ControlNet Coupler
BK7000

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BECKHOFF

Contents

Foreword

Notes on the documentation

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 following notes and explanations are followed when installing and commissioning these components.

Liability Conditions

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.
The documentation has been prepared with care. The products described are, however, constantly under development. For that reason the documentation is not in every case checked for consistency with performance data, standards or other characteristics. None of the statements of this manual represents a guarantee (Garantie) in the meaning of § 443 BGB of the German Civil Code or a statement about the contractually expected fitness for a particular purpose in the meaning of § 434 par. 1 sentence 1 BGB. In the event that it contains technical or editorial errors, we retain the right to make alterations at any time and without warning. 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.

Delivery conditions

In addition, the general delivery conditions of the company Beckhoff Automation GmbH apply.

Copyright

Safety Instructions

State at Delivery

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.

Description of safety symbols

The following safety symbols are used in this documentation. They are intended to alert the reader to the associated safety instructions..

Danger

This symbol is intended to highlight risks for the life or health of personnel.

Attention

This symbol is intended to highlight risks for equipment, materials or the environment.

Note

This symbol indicates information that contributes to better understanding.

Basic information

The Beckhoff bus terminal system

Up to 64 bus terminals

each with 2 I/O channels for any form of signal

The bus terminal system is the universal connecting link between a fieldbus system and the sensor/actor level. A unit consists of a bus coupler, which is the interface to the fieldbus, and up to 64 electronic terminals, of which the last is an end terminal. Terminals, each with two I/O channels, are available for any form of technical signal and can be combined as desired. The various types of terminal are all constructed in the same way, so that the planning costs are kept extremely low. The height and depth of the construction are calculated for compact terminal cabinets.

Decentralized wiring of the I/O level

IPC as control unit

Fieldbus technology makes it possible to use compact control architectures. The I/O level does not need to be taken right up to the control unit. Sensors and actors can be connected decentrally with minimal lengths of cable. You can position the control unit at any convenient location in the installation. Using an industrial PC as control unit makes it possible to implement the operating and monitoring element as part of the control hardware, so the control unit can be located on an operating desk, control point or similar. The bus terminals constitute the decentralized input/output level of the control unit in the switch cabinet and its subordinate terminal cabinets. As well as the sensor/actor level, the power unit of the equipment is also controlled via the bus system. The bus terminal replaces a conventional terminal as the cabling level in the switch cabinet; the switch cabinet can be made smaller.

Bus couplers for all current bus systems

The Beckhoff bus terminal system combines the advantages of a bus system with the functionality of compact terminals. Bus terminals can be used on all current bus systems and serve to reduce the diversity of parts in the control unit, while behaving like the conventional standard units for the relevant bus system and supporting the entire range of functionality of the bus system.

Standard C rail assembly

The simple and compact assembly on a standard C rail, and the direct cabling of actors and sensors without cross connections between the terminals, serve to standardize the installation, as does the uniformly designed labeling.

The small size and great flexibility of the bus terminal system mean that you can use it anywhere that you could use a terminal and use any type of connection – analog, digital, serial or direct sensors.

Modularity

Display of channel status

The modular construction of the terminal row, using bus terminals with various functions, limits the number of unused channels to at most one per function. Two channels to a terminal is the optimum solution for the number of unused channels and the cost per channel. The possibility of using power input terminals to provide separate power supplies also helps to minimize the number of unused channels.

The integrated light-emitting diodes close to the sensor/actor indicate the status of each channel.

The K-bus

End terminal

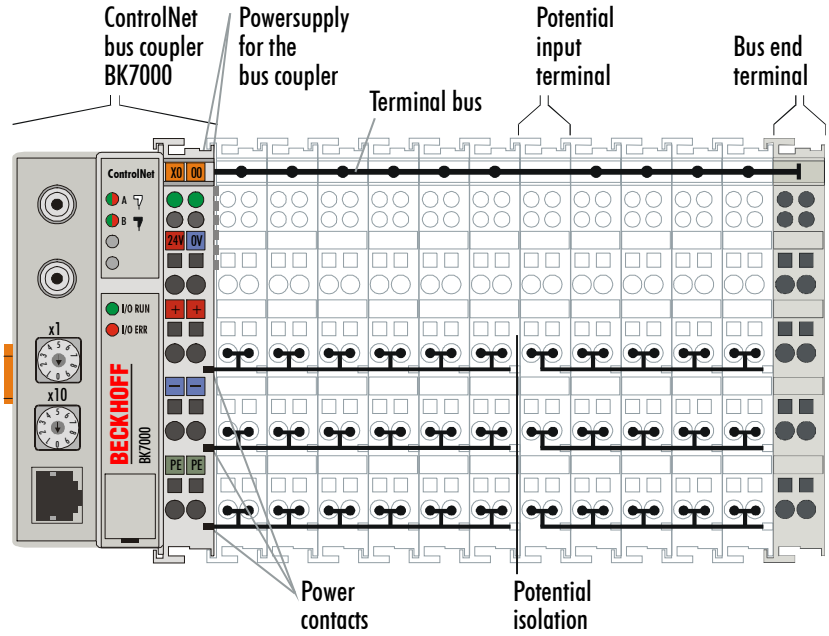
The K-bus is the path taken by data within the terminal row. The bus coupler carries the K bus through all the terminals by means of six contacts on the side walls of the terminals, and the end terminal terminates the K bus. The user does not need to know anything about the function of the K bus or the internal operation of terminals and bus couplers. There are numerous software tools available which provide for convenient planning, configuration and operation.

Power input terminals for separately powered groups

Three power contacts pass the operating power to the following terminals. You can use power input terminals to subdivide the terminal row as desired into groups, each with a separate power supply. These power input terminals are not taken into account for addressing the terminals, you can insert them at any position along the terminal row.

You can install up to 64 terminals on a terminal row, including power input terminals and the end terminal.

The principle of the bus terminal



Bus couplers for various fieldbus systems

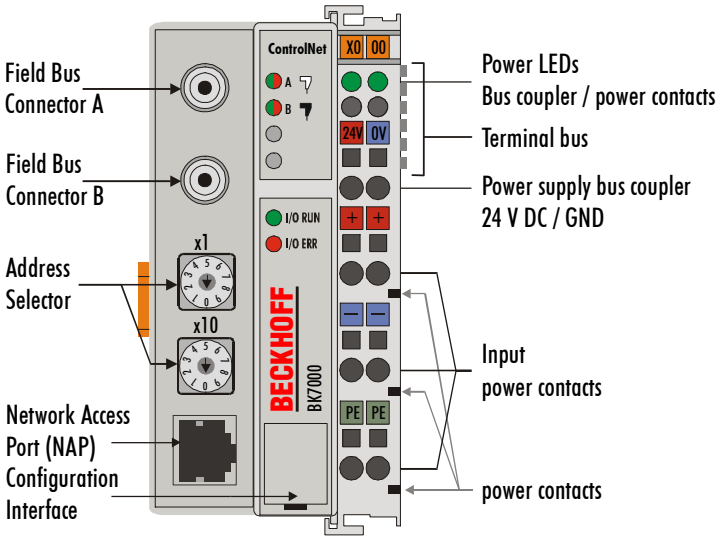
You can use a variety of bus couplers to attach the electronic terminal row quickly and easily to the various fieldbus systems, and you can also subsequently convert to a different fieldbus system. The bus coupler deals with all the necessary monitoring and control tasks for operating the attached bus terminals, indeed all the operation and configuration of the bus terminals is carried out via the bus coupler. The fieldbus, K bus and I/O level are electrically isolated.

If the exchange of data across the fieldbus is temporarily interrupted, logic states are preserved, digital outputs are cleared and analog outputs revert to a reset value which can be individually configured for each output when the equipment is set up.

The interfaces

There are six ways of making a connection to a ControlNet bus coupler. These interfaces are designed as plug connections and spring terminals.

The ControlNet coupler BK7000



Power supply

24 V DC on the topmost terminals

The bus couplers need an operating power of 24 V DC which is connected via the topmost spring terminals, labeled "24 V" and "0 V". This power supply serves not only the electronic components of the bus coupler but (via the K bus) also the bus terminals. The power supply of the bus coupler circuitry and that of the K-bus (Terminal bus) are electrically isolated from the voltage of the field level.

Power supply to the power contacts

Lower 3 terminal pairs for power input

maximum 24 V

maximum 10 A

The six lower connections with spring terminals can be used to supply power to the peripherals. The spring terminals are connected in pairs to the power contacts. The power supply to the power contacts has no connection to the power supply of the bus couplers. The power input is designed to permit voltages up to 24 V. The pair-wise arrangement and the electrical connection between the feed terminal contacts makes it possible to loop through the wires connecting to different terminal points. The load on the power contact may not continuously exceed 10 A. The current capacity between two spring terminals is the same as the capacity of the connecting wires.

Power contacts

Spring contacts at the side

On the right-hand side face of the bus coupler are three spring contacts which are the power connections. The spring contacts are recessed in slots to prevent them from being touched. When a bus terminal is connected, the blade contacts on the left-hand side of the bus terminal are connected to the spring contacts. The slot and key guides at the top and bottom of the bus couplers and bus terminals ensure reliable location of the power contacts.

Fieldbus connection

Control-Net connectors

On the left-hand side there are two ControlNet connectors A and B and a NAP-Port. You will find a detailed description of the fieldbus interfaces in another part of this manual (In the chapter "The transfer medium: plugs and cables").

Configuration interface

Serial interface under the front flap

On the lower part of the front face you will find the standard bus couplers which are fitted with an RS232 interface. The miniature plug can be attached to a PC by means of a connection cable and the configuration software KS2000. This interface enables you to configure the analog channels. You can also access the functionality of the configuration interface via the fieldbus by means of the PLC interface communications.

K-bus contacts

6 contacts at the side

The connections between the bus coupler and the bus terminals are effected by gold contacts at the right-hand side of the bus coupler. When the bus terminals are plugged together, these gold contacts automatically complete the connection to the bus terminals. The K bus is responsible for the power supply to the electronic components of the K bus in the bus terminals, and for the exchange of data between the bus coupler and the bus terminals. Part of the data exchange takes place via a ring structure within the K bus. Disengaging the K bus, for example by pulling on one the bus terminals, will break this circuit so that data can no longer be exchanged. However, there are mechanisms in place which enable the bus coupler to locate the interruption and report it.

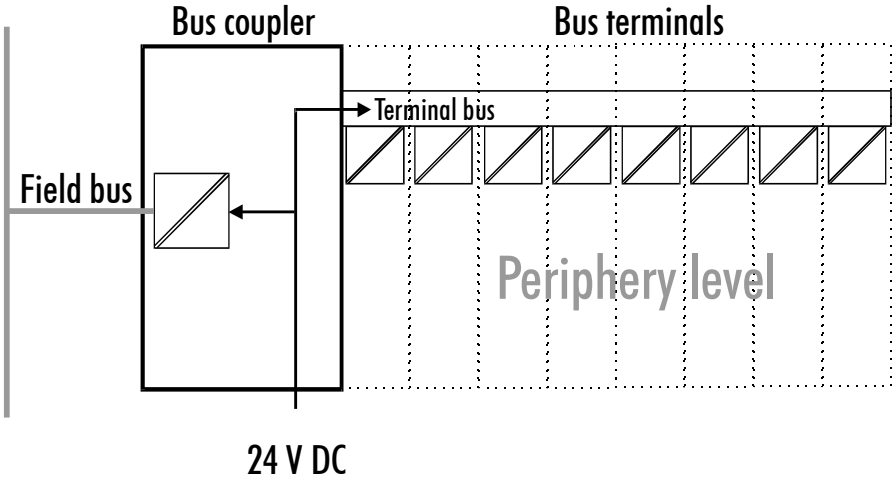
Supply isolation

3 supply groups:
fieldbus
K-bus
peripheral level

The bus couplers operate with three independent supplies. The input power supplies the electrically isolated K-bus circuitry in the bus coupler and the K-bus itself. The power supply is also used to generate the operating power for the fieldbus.

Note: All the bus terminals are electrically isolated from the K bus, so that the K-bus is completely electrically isolated.

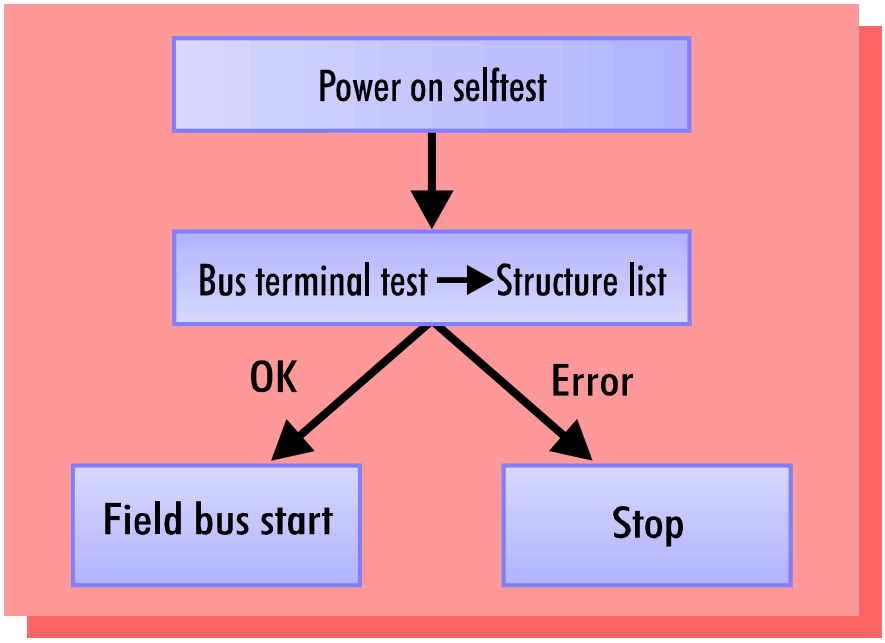
Setting up the power levels in the bus terminal system



The operating modes

When it is first switched on the bus coupler carries out a self-test to check the functions of its components and the communications of the K bus, and while this is going on the red I/O LED will flash. When the self-test has been completed successfully, the bus coupler will begin to test the attached bus terminals (the "bus terminal test") and read in the configuration from which it constructs an internal structure list, which is not accessible from outside. If an error occurs the bus coupler will enter the operating mode "STOP". If the start-up sequence is completed without errors the bus coupler will enter the mode "fieldbus start".

Start-up behavior of the bus coupler

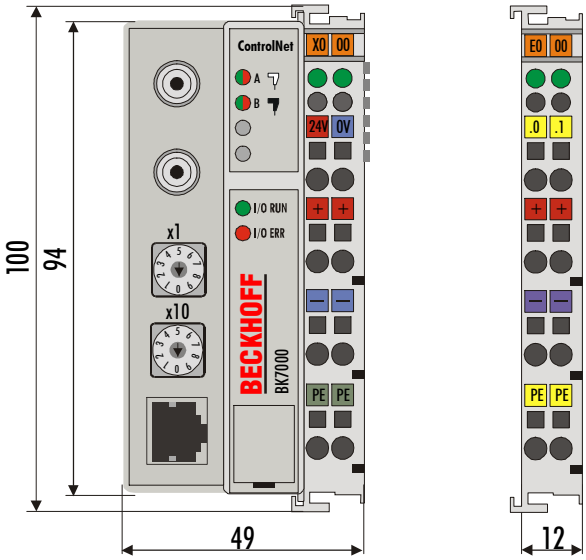


The bus coupler reports the error by means of the IO-ERR-LED. Clearing the error returns the bus coupler to its normal operating mode.

Mechanical design

The Beckhoff bus terminal system is remarkable for its compact construction and high degree of modularity. When you design the installation you will need to plan for one bus coupler and some number of bus terminals. The dimensions of the bus couplers do not depend on the fieldbus system. If you use large plugs, for example like some of the bus plugs used for the Profibus, they may protrude above the overall height of the cabinet.

Dimensions of a bus coupler



The overall width of the construction is the width of the bus coupler, including the bus end terminal, plus the width of the installed bus terminals. The bus terminals are 12 mm or 24 mm wide, depending on their function. Depending on the gauge of cables used the overall height of 68 mm may be overstepped by about 5 mm to 10 mm by the cables at the front.

Assembly and connections

It takes only a slight pressure to latch the bus coupler and the various bus terminals onto a supporting 35mm C rail and a locking mechanism then prevents the individual housings from being removed. You can remove them without effort if you first release the latching mechanism by pulling the orange tab. You should carry out work on the bus terminals and the bus coupler only while they are switched off: if you plug or unplug components while the power is on you may briefly provoke some undefined state (and, for instance, reset the bus coupler).

You can attach up to 64 bus terminals in series on the right-hand side of the bus coupler. When you assemble the components, make sure that you mount the housings so that each slot comes together with the corresponding key. You cannot make any functional connections merely by pushing the housings together along the supporting track. When they are correctly mounted there should be no appreciable gap between the adjacent housings.

The right-hand side of a bus coupler is mechanically similar to a bus terminal. There are eight connections on the top which can be used to connect to thick-wire or thin-wire lines. The connection terminals are spring loaded. You open a spring terminal by applying a slight pressure with a screwdriver or other pointed tool in the opening above the terminal and you can then insert the wire into the terminal without any obstruction. When you release the pressure the terminal will automatically close and hold the wire securely and permanently.

The connection between bus couplers and bus terminals is automatically effected by latching the components together. The K bus is responsible for passing data and power to the electronic components of the bus terminals. In the case of digital bus terminals, the field logic receives power via the power contacts. Latching the components together has the effect that the series of power contacts constitutes a continuous power track. Please refer to the circuit diagrams of the bus terminals: some bus terminals do not loop these power contacts through, or not completely (e.g. analog bus terminals or 4-channel digital bus terminals). Each power input terminal interrupts the series of power contacts and constitutes the beginning of a new track. The bus coupler can also be used to supply power to the power contacts.

Insulation test

The power contact labeled "PE” can be used as protective earth or ground. This contact stands proud for safety reasons and can carry short-circuit currents of up to 125A. Note that in the interests of electromagnetic compatibility the PE contacts are capacitively connected to the supporting track. This may lead to spurious results and even damage to the terminal when you test the insulation (e.g. insulation test for breakdown using a 230V mains supply to the PE line). You should therefore disconnect the PE line on the bus coupler while you carry out insulation tests. You can disconnect other power supply points for the duration of the test by drawing the power supply terminals out from the remaining row of terminals by at least 10mm. If you do this, there will be no need to disconnect the PE connections.

PE power contacts

The protective earth power contact ("PE”) may not be used for any other connections.

Electrical data

The electrical data specific to the fieldbus is given in this chapter. The following table lists an overview of all data:

Technical data	BK7000
Voltage supply	24 V DC (20 V...29 V DC)
Input current	70 mA + (total K-Bus current)/4 500 mA max.
Starting current	2.5 x continuos current
Output current K bus	1750 mA max.
Configuration possibility	by KS2000 or the controller
Number of bus terminals	64
Digital peripheral signals	256 inputs/outputs
Analog peripheral signals	256 inputs/outputs
Peripheral bytes	512 bytes I and 512 bytes O
Bus connection	Two BNC-connectors (ControlNet A and B) and 1 NAP-Port
Baud rates	5 MBaud (ControlNet V1.5)
Voltage power contact	24V DC / AC max.
Current load power con.	10 A max.
Max. voltage capacity	500 Veff (power contact / supply voltage/field bus)
Weight approx.	170g
Operating temperature	0℃ ... +55℃
Storage temperature	-20℃ ... +85℃
Relative humidity	95% non-condensing
Vibration /shock resistance	conforms to IEC 68-2-6 / IEC 68-2-27
EMC resistance burst / ESD	conforms to EN 50082 (ESD,Burst) / EN50081
Orientation for mounting	Any
Type of fuse	IP20

Current consumption on the K-Bus

For operation of the K-bus electronics, the bus terminals require energy from the K-bus that is supplied by the bus coupler. Refer to the catalog or the corresponding data sheets of the bus terminals for details of the K-bus current consumption. In doing so, pay attention to the maximum output current of the bus coupler that is available for powering the bus terminals. Using a special power supply terminal (KL9400), power can be fed back into the K-bus at any chosen point. If you wish to use a power supply terminal, please contact Beckhoff's technical support. .

The peripheral data in the process image

When the bus coupler is first switched on it determines the configuration of the attached input/output terminals and automatically assigns the physical slots of the input/output channels to the addresses in the process image.

The bus coupler sets up an internal list of assignments in which each of the input and output channels has a specific position in the process image. A distinction is made here between input and output and between bit-oriented (digital) and byte-oriented (analog, or complex) signal processing.

It also forms two groups, whereby one contains only inputs and the other only outputs. In each group, the byte-oriented channels take the lowest addresses, in ascending order, and these are then followed by the bit-oriented channels.

Digital signals (bit-oriented)

Digital signals are bit-oriented. This means that one bit of the process image is assigned to each digital channel. The bus coupler sets up a block of memory containing the current input bits and arranges to immediately write out the bits from a second block of memory which belongs to the output channels.

The precise assignment of the input and output channels to the process image of the control unit is explained in detail in the Appendix by means of an example.

Analog signals (byte-oriented)

The processing of analog signals is always byte-oriented and analog input and output values are stored in memory in a two-byte representation. The values are held as "SIGNED INTEGER” or "twos-complement”. The digit "0” represents the input/output value "0V”, "0mA” or "4mA”. When you use the default settings, the maximum value of the input/output value is given by "7FFF” hex. Negative input/output values, such as -10V, are represented as "8000” hex and intermediate values are correspondingly proportional to one another. The full range of 15-bit resolution is not realized at every input/output level. If you have an actual resolution of 12 bits, the remaining three bits have no effect on output and are read as "0” on input. Each channel also possesses a control and status byte in the lowest value byte. If the control/status byte is mapped in the control unit has to be configured in the master configuration software. An analog channel is represented by 2 bytes user data in the process image.

Special signals and interface

A bus coupler supports bus terminals with additional interfaces, such as RS232, RS485, incremental encoder, etc.. These signals can be regarded in the same way as the analog signals described above. A 16-bit data width may not be sufficient for all such special signals; the bus coupler can support any data width.

Default assignment of inputs and outputs to the process image

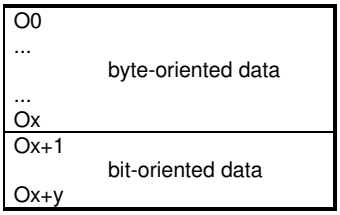
When the bus coupler is first switched on it determines the number of attached bus terminals and sets up a list of assignments. This list distinguishes between analog channels and digital channels and between input and output; which are grouped separately. The assignments begin immediately to the left of the bus coupler. The software in the bus coupler creates the assignment list by collecting the entries for the individual channels one at a time, counting from left to right. These assignments distinguish four groups:

	Function type of the channel	Assignment level
1.	Analog outputs	byte-wise assignment
2.	Digital outputs	bit-wise assignment
3.	Analog inputs	byte-wise assignment
4	Digital inputs	bit-wise assignment

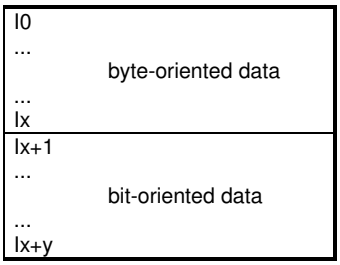
Analog inputs/ouputs are representative of other complex multi-byte signal bus terminals (RS232, SSI sensor interface, ...)

Overview of the subdivision of the process image in the bus coupler:

Output data in the bus coupler



Input data in the bus coupler



Data consistency

Data which contains no contradictions is said to be consistent. The following consistency is required here: 1. The high byte and low byte of an analog value (word consistency), 2. The control/status byte and the corresponding parameter word for accessing the register. The interaction of the peripherals with the control unit means that data can initially be guaranteed consistent only within an individual byte: the bits which make up a byte are read in together, or written out together. Byte-wise consistency is quite adequate for processing digital signals but is not sufficient for transferring values longer than eight bits, such as analog values. The various bus systems guarantee consistency to the required length. It is important to use the appropriate procedure for importing this consistent data from the master bus system to the control unit. You will find a detailed description of the correct procedure in the User Guide of the appropriate bus system, in particular in the description of the standard master units that are installed. The chapters of this manual which deal with the fieldbus refer to the most common of these standard units.

Processing complex signals

All byte-oriented signal channels such as RS232, RS485 and incremental encoder, can use byte lengths greater than two. Apart from the actual difference in length, the procedure is always comparable with that for analog signals. In the configuration software for the bus masters of the second generation (from around 09.96), the corresponding channel can be selected directly from the "GSD file". The configuration software automatically ensures the settings for maintaining data consistency.

Starting operation and diagnostics

When the bus coupler is first switched on it at once checks the attached configuration. A correct start-up procedure is indicated by the red LED "I/O ERR" going out. If this LED flashes, this indicates a fault somewhere in the terminals. You can determine the actual error code by observing the speed of flashing and number of flashes. This will enable you to clear the fault quickly. You will find a detailed description in the chapter "The diagnostic LEDs".

The diagnostic LEDs

The bus coupler has a status display consisting of two groups of LEDs. The upper group has four LEDs which indicate the mode of the installed fieldbus. The significance of these "fieldbus status LEDs" is explained in the appropriate chapters of this manual; they correspond to the usual displays for fieldbuses.

There are two more green LEDs at the top right-hand side of the bus coupler to indicate the supply voltage. The left-hand LED shows the 24V supply of the bus coupler. The left-hand LED shows the supply to the power contacts.

Local errors

Two LEDs, the "I/O LEDs", which are situated below the fieldbus status LEDs described above, are used to display the operating mode of the bus terminals and the connection to these bus terminals. The green LED lights up to indicate error-free operation, where "error-free" implies that communication with the fieldbus system is also operating correctly. The red LED flashes at two different rates to indicate a fault, whereby the specific error is encoded in the pattern of flashes, as follows.

Code of flashes

Rapid flashing	Start of the error code
First slow sequence	Type of error
Second slow sequence	Location of error

Error

Error code	Error argument	Description
1 pulse	0 1 2	EEPROM checksum error I/0 line buffer overflow Unknown data type
2 pulses	 0 n (n > 0)	Programmed configuration Invalid table entry/bus coupler Invalid table comparison (terminal n)
3 pulses	0	Terminal bus command error
4 pulses	0 n	Terminal bus data error Rupture point after terminal n (0: coupler)
5 pulses	N	Terminal bus error during register communication with terminal n
>= 6 pulses		ControlNet specific, will be described later in this document

Location of error

The number of flashes corresponds to the position of the last bus terminal before the error, not counting passive bus terminals such as power input terminals.

The bus coupler will carry on flashing the error code even when you have cleared the fault and its operating mode will remain at "Stop". The only way to restart the bus coupler is by switching the power supply off and on again.

You should not plug or unplug bus terminals from the series without first turning off the power. The circuitry of the bus terminals and the bus coupler is largely protected against damage, but if you modify the assembly while it is under power, malfunctions and damage cannot be ruled out.

If a fault occurs during normal operation, the error code will not be output on the LEDs until the bus coupler has been requested to diagnose the bus terminals. This diagnostic request is generated after the equipment is switched on.

Fieldbus errors

The fieldbus status LEDs A and B indicate the current ControlNet bus status of the corresponding channel. The other two LEDs are reserved for the future.

Priority	indicator state	how to view	cause
Highest (1)	both steady off	viewed together	reset or no power
2	both steady red	viewed together	failed link interface
3	alternating red / green	viewed together	self test
4	alternating red / off	viewed together	bad node configuration (such as duplicate MAC ID)
5	steady off	viewed independently	channel disabled or channel not supported
6	flashing red / green	viewed independently	invalid link configuration
7	flashing red / off	viewed independently	link fault or no MAC frames received
8	flashing green / off	viewed independently	temporary channel error, or listen-only
Lowest (9)	steady green	viewed independently	normal operation

Please note that there is an association between the green I/O LED and the fieldbus. The I/O LED lights up when access is made to the internal K bus. The green I/O LED is not lit until data begins to be exchanged via the fieldbus.

The bus coupler does, however, interrogate the configuration of the bus terminals after power on and does not exchange any data with the terminals. That is to say, the red I/O LED goes off after an error-free start up without the green I/O LED having to light up. Then, the green I/O LED does not light up until data transfer is begun via the field bus.

If a terminal bus error occurs during operation, the procedure followed conforms to the reaction to the terminal bus errors parameterisation. If the terminal bus error already occurs during start up, the slave does not assume ControlNet data transfer.

Run times and reaction times

Transfer of the signals from the input to the controller and from the controller to the outputs requires a run time. This is composed of various components. Transfer from the controller to the scanner, transfer through the ControlNet and transfer from the bus coupler to the outputs. This applies analogously to the return distance.

Controller / Scanner

Please refer to the data provided by the scanner manufacturer for details of the reaction time from the controller to the master. These times are comparatively short and normally do not need to be considered.

The reaction time on the ControlNet depends on the NUT and the transfer rate

K-Bus reaction time

The reaction time on K-Bus is determined by movement and backing up of the data. The following table contains measured values for typical setups. Extrapolation to larger quantities is possible.

Terminals fitted on the bus coupler			Run time on the K-bus
Digital OUT	Digital IN	Analog IN/OUT	T_Zyklus (us)
4	**0**	**0**	150
8	**0**	**0**	170
12	**0**	**0**	170
16	**0**	**0**	200
20	**0**	**0**	200
24	**0**	**0**	220
28	**0**	**0**	220
32	**0**	**0**	245
0	**4**	**0**	150
0	**8**	**0**	180
0	**12**	**0**	180
0	**16**	**0**	200
0	**20**	**0**	200
0	**24**	**0**	230
0	**28**	**0**	230
0	**32**	**0**	250
4	**4**	**0**	170
8	**8**	**0**	195
12	**12**	**0**	220
16	**16**	**0**	250
20	**20**	**0**	275
24	**24**	**0**	300
28	**28**	**0**	325
32	**32**	**0**	350
4	**4**	**1 (KL3202)**	630
4	**4**	**2 (KL3202)**	700

ControlNet coupler BK7000 in the ControlNet

Introducing the system

The deterministic control network is a serial communication system for communication between devices that wish to exchange time-critical application information in a deterministic and predictable manner. These devices include simple I/O devices, such as sensors/actuators as well as complex control devices such as robots, programmable logic controllers, welders, process controllers, etc. Unlike general-purpose communication systems that rely on the destination delivery model, this network uses the producer/consumer model. The producer/consumer model allows the exchange of time-critical application information between a sending device (e.g., the producer) and many receiving devices (e.g., the consumers) without the need to send the data multiple times to multiple destinations. This is accomplished by attaching a unique identifier to each piece of application information that is being produced onto the network medium. Any device that requires a specific piece of application information simply filters the data on the network medium for the appropriate identifier. Many devices can receive the same produced piece of application information from a single producing device. The deterministic control network provides a high degree of protocol efficiency by utilising an implied token passing mechanism. This mechanism allows all devices equal access to the network without the network overhead associated with passing a “token” to each device granting it permission to send data. The protocol utilises a time-based Scheduling mechanism that provides network devices with deterministic and predictable access to the medium while preventing network collisions. This scheduling mechanism allows time-critical data, which is required on a periodic, repeatable and predictable basis, to be produced on a predefined schedule without the loss of efficiency associated with continuously requesting or “polling” for the required data. The network protocol supports an additional mechanism that allows data that is not time-critical in nature or that is only required on a occasional basis to utilise any available network time. This unscheduled data is transmitted after the production of the time-critical data has been completed and before the beginning of the next scheduled production of time-critical data.

The transfer medium: plugs and cables

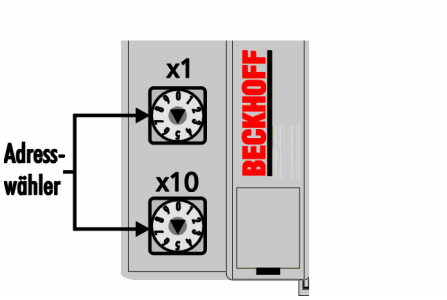
Physics of the transmission

The physical data transfer is defined in the ControlNet standard.
The BK7000 supports redundant media access with the two BNC connectors A and B. Additionally a monitor or configurating system can be connected over the NAP-Port.

Setting the station Addresses

The station address is set by way of the rotary switches on the left of the bus coupler. The address is set as a decimal number. The top rotary switch stands for the units position and the bottom one stands for the tens position of the address. (Example: station address 18: bottom rotary switch = 1, top rotary switch = 8). To ensure that the rotary switch setting is saved by the BK7000 it must be reset (by briefing interrupting the power supply or by means of a software reset).

Address selector



Configuring the master

The assembly object of the BK7000 represents the process image buffer of the terminal bus inputs and outputs. The data of this buffer can be sent or received over a single connection. Assembly objects are used to produce (terminal bus inputs) and/or consume (terminal bus outputs) data to/from the network.

So the inputs and ouputs of the terminals will be connected to the ControlNet with the assembly object. All output data will be sent from the scanner in one scheduled telegram and all input data will be sent to the scanner in another scheduled telegram.

To set up this connection, the following parameters of the FwdOpen-service have to be adjusted:

Net O->T connection parameters	network connection type	Multicast
	fixed/variable	Fixed
	priority	Scheduled priority
	size	No of bytes (word-aligned) of the terminal bus output data (depending on the calculating rules for terminal bus input and output data) + 4 bytes scanner status + 2 bytes transport header
Net T->O connection parameters	network connection type	Point-To-Point
	fixed/variable	Fixed
	priority	Scheduled priority
	size	No of bytes (word-aligned) of the terminal bus input data (depending on the calculating rules for terminal bus input and output data) + 4 bytes adapter status + 2 bytes transport header
Transport class / trigger	client / server	Client
	transport type	Cyclic
	transport class	Class 1
Connection path	class	0x04
	connection point inputs	0x00
	connection point outputs	0x00
	electronic key, vendor ID	0x006C
	electronic key, product type	0x0080
	electronic key, product code	0x1B58

The status code and objectic specific status code of the FwdOpen-Response can report the following codes:

Status code	Object specific status code	Meaning	Displayed by blinking IO-ERR LED:
0x00	Not available	Connection successful	Off
0x01	0x0100	Connection already in use	Fast, 8*slow, 1*slow
0x01	0x0113	Connection Manager out of connections	Fast, 8*slow, 2*slow
0x01	0x0108	Unsupported connection type	Fast, 8*slow, 3*slow
0x01	0x0103	Transport type not supported	Fast, 8*slow, 4*slow
0x01	0x0117	Nonexistant instance number	Fast, 8*slow, 5*slow
0x25	0x0114	Electronic key in IOI failed (Vendor ID)	Fast, 8*slow, 6*slow
0x25	0x0115	Electronic key in IOI failed (Product type)	Fast, 8*slow, 7*slow
0x25	0x0114	Electronic key in IOI failed (Product code)	Fast, 8*slow, 8*slow
0x05	0x0000	invalid class	Fast, 8*slow, 9*slow
0x01	0x0400	Terminal bus fault	Fast, 8*slow, 10*slow
0x01	0x0109	Connection size mismatch	Fast, 8*slow, 11*slow
0x01	0x011A	Application out of connections	Fast, 8*slow, 12*slow
0x01	0x1000	Bad config data size	Fast, 8*slow, 13*slow
0x01	0x1001	Bad config data word 0	Fast, 8*slow, 14*slow
0x01	0x1002	Bad config data word 1	Fast, 8*slow, 15*slow
0x01	0x1003	Bad config data word 2	fast, 8*slow, 16*slow
0x01	0x1004	Bad config data word 3	fast, 8*slow, 17*slow
0x01	0x1010	Config buffer overflow	fast, 8*slow, 18*slow
0x01	0x0315	Invalid segment in path	fast, 9*slow, 1*slow
0x06	0x0000	Not all expected data sent in the connection path	fast, 9*slow, 1*slow
0x01	0x0110	Connection unconfigured step 1	fast, 9*slow, 3*slow
0x01	0x0110	Connection unconfigured step 2	fast, 9*slow, 4*slow
0x01	0x0110	Connection unconfigured step 3	fast, 9*slow, 5*slow
0x01	0x0110	Connection unconfigured step 4	fast, 9*slow, 6*slow

Config data of the Assembly object

Sending the config data is optional, but they must consist of 4 words when sent.

Word	Meaning (default value is printed in bold type)
0	Reserved: must be 0
1	Bit 0: 2-Byte-PLC-interface **off (0)** / on (1) Bit 1: 2-Byte-Diag-interface **off (0)** / on (1)
2	Bit 0: Terminal bus auto-reset **off (0)** / on (1) Bit 1: Terminal diagnosis **off (0)** / on (1) Bit 4: Digital terminal diagnosis mapped to input data **on (0)** / off (1)
3	Bit 2: Complex terminals are mapped **with data only, if possible (0)** / completely (1) Bit 3: Complex terminals are mapped in **Intel- (0)** / Motorola (1) format Bit 5: Complex terminals are mapped **without (0)** / with (1) word-alignment Bit 6: Terminal bus will be synchronous to the Receive-connection (0) / **free running (1)**

Undescribed bits are reserved for internal or future use and must not be changed.

The config data are stored in the bus coupler's registers 0..3 in table 0. If no config data are sent, the values are read from these registers. The registers can be read and written using the bus coupler configuration software KS2000.

Calculating rules for terminal bus input and output data sizes

There are three options for mapping analog terminals and other complex terminals: data only (if possible), complete without word-alignment, or complete with word-alignment. The input and output data sizes depend on which mapping option is chosen.

If no config data are sent when connecting the Assembly object, the BK7000 will at first try to use the most recently used mapping option. Failing that, it will try the options in the following order, choosing the first option that will make the data sizes match with the sizes received from the scanner. This option will then be stored in the register table.

Rule 1 Analog terminals are mapped with data only. Other complex terminals are mapped with data only if applicable, otherwise they are mapped completely, without word-alignment.

Rule 2 All complex terminals are mapped completely, without word-alignment.

Rule 3 Analog terminals are mapped with data only, other complex terminals are mapped with data only if applicable, otherwise they are mapped completely, with word-alignment.

Rule 4 All complex terminals are mapped completely, with word-alignment.

If config data are sent when connecting the Assembly object, the input and output data sizes are calculated using the selected option.

If the 2-Byte-PLC-interface or the 2-Byte-Diag-interface are enabled by the config data, 2 additional bytes of input and output data are needed for each enabled interface.

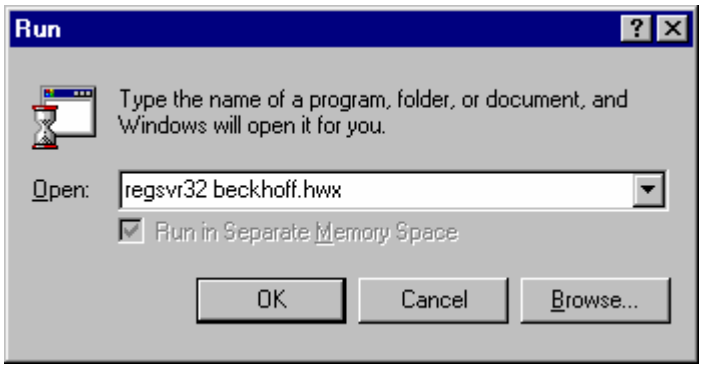
The data of the Assembly object have the following stucture:

Offset (in bytes)	Meaning	Remark
0	Transport header	
2	Scanner / Adapter status	
6	2-Byte-PLC-interface	Optional
8	2-Byte-Diag-Interface	Optional
10	Complex terminals (left to right)	
10 + size of complex terminals	Digital terminals (left to right)	

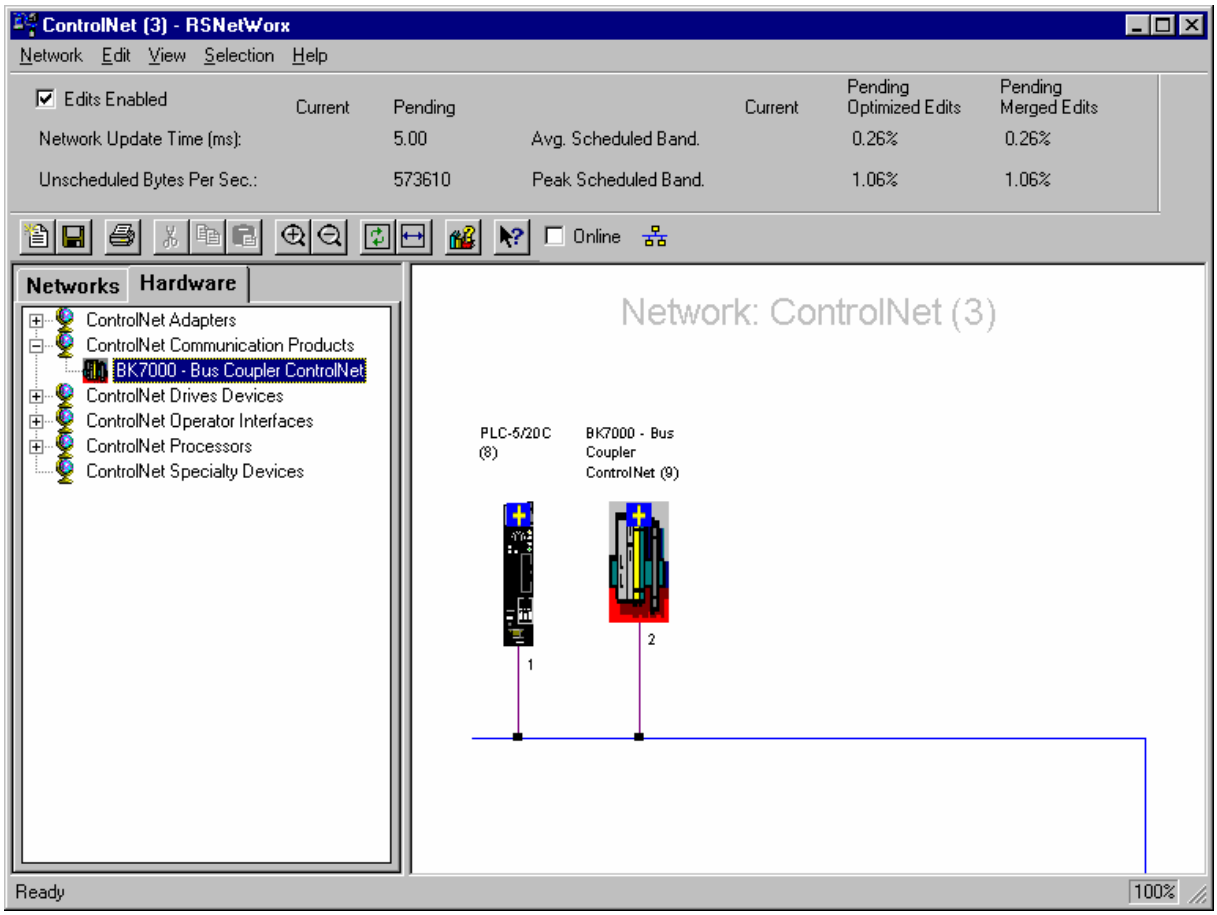
Note that the terminal data begin at offset 8 or 6 if any or both of the optional interfaces are disabled.

Configuration with RS Networx 1.06

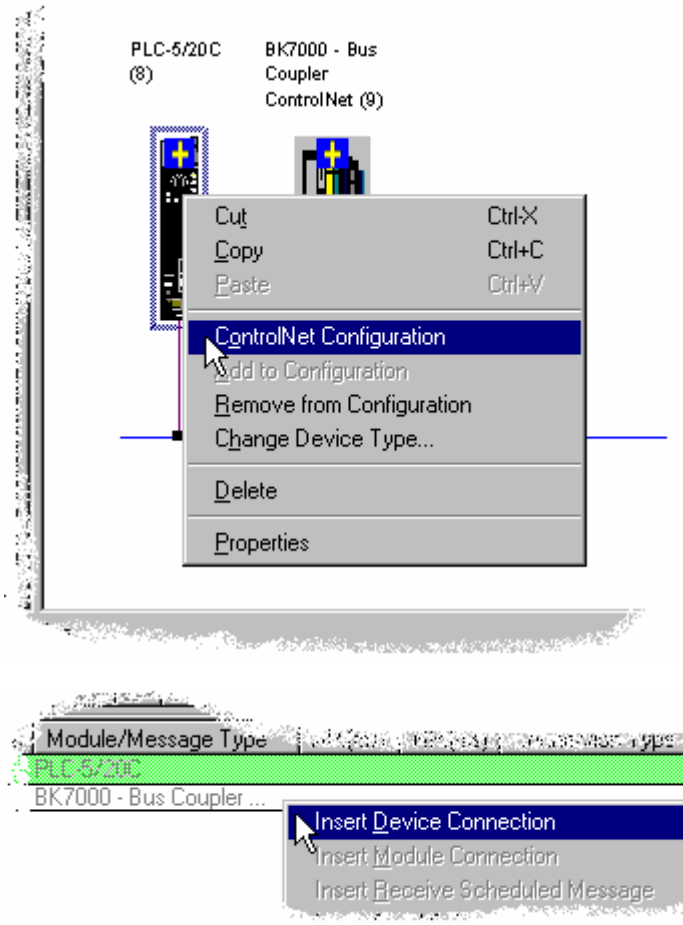
Make sure that beckhoff.hwx is registered with regsvr32.exe. This needs to be done only once. If you aren't sure whether this has been done already, skip to step 2.



Select BK7000 from the list of communication products to add it to the configuration. If the BK7000 isn't in the list as shown, you need to perform step 1.



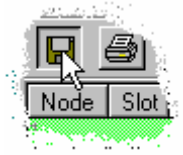
Open the ControlNet configuration of the controller (PLC-5/20C in the example), and insert a device connection to the BK7000.



Set the input and output data size for the BK7000 according to the connected terminals and the desired mapping. Set the config size to 0 for default settings or 4 for custom settings.

Node	Slot	Message	Module/Message Type	API(ms)	RPI(ms)	Connection Type	Input Address	Input Size	Output Address	Output Size	Status Address	Config Address	Config Size
1			PLC-5/20C										
2			BK7000 - Bus Coupler ...	5		Exclusive Owner	N10:0	8	N11:0	8	N12:0	n/a	0

Save the configuration



Configuration with RS Networx 1.03

With RS Networx 1.03 the BK7000 in standard will not be supported. The BK7000 can be configured like an 1771 ACN®15-I/O-adapter from Allen-Bradley. Instead of the assembly object the BK7000 in 1771-Mode supports two objects: the rack object for digital terminals and the 1771-generic module for anlog terminals.

The input and output size of the digital object must be the number of words of the digital inputs/outputs.

The input and output size of the analog object must be the number of words of the analog inputs/outputs. The same rules as for the assembly object will be used for the analog object.

For the digital object insert a discrete rack in the ControlNet configuration, for the analog object insert a module and select the „1771-Generic“-module.

The config size in the 1771-Mode must be zero.

Appendix

Sample arrangement of a process image in the bus coupler

The following example will illustrate the assignment of input/output channels to the process image. Our sample construction is to consist of the following bus terminal components:

For this configuration the bus coupler will create the list of assignments shown below

Position	Function component on the track
POS01	Bus coupler
POS02	2-channel digital input
POS03	2-channel digital input
POS04	2-channel digital input
POS05	2-channel digital input
POS06	2-channel digital input
POS07	2-channel digital output
POS08	2-channel digital output
POS09	2-channel digital output
POS10	2-channel analog input
POS11	2-channel analog output
POS12	2-channel analog output
POS13	2-channel analog input
POS14	Power input terminal
POS15	2-channel digital input
POS16	2-channel digital input
POS17	2-channel digital input
POS18	2-channel digital output
POS19	2-channel digital output
POS20	2-channel analog output
POS21	End terminal

Besides transfer of the user information signal, when using analog terminals the control/status byte is also available via the process image by parameterisation of a three-byte channel (see PROFIBUS-DP).

Area for byte-oriented data, analog outputs

Relative byte address	Bit position	Process image in the control unit	Position in the block
0, 1	none	O0, O1	POS11
2, 3	none	O2, O3	POS11
4, 5	none	O4, O5	POS12
6, 7,	none	O6, O7	POS12
8, 9	none	O8, O9	POS20
10, 11	none	O10, O11	POS20

Area for bit-oriented data, digital outputs

Relative byte address	Bit position	Process image in the control unit	Position in the block
12	0	O12	POS07
12	1	O12	POS07
12	2	O12	POS08
12	3	O12	POS08
12	4	O12	POS09
12	5	O12	POS09
12	6	O12	POS18
12	7	O12	POS18
13	0	O13	POS19
13	1	O13	POS19

Area for byte-oriented data, analog inputs

Relative byte address	Bit position	Process image in the control unit	Position in the block
0, 1	none	I0, I1	POS10
2, 3	none	I2, I3	POS13

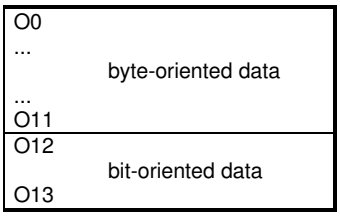
Area for bit-oriented data, digital inputs

Relative byte address	Bit position	Process image in the control unit	Position in the block
4	0	I4	POS02
4	1	I4	POS02
4	2	I4	POS03
4	3	I4	POS03
4	4	I4	POS04
4	5	I4	POS04
4	6	I4	POS05
4	7	I4	POS05
5	0	I5	POS06
5	1	I5	POS06
5	2	I5	POS15
5	3	I5	POS15
5	4	I5	POS16
5	5	I5	POS16
5	6	I5	POS17
5	7	I5	POS17

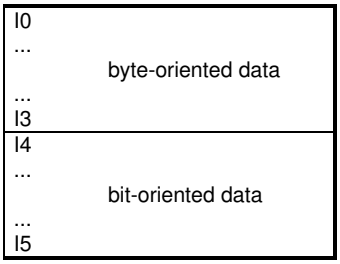
The items POS14 and POS21 are not relevant to data exchange and do not appear in the list. If a byte is not fully used, for example O13, the bus coupler pads its remaining bits with zeroes.

Overview of the distribution of the process image in the bus coupler:

Output data in the bus coupler



Input data in the bus coupler



The base addresses I0 and O0 listed here are used as relative addresses or addresses in the bus coupler. If you have an appropriate superordinate Profibus system you can use the bus master to enter these addresses at any desired position in the process image of the control unit. You can use the configuration software of the master to assign the bytes to the addresses in the process image of the control unit.

Representation of analog signals in the process image

In the standard case, the analog signals are presented as follows: to input bytes or to output bytes of the process image are needed for each analog channel. The two bytes represent the value as unsigned interger, i.e. 15 bits with the sign. The data format is used independently of the actual resolution. Example: with a resolution of 12 bits in the case of analog values in the positive and negative value ranges, the four least significant bits are of no importance. If the value of the analog signal is only positive, the sine bit (bit 15, MSB) is always "0". In this case, the 12 bits of the analog value are represented in bit 14 to bit 3. The three least significant bits are of no importance.

By configuration via the Profibus master software or the KS2000 software, the bus coupler can represent all or individual analog channels in an extended mode. Optionally, the control and status byte of a channel can also be inserted. The least significant byte of three bytes has control and status functions. The other two bytes become inputs and outputs. Various operating modes can be set with the control byte. The 6 least significant bits of the control and status byte can be used as addressing bits. Addressing serves to read and write a register set inside the terminal. The register set has 64 registers. The settings are stored permanently

I/O bytes of an analog channel in the process image

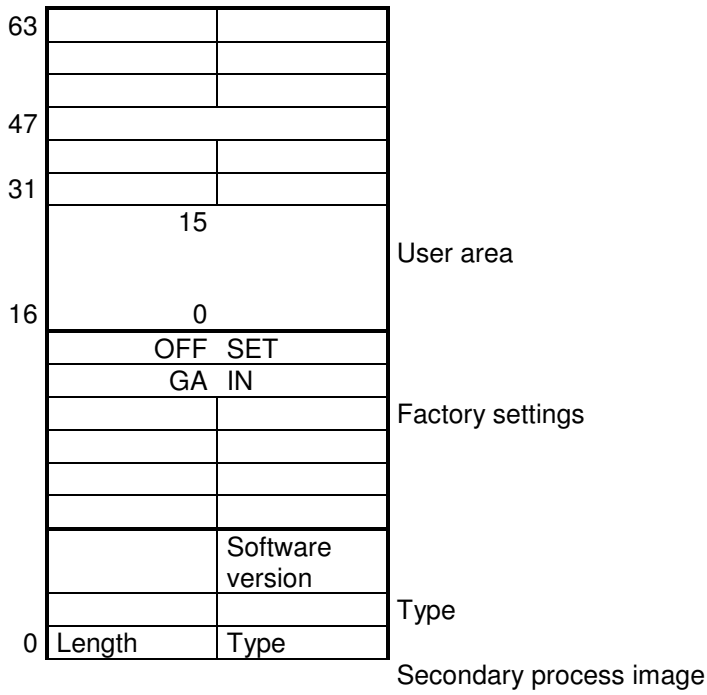
Output byte 1	Output byte 0	Control byte

Input byte 1	Input byte 0	Status byte

Significance of the control/status bytes for accessing the register model

BIT 7	**0 = NORMAL MODE,**	**1 = CONTROL MODE**
BIT 6	0 = READ,	1 = WRITE
BIT 5	Register address, MSB	
BIT 4	Register address	
BIT 3	Register address	
BIT 2	Register address	
BIT 1	Register address	
BIT 0	Register address, LSB	

Register set of an analog channel



The significance of the registers and status bytes is explained in the data sheets for the corresponding bus terminals. The construction of the module is identical for bus terminals with more extensive signal processing.

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