Protocol manual

InterBus Slave

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1	08.05.96	1.000	all	Translation of the german manual (also index 1)
2	21.05.99	1.100	2.5 .. 2.10	PCP description added

Although this protocol implementation has been developed with great care and intensively tested, Hilscher Gesellschaft für Systemautomation mbH cannot guarantee the suitability of this protocol implementation for any purpose not confirmed by us in writing.

Guarantee claims shall be limited to the right to require rectification. Liability for any damages which may have arisen from the use of this protocol implementation or its documentation shall be limited to cases of intent.

We reserve the right to modify our products and their specifiactions at any time in as far as this contributes to technical progress. The version of the manual supplied with the protocol implementation applies.

1 Introduction

The implemantation of the InterBus protocol is documented in this description. It should be noted that the scope of functions described may be limited for some equipment or applications. For protocol conversions in particular, a reduced scope of functions is as a rule used!

2 Introduction to the System and Protocol Fundamentals

The processing of closed loop and open loop control information for machinery and systems with the aid of powerful microchips is widespread in modern automation technology. As a rule, such intelligent units of an automation complex are connected together by one or more communications networks. Within the production facility as a whole, the networks are incorporated in various hierarchical levels, starting with the administration network for the works and ranging up to the network of sensors and actuators in the manufacturing process.

The growing degree of automation and the demand for more and more decentralised units has caused a considerable increase in the quantity of data exchanged in all areas. The establishment of a new concept to accommodate this large flow of data therefore appeared unavoidable.

The lowest hierarchical level in particular, that of sensors and actuators, required the industry to establish a communications network in which the data generated there simultaneously could be transmitted qualitatively and quantitatively as rapidly as possible to the higher level process without the already time critical process sequences noticeably suffering from the transmission speed of the bus.

In the search for a suitable bus system in the field bus area, the parallel transmission process in which each sensor or actuator is connected individually to the higher level controller in a network with star topography was found unsuitable as soon as cost effectiveness calculations revealed that the costs of installation and maintenance exceeded the benefits derived from rapid data transfer.

The only solution here was single cable transmission with serial bus systems, meeting the modern demands for flexible process adaptation and reconfiguration or system expansions.

2.1 Sensor / Actuator Level

As the interface between the real process sequence and the access to the controller via the communications system, the field units used on the sensor / actuator level are divided into two groups. On the one hand, there are "passive" field devices such as limit switches or temperature sensors. With these devices, the condition data can be transmitted direct in digitally encoded form or after analog-digital conversion as process data, and can be processed by the higher level controller without any special setting parameters. On the other hand, the "intelligent" field devices such as frequency converters or closed loop controllers require not only classical I/O handling but also parameterisation facilities, for instance for the measurement range or speed of rotation.

2.1.1 Process Data

Process data indicate the condition of the peripheral devices to be controlled. They are normally also known as I/O data, as they are used bidirectionally to establish peripheral conditions as output data and to form an image of peripheral conditions as input data. The spectrum of the binary I/O data comprises both the simplest switch conditions and complex setpoint and actual value acquisition of an analog nature, resulting in a number of bits of information for each terminal unit. The input data in particular, whose information content changes within milliseconds, require rapid data transfer so that the output data can be used to react as rapidly as possible to changes in inputs. The reaction time is specified by the process time constants and the processing time. The updating of all incoming process data should therefore be handled within a time of approx. 0.5 - 5 ms and with constant periodicity wherever possible.

2.1.2 Parameter Data

The parameter data for setting of a device may comprise only a few bytes or up to a hundred bytes per setting to be made. As a rule, they are only used on commissioning of the equipment and are not to be regarded as critical in terms of time. Here too, a bus system must not permit the additional parameter data to prolong the data transfer unnecessarily or even to cause different cycle times.

2.1.3 Specification

In order to avoid a network of various different bus systems in the light of the differentiated requirements, the paramount objective had to be a global bus development which simultaneously covered the complexity of parameter transfer and conventional I/O data exchange. In response to these requirements, InterBus, whose specification combines the cyclical I/O data exchange with a low data width per station with acyclical communications services involving large quantities of data without compromise, was created in the mid -1980s.

2.2 InterBus Fundamentals

2.2.1 Ring Bus Structure

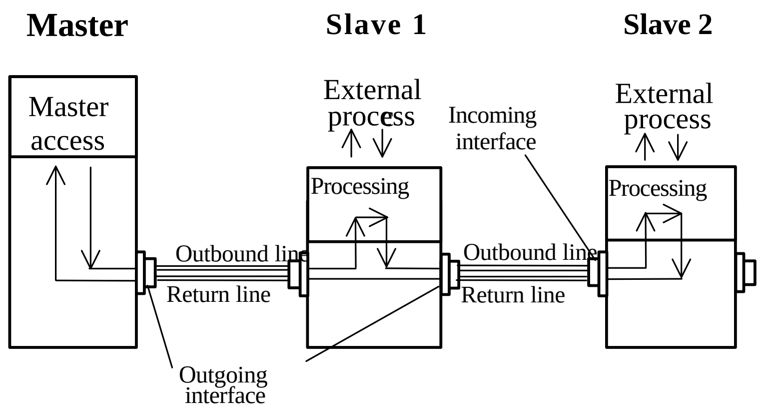
The InterBus uses the master-slave bus access process. In contrast to conventional serial bus system solutions, InterBus is designed as a ring bus. The first slave station in the ring is physically connected direct to the central master via a two core cable, the second slave station connected to the first by a further two core cable. The last slave station is thus connected to the penultimate station and also to the master, thus closing the ring.

2.2.2 Physical Interfaces

The implementation of point to point connections by single cables means that no separate line has to be laid back to the master to close the ring, as each cable contains both a signal and feedback line. As a result of the ring topography, each slave has to be fitted with at least two physical interfaces to implement both the receiving side from the master and the transmitting side towards the master in each interface.

2.2.3 Ring Circuit

The receive data from the return line at the outgoing interface are passed on by each slave through the return line of the incoming interface without alteration to the data. The physically last slave station is thus directly connected to the master. The figure below illustrates this seemingly complex configuration.



The physical point to point connections of the InterBus

2.3 Characteristics of the InterBus System

2.3.1 Full Duplex Transmission

The send and receive lines are separate at each interface, which facilitates simultaneous transmission and receiving of data within one bus access in the ring system (Full Duplex). This results in a double transmission speed, as the usual message handshake is dispensed with. At the same time, the signal passed back to the master is also electrically conditioned at each station before it is passed on. As both signals are accommodated in a single cable, there is no need to lay a line back from the last station to the master.

2.3.2 Differential Signal Transmission to RS422

The RS422 transmission system used, with establishment of the signal level by means of the line differential signal, is regarded as a particularly interference proof transmission method and makes the InterBus almost resistant to interference peaks and the resulting transmission errors in today's harsh industrial environments. Transmission lines of up to 400 m between two stations on the bus can therefore be safely used.

2.3.3 Active Return Circuit

In the InterBus, the data signal is transmitted back to the master through every station and electrically conditioned. This theoretically permits an infinite extension for the overall structure of the field bus. Normally, a total system length of up to 12.8 km is guaranteed.

2.3.4 Active Coupling

The ring structure with active coupling stations with three interfaces facilitates the segmentation of the network as a whole into physically independent partial systems.

In the case of a line break or even a short circuit in one segment, bus operation is temporarily disrupted. Diagnosis functions at the master interface assembly can locate the source of the error and shut down the faulty segment.

The search for the fault location is limited to the faulty segment displayed by the master system, thus relieving the user of time consuming searches through the entire bus network.

2.4 Transmission Process

The protocol mechanism of the InterBus is based on sum frame messages. The bus master uses these to transmit all output data to the slaves in one bus cycle and, simultaneously in the same cycle, receives all the input data from the slaves through the ring structure. The request to the slaves to send input data is thus implicit in the output data transmitted by the master.

Each slave station occupies a precisely stipulated data length in the InterBus sum frame, and therefore each station can be assigned an unequivocal location in the sum frame message and in the process data image at the master. Inconvenient assignment of addresses to distinguish between the slaves and transmission of the bus address in the frame data are therefore unnecessary.

2.4.1 Sum Frame Message

Each slave has an internal bus shift register of a constant size. At the start of the transmission cycle, all the slave stations load their input data into this shift register. The slaves in sequence in the ring thus create a huge memory which holds the data for the system by the first in first out method. The master transmits all the output data for the slaves into the ring in sequence during the cycle. With the shift register structure in each slave, the output data are transported through the entire ring, pushing the slave input data out of the ring. At the end of the cycle, all the output data are in the shift registers of the slaves and all the input data in the master.

2.4.2 Data Cycle

In the data cycle, the input data which are transmitted to the master are process data from the current status of the slave input peripherals. These process data are passed on by the master at the end of the cycle to the higher level controller as a block. The output data arriving at the slaves are used for process control and are passed on to the connected slave output peripherals at the end of the cycle.

Slave stations with communications capability and having parameter data channels (**P**eripherals **C**ommunication **P**rotocol) have an extended shift register through which the parameter communications services are transacted. The expansion normally comprises 2 bytes, so as not to extend the InterBus shift register unnecessarily.

The additional PCP data are thus also imaged in the sum frame message, but they are evaluated selectively by the master and removed from the process receive memory or inserted in the process send memory. Parameter data which are to be transmitted to a slave are handed over to the master as a block. The master inserts the data block in the parameter registers of the slaves by splitting it up into small data packages. If a slave module transmits data through the parameter channel, the data packages are grouped together cycle by cycle to form a block and then passed on to the higher level controller.

2.4.3 Identification Cycle

In the identification cycle, the master loads the identification codes of the slaves in place of the input data. It can determine the identity and length codes from these. In addition, the master detects the number of slaves connected. The slave output data in the identification cycle are slave control codes from the master.

2.4.4 Status Messages

Status messages are transmitted by the master in cycle breaks or between the messages of the identification or data cycle. They do not contain any user data, and are passed on by each slave to the following slave without any effect on the shift register. Status messages therefore signal master activity to all stations and maintain communications in the breaks between cycles.

If a slave station detects the connection to the master by incoming status messages, it activates the green RC LED (Remotebus Check LED). Even before start up of the network, it can be seen by the condition of the LED on the relevant slave whether the connection to the master has at least physically been established.

2.4.5 CRC Test process

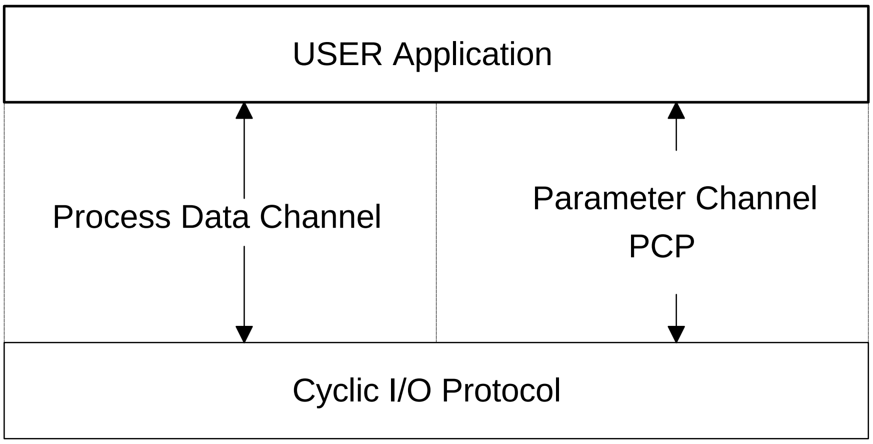
The InterBus protocol uses cyclic redundancy checks for error detection in the transmission cycle. All stations use a polynomial to calculate a checksum from all data bits, in both the incoming and outgoing directions. After each cycle, starting with the master, the checksum is passed from module to module and checked in every slave module. Slave modules do not accept any output data when they have detected an incorrect checksum. The error detection by a module is passed back to the master through the InterBus ring loop. The master then starts a new cycle with the latest data. With the aid of the CRC check, the InterBus transmission protocol achieves a Hamming distance of 4.

2.5 PCP System Achitecture

2.5.1 Communication Structure

Additional to the cyclic process data channel the PCP protocol software (**P**eripherals **C**ommunication **P**rotocol) manages the exchange of complex data blocks for parametriziation purposes between communication partners using a standard form.

Both the process data channel and the PCP data channel build the communication structure of the InterBus system. See follwoing figure:



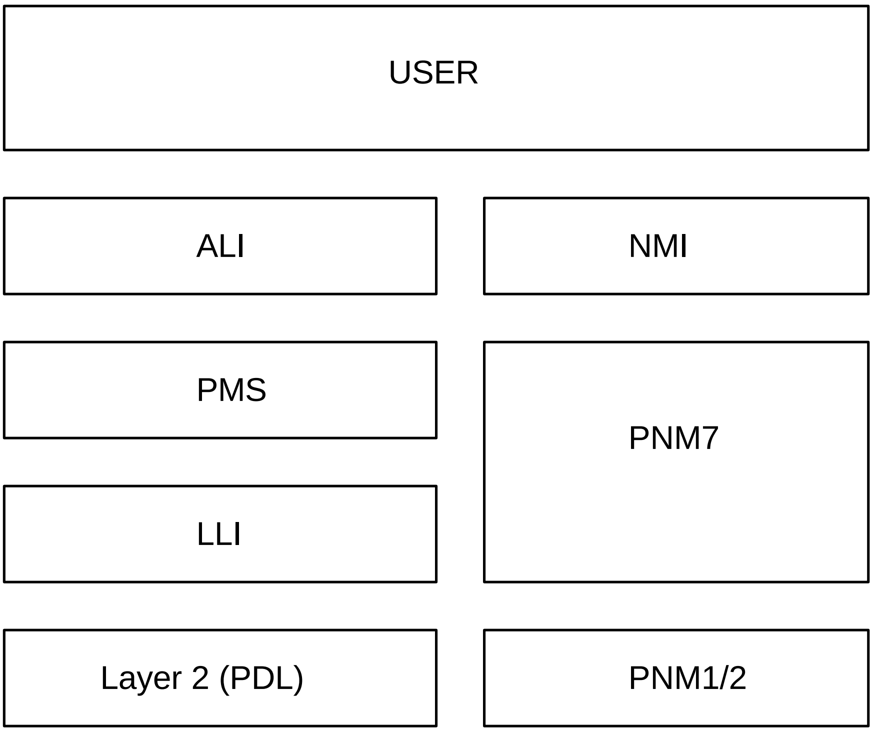
Communication Structure

The PCP protcol covers the high level of Layer 2 and the whole Layer 7 of the ISO model for open communication. The parts of Layer 2, which controls the cyclic medium access (MAC) and the low level data consistence, are integrated within the InterBus protocol chip (SUPI).

To transmit complex data blocks in a sequential manner the part of the software for the Layer 2 uses the interface which is available from the SUPI protocol chip. This part of the software is seperated into two blocks: one to process the Layer 2 services and one to process the cyclic I/O protocol. This block is called PDL-MAC. The second block realises the interface for the on top layer and supports a buffered mechanism to process requested services. This block is called Request Block Interface.

The funtions of the Layers 3 to Layer 6 are combined to the so called Lower Layer Interface (LLI). The LLI here is part of the Layer 7 because of effency purposes.

Additional the PCP software contains a common interface to the user application: The Application Layer Interface (ALI) and the Network Manager Interface (NMI).



PCP System Architecture

ALI:	Application Layer Interface
PMS:	Peripherals Message Specification
LLI:	Lower Layer Interface
PDL:	Peripherals Data Link
NMI:	Network Management Interface
PNM7:	Peripherals Network Management Layer 7
PNM1/2:	Peripherals Network Management Layer 1/2

The PMS, LLI, NMI, PNM7, and PNM1/2 are controled by a Scheduler and a Memory Manager, which is responsible for the system resources.

2.6 Signal Functions of Slave Modules

Communications in the InterBus are designed in such a way that apart from the input data only the identification codes of the slave modules can be read by the master system. For this reason, there are three reserved bits in the identification code for each slave, which are used to signal the following statuses to the master system:

- CRC Error
- Module Error
- Reconfiguration Error

The CRC error bit is used by each slave module to signal a CRC error detected by the relevant module in the last identification or data cycle. The master system can read the identification code and thus precisely locate the error location on the bus.

If a slave module signals a module error, the module has either detected a failure of the peripheral power supply or a short circuit at at least one of the peripheral inputs or outputs. The communications capability of the other slave modules in the network is not in general affected by the error, and bus operation can continue normally.

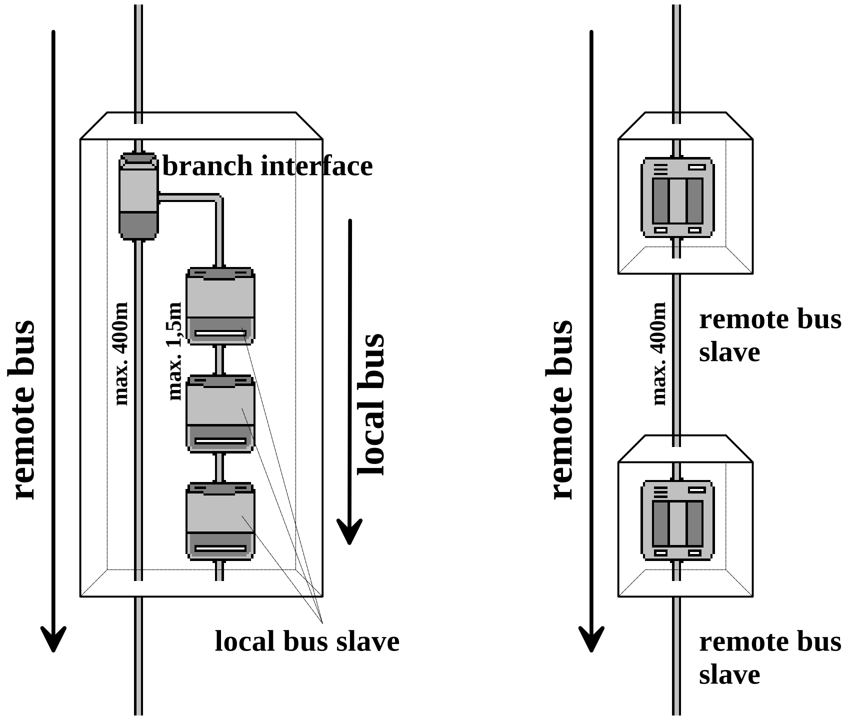
Bus terminals normally have an external reconfiguration button. If this button is pressed locally at the module, the module signals the corresponding reconfiguration request to the master system in the relevant bit of its ID code. The reconfiguration bit thus signals the request to restore the current configuration to the master firmware and thus to the application program or diagnosis tool.

2.7 Station Classes

The station classes on the InterBus comprise remote bus slaves, peripheral bus slaves and bus terminals. Remote bus slaves and peripheral bus slaves function as I/O modules establishing the connection between the sensors or actuators and the bus system.

Whereas remote bus slaves and bus terminals are located on the central bus cable from the master, peripheral bus slaves can only be looped into the ring in sub-ring systems of a local nature via bus terminals. The peripheral bus is used to establish decentralised sub-stations in switchgear cabinets, with a maximum line length of 1.5 m between the modules.

The main line between the bus terminals and remote bus slaves is used to cover the great distances between the decentralised subsystems. A length of 400 m between two stations must not be exceeded.



Remote bus- and local bus structure

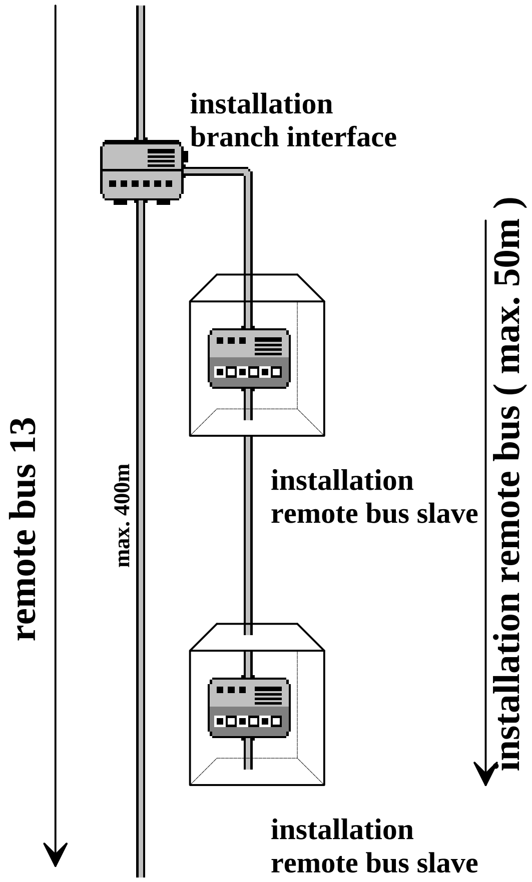
The peripheral side of the relevant I/O module has its own supply volt age and is electrically isolated from the bus logic.

- Failure or shutdown of the peripheral power does not lead to shutdown of the peripheral system.
- Failure of the power supply to the module leads to a stop of the bus system and resetting of the module outputs.

In contrast to all other stations, bus terminals have two communications interfaces and do not as a rule have any inputs and outputs of their own.

Depending on the version of the secondary line, the spur is known as an installation remote bus or peripheral bus. A bus terminal which leads to an installation remote bus is designated an installation remote bus terminal, and the modules connected in the spur as installation remote bus slaves.

The topology of the installation remote bus corresponds to that of a remote bus. In contrast to the peripheral bus, it is possible to cover greater distances in the spur between the individual modules. The supply voltage for the module electronics in the installation remote bus cable limits its maximum distance to 50 m.



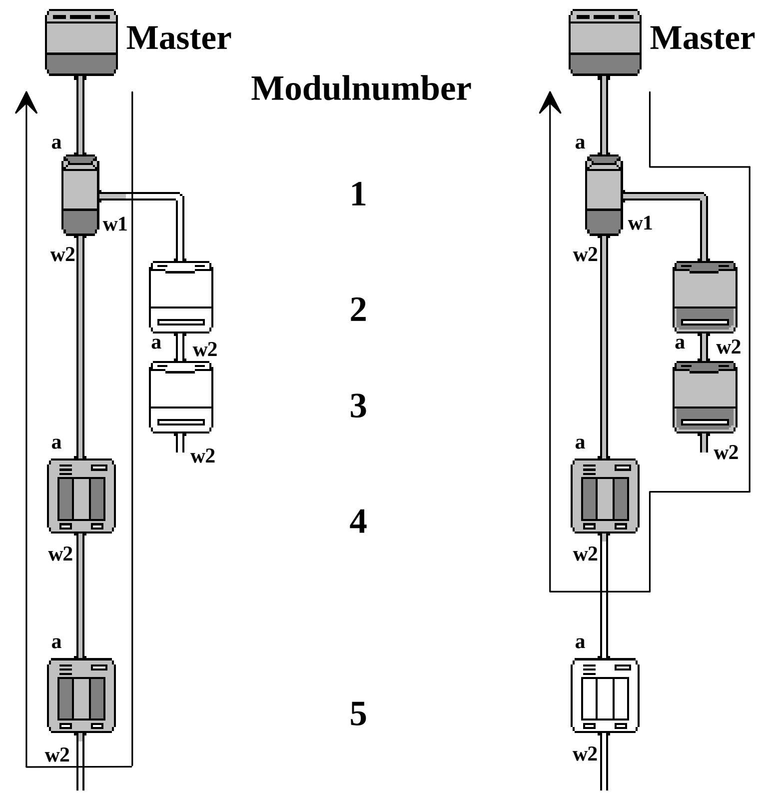
The installation remote bus

2.8 Segmentation of InterBus

Control codes can be used to connect or disconnect the interfaces of the remote bus slaves and the bus terminals.

To distinguish between the outgoing interfaces, these are marked 'w1' = outgoing interface 1 and 'w2' = outgoing interface 2. The incoming interface of each station is marked with 'a'.

The counting sequence starts at the first slave module after the master system. The w1 interface of a slave module - assuming it is supported by the module - is located physically in front of the w2 interface. This means that in the numerical sequence, modules which are looped into the InterBus ring through the w1 interface have priority over modules which are connected via the w2 interface in the previous module.



Segmentation of the InterBus ring by connection or disconnection of interfaces

It is to be noted that a peripheral bus can only be put into operation as a complete segment, as the peripheral modules do not have any interface switching facilities.

If an outgoing interface 'w2' in the remote bus or installation remote bus is disconnected, all the modules connected to that interface can no longer be operated and are automatically deactivated.

2.9 Connection Process

Before the actual exchange of user data between the master and the slave stations, the InterBus network first has to be activated by the master.

This is done by reading the identity and length codes of each connected station in identification cycles and connection and disconnection of the individual bus segments. If no new station is detected in the last identification cycle, the connection process is complete. The entire network constellation is stored in an internal configuration list in the master.

After the connection process, a comparison is made between the detected configuration list and that specified by the application program. This ensures that the bus configuration corresponds to the actual conditions. Only if this is so does the master enable user data exchange.

2.10 Physical Bus Data in Brief

Remote bus Data transfer with RS422
No power supply in the bus cable

- Maximum length of bus cable between:

master and first remote bus station	400m
two remote bus stations	400m
master and last remote bus station	12.8 km

Installation remote bus Data transfer with RS422
Power supply to modules in cable

- Maximum total current consumption 4.5A
- Maximum length of bus cable between:

bus terminal and first I/O module	50 m
two I/O modules	50m
bus terminal and last I/O module	50m

Peripheral bus Data transfer with TTL signal
Power supply to modules in cable

- Maximum number of modules 8
- Maximum length of bus cable between:

bus terminal and first peripheral bus module	1.5 m
two peripheral bus modules	1.5m
bus terminal and last peripheral bus module	10 m

3 Configuration of InterBus Slave

In order to ensure InterBus communications via the InterBus master, the InterBus slave module has to be configured first in its configuration data. From this configuration data the real data width of the slave in its both process data areas in the dualport memory and the bus constellation and configuration, which are transferred during the identification cycle of the master, are derived.

Without being configured the slave module represents an InterBus participant without input and output data with an identcode 08dec and a lengthcode 00dec. These both codings classifies it as a remote bus slave with no input and output data.

3.1 Identity and Length Codes for Slave Stations

The master must be aware of the identity and length codes of the slaves for data exchange with them:

Identity Code	Unequivocally marks the station class of the InterBus station. Is either printed on the relevant module (Module Ident: xx) or can be found in a general table of the InterBus stations.
Length Code	Indicates the data width occupied by the module on the InterBus in coded form. Is either printed on the relevant module or can be taken from the general table of InterBus stations.

3.2 Identidy Code and Length Code of the Device

3.2.1 Identity Code

- 03h Digital I/O (default)
- 0Fh 2 Words PCP channel

3.2.2 Length Code

The length codes supported by the slave module are stated in the following table. The length codes for special functions contain not only the data width but also encoded additional information which is not required for the actual exchange of data on the InterBus.

Slave Length Code as Parameter	Real Data Width of the Slave in Byte
0	Reserved
1	2
2	4
3	6
4	8
5	10
6	16
7	18
8	Reserved
9	1
10 .. 13	Reserved
14	12
15	14
16-20	Reserved
21	20
22-255	Reserved

Data Width and Length Codes