

# **PROFIBUS Coupler**

**BK3000, BK3010, BK3100,  
BK3110, BK3500, LC3100**

**Technical Hardware Documentation**  
**2006-11-27**  
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**BECKHOFF**

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# 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

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# 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*

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.

### *Display of channel status*

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

### *The K-bus*

### *End terminal*

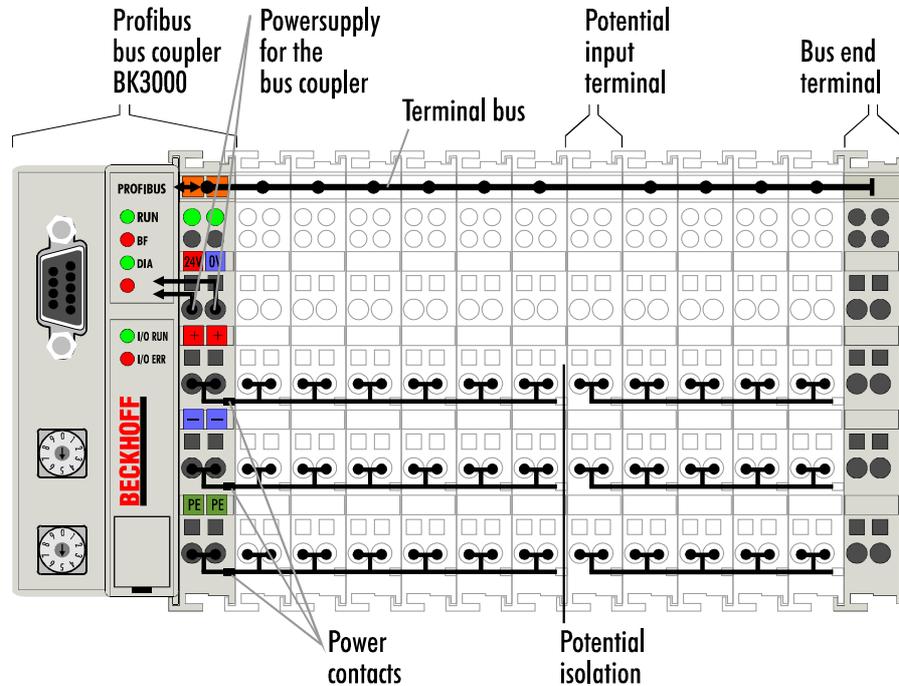
The K-bus is the path taken by data within the terminal row. The bus coupler carries the K bus through all the terminals by means of six contacts on the side walls of the terminals, and the end terminal terminates the K bus. The user does not need to know anything about the function of the K bus or the 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*

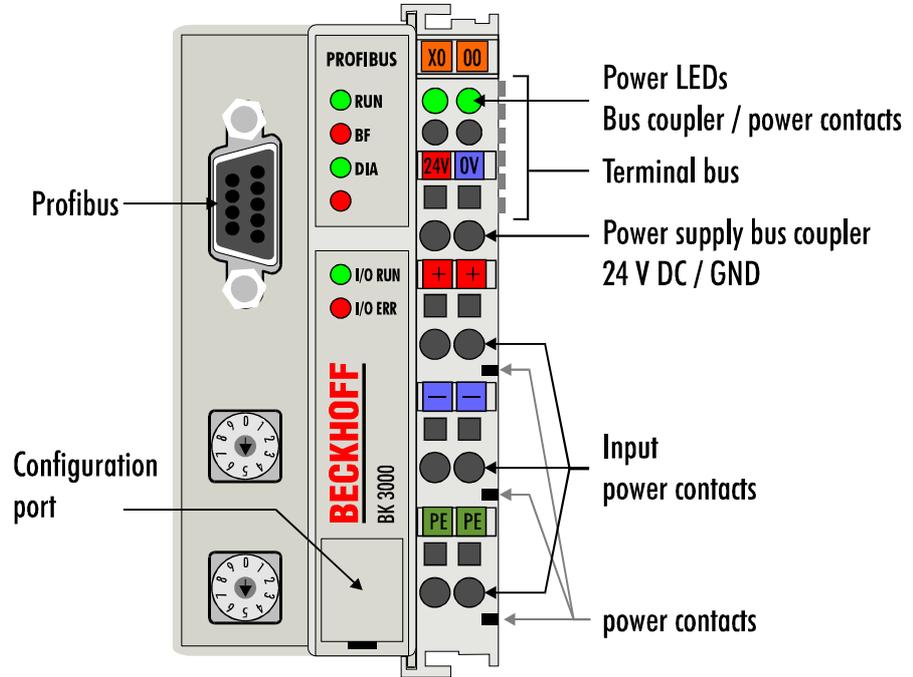
You can use a variety of bus couplers to attach the electronic terminal row quickly and easily to the various fieldbus systems, and you can also subsequently convert to a different fieldbus system. The bus coupler deals with all the necessary monitoring and control tasks for operating the attached bus 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

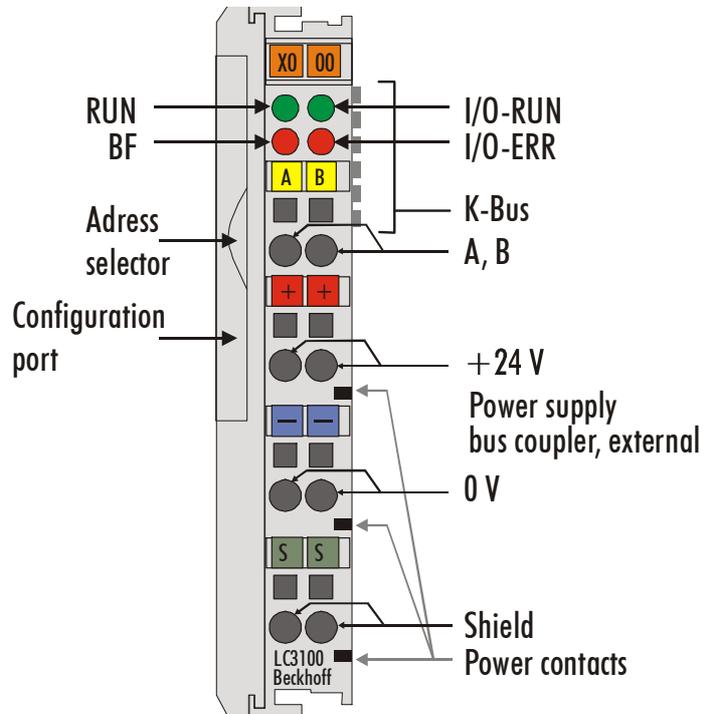
There are six ways of making a connection to a bus coupler. These interfaces are designed as plug connections and spring terminals.

*The Profibus coupler BK3xx0*



The LC3100 bus coupler integrates the bus connection into the spring-loaded terminals.

*The Profibus coupler LC3100*



LC3100

*BK3xx0:  
24 V DC on the topmost  
terminals*

### Power supply

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.

*LC3100:  
24 V DC to the central pairs  
of terminals*

The LC3100 bus coupler is supplied via the two central terminal pairs. The power contacts pass the supply voltage on to the field level.

*Lower 3 terminal pairs for  
power input*

*maximum 24 V*

*maximum 10 A*

### Power supply to the power contacts

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.

*Spring contacts at the side*

### Power contacts

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.

*BK30X0, BK31X0  
9 pin sub-D socket strip*

### Fieldbus connection

There is a recessed front face on the left hand side. The typical Profibus connecting plug can be inserted here. A full description of the fieldbus interfaces is found elsewhere in this manual. (In the section on The Medium: Plugs and Cables)

*BK3500 LWL (optical  
fibres)*

The plugs for the optical fibres are 2 HP Simplex plugs that are inserted into the sockets. The two required plugs are included.

*LC3100: Bus connection  
via spring loaded terminals*

In the LC3100 bus coupler the bus is connected directly at the upper terminal pair.

*Serial interface under the  
front flap*

### Configuration interface

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.

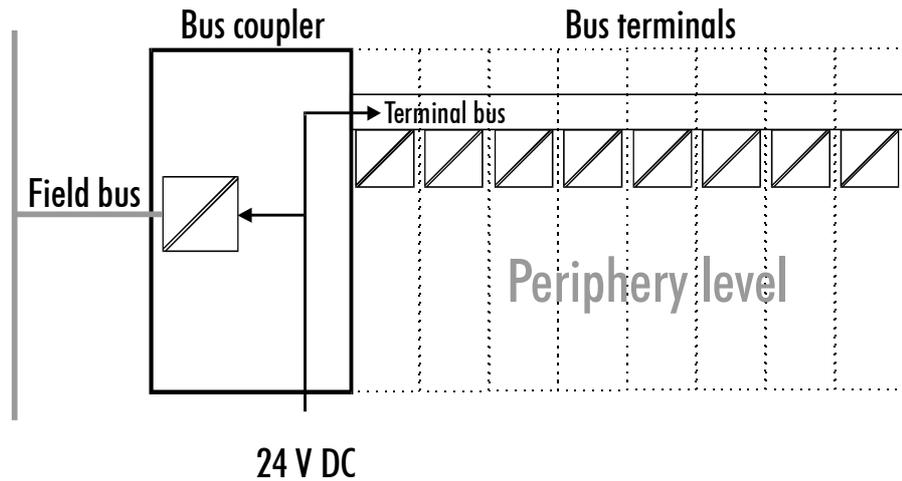
**Supply isolation**

*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.

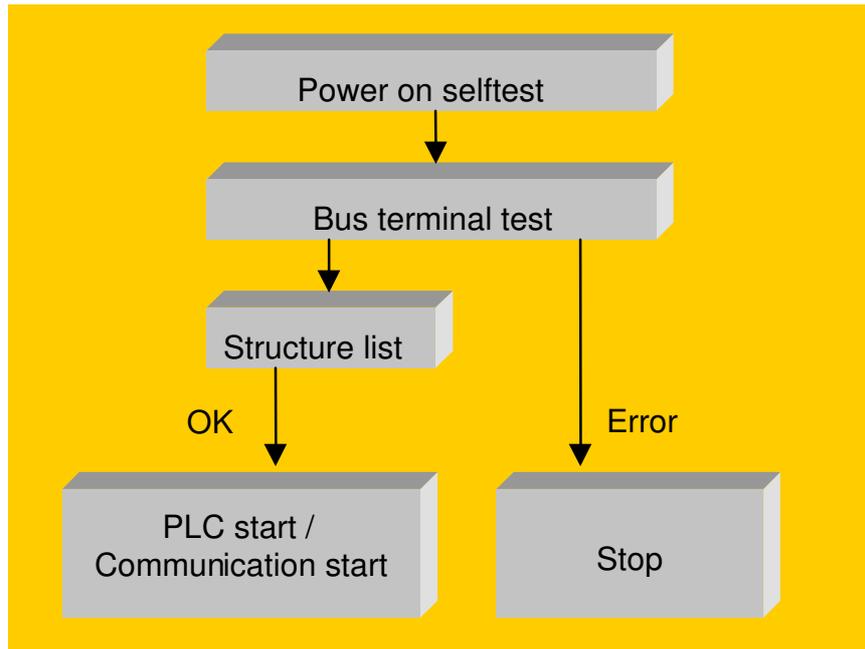
*Setting up the power levels in the bus terminal system*



## The operating modes of the bus coupler

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*

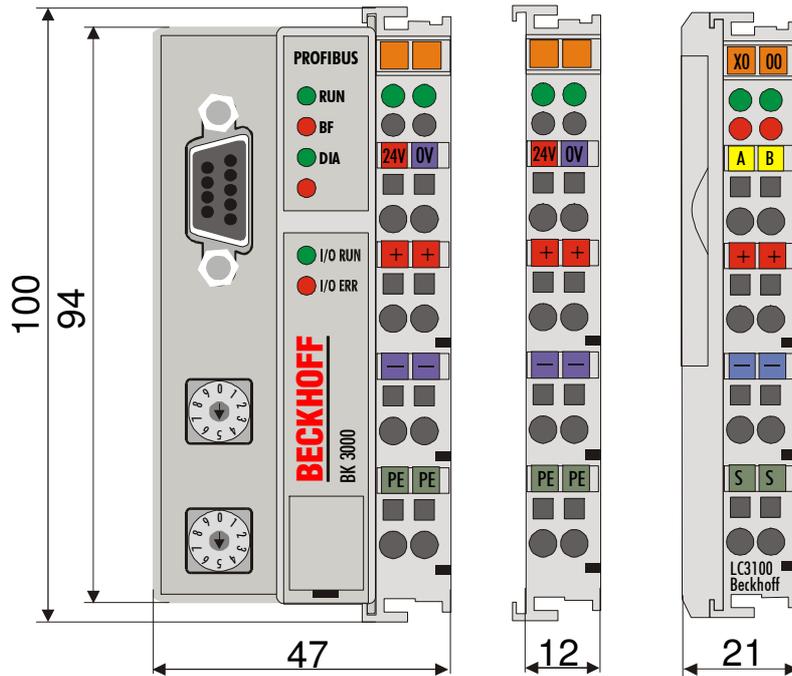


The bus coupler reports the error to the master by means of the Profibus diagnostics. Clearing the error returns the bus coupler to its normal operating mode.

## Mechanical construction

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. The LC3100 has a width of 21 mm and the terminals then follow, as on the coupler. 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).

### *Maximum number of terminals*

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 Profibus couplers differ by virtue of their capacity levels and maximum baud rates. The BK30xx variants are capable of supporting up to 1.5 Mbaud and the LC3100 and BK31xx series support up to 12 Mbaud. The electrical data specific to the fieldbus is given in this chapter. The following data distinguishes between a standard and an economy variant (BK3x00 and BK3x10) and an low cost variant (LC3100). Compatibility with the Profibus is guaranteed in any case. Contrary to the standard bus coupler, the economy variant is limited of the number of I/O's. Thus, there is no possibility of connecting inputs and outputs other than digital ones. The following table lists an overview of all data:

Technical Data	BK3000	BK3010	BK3100	BK3110	BK3500	LC3100
Supply voltage	24 V DC					
Input current	70mA + (total K bus current)/4, 500 mA max.	80mA + (total K bus current)/4, 200 mA max.	70mA + (total K bus current)/4, 500 mA max.	80mA + (total K bus current)/4, 200 mA max.	80mA + (total K bus current)/4, 500 mA max.	60mA + (total K bus current)/4, 200 mA max.
Power-on surge	2.5 x steady operating current					
K bus supply current up to	1750 mA max.	500 mA max.	1750 mA max.	500 mA max.	1750 mA max.	500 mA max.
Configuration facility	via KS2000 or the controller					
Number of bus terminals	64					
Digital peripheral signals	256 inputs/outputs					
Analogue peripheral signals	128 inputs/outputs	---	128 inputs/outputs	---	128 inputs/outputs	---
Peripheral bytes	244 bytes I / 244 bytes O	32 bytes I / 32 bytes O	64 bytes I / 64 bytes O DP only 128 bytes I / 128 bytes O	32 bytes I / 32 bytes O	128 bytes I / 128 bytes O	32 bytes I / 32 bytes O
Baud rate	1.5 Mbaud	1.5 Mbaud	12 Mbaud	12 Mbaud	1.5 Mbaud	12 Mbaud
Protocol	DP FMS	DP DPV1	DP FMS	DP DPV1	DP DPV1	DP DPV1
Bus connection	D-sub 9-pin	D-sub 9-pin	D-sub 9-pin	D-sub 9-pin	2 x HP Simplex plug	Directly to the spring-loaded terminals
Voltage of the power contact	24 V DC / AC max.					
Power contacts current drawn	10 A max.					
Electric strength	500 V <sub>eff</sub> (power contact / supply voltage / fieldbus) none					
Typical weight	170 g	150 g	170 g	150 g	170 g	75 g
Operating temperature	0 °C ... +55 °C					
Storage temperature	-20 °C ... +85 °C					
Relative humidity	95% without dew formation					
Vibration/shock stability	according to IEC 68-2-6 / IEC 68-2-27					
EMC immunity/transmission	according to EN 50082 (ESD, burst) / EN 50081					
Installation location	arbitrary					
Protection class	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  
interface*

*and* 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.

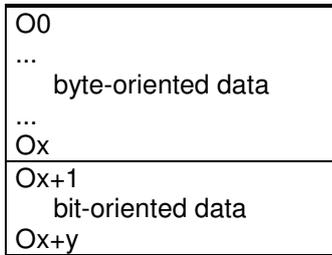
*Default assignment of inputs and outputs to the process image* When the bus coupler is first switched on it determines the number of attached bus terminals and sets up a list of assignments. This list distinguishes between analog channels and digital channels and between input and output; which are 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

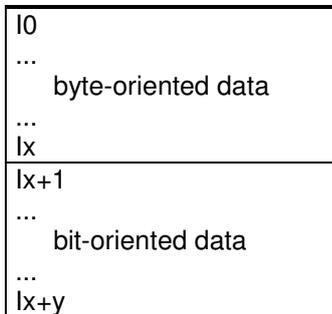
Analog inputs/outputs are representative of other complex multi-byte signal bus terminals (RS232, SSI sensor interface, ...)

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

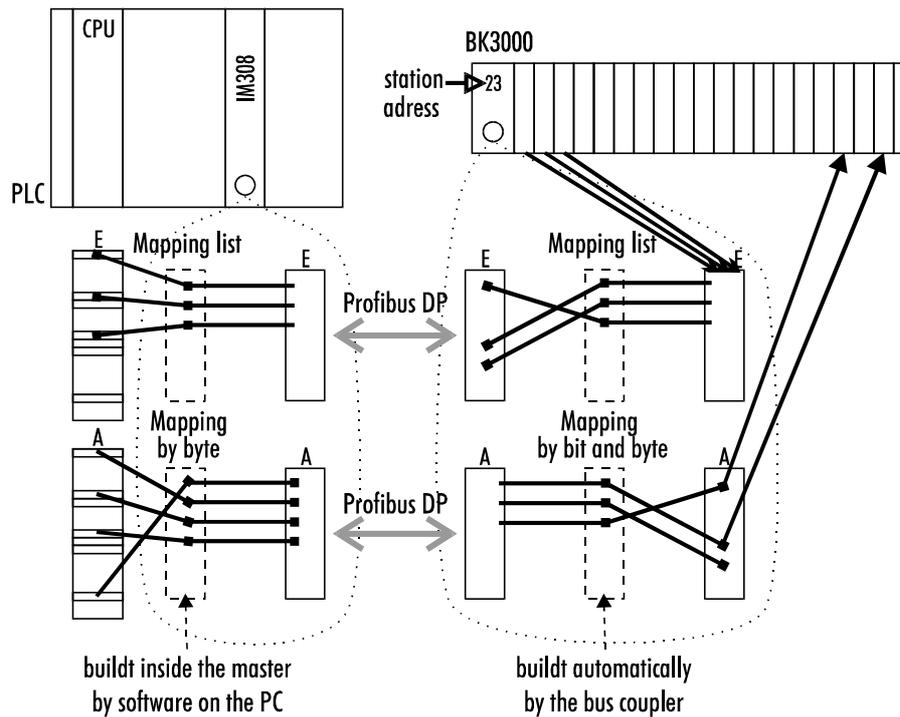
*Output data in the bus coupler*



*Input data in the bus coupler*



The path from the I/Os to the PROFIBUS process image



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

### *Installation guidelines*

The "PROFIBUS Nutzerorganisation e.V." technical guidelines must be followed when installing and laying the lead.

PROFIBUS-DP/FMS assembly guidelines

[www.profibus.com](http://www.profibus.com)

After switching on, the bus coupler immediately checks the connected configuration. Error-free start-up is signalled by extinction of the red LED "I/O ERR". If the "I/O ERR" LED blinks, an error in the area of the terminals is indicated. The error code can be determined from the frequency and number of blinks. This permits rapid rectification of the error.

### *The diagnostic LEDs*

The bus coupler has two groups of LEDs for the display of status. The upper group with four LEDs indicates the status of the respective field bus. The significance of the "field bus status" LED is explained in the relevant sections of this manual - it conforms to conventional field bus displays.

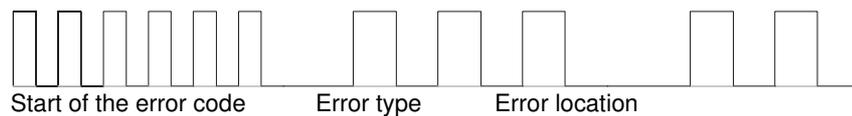
On the upper right hand side of the bus couplers are two more green LEDs that indicate the supply voltage. The left hand LED indicates the 24 V supply of the bus coupler. The right hand LED signals the supply to the power contacts.

### *Local errors*

Two LEDs, the "I/O" LEDs, in the area below the field bus status LEDs referred to above, serve to indicate the operating status of the bus terminals and the connections to these terminals. The green LED lights up in order to indicate fault-free operation. The red LED blinks with two different frequencies in order to indicate an error. The error is encoded in the blinks as follows:

### *Code of flashes*

<b>Rapid flashing</b>	Start of the error code
<b>First slow sequence</b>	Type of error
<b>Second slow sequence</b>	Location of error



### Start PLC

## Terminal bus error

Error code	Error code argument	Description	Remedy
Persistent, continuous blinking		EMC problems	<ul style="list-style-type: none"> <li>- Check power supply for overvoltage or undervoltage peaks</li> <li>- Implement EMC measures</li> <li>- If a K-bus error is present, it can be localised by a restart of the coupler (by switching it off and then on again)</li> </ul>
1 pulse	0	EEPROM checksum error	- Set manufacturer's setting with the KS2000
	1	Inline code buffer overflow	- Connect fewer terminals; too many entries in the table for the programmed configuration
	2	Unknown data type	- Software update required for the coupler
2 pulses	0	Programmed configuration Incorrect table entry / bus coupler	- Check programmed configuration for correctness
	n (n > 0)	Incorrect table comparison (terminal n)	- Incorrect table entry / bus coupler
3 pulses	0	Terminal bus command error	<ul style="list-style-type: none"> <li>- No terminal connected; attach terminals.</li> <li>- 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.</li> </ul>
4 pulses	0	Terminal bus data error	- Check whether the n+1 terminal is correctly connected; replace if necessary.
	n	Break behind terminal n (0: coupler)0 n	- Check whether the end terminal 9010 is connected.
5 pulses	n	Terminal bus error with register communication with terminal n	Replace terminal n.
7 pulses (BK3010, BK3110, LC3100 only)	n	Analogue terminal inserted n <sup>th</sup> terminal is an analogue terminal	Remove n <sup>th</sup> terminal and switch the coupler off and then on again.

## Profibus configuration data errors: BK3000/BK3100

I/O-Err			Remedy
6 pulses	0	Not enough DP-Cfg data received.	Check DP configuration.
	n (n>0)	Faulty DP-Cfg data byte.	
8 pulses	0	Not enough User-Prm data received	Check DP user parameters.
	n (n>0)	Faulty User-Prm data byte	

## Profibus configuration data errors: BK3010/BK3110/BK3500

DIA			Remedy
1 pulse	0	Not enough DP-Cfg data received.	Check DP configuration.
	n (n>0)	Faulty DP-Cfg data byte.	
2 pulses	0	Not enough User-Prm data received	Check DP user parameters.
	n (n>0)	Faulty User-Prm data byte	

Profibus configuration data error  
LC3100 only

BF		
1 pulse	0	Not enough DP-Cfg data received
	n (n>0)	Faulty DP-Cfg data byte
2 pulses	0	Not enough User-Prm data received
	n (n>0)	Faulty User-Prm data byte

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.

The fieldbus status LEDs indicate the current operating mode of the fieldbus. The functions of the Profibus are shown by the LEDs "RUN", "BF" and "DIA"; the fourth LED has no significance.



Note

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, because the Profibus initiates a new data exchange on the K bus each time it accesses the bus coupler, which means that the fieldbus has to access the bus coupler.

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 exchange 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 DP data transfer (Diag remains set).

## Remedial measures for fieldbus errors

### Fieldbus errors

The fieldbus status LEDs indicate the operational state of the fieldbus. The functions of the Profibus are indicated by the "I/O-RUN" and "BF" LEDs in the BK3000 and BK3100, and by the "I/O-RUN", "BF" and "DIA" LEDs in the BK3010, BK3110 and BK3500.

### Fieldbus errors in the BK3000/BK3100

I/O-RUN	BF	Meaning	Remedy
on	off	Operating state: RUN Inputs are read and outputs are set.	Everything is operating correctly
on	on	1. Bus activity, but slave is not yet parameterised 2. Bus error in which the outputs a.) become 0 b.) remain unchanged	- Start master - Check bus cable - Check parameters (-> Diagnostics data) - Check configuration (-> Diagnostics data)
off	off	1. Terminal bus cycles synchronised DP-watchdog switched off, no exchange of data 2. Reaction to Clear_Data Master in Clear_Mode, reaction of the terminal bus is stopped	PLC is in STOP mode
off	on	1. No bus activity 2. Bus error with reaction Terminal bus cycles are stopped	- Start master - Check bus cable - Check parameters (-> Diagnostics data) - Check configuration (-> Diagnostics data)

### Fieldbus errors in the BK3010/BK3110/BK3500

I/O-RUN	BF	DIA	Meaning	Remedy
on	off	off	Operating state: RUN Inputs are read and outputs are set.	Everything is operating correctly
on	on	off, blinking	1. Bus activity, but slave is not yet parameterised 2. Bus error in which the outputs a.) become 0 b.) remain unchanged	- Start master - Check parameters (-> Diagnostics data, DIA-LED) - Check configuration (-> Diagnostics data, DIA-LED)
off	off	off	Terminal bus cycles synchronised DP-watchdog switched off, no exchange of data	PLC is in STOP mode
off	on	on	No bus activity	- Start master - Check bus cable
off	on	off, blinking	Bus error, reaction Terminal bus cycles are stopped	- Start master - Check parameters (-> Diagnostics data, DIA-LED) - Check configuration (-> Diagnostics data, DIA-LED)

### Fieldbus errors in the LC3100

I/O-RUN	BF	RUN	Meaning	Remedy
on	off	on	Operating state: RUN Inputs are read and outputs are set.	Everything is operating correctly
on	on	on, blinking	1. Bus activity, but slave is not yet parameterised 2. Bus error in which the outputs a.) become 0 b.) remain unchanged	- Start master - Check parameters (-> Diagnostics data, BF-LED) - Check configuration (-> Diagnostics data, BF-LED)
off	off	on	Terminal bus cycles synchronised DP-watchdog switched off, no exchange of data	PLC is in STOP mode
off	on	off, blinking	No bus activity	- Start master - Check bus cable
off	on	on	Bus error, reaction Terminal bus cycles are stopped	- Start master - Check parameters (-> Diagnostics data, BF-LED) - Check configuration (-> Diagnostics data, BF-LED)

### 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 master, transfer through the Profibus and transfer from the bus coupler to the outputs. This applies analogously to the return distance.

#### Controller / Master

Please refer to the data provided by the master 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  $t_{DP}$  on the Profibus is composed of the following. The constants A, B and  $T_{BYTE}$  depend on the baud rate.

$$T_{DP} = \text{Constant A} + (\text{Constant B} + (\text{Number of E/A-Byte} \times T_{BYTE})) \quad [\text{Slave 1}]$$

$$+ (\text{Constant B} + (\text{Number of E/A-Byte} \times T_{BYTE})) \quad [\text{Slave 2}]$$

$$+ (\text{Constant B} + (\text{Number of E/A-Byte} \times T_{BYTE})) \quad [\text{Slave 3}]$$

$$+ \dots \quad [\text{Slave } ]$$

$$+ (\text{Constant B} + (\text{Number of E/A-Byte} \times T_{BYTE})) \quad [\text{Slave n}]$$

Baud rate	Constant A (in ms)	Constant B (in ms)	$T_{BYTE}$ (in ms)
9,6 kBaud	64,5	25,6	1,15
19,2 kBaud	32,3	12,8	0,573
93,75 kBaud	6,6	2,62	0,118
187,5 kBaud	3,3	1,31	0,059
500 kBaud	1,6	0,49	0,022
1,5 MBaud	0,67	0,164	0,00733
3 MBaud	0,436	0,085	0,00367
6 MBaud	0,27	0,044	0,00183
12 MBaud	0,191	0,024	0,00092



Pay attention to the special restrictions when using an ET200U or S5-95U in one system. In certain circumstances, cycle times may be clearly prolonged and more than 1.5 Mbaud is not possible.

*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

# PROFIBUS coupler BK3xx0 in the PROFIBUS DP

## Introducing the system

The PROFIBUS enjoys a very wide acceptance in automation technology due to its openness and its wide manufacturer-independent distribution. The PROFIBUS was developed in the course of a group project on the fieldbus concept which aimed at agreeing on a standard. Numerous different products are now available from independent manufacturers which all conform to the standard DIN 19245 parts 1 and 2. Standards-conform PROFIBUS devices can be operated on any bus system.

PROFIBUS specifies the technical and functional characteristics of a serial fieldbus system which can be used to network distributed digital and analog field automation devices with low range (sensor/actuator level) to midrange performance (cell level). PROFIBUS makes a distinction between master and slave devices; master devices are those which govern the data traffic on the bus.

A master may send messages without an external request, provided it has the authority to access the bus. The PROFIBUS protocol also describes masters as "active subscribers".

Slave devices are peripheral devices. Typical slave devices are sensors, actors, signal transformers and the Beckhoff bus couplers BK3000, BK3100, BK3110 and BK3010. They are not given authority to access the bus, so they may only acknowledge the messages they receive, or pass messages to a master when requested to do so. Slaves are also described as "passive subscribers". Beckhoff bus couplers are passive subscribers which support PROFIBUS DP and PROFIBUS FMS. They are also described as "FMS/DP combislaves".

## PROFIBUS DP

PROFIBUS DP is designed for rapid data exchange at sensor/actor level, where centralized control devices (such as stored program control units) communicate with decentralized input and output devices by means of a fast serial connection. The exchange of data with these decentralized devices is carried out predominantly cyclically. The centralized control unit (master) reads the input data from the slaves and writes the output data to the slaves, whereby the cycle time of the bus needs to be shorter than the program cycle time of the central control unit, which will be under 10 ms in many applications.

Rapid data throughput alone is not sufficient for the successful implementation of bus system. Ease of handling, good diagnostic facilities and fault-proof data transfer technology must all be provided in order to fulfill the users' requirements. The characteristics have been optimally combined in PROFIBUS DP.

At a transfer rate of 1.5 Mbit/s (BK3000 and BK3010) PROFIBUS DP will take 6 ms to transfer 512 bits of input data and 512 bits of output data distributed to 32 subscribers, and at 12 Mbit/s (BK3100 and BK3110) less than 2 ms. This fulfills the requirement for a fast system response time.

*System configurations and device types* You can use PROFIBUS DP to implement mono-master or multi-master systems, which gives you a high degree of flexibility as regards the system configuration. Up to 126 miscellaneous devices (master or slaves) can be attached to one bus. The bus couplers BK3xx0 permit you to select a

station address between 0 and 99. The quantities specified in the system configuration include the number of stations, the assignments of station addresses to I/O addresses, the consistency of the I/O data, the format to be used for diagnostic messages and bus parameters that are to be used. Each PROFIBUS DP system is made up of a number of different types of device. We distinguish three types, depending on the tasks involved:

DP master class 1 (DPM1), for example such as a FC3101

This is a central control unit which exchanges information with the decentralized stations (DP slaves) in a fixed message cycle. Typical devices include stored program control units (SPS), numeric control units (CNC) or robot control units (RC).

DP master class 2 (DPM2)

Devices of this type are programming, planning or diagnostic devices. They are used to configure the DP system when the equipment is set up and taken into service.

DP slave, such as the Profibus coupler BK3000

A DP slave is a peripheral device (sensor/actor), which reads in input information and passes output information to the peripherals. Devices which only input information, or only output information, are also possible. Typical DP slaves are devices with binary I/O ports for 24V or 230V, analog inputs, analog outputs, counters etc.. The volume of input and output information depends on the individual device, up to a maximum of 244 bytes for input data and 244 bytes for output data. Due to cost factors, and for technical and implementational reasons, many of the currently available devices operate with a maximum data length of 32 bytes. The Profibus coupler BK3000 can use the full length of 244 bytes, although the master unit IM308-C restricts this to 52 bytes for input data. The IM308-B enables you to use up to 122 bytes of input data.

In a mono-master system, only one master is active on the bus during the operating phase of the bus system. The SPS control unit is the central control element. The DP slaves are coupled to the SPS control unit decentrally by means of the transfer medium. This system configuration achieves the shortest bus cycle time.

In multi-master operation there are a number of masters on a single bus. These either constitute independent subsystems, each consisting of one DPM1 and the corresponding DP slaves or additional planning and diagnostic devices. All the DP masters can read the input and output mappings of the DP slaves. Although the output can be written by only one DP master (namely the DPM1 which was appointed when the system was specified). Multi-master systems achieve an average bus cycle time. If timing is critical to your application you should connect up a diagnostic tool to monitor increases in the bus cycle time.

*Device master file (GSD)*

The manufacturers of PROFIBUS DP provide users with documentation covering the performance characteristics of the devices, in the form of a device data sheet and a device master data file. The layout, content and coding of this device master data (the GSD) are standardized. It facilitates convenient project planning with any desired DP slaves using planning devices from a variety of manufacturers. The PNO archives this information for all manufacturers and will supply information on request about manufacturers' device master files.

A PROFIBUS master configuration program reads the DMF data and transfers the appropriate settings to the master. You will find a description of this in the relevant software manual supplied by the manufacturer of your master.

*Type file (200)*

One of the most common and most user-friendly master units for an SPS is Siemens' IM308-C. The Windows software COMWIN is available for configuring the master. The task of configuring this master unit for the PROFIBUS is supported by the manufacturers' documentation which describes the performance characteristics of the slave devices. This is supplied to users in the form of a type file. The same applies to the IM308-B, although the software COMET200.COM provides a more modest operating environment. The layout, content and coding of the type file are Siemens-specific and are supported by Beckhoff, as by other manufacturers. This file facilitates convenient project planning for any desired DP slaves on a PC under the graphical user interface Windows 3.1. The PNO does not yet support all of this information, but will supply information on request about manufacturers' type files. Type files and bitmaps are available for Beckhoff Profibus couplers.

Contact the mailbox 0 52 46 / 96 3 - 45 5, AREA 15 or via Internet ([www.beckhoff.com](http://www.beckhoff.com) or [ftp.beckhoff.com](ftp://ftp.beckhoff.com)).

to download the type file or to order it on a diskette. The name of the file for the IM308-B is "BK3000TE.200", and the file for the IM308-C is called "BK3000AE.200". If you use German versions of COMET200.COM and WINCOM.COM you should download the files "BK3000TD.200" and "BK3000AD.200" respectively.

*Diagnostic functions*

The extensive diagnostic functions of PROFIBUS DP make it possible to localize errors rapidly. The diagnostic messages are transferred via the bus and collated by the master. They are subdivided into three levels:

Diagnostic type	
<b>Station-related</b>	Messages dealing with the general operating condition of a subscriber, such as overheating or low voltage
<b>Module-related</b>	These messages indicate a diagnostic message is pending for a subscriber within a particular I/O sub-area (e.g. 8-bit output module)
<b>Channel-related</b>	This locates the cause of the error in an individual input/ output bit (channel), such as: short circuit on output 2

The bus couplers BK3xx0 support the diagnostic functions of the PROFIBUS DP. The manner in which the control unit evaluates the diagnostic data depends on what support is given by the master. Please refer to the device manual of your master units to see how to handle the diagnostics. (Note for ET200U experts: the diagnostics is device-specific, as for the ET200U; a module in the bus terminal enables you to evaluate the diagnostics for a specific station and track it right down to an individual channel in the bus terminal.)

*Sync and Freeze Mode*

In addition to the subscriber-related user data traffic, which DPM1 deals with automatically, the DP master can also send control commands to an individual DP slave, to a group, or to all of the slaves simultaneously; these control commands are transferred as multicast functions. You can use such control commands to impose the operating modes Sync and Freeze to synchronize the DP slaves. This facility provides for an event-driven synchronization of the slaves. They enter Sync mode when they receive a Sync control command from their appointed DP master. In this operating mode, the outputs from all the DP slaves are frozen in their current state. If user data is subsequently transferred, the output data is stored at the DP slaves, although the output status values remain unchanged. When the next Sync control command is received from the master, the stored output

data is switched through to the outputs. The user can terminate Sync operation by issuing an Unsync control command.

Similarly, a Freeze control command sends the addressed DP slaves into Freeze mode. In this operating mode, the inputs of all the DP slaves are frozen in their current state. The input data is not updated again until the DP master sends the next Freeze control command to the relevant devices. You terminate Freeze operation by issuing an Unfreeze control command.

*System behavior*

To ensure that the devices are largely exchangeable, the system behavior for the PROFIBUS DP has also been standardized. It depends principally on the operating mode of the DPM1, which can be governed either locally or from the planning device via the bus. The following principal modes are distinguished:

Operating modes	
<b>Stop</b>	No data is transferred between the DPM1 and the DP slaves. The bus coupler addresses the bus terminals only once after the power supply has been turned on and then no more (none of the I/O LEDs is lit)
<b>Clear</b>	The DPM1 reads input information from the DP slaves and maintains the outputs to the DP slaves in a secure state (the outputs are set to logical zero, none of the I/O LEDs is lit)
<b>Operate</b>	The DPM1 is in the data transfer phase. Data is transferred cyclically: inputs are read from the DP slaves and output information is sent to them (the green I/O LED is lit).

The DPM1 uses a multicast command to broadcast its local status cyclically at regular intervals to all its subordinate DP slaves (the interval can be configured). The system's response to an error (such as the failure of a DP slave) which occurs during the data transfer phase of the DPM1 is determined by the operating parameter "Auto Clear". If this parameter has been set to "True", then, as soon as any one DP slave ceases to be ready to transfer user data, the DPM1 will switch the outputs of all its subordinate DP slaves to a stable state and then enter Clear mode. If the parameter is set to "False", then the DPM1 will remain in Operate mode even in an error situation and the user can govern the system response himself.

*Data traffic between DPM1 and the DP slaves*

The DPM1 automatically deals with data traffic between itself and its subordinate DP slaves in a fixed and continually repeating order. During the planning phase of the bus system, the user specifies which DP slaves belong to which DPM1, which DP slaves should be included in the cyclic transfer of user data, and which should be excluded from it.

The data traffic between the DPM1 and the DP slaves can be subdivided into three phases: parametrization, configuration and data transfer. Before it admits a DP slave to the data transfer phase, the DPM1 checks – in the phases parametrization and configuration – whether the intended configuration from the original plan agrees with the actual device configuration. This check covers the device type, the format and length information and the number of inputs and outputs, all of which must agree. This gives the user reliable protection against parameter errors. In addition to transferring user data, which the DPM1 carries out automatically, it is also possible, at the user's request, to transmit new parameters to the DP slaves.

*Protective mechanisms* In the field of decentralized peripherals, security considerations make it imperative that systems should be equipped with highly effective protective functions to prevent incorrect parametrization or a failure of the communications equipment. On both the DP master and the DP slaves, PROFIBUS DP uses monitoring mechanisms which are implemented as timeout monitors. The monitoring interval is specified when the DP system is planned.

#### **On the DP master**

The DPM1 uses the Data\_Control\_Timer to monitor the transfer of user data to and from the DP slaves. A separate monitoring timer is used for each of the subordinate DP slaves. If a monitoring interval elapses without any data being transferred, the monitor will report a timeout. The user will be informed if this occurs. If automatic error response has been specified (Auto\_Clear = True), the DPM1 will leave Operate mode, switch the outputs of its DP slaves to a secure state and go into Clear mode.

#### **On the DP slave**

Each DP slave maintains a response monitor to enable it to recognize errors in the DP master or the transfer route. If a response monitoring interval elapses without any data being exchanged with the superordinate DP master, the DP slave will independently switch its outputs to the secure state. In the case of a multi-master system additional security is necessary to restrict access to the inputs and outputs of the DP slaves and to ensure that direct accesses are made only by the authorized master. The DP slaves therefore provide the other DP masters with a mapping of their inputs and outputs which can be read by any DP master, even without authority.

#### *Identity number*

Each DP slave and each DPM1 must have an individual identity number so that a DP master can recognize the types of the attached devices without entailing a significant protocol overhead. The master compares the identity numbers of the attached DP devices with the identity numbers in the planning data specified by the DPM2. No user data will be transferred unless the correct device types have been attached to the bus with the correct station addresses. This ensures that the system is protected from planning errors.

Beckhoff PROFIBUS couplers, like all DP slaves and DPM1s, possess an identity number allocated by the PNO. The PNO administers these identity numbers together with the device master data and identity numbers are also given in the type files. (The identity number of the bus couplers is BECF (BK3000, BK3010) and BECE (BK3100, BK 3110).

## The transfer medium: plugs and cables

*Physics of the transmission* The physical data transfer is defined in the PROFIBUS standard. See PROFIBUS layer 1 (physical layer).

The sphere of operation of a fieldbus system is substantially determined by the selected transfer medium and the physical bus interface. Besides the requirements of data transfer security, the necessary expenditure for procuring and installing the bus cable is of crucial significance. The PROFIBUS standard therefore provides for various forms of communications technology while maintaining its standard bus protocol.

Cable transfer: this version, which conforms to the US standard EIA RS-485, has been specified as the basic version for applications in the field of production technology, building management technology and drive technology. It uses a single twisted-pair copper cable. Shielding may be unnecessary, depending on the planned application (take electromagnetic compatibility aspects into consideration).

*Channel-related disturbances*

Two cable types with different maximum cable lengths are available. See table entitled "RS485". The pin assignments on the connector and the wiring are shown in the figure. Please pay attention to the special requirements for the data cable at board rates in excess of 1.5 MBaud. The right cable is a basic requirement for disturbance-free operation of the bus system. When using the "normal" 1.5 Mbaud cable, astonishing phenomena may occur as the result of reflections and excessive attenuation. This may consist of the following: any one station is without a connection and it resumes the connection when the neighbouring station is extracted. Or, data transfer errors may occur when a certain bit pattern is transferred. This means that the Profibus operates without disturbance but without functioning of the system and randomly reports bus errors after start up. The error behaviour described is eliminated by reducing the baud rate (< 93.75 kBaud).

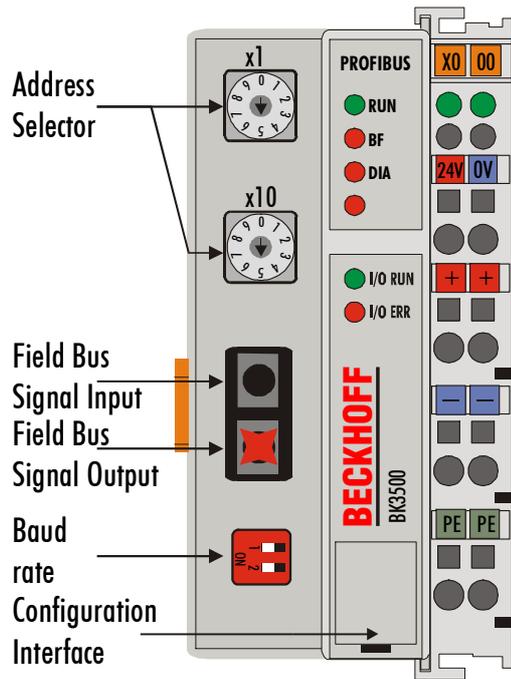
If reducing the baud rate does not remedy the problem, this is frequently due to a wiring error. Either the two data lines have been swapped on one or several connectors or the terminators are not on or are activated in the wrong place.

*BK3500 Profibus coupler with fiber optic conductor*

Fiber optic conductor: the Profibus User group elaborated the specification of a transmission technology based on fiber optic conductors for applications in highly interference-prone environments and also to increase the range.

Using the Beckhoff Profibus bus couplers with fiber optic interface (BK3500) the realization of optical Profibus networks with ring technology (optical one fiber with plastic fiber conductor) is possible. As the head of a Profibus fiber optic ring a Coordinator (e.g. OZD Profi from Hirschmann) is required. The maximum amount of stations in a Profibus fiber optic ring depends on the baud rate. With 1.5 MBaud a maximum of 10 Stations in one ring are allowed. Between two stations a minimal and maximal fiber optic conductor length has to be observed (1 - 25 m). The baud rate can be adjusted via DIP switches on the BK3500. Additional information can be found in the following table.

*BK3500*



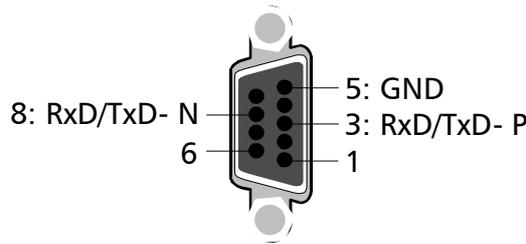
*Profibus fiber optic net Characteristics*

Characteristics	
<b>Topology</b>	Subring
<b>max. amount of stations</b>	93,75 kBaud: 13            187,5 kBaud: 12 500 kBaud: 12            1500 kBaud : 10
<b>min./max.length between two stations</b>	Coordinator – Station: Lmin = 1 m, Lmax = 34 m Station – Station: Lmin = 1 m, Lmax = 25 m Station – Coordinator: Lmin = 0 m, Lmax = 46 m
<b>Bus connector</b>	2 x HP Simplex connector (included)
	APF (plastic)- fiber conductor (Z1101)
<b>Baud rate</b>	93,75; 187,5; 500; 1500 kBaud
<b>Switch position</b>	S1=0,S2=0; S1=0,S2=1; S1=1,S2=0; S1=1,S2=1

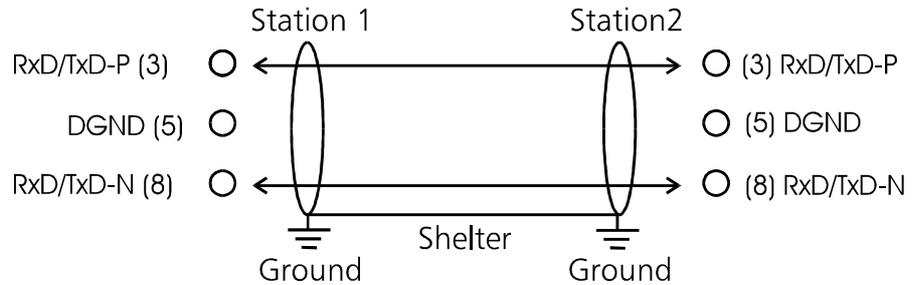
*RS485 Fundamental characteristics*

RS-485 Data transfer technology to the Profibus standard	
<b>Network topology</b>	Linear bus, active bus terminator at both ends, branch lines are possible
<b>Medium</b>	Shielded twisted cable, shielding may be dispensed with in suitable environments (electromagnetic compatibility)
<b>Number of stations</b>	32 stations in each segment without repeaters, extendible to 127 with repeaters
<b>Max. bus length without repeaters</b>	100 m at 12 Mbit/s 200 m at 1500 Kbit/s, up to 1.2 km at 93.75 Kbit/s
<b>with repeaters</b>	Using repeaters (line amplifiers) increases the max. bus length to the order of 10 km. The number of possible repeaters is at least 3 and may be up to 10, depending on the manufacturer
<b>Transfer rates</b>	9.6, 19.2, 93.75, 187.5, 500, 1500 Kbit/s, up to 12 Mbit/s in discrete steps
<b>Plug</b>	9-Pin D-Sub plug

Pin assignments of the D-Sub socket



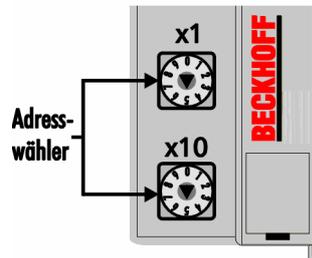
Cables for PROFIBUS DP and PROFIBUS FMS



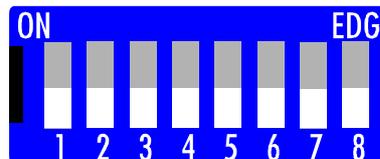
Setting the station Addresses

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 BK3xxxit must be reset (by briefing interrupting the power supply or by means of a software reset).

Address selector



Address selector LC3100



The address of the coupler can be set by means of DIP switches 1 – 6. Switch 1 here is the least significant bit,  $2^0$ , and switch 6 is the most significant bit,  $2^6$ . When the switch is ON the bit is set. The address can be set in the range from 0 to 127 (e.g. node ID = 14 -> switch 2, 3, 4 to ON), but the address 0 is not allowed. DIP switch 8 has no function.

In systems which contain more than two stations, all the subscribers are connected in parallel. The bus cable must always be terminated at the ends of the lines, to prevent reflections and the transmission problems they cause.

In order to loop the cable through without any gaps it is necessary to affix two cables within one plug. Siemens' SINEC L2 bus connections are very suitable for this. These SINEC plugs are constructed to accommodate two bus cables with the corresponding wire terminals and shielding. At the end of the line you can use a small switch in the plug to activate the terminating resistor. Please observe the manufacturer's assembly instructions.

You should also note that the terminating resistor requires a 5 V power supply for optimal operation. This means that if the plug is removed from the bus coupler, or the power supply of the bus coupler fails, the level at the terminating resistor will vary, which may affect the data transfer.

## Configuring the master

As explained above, the Profibus coupler sets up a data area containing the input and output bytes. The assignments between the channels of the bus terminals and the bits and bytes of the process image are carried out by the bus coupler.

The Profibus master exchanges a coherent input and output data block with each Profibus coupler. The correlation between the bytes in this data block and the addresses of the process image is carried out by the master. In the case of the IM308-C SPS master, this parametrization is supported by the software COMWIN, and for the IM308-B by the software COMET200. For other masters you should use the corresponding tools provided by the manufacturer (see also the chapters Device master file and Type file).

*Support files for configuring the master*

Master / Software	Coupler	File
<b>General for all Profibus masters</b>	BK3XX0	BUSKLEMN.BMP BUSKLEMS.BMP
<b>General for all Profibus masters</b>	BK3000 BK3010 BK3100 BK3110 BK3500 LC3100	BK30BECF.GSD BK3010.GSD BK31BECE.GSD BK3110.GSD BK3500.GSD BK3110.GSD
<b>COM PROFIBUS and COM Profibus Windows software / TYPDAT5X</b>	BK3000 BK3010 BK3100 BK3110 BK3500 LC3100	BK3000AD.200 BK3010AD.200 BK3100AD.200 BK3110AD.200 BK3500AD.200 BK3110AD.200
<b>IM308-B COMET200</b>	BK3000 BK3010 BK3100 BK3110 BK3500 LC3100	BK3000TD.200 BK3010AD.200 BK3100AD.200 BK3110AD.200 BK3500AD.200 BK3110AD.200

## Quick start

When the coupler is started up, all the terminals are written into the process image. The coupler then proceeds in accordance with the following rules: first all the terminals with byte-oriented operation, then all the bit-oriented terminals.

Byte oriented bus terminals	Bit oriented bus terminals
KL1501	KL10XX, KL11XX, KL12XX, KL17XX
KL2502	KL20XX, KL21XX, KL22XX, KL26XX KL27XX
KL3XXX	
KL4XXX	
KL5XXX	
KL6XXX	
	KL9110, KL9160, KL9210, KL9260

All the byte oriented bus terminals must first be entered into the configuration in the sequence in which they are plugged in. No distinction is made here between input terminals and output terminals. The bit-oriented bus terminals come next. These are always rounded up to one byte, so that, for instance, 6 digital terminals with two channels (which therefore comprise 12 bits) are represented by two bytes, the extra 4 bits being filled with zeroes. The GSD file contains the 8/16/32... digital inputs and/or outputs for the bit-oriented terminals.

For the byte oriented bus terminals, only the initial identification plus placeholders is given (e.g. KL3XXX) rather than the full terminal name. All of these terminals are equal in the size of their process images. After this, the number of channels can be specified. This is useful if it is desired to assign different addresses in the PLC to the terminal channels.

16In            only user data  
 24In/8Out    user data with control and status (only in the KL3XXX)  
 8In/24Out    user data with control and status (only in the KL4XXX)  
 24In/24Out   complete process image

The Appendix contains more detailed information.

## S5 Example

	Kennung	Bestellnummer	Kommentar	E-Adr.	A-Adr.
0	178	KL3xxx 1 Kanal 24In/24Out		P000	P000
1	178	KL3xxx 1 Kanal 24In/24Out		P004	P004
2	2AA	KL4xx2 2 Kanäle 16Out			P008
3	16DE	16 Bit Digitale Inputs		P007	
4	8DA	8 Bit Digitale Outputs			P012
5					
6					
7					
8					
9					
10					
11					
12					
13					

*Example for Master IM308, connection for Simatik S5 PLC*

The window illustrates the configuration of an IM308-C with a BK3000 slave and with station number 3. Bus terminals:

8 x KL1002,  
 4 x KL2012,  
 1 x KL3002 and  
 1 x KL4002

are connected to the BK3000 bus coupler. The arrangement of the bus terminals next to the bus coupler is not significant for the assignment of identifications to digital inputs and outputs. It is only the width, in bits, of the bus terminals in the K bus, and therefore in the process image, that matters. For the byte-oriented bus terminals the sequence always starts in the sequence as seen from the left. The listing of the byte-oriented bus terminals is followed by that of the bit-oriented digital bus terminals. The analogue bus terminals can be identified as two individual inputs or as double channel.

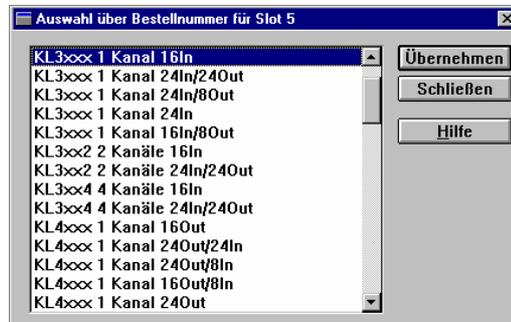
If the composition shown above is extended with a KL3002:

8 x KL1002,  
 4 x KL2012,  
 1 x KL3002 and  
 1 x KL4002  
 1 x KL3002 (additional)

the extension must be inserted into the list at the second location. The entries for the digital terminals are pushed correspondingly downwards.

All the inserted terminals have to be configured. Unused inputs and outputs can be omitted from the address assignment in order to save address space in the PLC.

“Double-clicking” on a field in the “Order number” column will cause a menu to appear for the selection of the desired identification for the corresponding inserted terminal.



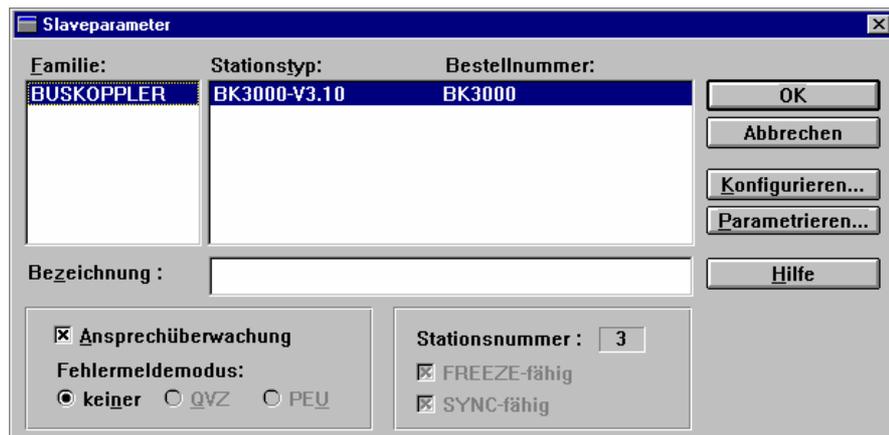
The analogue channels provide an opportunity of inserting another byte in addition to the 16 bits of user data. This byte is a control/status byte that controls access to a 64-byte register set. This register can for example be used to switch a thermocouple from type K to type S. The data word containing the user data always takes the form of an IN/OUT word if the control/status byte is used. Allocation of input and output addresses is necessary to enable access to the registers.

	Kennung	Bestellnummer	Kommentar	E-Adr.	A-Adr.
0	178	KL3xxx 1 Kanal 24In/24Out		P000	P000
1	178	KL3xxx 1 Kanal 24In/24Out		P004	P004
2	2AE	KL3xx2 2 Kanäle 16In		P010	
3	2AA	KL4xx2 2 Kanäle 16Out			P008
4	16DE	16 Bit Digitale Inputs		P007	
5	8DA	8 Bit Digitale Outputs			P012
6					
7					
8					
9					
10					
11					
12					
13					

The possible identifications are precisely described in the appendix and in the descriptions of the particular terminals.

*Ensuring data consistency*

The consistency of the data related to a station is secured by the Profibus transmission protocol. Consistency over the whole process image is achieved by activating the “SYNC” and “FREEZE” operating modes in the masters.



The FREEZE and SYNC capabilities are pre-set in the slave parameters, (see figure), and can not be switched off. FREEZE and SYNC are controlled by the controller software.

Switching on the communication monitoring ensures that, in the event of the failure of a particular station, the master will generate an error message, allowing the control software to initiate exception handling routines. Communication monitoring can be individually selected for each station. The communication monitoring is switched on as default setting. The COM PROFIBUS software issues a warning if the monitoring is switched off.

The asynchronous access of the control CPU (usually a PLC) to the PROFIBUS master's data area can give rise to inconsistencies. The configuration of a "multiple byte signal" and module consistency in the COM PROFIBUS configuration software for the IM308-C automatically ensures data consistency. Please refer to explanations in the manuals from the appropriate manufacturers for further master interfaces.

Common PLC connection types are the IM308-B and IM 308-C as Profibus DP master and the CP5431 as DP and FMS master.

Detailed information regarding the IM308-B is contained in the ET200 Distributed Peripheral System Manual, order no.: 6ES5 895-6SE11 from Siemens in relation to data exchange with the Siemens S5. The manual explains the use of the ET200COM software. Rules for ensuring consistency are described in Appendix B, "Access to the Distributed Peripherals".

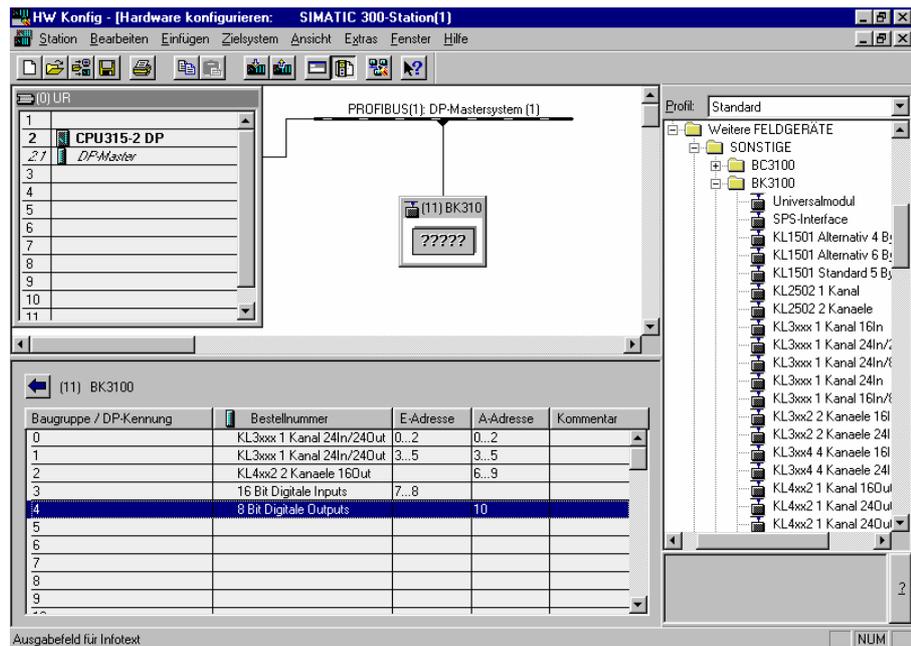
A Windows program, COM PROFIBUS, and extensive descriptions are available for the IM308-C Profibus DP master interface. For work with the Siemens S5, the IM308-C has the advantage of improved handling and the possibility of freely allocating the peripheral address bytes. Versions 2.1 and higher are particularly convenient. With them it is possible to read an extended type file. The settings required to ensure data consistency are automatically made by the entries in the type file. (The figures on the previous pages are taken from the COM PROFIBUS software.)

### S7 Example

*Insert GSD*

The hardware configuration tool is started in order to insert a Beckhoff slave into the controller. A new GSD file can be installed via the menu item 'Extras'. The directory or drive in which the new GSD file is located is selected. When the installation has been completed, the new slave is found in the catalogue under “More field devices” / “Other”.

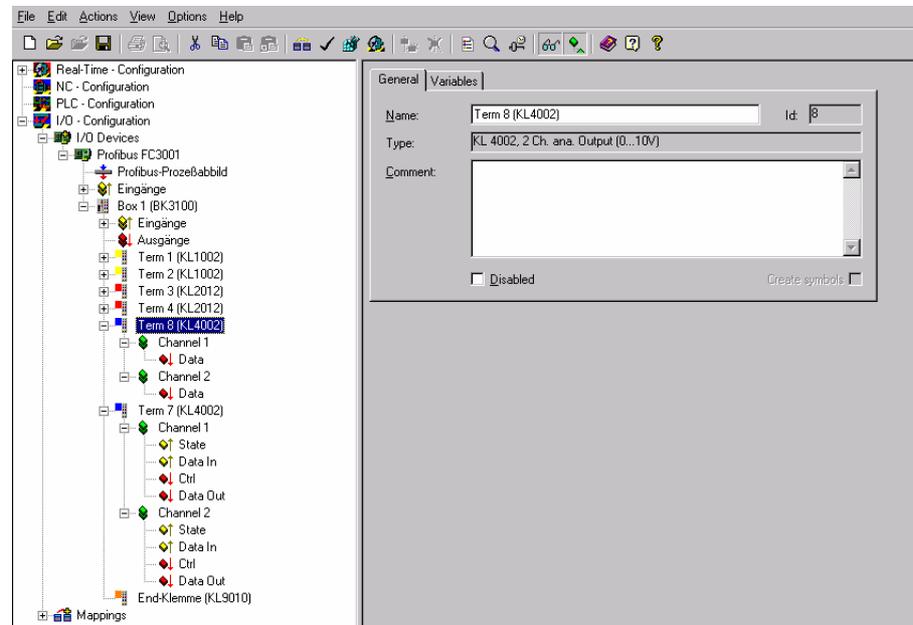
A Profibus network must exist before the new slave can be inserted. The rest of the procedure corresponds to that described above under “Quick start”.



If the data is more than 4 bytes long, the SFC14 / SFC15 blocks are needed with an S7 controller if the data is to be consistently read or written. The data can neither be read or written, nor can it be directly be observed or forced without these blocks. In the S7-300 it is only possible to start at even addresses, while in the S7-400 the start addresses must be divisible by 4.

### TwinCAT Example

In TwinCAT the terminals are entered in precisely the same sequence in which the terminals are physically plugged together. For analogue terminals there is a difference between “Complex” and “Compact”. “Complex” refers to complete mapping of the terminal, while “Compact” refers only to user data.



# Appendix

## Example: 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 (this example is related to the standard bus coupler; no analogue terminals can be configured for the Economy and LowCost couplers):

*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	%QB0, %QB1	POS11
2, 3	none	%QB2, %QB3	POS11
4, 5	none	%QB4, %QB5	POS12
6, 7,	none	%QB6, %QB7	POS12
8, 9	none	%QB8, %QB9	POS20
10, 11	none	%QB10, %QB11	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	%QB12	POS07
12	1	%QB12	POS07
12	2	%QB12	POS08
12	3	%QB12	POS08
12	4	%QB12	POS09
12	5	%QB12	POS09
12	6	%QB12	POS18
12	7	%QB12	POS18
13	0	%QB13	POS19
13	1	%QB13	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	%IB0, %IB1	POS10
2, 3	none	%IB2, %IB3	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	%IB4	POS02
4	1	%IB4	POS02
4	2	%IB4	POS03
4	3	%IB4	POS03
4	4	%IB4	POS04
4	5	%IB4	POS04
4	6	%IB4	POS05
4	7	%IB4	POS05
5	0	%IB5	POS06
5	1	%IB5	POS06
5	2	%IB5	POS15
5	3	%IB5	POS15
5	4	%IB5	POS16
5	5	%IB5	POS16
5	6	%IB5	POS17
5	7	%IB5	POS17

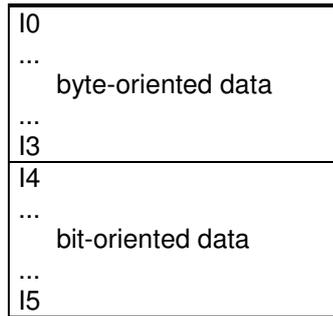
The items POS14 and POS21 are not relevant to data exchange and do not appear in the list. If a byte is not fully used, for example A13, the bus coupler pads its remaining bits with zeroes.

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

Output data in the bus coupler

O0
...
byte-oriented data
...
O11
O12
bit-oriented data
O13

*Input data  
in the bus coupler*



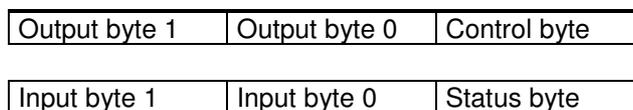
The base addresses I0 and O0 listed here are used as relative addresses or addresses in the bus coupler. If you have an appropriate superordinate Profibus system you can use the bus master to enter these addresses at any desired position in the process image of the control unit. You can use the configuration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



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

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

Register set of an analog channel

63			
47			
31			
	15		User area
16	0		
	OFF	SET	
	GA	IN	Factory settings
		Software version	Type
0	Length	Type	Secondary process image

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.

## PROFIBUS DP

### Parameterisation telegram

The Set\_Prm service can be used to transfer not only the parameterisation described in the DP standard, but also manufacturer-specific operating parameters (User\_Prm\_Data). These are characterised by the fact that they are transmitted once as the connection from the master to the slave is established. Usually the settable operating parameters can be displayed textually by the DP master's configuration tool by reading in the bus coupler's GSD file. The following operating parameters can be set using the User\_Prm\_Data:

#### *Terminal bus settings*

If an error occurs on the terminal bus during operation, the bus coupler can make cyclical attempts to recommence operation of the terminal bus (reaction to terminal bus error: automatic reset) or can remain in an error state until terminal bus operation is re-started with the KS2000 configuration software by way of the 2 byte PLC interface or by way of the DPV1 service (reaction to terminal bus error: manual reset).

The complex terminals indicate through an error bit (bit 6) in the status byte whether they have detected an error. The bus coupler can be parameterised in such a way that it sends a message to the DP master in the DP diagnostic data (Ext\_Diag\_Data) if this error bit changes (terminal bus diagnostics).

The digital output terminals with diagnostics can send the diagnostic bits in the input data to the DP master cyclically (digital terminal diagnostic data in the process image), or they can send it only by means of a message in the external diagnostic data (digital terminal diagnostic data not in the process image). The latter case however requires the terminal bus diagnostics to be switched on so that the digital terminal diagnostic bits appear in the DP diagnostic data.

New complex terminals (since the middle of 1998) support the BK200 mode, which makes the terminal cycle time about 1/3 shorter.

The terminal bus settings are found in byte 7 of the User\_Prm\_Data (the default settings are printed bold):

Bit no.	Description	is supported by
Bit 0	Reaction to terminal bus error <b>0: manual reset</b> 1: automatic reset	All BK3xx0 / LC3100
Bit 1	Terminal bus diagnostics <b>0: is not executed</b> 1: is executed	All BK3xx0 / LC3100
Bit 4	Digital terminal diagnostic data <b>0: in the process image</b> 1: not in the process image	BK3x10 / BK3500 / LC3100
Bit 6	BK200 mode <b>0: is not active</b> 1: is active	BK3500

#### *Process image settings*

Complex terminal data can be represented in either INTEL or MOTOROLA format, although controllers generally expect the data to be in MOTOROLA format.

In addition to automatic configuration, in which the terminals appear in the output and/or input data in the sequence in which they are mechanically inserted (first analogue then digital), a "programmed configuration" can also be loaded by the KS2000 configuration software, in which the

sequence of the terminals in the output or input data can be freely programmed.

The terminal bus cycle can be started cyclically (updating of the process image: free running) or synchronously with reception of the DP Data\_Exchange telegram (updating of the process image: synchronous with the cycle).

The reaction to a PROFIBUS error (the plug is pulled out, the DP master enters STOP, etc.) can be set. The possible reactions are that the terminal bus is stopped, the outputs are set to 0 or that the old outputs are sent onto the terminal bus.

It is also possible to set a reaction to a terminal bus error. The possible reactions are abortion of the DP data exchange, setting the inputs to 0 or sending the old inputs onto the PROFIBUS.

The terminal bus settings are found in bytes 9 and 10 of the User\_Prm\_Data (the default settings are printed bold):

Bit no.	Description	is supported by
Byte 9 Bit 1	Configuration type 0: Programmed configuration <b>1: Auto-configuration</b>	BK3000 / BK3100
Byte 9 Bit 3	Auto-configuration data format 0: INTEL <b>1: MOTOROLA</b>	BK3000 / BK3100 / BK3500
Byte 9 Bit 6	Updating of the process image 0: synchronous with cycle <b>1: free running</b>	BK3100/BK3x10/BK3500/LC3100
Byte 10 Bit 0/1	Reaction to PROFIBUS error <b>0: K bus cycle stopped</b> 1: K bus outputs set to 0 2: K bus outputs remain unchanged	All BK3xx0 / LC3100
Byte 10 Bit 2/3	Reaction to terminal bus error <b>0: Data exchange is aborted</b> 1: DP inputs set to 0 2: DP inputs remain unchanged	All BK3xx0 / LC3100

*2 byte PLC interface/  
2 byte diagnostic interface*

Registers in the complex terminals and bus coupler registers can both be read or written using the 2 byte PLC interface. The complex terminal registers are described in the associated terminal documentation. The bus coupler registers can be used, for example, to read terminal bus diagnostics data, the terminal composition or the cycle times, and the programmed configuration can be written. It is also possible for a manual terminal bus reset to be carried out. The 2 byte PLC interface needs 2 bytes both in the output data and in the input data, and a special protocol is used with them (the two bytes are always located at the start of the output or input data). A description of the 2 byte PLC interface, the registers available in the bus couplers and of function blocks for various PLCs that implement the 2 byte PLC interface can be supplied on request.

The terminal's error messages can also be sent via the 2 byte diagnostic interface as an alternative to transmission with the DP diagnostic data. Terminal bus diagnostics must however be activated for this purpose. The 2 byte diagnostic interface occupies two bytes in the output data and two in the input data, and a protocol is used with them (the two bytes are always located at the start of the output or input data behind the 2 byte PLC interface (if that is switched on)). A description of the 2 byte-diagnostic interface can be supplied on request.

The settings for the 2 byte PLC and 2 byte diagnostic interface are located in byte 5 of the User\_Prm\_Data (the default settings are printed bold):

Bit no.	Description	is supported by
<b>Bit 0</b>	PLC interface <b>0: is not used</b> 1: is used	All BK3xx0 / LC3100
<b>Bit 1</b>	Event channel <b>0: DP diagnostics</b> 1: diagnostic interface	BK3x10 / BK3500 / LC3100

*Max. diagnostic data length* Since not all DP masters can support the maximum diagnostic data length of 64 that is possible with a bus coupler, this can be adjusted. The settings for the maximum diagnostic data length are located in byte 11 of the User\_Parameter\_Data (the default settings are printed bold):

Bit no.	Description	is supported by
<b>Byte 11</b>	Diagnostic data length <b>16, 24, 32, 40, 48, 56, 64</b>	All BK3xx0 / LC3100

*Synchronous input update* If the updating of the process image is set to be synchronous with the cycles, the terminal bus cycles is started after receipt of the Data\_Exchange telegram. The outputs are then fully current, but since the inputs are read with the same terminal bus cycle, they can be out of date by the time of the next transmission to the DP master, if the PROFIBUS cycle time is significantly greater than the terminal bus cycle. For this reason it is possible to shift the time of the terminal bus cycle after receipt of the Data\_Exchange telegram. It is also possible, if the PROFIBUS cycle time is more than twice as long as the terminal bus cycle time, for there to be two terminal bus cycles. The first cycle is started immediately after receipt of the Data\_Exchange telegram, (synchronous output), and the second cycle is started at a specified time (delay time) after the first cycle (synchronous input).

The settings for synchronous input update are located in byte 12 of the User\_Prm\_Data (the default settings are printed bold), the delay time being in bytes 13 and 14:

Bit no.	Description	is supported by
<b>Byte 12</b> <b>Bit 0/1</b>	Synchronous input update <b>0: not active</b> 1: one terminal bus cycle 2: two terminal bus cycles	BK3x10 / BK3500 / LC3100
<b>Bytes 13/14</b>	Delay time for synchronous input update (in 8 microsecond units)	BK3x10 / BK3500 / LC3100

*Start-up mode* In order to be able to parameterise the complex terminals at start-up using the 2 byte PLC interface or with the DPV1 services, the bus coupler can be switched into parameter mode at start-up, which means that after the DP start-up is successfully completed, terminal bus cycles can still not be carried out. After parameterisation of the complex terminals the coupler must also be transferred into process data mode by means of the 2 byte PLC interface, or by making use of the DPV1 services. After this the bus coupler executes terminal bus cycles again. This makes it possible to program the DP master in such a way that, during a DP (re-)start, the appropriate registers for the complex terminals are transmitted via the 2 byte PLC interface or the DPV1 services before it switches the bus coupler into process data mode. A terminal can thus be changed at any time, without having to consider the correct register settings.

In parameter mode a distinction is made as to whether the bus coupler must signal to the DP master that it is ready for data exchange (necessary if the parameterisation is to take place by means of the 2 byte PLC interface) or whether it should send static diagnostics to the DP master.

The settings for start-up mode are located in byte 3 of the User\_Prm\_Data (the default settings are printed bold):

Bit no.	Description	is supported by
<b>Bit 0/1</b>	Start-up mode <b>0: Process data exchange</b> 1: Parameter mode 2: Parameter mode with Stat_Diag	BK3500

### DPV1 settings

More details regarding the DPV1 services will be given in a later chapter (DPV1). In order, however, to be able to use the DPV1 services with the DP master that is also executing the cyclical data exchange (class 1 master), DPV1 functionality must be switched on.

A new diagnostics format is also described in the DPV1 standard that can be activated in place of the diagnostic formats used formerly. The structure of the diagnostic data for both formats is described in detail in a later chapter (Diagnostics).

The DPV1 settings are located in bytes 0-2 of the User\_Prm\_Data (the default settings are printed bold):

Bit no.	Description	is supported by
<b>Byte 0</b> <b>Bit 7</b>	DPV1 service (class 1) <b>0: are not supported</b> 1: are supported	BK3x10 / BK3500 / LC3100
<b>Byte 2</b> <b>Bit 3</b>	Diagnostic format <b>0: old format</b> 1: DPV1 format	BK3x10 / BK3500 / LC3100

### Multi-Master Operation

It is possible with the DPV1 services to access the terminals acyclically. In order to avoid access conflict with the cyclical data exchange, a decision can be made for each terminal as to whether it can be accessed by means of the cyclical data exchange or acyclically via the DPV1 services.

The assignments of the terminals are located in bytes 15-31 of the User\_Prm\_Data (the default settings are printed bold):

Bit no.	Description	is supported by
<b>Byte 15</b> <b>Bit 0/1</b>	Assignment for terminal 1 <b>0: DP data exchange</b> 1: acyclical DPV1 services	BK3x10 / BK3500 / LC3100
<b>Byte 15</b> <b>Bit 2/3</b>	Assignment for terminal 2 <b>0: DP data exchange</b> 1: acyclical DPV1 services	BK3x10 / BK3500 / LC3100
...	Assignment for terminal i <b>0: DP data exchange</b> 1: acyclical DPV1 services	BK3x10 / BK3500 / LC3100
<b>Byte 31</b> <b>Bits 6/7</b>	Assignment for terminal 64 <b>0: DP data exchange</b> 1: acyclical DPV1 services	BK3x10 / BK3500 / LC3100

If no User\_Prm\_Data are transmitted, the bus couplers adopt the most recently programmed value. If the bus coupler does not support any particular setting, then the default value is set at the coupler.

## Configuration telegram

The configuration data to be transferred with the Chk\_Cfg service determines which process data is exchanged with the Data\_Exchange service.

Bit 1 from byte 9 of the User\_Prm\_Data is used to decide whether auto-configuration or programmed configuration is expected (see parameterisation).

If bit 0 from byte 5 of the User\_Prm\_Data is set, the first code in the configuration data indicates that the 2 byte PLC interface is switched on, otherwise this code is omitted:

Code	Description
0xB1	2 byte PLC interface

### 2 byte diagnostic interface

If bit 1 from byte 5 of the User\_Prm\_Data is set, the next code in the configuration data indicates that the 2 byte diagnostic interface is switched on, otherwise this code is omitted:

Code	Description
0xB1	2 byte diagnostic interface

### Digital terminals

## Auto-configuration

The data for all the digital input and output terminals is collected into a byte array for inputs and a byte array for outputs in the sequence of the sockets. The following codes can be used for digital data:

Code	Description
0x1n	(n+1) bytes digital inputs
0x2n	(n+1) bytes digital outputs
0x3n	(n+1) bytes digital inputs and outputs

These codes can be used freely, so that the total of the input and/or output bytes corresponds in each case to the existing data length for digital inputs and outputs (rounded up to the next byte).

Since the digital data is transferred after all the analogue data, the digital codes are to be defined after all the analogue codes.

### Analogue terminals

8 bits of control and/or status data are available as well as the user data to each channel in the analogue terminals. These terminals are classified as intelligent terminals, and support register communication (8 bit control/status data, 16 bits I/O data per channel). A specific coding in the control/status data determines whether the first 16 bits of the user data are to be interpreted as I/O data for the register communication.

A code is first to be defined for each analogue terminal, where the sequence depends on the socket positions.

The DP configuration data for the various terminals looks like this:

Terminal	DP configuration data
<b>KL3xx2, KL3351</b>	1 channel 16 bits in (compact): 0x50 (must be used twice for each terminal) 1 channel 24 bits in/out (complete): 0xB2 (must be used twice for each terminal) 1 channel 24 bits in / 8 bits out (user data, status and control): 0xC0,0x00,0x82 (must be used twice for each terminal) 1 channel 24 bits in (user data, status): 0x40,0x82 (must be used twice for each terminal) 1 channel 16 bits in / 8 bits out (user data, control): 0xC0,0x00,0x81 (must be used twice for each terminal) 2 channels 16 bits in (compact): 0x51 (must only be used once for each terminal) 2 channels 24 bits in/out (complete): 0xB5 (must only be used once for each terminal)
<b>KL3xx4</b>	1 channel 16 bits in (compact): 0x50 (must be used four times for each terminal) 1 channel 24 bits in/out (complete): 0xB2 (must be used four times for each terminal) 1 channel 24 bits in / 8 bits out (user data, status and control): 0xC0,0x00,0x82 (must be used four times for each terminal) 1 channel 24 bits in (user data, status): 0x40,0x82 (must be used four times for each terminal) 1 channel 16 bits in / 8 bits out (user data, control): 0xC0,0x00,0x81 (must be used four times for each terminal) 4 channels 16 bits in (compact): 0x53 (must only be used once for each terminal) 4 channels 24 bits in/out (complete): 0xBB (must only be used once for each terminal)
<b>KL4xx2</b>	1 channel 16 bits out (compact): 0x60 (must be used twice for each terminal) 1 channel 24 bits in/out (complete): 0xB2 (must be used twice for each terminal) 1 channel 24 bits in / 8 bits out (user data, status and control): 0xC0,0x82,0x00 (must be used twice for each terminal) 1 channel 16 bits out / 8 bits in (user data, status): 0xC0,0x81,0x00 (must be used twice for each terminal) 1 channel 24 bits out (user data, control): 0x80,0x82 (must be used twice for each terminal) 2 channels 16 bits out (compact): 0x61 (must only be used once for each terminal) 2 channels 24 bits in/out (complete): 0xB5 (must only be used once for each terminal)
<b>KL4xx4</b>	1 channel 16 bits out (compact): 0x60 (must be used four times for each terminal) 1 channel 24 bits in/out (complete): 0xB2 (must be used four times for each terminal) 1 channel 24 bits in / 8 bits out (user data, status and control): 0xC0,0x82,0x00 (must be used four times for each terminal) 1 channel 16 bits out / 8 bits in (user data, status): 0xC0,0x81,0x00 (must be used four times for each terminal) 1 channel 24 bits out (user data, control): 0x80,0x82 (must be used four times for each terminal) 2 channels 16 bits out (compact): 0x63 (must only be used once for each terminal) 2 channels 24 bits in/out (complete): 0xBB (must only be used once for each terminal)

Terminal	DP configuration data
KL1501	Standard format: 0xB4 Alternative format (compact): 0xB3 Alternative format (complete): 0xB5
KL2502, KL5302	1 channel: 0xB2 (must be used twice for each terminal) 2 channels: 0xB5 (must only be used once for each terminal)
KL5001	Standard 32 bits in (compact): 0x93 Standard 40 bits in/out (complete): 0xB4 Standard 40 bits in/ 8 bits out (user data, status, control): 0xC0,0x00,0x84 Standard 40 bits in (user data, status): 0x40,0x84 Standard 32 bits in, 8 bit out (user data, control): 0xC0,0x00,0x83 Alternative compact: 0x93 Alternative complete: 0xB5
KL5051, KL5101, KL5111	0xB5
KL6001, KL6011, KL6021	Standard 2 bytes (control and 1 data byte): 0xB1 Standard 3 bytes (control and 2 data bytes): 0xB2 Standard 4 bytes (control and 3 data bytes): 0xB3 Standard 5 bytes (control and 4 data bytes): 0xB4 Standard 6 bytes (control and 5 data bytes): 0xB5 Alternative compact: 0xB3 Alternative complete: 0xB5
KL6051	4 bytes (compact): 0xB3 6 bytes (complete): 0xB5

### Programmed configuration (only BK3000 and BK3100)

You can use the configurator to place the terminals as desired into the local process image, and this image is then transferred by the Data\_Exchange service.

The DP configuration data of the programmed configuration is located in table 70 of the bus coupler:

Table 70	Description
Register 0	Length of the DP configuration data (n, in the range 1-64)
Register 1-n	DP configuration data

This configuration data is also expected for the Chk\_Cfg service and any other configuration data will be rejected.

### Diagnostics

The diagnostic data is automatically reported to the DP master by the bus coupler whenever it changes. The meaning of the first 6 bytes is the same for all DP slaves, after which device-specific diagnostic data follows. The structure for a bus coupler is specified according to the setting of "Old format / DPV1 format".

Usually the DP master has the ability to interrogate a flag in the PLC to determine whether diagnostic data has changed. The diagnostic data itself can then in most cases be read by means of a function block. In the S5 the diagnostic data is read with the FB IM308C function block, and in the S7

with the SFC13 and in TwinCAT it is read with the ADSREAD FB. The maximum length of the diagnostic data can be altered through User\_Prm\_Data (byte 11). If there is more diagnostic data available than can be sent, this is itself indicated in the diagnostic data.

*DPV1 format*

If the DPV1 diagnostic format is set in User\_Prm\_Data (byte 2, bit 3 = 1), the diagnostic data appears as follows (this is only supported by the BK3x10 / BK3500 / LC3100):

Byte no.; bit no.	Description
<b>Byte 0</b>	Bit 0: slave does not answer (is set internally by the DP master) Bit 1: slave is starting up (parameterisation and configuration are being evaluated) Bit 2: configuration error Bit 3: Ext_Diag_Data available (from byte 6) Bit 4: function not supported Bit 5: incorrect answer from slave (is set internally by the DP master) Bit 6: parameterisation error Bit 7: slave is exchanging data with another master (is set internally by the DP master)
<b>Byte 1</b>	Bit 0: slave must be parameterised again Bit 1: slave has static diagnostics Bit 2: 1 Bit 3: DP watchdog is active Bit 4: slave is in freeze mode Bit 5: slave is in sync mode Bit 6: reserved Bit 7: slave is deactivated (is set internally by the DP master)
<b>Byte 2</b>	Bit 0-6: reserved Bit 7: too much Ext_Diag_Data
<b>Byte 3</b>	Station address of the master with which data is being exchanged
<b>Byte 4,5</b>	Ident number
<b>Manufacturer-specific diagnostics</b>	
<b>Byte 6</b>	Length of the Ext_Diag_Data, including length byte
<b>Byte 7</b>	0x81
<b>Byte 8</b>	0x00
<b>Byte 9</b>	0x00
<b>Byte 10</b>	Bit 0: error reading EEPROM Bit 1: buffer for inline code is too small Bit 2: error when checking the programmed configuration Bit 3: error reading the terminal types on the terminal bus Bit 4: terminal not supported Bit 5: too much configuration data Bit 6: too much output data Bit 7: too much input data
<b>Byte 11</b>	Bit 0: too many K bus command errors Bit 1: too many K bus timeouts Bit 2: too many K bus receive errors Bit 3: too many K bus transmit errors Bit 4: error in bus reset Bit 5: terminal bus error
<b>Byte 12</b>	Faulty test at K bus reset (0: no error)
<b>Byte 13</b>	First faulty terminal number at K bus reset (0: no error)
<b>Byte 14</b>	First faulty UserPrmData byte (0: no error)
<b>Byte 15</b>	First faulty CfgData byte (0: no error)
<b>Byte 16</b>	Bit 0-5: faulty terminal number (0-63) Bit 6-7: faulty channel number (0-3)
<b>Byte 17</b>	Channel status byte
<b>Byte 18</b>	Bit 0-5: faulty terminal number (0-63) Bit 6-7: faulty channel number (0-3)
<b>Byte 19</b>	Channel status byte
...	
<b>Byte 60</b>	Bit 0-5: faulty terminal number (0-63) Bit 6-7: faulty channel number (0-3)
<b>Byte 61</b>	Channel status byte

*Old format*

If the old diagnostic format is set in the User\_Prm\_Data (byte 2, bit 3 = 0), the diagnostic data has the following form (is supported by all BK3xx0 devices and the LC3100):

Byte no.; bit no.	Description
<b>Byte 0</b>	Bit 0: slave does not answer (is set internally by the DP master) Bit 1: slave is starting up (parameterisation and configuration are being evaluated) Bit 2: configuration error Bit 3: Ext_Diag_Data available (from byte 6) Bit 4: function not supported Bit 5: incorrect answer from slave (is set internally by the DP master) Bit 6: parameterisation error Bit 7: slave is exchanging data with another master (is set internally by the DP master)
<b>Byte 1</b>	Bit 0: slave must be parameterised again Bit 1: slave has static diagnostics Bit 2: 1 Bit 3: DP watchdog is active Bit 4: slave is in freeze mode Bit 5: slave is in sync mode Bit 6: reserved Bit 7: slave is deactivated (is set internally by the DP master)
<b>Byte 2</b>	Bit 0-6: reserved Bit 7: too much Ext_Diag_Data
<b>Byte 3</b>	Station address of the master with which data is being exchanged
<b>Byte 4,5</b>	Ident number
<b>Manufacturer-specific diagnostics</b>	
<b>Byte 6</b>	Length of the Ext_Diag_Data, including length byte
<b>Byte 7</b>	0 (reserved for extensions)
<b>Byte 8 – x:</b>	8 bytes per diagnostic message (x: 9,17,25,33,41,49,57)

*Diagnostic messages from the terminals* There is a diagnostic message for each terminal, which is laid out as follows:

Byte no.	Description
<b>Byte 0</b>	Terminal no. (1-64)
<b>Byte 1</b>	Channel no. (1-4)
<b>Byte 2</b>	reserved for expansions
<b>Byte 3</b>	reserved for expansions
<b>Byte 4</b>	reserved for expansions
<b>Byte 5</b>	Analogue terminals: Status byte of terminal Digital terminals: bit 1: short circuit channel 0 short circuit channel 1
<b>Byte 6</b>	reserved for expansions
<b>Byte 7</b>	reserved for expansions

*Diagnostic messages from the bus coupler* In addition to the diagnostic messages from the terminals, there are also two diagnostic messages from the bus coupler.

Byte no.	Description
<b>Byte 0</b>	0
<b>Byte 1</b>	0
<b>Byte 2</b>	Initialization error
<b>Byte 3</b>	Terminal bus error
<b>Byte 4</b>	Test of bus reset revealed errors
<b>Byte 5</b>	Incorrect terminal number on bus reset
<b>Byte 6</b>	Number of first terminal which is not supported
<b>Byte 7</b>	0

Byte no.	Description
Byte 0	0
Byte 1	255
Byte 2	UserPrmData error 0: no error 1: reserved 2: not enough UserPrmData 3: faulty byte or word in UserPrmData
Byte 3	first faulty byte in UserPrmData (0-63)
Byte 4	CfgData error 0: no error 1: not enough CfgData 2: CfgData byte faulty 3: reserved
Byte 5	First incorrect byte in CfgData (0 - 63)
Byte 6	0
Byte 7	0

Initialization errors	Description
Bit 0	Error on reading the EEPROM
Bit 1	Compile buffer is too small
Bit 2	Error on checking the programmed configuration
Bit 3	Error on reading out the terminal types on the terminal bus
Bit 4	Terminal is not supported
Bit 5	Too much configuration data
Bit 6	Too much output data (total output data of all terminals is too long)
Bit 7	Too much input data (total input data of all terminals is too long)

While there is an initialization error pending, the flag Stat\_Diag will be set in the fixed diagnostic data, with the effect that you will not be able to execute a process data cycle on the terminal bus.

Terminal bus errors	Description
Bit 0	Too many errors on sending a command on the terminal bus (slave detected an error on comparing the command with the inverted command)
Bit 1	Too many timeouts on command execution (slave did not acknowledge command execution)
Bit 2	Too many errors on receiving input data (master detected an error on comparing the input data with the inverted input data)
Bit 3	Too many errors on transmitting the output data (slave detected an error on comparing the output data with the inverted output data)
Bit 4	Error on bus reset
Bit 5	Terminal bus error
Bit 6-7	--

## DPV1 PROFIBUS

(BK3x10 / BK3500 / LC3100 only)

The DPV1 PROFIBUS specification includes a description of the acyclical read/write services. The acyclical read/write services can be used to transfer larger quantities of data than the maximum of 244 bytes of cyclical output or input data.

A distinction is drawn between the master with which data is also cyclically exchanged (the class 1 master) and other masters (class 2 masters).

The acyclical connection between the class 1 master and a slave is automatically established at the same time as the cyclical connection (parameterisation, configuration), provided the DPV1 services are activated in the User\_Prm\_Data (byte 0, bit 7 = 1).

The acyclical connection between a class 2 master and a slave is established by means of an initiate service. The connection is established as soon as the initiate service has successfully been completed.

Once established, read or write services can be used to address various data sets within the slave with the aid of a slot number and an index.

In the S7 the DPV1 services can be used with SFC58 (write) and SFC59 (read). Since the S7 master is a class 1 master, the DPV1 services must additionally be activated in the User\_Prm\_Data (byte 0, bit 7).

In TwinCAT a "Protnumber" can be set on the bus coupler ADS tab to use the DPV1 services with the transfer functions ADSRead and ADSWrite.

The possible values for the slot number and the index defined for the bus coupler are listed below.

DPV1-Read

Slot number	Index	Description
0	9	List of terminals 0 – 23 (table 9, register 0 – 23)
0	10	List of terminals 24 – 47 (table 9, register 24 – 47)
0	11	List of terminals 48 – 64 (table 9, register 48 – 64)
0	90	Terminal bus state register (table 90, register 0 – 20)
0	97	Error counter for synchronous input update (table 97, register 0)
0	98	Cycle time for cycle measurement (table 98, register 0-3) Word 0: minimum cycle time (in 8 microsecond units) Word 1: maximum cycle time (in 8 microsecond units) Word 2: current cycle time (in 8 microsecond units) Word 3: mean cycle time (in 8 microsecond units)
1	0-63	1 <sup>st</sup> complex terminal, channel 0, register 0 - 63
1	64-127	1 <sup>st</sup> complex terminal, channel 1, register 0 - 63
1	128-191	1 <sup>st</sup> complex terminal, channel 2, register 0 - 63
1	192-255	1 <sup>st</sup> complex terminal, channel 3, register 0 - 63
2	0-63	2 <sup>nd</sup> complex terminal, channel 0, register 0 - 63
...	...	...
64	192-255	64 <sup>th</sup> complex terminal, channel 3, register 0 – 63
65	0	1 <sup>st</sup> complex terminal, channel 0: output process data
65	1	1 <sup>st</sup> complex terminal, channel 1: output process data
65	2	1 <sup>st</sup> complex terminal, channel 2: output process data
65	3	1 <sup>st</sup> complex terminal, channel 3: output process data
65	4	1 <sup>st</sup> complex terminal, channel 0: input process data
65	5	1 <sup>st</sup> complex terminal, channel 1: input process data
65	6	1 <sup>st</sup> complex terminal, channel 2: input process data
65	7	1 <sup>st</sup> complex terminal, channel 3: input process data
66	0	2 <sup>nd</sup> complex terminal, channel 0: output process data
...	...	...
128	7	64 <sup>th</sup> complex terminal, channel 3: input process data
129	0	Output process data (bytes 0-15) of the digital terminals
129	1	Output process data (bytes 16-31) of the digital terminals
129	4	Input process data (bytes 0-15) of the digital terminals
129	5	Input process data (bytes 16-31) of the digital terminals

## DPV1-Write

Slot number	Index	Description
0	98	Cycle time for cycle measurement (table 98, register 0-3) Word 0: minimum cycle time (in 8 microsecond units) Word 1: maximum cycle time (in 8 microsecond units) Word 2: current cycle time (in 8 microsecond units) Word 3: mean cycle time (in 8 microsecond units)
0	99	Function table (table 99) Word 0: 0x0101 – change write protection Word 1: 0xAFFE – remove, otherwise: set Word 0: 0x0104 – set manufacturer's setting Word 1: irrelevant, but must be sent Word 0: 0x0105 – set start-up mode Word 1: 0x0000 – process data mode Word 1: 0x0001 – parameter mode Word 1: 0x0002 – parameter mode with Stat_Diag Word 0: 0x0201 – terminal bus reset Word 1: irrelevant, but must be sent Word 0: 0x0401 – cycle time measurement Word 1: 0x0000 – stop, otherwise - start
1	0-63	1 <sup>st</sup> complex terminal, channel 0, register 0 - 63
1	64-127	1 <sup>st</sup> complex terminal, channel 1, register 0 - 63
1	128-191	1 <sup>st</sup> complex terminal, channel 2, register 0 - 63
1	192-255	1 <sup>st</sup> complex terminal, channel 3, register 0 - 63
2	0-63	2 <sup>nd</sup> complex terminal, channel 0, register 0 - 63
...	...	...
64	192-255	64 <sup>th</sup> complex terminal, channel 3, register 0 – 63
65	0	1 <sup>st</sup> complex terminal, channel 0: output process data
65	1	1 <sup>st</sup> complex terminal, channel 1: output process data
65	2	1 <sup>st</sup> complex terminal, channel 2: output process data
65	3	1 <sup>st</sup> complex terminal, channel 3: output process data
66	0	2 <sup>nd</sup> complex terminal, channel 0: output process data
...	...	...
128	3	64 <sup>th</sup> complex terminal, channel 3: output process data
129	0	Bytes 0-15: output process data (bytes 0-15) of the digital terminals Bytes 16-31: mask (bytes 0-15, 1 means that the output will be affected)
129	1	Bytes 0-15: output process data (bytes 16-31) of the digital terminals Bytes 16-31: mask (bytes 16-31, 1 means that the output will be affected)

Max. DPV1 data length

The maximum DPV1 data length is 52 (including 4 bytes DPV1 header)

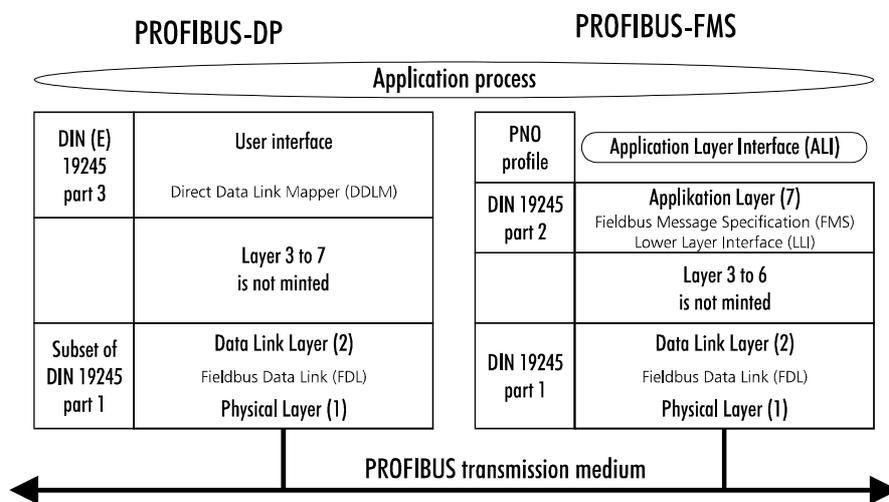
## Combined operation with PROFIBUS DP and PROFIBUS FMS

(only BK3000 and BK3100)

PROFIBUS is based on numerous recognized national and international standards. The protocol architecture follows the OSI (Open System Interconnection) reference model, which corresponds to the international standard ISO 7498. The architecture of PROFIBUS FMS and the PROFIBUS DP protocol is shown in the illustration "Protocol architecture of PROFIBUS FMS and PROFIBUS DP".

Both versions use the same protocol to access the bus (layer 2) and the same data transfer technology (layer 1).

Protocol architecture of PROFIBUS DP and PROFIBUS FMS



Layers 3 to 6 are not developed in PROFIBUS FMS. Those facilities of these layers that are necessary for this field of operation have been grouped together in the lower layer interface (LLI). The LLI is an element of layer 7.

The FMS (fieldbus message specification) includes the application protocol and provides a large number of powerful communication services. FMS is the interface to the application process. The FMS services are a subset of the MMS services (MMS, manufacturing message specification, ISO 9506) of the MAP protocol. The complex MMS services have been optimized to suit the requirements of fieldbus operations and supplemented by the addition of special functions for administering communications objects and network management functions.

Layers 3 to 7 are not developed in PROFIBUS DP. The application layer (7) is also omitted in order to achieve the necessary transfer rates. The Direct Data Link Mapper (DDLMM) provides the user interface with convenient access to layer 2. The application functions which are available to the user, the system behavior, and the behavior of the various PROFIBUS DP device types, are all specified in the user interface.

One particular advantage of PROFIBUS is the ability to operate the components PROFIBUS FMS and PROFIBUS DP together on a single bus. For applications which are content with an increased system response time, the combined operation of PROFIBUS FMS and PROFIBUS DP bus couplers on a single bus is both possible and advantageous. It is even possible to operate both versions of the protocol on a single bus coupler simultaneously. These devices are then described as a "combislave".

Using bus couplers as combislaves carries a number of advantages for the user:

It reduces the variety of different devices involved, because the identical device can be used flexibly, either for fast cyclic data transfer with PROFIBUS DP or with the more powerful PROFIBUS FMS services. For example, you can use the FMS services for parametrization when the installation is initially set up, when speed is not such a critical factor, and the fast DP functions for the cyclic transfer of user data in the operating phase of a controller. Such possible combinations offer manifold ways of utilizing these devices.

This combined operation is possible because both versions of the protocol use the same transfer and bus access procedures (layers 1/2). The various application functions are separated by the different service access points of layer 2. The bus coupler automatically recognizes the appropriate processing mode.

## PROFIBUS FMS

(only BK3000 and BK3100)

PROFIBUS FMS makes it possible for automation devices to communicate with one another and with the intelligent field devices. The available functionality is more important here than a fast system response time. Many applications carry out predominantly acyclic data exchanges in response to requests from the application process. Beckhoff bus couplers can operate both as DP slaves and FMS slaves.

### *PROFIBUS LAYER 7 (application layer)*

Layer 7 of the ISO/OSI reference model provides useful communication services for the user. These application services permit efficient and open data transfer between application processes. The PROFIBUS application layer is specified in DIN 19 245 part 2 and consists of:

- Fieldbus Message Specification (FMS) and
- Lower Layer Interface (LLI).

FMS describes the communications objects, application services and the resulting models from the point of view of the communications partner. The LLI is used to adapt the application functions to the manifold features of the PROFIBUS layer 2.

### *PROFIBUS communication model*

An application process includes all the programs, resources and tasks which do not belong to any of the communication layers. The PROFIBUS communication model makes it possible to use communication relationships to combine distributed application processes into one overall process.

That part of an application process in a field device which is accessible via communications is described as a virtual field device (VFD).

In the PROFIBUS communication model, the mapping of the functions of the VFD onto the actual device is carried out by the application layer interface (ALI).

### *Communications objects and object directory (OD)*

All the communications objects belonging to a PROFIBUS subscriber are recorded in his local object directory. For simple devices, the object directory may be predefined. For complex devices, the object directory is planned and loaded into the device locally or remotely. The OD contains descriptions, structures and data types, and also the correlation of the internal device addresses of the communications objects with their

identifier on the bus (index/name). The OD is made up as follows:

- Header (contains information about the structure of the OD).
- List of the static data types (list of the supported static data types)
- Static object directory (contains all the static communications objects)
- Dynamic list of variable lists (list of the currently known variable lists)
- Dynamic program list (list of the currently known programs)

The individual sections of the OD only have to be present if the device actually supports the corresponding functions.

Static communications objects are entered in the static object directory and may be predefined by the device manufacturer or be specified during the planning of the bus system. Communications in field applications uses principally static communications objects. PROFIBUS recognizes the following static communications objects:

- Simple Variable
- Array (series of simple variables of the same type)
- Record (series of simple variables of various types)
- Domain (data area)
- Event (a reported occurrence)

Dynamic communications objects are entered in the dynamic part of the OD (variable list directory / program invocation directory). They may be predefined and you can also use the application services to define, modify or delete them during the operating phase.

PROFIBUS supports the following dynamic communications objects:

- Program Invocation
- Variable List (series of simple variables, arrays or records)

Logical addressing is the preferred method for addressing communications objects in PROFIBUS. This accesses the communications objects by means of a short address, known as an index, which is a number of type Unsigned16. This permits efficient telegrams and reduces the protocol overhead. An index is specified in the OD for each of the communications objects of a device. All PROFIBUS subscribers must support logical addressing.

PROFIBUS FMS also permits the following optional addressing methods for particular applications:

Symbolic addressing using names: in this case the symbolic name of the communications object is transferred over the bus.

Physical addressing: here you can access any desired physical memory address in the field devices by using the services Physical Read and Physical Write.

Each communications object can (optionally) be protected from unauthorized access. You can permit access to an object only with a specific password, or restrict it to a particular device group. You can specify the password and device group in the object directory separately for each individual object, and you can make an entry in the object directory to restrict the services which may be used to access the object (e.g. read-only access).

*FMS for BK3xxx*

Connection monitoring can be set up when acyclical connections are established. The slave adapts to the setting desired by the master.

*Process data*

Various settings related to the FMS process image can be made in register 4 of table 0 in the bus coupler:

<b>Register 4 low</b>	Bit 0: 0 Bit 1: programmed configuration (0)/auto-configuration (1) Bit 2: 1 Bit 3: data format for analogue terminals: INTEL (0)/MOTOROLA(1) Bit 4,5: 0 Bit 6,7: 1
<b>Register 4 high</b>	Bit 0,1: reaction to fieldbus error / disconnection of all connections 0: process data operation on the terminal bus is stopped 1: outputs go to 0 2: outputs remain unchanged Bit 2,3: reaction to terminal bus error 0: error response OBJECT_INVALIDATED 1: inputs go to 0 2: inputs remain unchanged Bit 4-7: 0 (reserved for extensions)

*Auto-configuration**Digital terminals*

The data for all the digital input and output terminals is collected into a byte array for inputs and a byte array for outputs in the sequence of the sockets. All digital input and output terminals are collected into one aggregate object each. The offset of the data for a digital terminal is thus determined by its physical socket.

FMS object for the digital input terminals:

<b>Object index</b>	1000
<b>Data type</b>	Octet string
<b>Data length</b>	Sum of the data widths of all the input terminals (byte align)
<b>Access rights</b>	read only

*FMS object for the digital output terminals:*

<b>Object index</b>	1001
<b>Data type</b>	Octet string
<b>Data length</b>	Sum of the data widths of all the output terminals (byte align)
<b>Access rights</b>	read write

*Analogue terminals*

8 bits of control and/or status data are available as well as the user data to each channel in the analogue terminals. These terminals are classified as intelligent terminals, and support register communication (8 bit control/status data, 16 bits I/O data per channel). A specific coding in the control/status data determines whether the first 16 bits of the user data are to be interpreted as I/O data for the register communication.

Two FMS objects are defined for each channel, the index depending on the socket and the channel. The socket location only has reference to the analogue terminals, so that the analogue terminal that is nearest to the bus coupler is assigned socket number 0, the analogue terminal that comes next has socket number 1, and so on. The first object addresses all of the channel's output data (control byte plus user data). When DP data exchange is being carried out, the bus coupler answers a write access with the negative ACCESS\_DENIED response.

The second object addresses all of the channel's input data (status byte plus user data). This object can only be read.

8 bits control/status, n x 8 bits of data

<b>Object index</b>	2000 + socket * 20 + channel * 2
<b>Data type</b>	Array of (n+1) x Unsigned8
<b>Data length</b>	n + 1 bytes 0
<b>Access rights</b>	read write
<b>Description</b>	Channel output data

8 bits control/status, n x 16 bits of data

<b>Object index</b>	2000 + socket * 20 + channel * 2
<b>Data type</b>	Record of (Unsigned8, n x Unsigned16)
<b>Data length</b>	n x 2 + 1 bytes 0
<b>Access rights</b>	read write
<b>Description</b>	Channel output data

8 bits control/status, n x 32 bits of data

<b>Object index</b>	2000 + socket * 20 + channel * 2
<b>Data type</b>	Record of (Unsigned8, n x Unsigned32)
<b>Data length</b>	n x 4 + 1 bytes 0
<b>Access rights</b>	read write
<b>Description</b>	Channel output data

*The second object*

addresses all of the channel's input data (status byte plus user data). This object can only be read.

8 bits control/status, n x 8 bits of data

<b>Object index</b>	2000 + socket * 20 + channel * 2 + 1
<b>Data type</b>	Array of (n+1) x Unsigned8
<b>Data length</b>	n + 1 bytes 1
<b>Access rights</b>	read only
<b>Description</b>	Channel input data

8 bits control/status, n x 16 bits of data

<b>Object index</b>	2000 + socket * 20 + channel * 2 + 1
<b>Data type</b>	Record of (Unsigned8, n x Unsigned16)
<b>Data length</b>	n x 2 + 1 bytes 1
<b>Access rights</b>	read only
<b>Description</b>	Channel input data

8 bits control/status, n x 32 bits of data

<b>Object index</b>	2000 + socket * 20 + channel * 2 + 1
<b>Data type</b>	Record of (Unsigned8, n x Unsigned32)
<b>Data length</b>	n x 4 + 1 bytes 1
<b>Access rights</b>	read only
<b>Description</b>	Channel input data

The FMS objects for various terminals appear as follows:

<b>KL3002, KL3012, KL3022, KL3032, KL3042, KL3052, KL3062, KL3202, KL3302, KL2502, KL4002, KL4012, KL4022, KL4032</b>	Object index i (channel 1), i+2 (channel 2) Data type Record of Unsigned8, Unsigned16 Data length 3 Access rights Read/Write Object index i+1 (channel 1), i+3 (channel 2) Data type Record of Unsigned8, Unsigned16 Data length 3 Access rights Read
<b>KL3004, KL3014, KL3024, KL3034, KL3064, KL4004, KL4014, KL4024, KL4034</b>	Object index i (channel 1), i+2 (channel 2), i+4 (channel 3), i+6 (channel 4) Data type Record of Unsigned8, Unsigned16 Data length 3 Access rights Read/Write Object index i+1 (channel 1), i+3 (channel 2), i+5 (channel 3), i+7 (channel 4) Data type Record of Unsigned8, Unsigned16 Data length 3 Access rights Read
<b>KL1501, KL5001</b>	Object index i Data type Record of Unsigned8, Unsigned32 Data length 5 Access rights Read/Write Object index i+1 Data type Record of Unsigned8, Unsigned32 Data length 5 Access rights Read
<b>KL5101</b>	Object index i Data type Record of Unsigned8, Unsigned16, Unsigned8, Unsigned16 Data length 6 Access rights Read/Write Object index i+1 Data type Record of Unsigned8, Unsigned16, Unsigned8, Unsigned16 Data length 6 Access rights Read
<b>KL6001, KL6011, KL6021</b>	Object index i Data type Octet string 6 Data length 6 Access rights Read/Write Object index i+1 Data type Octet string 6 Data length 6 Access rights Read

*Programmed configuration* The configuration tool allows further objects to be defined, into which any desired process data can be collected. The index range above 1000 is available for this. The bus coupler software needs the configuration tool to supply it with the offset and the length in the process image, and must know whether input or output data are involved. The first programmed FMS object is allocated index 1000, after which the index increases without gaps. If the programmed configuration is selected, the objects described above in association with auto-configuration are omitted. The newly generated FMS objects have the following properties:

<b>Object index</b>	1000 + x
<b>Data type</b>	Octet string
<b>Data length</b>	Sum of the data widths of the associated terminals (byte align)
<b>Access rights</b>	read only (for input data) read write (for output data)

The programmed configuration requires the descriptions of the FMS objects that are found in tables 71 and 72 of the bus coupler:  
Tables 71-72

<b>Register 0</b>	Number of programmed FMS objects
<b>Register 1-2</b>	1 <sup>st</sup> programmed FMS object, index 1000 Byte 0: offset in local process image, lo Byte 1: offset in local process image, hi Byte 2: length of the object's data Byte 3: input (0), output (1)
...	
<b>Register 254-255</b>	127 <sup>th</sup> programmed FMS object, index 1126 Byte 0: offset in local process image, lo Byte 1: offset in local process image, hi Byte 2: length of the object's data Byte 3: input (0), output (1)

*Diagnostic messages*

One object is defined for each diagnostic message, its index depending on the socket and on the channel. The socket location only has reference to the analogue terminals, so that the analogue terminal that is nearest to the bus coupler is assigned socket number 0, the analogue terminal that comes next has socket number 1, and so on.

The structure of the diagnostic messages corresponds to that described for the DP.

<b>Index:</b>	10000
<b>Data type:</b>	Octet string[8]
<b>Data length:</b>	8 bytes
<b>Access rights:</b>	read only
<b>Description:</b>	Bus coupler diagnostic message

<b>Index:</b>	$10000 + (\text{socket}+1) * 10 + \text{channel}$
<b>Data type:</b>	Octet string[8]
<b>Data length:</b>	8 bytes
<b>Access rights:</b>	read only
<b>Description:</b>	Terminal/channel diagnostic message (from index 100)

For each diagnostic message object there is also an event object, whose index corresponds to that of the associated diagnostic message object + 5000.

*2 byte PLC interface*

The 2 byte PLC interface is implemented with object 500. The 2 byte outputs are addressed when writing this object, and the 2 byte inputs when reading it.

<b>Index</b>	500
<b>Data type</b>	Octet string
<b>Data length</b>	2
<b>Access rights</b>	read write
<b>Data</b>	Byte 0: control/status byte Byte 1: data byte

## KBL - BK 3000

## Bus coupler KBL

kr	2	3	4	5	6	7	8
lsap	2	3	4	5	6	7	8
type	MSAZ	MSAZ	MSAZ_ SI	MSZY	MSZY	MSZY_ SI	MSZY_ SI
mpsh	0	0	241	0	0	241	241
mpsl	241	241	241	241	241	241	241
mprh	0	0	0	0	0	0	0
mprl	241	241	241	241	241	241	241
scc	0	0	0	0	0	0	0
rcc	1	1	1	0	0	0	0
sac	0	0	1	0	0	1	1
rac	0	0	0	0	0	0	0
feature_support ed req/con	0x00 0x00 0x00	0x00 0x00 0x00	0x00 0x00 0x10	0x00 0x00 0x00	0x00 0x00 0x00	0x00 0x00 0x10	0x00 0x00 0x10
feature_support ed ind/res	0x80 0x33 0x06	0x80 0x33 0x06	0x80 0x33 0x06	0x00 0x30 0x00	0x00 0x30 0x00	0x00 0x30 0x00	0x00 0x30 0x00
ci	*	*	*	3000	3000	3000	3000

## FMS Master KBL

kr	2	3	4	5	6	7	8
rsap	2	3	4	5	6	7	8
type	MSAZ	MSAZ	MSAZ_ SI	MSZY	MSZY	MSZY_ SI	MSZY_ SI
mpsh	0	0	0	0	0	0	0
mpsl	241	241	241	241	241	241	241
mprh	0	0	241	0	0	241	241
mprl	241	241	241	241	241	241	241
scc	1	1	1	0	0	0	0
rcc	0	0	0	0	0	0	0
sac	0	0	0	0	0	0	0
rac	0	0	1	0	0	1	1
feature_support ed req/con	0x80 0x33 0x06	0x80 0x33 0x06	0x80 0x33 0x06	0x00 0x30 0x00	0x00 0x30 0x00	0x00 0x30 0x00	0x00 0x30 0x00
feature_support ed ind/res	0x00 0x00 0x00	0x00 0x00 0x00	0x00 0x00 0x10	0x00 0x00 0x00	0x00 0x00 0x00	0x00 0x00 0x10	0x00 0x00 0x10
ci	*	*	*	3000	3000	3000	3000

## CP5431 (connection editor) settings:

kr	2	3
External LSAP	2	3
Connection type	MSAZ	MSAZ
max. PDU length	241	241
Monitoring interval	*	*

## CP5431 (ZI editor) settings:

kr	5	6
External LSAP	5	6

KBL - BK 3100

**Bus coupler KBL**

Connections kr 3-8 are only active if register 16 in table 0 of the bus coupler has the value 2 (FMS only).

<b>Kr</b>	2	3	4	5	6	7	8
<b>lsap</b>	2	3	4	5	6	7	8
<b>type</b>	MSAZ	MSAZ	MSAZ_ SI	MSZY	MSZY	MSZY_ SI	MSZY_ SI
<b>mpsh</b>	0	0	90	0	0	50	50
<b>mspl</b>	241	90	90	50	50	50	50
<b>mprh</b>	0	0	0	0	0	0	0
<b>mspl</b>	241	90	90	50	50	50	50
<b>scc</b>	0	0	0	0	0	0	0
<b>rcc</b>	1	1	1	0	0	0	0
<b>sac</b>	0	0	1	0	0	1	1
<b>rac</b>	0	0	0	0	0	0	0
<b>Feature_su pported req/con</b>	0x00 0x00 0x00	0x00 0x00 0x00	0x00 0x00 0x10	0x00 0x00 0x00	0x00 0x00 0x00	0x00 0x00 0x10	0x00 0x00 0x10
<b>Feature_su pported ind/res</b>	0x80 0x33 0x06	0x80 0x33 0x06	0x80 0x33 0x06	0x00 0x30 0x00	0x00 0x30 0x00	0x00 0x30 0x00	0x00 0x30 0x00
<b>ci</b>	*	*	*	3000	3000	3000	3000

**FMS Master KBL**

<b>kr</b>	2	3	4	5	6	7	8
<b>rsap</b>	2	3	4	5	6	7	8
<b>type</b>	MSAZ	MSAZ	MSAZ_ SI	MSZY	MSZY	MSZY_ SI	MSZY_ SI
<b>mpsh</b>	0	0	0	0	0	0	0
<b>mspl</b>	241	90	90	50	50	50	50
<b>mprh</b>	0	0	90	0	0	50	50
<b>mspl</b>	241	90	90	50	50	50	50
<b>scc</b>	1	1	1	0	0	0	0
<b>rcc</b>	0	0	0	0	0	0	0
<b>sac</b>	0	0	0	0	0	0	0
<b>rac</b>	0	0	1	0	0	1	1
<b>Feature_su pported req/con</b>	0x80 0x33 0x06	0x80 0x33 0x06	0x80 0x33 0x06	0x00 0x30 0x00	0x00 0x30 0x00	0x00 0x30 0x00	0x00 0x30 0x00
<b>Feature_su pported ind/res</b>	0x00 0x00 0x00	0x00 0x00 0x00	0x00 0x00 0x10	0x00 0x00 0x00	0x00 0x00 0x00	0x00 0x00 0x10	0x00 0x00 0x10
<b>ci</b>	*	*	*	3000	3000	3000	3000

**CP5431 (connection editor) settings:**

<b>kr</b>	2	3
<b>External LSAP</b>	2	3
<b>Connection type</b>	MSAZ	MSAZ
<b>max. PDU length</b>	241	90
<b>Monitoring interval</b>	*	*

**CP5431 (ZI editor) settings:**

<b>kr</b>	5	6
<b>External LSAP</b>	5	6

*Object Directory***Auto-configuration**

<b>Index</b>	<b>Description</b>
<b>0</b>	OV-Header
<b>5</b>	Data type Unsigned8
<b>6</b>	Data type Unsigned16
<b>7</b>	Data type Unsigned32
<b>10</b>	Data type octet string
<b>40</b>	Record type Unsigned8, Unsigned16
<b>41</b>	Record type Unsigned8, 2 x Unsigned16
...	
<b>49</b>	Record type Unsigned8, 10 x Unsigned16
<b>60</b>	Record type Unsigned8, Unsigned32
<b>61</b>	Record type Unsigned8, 2 x Unsigned32
...	
<b>69</b>	Record type Unsigned8, 10 x Unsigned32
<b>70</b>	Record type Unsigned8, Unsigned16
<b>71</b>	Record type 2 x (Unsigned8, Unsigned16)
...	
<b>79</b>	Record type 10 x (Unsigned8, Unsigned16)
<b>80</b>	Record type Unsigned8, Unsigned32
<b>81</b>	Record type 2 x (Unsigned8, Unsigned32)
...	
<b>89</b>	Record type 10 x (Unsigned8, Unsigned32)
<b>500</b>	2 byte PLC interface
<b>1000</b>	Digital inputs
<b>1001</b>	Digital outputs
<b>2000-3267</b>	Analogue inputs/outputs
<b>10000-10643</b>	Diagnostic messages
<b>15000-15643</b>	Events for diagnostic messages

### Programmed configuration

Index	Description
0	OV-Header
5	Data type Unsigned8
6	Data type Unsigned16
7	Data type Unsigned32
10	Data type octet string
40	Record type Unsigned8, Unsigned16
41	Record type Unsigned8, 2 x Unsigned16
...	
49	Record type Unsigned8, 10 x Unsigned16
60	Record type Unsigned8, Unsigned32
61	Record type Unsigned8, 2 x Unsigned32
...	
69	Record type Unsigned8, 10 x Unsigned32
70	Record type Unsigned8, Unsigned16
71	Record type 2 x (Unsigned8, Unsigned16)
...	
79	Record type 10 x (Unsigned8, Unsigned16)
80	Record type Unsigned8, Unsigned32
81	Record type 2 x (Unsigned8, Unsigned32)
...	
89	Record type 10 x (Unsigned8, Unsigned32)
500	2 byte PLC interface
1000-1254	Programmed inputs/outputs
10000-10643	Diagnostic messages
15000-15643	Events for diagnostic messages

### Miscellaneous

#### DP/FMS operation

The BK 3000 always supports both DP and FMS operation up to 1.5 Mbaud. The BK 3100 supports the operation set in register 16 in table 0 of the bus coupler up to 12 Mbaud:

0	DP/FMS operation (default)
1	DP operation
2	FMS operation

In either pure DP operation or pure FMS operation it is possible for more input and output data and/or more connections can be defined (see above).

*Min. TSDR*

The bus coupler's minimum answer time can be set through register 17 in table 0 of the bus coupler. The default value is 11 (bit times), but values from 11 to 255 are possible.

*Important:*

some FMS Masters are too slow to react to the bus coupler's default answer time. The bus coupler's answer time can however with the KS2000 be changed via the serial interface. In such cases, the min. TSDR should be changed as follows:

Baud rate	min. TSDR
9.6 kbaud	30
19.2 kbaud	60
93.75 kbaud	125
187.5 kbaud	250
greater than 187.5 kbaud	255

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## Beckhoff Headquarters

Beckhoff Automation GmbH

Eiserstr. 5

33415 Verl

Germany

phone: + 49 (0) 5246/963-0

fax: + 49 (0) 5246/963-198

e-mail: [info@beckhoff.com](mailto:info@beckhoff.com)

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