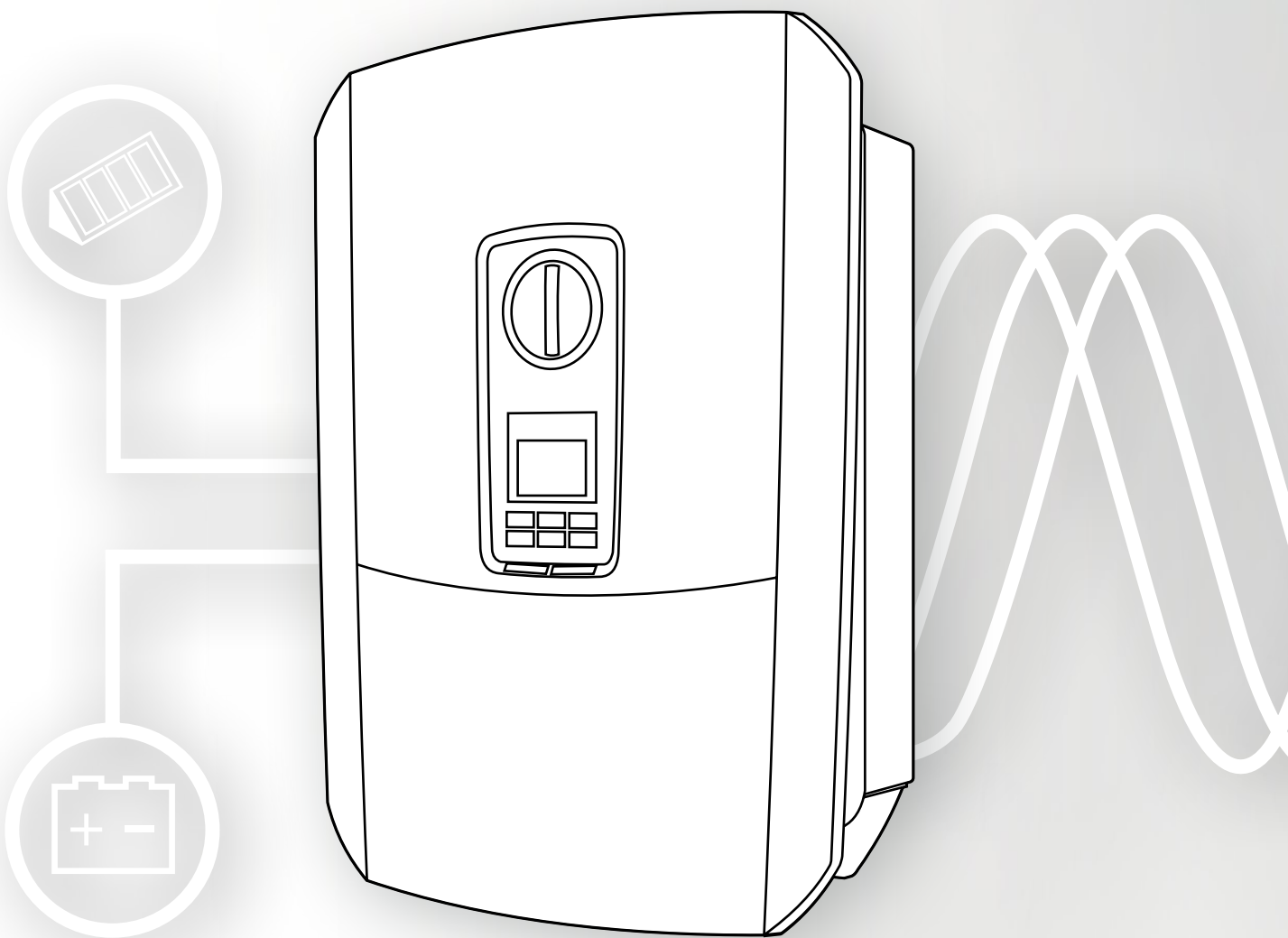


# PIKO IQ/PLENTICORE



Smart connections.

KOSTAL Interface description  
MODBUS (TCP) & SunSpec  
with control information

# Version

Release date: 2021-06-16

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# Inhalt

|                                                   |           |
|---------------------------------------------------|-----------|
| <b>1. Introduction</b>                            | <b>4</b>  |
| 1.1 Disclaimer of liability .....                 | 4         |
| 1.2 Intended Use.....                             | 4         |
| 1.3 Target group.....                             | 5         |
| 1.4 Safety Information .....                      | 5         |
| 1.5 MODBUS Protocol .....                         | 6         |
| 1.6 Data Formats .....                            | 6         |
| <b>2. MODBUS protocol description</b>             | <b>7</b>  |
| 2.1 Application Layer.....                        | 7         |
| 2.2 Data Link Layer .....                         | 7         |
| 2.3 Physical Layer .....                          | 8         |
| <b>3. MODBUS Register table</b>                   | <b>9</b>  |
| 3.1 TCP-Port and Unit-ID .....                    | 9         |
| 3.2 Query the operating data.....                 | 9         |
| 3.3 Active power and reactive power control ..... | 15        |
| 3.4 External battery management.....              | 16        |
| <b>4. SunSpec Interface</b>                       | <b>18</b> |
| 4.1 Overview .....                                | 18        |
| 4.2 Implemented SunSpec Models.....               | 18        |
| 4.3 Startaddresses.....                           | 18        |

# 1. Introduction

## 1.1 Disclaimer of liability

The activities described in this document may only be carried out by specialists who have the following qualifications:

- Knowledge of IP-based network protocols
- Training in the installation and configuration of IT systems
- Knowledge of the functionality and operation of inverters
- Training in dealing with dangers and risks associated with the operation of electrical devices and systems
- Knowledge of and observance of this document

Any instance of misuse will result in the termination of the warranty, guarantee and general liability to the fullest extent permitted by law of the manufacturer.

Nothing in this conditions limits or excludes the liability of KOSTAL for:

Death or personal injury resulting from its negligence; or fraud or fraudulent misrepresentation. KOSTAL shall not under any circumstances whatever be liable for loss of profits; or any special, indirect or consequential loss, costs, damages, charges or expenses.

## 1.2 Intended Use

The Modbus interface is designed for industrial use and has the following tasks:

- Remote control of the grid management services of a PV system.
- Remote-controlled query of measured values from a PV system.
- Remote-controlled change of parameters of a PV system.
- Remote charge and discharge control of hybrid and battery inverters

The Modbus interface can be used via the Modbus TCP protocol.

All components have to stay within their permitted operating and installation requirements. The products should only be used in line with their documentation and the local applicable standards and directives.

Alterations to the product, e.g. changes or modifications, are prohibited. Any use of the product other than that described in the Intended Use section does not qualify as the intended use. To observe all instructions contained therein.

## 1.3 Target group

These instructions are aimed at the aforementioned qualified specialist who needs information on the Modbus interface in order to use it for industrial use and to create their own products.

## 1.4 Safety Information

This section contains safety information that must be observed at all times. Opening the Modbus interface from extern can be results in the manipulation of the PV system data in the Ethernet network.

If KOSTAL solar inverters are connected to the Internet, there is a risk that unauthorized users can access and manipulate the data of your PV system.

- Set up a firewall.
- Close unnecessary network ports in your router.
- Remote access should only be done through a virtual private network (VPN).
- Do not set up port forwarding for the Modbus ports used.

KOSTAL under no circumstances shall have any liability for any loss or damage incurred by the use of the Modbus interface. The use of the interface and reliance on the information is solely at the users risk.

## 1.5 MODBUS Protocol

MODBUS is an application layer messaging protocol, positioned at level 7 of the OSI model, which provides client/server communication between devices connected on different types of buses or networks.

The industry's serial de facto standard since 1979, MODBUS continues to enable millions of automation devices to communicate. Today, support for the simple and elegant structure of MODBUS continues to grow. The Internet community can access MODBUS at a reserved system port 502 on the TCP/IP stack.

MODBUS is a request/reply protocol and offers services specified by function codes. MODBUS function codes are elements of MODBUS request/reply PDUs. The objective of this document is to describe the function codes used within the framework of MODBUS transactions.

The MODBUS Application Protocol is currently used in the solar sector mainly for system communication in PV power plants. The MODBUS protocol has been developed for reading data from- or writing data to clearly defined data areas.

## 1.6 Data Formats

The following data formats describe how data is to be interpreted. The data formats are important, for example, for the display of data or for its further processing. The data formats are listed in the Format column of the assignment tables.

|     |                                               |
|-----|-----------------------------------------------|
| U16 | An unsigned integer 16-bit-value, 1 register  |
| U32 | An unsigned integer 32-bit-value, 2 registers |
| R32 | A real (float) 32-bit-value, 2 registers      |
| S16 | A signed integer 16-bit-value, 1 register     |
| S32 | A signed integer 32-bit-value, 2 registers    |

# 2. MODBUS protocol description

## 2.1 Application Layer

MODBUS is an application layer messaging protocol, positioned at level 7 of the OSI model, which provides client/server communication between devices connected on different types of buses or networks.

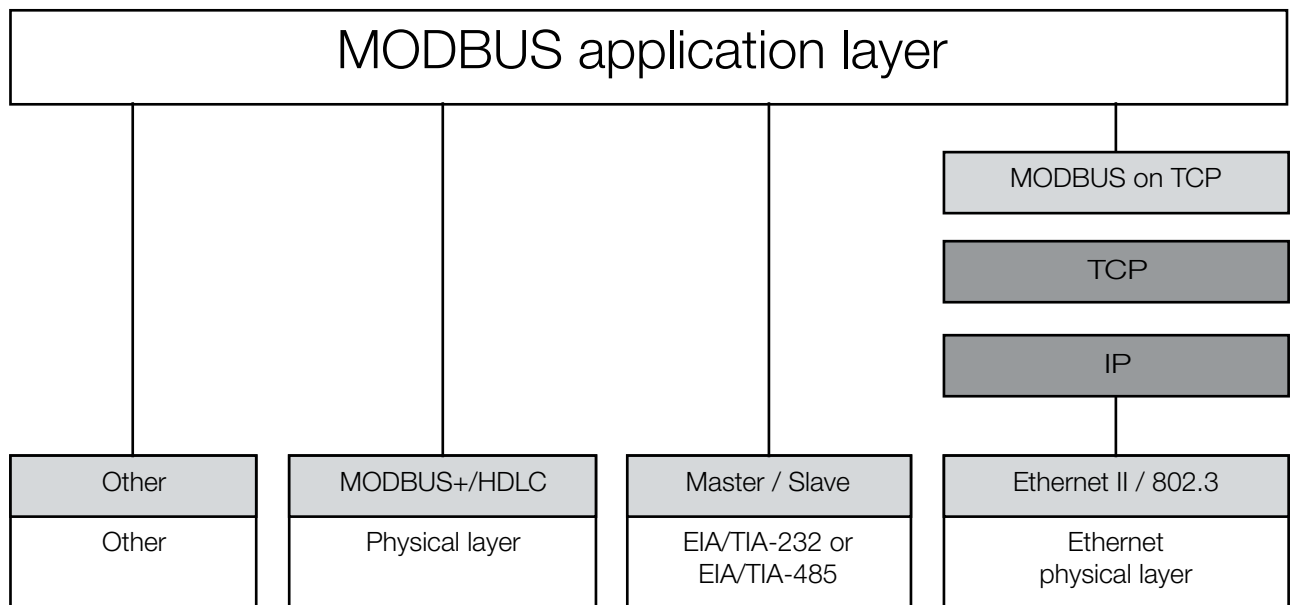


Abb. 1: MODBUS communication stack

MODBUS is an application layer messaging protocol for client/server communication between devices connected on different types of buses or networks.

Scope of this document is the implementation TCP/IP over Ethernet. See MODBUS Messaging Implementation Guide V1.0a.

## 2.1.1 MODBUS frame

The MODBUS protocol defines a simple protocol data unit (PDU) independent of the underlying communication layers. The mapping of MODBUS protocol on specific buses or network can introduce some additional fields on the application data unit (ADU).

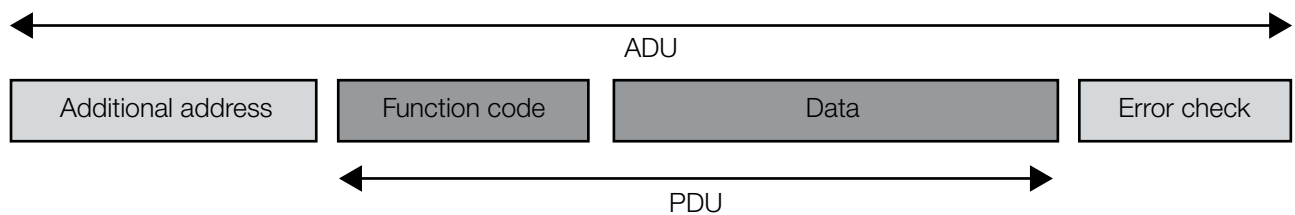


Abb. 2: General MODBUS frame

### Abbreviations:

|      |                                 |
|------|---------------------------------|
| ADU  | Application Data Unit           |
| HDLC | High Level Data Link Control    |
| HMI  | Human Machine Interface         |
| IETF | Internet Engineering Task Force |
| I/O  | input/Output                    |
| IP   | Internet Protokoll              |
| MAC  | Media Access Control            |
| MB   | MODBUS Protokol                 |
| MBAP | MODBUS Appllication Protokol    |
| PDU  | Protocol Data Unit              |
| PLC  | Programmable Logic Control      |
| TCP  | Transmission Control Protocol   |

The MODBUS application data unit is built by the client that initiates a MODBUS transaction. The function indicates to the server what kind of action to perform.

The function code field of a MODBUS data unit is coded in one byte. Valid codes are in the range of 1 ... 255 decimal (the range 128 – 255 is reserved and used for exception responses). When a message is sent from a Client to a Server device the function code field tells the server what kind of action to perform. Function code "0" is not valid.



## 2.1.2 Data Encoding

MODBUS uses a 'big-Endian' representation for addresses and data items. This means that when a numerical quantity larger than a single byte is transmitted, the most significant byte is sent first. So for example

| Register size | value  |                                        |
|---------------|--------|----------------------------------------|
| 16 - bits     | 0x1234 | the first byte sent is 0x12, then 0x34 |

## 2.1.3 Function code list

The following MODBUS commands are supported by the implemented MODBUS interface:

| MODBUS command         | Function code | Quantity of Registers <sup>1</sup> |
|------------------------|---------------|------------------------------------|
| Read Holding Registers | 0x03          | 1 to 125                           |
| Write Single Register  | 0x06          | 1                                  |

<sup>1</sup> Register content is 16-bits width.

## 2.1.4 Read Holding Registers (0x03)

This function code is used to read the contents of a contiguous block of holding registers in the inverter. The Request PDU specifies the starting register address and the number of registers. In the PDU Registers are addressed starting at zero. Therefore registers numbered 1-16 are addressed as 0-15.

The register data in the response message are packed as two bytes per register, with the binary contents right justified within each byte. For each register, the first byte contains the high order bits and the second contains the low order bits.

### Request

|                       |         |                  |
|-----------------------|---------|------------------|
| Function code         | 1 Byte  | 0x03             |
| Starting Address      | 2 Bytes | 0x0000 to 0xFFFF |
| Quantity of Registers | 2 Bytes | 1 to 125 (0x7D)  |

### Response

|                |                          |                  |
|----------------|--------------------------|------------------|
| Function code  | 1 Byte                   | 0x03             |
| Byte count     | 1 Bytes                  | 0x0000 to 0xFFFF |
| Register value | N <sup>1</sup> x 2 Bytes | 1 to 125 (0x7D)  |

<sup>1</sup>N = Quantity of Registers

### Error

|                |         |                      |
|----------------|---------|----------------------|
| Error code     | 1 Byte  | 0x83                 |
| Exception code | 1 Bytes | 01 or 02 or 03 or 04 |

Here is an example of a request to read registers 108 – 110:

| Request              |       | Response                 |       |
|----------------------|-------|--------------------------|-------|
| Field Name           | (hex) | Field Name               | (hex) |
| Function             | 03    | Function                 | 03    |
| Starting Address Hi  | 00    | Byte Count               | 06    |
| Starting Address Low | 6B    | Register value Hi (108)  | 02    |
| No. of Registers Hi  | 00    | Register value Low (108) | 2B    |
| No. of Registers Low | 03    | Register value Hi (109)  | 00    |
|                      |       | Register value Low (109) | 00    |
|                      |       | Register value Hi (110)  | 00    |
|                      |       | Register value Low (110) | 64    |

The contents of register 108 are shown as the two byte values of 0x022B. The contents of registers 109 –110 are 0x0000 and 0x0064.

## 2.1.5 Write Single Register (0x06)

This function code is used to write a single holding register in the inverter.

The Request PDU specifies the address of the register to be written.

The normal response is an echo of the request, returned after the register contents have been written.

### Request

|                       |         |                  |
|-----------------------|---------|------------------|
| Function code         | 1 Byte  | 0x06             |
| Starting Address      | 2 Bytes | 0x0000 to 0xFFFF |
| Quantity of Registers | 2 Bytes | 0x0000 to 0xFFFF |

### Response

|                |         |                  |
|----------------|---------|------------------|
| Function code  | 1 Byte  | 0x06             |
| Byte count     | 1 Bytes | 0x0000 to 0xFFFF |
| Register value | 2 Bytes | 0x0000 to 0xFFFF |

### Error

|                |         |                      |
|----------------|---------|----------------------|
| Error code     | 1 Byte  | 0x86                 |
| Exception code | 1 Bytes | 01 or 02 or 03 or 04 |

Here is an example of a request to write register 2 to 0x0003:

| Request              |       | Response             |       |
|----------------------|-------|----------------------|-------|
| Field Name           | (hex) | Field Name           | (hex) |
| Function             | 06    | Function             | 06    |
| Register Address Hi  | 00    | Register Address Hi  | 00    |
| Register Address Low | 01    | Register Address Low | 01    |
| Register Value Hi    | 00    | Register Value Hi    | 00    |
| Register Value Low   | 03    | Register Value Low   | 03    |

## 2.1.6 Exception Responses

When a client device sends a request to a server device it expects a normal response. One of four possible events can occur from the client's query:

- If the server device receives the request without a communication error, and can handle the query normally, it returns a normal response.
- If the server does not receive the request due to a communication error, no response is returned. The client program will eventually process a timeout condition for the request.
- If the server receives the request, but detects a communication error (parity, CRC...), no response is returned. The client program will eventually process a timeout condition for the request.
- If the server receives the request without a communication error, but cannot handle it (for example, if the request is to read a non-existent output or register), the server will return an exception response informing the client of the nature of the error.

The exception response message has two fields that differentiate it from a normal response:

**Function Code Field:** In a normal response, the server echoes the function code of the original request in the function code field of the response. All function codes have a most – significant bit (MSB) of 0 (their values are all below 80 hex). In an exception response, the server sets the MSB of the function code to 1. This makes the function code value in an exception response exactly 80 hex higher than the value would be for a normal response.

With the function code's MSB set, the client's application program can recognize the exception response and can examine the data field for the exception code.

**Data Field:** In a normal response, the server may return data or statistics in the data field (any information that was requested in the request). In an exception response, the server returns an exception code in the data field. This defines the server condition that caused the exception.

The exception codes are listed:

| MODBUS Exception Codes |                  |                                                                                                                                                                                                                                                                                                                                                                                                   |
|------------------------|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Code                   | Name             | Meaning                                                                                                                                                                                                                                                                                                                                                                                           |
| 01                     | ILLEGAL FUNCTION | The function code received in the query is not an allowable action for the server. This may be because the function code is only applicable to newer devices, and was not implemented in the unit selected. It could also indicate that the server is in the wrong state to process a request of this type, for example because it is un-configured and is being asked to return register values. |

| <b>MODBUS Exception Codes</b> |                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------------------------------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>02</b>                     | ILLEGAL DATA ADDRESS     | The data address received in the query is not an allowable address for the server. More specifically, the combination of reference number and transfer length is invalid. For a controller with 100 registers, the PDU addresses the first register as 0, and the last one as 99. If a request is submitted with a starting register address of 96 and a quantity of registers of 4, then this request will successfully operate (address-wise at least) on registers 96, 97, 98, 99. If a request is submitted with a starting register address of 96 and a quantity of registers of 5, then this request will fail with Exception Code 0x02 "Illegal Data Address" since it attempts to operate on registers 96, 97, 98, 99 and 100, and there is no register with address 100. |
| <b>03</b>                     | ILLEGAL DATA VALUE       | A value contained in the query data field is not an allowable value for server. This indicates a fault in the structure of the remainder of a complex request, such as that the implied length is incorrect. It specifically does NOT mean that a data item submitted for storage in a register has a value outside the expectation of the application program, since the MODBUS protocol is unaware of the significance of any particular value of any particular register.                                                                                                                                                                                                                                                                                                      |
| <b>04</b>                     | SERVER DEVICE FAILURE    | An unrecoverable error occurred while the server was attempting to perform the requested action.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>05</b>                     | ACKNOWLEDGE              | Specialized use in conjunction with programming commands.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| <b>06</b>                     | SERVER DEVICE BUSY       | Specialized use in conjunction with programming commands. The server is engaged in processing a long – duration program command. The client should retransmit the message later when the server is free.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>08</b>                     | MEMORY PARITY ERROR      | Specialized use in conjunction with function codes 20 and 21 and reference type 6, to indicate that the extended file area failed to pass a consistency check. The server attempted to read record file, but detected a parity error in the memory. The client can retry the request, but service may be required on the server device.                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>0A</b>                     | GATEWAY PATH UNAVAILABLE | Specialized use in conjunction with gateways, indicates that the gateway was unable to allocate an internal communication path from the input port to the output port for processing the request. Usually means that the gateway is misconfigured or overloaded.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>0B</b>                     | GATEWAY PATH UNAVAILABLE | Specialized use in conjunction with gateways, indicates that no response was obtained from the target device. Usually means that the device is not present on the network.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

## 2.2 Data Link Layer

### 2.2.1 Overview

The MODBUS TCP protocol is used in this interface.

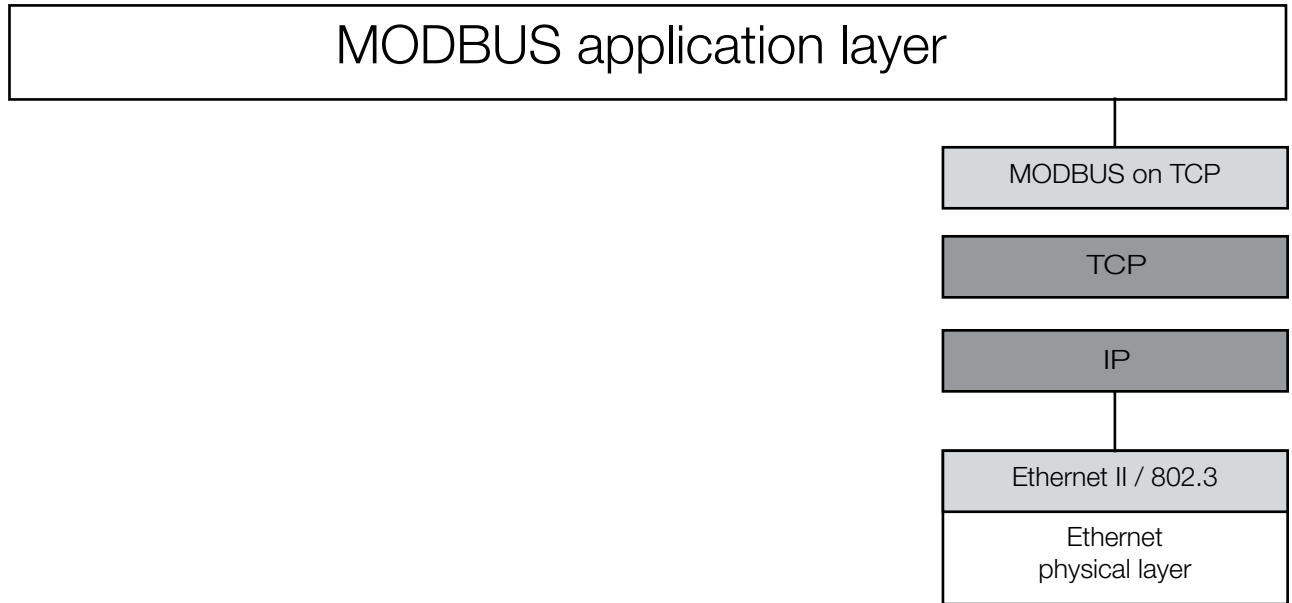


Abb. 3: MODBUS Protocols and ISO/OSI Model

| Layer | ISO/OSI Layer | Protocol              |
|-------|---------------|-----------------------|
| 7     | Application   | MODBUS / TCP          |
| 6     | Presentation  | MODBUS / TCP          |
| 5     | Session       | MODBUS / TCP          |
| 4     | Transport     | TCP                   |
| 3     | Network       | IP                    |
| 2     | Data Link     | IEEE 802.3 (Ethernet) |
| 1     | Physical      | IEEE 802.3 (Ethernet) |

## 2.3 Physical Layer

### 2.3.1 Ethernet port

A electrical interface in accordance with IEEE 802.3 standard is used for the interface. A RJ45 connector is used for connection.

### 2.3.2 Electrical interface

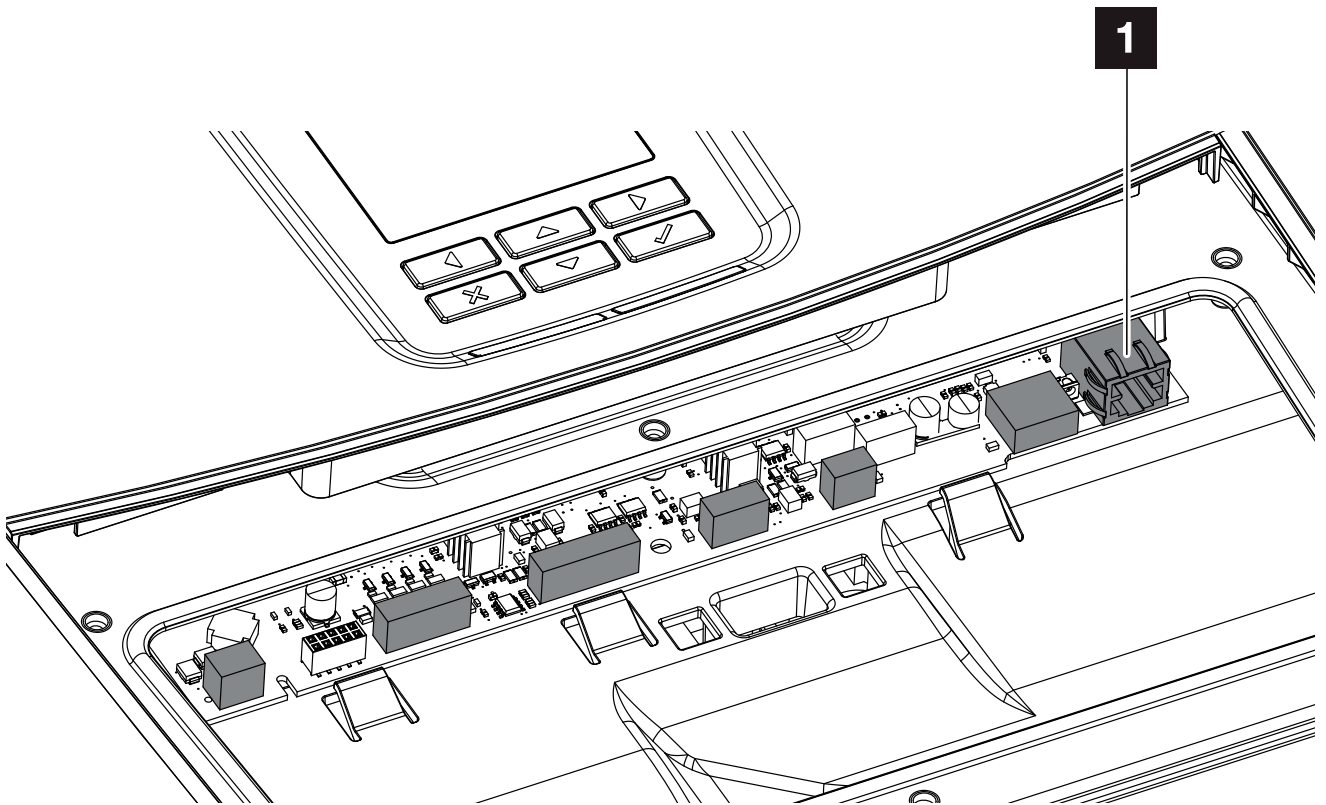


Abb. 4: Smart Communication Board - Interface

| Item | Designation                | terminal | Explanation                                                              |
|------|----------------------------|----------|--------------------------------------------------------------------------|
| 1    | Ethernet connection (RJ45) | X206     | RJ45 max. 100 Mbit (LAN connection for linking to a router, for example) |

# 3. MODBUS Register table

## 3.1 TCP-Port and Unit-ID

To access the inverter via MODBUS / TCP, the following TCP-Port and MODBUS-Unit-ID are used as default values:

|                      |            |
|----------------------|------------|
| TCP-Port             | 1502 (dec) |
| Unit-ID <sup>1</sup> | 71 (dec)   |

<sup>1</sup> The Unit-ID is modifiable.

## 3.2 Query the operating data

| Addr (hex) | Addr (dec) | Description                          | Unit | Format | N <sup>1)</sup> | Access | Function Code |
|------------|------------|--------------------------------------|------|--------|-----------------|--------|---------------|
| 0x02       | 2          | MODBUS Enable                        | -    | Bool   | 1               | R/W    | 0x03/0x06     |
| 0x04       | 4          | MODBUS Unit-ID                       | -    | U16    | 1               | R/W    | 0x03/0x06     |
| 0x05       | 5          | MODBUS Byte Order Note <sup>7</sup>  | -    | U16    | 1               | R/W    | 0x03/0x06     |
| 0x06       | 6          | Inverter article number              | -    | String | 8               | RO     | 0x03          |
| 0x0E       | 14         | Inverter serial number               | -    | String | 8               | RO     | 0x03          |
| 0x1E       | 30         | Number of bidirectional converter    | -    | U16    | 1               | RO     | 0x03          |
| 0x20       | 32         | Number of AC phases                  | -    | U16    | 1               | RO     | 0x03          |
| 0x22       | 34         | Number of PV strings                 | -    | U16    | 1               | RO     | 0x03          |
| 0x24       | 36         | Hardware-Version                     | -    | U16    | 2               | RO     | 0x03          |
| 0x26       | 38         | Software-Version Maincontroller (MC) | -    | String | 8               | RO     | 0x03          |
| 0x2E       | 46         | Software-Version IO-Controller (IOC) | -    | String | 8               | RO     | 0x03          |
| 0x36       | 54         | Power-ID                             | -    | U16    | 2               | RO     | 0x03          |
| 0x38       | 56         | Inverter state <sup>2</sup>          | -    | U16    | 2               | RO     | 0x03          |
| 0x62       | 98         | Temperature of controller PCB        | °C   | Float  | 2               | RO     | 0x03          |
| 0x64       | 100        | Total DC power                       | W    | Float  | 2               | RO     | 0x03          |
| 0x68       | 104        | State of energy manager <sup>3</sup> | -    | U32    | 2               | RO     | 0x03          |
| 0x6A       | 106        | Home own consumption from battery    | W    | Float  | 2               | RO     | 0x03          |
| 0x6C       | 108        | Home own consumption from grid       | W    | Float  | 2               | RO     | 0x03          |
| 0x6E       | 110        | Total home consumption Battery       | Wh   | Float  | 2               | RO     | 0x03          |
| 0x70       | 112        | Total home consumption Grid          | Wh   | Float  | 2               | RO     | 0x03          |
| 0x72       | 114        | Total home consumption PV            | Wh   | Float  | 2               | RO     | 0x03          |
| 0x74       | 116        | Home own consumption from PV         | W    | Float  | 2               | RO     | 0x03          |
| 0x76       | 118        | Total home consumption               | Wh   | Float  | 2               | RO     | 0x03          |
| 0x78       | 120        | Isolation resistance                 | Ohm  | Float  | 2               | RO     | 0x03          |
| 0x7A       | 122        | Power limit from EVU                 | %    | Float  | 2               | RO     | 0x03          |
| 0x7C       | 124        | Total home consumption rate          | %    | Float  | 2               | RO     | 0x03          |
| 0x90       | 144        | Worktime                             | s    | Float  | 2               | RO     | 0x03          |



| Addr (hex) | Addr (dec) | Description                                       | Unit | Format | N <sup>1)</sup> | Access | Function Code |
|------------|------------|---------------------------------------------------|------|--------|-----------------|--------|---------------|
| 0x96       | 150        | Actual cos $\phi$                                 | -    | Float  | 2               | RO     | 0x03          |
| 0x98       | 152        | Grid frequency                                    | Hz   | Float  | 2               | RO     | 0x03          |
| 0x9A       | 154        | Current Phase 1                                   | A    | Float  | 2               | RO     | 0x03          |
| 0x9C       | 156        | Active power Phase 1                              | W    | Float  | 2               | RO     | 0x03          |
| 0x9E       | 158        | Voltage Phase 1                                   | V    | Float  | 2               | RO     | 0x03          |
| 0xA0       | 160        | Current Phase 2                                   | A    | Float  | 2               | RO     | 0x03          |
| 0xA2       | 162        | Active power Phase 2                              | W    | Float  | 2               | RO     | 0x03          |
| 0xA4       | 164        | Voltage Phase 2                                   | V    | Float  | 2               | RO     | 0x03          |
| 0xA6       | 166        | Current Phase 3                                   | A    | Float  | 2               | RO     | 0x03          |
| 0xA8       | 168        | Active power Phase 3                              | W    | Float  | 2               | RO     | 0x03          |
| 0xAA       | 170        | Voltage Phase 3                                   | V    | Float  | 2               | RO     | 0x03          |
| 0xAC       | 172        | Total AC active power                             | W    | Float  | 2               | RO     | 0x03          |
| 0xAE       | 174        | Total AC reactive power                           | Var  | Float  | 2               | RO     | 0x03          |
| 0xB2       | 178        | Total AC apparent power                           | VA   | Float  | 2               | RO     | 0x03          |
| 0xBE       | 190        | Battery charge current                            | A    | Float  | 2               | RO     | 0x03          |
| 0xC2       | 194        | Number of battery cycles                          | -    | Float  | 2               | RO     | 0x03          |
| 0xC8       | 200        | Actual battery charge (-) / discharge (+) current | A    | Float  | 2               | RO     | 0x03          |
| 0xCA       | 202        | PSSB fuse state <sup>5</sup>                      | -    | Float  | 2               | RO     | 0x03          |
| 0xD0       | 208        | Battery ready flag                                | -    | Float  | 2               | RO     | 0x03          |
| 0xD2       | 210        | Act. state of charge                              | %    | Float  | 2               | RO     | 0x03          |
| 0xD6       | 214        | Battery temperature                               | °C   | Float  | 2               | RO     | 0x03          |
| 0xD8       | 216        | Battery voltage                                   | V    | Float  | 2               | RO     | 0x03          |
| 0xDA       | 218        | Cos $\phi$ (powermeter)                           | -    | Float  | 2               | RO     | 0x03          |
| 0xDC       | 220        | Frequency (powermeter)                            | Hz   | Float  | 2               | RO     | 0x03          |
| 0xDE       | 222        | Current phase 1 (powermeter)                      | A    | Float  | 2               | RO     | 0x03          |
| 0xE0       | 224        | Active power phase 1 (powermeter)                 | W    | Float  | 2               | RO     | 0x03          |
| 0xE2       | 226        | Reactive power phase 1 (powermeter)               | Var  | Float  | 2               | RO     | 0x03          |
| 0xE4       | 228        | Apparent power phase 1 (powermeter)               | VA   | Float  | 2               | RO     | 0x03          |
| 0xE6       | 230        | Voltage phase 1 (powermeter)                      | V    | Float  | 2               | RO     | 0x03          |
| 0xE8       | 232        | Current phase 2 (powermeter)                      | A    | Float  | 2               | RO     | 0x03          |
| 0xEA       | 234        | Active power phase 2 (powermeter)                 | W    | Float  | 2               | RO     | 0x03          |
| 0xEC       | 236        | Reactive power phase 2 (powermeter)               | Var  | Float  | 2               | RO     | 0x03          |
| 0xEE       | 238        | Apparent power phase 2 (powermeter)               | VA   | Float  | 2               | RO     | 0x03          |
| 0xF0       | 240        | Voltage phase 2 (powermeter)                      | V    | Float  | 2               | RO     | 0x03          |
| 0xF2       | 242        | Current phase 3 (powermeter)                      | A    | Float  | 2               | RO     | 0x03          |
| 0xF4       | 244        | Active power phase 3 (powermeter)                 | W    | Float  | 2               | RO     | 0x03          |
| 0xF6       | 246        | Reactive power phase 3 (powermeter)               | Var  | Float  | 2               | RO     | 0x03          |
| 0xF8       | 248        | Apparent power phase 3 (powermeter)               | VA   | Float  | 2               | RO     | 0x03          |
| 0xFA       | 250        | Voltage phase 3 (powermeter)                      | V    | Float  | 2               | RO     | 0x03          |

| Addr (hex) | Addr (dec) | Description                                                                                                                                                                                  | Unit | Format | N <sup>1)</sup> | Access | Function Code |
|------------|------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|--------|-----------------|--------|---------------|
| 0xFC       | 252        | Total active power (powermeter)<br>Sensor position 1 (home consumption):<br>(+) House consumption, (-) generation<br>Sensor position 2 (grid connection):<br>(+) Power supply, (-) feed-in   | W    | Float  | 2               | RO     | 0x03          |
| 0xFE       | 254        | Total reactive power (powermeter)<br>Sensor position 2 (grid connection):<br>(+) Power supply, (-) feed-in<br>Sensor position 1 (home consumption):<br>(+) House consumption, (-) generation | Var  | Float  | 2               | RO     | 0x03          |
| 0x100      | 256        | Total apparent power (powermeter)<br>Sensor position 2 (grid connection):<br>(+) Power supply, (-) feed-in<br>Sensor position 1 (home consumption):<br>(+) House consumption, (-) generation | VA   | Float  | 2               | RO     | 0x03          |
| 0x102      | 258        | Current DC1                                                                                                                                                                                  | A    | Float  | 2               | RO     | 0x03          |
| 0x104      | 260        | Power DC1                                                                                                                                                                                    | W    | Float  | 2               | RO     | 0x03          |
| 0x10A      | 266        | Voltage DC1                                                                                                                                                                                  | V    | Float  | 2               | RO     | 0x03          |
| 0x10C      | 268        | Current DC2                                                                                                                                                                                  | A    | Float  | 2               | RO     | 0x03          |
| 0x10E      | 270        | Power DC2                                                                                                                                                                                    | W    | Float  | 2               | RO     | 0x03          |
| 0x114      | 276        | Voltage DC2                                                                                                                                                                                  | V    | Float  | 2               | RO     | 0x03          |
| 0x116      | 278        | Current DC3                                                                                                                                                                                  | A    | Float  | 2               | RO     | 0x03          |
| 0x118      | 280        | Power DC3                                                                                                                                                                                    | W    | Float  | 2               | RO     | 0x03          |
| 0x11E      | 286        | Voltage DC3                                                                                                                                                                                  | V    | Float  | 2               | RO     | 0x03          |
| 0x140      | 320        | Total yield                                                                                                                                                                                  | Wh   | Float  | 2               | RO     | 0x03          |
| 0x142      | 322        | Daily yield                                                                                                                                                                                  | Wh   | Float  | 2               | RO     | 0x03          |
| 0x144      | 324        | Yearly yield                                                                                                                                                                                 | Wh   | Float  | 2               | RO     | 0x03          |
| 0x146      | 326        | Monthly yield                                                                                                                                                                                | Wh   | Float  | 2               | RO     | 0x03          |
| 0x180      | 384        | Inverter network name                                                                                                                                                                        | -    | String | 32              | RO     | 0x03          |
| 0x1A0      | 416        | IP enable                                                                                                                                                                                    | -    | U16    | 1               | RO     | 0x03          |
| 0x1A2      | 418        | Manual IP / Auto-IP                                                                                                                                                                          | -    | U16    | 1               | RO     | 0x03          |
| 0x1A4      | 420        | IP-address                                                                                                                                                                                   | -    | String | 8               | RO     | 0x03          |
| 0x1AC      | 428        | IP-subnetmask                                                                                                                                                                                | -    | String | 8               | RO     | 0x03          |
| 0x1B4      | 436        | IP-gateway                                                                                                                                                                                   | -    | String | 8               | RO     | 0x03          |
| 0x1BC      | 444        | IP-auto-DNS                                                                                                                                                                                  | -    | U16    | 1               | RO     | 0x03          |
| 0x1BE      | 446        | IP-DNS1                                                                                                                                                                                      | -    | String | 8               | RO     | 0x03          |
| 0x1C6      | 454        | IP-DNS2                                                                                                                                                                                      | -    | String | 8               | RO     | 0x03          |
| 0x200      | 512        | Battery gross capacity                                                                                                                                                                       | Ah   | U32    | 2               | RO     | 0x03          |
| 0x202      | 514        | Battery actual SOC                                                                                                                                                                           | %    | U16    | 1               | RO     | 0x03          |
| 0x203      | 515        | Firmware Maincontroller (MC)                                                                                                                                                                 | -    | U32    | 2               | RO     | 0x03          |
| 0x205      | 517        | Battery Manufacturer                                                                                                                                                                         | -    | String | 8               | RO     | 0x03          |

| Addr (hex) | Addr (dec) | Description                                      | Unit | Format | N <sup>1)</sup> | Access | Function Code |
|------------|------------|--------------------------------------------------|------|--------|-----------------|--------|---------------|
| 0x20D      | 525        | Battery Model ID                                 | -    | U32    | 2               | RO     | 0x03          |
| 0x20F      | 527        | Battery Serial Number                            | -    | U32    | 2               | RO     | 0x03          |
| 0x211      | 529        | Work Capacity                                    | Wh   | U32    | 2               | RO     | 0x03          |
| 0x213      | 531        | Inverter Max Power                               | W    | U16    | 1               | RO     | 0x03          |
| 0x214      | 532        | Inverter Max Power Scale Factor <sup>4</sup>     | -    | -      | 1               | RO     | 0x03          |
| 0x215      | 533        | Active Power Setpoint                            | %    | U16    | 1               | RW     | 0x03/0x06     |
| 0x217      | 535        | Inverter Manufacturer                            | -    | String | 16              | RO     | 0x03          |
| 0x22F      | 559        | Inverter Serial Number                           | -    | String | 16              | RO     | 0x03          |
| 0x23F      | 575        | Inverter Generation Power (actual)               | W    | S16    | 1               | RO     | 0x03          |
| 0x240      | 576        | Power Scale Factor <sup>4</sup>                  | -    | -      | 1               | RO     | 0x03          |
| 0x241      | 577        | Generation Energy                                | Wh   | U32    | 2               | RO     | 0x03          |
| 0x243      | 579        | Energy Scale Factor <sup>4</sup>                 | -    | -      | 1               | RO     | 0x03          |
| 0x246      | 582        | Actual battery charge/discharge power            | W    | S16    | 1               | RO     | 0x03          |
| 0x247      | 583        | Reactive Power Setpoint                          | %    | S16    | 1               | RW     | 0x03/0x06     |
| 0x249      | 585        | Delta-cos $\phi$ Setpoint                        | -    | S16    | 1               | RW     | 0x03/0x06     |
| 0x24A      | 586        | Battery Firmware                                 | -    | U32    | 1               | RO     | 0x03          |
| 0x24C      | 588        | Battery Type <sup>6</sup>                        | -    | U16    | 1               | RO     | 0x03          |
| 0x300      | 768        | Productname (e.g. PLENTICORE plus)               | -    | String | 32              | RO     | 0x03          |
| 0x320      | 800        | Power class (e.g. 10)                            | -    | String | 32              | RO     | 0x03          |
| 0x416      | 1046       | Total DC charge energy (DC-side to battery)      | Wh   | Float  | 2               | RO     | 0x03          |
| 0x418      | 1048       | Total DC discharge energy (DC-side from battery) | Wh   | Float  | 2               | RO     | 0x03          |
| 0x41A      | 1050       | Total AC charge energy (AC-side to battery)      | Wh   | Float  | 2               | RO     | 0x03          |
| 0x41C      | 1052       | Total AC discharge energy (battery to grid)      | Wh   | Float  | 2               | RO     | 0x03          |
| 0x41E      | 1054       | Total AC charge energy (grid to battery)         | Wh   | Float  | 2               | RO     | 0x03          |
| 0x420      | 1056       | Total DC PV energy (sum of all PV inputs)        | Wh   | Float  | 2               | RO     | 0x03          |
| 0x422      | 1058       | Total DC energy from PV1                         | Wh   | Float  | 2               | RO     | 0x03          |
| 0x424      | 1060       | Total DC energy from PV2                         | Wh   | Float  | 2               | RO     | 0x03          |
| 0x426      | 1062       | Total DC energy from PV3                         | Wh   | Float  | 2               | RO     | 0x03          |
| 0x428      | 1064       | Total energy AC-side to grid                     | Wh   | Float  | 2               | RO     | 0x03          |
| 0x42A      | 1066       | Total DC power (sum of all PV inputs)            | W    | Float  | 2               | RO     | 0x03          |

**Notes:**

<sup>1</sup> N = Quantity of Registers

<sup>2</sup> Inverter States

|    |                   |
|----|-------------------|
| 0  | Off               |
| 1  | Init              |
| 2  | IsoMeas           |
| 3  | GridCheck         |
| 4  | StartUp           |
| 5  | -                 |
| 6  | FeedIn            |
| 7  | Throttled         |
| 8  | ExtSwitchOff      |
| 9  | Update            |
| 10 | Standby           |
| 11 | GridSync          |
| 12 | GridPreCheck      |
| 13 | GridSwitchOff     |
| 14 | Overheating       |
| 15 | Shutdown          |
| 16 | ImproperDcVoltage |
| 17 | ESB               |
| 18 | Unknown           |

<sup>3</sup> States of energy manager (internal energy flow)

|      |                          |
|------|--------------------------|
| 0x00 | Idle                     |
| 0x01 | n/a                      |
| 0x02 | Emergency Battery Charge |
| 0x04 | n/a                      |
| 0x08 | Winter Mode Step 1       |
| 0x10 | Winter Mode Step 2       |

<sup>4</sup> Scale factors: As an alternative to floating point format, values are represented by integer values with a signed scale factor applied. The scale factor explicitly shifts the decimal point to the left (negative value) or the right (positive value). Scale factors are 16 bit two's complement integer, the signed range is -10 ... 10.

<sup>5</sup> PSSB-fuse-state

|      |           |
|------|-----------|
| 0x00 | Fuse fail |
| 0x01 | Fuse ok   |
| 0xFF | Unchecked |

<sup>6</sup> Battery type

|      |                               |
|------|-------------------------------|
| 0x00 | No battery (PV-functionality) |
| 0x02 | Li-Io battery SONY / MURATA   |
| 0x04 | Li-Io battery BYD / BBOX      |

<sup>7</sup> MODBUS Byte Order, important for read or write accesses to float-formatted registers

|      |                      |
|------|----------------------|
| 0x00 | Little-endian (CDAB) |
| 0x01 | Big-endian (ABCD)    |

## 3.3 Active power and reactive power control

These registers are only writeable and their parameters are not stored in the long-term storage memory of the inverter. That means the inverter will discard these settings when it powers on or resets.

| Addr(Hex) | Addr(DEC) | Description                                                          | Format | *N | Function |
|-----------|-----------|----------------------------------------------------------------------|--------|----|----------|
| 0x215     | 533       | Active power setpoint (%), range:1..100                              | U16    | 1  | 0x06     |
| 0x247     | 583       | Reactive power setpoint (%), range: -100...0...100                   | S16    | 1  | 0x06     |
| 0x249     | 585       | Delta cos $\phi$ setpoint <sup>1</sup> range: -32768...0...32767     | S16    | 1  | 0x06     |
| 0x340     | 832       | Low-Priority Active power setpoint (W), range 0...65535 <sup>2</sup> | U16    | 1  | 0x06     |
| 0x341     | 833       | Low-Priority Active power setpoint scale factor <sup>2,3</sup>       | S8     | 1  | 0x03     |

\*N = Quantity of Registers

### Note:

<sup>1</sup> The inverters can contribute to grid management by feeding in with a fixed cos  $\phi$ . The displacement factor cos  $\phi$  is an unsigned factor that is nonetheless characterized by the suffix „underexcited“ or „overexcited“. However, a „delta cos  $\phi$ “ is transmitted here to the inverter, whereby a negative value corresponds to underexcited operation and a positive value corresponds to overexcited operation.

The value range -1.0...+1.0 is shown for the transmission of the desired value to the value range -32768...+32767 of a 16 bit whole number (signed short) with a suffix.

Example:

| Setting | Delta cos $\phi$ | Reactive power                 |
|---------|------------------|--------------------------------|
| 0       | 0                | cos $\phi$ = 1.00              |
| -1638   | -0.05            | cos $\phi$ = 0.95 underexcited |
| +3276   | +0.10            | cos $\phi$ = 0.90 overexcited  |

The maximum setting range is -26214...26214 (corresponds to a max. cos  $\phi$  of 0.80). The setting range actually realizable by the inverter is found in the data sheet of the inverter.

<sup>2</sup> Supported with SW-Version 1.30 or greater

<sup>3</sup> Scale factor:

As an alternative to floating point format, the low-priority Active Power Setpoint is represented by an integer value with a signed scale factor applied. The scale factor explicitly shifts the decimal point to the left (negative value) or the right (positive value). Scale factors are 8 bit two's complement integer, the signed range is -10 ... 10.

I.e., a setpoint of 10kW is represented by a value of 10,000 and a scale factor of 0. A setpoint of 200kW is represented by a value of 20000 and a scale factor of +1. The scale factor is read only and has to be read first to get the factor used by the inverter. The desired setpoint has to be scaled with this factor:

$$\text{Setpoint [W]} = \text{Register-Value}_{832} * (10 \wedge \text{Register-Value}_{833})$$

## 3.4 External battery management

| Addr (hex) | Addr (dec) | Description                                                        | Unit | Format | N <sup>1)</sup> | Access | Function Code |
|------------|------------|--------------------------------------------------------------------|------|--------|-----------------|--------|---------------|
| 0x400      | 1024       | Battery charge power (AC) setpoint Note <sup>1,6</sup>             | W    | S16    | 1               | WO     | 0x06          |
| 0x401      | 1025       | Power Scale Factor Note <sup>2, 6</sup>                            | -    | S16    | 1               | RO     | 0x03          |
| 0x402      | 1026       | Battery charge power (AC) setpoint, absolute Note <sup>1</sup>     | W    | Float  | 2               | RW     | 0x03/0x10     |
| 0x404      | 1028       | Battery charge current (DC) setpoint, relative Note <sup>1,3</sup> | %    | Float  | 2               | RW     | 0x03/0x10     |
| 0x406      | 1030       | Battery charge power (AC) setpoint, relative Note <sup>1,3</sup>   | %    | Float  | 2               | RW     | 0x03/0x10     |
| 0x408      | 1032       | Battery charge current (DC) setpoint, absolute Note <sup>1</sup>   | A    | Float  | 2               | RW     | 0x03/0x10     |
| 0x40A      | 1034       | Battery charge power (DC) setpoint, absolute Note <sup>1</sup>     | W    | Float  | 2               | RW     | 0x03/0x10     |
| 0x40C      | 1036       | Battery charge power (DC) setpoint, relative Note <sup>1,3</sup>   | %    | Float  | 2               | RW     | 0x03/0x10     |
| 0x40E      | 1038       | Battery max. charge power limit, absolute                          | W    | Float  | 2               | RW     | 0x03/0x10     |
| 0x410      | 1040       | Battery max. discharge power limit, absolute                       | W    | Float  | 2               | RW     | 0x03/0x10     |
| 0x412      | 1042       | Minimum SOC                                                        | %    | Float  | 2               | RW     | 0x03/0x10     |
| 0x414      | 1044       | Maximum SOC                                                        | %    | Float  | 2               | RW     | 0x03/0x10     |
| 0x42C      | 1068       | Battery work capacity                                              | Wh   | Float  | 2               | RO     | 0x03          |
| 0x42E      | 1070       | Battery serial number                                              | -    | U32    | 2               | RO     | 0x03          |
| 0x430      | 1072       | Reserved                                                           | -    | -      | 2               | RO     | 0x03          |
| 0x432      | 1074       | Reserved                                                           | -    | -      | 2               | RO     | 0x03          |
| 0x434      | 1076       | Maximum charge power limit (read-out from battery)                 | W    | Float  | 2               | RO     | 0x03          |
| 0x436      | 1078       | Maximum discharge power limit (read-out from battery)              | W    | Float  | 2               | RO     | 0x03          |
| 0x438      | 1080       | Battery management mode Note <sup>4</sup>                          | -    | U8     | 1               | RO     | 0x03          |
| 0x439      | 1081       | reserved                                                           | -    | -      | 1               | RO     | 0x03          |
| 0x43A      | 1082       | Installed sensor type Note <sup>5</sup>                            | -    | U8     | 1               | RO     | 0x03          |

**Notes:**

<sup>1</sup> Negative values will charge the battery, positive values will discharge the battery.

<sup>2</sup> Scale factor:

As an alternative to floating point format, the battery charge power setpoint is represented by an integer value with a signed scale factor applied. The scale factor explicitly shifts the decimal point to the left (negative value) or the right (positive value). Scale factors are 8 bit two's complement integer, the signed range is -10 ... 10.

I.e., a setpoint of 10kW is represented by a value of 10,000 and a scale factor of 0. A setpoint of 200kW is represented by a value of 20000 and a scale factor of +1. The scale factor is read only and has to be read first to get the factor used by the inverter. The desired setpoint has to be caled with this factor:

Setpoint [W] = Register-Value 1024 \* (10 ^ Register-Value 1025)

<sup>3</sup> In relation to the corresponding nominal values  $I_{nom}$  or  $P_{nom}$

<sup>4</sup> Battery management modes

|      |                                                 |
|------|-------------------------------------------------|
| 0x00 | No external battery management                  |
| 0x01 | External battery management via digital I/O     |
| 0x02 | External battery management via MODBUS protocol |

<sup>5</sup> Sensor types

|      |                                    |
|------|------------------------------------|
| 0x00 | SDM 630 (B+G E-Tech GmbH)          |
| 0x01 | B-Control EM-300 LR (TQ Systems)   |
| 0x02 | reserved                           |
| 0x03 | KOSTAL Smart Energy Meter (KOSTAL) |
| 0xFF | No sensor                          |

<sup>6</sup> PLENTICORE BI only



# 4. SunSpec Interface

## 4.1 Overview

Information in SunSpec is defined through a set of 'Information Models' representing functionality implemented by devices or plants. SunSpec Alliance Interoperability Specifications describe these information models, data exchange formats and communication protocols used in distributed energy resource systems.

SunSpec information Models are defined using the SunSpec Model Definition XML (SMDX) encoding. Please reference the SMDX file for the definitive version of any SunSpec Information Model, at <http://sunspec.org/download>.

SunSpec information Models are communication protocol agnostic, but MODBUS is currently the most popular transport protocol in use.

For further information refer to [www.sunspec.org](http://www.sunspec.org).

## 4.2 Implemented SunSpec Models

Currently the following SunSpec-Models are implemented:

| Model-No | Model-Name                  |
|----------|-----------------------------|
| 1        | Common                      |
| 103      | Three Phase Inverter        |
| 113      | Three Phase Inverter, float |
| 120      | Nameplate                   |
| 123      | Immediate Controls          |
| 160      | Multiple MPPT               |
| 802      | Battery Base Model          |
| 65535    | End Model                   |

## 4.3 Startaddresses

| Model-No | Startaddress (dec) |
|----------|--------------------|
| 1        | 40003              |
| 103      | 40071              |
| 113      | 40123              |
| 120      | 40185              |
| 123      | 40213              |
| 160      | 40239              |
| 802      | 40309              |
| 65535    | 40373              |

# KOSTAL

KOSTAL Solar Electric GmbH  
Hanferstr. 6  
79108 Freiburg i. Br.  
Deutschland  
Telefon: +49 761 47744 - 100  
Fax: +49 761 47744 - 111

KOSTAL Solar Electric Ibérica S.L.  
Edificio abm  
Ronda Narciso Monturiol y Estarriol, 3  
Torre B, despachos 2 y 3  
Parque Tecnológico de Valencia  
46980 Valencia  
España  
Teléfono: +34 961 824 - 934  
Fax: +34 961 824 - 931

KOSTAL Solar Electric France SARL  
11, rue Jacques Cartier  
78280 Guyancourt  
France  
Téléphone: +33 1 61 38 - 4117  
Fax: +33 1 61 38 - 3940

KOSTAL Solar Electric Hellas E.Π.Ε.  
47 Steliou Kazantzidi st., P.O. Box: 60080  
1st building – 2nd entrance  
55535, Pilea, Thessaloniki  
Ελλάδα  
Τηλέφωνο: +30 2310 477 - 550  
Φαξ: +30 2310 477 - 551

KOSTAL Solar Electric Italia Srl  
Via Genova, 57  
10098 Rivoli (TO)  
Italia  
Telefono: +39 011 97 82 - 420  
Fax: +39 011 97 82 - 432

[www.kostal-solar-electric.com](http://www.kostal-solar-electric.com)

Smart  
connections.