PROFIBUS
Bus Terminal Controller
BC3100

Technical Hardware Documentation

Version 2.1
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BECKHOFF

Contents

Foreword

Notes on the documentation

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards. It is essential that the following notes and explanations are followed when installing and commissioning these components.

Liability Conditions

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

The documentation has been prepared with care. The products described are, however, constantly under development. For that reason the documentation is not in every case checked for consistency with performance data, standards or other characteristics. None of the statements of this manual represents a guarantee (Garantie) in the meaning of § 443 BGB of the German Civil Code or a statement about the contractually expected fitness for a particular purpose in the meaning of § 434 par. 1 sentence 1 BGB. In the event that it contains technical or editorial errors, we retain the right to make alterations at any time and without warning. No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

Delivery conditions

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

Copyright

Safety Instructions

State at Delivery

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

Description of safety symbols

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

Danger	This symbol is intended to highlight risks for the life or health of personnel.
Attention	This symbol is intended to highlight risks for equipment, materials or the environment.
Note	This symbol indicates information that contributes to better understanding.

Basic information

The Beckhoff bus terminal system

Up to 64 bus terminals

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

The bus terminal system is the universal connecting link between a fieldbus system and the sensor/actor level. A unit consists of a bus terminal controller or 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 terminal controllers 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

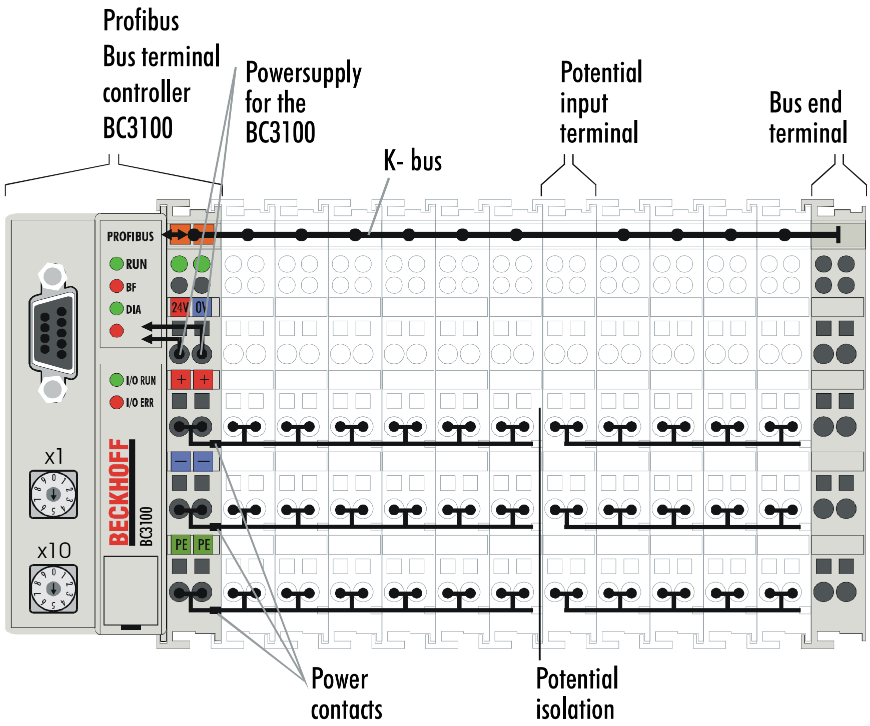
The K-bus is the path taken by data within the terminal row. The bus terminal controller carries the K bus through all the terminals by means of six contacts on the side walls of the terminals, and the end terminal terminates the K bus. The user does not need to know anything about the function of the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



Additional characteristics of the bus terminal controllers

The bus terminal controllers (BC) differ from the bus couplers (BK) by virtue of the fact that a real time PLC task runs in addition to processing of the K-bus. Contrary to the bus couplers, by default the signals of the terminals are processed by the PLC task while inputs and outputs of the PLC task are then transmitted through the field bus. It is possible, however, to split up terminals so that some terminals are preprocessed by the PLC task, while others are forwarded directly via the field bus to the higher-level system.

Bus terminal controllers for various field bus systems

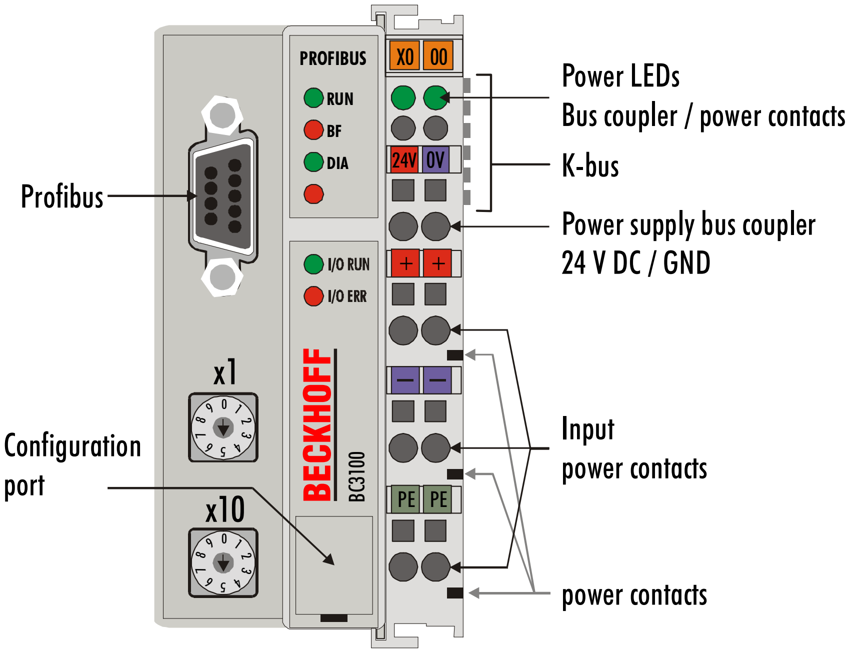
Various bus terminal controllers can be used to link the electronic terminal strip with an integrated PLC task swiftly and easily to diverse field bus systems. Later conversion to a different field bus system is also possible. The bus terminal controller assumes all checking and control tasks that are needed for operation of the connected bus terminals. The bus terminals are operated and configured exclusively via the bus terminal controller. The field bus, the K-bus and the I/O level are electrically isolated.

The PLC task continues running as an autonomous system if the exchange of data via the field bus should temporarily fail.

The interfaces

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

The Profibus controller BC3100



Power supply

24 V DC on the topmost terminals

The bus terminal controllers 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 terminal controller but (via the K bus) also the bus terminals. The power supply of the bus terminal controller circuitry and that of the K-bus (Terminal bus) are electrically isolated from the voltage of the field level.

Power supply to the power contacts

Lower 3 terminal pairs for power input

maximum 24 V

maximum 10 A

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

Power contacts

Spring contacts at the side

On the right-hand side face of the BC3100 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 terminal controller and bus terminals ensure reliable location of the power contacts.

Fieldbus connection

9-pin Sub-D female connector

On the left-hand side there is a flat recessed area where you can plug in the typical Profibus male connectors. You will find a detailed description of the fieldbus interfaces in another part of this manual (In the chapter "The transfer medium: plugs and cables“).

Configuration interface

Serial interface under the front flap

On the bottom side of the front area, the bus terminal controllers are equipped with an RS 232 interface. The miniature connector can be connected to a PC with a connecting cable and the KS2000 configuration software. The interface permits configuration of the analog channels.

Depending on the scope of performance of the field bus, this functionality can also be realized with field bus-specific functions.

The miniature connector also serves to connect to the TwinCAT PLC programming environment on a PC. It is used to load, start and stop the program, breakpoints are set and the program is run in the STEP mode etc.

Depending on the scope of performance of the field bus and the availability of a corresponding TwinCAT field bus interface, this functionality can also be realized via the field bus, with the result that several bus terminal controllers that are physically connected to the same field bus can be operated without replugging an RS 232 connection. This feature is currently not yet supported by TwinCAT.

K-bus contacts

6 contacts at the side

The connections between the BC3100 and the bus terminals are effected by gold contacts at the right-hand side of the bus terminal controller. 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 BC3100 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 terminal controller to locate the interruption and report it.

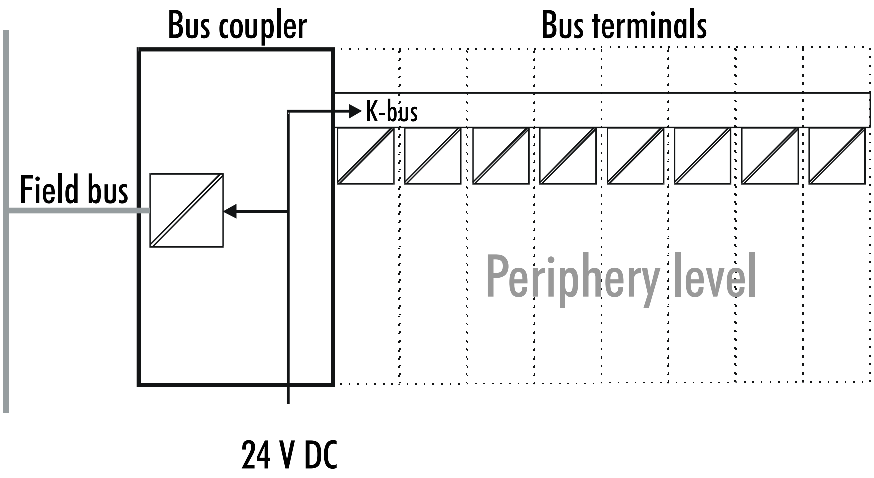
Supply isolation

3 supply groups:
fieldbus
K-bus
peripheral level

The BC3100 operate with three independent supplies. The input power supplies the electrically isolated K-bus circuitry in the bus terminal controller 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.

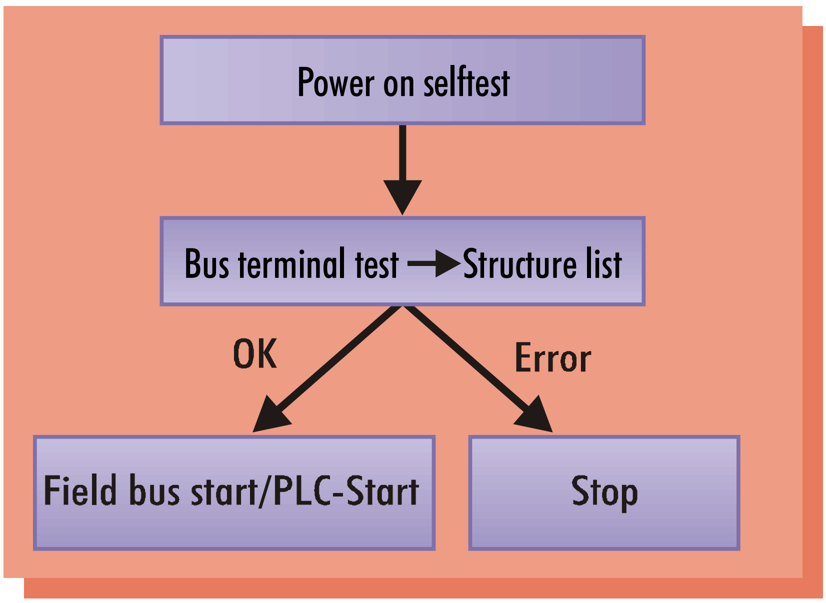
Setting up the power levels in the bus terminal system



The operating modes of the bus coupler

After power on, in a "self-test" the bus terminal controller checks all functions of its components and communication by the K-bus. The red I/O LED flashes during this phase. After successful completion of the self-test, the bus terminal controller begins to test the plugged in bus terminals (bus terminal test) and reads the configuration. An internal structure list is created on the basis of the bus terminals' configuration. The bus terminal controller assumes the "STOP" operating state in the event of an error. After error-free start up, the bus terminal controller assumes the "field bus start/PLC start" state. If a PLC program is stored in the flash memory, it is loaded and started regardless of whether the field bus is running. The inputs of the PLC task have been set to zero during start up.

Start-up behavior of the bus terminal controller

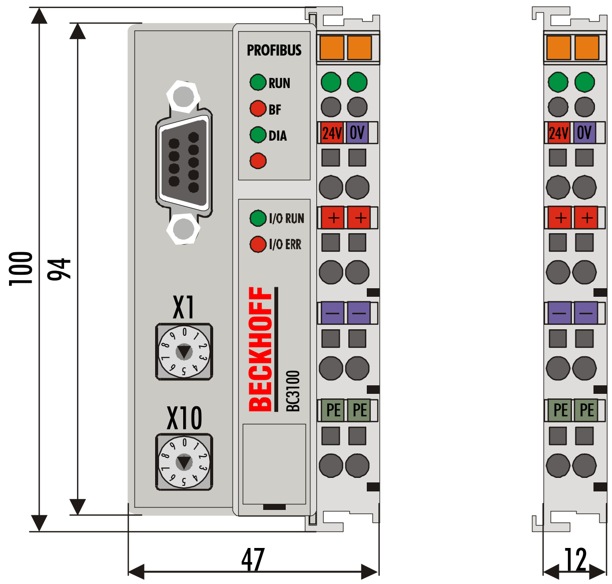


Depending on the field bus functionality, the bus terminal controller reports a possible error via the field bus. The BC3100 generally has to be restarted after the error has been remedied.

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 terminal controller and some number of bus terminals. The dimensions of the bus terminal controller 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 terminal controller



The overall width of the construction is the width of the BC3100, including the bus end terminal, plus the width of the installed bus terminals. The bus terminals are 12 mm or 24 mm wide, depending on their function. Depending on the gauge of cables used the overall height of 68 mm may be overstepped by about 5 mm to 10 mm by the cables at the front.

Assembly and connections

It takes only a slight pressure to latch the bus terminal controller 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 terminal controller only while they are switched off: if you plug or unplug components while the power is on you may briefly provoke some undefined state (and, for instance, reset the bus coupler).

You can attach up to 64 bus terminals in series on the right-hand side of the BC3100. 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 BC3100 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 terminal controller 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 terminal controller can also be used to supply power to the power contacts.

Insulation test

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

PE power contacts

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

Electrical data

The electrical data specific to the field bus is listed in this chapter. The following table shows the data in an overview:

Technical data's	BC3100
Number of bus terminals	64
Digital peripheral signals	256 inputs/outputs
Analog peripheral signals	128 inputs/outputs
Maximum number of bytes	512 bytes I and 512 bytes O
Programming possibility	via programming interface (TwinCAT BC) or Profibus-DP (TwinCAT)
Program size	approximately 3000 plc statements
Program memory	32 kbytes
Data memory	32 kbytes
Permanent flags	512 bytes
Run time system	1 PLC task
PLC cycle time	approximately 3 ms for 1000 commands (including K-bus I/O cycle)
Programming languages	IL, LAD, CSF, SFC, ST
Field bus interface	Profibus-DP
Baud rates	automatic baud rate detection up to 12 MBaud
Bus connection	1 x D-sub connector, 9-pole, with screen
Power supply	24 V DC, (20...29 V DC)
Input current	70 mA + (total K-bus current/4 500 mA max.
Power-on current	2.5 x continuous current
Recommended fuse	≤ 10 A,
K-bus power supply up to	1750 mA
Power contact voltage	24 V DC max.
Power contact current load	10 A max.
Diaelectric strength	500 Vrms (Power contact/supply voltage/field bus)
Operating temperature	0°C ... +55°C
Storage temperature	-25°C ... +85°C
Relative humidity	95%, no condensation
Vibration/shock resistance	in accordance withIEC 68-2-6 / IEC 68-2-27
EMC/emssion	in accordance with EN 50082 (ESD, Burst) / EN 50081
Installed position	any
Degree of protection	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 terminal controller. 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 terminal controller 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

After power on, the BC3100 determines the configuration of the plugged-in input/output terminals. The affiliations between the physical slots of the input/output channels and the addresses of the process image are defined automatically or by programming by the bus terminal controller depending on the settings via the configuration interface. If these affiliations are programmed, digital and analog signals can be distributed channel by channel in any order to the process image of the PLC task (global variables %I* (inputs) and %Q* (outputs)) or of the field bus (process data that is transferred through the field bus). The setting is defined manually with the configuration interface or, depending on the field bus functionality of the bus terminal controller, with the TwinCat System Manager at the variable level.

By default, automatic allocation is set for the bus terminal controllers. This is described below:

The BC3100 creates an internal allocation list in which the input/output channels have a specific position in the process image. Here, a distinction is made according to inputs and outputs and according to bit-oriented (digital) and byte-oriented (analog or complex) signal processing.

Two groups with only inputs and only outputs each are formed. The byte-oriented channels are located in ascending order at the lowest address in one group. The bit-oriented channels are located after this block.

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 terminal controller sets up a block of memory containing the current input bits and arranges to immediately write out the bits from a second block of memory which belongs to the output channels.

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

Analog signals (byte-oriented)

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

Special signals and interface

A bus terminal controller 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.

Word Alignment

The analog or special signals are mapped with word alignment when the peripheral signals are allocated into the process image of the PLC task and, depending on the field bus, into the process image.

Process image allocation

By default, all terminals are allocated to the process image of the PLC task (beginning with the address %Q*0 or %I*0) but, via the configuration interface, the peripheral signals can also be allocated terminal by terminal to the field bus process image, with the result that they would be transmitted directly via the field bus without pre-processing by the PLC task.

Default assignment of inputs and outputs to the process image

When the BC3100 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 BC3100. 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 BC3100

Output data in the BC3100

O0 ... ... Ox	byte-oriented data
Ox+1 Ox+y	bit-oriented data

Input data in the BC3100

I0 Ix	byte-oriented data
Ix+1 ... ... Ix+y	bit-oriented data

Assignment of the process image of the PLC task to the field bus process image

Depending on the setting, the affiliations between the inputs and the outputs of the PLC task and the field bus process image are defined automatically by the BC3100 via the configuration interface or by programming. When assignments are programmed, inputs and outputs can be distributed bit by bit in any order to the field bus process image. This is set manually with the configuration interface or, depending on the field bus functionality of the bus terminal controller, with the TwinCAT System Manager at the variable level.

By default, automatic assignment is set for the bus terminal controllers. In this case, one coherent area each of the inputs or outputs of the PLC task can be mapped into the field bus process image. The initial offset and length of the area to be mapped can be set by way of the configuration interface. As the terminal signals are placed into the process image of the PLC task as from address zero, the first meaningful offset as from when inputs and outputs of the PLC task are mapped into the field bus process image is the first free address where there are no longer any terminal signals.

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.

Commissioning and diagnostics

After power on, the bus terminal controller immediately checks the connected configuration. Error-free start up is signalled by virtue of the fact that the red "I/O ERR" LED goes off. When it flashes, the "I/O ERR" LED indicates an error in the area of the terminals. The error code can be determined by the frequency and number of flashes. This enables swift troubleshooting.

The diagnostic LEDs

The bus terminal controller has two groups of LEDs to provide a status display. The top group consisting of four LEDs indicates the status of the respective field bus. The meanings of the "field bus" status LEDs are explained in the corresponding chapters of this manual. They correspond to the usual field bus displays.

There are two further green LEDs on the top right hand side of the bus terminal controller to indicate the supply voltage. The left hand LED indicates the 24 V power supply of the bus terminal controller. The right hand LED signals the power supply of the Power contacts.

Local errors

Two LEDs, the "I/O Leds" in the area under the above-mentioned field bus status LEDs, serve to indicate the operating states of the bus terminals and of the connection to these bus terminals. The green LED lights up whenever the signals to the terminals are being exchanged via the K-bus. After an error-free start up of the bus terminal controller, the K-bus exchange always takes place, even if the PLC program or the field bus is not running. The reaction (inputs or outputs change to zero or remain unchanged) to errors (field bus not running correctly or PLC task has assumed the STOP state) can be set via the configuration interface. To indicate errors, the red LED flashes at two different frequencies. Errors are encoded as follows in the flashing code:

Fast flashing	Start of the error code
First slow sequence	Error code
Second slow sequence	Error argument

Error code	Error argument	Description
1 pulse	0 1 2	EEPROM checksum error Inline code buffer overflow Unknown data type
2 pulses	 0 n (n > 0)	Programmed configuration Invalid table entry/ Bus terminal controller Invalid table comparison (terminal n)
3 pulses	0	Terminal bus command error
4 pulses	0 n	Terminal bus data error Breakage after terminal n (0: BC3100)
5 pulses	n	Terminal bus error during register communication with terminal n
6 pulses	0 p(p>0)	Not enough DP-Cfg_Data received Invalid DP-Cfg_Data byte
8 pulses	0 p(p>0)	Not enough DP-User_Prm_Data received Invalid DP-User_Prm_Data byte
9 pulses	0	Invalid checksum in the PLC program

The number of pulses (n) indicates the position of the last bus terminal before the error. Passive bus terminals, for example an infeed terminal, are not counted.

In the case of some errors, the bus terminal controller does not end the flashing sequence when the error has been remedied. The bus terminal controller's operating state is still "Stop". The bus terminal controller can only be restarted by switching the supply voltage off and on or by means of a software reset.

It is only permitted to unplug bus terminals from the network and to plug them in again after switching off. The electronic circuitries of the bus terminals and of the bus terminal controller are largely protected against destruction, but malfunctions and damage cannot be ruled out if terminals are plugged together under a live voltage.

The occurrence of an error during ongoing operation does not immediately trigger output of the error code via the LEDs. The bus terminal controller must be prompted to diagnose the bus terminals. The diagnostic request is generated after power on.

Field bus error

The red BF LED on the bus terminal controller lights up whenever the BC3100 is not participating in the Profibus-DP exchange of data.

PLC-RUN

The Green RUN LED on the bus terminal controller lights up whenever the PLC task is in the RUN state.

PLC program in flash memories

When the PLC program is downloaded with the TwinCAT PLC programming environment, the program is initially stored only in the RAM. The program is transferred from the RAM to the flash memory by means of the Online -> Create a boot project command. The red DIA LED on the bus terminal controller goes on during this storage operation.

Run and reaction times

Cycle time of the PLC task

The PLC task is called up cyclically and time-controlled, whereby the cycle time can be set via the configuration interface (default time: 5 ms). The minimum cycle time is 1 ms. 20% of the timing resources should be reserved for execution of the background processes. The PLC task's run time is composed of the data exchange via the K-bus, the operating system of the PLC task and the actual PLC program.

The PLC task's run time can be measured with the KS2000 configuration software. The nominal cycle time and the time for background execution can then be set on the basis of this measurement.

K-bus reaction time

The reaction time on the K-bus is determined by shifting and saving of the data. The following table contains measured values for typical setups. It is possible to extrapolate to larger numbers.

Terminals inserted on the bus terminal controller			Run time on the K-bus
Digital OUT	Digital IN	Analog IN/OUT	T_cycle (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

Memory requirement

Memory requirement for various PLC commands

The PLC task currently has 32 kbytes each for program and data memory.

The memory requirement for a number of PLC commands is given below:

Command / Library	Code	Data	Comment
	32k available	32k RAM available	
Overhead	1k	6,5k	
BITFUN.LIB	0	0	Created INLINE
CONVERT.LIB	0	0	Created INLINE
COUNTER.LIB	1.5k	0	
MATH.LIB	--	--	Not yet available
STDFB.LIB	1k	0	
STRING.LIB	2.5k	0	
TIMER.LIB	1.5k	0	
TRIGONOM.LIB	--	--	Not yet available
LD/ST Byte variable	4		
LD /ST Word variable	4		
LD /ST Dword variable	8		
ADD Byte variable	6		
ADD Word variable	6		
ADD Dword variable	16		
SHL / ROL Byte variable	6		
SHL / ROL Word variable	6		
SHL / ROL Dword variable	--		Not yet available

PROFIBUS-DP basics

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 stations".

Slave devices are peripheral devices. Typical slave devices are sensors, actuators, transducers and Beckhoff bus couplers or bus terminal controllers. They are not assigned any bus access privileges, i.e. they may only acknowledge received messages or send messages to a master at its request. Slaves are also referred to as passive stations.

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 data transfer rate of 12 Mbits/s, Profibus-DP needs less than 2 ms to transfer 512 bits of input data and 512 bits of output data distributed to 32 stations. This meets the requirement for a short system reaction 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), such as an IM308-C or TwinCAT

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 (PLC), 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, e.g. the bus couplers or bus terminal controllers.

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 die 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)

The widespread and user-friendly master interfaces for a PLC include the IM308-C from Siemens. A COMProfibus software under Windows is available for configuration of the master. During configuration of this master interface for the Profibus, the features of the slave devices are documented by the manufacturers in the form of a type file and are made available to users as a file. The contents and coding of this type file are Siemens-specific and are supported by Beckhoff, as well as by other manufacturers. It enables convenient configuration of any chosen DP slaves with a PC under the user interface of Windows 3.1 and subsequent Windows versions. GSD files, type files and bitmaps are available for the Beckhoff bus couplers or bus terminal controllers.

The GSD or type file can be downloaded from the mailbox 0 52 46 / 96 3 - 45 5, AREA 15, or via the Internet (www.beckhoff.com or ftp.beckhoff.com) or can be ordered on a diskette.

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

The bus couplers and bus terminal controller 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:

Modes	
Stop	No data communication is taking place between the DPM1 and the DP slaves.
Clear	The DPM1 reads the input information of the DP slaves and keeps the outputs of the DP slaves in a safe state.
Operate	The DPM1 is in the data transfer phase. In a cyclic communication, the inputs of the DP slaves are read and the output information is transferred to the DP slaves.

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 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 confirms 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

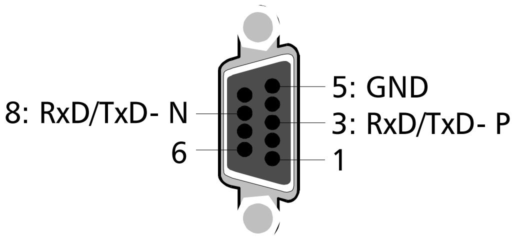
Two cable types with different maximum cable lengths are available. See table entitled "RS485". The pin assignments on the connector and the wiring are shown in the figure. Please pay attention to the special requirements for the data cable at board rates in excess of 1.5 MBaud. The right cable is a 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.

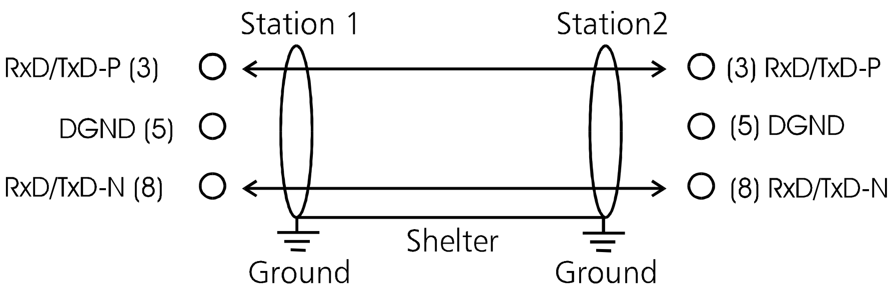
Fiber-optic conductor: the specification for a data transfer technology based on fiber-optic conductors was elaborated in PNO for applications in environments that are subject to extreme interference and to increase the range at high data transfer rates. The specification is currently available as a draft PNO guideline. The PROFIBUS COUPLER requires an external module for conversion from RS485 to fiber-optic. The setup is clearly more complex because of the need for an optical converter to convert from RS485 to the "fiber-optic sub ring".

RS-485 Data transfer technology to the Profibus standard	RS485 fundamental characteristics:
Network topology	Linear bus, active bus terminator at both ends, branch lines are possible
Medium	Shielded twisted cable, shielding may be dispensed with in suitable environments (electromagnetic compatibility)
Number of stations	32 stations in each segment without repeaters, extendible to 127 with repeaters
Max. bus length	
without repeaters	9.6, 19.2, 93.75 kBaud = 1200 m 187.5 kBaud = 1000 m 500 kBaud = 400 m 1500 kBaud = 200 m 3, 6 12 Mbaud = 100 m
with repeaters	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
Transfer rates	9.6, 19.2, 93.75, 187.5, 500, 1500 Kbit/s, up to 12 Mbit/s in discrete steps
Plug	9-Pin D-Sub plug

Pin assignments of the D-Sub socket



Cables for PROFIBUS DP and PROFIBUS FMS



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.

Configuration of the masters

The Profibus bus terminal controller operates with two different process images: the PLC process image to which all bus terminals or only some of the bus terminals configured on the one specific BC3100 are assigned, as well as the Profibus DP process image to which a part of the bus terminals can be assigned. For details of parameterization and configuration, please refer to the chapter entitled Profibus bus terminal controller BC3100.

The Profibus master exchanges a coherent input and output data block with each Profibus coupler/controller. The master assigns the bytes from this data block from the addresses of the process image. The COMProfibus software supports configuration when using the PLC master of the IM308-C. Use the manufacturers' corresponding tools for other masters (see also chapter entitled Master device file and type file).

Support files for master configuration:

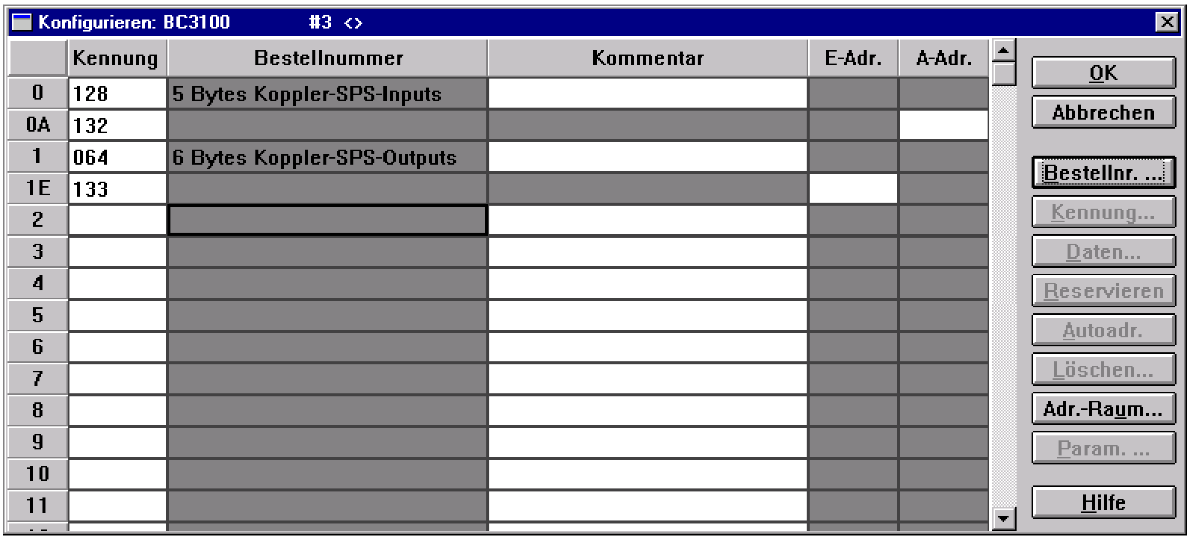
Master / Software	Remarks	File
IM308-B COMET200		BK3000TD.200
IM308-C COMProfibus	Bitmaps	BUSKLEMN.BMP BUSKLEMS.BMP
English Language-independent		BK3000AD.200 BK3000AE.200 BK3000AX.200
General	(for BK30XX)	BK30BECF.GSD BK3010.GSD
General	(for BK31XX)	BK31BECE.GSD BK3110.GSD
General	(for BC3100)	BC3100.GSD

Example for the master IM308-C
Interfacing for PLC Simatic S5

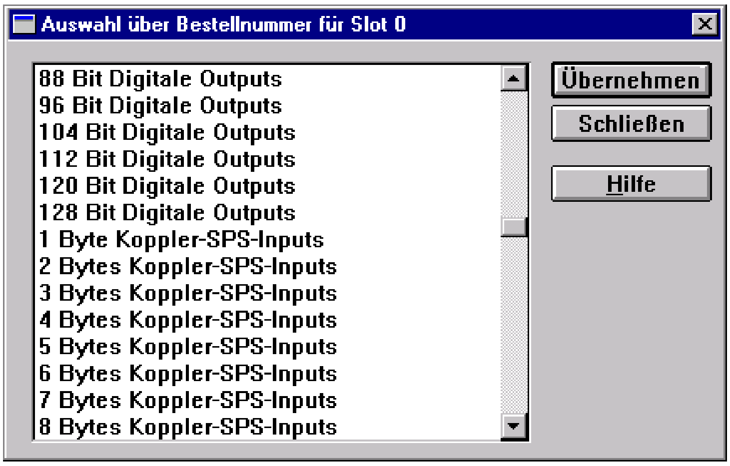
In an example, we will show what settings have to be made in COMProfibus to configure the Profibus master IM308-C.
Diverse bus terminals are connected to a BC3100:

In this example, the bus terminal controller's PLC program requires 5 bytes of input signals (DP outputs of the master) and returns 6 bytes of output signals (DP inputs of the master).

The corresponding entries for the identifiers can be selected conveniently by way of the order number. The following window shows the selected identifier:



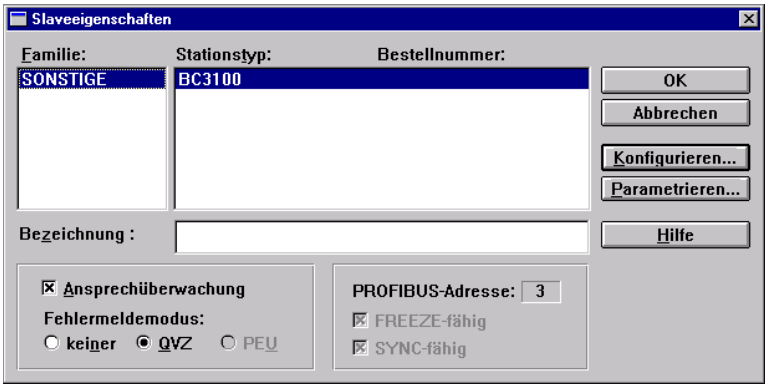
When a box in the "Order no." column is double clicked, a menu appears for selection of the required identifier for the correspondingly plugged in terminals or data lengths of the PLC process image.



Various possibilities of assigning process data are available in the case of the BC3100. The various assignment possibilities are explained in detail in the next chapter (Profibus bus terminal controller BC3100). In the appendix, you will also find an example in relation to the possible settings.

Ensuring data consistency

Consistency of a station's data is ensured by the Profibus data transfer protocol. Consistency throughout the entire process image must be achieved by activating the "SYNC" and "FREEZE" operating modes in the masters.



FREEZE and SYNC capability is preselected for the slave parameters (see figure) and cannot be deactivated. The control software checks FREEZE and SYNC.

Activation of response monitoring ensures that an error message is created in the event of failure of the corresponding station belonging to the master and that the control software is enable to initiate exception handling. Response monitoring can be selected individually for each station. Response monitoring on is the default. The COMProfibus software issues a warning whenever monitoring is to be deactivated.

Inconsistencies may occur as the result of asynchronous access by the controller CPU (mostly PLC) to the data area of the Profibus master. Data consistency is ensured automatically with the configuration of a "multi-byte signal" and module consistency in the COMProfibus configuration software for IM308-C. With regard to further master interfaces, please consult the corresponding manufacturers' manuals for an explanation.

The IM 308-C as Profibus DP master is a common PLC interface.

A Windows program, COMProfibus, and extensive descriptions are available for the Profibus DP master interface IM308-C. In connection with the Siemens S5, it is recommended to use the IM308-C because of its better handling and the possibility of freely assigning peripheral addresses byte by byte. Versions 2.1 or higher can be considered to be particularly convenient. An extended type file can be read in with these versions. The entries in the type file automatically assume the settings for guaranteeing data consistency. (The figures on the previous pages originate from the COMProfibus software.)

PROFIBUS bus terminal controller BC3100

Parameterization

Besides the parameterization in the DP standard, manufacturer-specific operating parameters (User_Prm_Data) can also be transferred with the Set_Prm service. These are distinguished by the fact that they are transferred once from the master to the slave during establishment of the connection. User_Prm_Data overwrites the settings that have been made by way of the configuration interface. If these settings are not to be overwritten, User_Prm_Data must not be sent. The User-Prm_Data of the bus terminal controller BC3100 is based on the following structure:

Byte No.	Description
Byte 0	Bit 0: Start-Bit monitoring on (0) / off (1) Bit 1: Stop-Bit monitoring on (0) / off (1) Bit 2: Watchdog time base 10ms (0) / 1ms (1) Bit 3-5: 0 (reserved for expansions) Bit 6: Fail_Safe off (0) / on (1) Bit 7: DPV1-MSAC_C1 connection disabled (0) / enabled (1)
Byte 1	0 (reserved for expansions)
Byte 2	0 (reserved for expansions)
Byte 3	0 (reserved for expansions)
Byte 4	0 (reserved for expansions)
Byte 5	Bit 1: diagnostics via 2-byte diagnostics interface (1) Diagnostics via DP diagnostics (Slave_Diag) (0) Bit 0, 2-7: 0 (reserved for expansions)
Byte 6	0 (reserved for expansions)
Byte 7	Bit 0: auto reset on the terminal bus in the event of an error on (1)/off(0) Bit 1: automatic terminal diagnostics on(1)/off(0) Bit 4: diagnostics of digital terminals is mapped to the process image (0)/ is not mapped to the process image (1) Bit 2,3, 5-7: 0 (reserved for expansions)
Byte 8	0 (reserved for expansions)
Byte 9	Bit 0: 1 Bit 1: 1 Bit 2: 0 Bit 3: data format for auto configuration: INTEL (0)/MOTOROLA(1) Bit 4: 0 Bit 5: 1 Bit 6: 1 Bit 7: 0
Byte 10	Bit 0,1: reaction to field bus error/termination of DP data exchange/Clear_Data 1: affiliated terminal bus outputs change to 0 2: affiliated terminal bus outputs remain unchanged Bit 2,3: Reaction to terminal bus error 1: affiliated DP inputs change to 0 2: affiliated DP inputs remain unchanged Bit 4-7: 0 (reserved for expansions)
Byte 11	Max. DP diagnostic data length (value range 16, 24, 32, 40, 48, 56, 64)

Byte No.	Description
Byte 12	Reserved for expansions
Byte 13	Bit 0: flags are stored in the NOVRAM (1)/are not stored (0) Bit 1: PLC run time measurement on (1)/off (0) Bit 2,3: terminal bus/PLC cycle sequence 0: terminal bus inputs before PLC cycle, terminal bus outputs after PLC cycle 1: terminal bus inputs and outputs before PLC cycle 2: terminal bus inputs and outputs after PLC cycle Bit 4: Nominal cycle time and background execution time are set via TWinCAT BC / TWinCAT PLC (1) / are set via UserPrmData (0) (Byte 43: Nominal cycle time, Byte 44: Background execution time) Bit 5: BC state is copied into flag (1) (PROFIBUS state into flag byte 508,509, terminal bus state into flag byte 510,511) / is not copied into flag
Byte 14	Bit 0: 1 Bit 3: in the event of a PLC STOP, the affiliated terminal bus outputs remain unchanged (1)/the affiliated terminal bus outputs are set to 0 (0)
	Bit 4: in the event of a terminal bus error, the affiliated PLC inputs remain unchanged (1) / the affiliated PLC intputs are set to 0 (0) Bit 5: in the event of a field bus error, the affiliated PLC inputs remain unchanged (1)/ the affiliated PLC inputs are set to 0 (0) Bit 6: in the event of a PLC STOP, the affiliated DP outputs remain unchanged (1)/the affiliated DP outputs are set to 0 (0)
Byte 15	Bit 0,1: 0: 1. Terminal is assigned to the DP process image 2: 1. Terminal is assigned to the PLC process image and is mapped compactly (only with useful data) 3: 1. Terminal is assigned to the PLC process image and mapped completely Bit 2,3: 0: 2. Terminal is assigned to the DP process image 2: 2. Terminal is assigned to the PLC process image and mapped compactly (only with useful data) 3: 2. Terminal is assigned to the PLC process image and mapped completely Bit 4,5: 0: 3. Terminal is assigned to the DP process image 2: 3. Terminal is assigned to the PLC process image and mapped compactly (only with useful data) 3: 3. Terminal is assigned to the PLC process image and mapped completely Bit 6,7: 0: 4. Terminal is assigned to the DP process image 2: 4. Terminal is assigned to the PLC process image and mapped compactly (only with useful data) 3: 4 Terminal is assigned to the PLC process image and mapped completely
...	...

Byte No.	Description
Byte 30	Bit 0,1: 0: 61. Terminal is assigned to the DP process image 2: 61. Terminal is assigned to the PLC process image and mapped compactly (only with useful data) 3: 61. Terminal is assigned to the PLC process image and mapped completely Bit 2,3: 0: 62. Terminal is assigned to the DP process image 2: 62. Terminal is assigned to the PLC process image and mapped compactly (only with useful data) 3: 62. Terminal is assigned to the PLC process image and mapped completely Bit 4,5: 0: 63. Terminal is assigned to the DP process image 2: 63. Terminal is assigned to the PLC process image and mapped compactly (only with useful data) 3: 63. Terminal is assigned to the PLC process image and mapped completely Bit 6,7: 0: 64. Terminal is assigned to the DP process image 2: 64. Terminal is assigned to the PLC process image and mapped compactly (only with useful data) 3: 64. Terminal is assigned to the PLC process image and mapped completely
Bytes 31-36	Reserved for expansions
Byte 37	Initial address in the PLC input process image as from which plc inputs are to be transferred as DP outputs (high byte)
Byte 38	Initial address in the PLC process image as from which PLC inputs are to be transferred as DP outputs (low bytes)
Byte 39	Length of the PLC inputs that are to be transferred as DP outputs
Byte 40	Initial address in the PLC output process image as from which PLC outputs are to be transferred as DP Inputs (high bytes)
Byte 41	Initial address in the PLC output process image as from which PLC outputs are to be transferred as DP inputs (low byte)
Byte 42	Length of the PLC outputs that are to be transferred as DP inputs
Byte 43	Nominal PLC cycle time (in ms, value range: 1 - 255)
Byte 44	Background execution time (in ms, value range: 1 -255)
Bytes 45,46	Length of the remanant flags (as from MB0, which are stored in the NOVRAM, value range: 1 - 512)

If no bus terminal controllers assume the last programmed value. Remark: the default setting of the User_Prm_Data can be taken from the GSD file.

Configuration

The configuration data to be transferred with the Chk_Cfg service defines which process data is exchanged with the Data_Exchange service.

Identifier	Description
0xB1	2-byte PLC interface

2-byte diagnostic interface

When the 2-byte diagnostic interface is activated, the next identifier in the configuration data must be assigned as follows, as otherwise this identifier is dropped:

Identifier	Description
0xB1	2-byte diagnostic interface

Auto-configuration

Assignment of terminals

When using auto configuration, only those terminals may be considered that have been assigned to the DP process image.

Digital terminals

The data of all digital input or output terminals is combined in one byte array each in the sequence of the slots. The following identifiers can be used for digital data:

Identifier	Description
0x1n	(n+1)-byte digital inputs
0x2n	(n+1)-byte digital outputs
0x3n	(n+1)-byte digital inputs and outputs

These identifiers can be assigned as required so that the total of the input or output bytes each corresponds to the existing data length of digital inputs and outputs (rounded up to 1 byte).
As the digital data is transferred after all analog data, the digital identifiers must be defined after all analog identifiers.

Analog terminals

For each channel, the analog terminals have 8 bits of control or status data and user data. These terminals belong to the intelligent terminals and support register communication (8 bits of control or status data, 16 bits of I/O data per channel). Specific coding in the control or status data defines whether the first 16 bits of the user data are to be interpreted as register communication I/O data.
One code must be defined for each analog terminal or each analog channel. Their sequence depends on the slots.

There are up to 5 different codes per channel for mapping them in the DP process data:

Identifier	Description
A:	Only the value is sent (no register communication possible)
B:	The complete channel is sent (register communication possible)
C:	The value plus control plus status is sent (no register communication possible)
D:	The value plus status is sent (no register communication possible)
E:	The value plus control is sent (no register communication possible)

There are also 2 different identifiers per terminal for mapping them into the process data.

Identifier	Description
F:	Only the values are sent (up to 16 words) (no register communication possible)
G:	All complete channels are sent (up to 16 words) (register communication possible)

Therefore, for each analog channel, the master can decide how much data the respective channel is to occupy in the process image.
As there are also DP masters that write back configuration read out in the slave (e.g. CP5431 from Siemens), bit 2 from register 3 in Table 0 of the bus terminal controller can be set to define whether the Cfg_Data of the Get_Cfg service is to be mapped according to A (bit 2 = 0) or B (bit 2 = 1) (see parametrisation). You have access to this table by way of the KS2000 configuration software.

The DP configuration data for the various terminals is as follows:

Terminal	DP Configuration data
KL3002, KL3012, KL3022, KL3032, KL3042, KL3052, KL3062, KL3202, KL3302	Channel 1 Channel 2 A: 0x50 0x50 B: 0xB2 0xB2 C: 0xC0 0x00 0x82 0xC0 0x00 0x82 D: 0x40 0x82 0x40 0x82 E: 0xC0 0x00 0x81 0xC0 0x00 0x81 Total F: 0x51 G: 0xF2
KL3004, KL3014, KL3024, KL3034, KL3064	Channel 1 Channel 2 Channel 3 Channel 4 A: 0x50 0x50 0x50 0x50 B: 0xB2 0xB2 0xB2 0xB2 C: 0xC0 0x00 0x82 0xC0 0x00 0x82 0xC0 0x00 0x82 0xC0 0x00 0x82 D: 0x40 0x82 0x40 0x82 0x40 0x82 0x40 0x82 E: 0xC0 0x00 0x81 0xC0 0x00 0x81 0xC0 0x00 0x81 0xC0 0x00 0x81 Total F: 0x53 G: 0xF5
KL4002, KL4012, KL4022, KL4032	Channel 1 Channel 2 A: 0x60 0x60 B: 0xB2 0xB2 C: 0xC0 0x82 0x00 0xC0 0x82 0x00 D: 0xC0 0x81 0x00 0xC0 0x81 0x00 E: 0x80 0x82 0x80 0x82 Total F: 0x61 G: 0xF2
KL4004, KL4014, KL4024, KL4034	Channel 1 Channel 2 Channel 3 Channel 4 A: 0x60 0x60 0x60 0x60 B: 0xB2 0xB2 0xB2 0xB2 C: 0xC0 0x82 0x00 0xC0 0x82 0x00 0xC0 0x82 0x00 0xC0 0x82 0x00 D: 0xC0 0x81 0x00 0xC0 0x81 0x00 0xC0 0x81 0x00 0xC0 0x81 0x00 E: 0x80 0x82 0x80 0x82 0x80 0x82 0x80 0x82 Total F: 0x63 G: 0xF5
KL1501	B: 0xB4 G: 0xF2
KL2502	B: 0xB2 G: 0xF2
KL5001	A: 0xD1 B: 0xB4 C: 0xC0 0x00 0x84 D: 0x40 0x84 E: 0xC0 0x00 0x83
KL5101	B: 0xB5 G: 0xF2
KL6001, KL6011, KL6021	B: 0xB5 G: 0xF2

Auto mapping of the PLC inputs and outputs

Once all terminals belonging to the DP process image have been defined, the PLC input and output area mapped into the DP process image now also has to be taken into account in DP configuration data.

In doing so, use must be made of the following identifiers, any number of which can be used. The only restriction is that the length of the respective area must come out at the end (The identifiers need not be entered manually. They can be inserted via a selection list):

Identifier	Description
0x90	1-byte PLC outputs (DP inputs)
0x91	2-byte PLC outputs (DP inputs)
...	...
0x9F	16-byte PLC outputs (DP inputs)
0x40, 0x90	17-byte PLC outputs (DP inputs)
0x40, 0x91	18-byte PLC outputs (DP inputs)
...	...
0x40, 0xBF	64-byte PLC outputs (DP inputs)
0xA0	1-byte PLC inputs (DP outputs)
0xA1	2-byte PLC inputs (DP outputs)
...	...
0xAF	16-byte PLC inputs (DP outputs)
0x80, 0x90	17-byte PLC inputs (DP outputs)
0x80, 0x91	18-byte PLC inputs (DP outputs)
...	...
0x80, 0xBF	64-byte PLC inputs (DP outputs)

Diagnostics

Besides the fixed diagnostics data, external diagnostics data can also be communicated with the Slave_Diag service. In the case of the external diagnostic data, the device-specific diagnostics format is used, in which each diagnostic message occupies 8 bytes. As the device-specific diagnostic data must not be more than 63 bytes long, up to 7 different diagnostics messages can be transferred. If more than 7 different diagnostics messages have occurred, the Ext_Diag_Overflow diagnostics flag is set in the fixed diagnostics data. The Ext_Diag_Data is structured as follows:

Byte No	Description
Byte 0:	Device-specific diagnostics header
Byte 1:	0 (reserved for expansions)
Byte 2 - x:	8 bytes per diagnostics message (x: 9,17,25,33,41,49,57)

Diagnostic messages of the terminals

There is one diagnostics message for each terminal, which is based on the following structure:

Byte No	Description
Byte 0	Terminal No (1-64)
Byte 1	Channel No (1-4)
Byte 2	PLC process image, low byte address
Byte 3	PLC process image, high byte address
Byte 4	PLC process image bit address
Byte 5	Analog terminals: status byte of the terminal Digital terminals: bit 1: short circuit channel 0 short circuit channel 1
Byte 6	(reserved for expansions)
Byte 7	(reserved for expansions)

The PLC process image addresses are entered only if the corresponding tables have been transferred (see Table 80 in the bus coupler).

Diagnostics messages of the bus coupler

Besides the diagnostics messages of the terminals, there are also 2 diagnostics messages of the bus coupler.

Byte No	Description
Byte 0	0
Byte 1	0
Byte 2	Initialisation error
Byte 3	Terminal bus error
Byte 4	Invalid test on bus reset or invalid terminal number in the event of a terminal bus error
Byte 5	Invalid terminal number on bus reset
Byte 6	First terminal number not supported
Byte 7	0

Byte No	Description
Byte 0	0
Byte 1	255
Byte 2	UserPrmData error 0: No error 1: Reserved 2: Input or output data too long 3: Invalid byte or word of the UserPrmData
Byte 3	First invalid byte or word of the UserPrmData
Byte 4	CfgData error 0: No error, 1: Not enough CfgData, 2: Invalid CfgData byte, 3: Error generating the DP process image 4: Error generating the PLC process image (BC3100 only)
Byte 5	Byte 4 = 2: First invalid byte of the CfgData (0 - 63) Byte 4 = 3: 0: Maximum input or output length exceeded 2: Compile buffer in the case of the DP process image is too small Byte 4 = 4: 0: Maximum input or output length exceeded 2: Compile buffer in the case of the PLC process image is too small (BC 3100 only)
Byte 6	0
Byte 7	0

Initialisation error	Description
Bit 0	Error reading out the EEPROMs

Bit 1	Compile buffer is too small
Bit 2	Error checking the programmed configuration
Bit 3	Error reading out the terminal types on the terminal bus
Bit 4	Terminal is not supported
Bit 5	Too many configuration data items
Bit 6	Too many output data items (excessive total of the output data of all terminals)
Bit 7	Too many input data items (excessive total of the input data of all terminals)

If an initialisation error occurs, the fixed dignostics data Stat_Diag flag is set, the result being that no process data cycle is realised on the terminal bus.

Terminal-bus error	Description
Bit 0	Too many errors sending a command on the terminal bus (slave has detected an error while comparing the command and the inverted command)
Bit 1	Too many timeouts during command execution (slave has not acknowledged command execution)
Bit 2	Too many errors of receiving the input data (Master has detected an error when comparing input data and inverted input data)
Bit 3	Too many errors when sending the output data (slave has detected an error when comparing output data and inverted output data)
Bit 4	Error on bus reset
Bit 5	Terminal bus error
Bit 6-7	--

Data exchange

The process data is placed in the input and output data according to the transferred configuration. In doing so, the digital data follows all analog data.

The BC3100 currently supports up to 128 bytes of input or output data.
As it is possible to set, via the configuration interface or the User_Prm_Data whether the user data can be placed in the process image in the INTEL or the MOTOROLA format, these values can be mapped in such a way that word or double word access is possible in the master without byte swapping.

Siemens DP master (IM 308B, IM 308C, CP5431)	
KL3002, KL3012, KL3022, KL3032, KL3042, KL3052, KL3062, KL3202,	A: MOTOROLA B: MOTOROLA C: MOTOROLA D: MOTOROLA

KL3302 **KL3004, KL3014, KL3024, KL3034, KL3064**	E: MOTOROLA F: MOTOROLA G: MOTOROLA
KL4002, KL4012, KL4022, KL4032 **KL4004, KL4014, KL4024, KL4034**	A: MOTOROLA B: MOTOROLA C: MOTOROLA D: MOTOROLA E: MOTOROLA F: MOTOROLA G: MOTOROLA
KL 1501	B: MOTOROLA G: MOTOROLA
KL 2502	B: MOTOROLA G: MOTOROLA

Siemens DP master (IM 308B, IM 308C, CP5431)	
KL5001	A: MOTOROLA B: MOTOROLA C: MOTOROLA D: MOTOROLA E: MOTOROLA
KL 5101	B: MOTOROLA G: MOTOROLA
KL6001, KL6011, KL6021	B: No influence G: No influence

Bosch DP master	
KL3002, KL3012, KL3022, KL3032, KL3042, KL3052, KL3062, KL3202, KL3302 **KL3064** **KL4002, KL4012, KL4022, KL4032**	A: MOTOROLA B: INTEL C: INTEL D: INTEL E: INTEL F: MOTOROLA G: Mapping difficult
KL 1501	B: MOTOROLA G: Mapping difficult
KL 2502	B: MOTOROLA G: Mapping difficult
KL5001	A: Mapping difficult B: INTEL C: INTEL D: INTEL E: INTEL
KL 5101	B: INTEL G: Mapping difficult
KL6001, KL6011, KL6021	B: No influence G: Mapping difficult

The other respective setting is naturally also possible, but leads to a situation in which bytes have to be swapped in the DP Master (or in the PLC) before word or double word access to them is possible. The "difficult to map" comment means that the individual bytes have to be remapped in the DP master, when using both the INTEL and the MOTOROLA formats, to enable individual access to them.

Other DP services

Global_Control

Sync and Freeze mode, both of which are supported by the bus terminal controllers, are controlled with the Global_Control service. Thus, the Clear_Data command is also set, which has the reaction defined in bits 8 and 9 from Register 3 in Table 0 of the bus terminal controller (see Parametrisation).

Set_Slave_Address

For the time being, modification of the station address via the bus is not supported.

Acyclic DPV1 services

The register of terminals and the input, output and flag process image can be accessed acyclically with the DPV1 services. Additionally, the available terminals can be read out and the cycle time can be measured.

The BC3100 supports the MSAC_C1 connection for the DP master class 1 as well as a MSAC_C2 connection for a second master with a maximum PDU length of 52 bytes (48 bytes of data). The significance of Slot_Number and Index for read and write services will be described in the following.

Terminal register (Slot_Number: 1 – 64)

As registers are only available to complex terminals, these are the only ones that must be considered when assigning the Slot_Number. The first complex (analogue) terminal is addressed with Slot_Number = 1, the next with Slot_Number = 2, etc. The Index designates the register number. The number of registers, which are to be read or written, can be determined from the length (in bytes, must be even as the terminal register is built up in words).

Bus coupler (Slot_Number: 0)

Bus controller data are addressed via Slot_Number 0. The following Indexes are thus defined:

Index Read	
0x00	Reserved for AMS
0x01-0x03	Table 9: Terminal designations (Length = 2 – 48 bytes): Index 1: Register 0- 23 Index 2: Register 24 – 47 Index 3: Register 48 – 64
0x21	Cycle times of the PLC (Length = 8 bytes): Word 0: minimum cycle time (in 1/125 ms) Word 1: maximum cycle time (in 1/125 ms) Word 2: actual cycle time (in 1/125 ms) Word 3: average cycle time (in 1/125 ms)
0x80 – 0x8A	PLC outputs (Length = 1 – 48 bytes): Index 0x80: Offset 0 – 47 Index 0x81: Offset 48 – 95 Index 0x82: Offset 96 – 143 Index 0x83: Offset 144 – 191 Index 0x84: Offset 192 – 239 Index 0x85: Offset 240 – 287 Index 0x86: Offset 288 – 335 Index 0x87: Offset 336 – 383 Index 0x88: Offset 384 – 431 Index 0x89: Offset 432 – 479 Index 0x8A: Offset 480 – 511
0x90 – 0x9A	PLC inputs (Length = 1 – 48 bytes): Index 0x80: Offset 0 – 47 Index 0x81: Offset 48 – 95 Index 0x82: Offset 96 – 143 Index 0x83: Offset 144 – 191 Index 0x84: Offset 192 – 239 Index 0x85: Offset 240 – 287 Index 0x86: Offset 288 – 335 Index 0x87: Offset 336 – 383 Index 0x88: Offset 384 – 431 Index 0x89: Offset 432 – 479 Index 0x8A: Offset 480 – 511
0xA0 – 0xAA	PLC flag (Length = 1 – 48 bytes): Index 0x80: Offset 0 – 47 Index 0x81: Offset 48 – 95 Index 0x82: Offset 96 – 143 Index 0x83: Offset 144 – 191 Index 0x84: Offset 192 – 239 Index 0x85: Offset 240 – 287 Index 0x86: Offset 288 – 335 Index 0x87: Offset 336 – 383 Index 0x88: Offset 384 – 431 Index 0x89: Offset 432 – 479 Index 0x8A: Offset 480 – 511

Index Write	
0x00	Reserved for AMS
0x10	Functions (Length = 1 – 3 bytes): Byte 0: 0 – Set write protection (Byte 1, 2 != 0xAFFE), reset (Byte 1 = 0xFE, Byte 2 = 0xAF) Byte 0: 1 – Set manufacturer configuration Byte 0: 2 – Terminal bus reset
0x20	Start cycle time measurement (Word 0 != 0) / stop (Word 0 = 0) (Length = 2 bytes)
0x21	Initialise cycle times of the PLC (Length = 8 bytes): Word 0: minimum cycle time (in 1/125 ms) Word 1: maximum cycle time (in 1/125 ms) Word 2: actual cycle time (in 1/125 ms) Word 3: average cycle time (in 1/125 ms)
0xE0	Write PLC output bytes (Length = 3 – 48 bytes) Byte 0/1: Byte-Offset Byte 2-n: Data
0xE1	Write PLC input bytes (Length = 3 – 48 bytes) Byte 0/1: Byte-Offset Byte 2-n: Data
0xE2	Write PLC flag bytes (Length = 3 – 48 bytes) Byte 0/1: Byte-Offset Byte 2-n: Data
0xE3	Write PLC output bits (Length = 3 bytes) Byte 0/1: Bit-Offset Byte 2: Bit is set (1) / reset (0)
0xE4	Write PLC input bits (Length = 3 bytes) Byte 0/1: Bit-Offset Byte 2: Bit is set (1) / reset (0)
0xE5	Write PLC flag bits (Length = 3 bytes) Byte 0/1: Bit-Offset Byte 2: Bit is set (1) / reset (0)

Read PLC data alternative (Slot_Number: 251-253)

In order that the PLC data can also be read individually, the Slot_Number 251 (PLC outputs), 252 (PLC inputs) and 253 (PLC flag) were defined. The Index designates the Wordoffset in the respective area. Unfortunately, this method of addressing is not supported by all masters.

Annex

Example: a process image in the bus terminal controller

An example explains the assignment of the input and output channels to the PLC process image. The example set up is to consist of the following bus terminal modules.

Whether the data of the analog terminals is to be evaluated completely (i.e. with control/status byte), or whether only the user data is evaluated, is set in the bus terminal controller. Evaluation with control/status byte (complete evaluation) is the default.

In this configuration, the bus terminal controller creates the following allocation lists:

Position	Function module on the rail
POS01	Bus terminal controller
POS02	Digital inputs 2 channels
POS03	Digital inputs 2 channels
POS04	Digital inputs 2 channels
POS05	Digital inputs 2 channels
POS06	Digital inputs 2 channels
POS07	Digital outputs 2 channels
POS08	Digital outputs 2 channels
POS09	Digital outputs 2 channels
POS10	Analog inputs 2 channels
POS11	Analog outputs 2 channels
POS12	Analog outputs 2 channels
POS13	Analog inputs 2 channels
POS14	Infeed terminal
POS15	Digital inputs 2 channels
POS16	Digital inputs 2 channels
POS17	Digital inputs 2 channels
POS18	Digital outputs 2 channels
POS19	Digital outputs 2 channels
POS20	Analog outputs 2 channels
POS21	End terminal

Analog terminals with user data only (no default setting)

All terminals are assigned to the process image of the PLC task. Analog terminals are mapped with user data only. Part for byte-oriented outputs:

Position in block	PLC task Process image	Description
POS11	QW0	Output signal 1st channel
POS11	QW2	Output signal 2nd channel
POS12	QW4	Output signal 1st channel
POS12	QW6	Output signal 2nd channel
POS20	QW8	Output signal 1st channel
POS20	QW10	Output signal 2nd channel

Part for bit-oriented data, digital outputs:

Position in block	PLC Task Process image	Description
POS07	QX12.0	Output signal 1st channel
POS07	QX12.1	Output signal 2nd channel
POS08	QX12.2	Output signal 1st channel
POS08	QX12.3	Output signal 2nd channel
POS09	QX12.4	Output signal 1st channel
POS09	QX12.5	Output signal 2nd channel
POS18	QX12.6	Output signal 1st channel
POS18	QX12.7	Output signal 2nd channel
POS19	QX13.0	Output signal 1st channel
POS19	QX13.1	Output signal 2nd channel

Part for byte-oriented data, analog inputs:

Position in block	PLC task Process image	Description
POS10	IW0	Input signal 1st channel
POS10	IW2	Input signal 2nd channel
POS13	IW4	Input signal 1st channel
POS13	IW6	Input signal 2nd channel

Part for bit-oriented data, digital inputs:

Position in block	PLC task Process image	Description
POS02	IX7.0	Input signal 1st channel
POS02	IX7.1	Input signal 2nd channel
POS03	IX7.2	Input signal 1st channel
POS03	IX7.3	Input signal 2nd channel
POS04	IX7.4	Input signal 1st channel
POS04	IX7.5	Input signal 2nd channel
POS05	IX7.6	Input signal 1st channel
POS05	IX7.7	Input signal 2nd channel
POS06	IX8.0	Input signal 1st channel
POS06	IX8.1	Input signal 2nd channel
POS15	IX8.2	Input signal 1st channel
POS15	IX8.3	Input signal 2nd channel
POS16	IX8.4	Input signal 1st channel
POS16	IX8.5	Input signal 2nd channel
POS17	IX8.6	Input signal 1st channel
POS17	IX8.7	Input signal 2nd channel

Analog terminals complete (default setting)

All terminals are assigned to the process image of the PLC task, and analog terminals are mapped completely.

For an understanding of the subject matter, note that, when complete mapping is set, input terminals (KL3xxx) also have output data and output terminals (KL4xxx) also have input data (3 bytes per channel).

Part for byte-oriented data, analog outputs:

Position in block	PLC task Process image	Description
POS10	QB0	Control byte, 1st channel
POS10	QB1	Blank, owing to word alignment
POS10	QW2	Register value, 1st channel
POS10	QB4	Control byte, 2nd channel

Position in	PLC task	Description

block	Process image	
POS10	QB5	Blank, owing to word alignment
POS10	QW6	Register value, 2nd channel
POS11	QB8	Control byte, 1st channel
POS11	QB9	Blank, owing to word alignment
POS11	QW10	Output signal/ Register value, 1st channel
POS11	QB12	Control byte, 2nd channel
POS11	QB13	Blank, owing to word alignment
POS11	QW14	Output signal/ Register value, 2nd channel
POS12	QB16	Control byte, 1st channel
POS12	QB17	Blank, owing to word alignment
POS12	QW18	Output signal/ Register value, 1st.channel
POS12	QB20	Control byte, 2nd channel
POS12	QB21	Blank, owing to word alignment
POS12	QW22	Output signal/ Register value, 2nd channel
POS13	QB24	Control byte, 1st channel
POS13	QB25	Blank, owing to word alignment
POS13	QW26	Register value, 1st channel
POS13	QB28	Control byte, 2nd channel
POS13	QB29	Blank, owing to word alignment
POS13	QW30	Register value, 2nd channel
POS20	QB32	Control byte, 1st channel
POS20	QB33	Blank, owing to word alignment
POS20	QW34	Output signal / Register value, 1st channel
POS20	QB36	Control byte 2nd channel
POS20	QB37	Blank, owing to word alignment
POS20	QW38	Output signal / Register value, 2nd channel

Part for bit-oriented data, digital outputs:

Position in block	PLC task Process image	Description
POS07	QX40.0	Output signal 1st channel
POS07	QX40.1	Output signal 2nd channel
POS08	QX40.2	Output signal 1st channel
POS08	QX40.3	Output signal 2nd channel
POS09	QX40.4	Output signal 1st channel
POS09	QX40.5	Output signal 2nd channel
POS18	QX40.6	Output signal 1st channel
POS18	QX40.7	Output signal 2nd channel
POS19	QX41.0	Output signal 1st channel
POS19	QX41.1	Output signal 2nd channel

Part for byte-oriented data, analog inputs:

Position in block	PLC task	Description

	Process Image	
POS10	IB0	Status byte, 1st channel
POS10	IB1	Blank, owing to word alignment
POS10	IW2	Input signal/ Register value, 1st channel
POS10	IB4	Status byte, 2nd channel
POS10	IB5	Blank, owing to word alignment
POS10	IW6	Input signal / Register value, 2nd channel
POS11	IB8	Status byte, 1st channel
POS11	IB9	Blank, owing to word alignment
POS11	IW10	Register value, 1st channel
POS11	IB12	Status byte, 2nd channel
POS11	IB13	Blank, owing to word alignment
POS11	IW14	Register value, 2nd channel
POS12	IB16	Status byte, 1st channel
POS12	IB17	Blank, owing to word alignment
POS12	IW18	Register value, 1st channel
POS12	IB20	Status byte, 2nd channel
POS12	IB21	Blank, owing to word alignment
POS12	IW22	Register value, 2nd channel
POS13	IB24	Status byte, 1st channel
POS13	IB25	Blank, owing to word alignment
POS13	IW26	Input signal / Register value, 1st channel
POS13	IB28	Status byte, 2nd channel
POS13	IB29	Blank, owing to word alignment
POS13	IW30	Input signal/ Register value, 2nd channel
POS20	IB32	Status byte, 1st channel
POS20	IB33	Blank, owing to word alignment
POS20	IW34	Register value, 1st channel
POS20	IB36	Status byte, 2nd channel
POS20	IB37	Blank, owing to word alignment
POS20	IW38	Register value, 2nd channel

Part for bit-oriented data, digital inputs:

Position in block	PLC Task Process Image	Description
POS02	IX40.0	Input signal 1st channel
POS02	IX40.1	Input signal 2nd channel
POS03	IX40.2	Input signal 1st channel
POS03	IX40.3	Input signal 2nd channel
POS04	IX40.4	Input signal 1st channel
POS04	IX40.5	Input signal 2nd channel
POS05	IX40.6	Input signal 1st channel
POS05	IX40.7	Input signal 2nd channel
POS06	IX41.0	Input signal 1st channel
POS06	IX41.1	Input signal 2nd channel
POS15	IX41.2	Input signal 1st channel
POS15	IX41.3	Input signal 2nd channel
POS16	IX41.4	Input signal 1st channel
POS16	IX41.5	Input signal 2nd channel
POS17	IX41.6	Input signal 1st channel
POS17	IX41.7	Input signal 2nd channel

Representation of analog signals in the process image

In the standard case, analog signals present themselves as follows: two input bytes or two output bytes of the process image are needed for each analog channel. The two bytes represent the value as an unsigned integer, i.e. 15 bits with a sign. The data format is used independently of the actual resolution. For example: with a resolution of 12 bits for analog values in the positive and negative value ranges the four least significant bits are of no significance.

If the value of the analog signal is only positive, the sign bit (bit 15 MSB) is always "0". In this case, the 12 bits of the analog value are reproduced in bits 14 to 3. The three least significant bits are of no relevance.

Via the configuration interface, it is possible to set the bus controller so that it represents all or individual analog channels in an extended mode. Optionally, the control and status byte of a channel can also be displayed. The least significant bit of three bytes has control and status functions. The further two bytes become inputs and outputs. Various modes can be set with the control byte. The six least significant bits of the control and status byte can be used as addressing bits. Addressing serves to write and read a register set inside the terminal. The register set has 64 registers. The settings are stored in a power fail safe manner.

I/O bytes of an analog channel

Offset 0	Offset 1	Offset 2	Offset 3
Control byte	Blank	Output word Low byte	Output word High byte

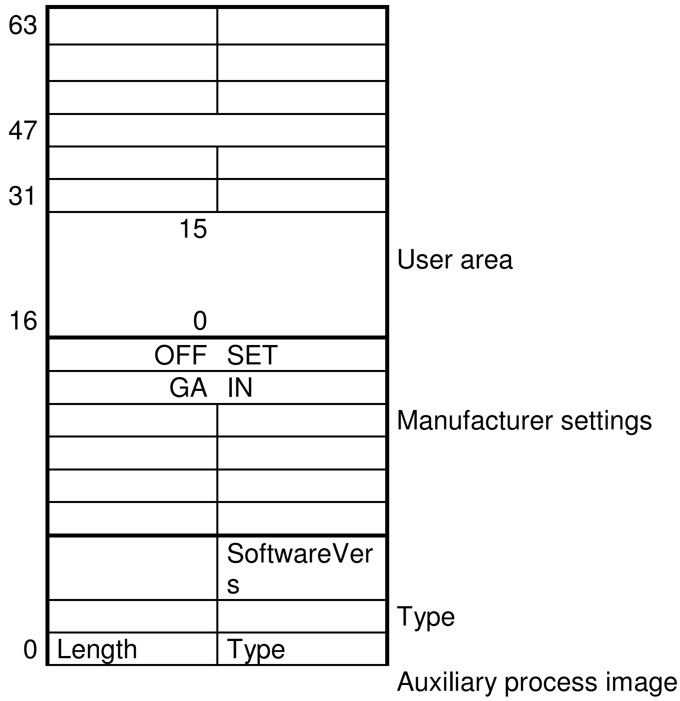
in the process image of the PLC task

Status byte	Blank	Input word Low byte	Input word High byte

Meanings of the control/status byte for access to the register model:

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

Register set of an analog channel



The meanings of the registers and of the status bytes are explained in the corresponding data sheets of the bus terminals. As far as its design is concerned, the module is identical for all bus terminals with more extensive signal processing.

Assignment of terminals in the integrated PLC

By default, in a delivered version of the BC3100 all terminals are assigned to the integrated PLC. As far as mapping of the terminal signals to the PLC process image is concerned, what has been said above applies. The first channel of the first analogue terminal is located at offset 0, in each case for inputs and outputs. By default, the complex terminals are mapped completely and in the INTEL format. As the 80161 processor of the BC3100 can only address words at even addresses, the terminal data is stored in the process image with word alignment.

Example:
1. KL1002
2. KL2012

3. KL3002
4. KL6021 in standard format

PLC inputs:
Offset 0: KL3002, 1st channel status byte
Offset 1: free because of word alignment
Offset 2: KL3002, 1st channel input value-Lo
Offset 3: KL3002, 1st channel input value-Hi
Offset 4: KL3002, 2nd channel status byte
Offset 5: free because of word alignment
Offset 6: KL3002, 1st channel input value-Lo
Offset 7: KL3002, 1st channel input value-Hi
Offset 8: KL6021, status byte
Offset 9: KL6021, 1st receive data byte
Offset 10: KL6021, 2nd receive data byte
Offset 11: KL6021, 3rd receive data byte
Offset 12: KL6021, 4th receive data byte
Offset 13: KL6021, 5th receive data byte
Offset 14: Bit 0: KL1002, 1st channel
Offset 14: Bit 1: KL1002, 2nd channel

PLC outputs:
Offset 0: KL3002, 1st channel Control byte
Offset 1: free because of word alignment
Offset 2: KL3002, 1st channel output value-Lo
Offset 3: KL3002, 1st channel output value-Hi
Offset 4: KL3002, 2nd channel Control byte
Offset 5: free because of word alignment
Offset 6: KL3002, 1st channel output value-Lo
Offset 7: KL3002, 1st channel output value-Hi
Offset 8: KL6021, Control byte
Offset 9: KL6021, 1st send data byte
Offset 10: KL6021, 2nd send data byte
Offset 11: KL6021, 3rd send data byte
Offset 12: KL6021, 4th send data byte
Offset 13: KL6021, 5th send data byte
Offset 14: Bit 0: KL2012, 1st channel
Offset 14: Bit 1: KL2012, 2nd channel

DP process image

Via the User_Prm_Data the terminals can be split up between the PLC process image and DP process image (evaluation takes place in the higher-level system). One area each in the PLC input or output process image can also be defined for transfer via the PROFIBUS. In this case, the data is copied byte-by-byte.

Example:
1. KL1002
2. KL2012
3. KL3002
4. KL6021 in standard format

The KL6021 is to be processed by a higher-level system and must therefore be assigned to the DP process image.
User_Prm_Data[15] = 00101010B
The PLC input bytes 17-23 and the PLC output bytes 22-26 are also to be transferred via the Profibus.

User_Prm_Data[37] = 0
User_Prm_Data[38] = 17
User_Prm_Data[39] = 7
User_Prm_Data[40] = 0
User_Prm_Data[41] = 22
User_Prm_Data[42] = 5

This results in the following configuration data (one of several possibilities):
Byte 0: 0xB5 (KL6021, 6 bytes standard)
Byte 1,2: 0x80,0x86 (7 bytes PLC inputs)
Byte 3,4: 0x40,0x84 (5 bytes PLC outputs)

DP outputs:
Offset 0: KL6021, 1st send data byte
Offset 1: KL6021, 2nd send data byte
Offset 2: KL6021, 3rd send data byte
Offset 3: KL6021, 4th send data byte
Offset 4: KL6021, 5th send data byte
Offset 5: PLC input byte 17
Offset 6: PLC input byte 18
Offset 7: PLC input byte 19
Offset 8: PLC input byte 20
Offset 9: PLC input byte 21
Offset 10: PLC input byte 22
Offset 11: PLC input byte 23

DP inputs:
Offset 0: KL6021, 1st receive data byte
Offset 1: KL6021, 2nd receive data byte
Offset 2: KL6021, 3rd receive data byte
Offset 3: KL6021, 4th receive data byte
Offset 4: KL6021, 5th receive data byte
Offset 5: PLC output byte 22
Offset 6: PLC output byte 23
Offset 7: PLC output byte 24
Offset 8: PLC output byte 25
Offset 9: PLC output byte 26

PLC inputs:
Offset 0: KL3002, 1st channel status byte
Offset 1: free because of word alignment
Offset 2: KL3002, 1st channel input value-Lo
Offset 3: KL3002, 1st channel input value-Hi
Offset 4: KL3002, 2nd channel status byte
Offset 5: free because of word alignment
Offset 6: KL3002, 1st channel input value-Lo
Offset 7: KL3002, 1st channel input value-Hi
Offset 8: Bit 0: KL1002, 1st channel
Offset 8: Bit 1: KL1002, 2nd channel

PLC outputs:
Offset 0: KL3002, 1st channel control byte
Offset 1: free because of word alignment
Offset 2: KL3002, 1st channel output value-Lo
Offset 3: KL3002, 1st channel output value-Hi
Offset 4: KL3002, 2nd channel control byte
Offset 5: free because of word alignment
Offset 6: KL3002, 1st channel output value-Lo
Offset 7: KL3002, 1st channel output value-Hi
Offset 8: Bit 0: KL2012, 1st channel
Offset 8: Bit 1: KL2012, 2nd channel

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