OPERATIONS MANUAL

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IQ SENSOR NET Field bus linking

LINKING THE IQ SENSOR NET TO A FIELD BUS

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1 Linking the IQ SENSOR NET to a field bus

1.1 Interfaces of the IQ SENSOR NET

The IQ SENSOR NET system provides interfaces for the following networks:

Field bus	Interface type	IQ SENSOR NET components with interfaces
Modbus RTU	RS485	XX-MOD
Profibus		XX-PR
Modbus TCP	Ethernet	MIQ/MC2(-XX)
Profinet		
Ethernet/IP		

1.2 Linking the IQ SENSOR NET

1.2.1 Linking the IQ SENSOR NET via the RS485 interface

Steps		Profibus	Modbus
1	Establish the physical connection	section 2.1	
2	Configure the interface of the IQ SENSOR NET	section 3.1	section 3.2
3	Program the queries and access authorization *	section 4.1	section 4.2
		GSD file section 3.1.2	
4	Interpret the data of the IQ SENSOR NET	section 5 ff	

* Configuring the order of the sensors in the IQ SENSOR NET (see section 3.6)

1.2.2 Linking the IQ SENSOR NET via the Ethernet interface

Steps		Ethernet IP	Profinet	Modbus TCP
1	Establish the physical connection	section 2.2		
2	Configure the interface of the IQ SENSOR NET	section 3.4		
3	Program the queries and access authorization *	section 4.1		section 4.2
		EDS file section 3.4.2	GSD file section 3.4.1	
4	Interpret the data of the IQ SENSOR NET	section 5 ff		

* Configuring the order of the sensors in the IQ SENSOR NET (see section 3.6)

2 Installing the interface in the IQ SENSOR NET

2.1 Installing the RS485 interface

Profibus and Modbus use the same interface (RS485) for data exchange.

We especially recommend the "Aufbaurichtlinie PROFIBUS/FMS", published by the PROFIBUS user organization PNO, (PNO order number 2.111) with many practical tips for installation that also apply to Modbus systems (http://www.profibus.com/download/installation-guide/).

Further instructions for the installation and operation of a Modbus network are availabe on the Internet under www.modbus.org.

Detailed information on the subject of PROFIBUS is given on the Internet by the PROFIBUS user organization (PNO) under www.profibus.com.

Connecting the Profibus / Modbus cable

The Profibus / Modbus cable is connected to the IQ SENSOR NET using a 9-pin D-SUB connector on the top of the housing.

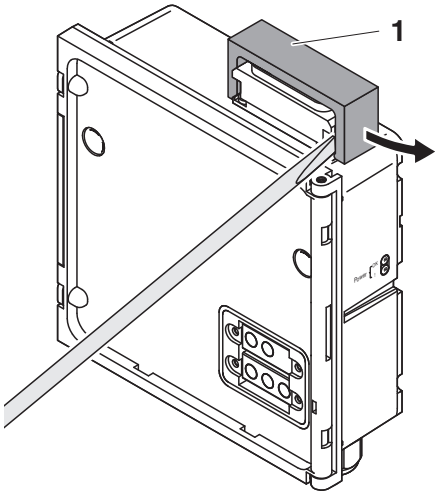
Suitable cables

Field bus type	Cable
Profibus	PROFIBUS cable
Modbus	Cable for RS485 (e.g. PROFIBUS cable)

Connectors to be used

Manufacturer	Type
Phoenix Contact GmbH & Co. KG Flachsmarkt 8 32825 Blomberg Germany http://www.phoenixcontact.com	VS-09-PROFB-SC (Phoenix article no. 1654549, with screwed contacts, available from YSI under the order no. 902 888Y)
	VS-09-PROFB-SP (Phoenix article no. 1654345, with spring contacts)

To remove the blind plug, lift the safety bracket with a suitable screw driver at both clamps on the left and right side (see Fig. 2-1).



1 Safety bracket

Fig. 2-1 Removing the safety bracket

Caution

If water gets into the enclosure of a module with internal power supply, there is danger of an electric shock.
If water gets into the enclosure of an MIQ module, there is a risk of short circuits.
To prevent the enclosures of the IQ SENSOR NET from being penetrated by water the following must be observed:

- **Follow the safety instructions of the IQ SENSOR NET system operating manual.**
- **Use connectors recommended by YSI only.**
- **When the connector is removed, the connection socket of the IQ SENSOR NET must be closed with the blind plug and secured with the safety bracket.**

Mounting the Phoenix connector

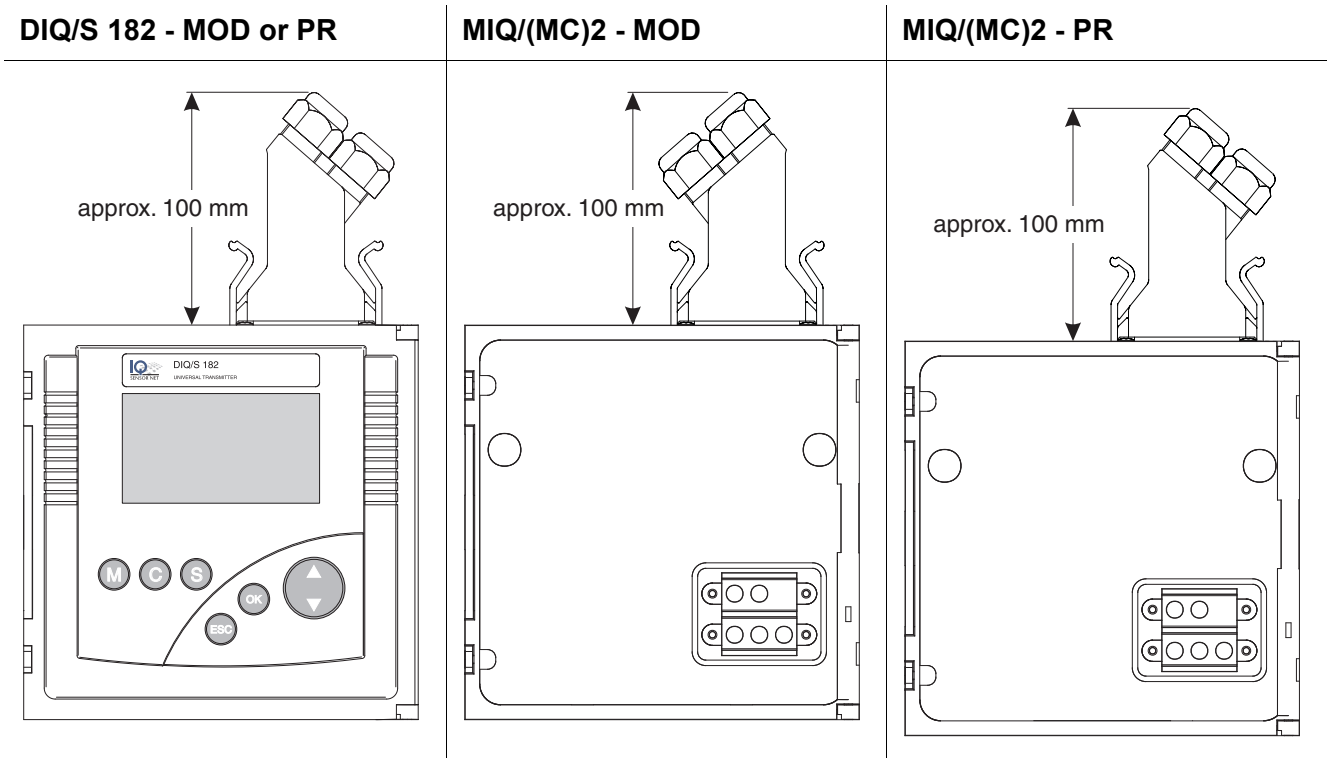


Fig. 2-2 IQ SENSOR NET modules with Phoenix connector

Phoenix connector		IQ SENSOR NET instrument		
Wire (color*)	**Terminals**	**Pin**	**Potential at instrument connector**	**Function**
		1		-
		2		-
Red	1B and 2B	3	B line	Positive RxD/TxD according to RS 485 specification
		4	RTS	Request To Send
		5	GND BUS	Reference potential for data wires and terminating resistors
		6	+5 V BUS	Supply voltage for terminating resistors
		7		-
Green	1A and 2A	8	A line	Negative RxD/TxD according to RS 485 specification
		9		-

* Wire colors when using a standard PROFIBUS cable.

Please observe the operating manual of the connector.

2.2 Installing the Ethernet interface

The IQ SENSOR NET system can be linked to a LAN through the MIQ/MC2 controller.

Basic knowledge of network engineering is helpful when establishing a local network.

Depending on the network configuration, several settings have to be made on the individual network components.

Settings that concern network components from third-party manufacturers (such as the router) are only referred to in general here. Detailed information on in which menus the settings should be done are given in the respective operating manual of your instrument.
If you have no network knowledge, please contact your network administrator.

Profinet, Modbus TCP and Ethernet IP use the same interface (Ethernet) and the same cable type (Ethernet) for data exchange.

2.2.1 Communication via Ethernet

The IQ SENSOR NET provides an interface for Fast Ethernet (100 MBit/s).

If configured as a DHCP client, the IQ SENSOR NET can automatically get its IP settings from a DHCP server in the network.

2.2.2 Ethernet connection in case of indoor installation

The Ethernet cable is connected to the IQ SENSOR NET with the RJ45 connector on the underside of the enclosure of the MIQ/MC2 controller.

2.2.3 Ethernet connection in case of outdoor installation

When plugged in, the RJ45 socket is not sufficiently protected against moisture. With outdoor installation, the Ethernet cable must therefore be clamped directly on the PCB of the MIQ/MC2 controller to ensure a safe Ethernet communication. For this purpose there is a 4-pole terminal strip and a shielding terminal on the main PCB. An LSA punch down tool is required for the assembly.

Connecting the Ethernet cable with the main PCB

1	Open the MIQ module.
2	Disconnect the flat flexible cable (pos. 1 in Fig. 2-3) from the main PCB.

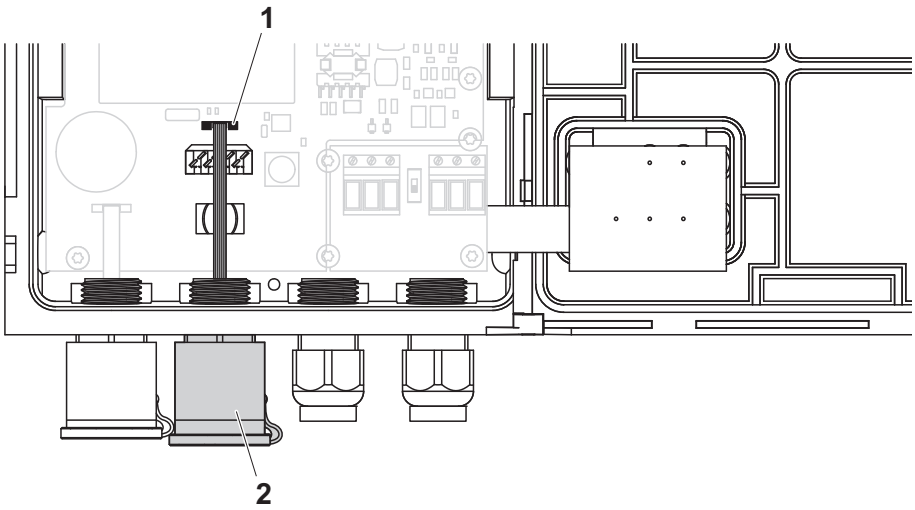


Fig. 2-3 Ethernet connection with RJ45 socket

3	Unscrew the RJ45 socket enclosure (pos. 2 in Fig. 2-3).
4	Screw a cable gland with sealing ring into the free duct. Then loosen the cap nut of the cable gland.

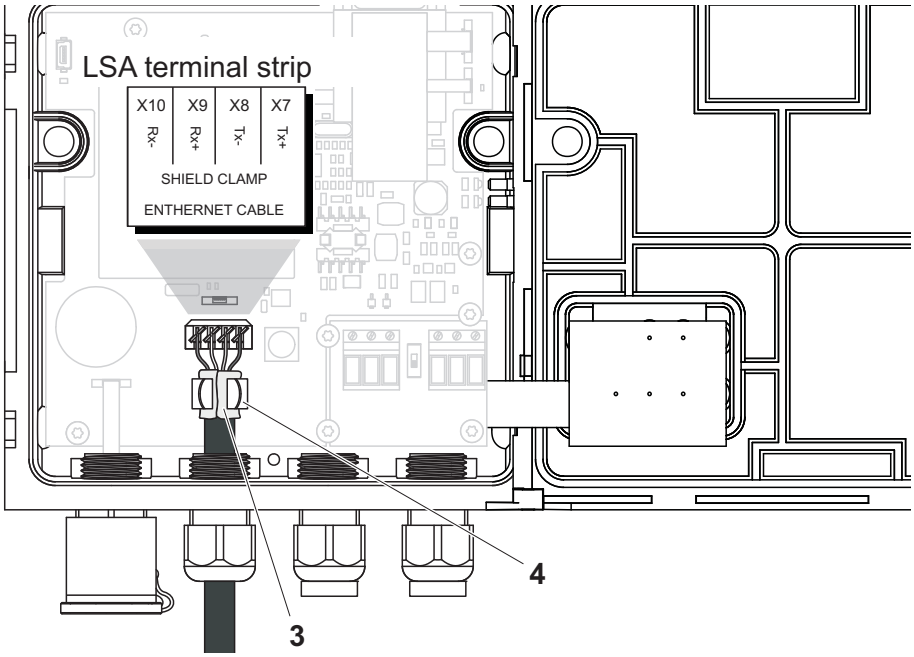


Fig. 2-4 Ethernet connection via terminal strip

5	Strip the Ethernet cable for approx. 2 cm and untwist the Rx+, Rx-, Tx+ and Tx wires.
6	Carefully slash the cable shield (foil + netting) lengthwise and put it backwards over the cable sheath (pos. 3 in Fig. 2-4).
7	Feed the Ethernet cable through the cable gland into the module housing.
8	Where the cable shield was put backwards, press the Ethernet cable into the shielding terminal (pos. 4 in Fig. 2-4). The shielding terminal must contact the cable shield across a wide area.
9	Connect the Rx+, Rx-, Tx+ and Tx- wires to the LSA terminal strip with the aid of an LSA punch down tool. Make sure that the cable assignment agrees with the specification on the terminal label under the terminal strip.
10	Fasten the cap nut of the screwed cable gland.
11	Close the module.

3 Configuring the IQ SENSOR NET

3.1 Configuring the IQ SENSOR NET for Profibus

3.1.1 Setting the PROFIBUS address

Opening the setting menu for Profibus

1	Open the setting menu with **<S>**.
2	For MIQ/MC2: Press **<▲▼◀▶>** and **<OK>** to select and confirm the menu item, *Settings of bus interfaces*
3	Select and confirm the bus interface with **<▲▼◀▶>** and **<OK>**.

Settings

Setting	Selection/Values	Explanation
Device Address	*1 ... 126*	Instrument address of the IQ SENSOR NET in the Profibus

4	Edit the settings.

To accept all settings, you have to highlight the *Save and quit* menu item at the lower end of the setting table and to confirm with **<OK>**. If you exit the setting table via **<M>**, **<ESC>**/*Quit* or the *Quit* menu item, all changes are ignored.

3.1.2 GSD file

The GSD file contains all necessary information on the Profibus module and is required by the configuration program of the Profibus master. The current GSD file is provided on the Internet under www.WTW.com.

3.2 Configuring the IQ SENSOR NET for Modbus RTU

3.2.1 Setting the Modbus interface parameters

Opening the setting menu for Modbus RTU

1	Open the setting menu with **<S>**.
2	For MIQ/MC2: Press **<▲▼◀▶>** and **<OK>** to select and confirm the menu item, *Settings of bus interfaces*
3	Select and confirm the bus interface with **<▲▼◀▶>** and **<OK>**.

Settings

Setting	Selection/Values	Explanation
Device Address	*1 ... 247*	Instrument address of the IQ SENSOR NET in the Modbus RTU
Baud rate	*1200* *2400* *4800* *9600* *19200* *38400* *57600*	Baud rate
Parity	*None* *Even* *Odd*	Parity *None* (2 stop bits) *Even* (1 stop bit) *Odd* (1 stop bit)

4	Edit the settings.

To accept all settings, you have to highlight the *Save and quit* menu item at the lower end of the setting table and to confirm with **<OK>**. If you exit the setting table via **<M>**, **<ESC>**/*Quit* or the *Quit* menu item, all changes are ignored.

3.3 PROFIBUS / Modbus RTU checklist

The following checklist supports you when planning, projecting and installing a PROFIBUS or Modbus RTU system with the IQ SENSOR NET. For smooth operation, you should be able to answer all questions with "Yes".

- Is the [bus system] (bus segment) installed without branch lines?
- Was the correct cable used (e.g. PROFIBUS cable, see section 2.1)?
- Are the poles of the signal lines A line and B line correctly connected at all bus connections?
- Is it guaranteed that there is no short-circuit between A line, B line and cable shielding?
- Is the shielding installed free of interruptions?
- Are the guidelines for shielding and grounding being observed, and doesn't any unallowed potential equalization current flow via the shielding?
- Is the maximum cable length (per bus segment) observed for the corresponding baud rate?
- Do all devices support the required baud rate?
- Only for Profibus:
  With 12 Mbit/s transmission rate only: Are the bus plugs suitable for this baud rate?
- Are exactly two terminators switched on at the ends of the [bus system] (bus segment)?
- Are the terminators supplied with voltage so the following applies: $U_{B\ line} - U_{A\ line} > + 500$ mV?
- Do all devices have individual bus addresses?
- After changing the bus address, have the devices been restarted (switched off and on again)?
  Note: The IQ SENSOR NET does not have to be restarted.
- Do the addresses projected in the master correspond to the actual addresses?
  Are all addresses less than or equal to the parameter HSA and less than 126 (HSA = Highest Station Address)?
- Only for Profibus:
  Is the currently valid GSD being used? If you are in doubt, download it from the Internet.
- Only for Profibus:
  Have admissible bus parameters been set only? If you are in doubt set them to default values.

- Is it guaranteed that the Profibus or Modbus master has consistent access to the 16 byte sensor data structure?
- After commissioning:
  Do all devices signal error-free behavior?
  (IQ SENSOR NET: status "Online" in the measured value and status display).

For consistent access with Siemens PLC with programming language STEP7, the following commands have to be used:

- SFC15 (for writing)
- SFC14 (for reading)

3.4 Configuring the IQ SENSOR NET for Ethernet field buses

Setting	Selection/Values	Explanation
DHCP	Yes	The IQ SENSOR NET is configured as a DHCP client. If a DHCP server is in the network, the IQ SENSOR NET receives all other network settings from the DHCP server.
	No	The IQ SENSOR NET is not configured as a DHCP client. All other settings have to be done as required.
IP address	Address	Permanent IP address for the IQ SENSOR NET in the LAN (if *DHCP No*).
Subnet mask	Address	Subnet mask (if *DHCP No*). The subnet mask depends on the network size (for small networks: e.g. 255.255.255.0).
DNS server	Address	Entry for field bus not required. For a connection with the Internet (if *DHCP No*), e.g.: ● IP address of the DNS server in the network ● Entry of *IP address* or e.g. 127.0.0.1
Standard gateway	Address	Entry for field bus not required. For a connection with the Internet (if *DHCP No*), e.g.: ● IP address of the instrument establishing the access to the Internet ● Entry of *IP address* or e.g. 127.0.0.1

3.4.1 GSD file for Profinet

The GSD file contains all necessary information on the Profinet module and is required by the configuration program for the Profinet master.

The current GSD file is provided on the Internet under www.WTW.com.

3.4.2 EDS file for Ethernet-IP

The EDS file contains information on the Ethernet-IP module. It is evaluated by some configuration programs.

The current EDS file is provided on the Internet under www.WTW.com.

3.5 Error elimination

Here you will find causes and actions to take of errors concerning the PROFIBUS and Modbus communication only. General errors of the IQ SENSOR NET system are dealt with in chapter 10 WHAT TO DO IF....

3.5.1 PROFIBUS error elimination

Data transmission between the bus master and IQ SENSOR NET is faulty

Cause	Remedy
– Incorrect wiring	– Check/change the connections (see section) – Use checklist according to section 3.3
– Incorrect setting of the address	– Check/change the setting of the address (see section 3.2.1)
– Incorrect protocol	– Check the version of the GSD file – Adapt the protocol
– IQ SENSOR NET defective	– Send IQ SENSOR NET to YSI

The PLC does not contain any plausible input data

Cause	Remedy
– Input data and output data are not consistent	– When programming the PLC, define input data and output data as consistent over the entire data length
– The data interpretation of the PLC is not correct	– Observe the data alignment of the PLC data representation. If necessary, exchange the high-order and low-order bytes word by word

3.5.2 Modbus RTU error elimination

Data transmission between the bus master and IQ SENSOR NET is faulty

Cause	Remedy
– Incorrect wiring	– Check/change the connections (see section) – Use checklist according to section 3.3
– Incorrect setting of address, baud rate, parity	– Check/change the settings (see section 3.2.1)
– Incorrect protocol	– Adapt the protocol
– Controller of the IQ SENSOR NET defective	– Return the controller to YSI

The PLC does not contain any plausible input data

Cause	Remedy
– The data interpretation is not correct	– Heed the data formats of the IQ SENSOR NET (see also section 4.1.3).

3.5.3 Ethernet field bus error elimination

No network connection

Cause	Remedy
– Ethernet hardware defective, e.g. – Ethernet cable defective – Ethernet connection to MIQ/MC2 – Switch or router to which the IQS is connected is defective	– Open the MIQ/MC2 and check the red Ethernet LED. – The red Ethernet LED is not illuminated (hardware defective): Use other hardware, e.g.: Ethernet cable, Ethernet connector on the router, router – The red Ethernet LED is illuminated (hardware OK): Check for other errors (see below)
– Wrong setting in the IQ SENSOR NET (system/*TCP/IP settings* menu)	– Correct the settings (e.g. DHCP yes, but no network addresses displayed)

Cause	Remedy
– Wrong setting in the router/switch	– Correct the settings
– Blocking by firewall	– Contact your network administrator or a network specialist

The PLC does not contain any plausible input data

Cause	Remedy
– Input data and output data are not consistent	– When programming the PLC, define input data and output data as consistent over the entire data length
– The data interpretation of the PLC is not correct	– Heed the data formats of the IQ SENSOR NET (see also section 4.1.3). – Observe the data alignment of the PLC data representation. If necessary, exchange the high-order and low-order bytes word by word

3.6 Assigning the sensor numbers

The basis for data transmission between the superordinate control system (PLC) and the IQ SENSOR NET is formed by the unique assignment of a sensor to its sensor number (Sxx) in the IQ SENSOR NET system. During the initial commissioning, the sensor numbers are assigned by the system in the order in which the sensors are recognized by the system.

Preparation of the IQ SENSOR NET for communication with a field bus may require, e.g. the following:

- Creating an IQ SENSOR NET system with specific assignment of sensor numbers to sensors
- Creating several IQ SENSOR NET systems with the identical assignment of sensor numbers to sensors
- Changing the order of the sensors in an already installed system

Creating the assignment of sensor numbers

You want to install an IQ SENSOR NET system and, at the same time, to create a specific sequence of sensor number assignments to the sensors.

1	Carry out a system start without any sensors (see system operating manual).
2	Connect the sensors to the system in the required order. After connecting each sensor, wait until the sensor is recognized by the system (see system operating manual, chapter Installation).

Changing the assignment of sensor numbers

You want to change the assignment of sensor numbers to the sensors in an already running IQ SENSOR NET system.

1	Unplug all sensors from the IQ SENSOR NET.

When the inactive datasets are deleted, all settings for the sensors are deleted as well.

2	Delete all inactive datasets in the list of sensors (see System operating manual, chapter *Deleting inactive datasets of sensors*).
3	Connect the sensors to the system in the required order. After connecting a sensor, wait until the sensor is recognized by the system (see system operating manual, chapter Installation).

Creating the identical assignment of sensor numbers in several systems

You want to install several identical IQ SENSOR NET systems and, at the same time, to create the same sequence of sensor number assignments to the sensors in all systems.

1	Copy the configuration to a further controller from the original one (see IQS Connect: ConfigSaveLoad).

4 Communication with field buses

The IQ SENSOR NET monitors the current state of each sensor operated on the system. The sensor status documents sensor information (measured value status and status info of the sensor) and current processes (e.g. calibration or cleaning).

The sensor status is superordinate to the measured value status. The influence of the sensor status on the measured value is documented with the status descriptions.

For the measured value to be evaluated, e.g. by a superordinate control system such as PLC, the sensor status and measured value status also have to be taken into account together with the measured value. A measured value is suitable for further evaluation if both of the following conditions are met:

1st	Sensor status	MEASURE
2nd	Measured value status	VALID

4.1 Communication with Profibus, Profinet, Ethernet IP

4.1.1 Data transmission

The sensor number (Sxx) is the identification for a sensor. The sensor number is always transmitted in the first byte of the output and input data. Thus the control system (PLC) can clearly query data of individual sensors.

The data is transferred cyclically in two steps:

- Output data of the PLC:
  The superordinate control system (PLC) sends a prompt to the IQ SENSOR NET to provide data of the sensor with a certain sensor number.
- Input data of the PLC:
  The IQ SENSOR NET checks whether the prompted sensor number is available and returns the data of the sensor with the relevant sensor number to the superordinate control system (PLC).

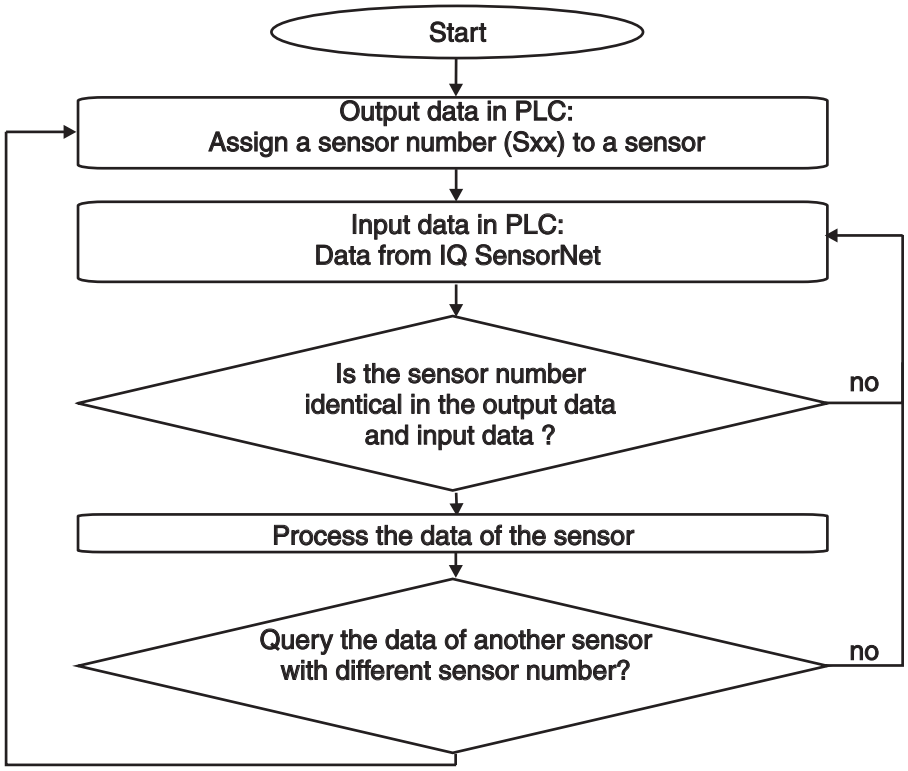


Fig. 4-1 Data transmission in (Profinet, Profibus, Ethernet IP)

4.1.2 Query format (output data of the PLC)

1 Byte - from the superordinate control system (PLC) to the IQ SENSOR NET
For Ethernet IP: Instance ID= 101 (SensorSelector)

Address	Information	Data format	
		Data type	Bit
Offset 0h	Sensor number (Sxx) in the IQ SENSOR NET	Int 8	7-0

4.1.3 Data block of the sensors (input data of the PLC)

16 bytes - from the IQ SENSOR NET to the superordinate control system (PLC)
For Ethernet IP: Instance ID =102 (SensorData)

Address	Information	Data format	
		Data type	Bit
Offset 0h	Sensor number	Int 8	7-0
Offset 1h	Sensor status	Int 8	7-0
Offset 2h	Sensor model	Int 16	15-8
Offset 3h			7-0
Offset 4h	Status info	Int 16	15-8
Offset 5h			7-0
Offset 6h	Measuring mode	Int 8	7-0
Offset 7h	Status of main measured value	Int 8	7-4
	Status of secondary measured value		3-0
Offset 8h	Main measured value (IEEE-754 floating point, 32-bit)	Float 32	31-24
Offset 9h			23-16
Offset Ah			16-8
Offset Bh			7-0
Offset Ch	Secondary measured value (IEEE-754 floating point, 32-bit)	Float 32	31-24
Offset Dh			23-16
Offset Eh			16-8
Offset Fh			7-0

4.1.4 Example

Sensor data			
Byte	**Value**	**Information**	**Meaning of the value**
Offset 0h	02h	Sensor number	02h (Int 8) --> 2 Sensor number **S02**
Offset 1h	02h	Sensor status	02h (Int 8) --> **MEASURE** see section 5.2
Offset 2h	04h	Sensor model	0401h (Int 16) --> **VisoTurb 700 IQ** see section 5.3
Offset 3h	01h	Sensor model	
Offset 4h	00h	Status info	0000h (Int 16) --> **no errors** see section 5.4
Offset 5h	00h	Status info	
Offset 6h	00h	Measuring mode	00h (Int 8) --> **FNU** *Turb* see section 5.5
Offset 7h	14h	Measured value status	14h (Int 8) Main measured value (bits 7-4): 1h --> **VALID** Secondary measured value (bits 3-0): 4h --> **MISSING** see section 5.6
Offset 8h	42h	Main measured value	429E46C2h (Float 32) --> **79,1382** Measured parameter and unit, see byte 10 (measuring mode)
Offset 9h	9Eh		
Offset Ah	46h		
Offset Bh	C2h		
Offset Ch	00h	Secondary measured value	00000000h (Float 32) --> **0** but measured value invalid (MISSING), see byte 11 (measured value status)
Offset Dh	00h		
Offset Eh	00h		
Offset Fh	00h		

4.2 Communication with Modbus RTU, Modbus TCP

4.2.1 Data transmission

On each query of sensor data with the Modbus protocol, a block of consecutive registers is read.

Query and response telegram

Data transmission takes place via query and response telegrams. The form of the telegrams is determined by the Modbus RTU protocol.
The Modbus master transmits a query telegram with a Modbus command to the Modbus slave (here, the IQ SENSOR NET). The Modbus slave transmits a response telegram with the requested data or an error message.

4.2.2 Query format

Supported Modbus commands

The IQ SENSOR NET provides the data block for read access only. Writing Modbus commands are not carried out.

The following commands are available:

Modbus commands	Command code
Read Input Register	04h
Read Holding Register	03h

For a query of sensor data, determine the first register and the number of registers to be read.

Determining the first register to be read

The first register to be read depends on the sensor number (Sxx):

$R = [(Sxx - 1) * 8] + 1.$

Example: Determine the first register with data block for the sensor S02:
$R = [(2 - 1) * 8] + 1 = 9$

The number of registers to be read for one sensor data block is 8 registers.
With one Modbus query, up to 125 registers (15 data blocks) can be read.

4.2.3 Data block of the sensors

The data block contains the data of the sensors in the order of their registering on the IQ SENSOR NET (Sxx number).

The data of a sensor are stored in 8 registers each.

	Modbus		Information	Data format	
	Register	Bit		Data type	Bit
Sensor S01	0001	1-8	Sensor number (S01)	Int 8	7-0
	0001	9-16	Sensor status	Int 8	7-0
	0002	1-16	Sensor model	Int 16	15-0
	0003	1-16	Status info	Int 16	15-0
	0004	1-8	Measuring mode	Int 8	7-0
	0004	9-16	Measured value status	Int 8	7-0
	0005	1-16	Main measured value (IEEE-754 floating point, 32-bit)	Float 32	31-16
	0006	1-16			15-0
	0007	1-16	Secondary measured value (IEEE-754 floating point, 32-bit)	Float 32	31-16
	0008	1-16			15-0
Sensor S02	0009	1-8	Sensor number (S02)	Int 8	7-0
	0009	9-16	Sensor status	Int 8	7-0
	0010	1-16	Sensor model	Int 16	15-0
	0011	1-16	Status info	Int 16	15-0
	0012	1-8	Measuring mode	Int 8	7-0
	0012	9-16	Measured value status	Int 8	7-0
	0013	1-16	Main measured value (IEEE-754 floating point, 32-bit)	Float 32	31-16
	0014	1-16			15-0
	0015	1-16	Secondary measured value (IEEE-754 floating point, 32-bit)	Float 32	31-16
	0016	1-16			15-0
Sensor S03 ...	0017	1-8		Int 8	7-0
	0018	9-16		Int 8	7-0
	...	...	...	...	...

The counting method of the Modbus registers and Modbus bits and the allocation of MSB and LSB is different from the usual method of most programming languages.

	Modbus	Usually
Count start of the register	1	0
MSB* allocation of the register	Bit 1	Bit 15
LSB* allocation of the register	Bit 16	Bit 0

* MSB = Most significant bit, LSB = Least significant bit

4.2.4 Example

Query of the sensor data block for sensor S02

Modbus query			
Byte	**Value**	**Information**	**Meaning of the value**
1	01h	Modbus address of the IQ SENSOR NET	01h --> **1**
2	04h	Function	04h --> 4 **Read Input Register** see section 4.2.2
3	00h	Start address HI	0008h --> 8 **Start with register 9** (Modbus counting method)
4	08h	Start address LO	
5	00h	Number of HI registers	0008h --> 8 **8 registers**
6	08h	Number of LO registers	
7	70h	CRC (HI)	Checksum (CRC)
8	0Eh	CRC (LO)	

Response with sensor data block of the sensors S02

Modbus response			
Byte	**Value**	**Information**	**Meaning of the value**
1	01h	Modbus address of the IQ SENSOR NET	01h --> **1**
2	04h	Function	04h --> 4 **Read Input Register**
3	10h	Number of bytes	10h --> **16** 16 Byte (8 registers)
4	02h	Contents of register 9 (HI) = sensor number	02h (Int 8) --> 2 Sensor number **S02**
5	02h	Contents of register 9 (LO) = sensor status	02h (Int 8) --> **MEASURE** see section 5.2
6	04h	Contents of register 10 (HI) = sensor model	0401h (Int 16) --> **VisoTurb 700 IQ** see section 5.3
7	01h	Contents of register 10 (LO) = sensor model	
8	00h	Contents of register 11 (HI) = status info	0000h (Int 16) --> **no errors** see section 5.4
9	00h	Contents of register 11 (LO) = status info	
10	00h	Contents of register 12 (HI) = measuring mode	00h (Int 8) --> **FNU** *Turb* see section 5.5
11	14h	Contents of register 12 (LO) = measured value status	14h (Int 8) Main measured value (bits 7-4): 1h --> **VALID** Secondary measured value (bits 3-0): 4h --> **MISSING** see section 5.6

Modbus response			
Byte	**Value**	**Information**	**Meaning of the value**
12	42h	Contents of register 13 (HI) = main measured value	429E46C2h (Float 32) --> **79,1382** Measured parameter and unit, see byte 10 (measuring mode)
13	9Eh	Contents of register 13 (LO) = main measured value	
14	46h	Contents of register 14 (HI) = main measured value	
15	C2h	Contents of register 14 (LO) = main measured value	
16	00h	Contents of register 15 (HI) = secondary measured value	00000000h (Float 32) --> **0** but measured value invalid (MISSING), see Byte 11 (measured value status)
17	00h	Contents of register 15 (LO) = secondary measured value	
18	00h	Contents of register 16 (HI) = secondary measured value	
19	00h	Contents of register 16 (LO) = secondary measured value	
20	23h	CRC (HI)	Checksum (CRC)
21	5Eh	CRC (LO)	

5 Encoded data for field bus communication

5.1 Data formats of the sensor datablock

Measured values (Float 32)

The data for the main and secondary measured values are transmitted in the IEE-754 standard 32-bit floating point format.

Address	Bit representation MSB* LSB*	
Offset 0h bits 31-24	S E E E E E E E	S = sign (bit 31) E = exponent (bits 30-23) M = mantissa (bits 22-0)
Offset 1h bits 23-16	E M M M M M M M	
Offset 2h bits 15-8	M M M M M M M M	
Offset 3h bits 7-0	M M M M M M M M	

* MSB = Most significant bit, LSB = Least significant bit

If not all of the bits of the exponent are 0, the value is calculated according to:

$$V = -1^{S} \cdot 2^{E-127} \cdot (1 + M_{b22} \cdot 2^{-1} + M_{b21} \cdot 2^{-2} + M_{b20} \cdot 2^{-3} + ... + M_{b0} \cdot 2^{-23})$$

If all of the bits of the exponent are 0, the value is calculated according to:

$$V = -1^{S} \cdot 2^{-126} \cdot (M_{b22} \cdot 2^{-1} + M_{b21} \cdot 2^{-2} + M_{b20} \cdot 2^{-3} + ... + M_{b0} \cdot 2^{-23})$$

A value is 0 if all the bits of both the exponent as well as the mantissa are 0.

Evaluation		Meaning
Measured value	0	Check the measured value status
Measured value status	<> 1	The measured value is invalid (error)

Apart from the byte order described in the bit representation, another order of the bytes is also possible.
Opposite to the order described, the two lower bytes have been exchanged with the two upper bytes in this order (b4 b3 b2 b1 - b2 b1 b4 b3).

For field bus applications that can independently interpret floating point numbers (or allow to select a data format for certain registers), the byte order the data interpretation is based on should be checked.

Sensor model Status info (INT16)

The data for the sensor model and status info is transmitted as INT16, i.e. consists of 2 bytes. The assignment is carried out in Motorola format (the higher value byte first).

Address	Bit representation	Information
	MSB LSB	
Offset 0h bits 15-8		High byte
Offset 1h bits 7-0		Low byte

Measured value status (Int8)

The data for the measured value status of the main and secondary measured values are encoded jointly into a single byte. Bits 7-4 encode the status of the main measured value, bits 3-0 encode the status of the secondary measured value.

Other data (INT8)

All other data always consist of only a single byte (Int8).

5.2 Sensor status

The sensor status applies to both the main and secondary measured value of a sensor.

Code	Status	Meaning of the status
00h	UNUSED_ID	Sensor and sensor number are not available in the IQ SENSOR NET system. The measured value status of the main and secondary measured value is **MISSING** (4h) (see section 5.6 MEASURED VALUE STATUS). The UNUSED_ID status also occurs when the field bus interface of the IQ SENSOR NET does not receive any data from the IQ SENSOR NET controller for more than 2 minutes. Possible cause: Communication malfunction or controller failure. The data transmitted last remain frozen for the two minutes delay time.
01h	INACTIVE	The sensor is currently inactive. The sensor number (ID) and respective setting dataset are available in the IQ SENSOR NET system. The sensor was removed from the IQ SENSOR NET system or the communication does not work. The measured value status of the main and secondary measured value is **MISSING** (4h) (see section 5.6 MEASURED VALUE STATUS). The measured value display on the terminal indicates *Init* or *Error*.

Code	Status	Meaning of the status
02h	MEASURE	The sensor is in measuring mode. The measured value status can be VALID, OFL or INVALID. The measured value display on the terminal indicates the valid measured value, *OFL* or "----" (invalid measured value). For the measured value to be evaluated, e.g. by a superordinate control system, the sensor status and measured value status also have to be taken into account together with the measured value (see also section 5.6 MEASURED VALUE STATUS)
03h	CALIBRATE	The sensor is being calibrated. No measured value is available. The measured value status of the main and secondary measured value is **MISSING** (4h) (see section 5.6 MEASURED VALUE STATUS). The measured value display on the terminal indicates *Cal*.
04h	ERROR	The sensor is in a serious error status.
05h	MAINTENANCE	The sensor is in maintenance condition or a cleaning cycle (cleaning including adjustment phase) is active. The measured value display on the terminal shows a flashing measured value or *Clean*. The measured value and measured value status are frozen while the sensor is in the MAINTENANCE condition. In the case of the measured value status VALID, the measured value is frozen with the value displayed at the start of the MAINTENANCE status.

5.3 Sensor model

The sensor model is the model name the sensor registers with on the IQ SENSOR NET.

Code	Model
0101h	SensoLyt700IQ
0201h	TetraCon700IQ
0301h	TriOxmatic700IQ
0302h	TriOxmatic701IQ
0303h	TriOxmatic702IQ
0304h	SC FDO 700 (FDO700IQ)
0305h	SC FDO 701 (FDO700IQ)
0401h	VisoTurb700IQ
0402h	ViSolid700IQ
0501h	AmmoLyt700IQ
0503h	AmmoLyt+ (AmmoLyt+700IQ)
0907h	AmmoLyt+K (AmmoLyt+700IQ)
0601h	NitraLyt700IQ
0602h	NitraLyt+ (NitraLyt+700IQ)
0701h	NitraVis700/1IQ
0702h	NitraVis700/5IQ
0703h	CarboVis700/5IQ
0704h	SolidVis700IQ (UV/VIS sensors with TSS option)
0705h	NitraVis700/5IQ (NiCaVis700IQ)
0706h	CarboVis700/5IQ (NiCaVis700IQ)
0707h	CarboVis700/1IQ
0801h	MIQ/IC2, current input 1
0802h	MIQ/IC2, current input 2
0901h	VARiON A (VARiON700IQ)
0902h	VARiON N (VARiON700IQ)
0905h	VARiON A (VARiON+700IQ)

Code	Model
0906h	VARiON N (VARiON+700IQ)
0907h	VARiON K (VARiON+700IQ)
0A01h	NitraVis701 IQ (+ NiCaVis701IQ NI)
0A02h	NitraVis705 IQ (+ NiCaVis705IQ + NiCaVis705IQ NI)
0A03h	CarboVis701 IQ (+ NiCaVis701IQ NI)
0A04h	CarboVis705 IQ (+ NiCaVis705IQ + NiCaVis705IQ NI)
0A07h	SolidVis701 IQ (UV/VIS sensors with TSS option)
0A08h	SolidVis705 IQ (UV/VIS sensors with TSS option)
0A1Ah	Virtual N sensor - NitraVis701IQ NI
0A1Bh	Virtual N sensor - NitraVis705IQ NI
0A1Ch	Virtual C sensor 1 - CarboVis701 IQ
0A1Dh	Virtual C sensor 2 - CarboVis701 IQ
0A1Eh	Virtual C sensor 3 - CarboVis701 IQ
0A1Fh	Virtual C sensor 4 - CarboVis701 IQ
0A20h	Virtual C sensor 1 - CarboVis705 IQ
0A21h	Virtual C sensor 2 - CarboVis705 IQ
0A22h	Virtual C sensor 3 - CarboVis705 IQ
0A23h	Virtual C sensor 4 - CarboVis705 IQ
0B01h	P 700 IQ
0C01h	IFL 700 IQ
0C02h	IFL 701 IQ

5.4 Status info of sensors

Model	Bit 0	Bit 1	Bit 2	Bit 3-31
SensoLyt700IQ	*Component hardware defective*	*SensCheck: pH electrode defective, glass broken*	-	-
TetraCon700IQ		-	-	-
TriOxmatic700IQ		*SensReg: Electrolyte supply is depleted*	*SensLeck: Membrane head damaged**	-
TriOxmatic701IQ				-
TriOxmatic702IQ			-	-
SC FDO 700		*Measurement interfered*	-	-
SC FDO 701		*Measurement interfered*	-	-
VisoTurb700IQ		*SensCheck: Sensor contaminated*	*SensCheck: Ultrasound cleaning system has failed*	-
ViSolid700IQ				-
AmmoLyt700IQ		-	-	-
AmmoLyt+		-	-	-
AmmoLyt+K		-	-	-
NitraLyt700IQ		-	-	-
NitraLyt+		-	-	-
NitraVis700/xIQ		-	-	-
CarboVis700/xIQ		-	-	-
SolidVis700IQ		-	-	-
NitraVis70xIQ		*Component hardware defective* xxx	*Optical measuring range exceeded*	-
CarboVis70xIQ				-
SolidVis70xIQ				-
MIQ/IC2		-	-	-
VARiON A		-	-	-
VARiON N		-	-	-
VARiON K		-	-	-

* The SensLeck function is not available with the sea water model (-SW variant)

continued

Model	Bit 0	Bit 1	Bit 2	Bit 3-31
IFL 700 IQ	*Component hardware defective*	-	-	-
IFL 701 IQ		-	-	-
P 700 IQ		*Liquid tank xxx almost depleted!*	*Air bubbles in the analyzer*	-

Note
The status info must be evaluated for each bit individually.

5.5 Measuring mode

	Code								
Model	**00h**	**01h**	**02h**	**03h**	**04h**	**05h**	**06h**	**07h**	**08h**
SensoLyt700IQ	pH	mV							
TetraCon700IQ	S/cm	*SAL*	TDS	S/m					
TriOxmatic700IQ TriOxmatic701IQ TriOxmatic702IQ	mg/l O2	% O2							
SC FDO 700 SC FDO 701	mg/l O2	% O2							
VisoTurb700IQ	FNU-*Turb*	NTU-*Turb*	TEF-*Turb*	mg/l SiO2	ppm SiO2	g/l TS			
ViSolid700IQ	g/l TSS (M11)	% TSS (M11)	g/l TSS (M21)	% TSS (M21)	g/l SiO2 (M1[1])	% SiO2 (M1[1])	g/l SiO2 (M2[1])	% SiO2 (M2[1])	
AmmoLyt700IQ AmmoLyt+	mg/l NH4-N	mg/l NH4	mV						
AmmoLyt+K	mg/l K	mV							
NitraLyt700IQ NitraLyt+	mg/l NO3-N	mg/l NO3	mV						

[1] M1 = matrix type 1, M2 = matrix type 2
matrix types: see ViSolid 700 IQ sensor operating manual

	Code								
Model	**00h**	**01h**	**02h**	**03h**	**04h**	**05h**	**06h**	**07h**	**08h**
NitraVis700/xIQ NitraVis70xIQ	mg/l NO3-N	mg/l NO3	mg/l NO3-N[4]						
NitraVis70xIQ NI	mg/l NO2-N	mg/l NO2							
CarboVis700/xIQ CarboVis70xIQ	mg/l*CODto*	mg/l*CODds*	mg/l*TOC*	mg/l*BOD*	mg/l*DOC*	*Abs/m SACto*	*Abs/m SACds*	mg/l *CSB*4	UVT 254[5]
SolidVis700IQ SolidVis70xIQ	(m)g/l TSS [2]								
MIQ/IC2	[3]								
VARiON A	mg/l NH4-N	mg/l NH4	mV						
VARiON N	mg/l NO3-N	mg/l NO3	mV						
VARiON K	mg/l K	mV							
P 700 IQ	mg/l PO4-P	mg/l PO4							
IFL 70x IQ	m								

1 M1 = matrix type 1, M2 = matrix type 2
matrix types: see ViSolid 700 IQ sensor operating manual

2 The measurement unit depends on the settings of the main sensor

3 The measured parameter and measurement unit depend on the settings of the display values (see MIQ/IC2 sensor operating manual).

4 Only xxxVis700/xIQ: Test measurement with standards

5 Only CarboVis70xIQ

5.6 Measured value status

The measured value status is available for both the main and secondary measured value of a sensor.

Code	Status	Meaning of the status
1h	VALID	The measured value is valid. In the case of the sensor status MAINTENANCE, the measured value is frozen on the value of the start of the MAINTENANCE status. The measured value display of the IQ SENSOR NET shows a flashing measured value or *Clean*.
2h	OFL	The measured value lies outside the selected measuring range. The transmitted measured value is set to 0. The measured value display of the IQ SENSOR NET indicates *OFL*.
3h	INVALID	The measured value is invalid. The transmitted measured value is set to 0. The measured value display of the IQ SENSOR NET indicates "----" (invalid measured value).
4h	MISSING	The measured value cannot be determined or is not available. The transmitted measured value is set to 0. The measured value display of the IQ SENSOR NET indicates *Cal* or *Error*.

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1) The tissue in plants that brings water upward from the roots;
2) a leading global water technology company.

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