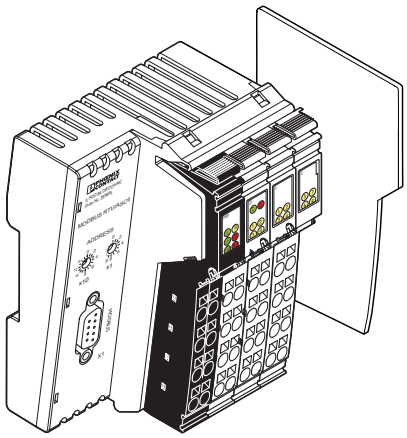
IL MOD BK DI8 DO4-PAC

Inline bus coupler for Modbus with eight digital inputs and four digital outputs



AUTOMATION

Data sheet
7258_en_03

1 Description

The bus coupler is the link between the Modbus RTU/ASCII system and the Inline installation system.

Up to 61 Inline terminals can be connected in any position to an existing Modbus RTU/ASCII system using the bus coupler. The bus coupler and the Inline terminals form one station with a maximum of 63 local bus devices. Here, the inputs and outputs of the bus coupler together form the first and second local bus devices.

Up to eight PCP devices can be operated on the bus coupler.

Features

- Modbus RTU/ASCII
- Modbus connection via 9-pos. D-SUB female connector
- Interface physics RS-485 for Modbus
- Electrical isolation of Modbus interface and logic
- Data transmission speed of 1.2 kbps to 115.2 kbps (configurable)
- Rotary encoding switches for setting the Modbus address and for configuration
- Supported Modbus addresses 1 to 99
- Up to 8 PCP devices can be connected
- Eight digital inputs
- Four digital outputs
- Diagnostic and status LEDs
- Automatic baud rate detection on the local bus (500 kbps or 2 Mbps)

WARNING: Explosion hazard when used in potentially explosive areas
When using the terminal in potentially explosive areas, observe the corresponding notes on page 11.

Make sure you always use the latest documentation.
It can be downloaded at www.phoenixcontact.net/download.

The intelligent wiring method used by Inline terminals enables the station to be created quickly and easily, since, e.g., time-consuming wiring of the terminal power supply is not required.

In the simplest case, it is only necessary for the power supply units integrated in the bus coupler to be supplied with 24 V DC on the input side. They then generate the required operating voltages for the bus coupler and the connected Inline terminals.

The end plate is supplied with the bus coupler. Place this plate at the end of the Inline station. The end plate has no electrical function. It protects the station from ESD pulses and the user from dangerous contact voltage.

Table of contents

2 Ordering data

Product

Description	Type	Order No.	Pcs./Pkt.
Inline bus coupler for Modbus RTU/ASCII with eight digital inputs and four digital outputs; complete with accessories (end plate, Inline connector, and labeling fields)	IL MOD BK DI8 DO4-PAC	2878696	1

Accessories: Additional system components

Description	Type	Order No.	Pcs./Pkt.
FO interface converters for fiber optic data conversion and transmission (see INTERFACE catalog)			
Power supply units for supplying the bus coupler (see INTERFACE catalog)			

Accessories: Connectors

Description	Type	Order No.	Pcs./Pkt.
SUBCON connector	SUBCON-PLUS-MODBUS/IL/BK	2310808	1
Connector set for Inline bus coupler with aligned I/Os (as replacement item)	IL BKDIO-PLSET	2778599	1

Accessories: Other

Description	Type	Order No.	Pcs./Pkt.
Quick mounting end clamp for securing the module/Inline station on the DIN rail for a horizontal mounting position; to the right and left of the module/Inline station	CLIPFIX 35-5	3022276	50
End clamp for securing the module/the Inline station on the DIN rail for a vertical mounting position; above and below the module/Inline station	E/AL-NS 35	1201662	10
Keying profile	IL CP	2878696	100
Zack marker strip to label the terminals	ZB 6 ... see CLIPLINE catalog ZB 12 ... see CLIPLINE catalog		
DIN EN 50022 DIN rail, 2 meters	NS 35/7,5 PERF NS 35/7,5 UNPERF	0801733 0801681	1 1

Documentation

Description	Type	Order No.	Pcs./Pkt.
"I/O terminals at bus couplers" application note	AH IL BK IO LIST	9015358	1
"Automation terminals of the Inline product range" user manual	IL SYS INST UM E	2698737	1
"Inline terminals for use in zone 2 potentially explosive areas" application note	AH EN IL EX ZONE 2	7217	1
"Peripherals Communication Protocol (PCP)" user manual	IBS SYS PCP G4 UM E	2745169	1
"Firmware services and error messages" user manual	IBS SYS FW G4 UM E	2745185	1
"Hardware and firmware manual for the FL IL 24 BK/FL IL 24 BK-PAC Ethernet/Inline bus terminal" user manual	FL IL 24 BK-PAC UM E	9014205	1

3 Technical data

General data	
Housing dimensions (width x height x depth)	80 mm x 119.8 mm x 71.5 mm
Weight	320 g (with connectors)
Ambient temperatures (operation)	-25°C ... +60°C
Ambient temperature (storage)	-45°C ... +85°C
Humidity (operation/storage/transport)	10% ... 95% (according to DIN EN 61131-2)
Air pressure (operation/storage/transport)	70 kPa to 106 kPa (up to 3000 m above sea level)
Degree of protection	IP20
Protection class	Class III according to EN 61131-2, IEC 61131-2
Response time (aligned I/Os)	4 ms, typical

Connection data	
Designation	Inline I/O connector
Connection method	Spring-cage connection
Conductor cross-section	0.08 mm^2 ... 1.5 mm^2 (solid or stranded), 28 - 16 AWG
Conductor cross section [AWG]	28 ... 16

Interface: Inline local bus	
Connection method	Inline data jumpers
Transmission speed	500 kbps, 2 Mbps (automatic detection, no combined system)

Interface: Modbus	
Connection method	9-pos. D-SUB female connector (electrically isolated supply; shielding directly connected to functional earth ground)
Number of positions	9
Transmission speed	1.2 kbps to 115.2 kbps (configurable)

System data of the bus coupler	
Number of supported devices	63, maximum (per station)
Number of connectable local bus devices	61, maximum (on board I/Os are two devices)
Number of devices with parameter channel (PCP)	8, maximum

Supply voltage for U_{BK}, U_S, U_M	
Recommended cable lengths	30 m, maximum; do not route cable through outdoor areas
Continuation	Through potential routing
Nominal value	24 V DC
Permissible range (according to EN 61131-2)	19,2 V to 30 V (ripple included)

NOTE: Electronics may be damaged when overloaded

Provide external fuses for the 24 V areas UL, US, and UM. The power supply unit must be able to supply four times the nominal current of the external fuse, to ensure that it trips in the event of an error.

Communications power U_L (7.5 V) and the analog supply U_{ANA} (24 V) are generated from the bus coupler supply U_{BK}.

Power consumption	
Current consumption from U_L (7.5 V)	0.07 mA, typical/0.8 A, maximum
Current consumption from U_S (24 V)	8 A, maximum
Current consumption from U_M (24 V)	8 A, maximum
Current consumption from U_{ANA} (24 V)	0.5 A, maximum
Power dissipation	1.7 W, typical

Digital inputs	
Number	8
Connection method for sensors	2 and 3-wire technology
Input design	According to EN 61131-2 Type 1
Definition of switching thresholds	
Maximum low-level voltage	U_{Lmax} < 5 V
Minimum high-level voltage	U_{Hmin} > 15 V
Common potentials	Sensor supply U_S, ground
Nominal input voltage U_{IN}	24 V DC
Permissible range	-30 V < U_{IN} < +30 V DC
Nominal input current for U_{IN}	3 mA, typical
Current flow	Limited to 3 mA, maximum
Response time	1.2 ms, typical
Permissible cable length to the sensor	100 m

Digital outputs	
Number	4
Connection method for actuators	2 and 3-wire technology
Nominal output voltage U_{OUT}	24 V DC
Differential voltage at I_{nom}	< 1 V
Nominal current I_{nom} per channel	0.5 A
Total current	2 A
Nominal load	
Ohmic	12 W
Lamp	12 W
Inductive	12 VA (1.2 H)
Switching frequency with nominal inductive load	0.5 Hz (1.2 H), maximum
Response time	1.2 ms, typical
Overload response	Auto restart
Response with inductive overload	Output may be damaged
Reverse voltage protection against short pulses	Protected against reverse voltages
Resistance to permanently applied reverse voltages	Protected against reverse voltages, permissible current 2 A, maximum
Response upon power down	The output follows the supply voltage without delay.
Limitation of the voltage induced on circuit interruption	-30.0 V, approximately
Maximum output current when switched off	10 µA (When not loaded, a voltage can be measured even at an output that is not set.)

Protection	
Supply	
Surge voltage, polarity reversal	Suppressor diode parallel to supply voltage
Digital inputs	
Polarity reversal	Diode for protection against polarity reversal
Digital outputs	
Short circuit protection, overload protection	Free running circuit

Error messages to the higher-level control or computer system	
Short circuit/overload of the digital outputs	Yes
Sensor supply not present	Yes

Mechanical tests	
Vibration resistance according to IEC 60068-2-6	5g
Shock test according to IEC 60068-2-27	Operation: 25g, 11 ms period, half-sine shock pulse

Conformance with EMC directive 2004/108/EC

Noise immunity test according to EN 61000-6-2

Electrostatic discharge (ESD)	EN 61000-4-2/ IEC 61000-4-2	Criterion B 6 kV contact discharge 8 kV air discharge
Electromagnetic fields	EN 61000-4-3 IEC 61000-4-3	Criterion A Field strength: 10 V/m
Fast transients (burst)	EN 61000-4-4/ IEC 61000-4-4	Criterion A All interfaces: 1 kV Criterion B All interfaces: 2 kV
Surge voltage	EN 61000-4-5/ IEC 61000-4-5	Criterion B DC supply lines: 0.5 kV/1 kV (symmetrical/asymmetrical) Fieldbus cable shielding 1 kV
Conducted interference	EN 61000-4-6 IEC 61000-4-6	Criterion A Test voltage 10 V

Noise emission test according to EN 61000-6-4

Noise emission of housing	EN 55011	Class A

Approvals

For the latest approvals, please visit www.phoenixcontact.net/download.

4 Basic circuit diagram

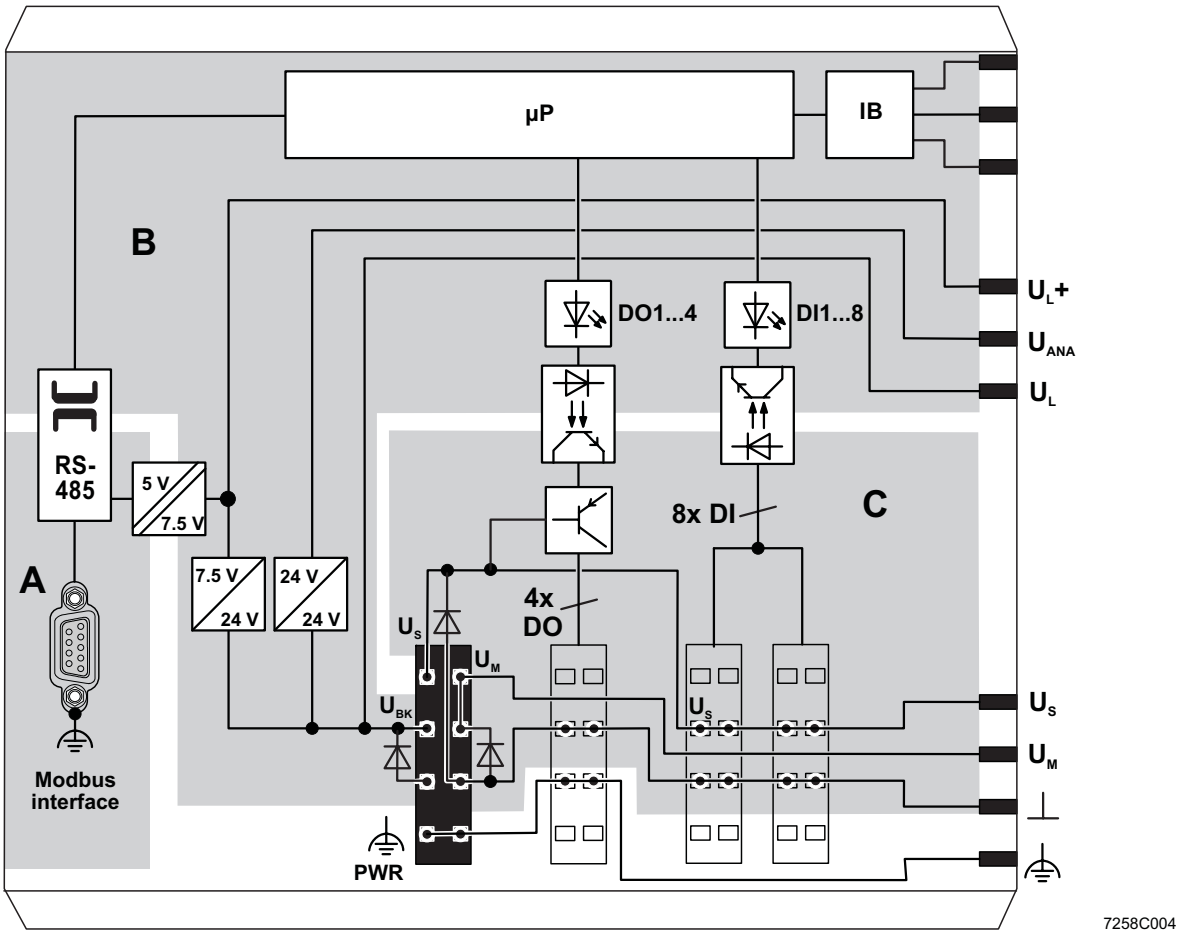


Figure 1 Basic circuit diagram for the bus coupler

Key:

µP	Microprocessor
IB	Protocol chip
	Optocoupler
	Power supply unit with electrical isolation
RS 485	RS-485 interface driver with electrical isolation
	PNP transistor

The gray areas in the basic circuit diagram represent the electrically isolated areas:

A: Modbus interface
B: Logic
C: I/O

5 Local diagnostic and status indicators

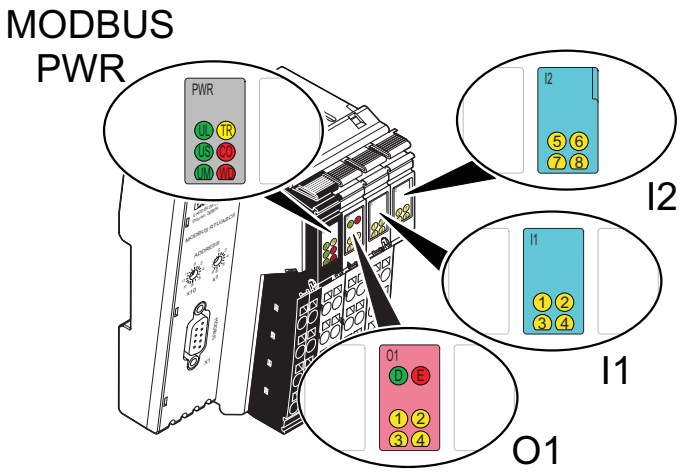


Figure 2 Indicators on the bus coupler

LED	Color	Meaning	State	Description of the LED states
PWR				
UL	Green	$\mathbf{U}_{\text{Logic}}$	ON	24 V bus coupler supply/7.5 V communications power present
			OFF	24 V bus coupler supply/7.5 V communications power not present
US	Green	$\mathbf{U}_{\text{Segment}}$	ON	24 V segment circuit supply present
			OFF	24 V segment circuit supply not present
UM	Green	$\mathbf{U}_{\text{Main}}$	ON	24 V I/O supply present
			OFF	24 V I/O supply not present
TR	Yellow	**TR**affic	ON	Data exchange at the RTU/ASCII interface
			OFF	No data exchange at the RTU/ASCII interface
CO	Red	**CO**nfiguration	ON	The active station configuration differs from the saved configuration
			OFF	The active station configuration matches the saved configuration.
WD	Red	**W**atch**D**og	ON	Time between two Modbus telegrams exceeded during active connection monitoring (Modbus telegram watchdog)
			Flashing at 2 Hz	On power on reset: Reading in new parameters
			Flashing at 0.5 Hz	On power on reset: Parameters transferred successfully
			Flashing at 5 Hz	On power on reset: Parameters not transferred
			OFF	No error

LED	Color	Meaning	State	Description of the LED states
O1				
D	Green	**D**iagnostics	ON	Data transmission active within the station
			Flashing at 0.5 Hz	Data transmission not active within the station
E	Red	**E**rror	ON	Short circuit/overload of local outputs
			OFF	No short circuit/overload of local outputs
1 - 4	Yellow	Output **1** to output **4**	ON	Outputs are active
			OFF	Outputs are not active
I1, I2				
1 - 8	Yellow	Input **1** to input **8**	ON	Inputs are active
			OFF	Inputs are not active

Error message sent to the higher-level control system

– Sensor supply not present (peripheral fault)
– Short circuit/overload at an output (peripheral fault)

See also "Local bus diagnostic status register (7997)" on page 27.

6 Connecting Modbus, power supply, actuators, and sensors

6.1 Connecting Modbus

Connect Modbus to the bus coupler using a 9-pos. D-SUB connector (see "Ordering data" on page 3). For the pin assignment, please refer to the figure and the table.

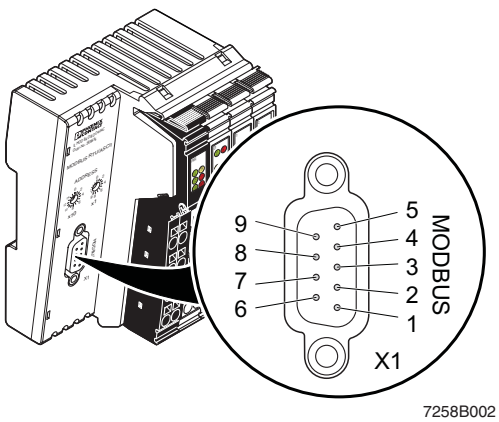


Figure 3 Pin assignment of the 9-pos. D-SUB female connector

Pin	Assignment
1	Reserved
2	Reserved
3	RxD/TxD-P (receive/transmit data +), cable B
4	CNTR-P (control signal for repeater), direction control
5	DGND (reference potential to 5 V)
6	VCC
7	Reserved
8	RxD/TxD-N (receive/transmit data –), cable A
9	Reserved

6.2 Mains termination resistors

The use of this SUBCON connector ensures that the cable termination meets the Modbus RTU/ASCII specification.

6.3 Terminal point assignment of input and output connectors

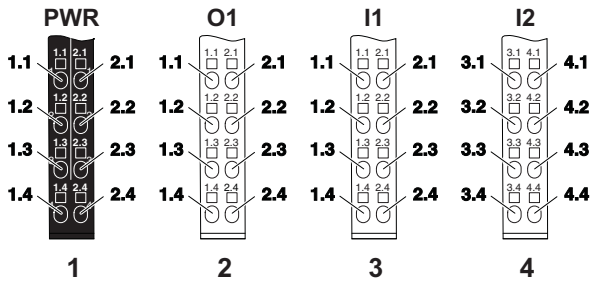


Figure 4 Terminal point assignment

Terminal point assignment of the power connector (1)

Terminal points	Assignment	Terminal points	Assignment
1.1	U_S	2.1	U_M
1.2	U_L	2.2	U_M
1.3	GND U_L	2.3	GND U_M, U_S
1.4	Functional earth ground (FE)	2.4	Functional earth ground (FE)

Terminal point assignment of the output connector (2)

Terminal points	Assignment	Terminal points	Assignment
1.1	OUT1	2.1	OUT2
1.2	PGND	2.2	PGND
1.3	FE	2.3	FE
1.4	OUT3	2.4	OUT4

Terminal point assignment of the input connector (3)

Terminal points	Assignment	Terminal points	Assignment
1.1	IN1	2.1	IN2
1.2	U_S	2.2	U_S
1.3	PGND	2.3	PGND
1.4	IN3	2.4	IN4

Terminal point assignment of the input connector (4)

Terminal points	Assignment	Terminal points	Assignment
3.1	IN5	4.1	IN6
3.2	U_S	4.2	U_S
3.3	PGND	4.3	PGND
3.4	IN7	4.4	IN8

7 Connection example

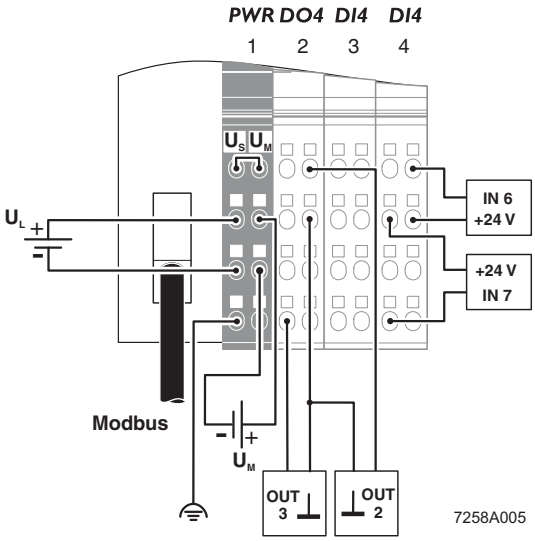


Figure 5 Connection example

8 Notes on using the terminal in potentially explosive areas

WARNING: Explosion hazard

Before startup, ensure that the following points and instructions have been observed.

Approval according to EC directive 94/9

II 3G Ex nA IIC T4 X

Installation notes

1. This Inline terminal can be installed in zone 2.
2. The Inline terminal must only be installed, operated, and maintained by qualified personnel.
3. Please follow the installation instructions given in the IL SYS INST UM E user manual and the package slip.
4. When installing and operating the device, the applicable safety directives (including national safety directives), accident prevention regulations, as well as general technical regulations, must be observed.
5. Please refer to the corresponding documentation (user manual, data sheet, package slip) and the certificates (EC type examination and other approvals, if applicable) for safety-related data.
6. It is not permitted to access the circuits inside the Inline terminal. Do not repair the Inline terminal by yourself but replace it with a terminal of the same type. Repairs may only be carried out by the manufacturer.
7. IP20 (EN 60529) protection of the device is provided for a clean and dry environment.
8. Do not subject the Inline terminal to mechanical strain and/or thermal loads, which exceed the limits specified in the product documentation.
9. The Inline terminal has not been designed for use in potentially dust-explosive atmospheres.

Installation in zone 2

1. Observe the specified conditions for use in potentially explosive areas.
2. When installing the terminal, use an appropriate and approved housing with a minimum protection of IP54. Please observe the EN 60079-14 requirements, e.g., a steel housing with a wall thickness of 3 mm.
3. In potentially explosive areas, only snap the Inline terminal onto the rail and connect the cables when the power is switched off.
4. In zone 2, only connect devices to the supply and signal circuits that are suitable for operation in potentially explosive areas of zone 2 and the conditions at the installation location.

Restrictions/limit values

1. **Only Inline terminals that are approved for use in potentially explosive areas may be snapped next to this Inline terminal.** Before using an Inline terminal in a zone 2 potentially explosive area, first check that the terminal has been approved for installation in this area. For a list of terminals that are approved for the potentially explosive areas of zone 2, please refer to the AH EN IL EX ZONE 2 application note.
2. Please make sure that the **maximum permissible current of 4 A** flowing through potential jumpers U_M and U_S (total current) is not exceeded when using the Inline terminals in potentially explosive areas.
3. The **supply of U_M and U_S** at the bus coupler must not exceed **4 A**.
4. Also ensure that the **maximum permissible current of 2 A** flowing through potential jumper U_L is not exceeded.

9 Startup

Default upon delivery/default settings

By default upon delivery, the following functions and features are available:

Configuration of the RS-485 interface	
- Transmission mode	RTU
- Baud rate	19200 bps
- Data bits	8
- Parity	Even
- Stop bits	1
Modbus telegram watchdog (connection monitoring)	10000 ms
Plug and play mode	Enabled
Fault response mode	Reset fault mode

10 Hardware configuration

10.1 Address setting

The address is set using two rotary encoding switches. The left switch is used to set the position in tens and the right switch is used to set the position in units. Addresses can be set between 1 and 99. The figure shows the address setting "74".

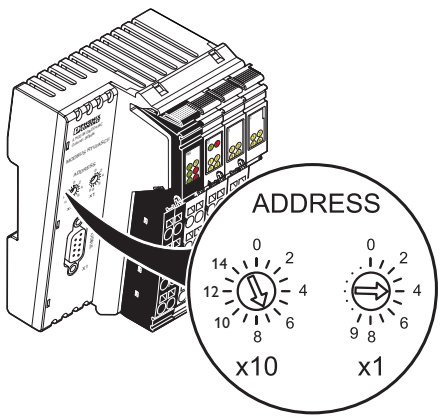


Figure 6 ADDRESS rotary encoding switches

A valid address is applied on power up. It cannot be modified during operation.

10.2 Parameterization via rotary encoding switches

In addition to the address, various operating parameters can also be set via these rotary encoding switches. The operating parameters are only read in following a power on reset. "Parameter setting" mode is assumed when the address switch for tens is set to a position that is not assigned to an address, i.e., ≥ 10.

Tens switch (x10)	Units switch (x1)
Position 10 (Transmission mode, factory configuration, plug and play mode (P&P))	Position 0: RTU (default) Position 1: ASCII Position 2: Factory configuration Position 3: P&P ON (default) Position 4: P&P OFF
Position 11 (baud rate)	Position 0: 1200 Position 1: 2400 Position 2: 4800 Position 3: 9600 Position 4: 19200 (default) Position 5: 38400 Position 6: 57600 Position 7: 115200
Position 12 (data bits)	Position 0: 7 bits Position 1: 8 bits (default)
Position 13 (parity)	Position 0: None Position 1: Even (default) Position 2: Odd
Position 14 (stop bits)	Position 0: 1 bit (default) Position 1: 2 bits
Position 15 (watchdog)	Position 0: ON (default) Position 1: OFF

By default upon delivery as well as after a reset to factory configuration, the parameters labeled "default" in the table are set.

In the event of a power on reset (voltage reset), only the set operating parameter is read in and stored. To set several parameters, this procedure must be repeated for each individual parameter.

While reading in a parameter, the watchdog LED flashes quickly (2 Hz). If the parameter has been accepted, the watchdog LED flashes slowly (0.5 Hz). If the parameter is invalid, the watchdog LED flashes very quickly (5 Hz).

Example: The following is to be set: "Plug and play OFF" and "ASCII".

- Set "Plug and play OFF" first.
- Execute a voltage reset.
- After the parameter has been accepted, set "ASCII".
- Execute a voltage reset again.

10.3 Parameterizing the IL MOD BK DI8 DO4-PAC via Modbus registers

In addition to the described setting options using rotary encoding switches, the configuration can be modified via the Modbus registers.

Register	Parameter	Value
2100 (16-bit word)	Transmission mode	0: RTU (default) 1: ASCII
2101 (16-bit word)	Baud rate	0: 1200 1: 2400 2: 4800 3: 9600 4: 19200 (default) 5: 38400 6: 57600 7: 115200
2102 (16-bit word)	Data bits	0: 7 bits 1: 8 bits (default)
2103 (16-bit word)	Parity	0: None 1: Even (default) 2: Odd
2104 (16-bit word)	Stop bits	0: 1 bit (default) 1: 2 bits
1280 (16-bit word)	Watchdog	0: Watchdog deactivated 200 ms to 65000 ms (1 ms steps) 10000 ms (default)
2002 (16-bit word)	Fault response mode	0: Standard fault mode 1: Reset fault mode (default)
2006 (16-bit word)	Command register	1: Enable plug and play mode (default) 0: Disable plug and play mode

The new parameters are applied following a positive response. This response is transmitted again with the "old" parameters. The next request is then made with the new parameters.

Default values: 19200 baud, 8 data bits, even parity, 1 stop bit, 10000 ms watchdog

Following a power up, the last valid parameter record applies.

When the baud rate changes, the RTU framing also changes by default, i.e., times t 1.5 and t 3.5 are adjusted.

t 1.5 = Maximum permissible gap between the bytes of a Modbus telegram

t 3.5 = Minimum pause between two Modbus telegrams

Detailed information can be found at: www.modbus.org.

10.4 Modbus telegram watchdog (connection monitoring)

The watchdog monitors Modbus telegrams and is triggered each time a Modbus telegram is received correctly. It can be enabled and disabled via the rotary encoding switches, see "Parameterization via rotary encoding switches" on page 12. The time can be set via register 1280 (0 = disabled; 200 ms to 65000 ms).

Actions after triggering the watchdog

The action taken when the watchdog is triggered depends on the set fault response mode. By default upon delivery, the fault response mode is set to reset fault mode. For reset fault mode, the following applies:

– Set digital outputs to zero
– Freeze analog outputs
– Watchdog LED ON

Special feature when **disabling** the watchdog via write access to register 1280:

– Settings modified by write access (disable watchdog, modify monitoring time) are only applied following a power up reset.

Watchdog **activation** via register 1280 is applied immediately during operation.

The Modbus telegram watchdog does not operate during plug and play mode.

10.5 Plug and play mode

The IL MOD BK DI8 DO4-PAC supports plug and play mode (P&P). This mode enables Inline terminals connected in the field to be started up using the bus coupler without a higher-level computer.

P&P mode can be enabled and disabled with the ADDRESS switches (see "Parameterization via rotary encoding switches" on page 12). The switch position is mapped to the command register (Modbus register 2006) (see page 26). By default upon delivery, P&P mode is activated. The P&P mode status (active or inactive) is stored retentively on the bus coupler. In P&P mode, the connected Inline terminals are detected and their function checked. If this physical configuration is ready for operation, it is stored retentively on the bus coupler as a reference configuration.

P&P mode must be deactivated again so that the reference configuration is not overwritten the next time the bus coupler is started. At the same time, the deactivation of P&P mode also acknowledges the reference configuration and enables process data exchange.

When P&P mode is deactivated, the reference configuration is compared to the physical configuration. If they are the same, the bus coupler can be set to the "RUN" state.

If the reference configuration and the physical configuration differ, the CO LED lights up and process data exchange is no longer possible for safety reasons.

In order to operate the bus you have the following two options:

1. Restore the original configuration so that the reference configuration and the physical configuration are the same again
2. Activate P&P mode so that the active physical configuration is accepted as the reference configuration.

If plug and play mode is disabled, the bus is only started up if the configuration of the connected bus matches the saved configuration.

If plug and play mode is enabled, the writing of process data is rejected by an exception. Read access to the process data is possible.

11 Modbus protocol

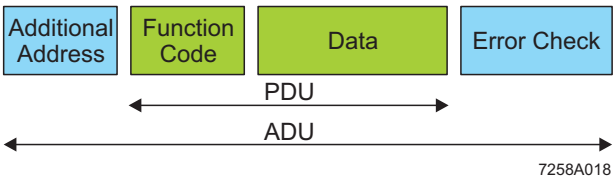


Figure 7 Modbus protocol

Key:

PDU	Protocol data unit
ADU	Application data unit (protocol frame)

The Modbus application protocol is created by the client that initiates a Modbus transmission.

The function code field of the protocol (1 byte) informs the server of which action it is to perform.

The data fields of messages, which are sent from a client to a server, contain additional information that the server uses in order to perform the action specified by the function code field. This includes, e.g., digital addresses and register addresses, the number of units to be managed, and the number of actual data bytes.

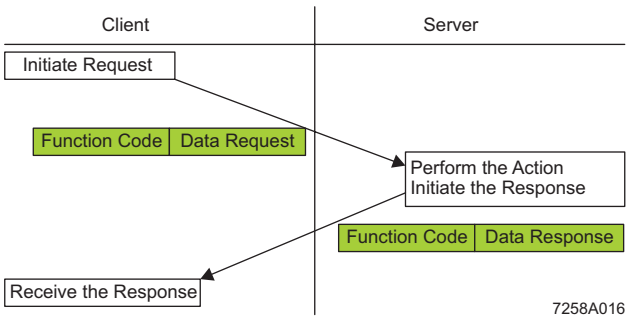


Figure 8 Modbus transmission (without errors)

Key:

Client	Control system
Server	Modbus devices

If no error occurs in a correctly received Modbus protocol for the requested Modbus function, the data field for a response from a server to a client contains the requested data.

When the server responds to the client, it uses the function code field to indicate either a normal (error-free) response or to indicate an error (this is also known as an exception response). For a normal response, the server returns the original function code to the request.

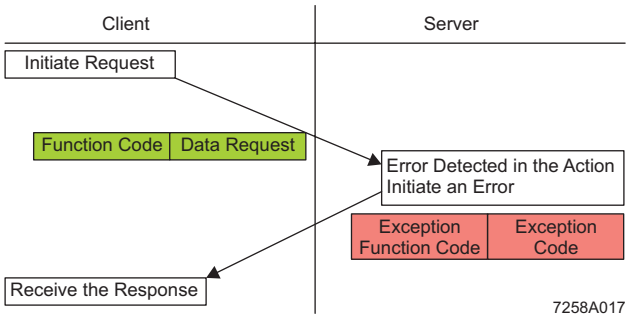


Figure 9 Modbus transmission (exception response)

Key:

Client	Control system
Server	Modbus devices

For an exception response, the server returns a code that corresponds to the original function code of the request PDU, whereby the MSB is set to logic 1.

There are two different transmission modes: RTU and ASCII. Both differ in terms of the type and form of information represented in a telegram. In a Modbus network, each device must have the same transmission mode.

Modbus RTU

Modbus RTU telegrams consist of the following parts:

Station address	Function	Data	CRC
1 byte	1 byte	0 - 252 bytes	2 bytes

Modbus RTU telegrams are separated by breaks known as end of frame times. The time is at least 3.5 times the time of a sent character. It cannot be adjusted.

The advantage the RTU transmission mode offers over the ASCII transmission mode is a higher data throughput with the same baud rate.

Modbus ASCII

Modbus ASCII telegrams consist of the following parts:

Start	Station address	Function	Data	LRC	END
1 character (:)	2 characters	2 characters	0 - 2 x 252 characters	2 characters	2 characters (CR, LF)

The transmitted characters comprise the ASCII code and consist of 1 byte each.
The advantage the ASCII transmission mode offers over the RTU transmission mode is non-time-critical data transmission.
The frame start (:) and end (CR, LF) are specified using special characters. Gaps between the bytes of a frame are not important.

12 Modbus functions

The Modbus protocol functions determine whether data is to be written or read and what type of data is involved.

The following Modbus functions are supported:

Code No.	Function code	Description
fc1	Read coils	Read digital outputs
fc2	Read input discretes	Read digital inputs
fc3	Read multiple registers	Read a multiple register (e.g., read back analog output)
fc4	Read input registers	Read an input register (e.g., analog input)
fc5	Write coil	Write a digital output bit
fc6	Write single register	Write an output register (e.g., analog output)
fc15	Write multiple coils	Write multiple digital outputs
fc16	Write multiple registers	Write multiple output registers

For additional information about Modbus functions, please refer to the FL IL 24 BK-PAC UM E user manual.

13 Examples for Modbus functions

Function code fc1

Request

Function code	1 byte	01_{hex}
Start address	2 bytes	0000_{hex} ... $FFFF_{hex}$
Number of outputs	2 bytes	1 ... 2000 ($7D0_{hex}$)

Response

Function code	1 byte	01_{hex}
Number of bytes	1 byte	N*
Output status	n bytes	n = N or N+1

*N = (Number of outputs)/8; if the remainder is > 0: N = N+1

Error

Function code	1 byte	Function code + 80_{hex}
Exception code	1 byte	01 or 02 or 03 or 04

Example for a request to read digital outputs 20 ... 38 38

Request		**Response**	
Field name	(Hex)	Field name	(Hex)
Function	01	Function	01
Start address (high)	00	Number of bytes	03
Start address (low)	13	Output status 27 ... 20	CD
Number of outputs (high)	00	Output status 35 ... 28	6B
Number of outputs (low)	13	Output status 38 ... 36	05

Function code fc2

Request

Function code	1 byte	02_{hex}
Start address	2 bytes	0000_{hex} ... $FFFF_{hex}$
Number of outputs	2 bytes	1 ... 2000 ($7D0_{hex}$)

Response

Function code	1 byte	01_{hex}
Number of bytes	1 byte	N*
Output status	N* x 1 byte	

*N = (Number of inputs)/8; if the remainder is > 0: N = N+1

Error

Error code	1 byte	82_{hex}

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Exception code	1 byte	01 or 02 or 03 or 04

Example for a request to read digital inputs 197 ... 218

Request		Response	
Field name	(Hex)	Field name	(Hex)
Function	02	Function	02
Start address (high)	00	Number of bytes	03
Start address (low)	C4	Input status 27 ... 20	AC
Number of inputs (high)	00	Input status 35 ... 28	DB
Number of inputs (low)	16	Input status 38 ... 36	35

Function code fc3

Request

Function code	1 byte	03_{hex}
Start address	2 bytes	0000_{hex} ... $FFFF_{hex}$
Number of registers	2 bytes	1 ... 125 ($7D_{hex}$)

Response

Function code	1 byte	03_{hex}
Number of bytes	1 byte	2 x N*
Register values	N* x 1 byte	

*N = Number of registers

Error

Error code	1 byte	83_{hex}
Exception code	1 byte	01 or 02 or 03 or 04

Example for a request to read registers 108 ... 110

Request		Response	
Field name	(Hex)	Field name	(Hex)
Function	03	Function	03
Start address (high)	00	Number of bytes	06
Start address (low)	6B	Register value (high) (108)	02
Register number (high)	00	Register value (low) (108)	2B
Register number (low)	03	Register value (high) (109)	00
		Register value (low) (109)	00
		Register value (high) (110)	00
		Register value (low) (110)	64

Function code fc4

Request

Function code	1 byte	04_{hex}
Start address	2 bytes	0000_{hex} ... $FFFF_{hex}$
Number of input registers	2 bytes	0001_{hex} ... $007D_{hex}$

Response

Function code	1 byte	04_{hex}
Number of bytes	1 byte	2 x N*
Input registers	N* x 2 byte	

*N = Number of input registers

Error

Error code	1 byte	84_{hex}
Exception code	1 byte	01 or 02 or 03 or 04

Example for a request to read input register 9

Request		**Response**	
Field name	(Hex)	Field name	(Hex)
Function	04	Function	04
Start address (high)	00	Number of bytes	02
Start address (low)	08	Input register 9 (high)	00
Number of input registers (high)	00	Input register 9 (low)	0A
Number of input registers (high)	01		

Function code fc5

Request

Function code	1 byte	05_{hex}
Output address	2 bytes	0000_{hex} ... $FFFF_{hex}$
Output value	2 bytes	0000_{hex} ... $FF00_{hex}$

Response

Function code	1 byte	05_{hex}
Output address	2 bytes	0000_{hex} ... $FFFF_{hex}$
Output value	2 bytes	0000_{hex} ... $FF00_{hex}$

Error

Error code	1 byte	85_{hex}
Exception code	1 byte	01 or 02 or 03 or 04

Example for a request to write output 173 ON

Request		Response	
Field name	(Hex)	Field name	(Hex)
Function	05	Function	05
Output address (high)	00	Output address (high)	00
Output address (low)	AC	Output address (low)	AC
Output value (high)	FF	Output value (high)	FF
Output value (low)	00	Output value (low)	00

Function code fc6

Request

Function code	1 byte	06_{hex}
Register address	2 bytes	0000_{hex} ... $FFFF_{hex}$
Register value	2 bytes	0000_{hex} ... $FFFF_{hex}$

Response

Function code	1 byte	06_{hex}
Register address	2 bytes	0000_{hex} ... $FFFF_{hex}$
Register value	2 bytes	0000_{hex} ... $FFFF_{hex}$

Error

Error code	1 byte	86_{hex}
Exception code	1 byte	01 or 02 or 03 or 04

Example for a request to write register 2 to 0003_{hex}

Request		Response	
Field name	(Hex)	Field name	(Hex)
Function	06	Function	06
Register address (high)	00	Register address (high)	00
Register address (low)	01	Register address (low)	01
Register value (high)	00	Register value (high)	00
Register value (low)	03	Register value (low)	03

Function code fc15

Request PDU

Function code	1 byte	$0F_{hex}$
Start address	2 bytes	0000_{hex} ... $FFFF_{hex}$
Number of outputs	2 bytes	0001_{hex} ... $07B0_{hex}$
Byte counter	1 byte	N*
Output value	N* x 1 byte	

*N = (Number of outputs)/8; if the remainder is > 0: N = N+1

Response PDU

Function code	1 byte	$0F_{hex}$
Start address	2 bytes	0000_{hex} ... $FFFF_{hex}$
Number of outputs	2 bytes	0001_{hex} ... $07B0_{hex}$

Error

Error code	1 byte	$8F_{hex}$
Exception code	1 byte	01 or 02 or 03 or 04

Example for a request to write a series of 10 outputs, starting with output 20

The request data contains two bytes. The binary values are assigned to the outputs as follows:

Byte (hex)	CD								01							
Bit	1	1	0	0	1	1	0	1	0	0	0	0	0	0	0	1
Output	27	26	25	24	23	22	21	20							29	28

The first transmitted byte (CD_{hex}) addresses outputs 27 to 30, whereby the LSB in this setting addresses output 20.

The next transmitted byte (01_{hex}) addresses outputs 29 and 28, whereby the LSB in this setting addresses output 28. In the last data byte, unused bits should be filled with zeros.

Request		**Response**	
Field name	(Hex)	Field name	(Hex)
Function	0F	Function	0F
Start address (high)	00	Start address (high)	00
Start address (low)	13	Start address (low)	13
Number of outputs (high)	00	Number of outputs (high)	00
Number of outputs (low)	0A	Number of outputs (low)	0A
Byte counter	02		
Output value (high)	CD		
Output value (low)	01		

Function code fc16

Request

Function code	1 byte	10_{hex}
Start address	2 bytes	0000_{hex} ... $FFFF_{hex}$
Number of registers	2 bytes	0001_{hex} ... 0078_{hex}
Byte counter	1 byte	2 x N*
Register value	N* x 2 bytes	Value

*N = Number of registers

Response

Function code	1 byte	10_{hex}
Start address	2 bytes	0000_{hex} ... $FFFF_{hex}$
Number of registers	2 bytes	1 ... 123 (78_{hex})

Error

Error code	1 byte	90_{hex}
Exception code	1 byte	01 or 02 or 03 or 04

Example for a request to write two registers, starting with 2 to $000A_{hex}$ and 0102_{hex}

Request		**Response**	
Field name	(Hex)	Field name	(Hex)
Function	10	Function	10
Start address (high)	00	Start address (high)	00
Start address (low)	01	Start address (low)	01
Number of registers (high)	00	Number of registers (high)	00
Number of registers (low)	02	Number of registers (low)	02
Byte counter	04		
Register value (high)	00		
Register value (low)	0A		
Register value (high)	01		
Register value (low)	02		

14 Modbus tables

14.1 Process data

The Modbus register tables provide information about the location of process data in the control system. Generally, the **bit**-oriented process data appears first in the registers followed by the **byte**-oriented process data.

Static table

Modbus register table	Digital Modbus inputs table	Digital Modbus outputs table	Internal IL MOD BK tables	Function codes that can be used
0 - 191 (16-bit word)	0 - 3071 (bits)	–	Digital inputs	fc2
192 - 383 (16-bit word)	–	–	Analog inputs	fc4
384 - 575 (16-bit word)	–	0 - 3071 (bits)	Digital outputs	fc1, fc5, fc15
576 - 767 (16-bit word)	–	–	Analog outputs	fc3, fc6, fc16

Assignment of the process data in static tables

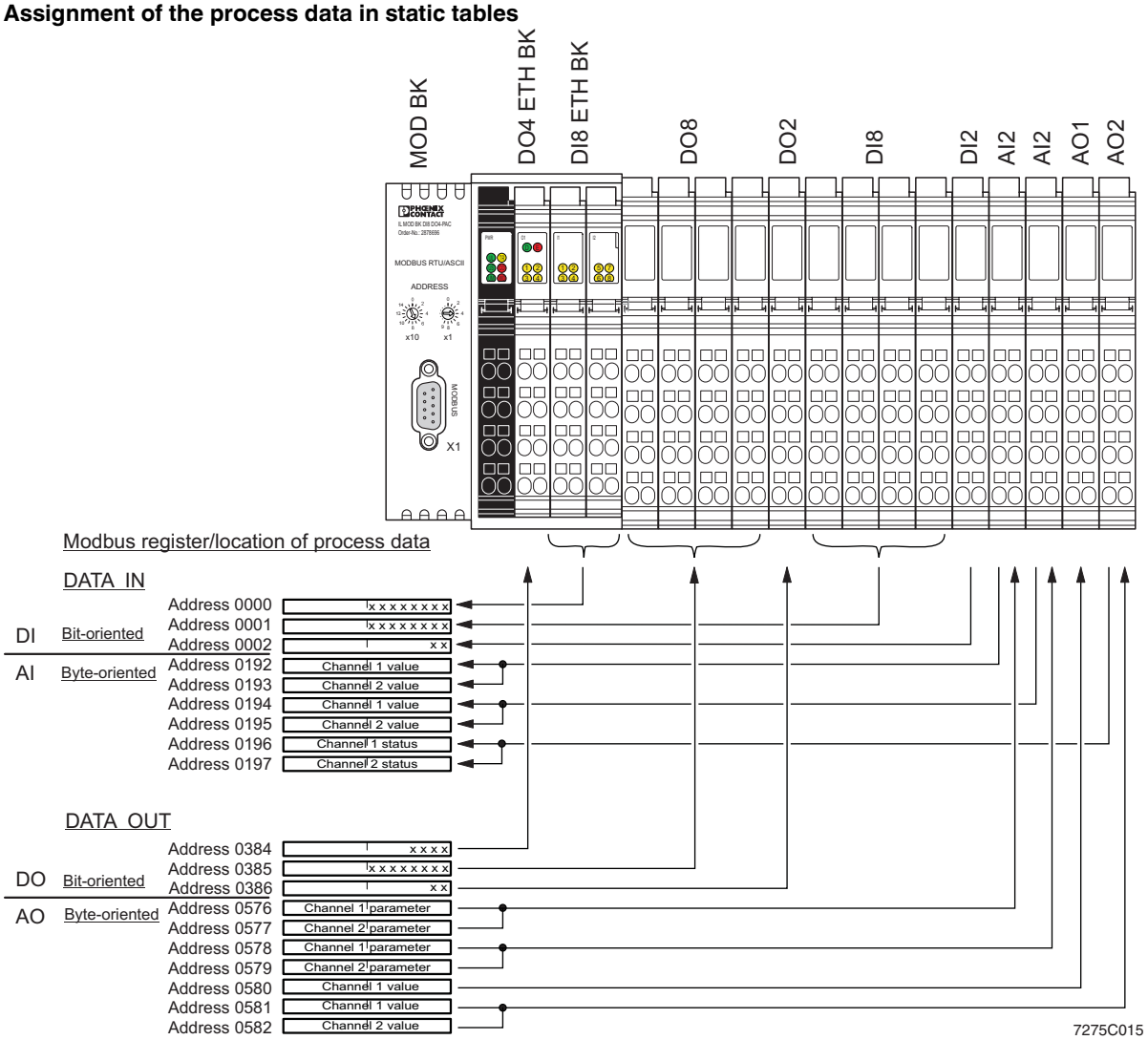

Figure 10 Example for the location of process data in static tables

Dynamic table

For dynamic tables, there is no fixed assignment of the register areas. Depending on the structure of the Inline station, the following general order of the process data applies:

– DATA IN (bit-oriented)
– DATA IN (byte-oriented)
– DATA OUT (bit-oriented)
– DATA OUT (byte-oriented)

Modbus register table	Internal IL MOD BK tables	Function codes that can be used
8000 - 8192 (16-bit word)	Dynamic process data table	fc2 to fc16

Assignment of the process data in dynamic tables

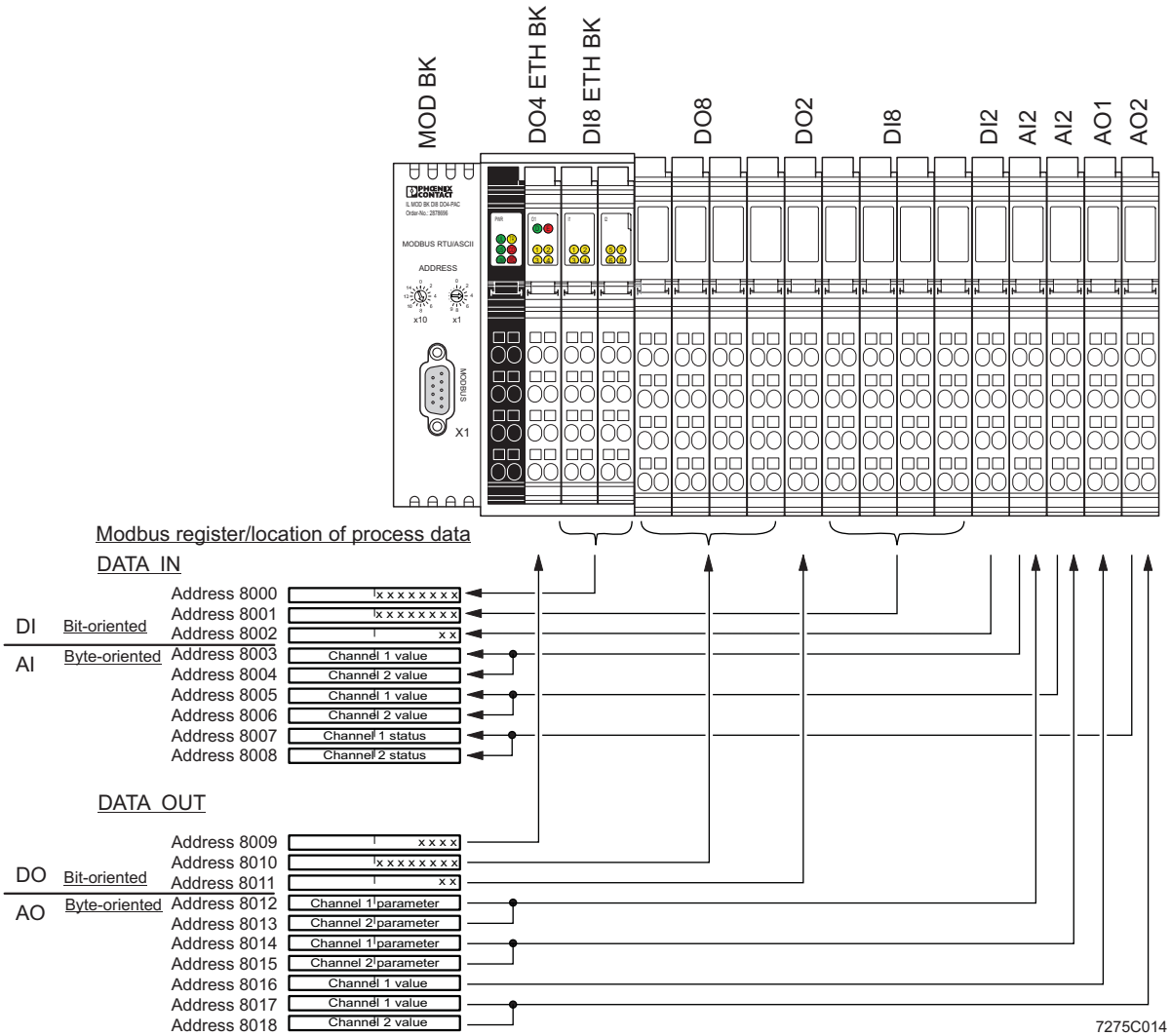

Figure 11 Example for the location of process data in dynamic tables

14.2 Special registers

Modbus register table	Access	Internal IL MOD BK tables
1280 (16-bit word)	Read/write	Modbus telegram watchdog (connection monitoring), (default = 10000 ms)
1400 – 1463 (16-bit word)	Read	Up to 1400: Number of local bus devices Above 1401: ID code of the relevant device
2002 (16-bit word)	Read/write	Fault response mode (default = reset fault mode)
2004 (16-bit word)	Read	Net Fail reason
2006 (16-bit word)	Read/write	Command register (command word)
2100 (16-bit word)	Write	Transmission mode: RTU, ASCII (default = 0 = RTU mode) see table on page 13
2101 (16-bit word)	Write	Baud rate: 1200 ... 115200 (Default = 4 = 19200), see table on page 13
2102 (16-bit word)	Write	Data bits: 7, 8 (default = 1 = 8 bits), see table on page 13
2103 (16-bit word)	Write	Parity: None, even, odd (default = 1 = even parity), see table on page 13
2104 (16-bit word)	Write	Stop bits: 1, 2 (default = 0 = 1 stop bit), see table on page 13
6020 - 6093 (16-bit word)	Write	PCP
7996 (16-bit word)	Read	Status register (status word)
7997 (16-bit word)	Read	Local bus diagnostic status register
7998 (16-bit word)	Read	Local bus diagnostic parameter register 1
7999 (16-bit word)	Read	Local bus diagnostic parameter register 2

14.3 Description of special registers

Modbus telegram watchdog (connection monitoring), (1280)

Valid values for the register are 0; 200 ms to 65000 ms.

The watchdog monitors Modbus telegrams and is triggered each time a Modbus telegram is received correctly. It can be enabled and disabled via the rotary encoding switches, see "Parameterization via rotary encoding switches" on page 12. The time can be set via register 1280 (0 = disabled; 200 ms to 65000 ms).

Actions after triggering the watchdog:

The action taken when the watchdog is triggered depends on the set fault response mode. By default upon delivery, the fault response mode is set to reset fault mode. For reset fault mode, the following applies:

– Set digital outputs to zero
– Freeze analog outputs
– Watchdog LED ON

Special feature when disabling the watchdog via write access to register 1280:

Settings modified by write access (disable watchdog, modify monitoring time) are only applied following a power up reset. Watchdog activation via register 1280 is applied immediately during operation.

Fault response mode, (2002)

Fault response mode	Value	Function
Standard fault mode	**0**	All outputs are set to "0".
Reset fault mode (default)	**1**	The digital outputs are set to "0" and the analog outputs are held at the last value.
Hold last state mode	**2**	All outputs are held at their last value.

Net Fail reason, (2004)

This register can be used to read the reason after the Net Fail signal has been triggered. For the IL MOD BK DI8 DO4-PAC there can only be one reason: the connection monitoring watchdog has failed. In Net Fail Reason register 2004, the value $000D_{hex}$ appears.

Command register (command word), (2006)

Activation/deactivation of plug and play mode is performed in the least significant bit of the command word. Bit 0 = "0" -> plug and play mode deactivated; bit 0 = "1" -> plug and play mode activated.
If a Net Fail occurred, it can be acknowledged by setting bit 1 in the command word. If the Net Fail has been acknowledged successfully, bit 1 is reset to "zero".

If a peripheral fault occurred, it can be acknowledged by setting bit 2 in the command word. If the peripheral fault has been acknowledged successfully, bit 2 is reset to 0.

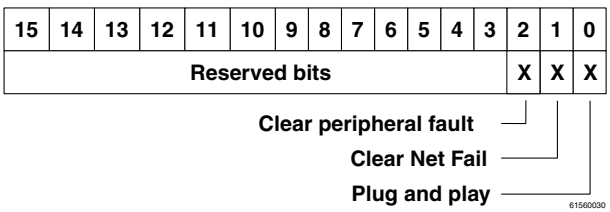

Figure 12 Command word

Status register (status word), (7996)

Only the two least significant bits have a function. If bit 0 = "0", this means that an error (e.g., a bus error) has occurred. If bit 0 = "1", no error has occurred. Bit 1 indicates whether a Net Fail occurred (bit 1 = 1) or not (bit 1 = 0).

This results in the following values for the status word:

– 0: An error occurred (e.g., bus error)
– 1: No error occurred
– 2: A Net Fail occurred

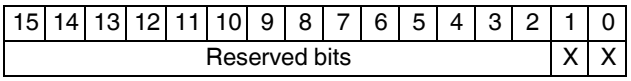

Figure 13 Status word

Local bus diagnostic status register (7997)

Each bit in the local bus diagnostic status register is assigned a state of the local bus master on the bus coupler. The states in the error bits (USER, PF, BUS, CTRL) are described in greater detail using the diagnostic parameter register. Whenever one of the error bits described above is set, the diagnostic parameter register is rewritten. Otherwise, the diagnostic parameter register has the value 0000_{hex}.

Bit	Constant	Meaning
0	USER_BIT	Application program error
1	PF_BIT	Local bus device detected a peripheral fault
2	BUS_BIT	Error on local bus
3	CTRL_BIT	Local bus master has an internal error
4	DETECT_BIT	Error localization ("LOOK FOR FAIL")
5	RUN_BIT	Exchanging data cycles
6	ACTIVE_BIT	Local bus master ACTIVE
7	READY_BIT	Local bus master READY, selftest completed

Local bus diagnostic parameter register 1 (7998)

For detected local bus errors, the local bus diagnostic parameter register contains the error location:

Error location, e.g., device number 0.3

Device number of a device, e.g., "0.3" for bus segment 0; device 3

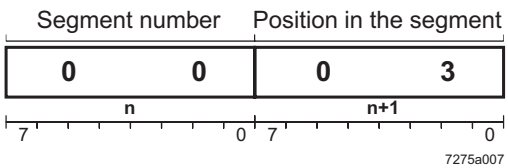

Figure 14 Contents of the local bus diagnostic parameter register (example)

Local bus diagnostic parameter register 2 (7999)

Local bus diagnostic parameter register 2 contains additional information about the error codes.

For additional information about local bus diagnostics, please refer to the IBS SYS FW G4 UM E user manual.

PCP registers (6020 - 6093)

The PCP registers are divided into two classes:

1. Communication registers for exchanging data with the desired PCP device
2. Configuration registers for selecting the invoke ID, index, and subindex of the PCP device

For additional information about PCP communication, please refer to the IBS SYS PCP G4 UM E user manual.

The terminal supports eight PCP devices, therefore eight communication registers and 24 configuration registers are supported.

PCP registers

Communication reference	Communication register	Configuration register	Remark
CR 2	6020		
		6021	Index
		6022	Subindex
		6023	Invoke ID
		6024 - 6029	Reserved
CR 3	6030		
		6031	Index
		6032	Subindex
		6033	Invoke ID
		6034 - 6039	Reserved
CR 4	6040		
		6041	Index
		6042	Subindex
		6043	Invoke ID
		6044 - 6049	Reserved
CR 5	6050		
		6051	Index
		6052	Subindex
		6053	Invoke ID
		6054 - 6059	Reserved
CR 6	6060		
		6061	Index
		6062	Subindex
		6063	Invoke ID
		6064 - 6069	Reserved
CR 7	6070		
		6071	Index
		6072	Subindex
		6073	Invoke ID
		60724 - 6079	Reserved
CR 8	6080		
		6081	Index
		6082	Subindex
		6083	Invoke ID
		6084 - 6089	Reserved
CR 9	6090		
		6091	Index
		6092	Subindex
		6093	Invoke ID
		6094 - 6099	Reserved

Example:

In order to read object $5FE0_{hex}$ of an IB IL RS 232 with communication reference 4, first set the configuration registers (6041 - 6043) to the desired values with the FC 16 command (e.g., 6041 index: $5FE0_{hex}$, 6042 subindex: 0_{hex}, 6043 invoke ID: 0_{hex}). The fc3 command can then be used to read 29 words via communication register 6040.

A Modbus function is only ever used for read/write access to a PCP index. For example, the fc3 command cannot be used to read 20 words from registers 6020 to 6039.

The communication register contains a different value range due to the selected values of the register and the terminal used. Therefore, the IB IL RS 232 terminal, for example, has three different PCP objects: two objects are one word long, but the third is 29 words long. The three configuration registers can be read/written with a single Modbus command. An attempt to access a reserved register generates an exception response.