.39
465	0x1D1	TxPDO6*, Nd.17	1020	0x3FC	TxPDO8*, Nd.60	1576	0x628	SDO Rx Nd.40
466	0x1D2	TxPDO6*, Nd.18	1021	0x3FD	TxPDO8*, Nd.61	1577	0x629	SDO Rx Nd.41
467	0x1D3	TxPDO6*, Nd.19	1022	0x3FE	TxPDO8*, Nd.62	1578	0x62A	SDO Rx Nd.42
468	0x1D4	TxPDO6*, Nd.20	1023	0x3FF	TxPDO8*, Nd.63	1579	0x62B	SDO Rx Nd.43
469	0x1D5	TxPDO6*, Nd.21	1025	0x401	RxPDO3*, Nd.1	1580	0x62C	SDO Rx Nd.44
470	0x1D6	TxPDO6*, Nd.22	1026	0x402	RxPDO3*, Nd.2	1581	0x62D	SDO Rx Nd.45
471	0x1D7	TxPDO6*, Nd.23	1027	0x403	RxPDO3*, Nd.3	1582	0x62E	SDO Rx Nd.46
472	0x1D8	TxPDO6*, Nd.24	1028	0x404	RxPDO3*, Nd.4	1583	0x62F	SDO Rx Nd.47
473	0x1D9	TxPDO6*, Nd.25	1029	0x405	RxPDO3*, Nd.5	1584	0x630	SDO Rx Nd.48
474	0x1DA	TxPDO6*, Nd.26	1030	0x406	RxPDO3*, Nd.6	1585	0x631	SDO Rx Nd.49
475	0x1DB	TxPDO6*, Nd.27	1031	0x407	RxPDO3*, Nd.7	1586	0x632	SDO Rx Nd.50
476	0x1DC	TxPDO6*, Nd.28	1032	0x408	RxPDO3*, Nd.8	1587	0x633	SDO Rx Nd.51
477	0x1DD	TxPDO6*, Nd.29	1033	0x409	RxPDO3*, Nd.9	1588	0x634	SDO Rx Nd.52
478	0x1DE	TxPDO6*, Nd.30	1034	0x40A	RxPDO3*, Nd.10	1589	0x635	SDO Rx Nd.53
479	0x1DF	TxPDO6*, Nd.31	1035	0x40B	RxPDO3*, Nd.11	1590	0x636	SDO Rx Nd.54
480	0x1E0	TxPDO6*, Nd.32	1036	0x40C	RxPDO3*, Nd.12	1591	0x637	SDO Rx Nd.55
481	0x1E1	TxPDO6*, Nd.33	1037	0x40D	RxPDO3*, Nd.13	1592	0x638	SDO Rx Nd.56
482	0x1E2	TxPDO6*, Nd.34	1038	0x40E	RxPDO3*, Nd.14	1593	0x639	SDO Rx Nd.57
483	0x1E3	TxPDO6*, Nd.35	1039	0x40F	RxPDO3*, Nd.15	1594	0x63A	SDO Rx Nd.58
484	0x1E4	TxPDO6*, Nd.36	1040	0x410	RxPDO3*, Nd.16	1595	0x63B	SDO Rx Nd.59
485	0x1E5	TxPDO6*, Nd.37	1041	0x411	RxPDO3*, Nd.17	1596	0x63C	SDO Rx Nd.60
486	0x1E6	TxPDO6*, Nd.38	1042	0x412	RxPDO3*, Nd.18	1597	0x63D	SDO Rx Nd.61
487	0x1E7	TxPDO6*, Nd.39	1043	0x413	RxPDO3*, Nd.19	1598	0x63E	SDO Rx Nd.62
488	0x1E8	TxPDO6*, Nd.40	1044	0x414	RxPDO3*, Nd.20	1599	0x63F	SDO Rx Nd.63
489	0x1E9	TxPDO6*, Nd.41	1045	0x415	RxPDO3*, Nd.21	1601	0x641	RxPDO10*, Nd.1
490	0x1EA	TxPDO6*, Nd.42	1046	0x416	RxPDO3*, Nd.22	1602	0x642	RxPDO10*, Nd.2
491	0x1EB	TxPDO6*, Nd.43	1047	0x417	RxPDO3*, Nd.23	1603	0x643	RxPDO10*, Nd.3
492	0x1EC	TxPDO6*, Nd.44	1048	0x418	RxPDO3*, Nd.24	1604	0x644	RxPDO10*, Nd.4
493	0x1ED	TxPDO6*, Nd.45	1049	0x419	RxPDO3*, Nd.25	1605	0x645	RxPDO10*, Nd.5
494	0x1EE	TxPDO6*, Nd.46	1050	0x41A	RxPDO3*, Nd.26	1606	0x646	RxPDO10*, Nd.6

dec	hex	Telegram type	dec	hex	Telegram type	dec	hex	Telegram type
495	0x1EF	TxPDO6*, Nd.47	1051	0x41B	RxPDO3*, Nd.27	1607	0x647	RxPDO10*, Nd.7
496	0x1F0	TxPDO6*, Nd.48	1052	0x41C	RxPDO3*, Nd.28	1608	0x648	RxPDO10*, Nd.8
497	0x1F1	TxPDO6*, Nd.49	1053	0x41D	RxPDO3*, Nd.29	1609	0x649	RxPDO10*, Nd.9
498	0x1F2	TxPDO6*, Nd.50	1054	0x41E	RxPDO3*, Nd.30	1610	0x64A	RxPDO10*, Nd.10
499	0x1F3	TxPDO6*, Nd.51	1055	0x41F	RxPDO3*, Nd.31	1611	0x64B	RxPDO10*, Nd.11
500	0x1F4	TxPDO6*, Nd.52	1056	0x420	RxPDO3*, Nd.32	1612	0x64C	RxPDO10*, Nd.12
501	0x1F5	TxPDO6*, Nd.53	1057	0x421	RxPDO3*, Nd.33	1613	0x64D	RxPDO10*, Nd.13
502	0x1F6	TxPDO6*, Nd.54	1058	0x422	RxPDO3*, Nd.34	1614	0x64E	RxPDO10*, Nd.14
503	0x1F7	TxPDO6*, Nd.55	1059	0x423	RxPDO3*, Nd.35	1615	0x64F	RxPDO10*, Nd.15
504	0x1F8	TxPDO6*, Nd.56	1060	0x424	RxPDO3*, Nd.36	1616	0x650	RxPDO10*, Nd.16
505	0x1F9	TxPDO6*, Nd.57	1061	0x425	RxPDO3*, Nd.37	1617	0x651	RxPDO10*, Nd.17
506	0x1FA	TxPDO6*, Nd.58	1062	0x426	RxPDO3*, Nd.38	1618	0x652	RxPDO10*, Nd.18
507	0x1FB	TxPDO6*, Nd.59	1063	0x427	RxPDO3*, Nd.39	1619	0x653	RxPDO10*, Nd.19
508	0x1FC	TxPDO6*, Nd.60	1064	0x428	RxPDO3*, Nd.40	1620	0x654	RxPDO10*, Nd.20
509	0x1FD	TxPDO6*, Nd.61	1065	0x429	RxPDO3*, Nd.41	1621	0x655	RxPDO10*, Nd.21
510	0x1FE	TxPDO6*, Nd.62	1066	0x42A	RxPDO3*, Nd.42	1622	0x656	RxPDO10*, Nd.22
511	0x1FF	TxPDO6*, Nd.63	1067	0x42B	RxPDO3*, Nd.43	1623	0x657	RxPDO10*, Nd.23
513	0x201	RxPDO1, DO, Nd.1	1068	0x42C	RxPDO3*, Nd.44	1624	0x658	RxPDO10*, Nd.24
514	0x202	RxPDO1, DO, Nd.2	1069	0x42D	RxPDO3*, Nd.45	1625	0x659	RxPDO10*, Nd.25
515	0x203	RxPDO1, DO, Nd.3	1070	0x42E	RxPDO3*, Nd.46	1626	0x65A	RxPDO10*, Nd.26
516	0x204	RxPDO1, DO, Nd.4	1071	0x42F	RxPDO3*, Nd.47	1627	0x65B	RxPDO10*, Nd.27
517	0x205	RxPDO1, DO, Nd.5	1072	0x430	RxPDO3*, Nd.48	1628	0x65C	RxPDO10*, Nd.28
518	0x206	RxPDO1, DO, Nd.6	1073	0x431	RxPDO3*, Nd.49	1629	0x65D	RxPDO10*, Nd.29
519	0x207	RxPDO1, DO, Nd.7	1074	0x432	RxPDO3*, Nd.50	1630	0x65E	RxPDO10*, Nd.30
520	0x208	RxPDO1, DO, Nd.8	1075	0x433	RxPDO3*, Nd.51	1631	0x65F	RxPDO10*, Nd.31
521	0x209	RxPDO1, DO, Nd.9	1076	0x434	RxPDO3*, Nd.52	1632	0x660	RxPDO10*, Nd.32
522	0x20A	RxPDO1, DO, Nd.10	1077	0x435	RxPDO3*, Nd.53	1633	0x661	RxPDO10*, Nd.33
523	0x20B	RxPDO1, DO, Nd.11	1078	0x436	RxPDO3*, Nd.54	1634	0x662	RxPDO10*, Nd.34
524	0x20C	RxPDO1, DO, Nd.12	1079	0x437	RxPDO3*, Nd.55	1635	0x663	RxPDO10*, Nd.35
525	0x20D	RxPDO1, DO, Nd.13	1080	0x438	RxPDO3*, Nd.56	1636	0x664	RxPDO10*, Nd.36
526	0x20E	RxPDO1, DO, Nd.14	1081	0x439	RxPDO3*, Nd.57	1637	0x665	RxPDO10*, Nd.37
527	0x20F	RxPDO1, DO, Nd.15	1082	0x43A	RxPDO3*, Nd.58	1638	0x666	RxPDO10*, Nd.38
528	0x210	RxPDO1, DO, Nd.16	1083	0x43B	RxPDO3*, Nd.59	1639	0x667	RxPDO10*, Nd.39
529	0x211	RxPDO1, DO, Nd.17	1084	0x43C	RxPDO3*, Nd.60	1640	0x668	RxPDO10*, Nd.40
530	0x212	RxPDO1, DO, Nd.18	1085	0x43D	RxPDO3*, Nd.61	1641	0x669	RxPDO10*, Nd.41
531	0x213	RxPDO1, DO, Nd.19	1086	0x43E	RxPDO3*, Nd.62	1642	0x66A	RxPDO10*, Nd.42
532	0x214	RxPDO1, DO, Nd.20	1087	0x43F	RxPDO3*, Nd.63	1643	0x66B	RxPDO10*, Nd.43
533	0x215	RxPDO1, DO, Nd.21	1089	0x441	RxPDO8*, Nd.1	1644	0x66C	RxPDO10*, Nd.44
534	0x216	RxPDO1, DO, Nd.22	1090	0x442	RxPDO8*, Nd.2	1645	0x66D	RxPDO10*, Nd.45
535	0x217	RxPDO1, DO, Nd.23	1091	0x443	RxPDO8*, Nd.3	1646	0x66E	RxPDO10*, Nd.46
536	0x218	RxPDO1, DO, Nd.24	1092	0x444	RxPDO8*, Nd.4	1647	0x66F	RxPDO10*, Nd.47
537	0x219	RxPDO1, DO, Nd.25	1093	0x445	RxPDO8*, Nd.5	1648	0x670	RxPDO10*, Nd.48
538	0x21A	RxPDO1, DO, Nd.26	1094	0x446	RxPDO8*, Nd.6	1649	0x671	RxPDO10*, Nd.49
539	0x21B	RxPDO1, DO, Nd.27	1095	0x447	RxPDO8*, Nd.7	1650	0x672	RxPDO10*, Nd.50
540	0x21C	RxPDO1, DO, Nd.28	1096	0x448	RxPDO8*, Nd.8	1651	0x673	RxPDO10*, Nd.51
541	0x21D	RxPDO1, DO, Nd.29	1097	0x449	RxPDO8*, Nd.9	1652	0x674	RxPDO10*, Nd.52
542	0x21E	RxPDO1, DO, Nd.30	1098	0x44A	RxPDO8*, Nd.10	1653	0x675	RxPDO10*, Nd.53
543	0x21F	RxPDO1, DO, Nd.31	1099	0x44B	RxPDO8*, Nd.11	1654	0x676	RxPDO10*, Nd.54
544	0x220	RxPDO1, DO, Nd.32	1100	0x44C	RxPDO8*, Nd.12	1655	0x677	RxPDO10*, Nd.55
545	0x221	RxPDO1, DO, Nd.33	1101	0x44D	RxPDO8*, Nd.13	1656	0x678	RxPDO10*, Nd.56
546	0x222	RxPDO1, DO, Nd.34	1102	0x44E	RxPDO8*, Nd.14	1657	0x679	RxPDO10*, Nd.57
547	0x223	RxPDO1, DO, Nd.35	1103	0x44F	RxPDO8*, Nd.15	1658	0x67A	RxPDO10*, Nd.58
548	0x224	RxPDO1, DO, Nd.36	1104	0x450	RxPDO8*, Nd.16	1659	0x67B	RxPDO10*, Nd.59
549	0x225	RxPDO1, DO, Nd.37	1105	0x451	RxPDO8*, Nd.17	1660	0x67C	RxPDO10*, Nd.60
550	0x226	RxPDO1, DO, Nd.38	1106	0x452	RxPDO8*, Nd.18	1661	0x67D	RxPDO10*, Nd.61
551	0x227	RxPDO1, DO, Nd.39	1107	0x453	RxPDO8*, Nd.19	1662	0x67E	RxPDO10*, Nd.62
552	0x228	RxPDO1, DO, Nd.40	1108	0x454	RxPDO8*, Nd.20	1663	0x67F	RxPDO10*, Nd.63
553	0x229	RxPDO1, DO, Nd.41	1109	0x455	RxPDO8*, Nd.21	1665	0x681	TxPDO5*, Nd.1

dec	hex	Telegram type	dec	hex	Telegram type	dec	hex	Telegram type
554	0x22A	RxPDO1, DO, Nd.42	1110	0x456	RxPDO8*, Nd.22	1666	0x682	TxPDO5*, Nd.2
555	0x22B	RxPDO1, DO, Nd.43	1111	0x457	RxPDO8*, Nd.23	1667	0x683	TxPDO5*, Nd.3
556	0x22C	RxPDO1, DO, Nd.44	1112	0x458	RxPDO8*, Nd.24	1668	0x684	TxPDO5*, Nd.4
557	0x22D	RxPDO1, DO, Nd.45	1113	0x459	RxPDO8*, Nd.25	1669	0x685	TxPDO5*, Nd.5
558	0x22E	RxPDO1, DO, Nd.46	1114	0x45A	RxPDO8*, Nd.26	1670	0x686	TxPDO5*, Nd.6
559	0x22F	RxPDO1, DO, Nd.47	1115	0x45B	RxPDO8*, Nd.27	1671	0x687	TxPDO5*, Nd.7
560	0x230	RxPDO1, DO, Nd.48	1116	0x45C	RxPDO8*, Nd.28	1672	0x688	TxPDO5*, Nd.8
561	0x231	RxPDO1, DO, Nd.49	1117	0x45D	RxPDO8*, Nd.29	1673	0x689	TxPDO5*, Nd.9
562	0x232	RxPDO1, DO, Nd.50	1118	0x45E	RxPDO8*, Nd.30	1674	0x68A	TxPDO5*, Nd.10
563	0x233	RxPDO1, DO, Nd.51	1119	0x45F	RxPDO8*, Nd.31	1675	0x68B	TxPDO5*, Nd.11
564	0x234	RxPDO1, DO, Nd.52	1120	0x460	RxPDO8*, Nd.32	1676	0x68C	TxPDO5*, Nd.12
565	0x235	RxPDO1, DO, Nd.53	1121	0x461	RxPDO8*, Nd.33	1677	0x68D	TxPDO5*, Nd.13
566	0x236	RxPDO1, DO, Nd.54	1122	0x462	RxPDO8*, Nd.34	1678	0x68E	TxPDO5*, Nd.14
567	0x237	RxPDO1, DO, Nd.55	1123	0x463	RxPDO8*, Nd.35	1679	0x68F	TxPDO5*, Nd.15
568	0x238	RxPDO1, DO, Nd.56	1124	0x464	RxPDO8*, Nd.36	1680	0x690	TxPDO5*, Nd.16
569	0x239	RxPDO1, DO, Nd.57	1125	0x465	RxPDO8*, Nd.37	1681	0x691	TxPDO5*, Nd.17
570	0x23A	RxPDO1, DO, Nd.58	1126	0x466	RxPDO8*, Nd.38	1682	0x692	TxPDO5*, Nd.18
571	0x23B	RxPDO1, DO, Nd.59	1127	0x467	RxPDO8*, Nd.39	1683	0x693	TxPDO5*, Nd.19
572	0x23C	RxPDO1, DO, Nd.60	1128	0x468	RxPDO8*, Nd.40	1684	0x694	TxPDO5*, Nd.20
573	0x23D	RxPDO1, DO, Nd.61	1129	0x469	RxPDO8*, Nd.41	1685	0x695	TxPDO5*, Nd.21
574	0x23E	RxPDO1, DO, Nd.62	1130	0x46A	RxPDO8*, Nd.42	1686	0x696	TxPDO5*, Nd.22
575	0x23F	RxPDO1, DO, Nd.63	1131	0x46B	RxPDO8*, Nd.43	1687	0x697	TxPDO5*, Nd.23
577	0x241	RxPDO6*, Nd.1	1132	0x46C	RxPDO8*, Nd.44	1688	0x698	TxPDO5*, Nd.24
578	0x242	RxPDO6*, Nd.2	1133	0x46D	RxPDO8*, Nd.45	1689	0x699	TxPDO5*, Nd.25
579	0x243	RxPDO6*, Nd.3	1134	0x46E	RxPDO8*, Nd.46	1690	0x69A	TxPDO5*, Nd.26
580	0x244	RxPDO6*, Nd.4	1135	0x46F	RxPDO8*, Nd.47	1691	0x69B	TxPDO5*, Nd.27
581	0x245	RxPDO6*, Nd.5	1136	0x470	RxPDO8*, Nd.48	1692	0x69C	TxPDO5*, Nd.28
582	0x246	RxPDO6*, Nd.6	1137	0x471	RxPDO8*, Nd.49	1693	0x69D	TxPDO5*, Nd.29
583	0x247	RxPDO6*, Nd.7	1138	0x472	RxPDO8*, Nd.50	1694	0x69E	TxPDO5*, Nd.30
584	0x248	RxPDO6*, Nd.8	1139	0x473	RxPDO8*, Nd.51	1695	0x69F	TxPDO5*, Nd.31
585	0x249	RxPDO6*, Nd.9	1140	0x474	RxPDO8*, Nd.52	1696	0x6A0	TxPDO5*, Nd.32
586	0x24A	RxPDO6*, Nd.10	1141	0x475	RxPDO8*, Nd.53	1697	0x6A1	TxPDO5*, Nd.33
587	0x24B	RxPDO6*, Nd.11	1142	0x476	RxPDO8*, Nd.54	1698	0x6A2	TxPDO5*, Nd.34
588	0x24C	RxPDO6*, Nd.12	1143	0x477	RxPDO8*, Nd.55	1699	0x6A3	TxPDO5*, Nd.35
589	0x24D	RxPDO6*, Nd.13	1144	0x478	RxPDO8*, Nd.56	1700	0x6A4	TxPDO5*, Nd.36
590	0x24E	RxPDO6*, Nd.14	1145	0x479	RxPDO8*, Nd.57	1701	0x6A5	TxPDO5*, Nd.37
591	0x24F	RxPDO6*, Nd.15	1146	0x47A	RxPDO8*, Nd.58	1702	0x6A6	TxPDO5*, Nd.38
592	0x250	RxPDO6*, Nd.16	1147	0x47B	RxPDO8*, Nd.59	1703	0x6A7	TxPDO5*, Nd.39
593	0x251	RxPDO6*, Nd.17	1148	0x47C	RxPDO8*, Nd.60	1704	0x6A8	TxPDO5*, Nd.40
594	0x252	RxPDO6*, Nd.18	1149	0x47D	RxPDO8*, Nd.61	1705	0x6A9	TxPDO5*, Nd.41
595	0x253	RxPDO6*, Nd.19	1150	0x47E	RxPDO8*, Nd.62	1706	0x6AA	TxPDO5*, Nd.42
596	0x254	RxPDO6*, Nd.20	1151	0x47F	RxPDO8*, Nd.63	1707	0x6AB	TxPDO5*, Nd.43
597	0x255	RxPDO6*, Nd.21	1153	0x481	TxPDO4*, Nd.1	1708	0x6AC	TxPDO5*, Nd.44
598	0x256	RxPDO6*, Nd.22	1154	0x482	TxPDO4*, Nd.2	1709	0x6AD	TxPDO5*, Nd.45
599	0x257	RxPDO6*, Nd.23	1155	0x483	TxPDO4*, Nd.3	1710	0x6AE	TxPDO5*, Nd.46
600	0x258	RxPDO6*, Nd.24	1156	0x484	TxPDO4*, Nd.4	1711	0x6AF	TxPDO5*, Nd.47
601	0x259	RxPDO6*, Nd.25	1157	0x485	TxPDO4*, Nd.5	1712	0x6B0	TxPDO5*, Nd.48
602	0x25A	RxPDO6*, Nd.26	1158	0x486	TxPDO4*, Nd.6	1713	0x6B1	TxPDO5*, Nd.49
603	0x25B	RxPDO6*, Nd.27	1159	0x487	TxPDO4*, Nd.7	1714	0x6B2	TxPDO5*, Nd.50
604	0x25C	RxPDO6*, Nd.28	1160	0x488	TxPDO4*, Nd.8	1715	0x6B3	TxPDO5*, Nd.51
605	0x25D	RxPDO6*, Nd.29	1161	0x489	TxPDO4*, Nd.9	1716	0x6B4	TxPDO5*, Nd.52
606	0x25E	RxPDO6*, Nd.30	1162	0x48A	TxPDO4*, Nd.10	1717	0x6B5	TxPDO5*, Nd.53
607	0x25F	RxPDO6*, Nd.31	1163	0x48B	TxPDO4*, Nd.11	1718	0x6B6	TxPDO5*, Nd.54
608	0x260	RxPDO6*, Nd.32	1164	0x48C	TxPDO4*, Nd.12	1719	0x6B7	TxPDO5*, Nd.55
609	0x261	RxPDO6*, Nd.33	1165	0x48D	TxPDO4*, Nd.13	1720	0x6B8	TxPDO5*, Nd.56
610	0x262	RxPDO6*, Nd.34	1166	0x48E	TxPDO4*, Nd.14	1721	0x6B9	TxPDO5*, Nd.57
611	0x263	RxPDO6*, Nd.35	1167	0x48F	TxPDO4*, Nd.15	1722	0x6BA	TxPDO5*, Nd.58
612	0x264	RxPDO6*, Nd.36	1168	0x490	TxPDO4*, Nd.16	1723	0x6BB	TxPDO5*, Nd.59

dec	hex	Telegram type	dec	hex	Telegram type	dec	hex	Telegram type
613	0x265	RxPDO6*, Nd.3	1169	0x491	TxPDO4*, Nd.17	1724	0x6BC	TxPDO5*, Nd.60
614	0x266	RxPDO6*, Nd.8	1170	0x492	TxPDO4*, Nd.18	1725	0x6BD	TxPDO5*, Nd.61
615	0x267	RxPDO6*, Nd39	1171	0x493	TxPDO4*, Nd.19	1726	0x6BE	TxPDO5*, Nd.62
616	0x268	RxPDO6*, N.40	1172	0x494	TxPDO4*, Nd.20	1727	0x6BF	TxPDO5*, Nd.63
617	0x269	RxPDO6*, d.41	1173	0x495	TxPDO4*, Nd.21	1729	0x6C1	TxPDO11*, Nd.1
618	0x26A	RxPDO6*,Nd.42	1174	0x496	TxPDO4*, Nd.22	1730	0x6C2	TxPDO11*, Nd.2
619	0x26B	RxPDO6* Nd.43	1175	0x497	TxPDO4*, Nd.23	1731	0x6C3	TxPDO11*, Nd.3
620	0x26C	RxPDO6, Nd.44	1176	0x498	TxPDO4*, Nd.24	1732	0x6C4	TxPDO11*, Nd.4
621	0x26D	RxPDO*, Nd.45	1177	0x499	TxPDO4*, Nd.25	1733	0x6C5	TxPDO11*, Nd.5
622	0x26E	RxPD6*, Nd.46	1178	0x49A	TxPDO4*, Nd.26	1734	0x6C6	TxPDO11*, Nd.6
623	0x26F	RxPO6*, Nd.47	1179	0x49B	TxPDO4*, Nd.27	1735	0x6C7	TxPDO11*, Nd.7
624	0x270	RxDO6*, Nd.48	1180	0x49C	TxPDO4*, Nd.28	1736	0x6C8	TxPDO11*, Nd.8
625	0x271	RPDO6*, Nd.49	1181	0x49D	TxPDO4*, Nd.29	1737	0x6C9	TxPDO11*, Nd.9
626	0x272	xPDO6*, Nd.50	1182	0x49E	TxPDO4*, Nd.30	1738	0x6CA	TxPDO11*, Nd.10
627	0x273	RxPDO6*, Nd.51	1183	0x49F	TxPDO4*, Nd.31	1739	0x6CB	TxPDO11*, Nd.11
628	0x274	RxPDO6*, Nd.52	1184	0x4A0	TxPDO4*, Nd.32	1740	0x6CC	TxPDO11*, Nd.12
629	0x275	RxPDO6*, Nd.53	1185	0x4A1	TxPDO4*, Nd.33	1741	0x6CD	TxPDO11*, Nd.13
630	0x276	RxPDO6*, Nd.54	1186	0x4A2	TxPDO4*, Nd.34	1742	0x6CE	TxPDO11*, Nd.14
631	0x277	RxPDO6*, Nd.55	1187	0x4A3	TxPDO4*, Nd.35	1743	0x6CF	TxPDO11*, Nd.15
632	0x278	RxPDO6*, Nd.56	1188	0x4A4	TxPDO4*, Nd.36	1744	0x6D0	TxPDO11*, Nd.16
633	0x279	RxPDO6*, Nd.57	1189	0x4A5	TxPDO4*, Nd.37	1745	0x6D1	TxPDO11*, Nd.17
634	0x27A	RxPDO6*, Nd.58	1190	0x4A6	TxPDO4*, Nd.48	1746	0x6D2	TxPDO11*, Nd.18
635	0x27B	RxPDO6*, Nd.59	1191	0x4A7	TxPDO4*, Nd.49	1747	0x6D3	TxPDO11*, Nd.19
636	0x27C	RxPDO6*, Nd.60	1192	0x4A8	TxPDO4*, Nd.40	1748	0x6D4	TxPDO11*, Nd.20
637	0x27D	RxPDO6*, Nd.61	1193	0x4A9	TxPDO4*, Nd.41	1749	0x6D5	TxPDO11*, Nd.21
638	0x27E	RxPDO6*, Nd.62	1194	0x4AA	TxPDO4*, Nd.42	1750	0x6D6	TxPDO11*, Nd.22
639	0x27F	RxPDO6*, Nd.63	1195	0x4AB	TxPDO4*, Nd.43	1751	0x6D7	TxPDO11*, Nd.23
641	0x281	TxPDO2, AI, Nd.1	1196	0x4AC	TxPDO4*, Nd.44	1752	0x6D8	TxPDO11*, Nd.24
642	0x282	TxPDO2, AI, Nd.2	1197	0x4AD	TxPDO4*, Nd.45	1753	0x6D9	TxPDO11*, Nd.25
643	0x283	TxPDO2, AI, Nd.3	1198	0x4AE	TxPDO4*, Nd.46	1754	0x6DA	TxPDO11*, Nd.26
644	0x284	TxPDO2, AI, Nd.4	1199	0x4AF	TxPDO4*, Nd.47	1755	0x6DB	TxPDO11*, Nd.27
645	0x285	TxPDO2, AI, Nd.5	1200	0x4B0	TxPDO4*, Nd.48	1756	0x6DC	TxPDO11*, Nd.28
646	0x286	TxPDO2, AI, Nd.6	1201	0x4B1	TxPDO4*, Nd.49	1757	0x6DD	TxPDO11*, Nd.29
647	0x287	TxPDO2, AI, Nd.7	1202	0x4B2	TxPDO4*, Nd.50	1758	0x6DE	TxPDO11*, Nd.30
648	0x288	TxPDO2, AI, Nd.8	1203	0x4B3	TxPDO4*, Nd.51	1759	0x6DF	TxPDO11*, Nd.31
649	0x289	TxPDO2, AI, Nd.9	1204	0x4B4	TxPDO4*, Nd.52	1760	0x6E0	TxPDO11*, Nd.32
650	0x28A	TxPDO2, AI, Nd.10	1205	0x4B5	TxPDO4*, Nd.53	1761	0x6E1	TxPDO11*, Nd.33
651	0x28B	TxPDO2, AI, Nd.11	1206	0x4B6	TxPDO4*, Nd.54	1762	0x6E2	TxPDO11*, Nd.34
652	0x28C	TxPDO2, AI, Nd.12	1207	0x4B7	TxPDO4*, Nd.55	1763	0x6E3	TxPDO11*, Nd.35
653	0x28D	TxPDO2, AI, Nd.13	1208	0x4B8	TxPDO4*, Nd.56	1764	0x6E4	TxPDO11*, Nd.36
654	0x28E	TxPDO2, AI, Nd.14	1209	0x4B9	TxPDO4*, Nd.57	1765	0x6E5	TxPDO11*, Nd.37
655	0x28F	TxPDO2, AI, Nd.15	1210	0x4BA	TxPDO4*, Nd.58	1766	0x6E6	TxPDO11*, Nd.38
656	0x290	TxPDO2, AI, Nd.16	1211	0x4BB	TxPDO4*, Nd.59	1767	0x6E7	TxPDO11*, Nd.39
657	0x291	TxPDO2, AI, Nd.17	1212	0x4BC	TxPDO4*, Nd.60	1768	0x6E8	TxPDO11*, Nd.40
658	0x292	TxPDO2, AI, Nd.18	1213	0x4BD	TxPDO4*, Nd.61	1769	0x6E9	TxPDO11*, Nd.41
659	0x293	TxPDO2, AI, Nd.19	1214	0x4BE	TxPDO4*, Nd.62	1770	0x6EA	TxPDO11*, Nd.42
660	0x294	TxPDO2, AI, Nd.20	1215	0x4BF	TxPDO4*, Nd.63	1771	0x6EB	TxPDO11*, Nd.43
661	0x295	TxPDO2, AI, Nd.21	1217	0x4C1	TxPDO9*, Nd.1	1772	0x6EC	TxPDO11*, Nd.44
662	0x296	TxPDO2, AI, Nd.22	1218	0x4C2	TxPDO9*, Nd.2	1773	0x6ED	TxPDO11*, Nd.45
663	0x297	TxPDO2, AI, Nd.23	1219	0x4C3	TxPDO9*, Nd.3	1774	0x6EE	TxPDO11*, Nd.46
664	0x298	TxPDO2, AI, Nd.24	1220	0x4C4	TxPDO9*, Nd.4	1775	0x6EF	TxPDO11*, Nd.47
665	0x299	TxPDO2, AI, Nd.25	1221	0x4C5	TxPDO9*, Nd.5	1776	0x6F0	TxPDO11*, Nd.48
666	0x29A	TxPDO2, AI, Nd.26	1222	0x4C6	TxPDO9*, Nd.6	1777	0x6F1	TxPDO11*, Nd.49
667	0x29B	TxPDO2, AI, Nd.27	1223	0x4C7	TxPDO9*, Nd.7	1778	0x6F2	TxPDO11*, Nd.50
668	0x29C	TxPDO2, AI, Nd.28	1224	0x4C8	TxPDO9*, Nd.8	1779	0x6F3	TxPDO11*, Nd.51
669	0x29D	TxPDO2, AI, Nd.29	1225	0x4C9	TxPDO9*, Nd.9	1780	0x6F4	TxPDO11*, Nd.52
670	0x29E	TxPDO2, AI, Nd.30	1226	0x4CA	TxPDO9*, Nd.10	1781	0x6F5	TxPDO11*, Nd.53
671	0x29F	TxPDO2, AI, Nd.31	1227	0x4CB	TxPDO9*, Nd.11	1782	0x6F6	TxPDO11*, Nd.54

dec	hex	Telegram type	dec	hex	Telegram type	dec	hex	Telegram type
672	0x2A0	TxPDO2, AI, Nd.32	1228	0x4CC	TxPDO9*, Nd.12	1783	0x6F7	TxPDO11*, Nd.55
673	0x2A1	TxPDO2, AI, Nd.33	1229	0x4CD	TxPDO9*, Nd.13	1784	0x6F8	TxPDO11*, Nd.56
674	0x2A2	TxPDO2, AI, Nd.34	1230	0x4CE	TxPDO9*, Nd.14	1785	0x6F9	TxPDO11*, Nd.57
675	0x2A3	TxPDO2, AI, Nd.35	1231	0x4CF	TxPDO9*, Nd.15	1786	0x6FA	TxPDO11*, Nd.58
676	0x2A4	TxPDO2, AI, Nd.36	1232	0x4D0	TxPDO9*, Nd.16	1787	0x6FB	TxPDO11*, Nd.59
677	0x2A5	TxPDO2, AI, Nd.37	1233	0x4D1	TxPDO9*, Nd.17	1788	0x6FC	TxPDO11*, Nd.60
678	0x2A6	TxPDO2, AI, Nd.38	1234	0x4D2	TxPDO9*, Nd.18	1789	0x6FD	TxPDO11*, Nd.61
679	0x2A7	TxPDO2, AI, Nd.39	1235	0x4D3	TxPDO9*, Nd.19	1790	0x6FE	TxPDO11*, Nd.62
680	0x2A8	TxPDO2, AI, Nd.40	1236	0x4D4	TxPDO9*, Nd.20	1791	0x6FF	TxPDO11*, Nd.63
681	0x2A9	TxPDO2, AI, Nd.41	1237	0x4D5	TxPDO9*, Nd.21	1793	0x701	Guarding nd. 1
682	0x2AA	TxPDO2, AI, Nd.42	1238	0x4D6	TxPDO9*, Nd.22	1794	0x702	Guarding Nd.2
683	0x2AB	TxPDO2, AI, Nd.43	1239	0x4D7	TxPDO9*, Nd.23	1795	0x703	Guarding Nd.3
684	0x2AC	TxPDO2, AI, Nd.44	1240	0x4D8	TxPDO9*, Nd.24	1796	0x704	Guarding Nd.4
685	0x2AD	TxPDO2, AI, Nd.45	1241	0x4D9	TxPDO9*, Nd.25	1797	0x705	Guarding Nd.5
686	0x2AE	TxPDO2, AI, Nd.46	1242	0x4DA	TxPDO9*, Nd.26	1798	0x706	Guarding Nd.6
687	0x2AF	TxPDO2, AI, Nd.47	1243	0x4DB	TxPDO9*, Nd.27	1799	0x707	Guarding Nd.7
688	0x2B0	TxPDO2, AI, Nd.48	1244	0x4DC	TxPDO9*, Nd.28	1800	0x708	Guarding Nd.8
689	0x2B1	TxPDO2, AI, Nd.49	1245	0x4DD	TxPDO9*, Nd.29	1801	0x709	Guarding Nd.9
690	0x2B2	TxPDO2, AI, Nd.50	1246	0x4DE	TxPDO9*, Nd.30	1802	0x70A	Guarding Nd.10
691	0x2B3	TxPDO2, AI, Nd.51	1247	0x4DF	TxPDO9*, Nd.31	1803	0x70B	Guarding Nd.11
692	0x2B4	TxPDO2, AI, Nd.52	1248	0x4E0	TxPDO9*, Nd.32	1804	0x70C	Guarding Nd.12
693	0x2B5	TxPDO2, AI, Nd.53	1249	0x4E1	TxPDO9*, Nd.33	1805	0x70D	Guarding Nd.13
694	0x2B6	TxPDO2, AI, Nd.54	1250	0x4E2	TxPDO9*, Nd.34	1806	0x70E	Guarding Nd.14
695	0x2B7	TxPDO2, AI, Nd.55	1251	0x4E3	TxPDO9*, Nd.35	1807	0x70F	Guarding Nd.15
696	0x2B8	TxPDO2, AI, Nd.56	1252	0x4E4	TxPDO9*, Nd.36	1808	0x710	Guarding Nd.16
697	0x2B9	TxPDO2, AI, Nd.57	1253	0x4E5	TxPDO9*, Nd.37	1809	0x711	Guarding Nd.17
698	0x2BA	TxPDO2, AI, Nd.58	1254	0x4E6	TxPDO9*, Nd.38	1810	0x712	Guarding Nd.18
699	0x2BB	TxPDO2, AI, Nd.59	1255	0x4E7	TxPDO9*, Nd.39	1811	0x713	Guarding Nd.19
700	0x2BC	TxPDO2, AI, Nd.60	1256	0x4E8	TxPDO9*, Nd.40	1812	0x714	Guarding Nd.20
701	0x2BD	TxPDO2, AI, Nd.61	1257	0x4E9	TxPDO9*, Nd.41	1813	0x715	Guarding Nd.21
702	0x2BE	TxPDO2, AI, Nd.62	1258	0x4EA	TxPDO9*, Nd.42	1814	0x716	Guarding Nd.22
703	0x2BF	TxPDO2, AI, Nd.63	1259	0x4EB	TxPDO9*, Nd.43	1815	0x717	Guarding Nd.23
705	0x2C1	TxPDO7*, Nd.1	1260	0x4EC	TxPDO9*, Nd.44	1816	0x718	Guarding Nd.24
706	0x2C2	TxPDO7*, Nd.2	1261	0x4ED	TxPDO9*, Nd.45	1817	0x719	Guarding Nd.25
707	0x2C3	TxPDO7*, Nd.3	1262	0x4EE	TxPDO9*, Nd.46	1818	0x71A	Guarding Nd.26
708	0x2C4	TxPDO7*, Nd.4	1263	0x4EF	TxPDO9*, Nd.47	1819	0x71B	Guarding Nd.27
709	0x2C5	TxPDO7*, Nd.5	1264	0x4F0	TxPDO9*, Nd.48	1820	0x71C	Guarding Nd.28
710	0x2C6	TxPDO7*, Nd.6	1265	0x4F1	TxPDO9*, Nd.49	1821	0x71D	Guarding Nd.29
711	0x2C7	TxPDO7*, Nd.7	1266	0x4F2	TxPDO9*, Nd.50	1822	0x71E	Guarding Nd.30
712	0x2C8	TxPDO7*, nd. 8	1267	0x4F3	TxPDO9*, Nd.51	1823	0x71F	Guarding Nd.31
713	0x2C9	TxPDO7*, Nd.9	1268	0x4F4	TxPDO9*, Nd.52	1824	0x720	Guarding Nd.32
714	0x2CA	TxPDO7*, Nd.10	1269	0x4F5	TxPDO9*, Nd.53	1825	0x721	Guarding Nd.33
715	0x2CB	TxPDO7*, Nd.11	1270	0x4F6	TxPDO9*, Nd.54	1826	0x722	Guarding Nd.34
716	0x2CC	TxPDO7*, Nd.12	1271	0x4F7	TxPDO9*, Nd.55	1827	0x723	Guarding Nd.35
717	0x2CD	TxPDO7*, Nd.13	1272	0x4F8	TxPDO9*, Nd.56	1828	0x724	Guarding Nd.36
718	0x2CE	TxPDO7*, Nd.14	1273	0x4F9	TxPDO9*, Nd.57	1829	0x725	Guarding Nd.37
719	0x2CF	TxPDO7*, Nd.15	1274	0x4FA	TxPDO9*, Nd.58	1830	0x726	Guarding Nd.38
720	0x2D0	TxPDO7*, Nd.16	1275	0x4FB	TxPDO9*, Nd.59	1831	0x727	Guarding Nd.39
721	0x2D1	TxPDO7*, Nd.17	1276	0x4FC	TxPDO9*, Nd.60	1832	0x728	Guarding Nd.40
722	0x2D2	TxPDO7*, Nd.18	1277	0x4FD	TxPDO9*, Nd.61	1833	0x729	Guarding Nd.41
723	0x2D3	TxPDO7*, Nd.19	1278	0x4FE	TxPDO9*, Nd.62	1834	0x72A	Guarding Nd.42
724	0x2D4	TxPDO7*, Nd.20	1279	0x4FF	TxPDO9*, Nd.63	1835	0x72B	Guarding Nd.43
725	0x2D5	TxPDO7*, Nd.21	1281	0x501	RxPDO4*, Nd.1	1836	0x72C	Guarding Nd.44
726	0x2D6	TxPDO7*, Nd.22	1282	0x502	RxPDO4*, Nd.2	1837	0x72D	Guarding Nd.45
727	0x2D7	TxPDO7*, Nd.23	1283	0x503	RxPDO4*, Nd.3	1838	0x72E	Guarding Nd.46
728	0x2D8	TxPDO7*, Nd.24	1284	0x504	RxPDO4*, Nd.4	1839	0x72F	Guarding Nd.47
729	0x2D9	TxPDO7*, Nd.25	1285	0x505	RxPDO4*, Nd.5	1840	0x730	Guarding Nd.48
730	0x2DA	TxPDO7*, Nd.26	1286	0x506	RxPDO4*, Nd.6	1841	0x731	Guarding Nd.49

dec	hex	Telegram type	dec	hex	Telegram type	dec	hex	Telegram type
731	0x2DB	TxPDO7*, Nd.27	1287	0x507	RxPDO4*, Nd.7	1842	0x732	Guarding Nd.50
732	0x2DC	TxPDO7*, Nd.28	1288	0x508	RxPDO4*, Nd.8	1843	0x733	Guarding Nd.51
733	0x2DD	TxPDO7*, Nd.29	1289	0x509	RxPDO4*, Nd.9	1844	0x734	Guarding Nd.52
734	0x2DE	TxPDO7*, Nd.30	1290	0x50A	RxPDO4*, Nd.10	1845	0x735	Guarding Nd.53
735	0x2DF	TxPDO7*, Nd.31	1291	0x50B	RxPDO4*, Nd.11	1846	0x736	Guarding Nd.54
736	0x2E0	TxPDO7*, Nd.32	1292	0x50C	RxPDO4*, Nd.12	1847	0x737	Guarding Nd.55
737	0x2E1	TxPDO7*, Nd.33	1293	0x50D	RxPDO4*, Nd.13	1848	0x738	Guarding Nd.56
738	0x2E2	TxPDO7*, Nd.34	1294	0x50E	RxPDO4*, Nd.14	1849	0x739	Guarding Nd.57
739	0x2E3	TxPDO7*, Nd.35	1295	0x50F	RxPDO4*, Nd.15	1850	0x73A	Guarding Nd.58
740	0x2E4	TxPDO7*, Nd.36	1296	0x510	RxPDO4*, Nd.16	1851	0x73B	Guarding Nd.59
741	0x2E5	TxPDO7*, Nd.37	1297	0x511	RxPDO4*, Nd.17	1852	0x73C	Guarding Nd.60
742	0x2E6	TxPDO7*, Nd.38	1298	0x512	RxPDO4*, Nd.18	1853	0x73D	Guarding Nd.61
743	0x2E7	TxPDO7*, Nd.39	1299	0x513	RxPDO4*, Nd.19	1854	0x73E	Guarding Nd.62
744	0x2E8	TxPDO7*, Nd.40	1300	0x514	RxPDO4*, Nd.20	1855	0x73F	Guarding Nd.63
745	0x2E9	TxPDO7*, Nd.41	1301	0x515	RxPDO4*, Nd.21	1857	0x741	RxPDO11*, Nd.1
746	0x2EA	TxPDO7*, Nd.42	1302	0x516	RxPDO4*, Nd.22	1858	0x742	RxPDO11*, Nd.2
747	0x2EB	TxPDO7*, Nd.43	1303	0x517	RxPDO4*, Nd.23	1859	0x743	RxPDO11*, Nd.3
748	0x2EC	TxPDO7*, Nd.44	1304	0x518	RxPDO4*, Nd.24	1860	0x744	RxPDO11*, Nd.4
749	0x2ED	TxPDO7*, Nd.45	1305	0x519	RxPDO4*, Nd.25	1861	0x745	RxPDO11*, Nd.5
750	0x2EE	TxPDO7*, Nd.46	1306	0x51A	RxPDO4*, Nd.26	1862	0x746	RxPDO11*, Nd.6
751	0x2EF	TxPDO7*, Nd.47	1307	0x51B	RxPDO4*, Nd.27	1863	0x747	RxPDO11*, Nd.7
752	0x2F0	TxPDO7*, Nd.48	1308	0x51C	RxPDO4*, Nd.28	1864	0x748	RxPDO11*, Nd.8
753	0x2F1	TxPDO7*, Nd.49	1309	0x51D	RxPDO4*, Nd.29	1865	0x749	RxPDO11*, Nd.9
754	0x2F2	TxPDO7*, Nd.50	1310	0x51E	RxPDO4*, Nd.30	1866	0x74A	RxPDO11*, Nd.10
755	0x2F3	TxPDO7*, Nd.51	1311	0x51F	RxPDO4*, Nd.31	1867	0x74B	RxPDO11*, Nd.11
756	0x2F4	TxPDO7*, Nd.52	1312	0x520	RxPDO4*, Nd.32	1868	0x74C	RxPDO11*, Nd.12
757	0x2F5	TxPDO7*, Nd.53	1313	0x521	RxPDO4*, Nd.33	1869	0x74D	RxPDO11*, Nd.13
758	0x2F6	TxPDO7*, Nd.54	1314	0x522	RxPDO4*, Nd.34	1870	0x74E	RxPDO11*, Nd.14
759	0x2F7	TxPDO7*, Nd.55	1315	0x523	RxPDO4*, Nd.35	1871	0x74F	RxPDO11*, Nd.15
760	0x2F8	TxPDO7*, Nd.56	1316	0x524	RxPDO4*, Nd.36	1872	0x750	RxPDO11*, Nd.16
761	0x2F9	TxPDO7*, Nd.57	1317	0x525	RxPDO4*, Nd.37	1873	0x751	RxPDO11*, Nd.17
762	0x2FA	TxPDO7*, Nd.58	1318	0x526	RxPDO4*, Nd.38	1874	0x752	RxPDO11*, Nd.18
763	0x2FB	TxPDO7*, Nd.59	1319	0x527	RxPDO4*, Nd.39	1875	0x753	RxPDO11*, Nd.19
764	0x2FC	TxPDO7*, Nd.60	1320	0x528	RxPDO4*, Nd.40	1876	0x754	RxPDO11*, Nd.20
765	0x2FD	TxPDO7*, Nd.61	1321	0x529	RxPDO4*, Nd.41	1877	0x755	RxPDO11*, Nd.21
766	0x2FE	TxPDO7*, Nd.62	1322	0x52A	RxPDO4*, Nd.42	1878	0x756	RxPDO11*, Nd.22
767	0x2FF	TxPDO7*, Nd.63	1323	0x52B	RxPDO4*, Nd.43	1879	0x757	RxPDO11*, Nd.23
769	0x301	RxPDO2, AO, Nd.1	1324	0x52C	RxPDO4*, Nd.44	1880	0x758	RxPDO11*, Nd.24
770	0x302	RxPDO2, AO, Nd.2	1325	0x52D	RxPDO4*, Nd.45	1881	0x759	RxPDO11*, Nd.25
771	0x303	RxPDO2, AO, Nd.3	1326	0x52E	RxPDO4*, Nd.46	1882	0x75A	RxPDO11*, Nd.26
772	0x304	RxPDO2, AO, Nd.4	1327	0x52F	RxPDO4*, Nd.47	1883	0x75B	RxPDO11*, Nd.27
773	0x305	RxPDO2, AO, Nd.5	1328	0x530	RxPDO4*, Nd.48	1884	0x75C	RxPDO11*, Nd.28
774	0x306	RxPDO2, AO, Nd.6	1329	0x531	RxPDO4*, Nd.49	1885	0x75D	RxPDO11*, Nd.29
775	0x307	RxPDO2, AO, Nd.7	1330	0x532	RxPDO4*, Nd.50	1886	0x75E	RxPDO11*, Nd.30
776	0x308	RxPDO2, AO, Nd.8	1331	0x533	RxPDO4*, Nd.51	1887	0x75F	RxPDO11*, Nd.31
777	0x309	RxPDO2, AO, Nd.9	1332	0x534	RxPDO4*, Nd.52	1888	0x760	RxPDO11*, Nd.32
778	0x30A	RxPDO2, AO, Nd.10	1333	0x535	RxPDO4*, Nd.53	1889	0x761	RxPDO11*, Nd.33
779	0x30B	RxPDO2, AO, Nd.11	1334	0x536	RxPDO4*, Nd.54	1890	0x762	RxPDO11*, Nd.34
780	0x30C	RxPDO2, AO, Nd.12	1335	0x537	RxPDO4*, Nd.55	1891	0x763	RxPDO11*, Nd.35
781	0x30D	RxPDO2, AO, Nd.13	1336	0x538	RxPDO4*, Nd.56	1892	0x764	RxPDO11*, Nd.36
782	0x30E	RxPDO2, AO, Nd.14	1337	0x539	RxPDO4*, Nd.57	1893	0x765	RxPDO11*, Nd.37
783	0x30F	RxPDO2, AO, Nd.15	1338	0x53A	RxPDO4*, Nd.58	1894	0x766	RxPDO11*, Nd.38
784	0x310	RxPDO2, AO, Nd.16	1339	0x53B	RxPDO4*, Nd.59	1895	0x767	RxPDO11*, Nd.39
785	0x311	RxPDO2, AO, Nd.17	1340	0x53C	RxPDO4*, Nd.60	1896	0x768	RxPDO11*, Nd.40
786	0x312	RxPDO2, AO, Nd.18	1341	0x53D	RxPDO4*, Nd.61	1897	0x769	RxPDO11*, Nd.41
787	0x313	RxPDO2, AO, Nd.19	1342	0x53E	RxPDO4*, Nd.62	1898	0x76A	RxPDO11*, Nd.42
788	0x314	RxPDO2, AO, Nd.20	1343	0x53F	RxPDO4*, Nd.63	1899	0x76B	RxPDO11*, Nd.43
789	0x315	RxPDO2, AO, Nd.21	1345	0x541	RxPDO9*, Nd.1	1900	0x76C	RxPDO11*, Nd.44

dec	hex	Telegram type	dec	hex	Telegram type	dec	hex	Telegram type
790	0x316	RxPDO2, AO, Nd.22	1346	0x542	RxPDO9*, Nd.2	1901	0x76D	RxPDO11*, Nd.45
791	0x317	RxPDO2, AO, Nd.23	1347	0x543	RxPDO9*, Nd.3	1902	0x76E	RxPDO11*, Nd.46
792	0x318	RxPDO2, AO, Nd.24	1348	0x544	RxPDO9*, Nd.4	1903	0x76F	RxPDO11*, Nd.47
793	0x319	RxPDO2, AO, Nd.25	1349	0x545	RxPDO9*, Nd.5	1904	0x770	RxPDO11*, Nd.48
794	0x31A	RxPDO2, AO, Nd.26	1350	0x546	RxPDO9*, Nd.6	1905	0x771	RxPDO11*, Nd.49
795	0x31B	RxPDO2, AO, Nd.27	1351	0x547	RxPDO9*, Nd.7	1906	0x772	RxPDO11*, Nd.50
796	0x31C	RxPDO2, AO, Nd.28	1352	0x548	RxPDO9*, Nd.8	1907	0x773	RxPDO11*, Nd.51
797	0x31D	RxPDO2, AO, Nd.29	1353	0x549	RxPDO9*, Nd.9	1908	0x774	RxPDO11*, Nd.52
798	0x31E	RxPDO2, AO, Nd.30	1354	0x54A	RxPDO9*, Nd.10	1909	0x775	RxPDO11*, Nd.53
799	0x31F	RxPDO2, AO, Nd.31	1355	0x54B	RxPDO9*, Nd.11	1910	0x776	RxPDO11*, Nd.54
800	0x320	RxPDO2, AO, Nd.32	1356	0x54C	RxPDO9*, Nd.12	1911	0x777	RxPDO11*, Nd.55
801	0x321	RxPDO2, AO, Nd.33	1357	0x54D	RxPDO9*, Nd.13	1912	0x778	RxPDO11*, Nd.56
802	0x322	RxPDO2, AO, Nd.34	1358	0x54E	RxPDO9*, Nd.14	1913	0x779	RxPDO11*, Nd.57
803	0x323	RxPDO2, AO, Nd.35	1359	0x54F	RxPDO9*, Nd.15	1914	0x77A	RxPDO11*, Nd.58
804	0x324	RxPDO2, AO, Nd.36	1360	0x550	RxPDO9*, Nd.16	1915	0x77B	RxPDO11*, Nd.59
805	0x325	RxPDO2, AO, Nd.37	1361	0x551	RxPDO9*, Nd.17	1916	0x77C	RxPDO11*, Nd.60
806	0x326	RxPDO2, AO, Nd.38	1362	0x552	RxPDO9*, Nd.18	1917	0x77D	RxPDO11*, Nd.61
807	0x327	RxPDO2, AO, Nd.39	1363	0x553	RxPDO9*, Nd.19	1918	0x77E	RxPDO11*, Nd.62
808	0x328	RxPDO2, AO, Nd.40	1364	0x554	RxPDO9*, Nd.20	1919	0x77F	RxPDO11*, Nd.63
809	0x329	RxPDO2, AO, nd. 41	1365	0x555	RxPDO9*, Nd.21	1921	0x781	RxPDO5*, Nd.1
810	0x32A	RxPDO2, AO, Nd.42	1366	0x556	RxPDO9*, Nd.22	1922	0x782	RxPDO5*, Nd.2
811	0x32B	RxPDO2, AO, Nd.43	1367	0x557	RxPDO9*, Nd.23	1923	0x783	RxPDO5*, Nd.3
812	0x32C	RxPDO2, AO, Nd.44	1368	0x558	RxPDO9*, Nd.24	1924	0x784	RxPDO5*, Nd.4
813	0x32D	RxPDO2, AO, Nd.45	1369	0x559	RxPDO9*, Nd.25	1925	0x785	RxPDO5*, Nd.5
814	0x32E	RxPDO2, AO, Nd.46	1370	0x55A	RxPDO9*, Nd.26	1926	0x786	RxPDO5*, Nd.6
815	0x32F	RxPDO2, AO, Nd.47	1371	0x55B	RxPDO9*, Nd.27	1927	0x787	RxPDO5*, Nd.7
816	0x330	RxPDO2, AO, Nd.48	1372	0x55C	RxPDO9*, Nd.28	1928	0x788	RxPDO5*, Nd.8
817	0x331	RxPDO2, AO, Nd.49	1373	0x55D	RxPDO9*, Nd.29	1929	0x789	RxPDO5*, Nd.9
818	0x332	RxPDO2, AO, Nd.50	1374	0x55E	RxPDO9*, Nd.30	1930	0x78A	RxPDO5*, Nd.10
819	0x333	RxPDO2, AO, Nd.51	1375	0x55F	RxPDO9*, Nd.31	1931	0x78B	RxPDO5*, Nd.11
820	0x334	RxPDO2, AO, Nd.52	1376	0x560	RxPDO9*, Nd.32	1932	0x78C	RxPDO5*, Nd.12
821	0x335	RxPDO2, AO, Nd.53	1377	0x561	RxPDO9*, Nd.33	1933	0x78D	RxPDO5*, Nd.13
822	0x336	RxPDO2, AO, Nd.54	1378	0x562	RxPDO9*, Nd.34	1934	0x78E	RxPDO5*, Nd.14
823	0x337	RxPDO2, AO, Nd.55	1379	0x563	RxPDO9*, Nd.35	1935	0x78F	RxPDO5*, Nd.15
824	0x338	RxPDO2, AO, Nd.56	1380	0x564	RxPDO9*, Nd.36	1936	0x790	RxPDO5*, Nd.16
825	0x339	RxPDO2, AO, Nd.57	1381	0x565	RxPDO9*, Nd.37	1937	0x791	RxPDO5*, Nd.17
826	0x33A	RxPDO2, AO, Nd.58	1382	0x566	RxPDO9*, Nd.38	1938	0x792	RxPDO5*, Nd.18
827	0x33B	RxPDO2, AO, Nd.59	1383	0x567	RxPDO9*, Nd.39	1939	0x793	RxPDO5*, Nd.19
828	0x33C	RxPDO2, AO, Nd.60	1384	0x568	RxPDO9*, Nd.40	1940	0x794	RxPDO5*, Nd.20
829	0x33D	RxPDO2, AO, Nd.61	1385	0x569	RxPDO9*, Nd.41	1941	0x795	RxPDO5*, Nd.21
830	0x33E	RxPDO2, AO, Nd.62	1386	0x56A	RxPDO9*, Nd.42	1942	0x796	RxPDO5*, Nd.22
831	0x33F	RxPDO2, AO, Nd.63	1387	0x56B	RxPDO9*, Nd.43	1943	0x797	RxPDO5*, Nd.23
833	0x341	RxPDO7*, Nd.1	1388	0x56C	RxPDO9*, Nd.44	1944	0x798	RxPDO5*, Nd.24
834	0x342	RxPDO7*, Nd.2	1389	0x56D	RxPDO9*, Nd.45	1945	0x799	RxPDO5*, Nd.25
835	0x343	RxPDO7*, Nd.3	1390	0x56E	RxPDO9*, Nd.46	1946	0x79A	RxPDO5*, Nd.26
836	0x344	RxPDO7*, Nd.4	1391	0x56F	RxPDO9*, Nd.47	1947	0x79B	RxPDO5*, Nd.27
837	0x345	RxPDO7*, Nd.5	1392	0x570	RxPDO9*, Nd.48	1948	0x79C	RxPDO5*, Nd.28
838	0x346	RxPDO7*, Nd.6	1393	0x571	RxPDO9*, Nd.49	1949	0x79D	RxPDO5*, Nd.29
839	0x347	RxPDO7*, Nd.7	1394	0x572	RxPDO9*, Nd.50	1950	0x79E	RxPDO5*, Nd.30
840	0x348	RxPDO7*, Nd.8	1395	0x573	RxPDO9*, Nd.51	1951	0x79F	RxPDO5*, Nd.31
841	0x349	RxPDO7*, Nd.9	1396	0x574	RxPDO9*, Nd.52	1952	0x7A0	RxPDO5*, Nd.32
842	0x34A	RxPDO7*, Nd.10	1397	0x575	RxPDO9*, Nd.53	1953	0x7A1	RxPDO5*, Nd.33
843	0x34B	RxPDO7*, Nd.11	1398	0x576	RxPDO9*, Nd.54	1954	0x7A2	RxPDO5*, Nd.34
844	0x34C	RxPDO7*, Nd.12	1399	0x577	RxPDO9*, Nd.55	1955	0x7A3	RxPDO5*, Nd.35
845	0x34D	RxPDO7*, Nd.13	1400	0x578	RxPDO9*, Nd.56	1956	0x7A4	RxPDO5*, Nd.36
846	0x34E	RxPDO7*, Nd.14	1401	0x579	RxPDO9*, Nd.57	1957	0x7A5	RxPDO5*, Nd.37
847	0x34F	RxPDO7*, Nd.15	1402	0x57A	RxPDO9*, Nd.58	1958	0x7A6	RxPDO5*, Nd.38

dec	hex	Telegram type	dec	hex	Telegram type	dec	hex	Telegram type
848	0x350	RxPDO7*, Nd.16	1403	0x57B	RxPDO9*, Nd.59	1959	0x7A7	RxPDO5*, Nd.39
849	0x351	RxPDO7*, Nd.17	1404	0x57C	RxPDO9*, Nd.60	1960	0x7A8	RxPDO5*, Nd.40
850	0x352	RxPDO7*, Nd.18	1405	0x57D	RxPDO9*, Nd.61	1961	0x7A9	RxPDO5*, Nd.41
851	0x353	RxPDO7*, Nd.19	1406	0x57E	RxPDO9*, Nd.62	1962	0x7AA	RxPDO5*, Nd.42
852	0x354	RxPDO7*, Nd.20	1407	0x57F	RxPDO9*, Nd.63	1963	0x7AB	RxPDO5*, Nd.43
853	0x355	RxPDO7*, Nd.21	1409	0x581	SDO Tx Nd.1	1964	0x7AC	RxPDO5*, Nd.44
854	0x356	RxPDO7*, Nd.22	1410	0x582	SDO Tx Nd.2	1965	0x7AD	RxPDO5*, Nd.45
855	0x357	RxPDO7*, Nd.23	1411	0x583	SDO Tx Nd.3	1966	0x7AE	RxPDO5*, Nd.46
856	0x358	RxPDO7*, Nd.24	1412	0x584	SDO Tx Nd.4	1967	0x7AF	RxPDO5*, Nd.47
857	0x359	RxPDO7*, Nd.25	1413	0x585	SDO Tx Nd.5	1968	0x7B0	RxPDO5*, Nd.48
858	0x35A	RxPDO7*, Nd.26	1414	0x586	SDO Tx Nd.6	1969	0x7B1	RxPDO5*, Nd.49
859	0x35B	RxPDO7*, Nd.27	1415	0x587	SDO Tx Nd.7	1970	0x7B2	RxPDO5*, Nd.50
860	0x35C	RxPDO7*, Nd.28	1416	0x588	SDO Tx Nd.8	1971	0x7B3	RxPDO5*, Nd.51
861	0x35D	RxPDO7*, Nd.29	1417	0x589	SDO Tx Nd.9	1972	0x7B4	RxPDO5*, Nd.52
862	0x35E	RxPDO7*, Nd.30	1418	0x58A	SDO Tx Nd.10	1973	0x7B5	RxPDO5*, Nd.53
863	0x35F	RxPDO7*, Nd.31	1419	0x58B	SDO Tx Nd.11	1974	0x7B6	RxPDO5*, Nd.54
864	0x360	RxPDO7*, Nd.32	1420	0x58C	SDO Tx Nd.12	1975	0x7B7	RxPDO5*, Nd.55
865	0x361	RxPDO7*, Nd.33	1421	0x58D	SDO Tx Nd.13	1976	0x7B8	RxPDO5*, Nd.56
866	0x362	RxPDO7*, Nd.34	1422	0x58E	SDO Tx Nd.14	1977	0x7B9	RxPDO5*, Nd.57
867	0x363	RxPDO7*, Nd.35	1423	0x58F	SDO Tx Nd.15	1978	0x7BA	RxPDO5*, Nd.58
868	0x364	RxPDO7*, Nd.36	1424	0x590	SDO Tx Nd.16	1979	0x7BB	RxPDO5*, Nd.59
869	0x365	RxPDO7*, Nd.37	1425	0x591	SDO Tx Nd.17	1980	0x7BC	RxPDO5*, Nd.60
870	0x366	RxPDO7*, Nd.38	1426	0x592	SDO Tx Nd.18	1981	0x7BD	RxPDO5*, Nd.61
871	0x367	RxPDO7*, Nd.39	1427	0x593	SDO Tx Nd.19	1982	0x7BE	RxPDO5*, Nd.62
872	0x368	RxPDO7*, Nd.40	1428	0x594	SDO Tx Nd.20	1983	0x7BF	RxPDO5*, Nd.63
873	0x369	RxPDO7*, Nd.41	1429	0x595	SDO Tx Nd.21		0x	

9.3 Switching to CANopen version 4

New features and notes regarding operation in existing networks

From firmware version C0, the Beckhoff CANopen bus nodes BK5120, BK5110 and LC5100 comply with the DS301 CANopen communication profile (version 4.01) and the new CiA recommendation for LED behavior (DRP303-3). The Bus Couplers have gained some new features, and the firmware performance was increased significantly. The Beckhoff CANopen devices pass the new CANopen conformance test. Unfortunately, the conversion also results in some functional changes, although compatibility problems are usually not encountered.

9.3.1 PDO behavior

Default identifier for PDO 3 + 4

New: Rx and Tx PDOs 3+4 now feature default identifiers. The same identifiers that were previously assigned via object 0x5500 are used. The default mapping was not changed. The PDOs are only created if the appropriate number of process data is available.

Advantage: Up to 12 analog inputs and outputs can be used, without PDOs having to be activated during start-up through identifier assignment.

Effects of using new Bus Couplers in existing networks: none

Increased firmware performance

New: PDO handling has become significantly faster (approx. 3-4 times).

Advantage: Shorter response times for input and output changes, higher sampling rate.

Effects of using new Bus Couplers in existing networks: The bus load may increase, particularly if PDOs with analog input data communicate in event-driven mode ("unbraked"). Remedy:

1. Activate cyclic update of the PDOs with analog input data through event timer (see below) (switch off global interrupt enable 0x6423!) or
2. communicate associated PDOs in synchronous mode (change transmission type from 255 to 254, e.g. to 1, 2 or 5).

Bus load

If the Beckhoff FC510x CANopen master cards are used, the bus load is displayed in a variable.

PDO event timer is supported

New: TxPDOs: Even if an event has not just occurred, event driven PDOs are sent after the event timer has elapsed. If an event occurs, the event timer is reset. Note: The event "analog input change" is switched on or off via the object 0x6423 [▸ 97] (default).
RxPDOs: The event timer is used as watchdog for monitoring the arrival of event-driven PDOs. If a PDO does not arrive within a set period of time, the bus node adopts the error state.

Advantage: The PDO transmission behavior can now be set even more individually. TxPDOs with analog inputs, e.g., can be sent with SNYC-independent cycle times. The arrival of event-driven RxPDOs can now be monitored.

Effects of using new Bus Couplers in existing networks: none

PDO synchronized throughout with I/O update

New: If all PDOs are set to synchronized communication (transmission type 0...240), the I/O update is triggered through the arrival of a SYNC telegram.

Advantage: Synchronization includes I/O behavior (previously only communication was synchronized).

Effects of using new Bus Couplers in existing networks: none

Variable mapping now only according to CANopen standard

New: The re-mapping sequence is now defined by the CANopen specification. CANopen devices may only allow the following sequence:

1. First delete PDO (0x1400ff or 0x1800ff, set sub-index 1 to "0")
2. Set sub-index 0 in the mapping parameters (0x1600ff or 0x1A00ff) to "0"
3. Change mapping entries (0x1600ff or 0x1800ff, SI 1..8)
4. Set sub-index 0 in the mapping parameters to the valid value.
5. Create PDO by entering the identifier (0x1400ff or 0x1800, sub-index 1).

Advantage: Since only one method is permitted, incompatibilities are reduced.

Effects of using new Bus Couplers in existing networks: only if the default mapping was actually changed.

Performance gain

The above-mentioned gain in performance is particularly pronounced for re-mapped PDOs.

9.3.2 LED behavior

LED behavior now according to DRP303-3

New: The LED behavior [▸ 101] was adapted to the new CiA recommendation DRP303-3.

Modifications:

Device state	Old LED behavior	New LED behavior
Device stopped	RUN LED off	RUN LED flashes once, then 1 s pause
CAN warning limit exceeded	ERR LED flashes continuously	ERR LED flashes once, then 1 s pause
Event Timer: RxPDO missing	-	ERR LED flashes 4 times, then 1 s pause

Advantage: Uniform, largely vendor-independent LED behavior

Effects of using new Bus Couplers in existing networks: Minor changes to visual diagnostics in the event of an error. No change during normal operation.

9.3.3 Object directory

Identity object is now supported

New: The new CANopen identity object 0x1018 [▸ 75] is now supported. It provides the following information about the device:

Sub-index 1: vendor ID. Beckhoff has vendor ID 2

Sub-index 2: Product Code BK5120: 0x11400; BK5110: 0x113F6; LC5100: 0x113EC; IPwxyz-B510: 0x2wxyz; IL2301-B510: 0x2008FD.

Sub-index 3: revision number

Sub-index 4: Production date low word, high byte: calendar week (dec), low byte: calendar year

Advantage: Additional, vendor-independent information about the device is available.

Effects of using new Bus Couplers in existing networks: None

0x100E: Guarding identifier now read only

New: The default identifier for the guarding and heartbeat protocol can no longer be changed.

Advantage: Unambiguous allocation of the associated CAN frames to the node addresses

Effects of using new Bus Couplers in existing networks: Only if the guarding identifier was changed.

Object 0x1004 no longer available

New: Object 0x1004 (number of PDOs) is no longer supported in CANopen version 4.0, since it was not sufficiently meaningful.

Advantage: reduced memory requirement. The CANopen conformance test can only be passed without object 0x1004.

Effects of using new Bus Couplers in existing networks: Only if the number of PDOs was determined via object 0x1004.

Timeout during SYNC monitoring extended

New: The watchdog for SNYC monitoring is now set to 1,5 times the value in object 0x1006 [▸ 72].

Advantage: The designated SYNC interval can now be entered in object 0x1006.

Effects of using new Bus Couplers in existing networks: none

9.3.4 Network Management:

Boot-up message now on guarding identifier

New: The boot-up message introduced by Beckhoff and others is specified vendor-independent for the first time in CANopen version 4. Instead of an emergency message without data, a guarding telegram with one data byte (0) is now sent.

Advantage: Uniform definition, the Data Length Code no longer changes at run time.

Effects of using new Bus Couplers in existing networks: Only if the boot-up message was evaluated previously.

Heartbeat is supported

New: In addition to node monitoring via guarding protocol (cyclic polling of the node state via remote frame) heartbeat is now also supported

Advantage: Reduced bus load, individual monitoring cycles can be configured, remote frames no longer required (some CAN controllers do not adequately support these).

Effects of using new Bus Couplers in existing networks: none

9.3.5 General notes

Firmware update also possible via CANopen

New: From version C0, further firmware updates may be carried out via CANopen. This requires the BECKHOFF FC5101 or FC5102 CANopen master card with firmware 0.74 or above and TwinCAT. The download software is available from Beckhoff support on request.

Advantage: It is no longer necessary to carry out the update individually for each bus node in the network via the serial interface. All firmware updates for a particular type can be carried out simultaneously.

Effects of using new Bus Couplers in existing networks: none

Note: Firmware update via CAN is only supported from firmware Version C0. Updates to C0 therefore have to be carried out conventionally.

Firmware update via serial interface

For firmware updates via the serial interface you need a KS 2000 interface cable and the update program. The update program is available from Beckhoff support on request.

9.4 General operating conditions

The following conditions must be met in order to ensure flawless operation of the fieldbus components.

Environmental conditions

Operation

The components may not be used without additional protection in the following locations:

- in difficult environments, such as where there are corrosive vapors or gases, or high dust levels
- in the presence of high levels of ionizing radiation

Condition	Permissible range
Permissible ambient temperature during operation	see technical data
Installation position	variable
Vibration resistance	According to EN 60068-2-6
Shock resistance	According to EN 60068-2-27
EMC resistance	According to EN 61000-6-2
Emission	According to EN 61000-6-4

Transport and storage

Condition	Permissible range
Permissible ambient temperature during storage	-25 °C... +85 °C
Relative humidity	95 %, no condensation
Free fall	up to 1 m in the original packaging

Protection classes and types

Condition	Permissible range
Protection class in accordance with IEC 536 (VDE 0106, Part 1)	A protective conductor connection to the mounting rail is necessary!
Protection class conforms to IEC 529	IP20 (protection against contact with a standard test finger)
Protection against foreign objects	Less than 12 mm in diameter
Protection against water	no protection

Component identification

Every supplied component includes an adhesive label providing information about the product's approvals. For example, on the BK2000:

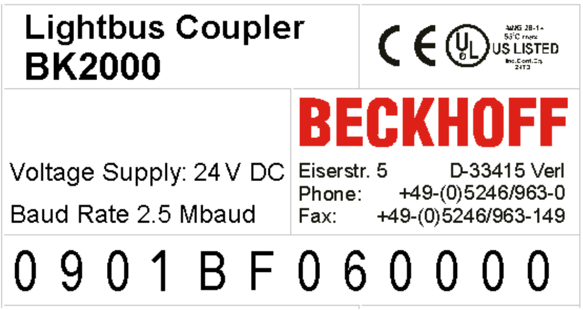

Fig. 51: Sticker with information about the BK2000 Bus Coupler certification

The following information is printed on the label:

Printed item	Meaning for this label
Precise product identification	Lightbus Coupler BK2000
Supply voltage	24 V_{DC}
Data transfer rate	2.5 Mbit/s
Manufacturer	Beckhoff Automation GmbH
CE mark	Conformity mark
UL mark	Mark for UL approval. UL stands for the Underwriters Laboratories Inc., the leading certification Organisation for North America, based in the USA. C = Canada, US = USA, LISTED 22ZA (the test results can be inspected under this entry)
Production identification	From left to right, this sequence of characters indicates the week of production (2 characters), the year of production (2 characters), the software version (2 characters) and hardware version (2 characters), along with any special indications (4 characters). This case therefore is a BK2000 - produced in the 9th calendar week - in the year 2001 - containing the BF firmware version - and using the 6th hardware version - with no special indications

9.5 Bibliography

German books

- Holger Zeltwander (Pub.):
  CANopen,
  VDE Verlag, 2001, 197 pages,
  ISBN 3-800-72448-0

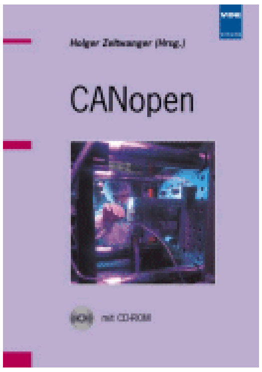

Fig. 52: CANopen

- Konrad Etschberger:
  Controller Area Network, Grundlagen, Protokolle, Bausteine, Anwendungen. (Principles, protocols, components, applications.)
  Hanser Verlag, 2000. 431 pages.
  ISBN 3-446-19431-2

General fieldbus technology

- Gerhard Gruhler (Pub.):
  Feldbusse und Geräte-Kommunikationssysteme, Praktisches Know-How mit Vergleichsmöglichkeiten. (Fieldbus and Device Communication Systems, Practical Know-how with Comparative Resources)
  Franzis Verlag, 2001. 244 pages.
  ISBN 3-7723-5745-8

English books

- Konrad Etschberger:
  Controller Area Network,
  Ixxat Press, 2001. 440 pages.
  ISBN 3-00-007376-0
- M. Farsi, M. Barbosa:
  CANopen Implementation,
  RSP 2000. 210 pages.
  ISBN 0-86380-247-8

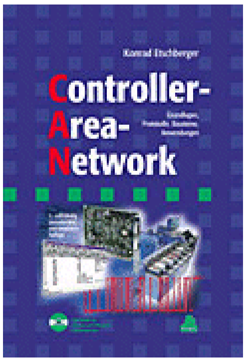

Fig. 53: Controller-Area-Network

Standards

- ISO 11898:
  Road Vehicles - Interchange of digital information - Controller Area Network (CAN) for high speed communication.
- CiA DS 301:
  CANopen Application Layer and Communication Profile.
  Available from the CAN in Automation Association.
- CiA DS 401:
  CANopen Device Profile for Generic I/O Modules.
  Available from the CAN in Automation Association.

9.6 List of Abbreviations

CAN

Controller Area Network. Serial bus system standardized in ISO 11898 that is used as the basic technology for CANopen

CiA

CAN in Automation e.V.. An international association of manufacturers and users based in Erlangen, Germany.

COB

Communication Object. A CAN telegram with up to 8 data bytes.

COB-ID

Communication Object Identifier. Telegram address (not to be confused with the node address). CANopen uses the 11-bit identifier according to CAN 2.0A.

NMT

Network Management. One of the service primitives of the CANopen specification. Network management is used to initialize the network and to monitor nodes.

PDO

Process Data Object. A CAN telegram for the transfer of process data (e.g. I/O data).

RxPDO

Receive PDO. PDOs are always identified from the point of view of the device under consideration. Thus a TxPDO with input data from an I/O module becomes an RxPDO from the controller's point of view.

SDO

Service Data Object. A CAN telegram with a protocol for communication with data in the object directory (typically parameter data).

TxPDO

Transmit PDO (named from the point of view of the CAN node).

9.7 Support and Service

Beckhoff and their partners around the world offer comprehensive support and service, making available fast and competent assistance with all questions related to Beckhoff products and system solutions.

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