



CONNECT INTERFACE

Interface electronics assembly for smartGAS sensors

Connection and operating manual

Edition 1.0

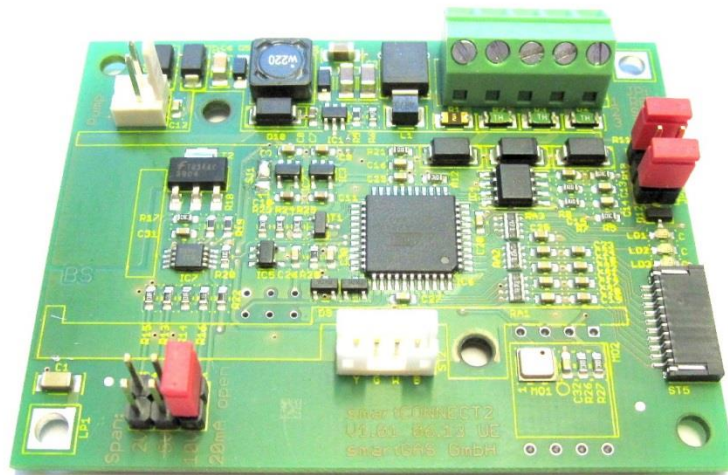


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List of abbreviations

| Abbreviations/symbols | Description |
|-----------------------|---|
| 'D' | ASCII characters |
| 0x5B | 0x has no numerical significance. It merely indicates that the notation behind it - 5B - should be considered a hexadecimal character. In this example, the value is equal to the decimal number 91 |
| 124 | Notation of a number in the decimal system |
| AC | Alternating current |
| DC | Direct current |
| FS | Full scale (measurement range end value) |
| Hex | Abbreviation for the hexadecimal character system |
| IR | Infra-red |
| JP | Jumper |
| kbps | Kilobit per second – data transmission rate |
| l | Litre (1l = 1000cm ³) – volume unit |
| m | Meter – unit of length |
| mA | Milliampere – amperage in A x10 ⁻³ |
| mbar | Millibar – unit of pressure in bar x10 ⁻³ |
| MBE | Measurement range end value |
| min | Minute – unit of time |
| mm ² | Square millimetre – conductor cross section value in (m x10 ⁻³) ² |
| Ms | Milliseconds – unit of time in s x10 ⁻³ |
| mV | Millivolt – voltage in V x10 ⁻³ |
| OEM | Original Equipment Manufacturer |
| ppm | Parts per million - volume unit |
| sec | Second – unit of time |
| ST | Connector |
| UEG | Lower explosion limit |
| V | Volt – voltage |

1. General

The CONNECT INTERFACE is an improved version of our proven smartCONNECT electronics assembly. As well as the well known features, they offer you many further advantages and improvements:

- reworked voltage output with freely selectable 0-2V, 0-5V or 0-10VDC signal output
- improved current interface, NAMUR NE 43 conformity (option) *
- optical display of the sensor states by LEDs (green, yellow, red)
- Simplified calibration (including setting of the sensor zero point via jumpers)
- Integrated pressure compensation (ambient or optional internal cell pressure, 800 – 1150 mbar)
- Operation by short-stroke keyboard possible (option)
- Connection option for micro pumps (6V DC/max. 200mA)

The CONNECT INTERFACE has identical dimensions and is interface-compatible with the previous smartCONNECT electronics assembly. This means that the numerous improvements in existing systems can be used without any problem and without the need for extensive redesign.

** Namur NE 43 is an industrial standard for standardized signal levels as failure information for digital transducers with an analogue output signal, see also chap. 2.2.1.*

Intended use:

The CONNECT INTERFACE assembly is only intended for use in accordance with your specification in conjunction with a smartGAS sensor module. It is not suitable for any other measurement or testing purposes, and must not be used in any other way.

The CONNECT INTERFACE assembly must not be operated in potentially explosive environments or under harsh conditions (e.g. high, condensing humidity, heavy air flow, in aggressive atmospheres, or outdoors without a housing)!

When mounting and handling the CONNECT INTERFACE as well as the sensors used, the usual ESD protection measures for electronic assemblies should be observed and transportation may only take place in ESD-suitable packages or containers!

Please contact our Service department if you have any questions concerning the above-mentioned issues.

Warranty / liability / disclaimer:

Opening of sensors, manipulation or damage to devices and circuit boards as well as operations outside the specifications will invalidate the warranty!

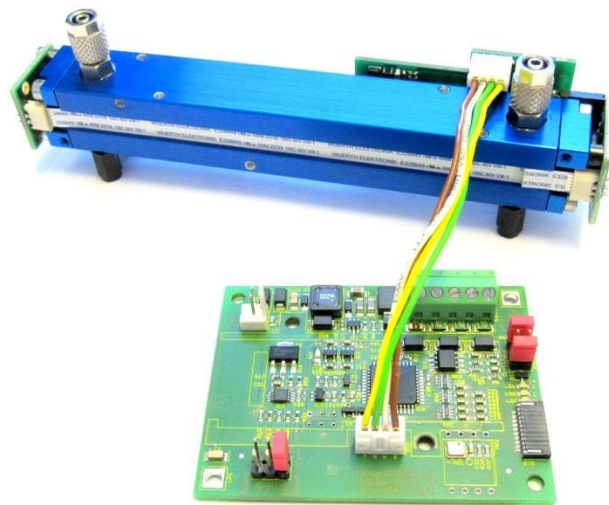
The warranty may also be invalidated if aggressive chemicals are used, contamination occurs, visible damage results due to liquids/moisture or the instructions in this Description of Module and Communication are not observed!

The smartGAS Mikrosensorik GmbH shall not be liable for consequential loss, property damage or personal injury caused by improper handling or failure to observe the connection and operating manual.

1.1. Mounting and installation position of the gas sensor used

The smartGAS sensors allow for installation on the customer's devices in various installation positions. Since the calibration ex factory cannot cover every installation situation and ambient condition, the zero point needs to be checked after installation and if necessary recalibrated.

In any case we recommend a functional test of every device after final installation in the customer's application in the course of commissioning. ***Please also note the instructions regarding the installation and calibration in the manual of the smartGAS sensor used!***



CONNECT INTERFACE combined with smartGAS FLOW^{EVO} sensor



CONNECT INTERFACE combined with smartGAS BASIC^{EVO} sensor

2. Connections, interfaces

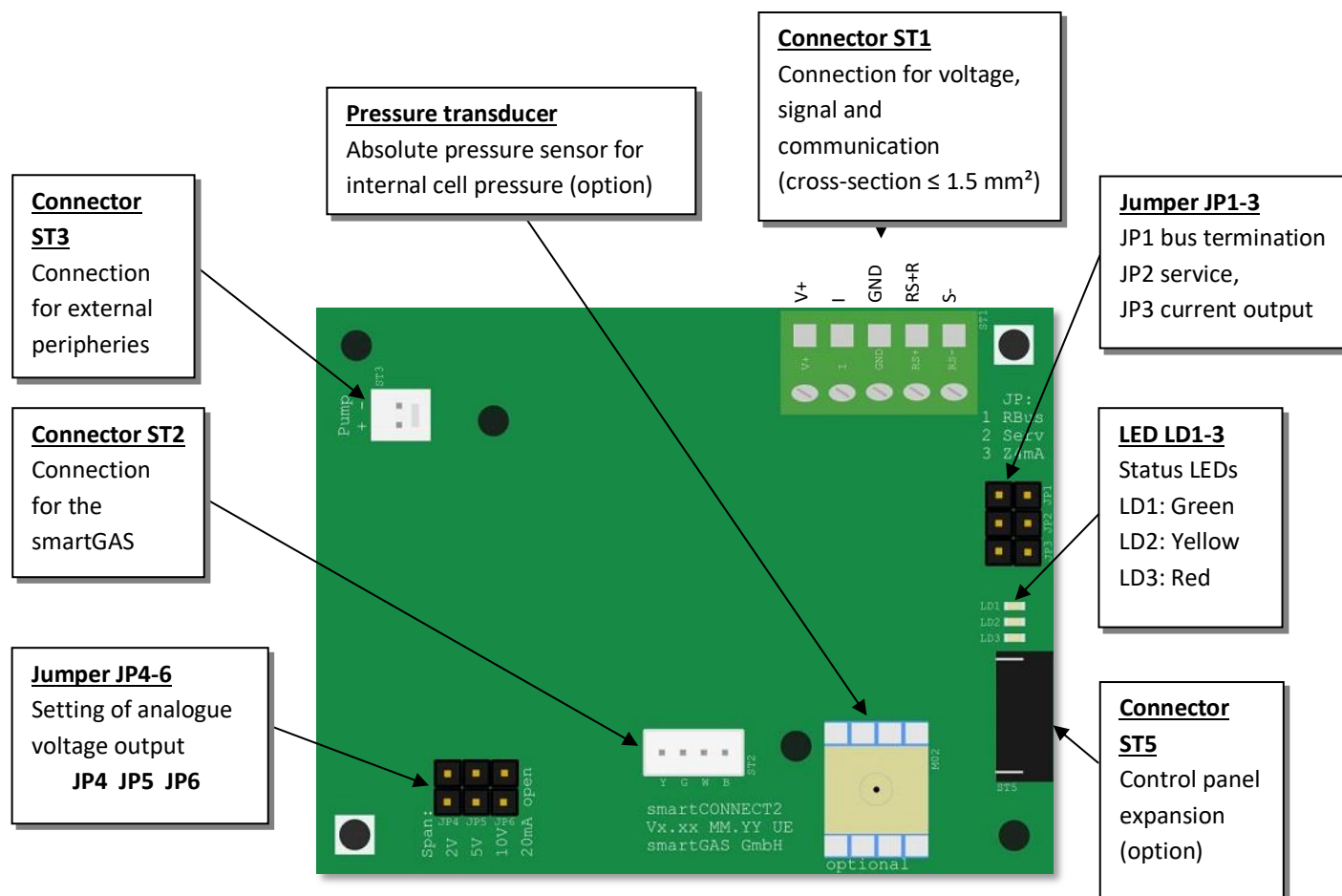


Figure 1: Connections of the CONNECT INTERFACE assembly

2.1. Operating voltage

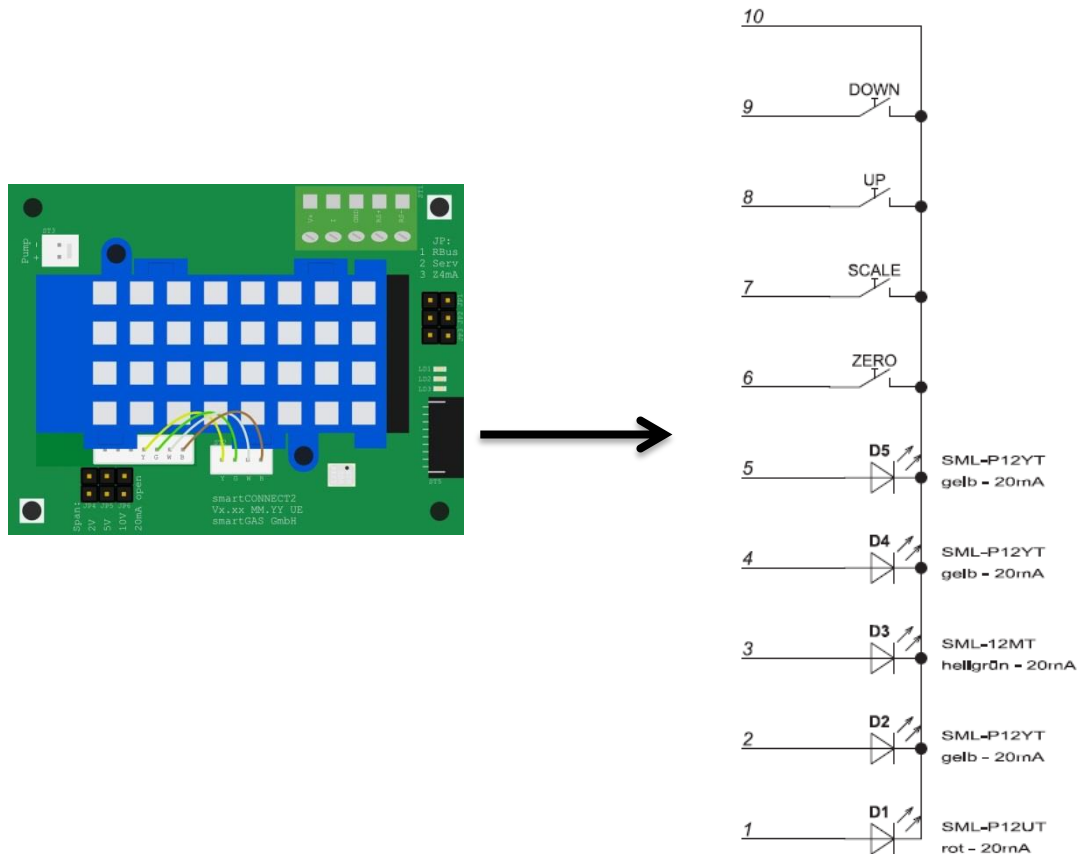
The CONNECT INTERFACE assembly is designed for operation with a supply voltage of 12 to 28V DC. Faultless functioning within these limits is guaranteed. Despite the internal voltage stabilisation function, the operating voltage must be kept as low as possible. In some cases, such as in plants where large loads are switched on and off, the relevant measures should therefore be taken. The supply voltage is connected to the plug connector ST1 (see figure 1).

Table 1: Operating voltage connection (ST1)

| Designation | Explanation |
|-------------|-----------------------------------|
| V+ | Supply voltage 12 - 28V DC |
| GND | Common ground for V+, I and RS485 |

2.1.1. Control panel expansion (option)

The CONNECT INTERFACE can be expanded with a control panel via the plug connector ST5 (Figure 1). The figure below shows how to connect the control panel:



The plug connector ST5 corresponds to a FFC/FPC socket (manufacturer's number: HFW10R-2STE1LF).

Please contact our customer service if you have any questions concerning the control panel expansion option!

2.2. Analogue outputs

2.2.1. Current output

The analogue current interface of the CONNECT INTERFACE offers two setting options for evaluating the measurement:

Current signal within the 0 to 20 mA range, linear with respect to the measurement or

current signal within the 4 to 20 mA range, linear with respect to the measurement, output signal according to Namur NE 43

(This option enables an open circuit or sensor failure to be detected)

Table 2: Setting at the current output

| JP3 | Explanation |
|---------------|---------------------------|
| Not connected | Current output 0 to 20 mA |
| Connected | Current output 4 to 20 mA |

Note: If jumpers (JP4, JP5, JP6) are additionally used, a voltage signal can be generated from the current signal. More details in sub-para. 2.2.2.

Caution: None of jumpers JP4 to JP6 must be connected for the current output!

Caution: It is possible to switch between the modes via jumper only in a de-energised state (voltage supply isolated).

When using the analogue signal of 0 or 4 to 20 mA, the CONNECT INTERFACE can be regarded as a 3-conductor transmitter. Consequently, the line can be run as shown in Figure 2. Power can be directly fed via the evaluation unit (shown here as the controller), but steps must be taken to ensure that sufficient power is available. Otherwise, an additional power supply is required.

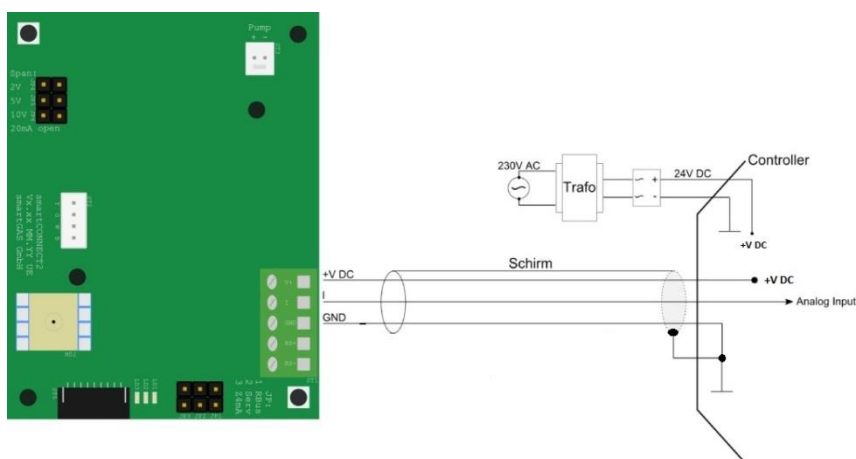


Figure 2: Current loop with 3-conductor connection

Table 3: Current output connection (ST1)

| Designation | Explanation |
|-------------|-----------------------------|
| I | Analogue output 0(4) – 20mA |

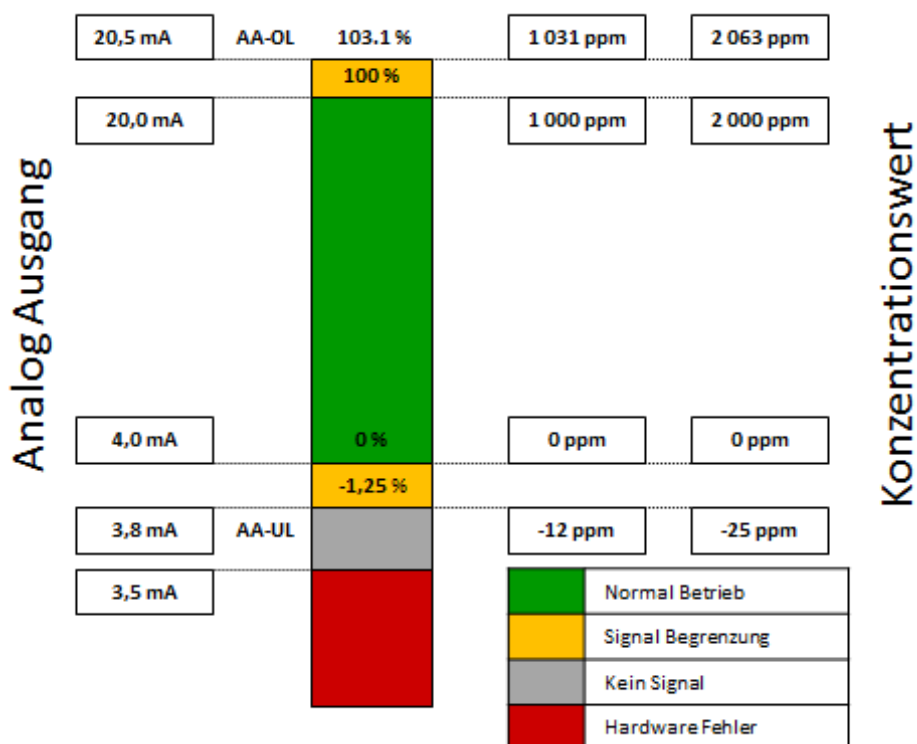
GND Common ground for V+, I and RS485

Output signals of the 4-20mA current interface according to Namur NE 43*

(here using the example of sensors with 1000ppm or 2000ppm measurement range end value)

AA-OL Analogue output upper limit

AA-UL Analogue output lower limit



* NAMUR is an international association linking users of automation technology within the process industry.

* Namur NE 43 is a standard for standardized signal levels as failure information for digital transducers with an analogue output signal.

Further information at www.namur.net

2.2.2. Voltage outputs

In certain applications, it is necessary to convert the output signals from the sensor to a linear voltage signal. This requires the relevant jumper (JP4-6) to be connected.

Note: The voltage signal may vary from the ideal value depending on the current load (observe R_i)!

The following modes can be set, depending on the operating mode selected:

Caution: Only one of the following jumpers can be connected at a time!

0..2V → JP4 connected ($R_i = 110\Omega$)

0..5 V → JP5 connected ($R_i = 260\Omega$)

0..10 V → JP6 connected ($R_i = 510\Omega$)

The configuration described above permits the following voltage values to be generated at the output:

| Table 4: Possible analogue output configurations | | |
|--|----------------------|-------------------|
| | 0-20mA (without JP3) | 4-20mA (with JP3) |
| 2 V (JP4) | 0 V – 2 V | 0.4 V – 2 V |
| 5 V (JP5) | 0 V – 5 V | 1.0 V – 5 V |
| 10V (JP6) | 0V – 10V | 2.0V – 10V |

| Table 5: Voltage output connection (ST1) | |
|--|---|
| Designation | Explanation |
| I | Analogue output voltage (with JP 4/5/6) |
| GND | Common ground for V+, I and RS485 |

2.2.3. Open circuit

If communication between the sensor and evaluation unit is ever interrupted while a CONNECT INTERFACE is operating (unintentional disconnection or open circuit), this situation is indicated as follows at the voltage output:

Operation at 0-20 mA → Output current indicates 0 mA
Operation at 4-20 mA → Output current is frozen (typically) at 3.5 mA

Depending on the operating mode and the downstream evaluation unit, such a state can then be used for fault detection purposes. Once the defect has been remedied, the system has to be restarted.

Note: An open circuit can be accurately detected only in the 4 to 20 mA mode!

2.3. MODBUS digital output

2.3.1. RS485 mode

The CONNECT INTERFACE has an RS485 interface in 2-conductor mode (half-duplex) as a standard feature. Data transmission is serial and occurs via a symmetrical signal on the RS+ and RS- lines. The reference signal is GND.

Table 6: MODBUS interface connection (ST1)

| Designation | Explanation |
|-------------|---|
| RS+ | Non-inverted data line |
| RS- | Inverted data line |
| GND | Common ground for V+, I and RS485 (Reference signal) |

The connection is established via the 5-pin plug ST1 (see Figure 1).

The RS485 interface facilitates single master/multiple slave mode, with the CONNECT INTERFACE acting as the slave. A PC or alternative evaluation unit (e.g. microcontroller, PLC...) can be used as the master.

To ensure trouble-free operation, we recommend that you choose a central power supply from the controller using shielded lines. Use a central ground point for the shield and ground line if possible.

If the users do not have the same null potential (the same ground), large potential differences can occur. Then, the RS 485 interface should be attached via optocouplers.

2.3.2. Termination

From a line length of > 30 m, it is advisable to use a terminating resistor to prevent reflections on the bus. The resistors can be connected via jumper JP1.

The termination should occur only on the device at the end of the line.

- | | | |
|----------------------|---|--|
| 1. JP1 not connected | ↔ | No terminating resistor is connected (condition as supplied) |
| 2. JP1 connected | ↔ | Terminating resistor is connected |

Note: The cable used for the wiring should be shielded and twisted (twisted pair cable).

2.4. Supply to external peripherals

The CONNECT INTERFACE provides 6 V with max. 200 mA at the output of ST3 for supplying system expansions (e.g. gas delivery pumps).

| Table 7: Pin configuration ST3 | |
|--------------------------------|----------------|
| Designation | Explanation |
| + | 6V DC / 200 mA |
| - | GND |

This interface can be accessed via the 2-pole connector (ST3 – see Figure 1).

Note: This voltage is not secured!

Further information on suitable gas delivery pumps can be obtained from our customer service on request.




2.5. Jumperfunctions

Table 8 summarises the different jumper functions of the CONNECT INTERFACE:

| Table 8: Jumper | |
|-----------------|--|
| Jumper | Explanation and function |
| JP1 | Terminating resistor for the digital communication via RS485. Further information in chapter 2.3.2. |
| JP2 | Service jumper Further information in chapter 5. |
| JP3 | Current output from 0 mA or 4 mA to 20 mA. Further information in chapter 2.2.1. |
| JP4 | Generates a voltage output from 0 V or 0.4 V to 2 V. Further information in chapter 2.2.2. |
| JP5 | Generates a voltage output from 0 V or 1 V to 5 V. Further information in chapter 2.2.2. |
| JP6 | Generates a voltage output from 0 V or 2 V to 10 V. Further information in chapter 2.2.2. |

2.6. Status LEDs

The CONNECT INTERFACE is equipped with three status LEDs (Position of the LEDs: see Figure 1)

| Green LED  | Yellow LED  | Red LED  | Device status |
|---|--|---|------------------------------------|
| on | off | off | Normal operation |
| Flashes | --- | --- | Initialisation/start phase |
| --- | on/flashes | --- | See notes in chap. 5 |
| --- | --- | Flashes | Degraded mode |
| --- | --- | on | Hardware error (service necessary) |

Normal operation

In normal operation, only the green LED lights up. The system is working error-free within its measurement range limits.

Degraded mode

A degraded mode (red LED flashing) exists if the concentration measuring range of the sensor has been exceeded or fallen short of to such an extent that a measuring range violation must be assumed. This state is reversible.

Hardware error

An irreversible hardware error exists when the red LED lights up permanently. This always requires an on-site service. An analogue value is output to indicate an error (see chap. 2.2.1.) if possible.

You can find further LED functions in chapter 5 (Operation/Calibration)

2.7. Pressure compensation

2.7.1. Ambient pressure

To achieve the most flexible CONNECT INTERFACE design possible and to enable applications at different altitudes, consideration must be given to the real gas equation. Owing to the physical properties of gases, their density changes depending on height and, as a result, the absorption of IR radiation in the measuring cell. Without the pressure compensation function, this would lead to inaccuracies in the concentration measurement.

If the gas outlet is open to the atmosphere, the ambient pressure must be included in the concentration measurement. An ambient pressure sensor is therefore already integrated into the CONNECT2 board.

A pressure compensation takes place within the range of 800 – 1150 mbar. If this range is fallen short of or exceeded, a loss of accuracy is to be expected. (These values apply to the ambient pressure measurement and optional internal cell pressure measurement, chap. 2.7.2).

Note: Configuration or parameterisation by the user is not required; the required correction factors of the gases to be measured are already integrated in the software of the CONNECT2.

Further information on this can be obtained from our customer service!

2.7.2. Internal cell pressure measurement

Since the internal cell pressure must be included in the concentration measurement in continuous flow mode¹ (when using a smartGAS FLOW^{EVO} sensor), there is an ex works (optional) version of the CONNECT2 board with a mounted absolute pressure transducer.

The hose is then connected as shown in figure 3.

If you have any questions regarding this design as well as the use of aggressive gases, please contact our support!

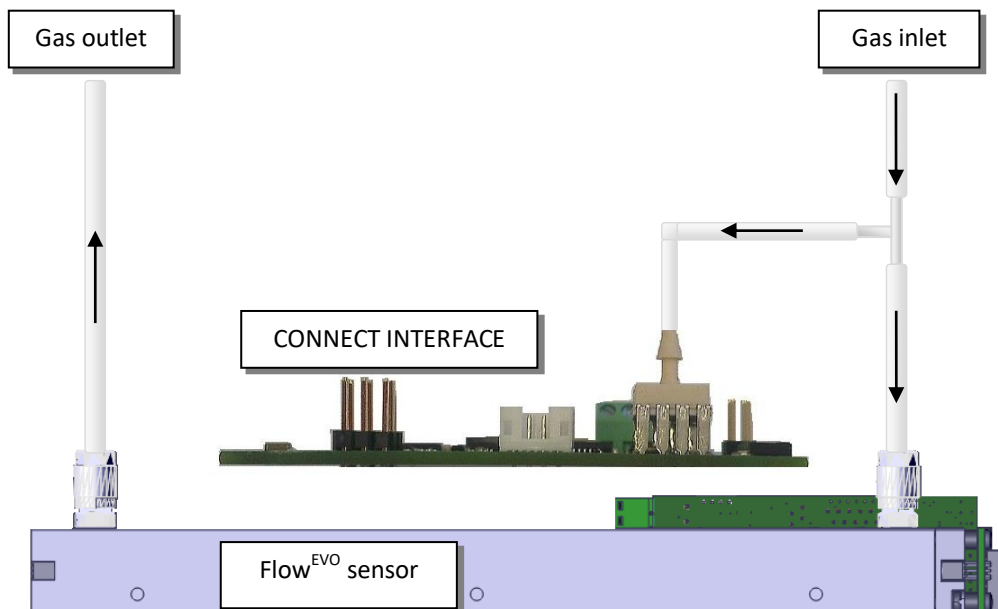


Figure 3: Hose connection of the (optional) pressure transducer for continuous flow mode

¹ Used for analysis measurement. The sample gas circulates in a closed system isolated from the environment.

3. Start-up

The CONNECT INTERFACE is connected and signals are output via connector ST1, see

Figure 1. To prevent errors and damage, the measuring system should be mounted and connected in the following order:

1. Ensure the system is de-energised.
2. Mount the CONNECT2 board in the desired position. Refer to Figure 4. The dimensions for the holes are shown here. At the same time, ensure that the screw heads are at a sufficient distance from components in order to prevent short-circuits or damage. Use spacer sleeves and plastic washers if necessary.
3. Connect supply voltage lines to V+ and GND.
4. Connect signal line for the current or voltage output to I and GND.
5. Connect digital output (RS485) to RS+, RS- and GND. GND is the common ground for the supply voltage, the analogue signal and the digital signal.
6. Mount the sensor module in the desired position (please observe the instructions in the corresponding manual of the sensor).
7. Connect the smartGAS sensor to the CONNECT INTERFACE via ST2.
8. Switch on supply voltage. The flashing of the (green) LED LD1, now indicates the establishment of a data connection between the sensor and CONNECT INTERFACE. This may take up to 2 minutes during the initial commissioning. Once data communication has been established between the sensor and CONNECT INTERFACE, the flashing of LD1 changes to a (green) continuous light, indicating that the system is now ready for operation. (If the red LED (LD3) permanently lights up after the 2 minutes have elapsed, this means that a data connection has not been established or the connected sensor has not been detected. This may be due to various reasons. In this case, please contact our Customer Service department).

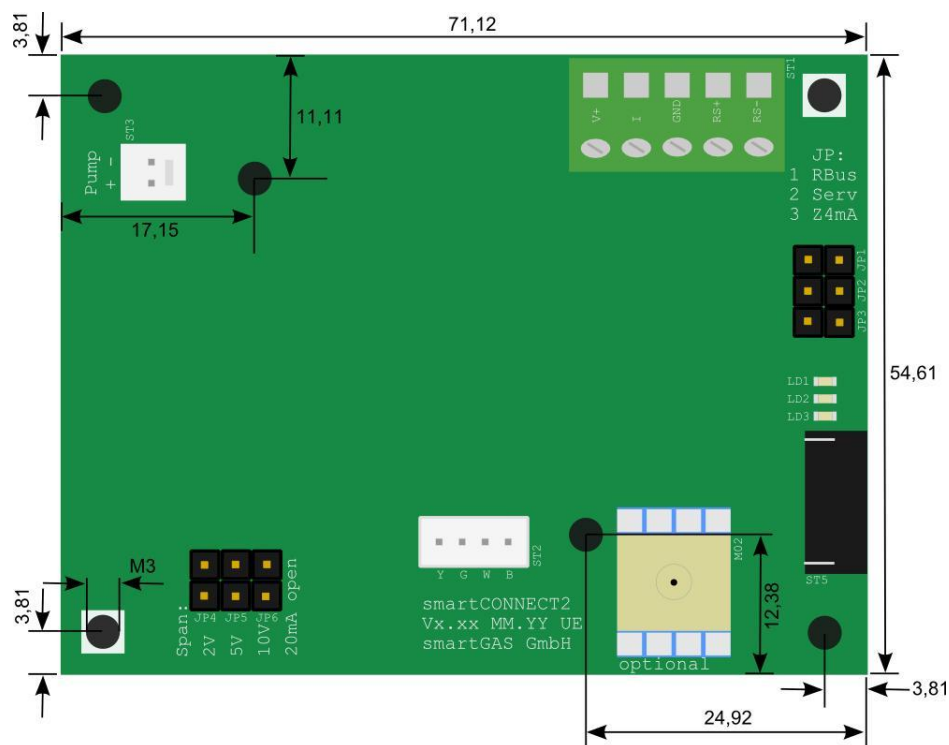


Figure 4: Connections and dimensions of the CONNECT INTERFACE board

Notes on wiring: The lines to be used must not have a cross-section of greater than 1.5 mm². Since screw terminals are used on connector ST1, ferrules must be fitted when connecting flexible lines.

You can find further information on connecting, installing and commissioning the different smartGAS sensors in the corresponding manual, which is included with the relevant sensor!

4. MODBUS communication

4.1. Operation with multiple slave subscribers

The RS485 data bus enables up to 32 subscribers to be integrated. The terminating resistors are used at the start and end of the data bus (JP1). The subscribers suspended between are guided on the terminated data bus by means of stubs or optimally by means of a "daisy chain" (series connection principle).

At a transmission rate of 2.4kbps (2400 baud), the total length of the data bus, including stubs, must be limited to 500 m. Basically, the higher the transmission rate, the smaller the total length of the stubs.

The baud rate is determined by the slowest respective subscriber and is the same for all subscribers.

Table 9: Example - Data bus with multiple subscribers

| Subscriber position | Designation | Address | Baud rate | Role | Termination |
|---------------------|--------------------|---------|-----------|--------|-------------|
| 1 | CONNECT INTERFACE | 22 | 2.4 kbps | Slave | Yes |
| 2 | Computer | - | 2.4 kbps | Master | No |
| 3 | Temperature sensor | 11 | 2.4 kbps | Slave | No |
| 4 | Pressure sensor | 117 | 2.4 kbps | Slave | Yes |

As Table 9 shows, the address assigned to the subscribers does not depend on their position in the topology. Since the MODBUS protocol is used, the master does not need an address. Only the slaves have to be clearly addressed. (You can find instructions regarding address settings on page 27).

The CONNECT INTERFACE is equipped with an autonomous baud rate detection function. This means that the CONNECT INTERFACE automatically detects the used framing as well as the MODBUS dialect. The framings listed in table 11 and the MODBUS baud rates harmonise with each another and can be freely combined among each other.

| Table 11: Framing formats and MODBUS baud rates | |
|---|------------|
| Framing formats | Baud rates |
| 7E1 | 2400 Bd |
| 7E2 | 4800 Bd |
| 7O1 | 9600 Bd |
| 7O2 | 9200 Bd |
| 7N2 | 38400 Bd |
| 8E1 | 57600 Bd |
| 8N1 | 115200 Bd |
| 8N2 | |
| 8O1 | |

Table 11: The framing formats can be freely combined with the baud rates

Note: A framing format of 8 data bits must be used for the communication via MODBUS RTU. (You can find further information regarding framing formats in Chapter 4.6.).

4.2. Signal profiles

The signals are transmitted differentially at the RS485 interface. RS+ routes the signal unchanged, and RS- in its inverted form – see Figure 5. The data signal is evaluated via the difference between the two signals $[RS+] - [RS-]$.

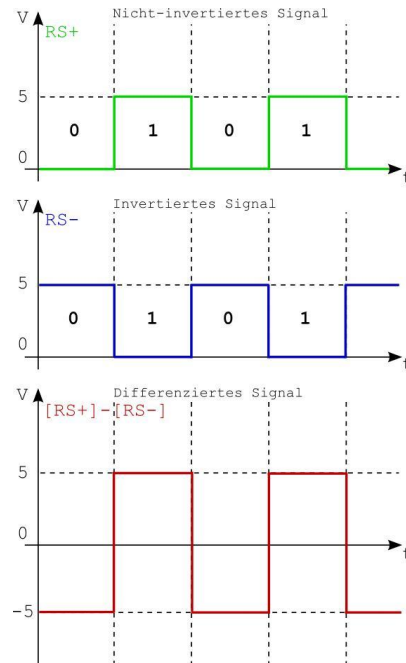


Figure 5: Signal transmission and evaluation on the RS485 data bus

Under load, RS485 transmitters provide a voltage difference of at least ± 2 V. The voltage difference can be smaller due to potential damping effects. The receivers are sensitive to ± 200 mV and are able to evaluate valid signals up to this value:

| | | | |
|-----------------|-------------|---------|--|
| $[RS+] - [RS-]$ | > 200 mV | → Mark | → logical "1" |
| $[RS+] - [RS-]$ | < -200 mV | → Space | → logical "0" |
| $[RS+] - [RS-]$ | < 200 mV | | → The data can be incorrectly interpreted. |

4.3. Data exchange between master and CONNECT INTERFACE

Figure 6 shows a possible scenario between master and CONNECT INTERFACE.

Note: The following times refer to MODBUS ASCII and a baud rate of 2400 Bd.

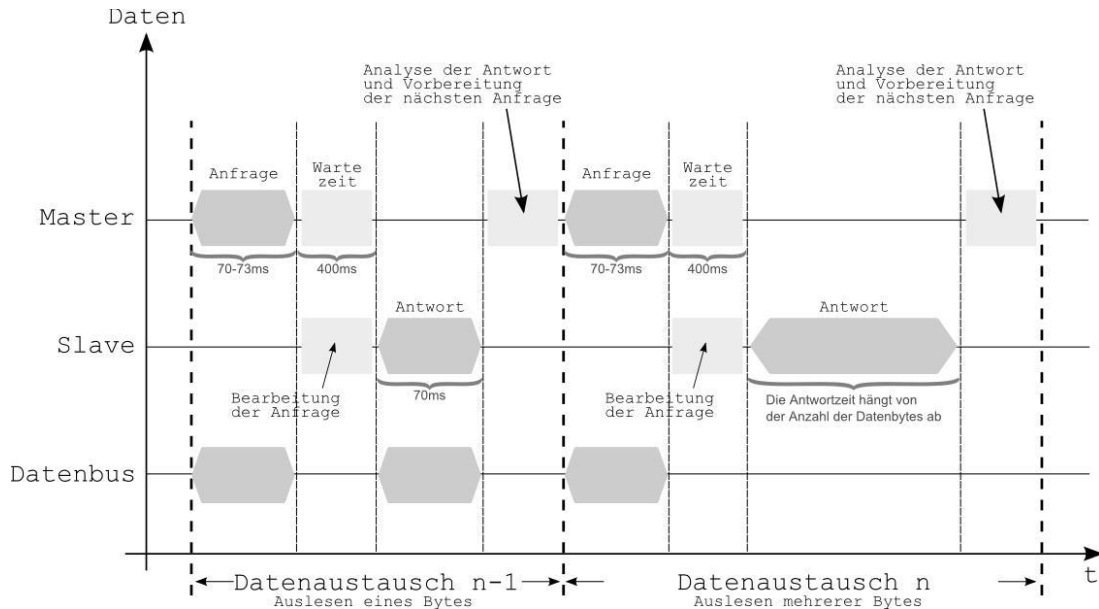


Figure 6: Time diagram – Data interchange between master and PREMIUM^{EVO}

The duration of a query string is 70–73 ms. A brief pause (max. 400 ms) may then follow. The module response then follows. This depends on the number of bytes being read out. If only one byte is read out, the module response is approx. 70 ms. When multiple bytes are being read out, the response phase is correspondingly longer.

Basically, it can be said that the CONNECT INTERFACE reacts to a query within 400ms. The character string is then sent immediately without a response pause.

Note: At higher baud rates (> 2400 Bd), significantly faster response times can be expected. This is also the case when using MODBUS RTU.

4.4. Communication via Modbus

The CONNECT INTERFACE supports the MODBUS protocol in ASCII as well as in RTU mode via its RS 485 interface. In ASCII mode, in addition to the standard variant, there is a smartGAS-specific derivative that differs from the standard in terms of the checksum calculation.

Modbus communication fundamentally functions based on a query/response mechanism. The master sends the query to one of possibly multiple slaves (subscribers). Each connected subscriber therefore receives a subscriber address that is unique in the network. Only the subscriber that has found its address in the query from the master will respond.

The type of query is determined by a control command (function code). This can, for example, be about writing data or reading data to/from the subscriber. Depending on the control command, there is a data portion for both the query and the response.

Each query and each response must be clearly identified by its beginning and by its end. The use of a check field (=check word/CRC) is envisaged in the protocol to enable any possible communication errors to be detected. The Modbus derivatives implement this in different ways.

You can obtain detailed information about the Modbus protocol at www.modbus.org

4.5. Structure of Modbus data telegrams

The following two tables show the basic structure of an ASCII data telegram and a RTU data telegram. The tables show that the address, control command and data portion are based on the same source data for both telegram types:

Table 1: ASCII data telegram

| Dialect | Start | Address | Control | Data | LRC | End |
|---------------------|--------------------------|---------------------------|---------------------------|--|---------------------------|-----------------------|
| Modbus ASCII | 1 characters e.g.:“A” | 2 characters e.g.:“A0” | 2 characters e.g.:“03” | 0 to 2x252 characters e.g.: “00050002” | 2 characters e.g.:“A6” | 2 characters CR,LF |
| Communication: | 0x3A | 0x41, 0x30 | 0x30, 0x33 | 0x30,0x30,0x30,0x35 0x30,0x30,0x30,0x32 | 0x41, 0x36 | 0x0D, 0x0A |

Table 2: RTU data telegram

| Dialect | Start | Address | Control comm. | Data | CRC | End |
|-------------------|----------------------|---------------------|---------------------|---|----------------------------|----------------------|
| Modbus RTU | | 1 byte e.g.:0xA0 | 1 byte e.g.:0x03 | 0 to 1x252 bytes e.g.:0x00,0x05, 0x00,0x02 | 2 bytes e.g.:0xA4, 0xD3 | |
| Communication: | Pause 3.5 characters | 0xA0 | 0x03 | 0x00, 0x05, 0x00, 0x02 | 0xA4, 0xD3 | Pause 3.5 characters |

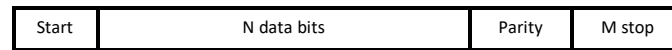
In ASCII mode, each 8-bit byte is therefore sent as two ASCII characters. One byte corresponds to two nibbles. One nibble consists of 4 bits and represents precisely one hexadecimal character. As can be seen in the telegram examples, the result of the byte containing the information “0xA6” is the two ASCII characters “0x41” = ‘A’ and “0x36” = ‘6’.

In ASCII mode, 7 data bits are sufficient for transporting the characters via the interface. The ASCII mode has a historical advantage. All Modbus data telegrams can be “read” with a ASCII terminal; plain text appears on the screen.

In RTU mode, however, each 8-bit byte is handed over unchanged. This inevitably means that in RTU mode. UART frames with 8 data bits need to be used. The advantage of the RTU mode lies in the more effective utilisation of the interface because only around half of the data volume needs to be transmitted compared to the ASCII mode.

4.6. Structure of UART frames

A UART frame is structured as follows:



- 1 start bit (always 0), followed by
- 7 or 8 data bits, starting with the lowest-value bit,
- 1 parity bit (optional). If used, the parity bit can be even or odd,
- 1 or 2 stop bits (always 1).

The nomenclature for describing a UART frame consists of a number, followed by a letter and ending with a number. The first number denotes the number of data bits contained in the frame. The following letter describes the type of parity with N for none, E for even and O for odd. The last number indicates how many stop bits are being sent. The standard specification for Modbus RTU is **8E1**, and **7E1** for Modbus ASCII.

Examples:

8N1 means that 8 data bits are being used, there is no parity (N) and 1 stop bit is being used.

7E1 means that 7 data bits are being used, there is even parity (E) and 1 stop bit is being used.

Furthermore, when transporting a UART frame via the electrical cable, how “quickly” the transmission occurs is important. The term **baud rate** is a definition for this. The baud rate describes how many bits are transmitted per second. Standard baud rates are 2400, 4800, 9600, **19200** (Modbus standard), 38400, 57600 and 115200. All of these are fully supported by the CONNECT INTERFACE.

4.7. MODBUS control commands

Two command codes (function codes) are sufficient for communication with the CONNECT INTERFACE. These are 0x03 – Read (multiple) holding registers and 0x06 – Write (exactly one) register. One register is 16 bits wide and therefore consists of 2 bytes:

| Register | | | | | | | | | | | | | | | |
|----------------------|-----|-----|-----|-----|-----|-----|-----|---------------------|-----|-----|-----|-----|-----|-----|---|
| 15 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0 |
| High order byte – Hi | | | | | | | | Low order byte – Lo | | | | | | | |
| | | | | | | | | | | | | | | | |

All the sensor data that the user can access is shown on registers that are each 16 bits wide. The two control commands will now be explained using some examples.

Control command 0x03 – Read (multiple) holding registers

This control command allows you to read values from the smartGAS sensor. The main thing is that only the registers described in the relevant sensor manuals can be read. This must therefore be checked especially when queries are sent to multiple registers. (A register overview for a smartGAS FLOW^{EVO} sensor can be found on page 26).

Example 1 – Reading out the 4 registers for “Device Type” with a FLOW^{EVO} sensor:

| Query | | Response | | Meaning of the data |
|------------------------|-------|-------------------------|-------|-----------------------|
| Field | (Hex) | Field | (Hex) | |
| Control command | 03 | Control command | 03 | |
| Hi start address | 00 | Number of bytes | 08 | |
| Lo start address | 80 | Hi register value (128) | 53 | 'S' |
| Number of Hi registers | 00 | Lo register value (128) | 4D | 'M' |
| Number of Lo registers | 04 | Hi register value (129) | 46 | 'F' |
| | | Lo register value (129) | 43 | 'C' |
| | | Hi register value (130) | 4F | 'O' |
| | | Lo register value (130) | 32 | '2' |
| | | Hi register value (131) | 20 | '' = Empty characters |
| | | Lo register value (131) | 20 | '' = Empty characters |

In this example, 4 registers of the FLOW^{EVO} sensor were read starting from register start address 0x0080 (decimal 128). The response consisted of a payload of 8 bytes. This was clearly a CO2 module. The 3 letters SMF mean that it is a FLOW sensor.

Example 2 – Reading out the “Concentration” register with a FLOW^{EVO} sensor:

| Query | | Response | | Meaning of the data |
|------------------------|-------|------------------------|-------|-------------------------|
| Field | (Hex) | Field | (Hex) | |
| Control command | 03 | Control command | 03 | |
| Hi start address | 00 | Number of bytes | 02 | |
| Lo start address | 0A | Hi register value (10) | 01 | Concentration is 456 |
| Number of Hi registers | 00 | Lo register value (10) | C8 | |
| Number of Lo registers | 01 | | | |

In this example, (only) one register was read starting from register start address 0x000A (decimal 10). The two data bytes were transmitted combined as a hexadecimal value. If this value (0x01C8) is converted to a decimal number, the result is a concentration value of 456.

Example 3 – Reading out the “Unit” register:

| Query | | Response | | Meaning of the data |
|------------------------|-------|------------------------|-------|---------------------|
| Field | (Hex) | Field | (Hex) | |
| Control command | 03 | Control command | 03 | |
| Hi start address | 00 | Number of bytes | 02 | |
| Lo start address | 4F | Hi register value (79) | 00 | 3, means ppm x 1 |
| Number of Hi registers | 00 | Lo register value (79) | 03 | |
| Number of Lo registers | 01 | | | |

In this example, (only) one register was read starting from register start address 0x004F (decimal 79). The two data bytes were transmitted combined as a hexadecimal value. If this value (0x0003) is converted into a decimal number, the result is 3. This stands for the unit ppm with the scaling x 1. Combined with the data from examples 1 and 2, the FLOW^{EVO} sensor that was read has therefore measured a gas concentration of 456 ppm CO₂.

This subchapter explains the calculation of the checksum (LRC) specifically for the ASCII smartGAS operating mode. How the calculation of the LRC checksum in ASCII standard and CRC checksum in RTU functions is described thoroughly in the documents of the Modbus standard. It is helpful to have a conversion table for ASCII values in hexadecimal and decimal format as follows:

| ASCII | '0' | '1' | '2' | '3' | '4' | '5' | '6' | '7' | '8' | '9' | 'A' | 'B' | 'C' | 'D' | 'E' | 'F' |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Hex | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 41 | 42 | 43 | 44 | 45 | 46 |
| Dec. | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 65 | 66 | 67 | 68 | 69 | 70 |

The checksum is calculated using the address, the control command and the associated data **after** the conversion to ASCII has occurred. By way of example, we generate a query for reading out the concentration register from the FLOW^{EVO} sensor with the address 35 (decimal).

Therefore, in hexadecimal format, the resulting byte string is **0x23, 0x03, 0x00, 0x0A, 0x00, 0x01**. After the ASCII conversion, the result is the data string **2303000A0001**. The data string is now converted and the checksum is formed:

| | Address | | Command | | Start register | | | | Number of registers | | | | Sum |
|-------|---------|----|---------|----|----------------|----|----|----|---------------------|----|----|----|------------|
| ASCII | 2 | 3 | 0 | 3 | 0 | 0 | 0 | A | 0 | 0 | 0 | 1 | --- |
| | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | |
| Dec. | 50 | 51 | 48 | 51 | 48 | 48 | 48 | 65 | 48 | 48 | 48 | 49 | 602 |

Sum = **602**

Checksum = $255 - 602 + 1 = -346$

Modulo sum (256) = $-346 + 256 + 256 = 166$ (dec.) → **A6** (ASCII hex.)

Putting the starting character at the beginning and the calculated checksum and end code at the end would mean that the following data string would be sent:

:2303000A0001**A6**<CR><LF>

The checksum is included each time data is sent and is then recalculated by the recipient again. If the data set is corrupted or adulterated, the checksum calculated by the recipient would deviate from that which was sent. The data set would then be unusable.

Control command 0x06 – Write to (exactly one) register

This command enables a new value to be systematically written to an addressed register. However, it is only possible to write to those registers intended for this purpose. For more information on this, see register assignment in Chapter 4.9.

Example 1 – Writing to the “Modbus_address” register:

| Query | | Response | | Meaning of the data |
|-------------------------|-------|-------------------------|-------|-------------------------------------|
| Field | (Hex) | Field | (Hex) | |
| Control command | 06 | Control command | 06 | The new address of the module (160) |
| Hi register address | 00 | Hi register address | 00 | |
| Lo register address | C0 | Lo register address | C0 | |
| Hi register value | 00 | Hi register value (192) | 00 | |
| Lo register value (192) | A0 | Lo register value (192) | A0 | |

In this example, a new Modbus address for the FLOW^{EVO} was set. Once this communication sequence is complete, the device is only responsive at the new address!

Note: The addresses 0 or 256 must not be assigned!

Example 2 – Writing to the “IR_4tagneu” register:

| Query | | Response | | Meaning of the data |
|------------------------|-------|------------------------|-------|-----------------------------------|
| Field | (Hex) | Field | (Hex) | |
| Control command | 06 | Control command | 06 | |
| Hi register address | 00 | Hi register address | 00 | |
| Lo register address | 47 | Lo register address | 47 | |
| Hi register value | 00 | Hi register value (71) | 00 | The zero point has been reset (1) |
| Lo register value (71) | 01 | Lo register value (71) | 01 | |

In this example, the zero point FLOW^{EVO} sensor has been reset. This was done by writing the value 1 to register 0x0047 (decimal 71). The device subsequently internally calculated and saved the current corrected value for the zero point. Reading out the register 0x0047 after a restart then shows the new, corrected value of the correction.

The zero point must only be set when zero gas and then a stable concentration value are applied! (You can find more information in Chapter 5).

Example 3 – Writing to the “Span” register:

| Query | | Response | | Meaning of the data |
|------------------------|-------|------------------------|-------|--|
| Field | (Hex) | Field | (Hex) | |
| Control command | 06 | Control command | 06 | |
| Hi register address | 00 | Hi register address | 00 | |
| Lo register address | 54 | Lo register address | 54 | |
| Hi register value | 27 | Hi register value (84) | 27 | Span was set to 10000 (pre-assignment) |
| Lo register value (84) | 10 | Lo register value (84) | 10 | |

In this example, a new end point correction for the FLOW^{EVO} sensor was set. A value of 10000 means that the correction factor is 10,000. This is also the delivery condition. A value of 11000 would mean that the concentration value displayed is 10% higher than internally measured. This register therefore enables deviations of the FLOW^{EVO} sensor in the concentration display to be corrected.

The end point must only be set in this way when a suitable test gas and then a stable concentration value are applied! (You can find more information in Chapter 5).

Note: Before setting the end point, the zero point must have previously been set correctly!

4.8. Modbus ASCII communication device

Figure 5 shows the state diagram of the transmission and receiving devices in principle, regardless of whether it is master or slave.

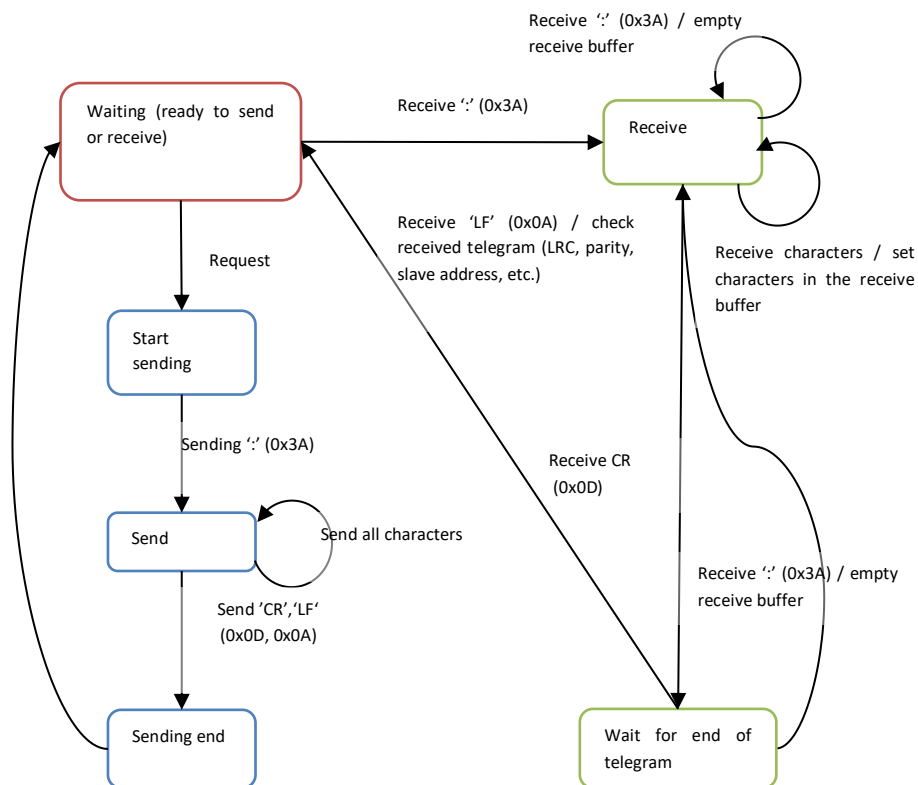


Figure 5: State diagram of a Modbus subscriber (ASCII operating mode)

If an incomplete query is sent to the CONNECT INTERFACE, it does not return a response. The module behaves as if at least one register in the register area being queried does not exist. Error-free telegrams are processed, others are discarded.

4.9. Example: Register overview of a FLOW^{EVO} sensor

Table 10: MODBUS register

| Address | Register name | Function/explanation |
|---------|---------------|--|
| 0x03 | T_m | Sensor temperature (x0.1°C) |
| 0x10 | Conc_corr | Gas concentration in pressure-compensated format. Output value is multiplied by the factor that indicates the unit code. Units: ppm, vol. % or %UEG |
| 0x11 | P_amb | Ambient or internal cell pressure Standard ambient pressure. Upon connecting an additional pressure sensor, output of the internal cell pressure. Output in hPa. |
| 0x47 | IR_4tagneu | Set value for sensor zeroing. Writing to the register with the value "1" sets the zero point. |
| 0x4F | Unit | Unit code for the concentration (see list below) |
| 0x60 | conc_offs | Calibration of the zero point |
| 0x61 | conc_gain | Calibration of the end value |
| 0x80 | Device | Sensor type Example SMFSF6 (FLOW ^{EVO} sensor for sulphur hexafluoride) |
| 0x81 | " | " |
| 0x82 | " | " |
| 0x83 | " | " |
| 0x84 | Version | Software version of the sensor Notation: X.XX |
| 0x85 | " | " |
| 0x86 | Serno | Serial number of the sensor Example SM-0000-001 |
| 0x87 | " | " |
| 0x88 | " | " |
| 0x89 | " | " |
| 0x8A | Version sC2 | Software version of the CONNECT INTERFACE Notation: X.XX |
| 0x8B | " | " |
| 0xC0 | mb_myaddr | Modbus address of the sensor Example 0x0001 The Modbus address must not be "0"! |

Caution: Accessing registers not listed here can cause irreparable damage to the sensor!

Overview of unit codes (0 = unoccupied)

| | | |
|--------------------|-------------------|-----------------|
| 1 → ppm x 0.01 | 5 → Vol.-% x 0.01 | 7 → %UEG x 0.01 |
| 2 → ppm x 0.1 | 6 → Vol.-% x 0.1 | 8 → %UEG x 0.1 |
| 3 → ppm | | |
| 4 → Vol.-% x 0.001 | | |

4.10. MODBUS address

In the examples above, the focus has been on the control commands without mentioning the scope of the telegram in detail. However, the telegram also includes the address of the slave subscriber, which is either queried or delivers a response to a query.

With CONNECT INTERFACE, the device address corresponds to the **last two numbers of the serial number** of the connected sensor (see Figure 7).

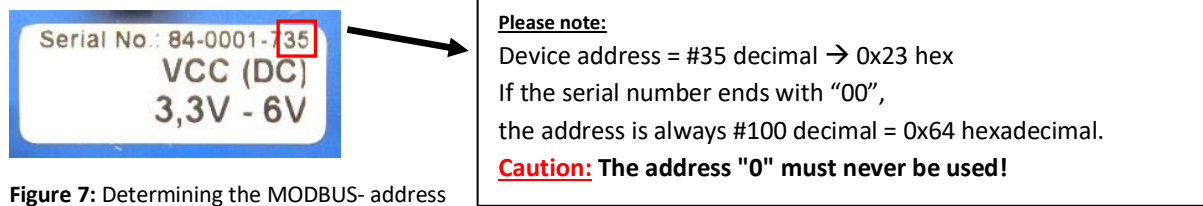


Figure 7: Determining the MODBUS- address

Figure 7 is a flow diagram that shows how unknown Modbus module addresses can be determined. Now, any register (e.g. serial number) can be queried via all module addresses (1–247) with a timeout of one second. If a module is queried with the correct address, it reacts by sending a response. The module address is included in this response. Thus, at the end of the search cycle, module responses can be used to analyse which module addresses are presently connected to the bus system. When querying the serial numbers, it is even possible to conclude which address is assigned to which module.

The permitted address range for the sensors is between 1 and 247. According to Modbus specifications, the addresses 248–255 are reserved. Address 0 stands for broadcast and must not be used!

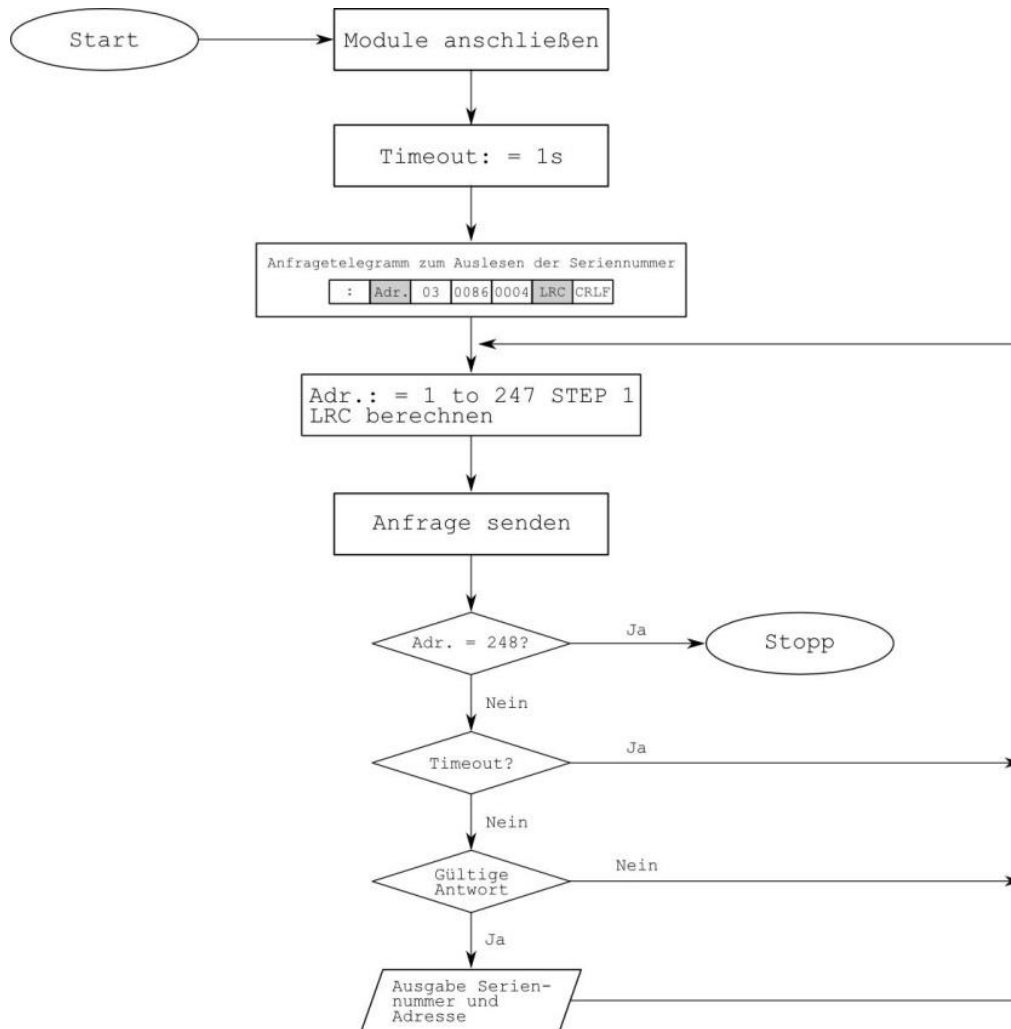


Figure 8: Flow diagram – Determining module addresses

Note: The permitted address range for CONNECT INTERFACE is between 1 and 247. According to MODBUS specifications, the addresses 248-255 are reserved. The address 0 stands for the broadcast.

5. Operation

5.1. Zero point calibration of the sensor via jumpers

It is used to set the zero point **in the connected sensor**. A genuine zero gas (e.g. nitrogen N₂ -100Vol%), with a concentration of 0% of the gas to be measured is required for the calibration.

Procedure of the sensor zero point calibration (please also observe table 12!):

JP2 and JP3 are not connected → Switch on device → LD3 (green) flashes → LD3 (green) lights up → connect zero gas, wait until lines are flushed and zero gas concentration is stably present → connect JP2 → LD2 (yellow) flashes → Device checks whether the concentration of gas corresponds to < 20% MBE (end point of the measurement range) → LD2 (yellow) lights up → Remove JP2 → LD3 (green) flashes 3 sec. → NP in sensor is set, LD3 (green) lights up → Device ready for operation

Notes:

If LD3 (yellow) flashes continuously, the device has detected a gas concentration > 20% MBE, and does not carry out the sensor zero calibration. In this case, the zero gas should be checked and the calibration repeated.

If LD1 (red) should flash during the calibration process, an error has occurred and the calibration must be repeated.

The values of the zero and span calibration of the analogue output are reset to the factory setting by this process.

5.2. Calibration of the analogue interface via jumpers

The CONNECT INTERFACE also offers the possibility to carry out a zero and span calibration of the analogue output via jumpers. In many applications, the used sensors have to be calibrated following initial start-up or at regular intervals.

Note:

It only makes sense to calibrate the analogue output if the zero point of the sensor was set previously (see chapter 5.1)!

The aforementioned calibration should be carried out at least once a year, and depending on the required accuracy, a more frequent calibration may also be necessary.

1. Zero point calibration (=zero calibration)

It tells the sensor what the gas concentration is in an environment corresponding to the normal zero point. A genuine zero gas with a concentration of 0% of the gas to be measured (e.g. nitrogen N₂ 100Vol%) is required for the calibration.

2. End point calibration (=span calibration)

The end point calibration is used to establish the end point of the measurement range. This is the maximum measurement that can be safely and precisely detected by the sensor. A test gas with a concentration (as accurately as possible) of 100% of the gas to be measured is required for the calibration.

Below are the procedures of the different options, please also observe table 12:

(Jumpers that are not used can be connected unilaterally)

5.2.1. Clearing zero calibration (reset to factory setting)

Connect JP2 → Switch on device → LD2 (yellow) lights up → Remove JP2 → Device starts → LD3 (green) flashes → LD3 (green) lights up → Device ready for operation

5.2.2. Clearing span calibration (reset to factory setting)

Connect JP2 and JP3 → Switch on device → LD2 (yellow) lights up → Remove JP2 → Device starts → LD3 (green) flashes → LD3 (green) lights up → Device ready for operation

Notes:

JP3 and JP2 not connected when switching on: Analogue output = 0 - 20mA

JP3 (without JP2 connected) connected when switching on: Analogue output = 4 - 20mA

5.2.3. Zero (zero point) and span (end point) calibration

With the aid of the corresponding gas concentration the CONNECT INTERFACE automatically detects whether a zero or span calibration should be performed:

In the case of a corresponding **concentration <20% MBE**, a **zero calibration** is performed and in the case of a **concentration >40% MBE**, a **span calibration** is performed.

Procedure, please also observe table 12:

JP3 is connected (JP2 is not connected) → Switch on device → LD3 (green) flashes → LD3 (green) lights up → Connect zero gas or test gas, wait until lines are flushed and zero gas concentration is stably present → JP2 connect → LD2 (yellow) flashes → Device checks whether the gas concentration is < 20% or > 40% MBE → LD2 (yellow) lights up → Remove JP2 → LD3 (green) flashes 3 sec. → Calibration was applied, LD3 (green) lights up → Device ready for operation

Notes:

If LD3 (yellow) flashes continuously, the device has detected an implausible gas concentration and does not perform the

calibration. In this case, the zero gas or test gas should be checked and the calibration repeated.

If LD1 (red) should flash during the calibration process, an error has occurred and the calibration must be repeated.

Table 11: Operation via jumpers

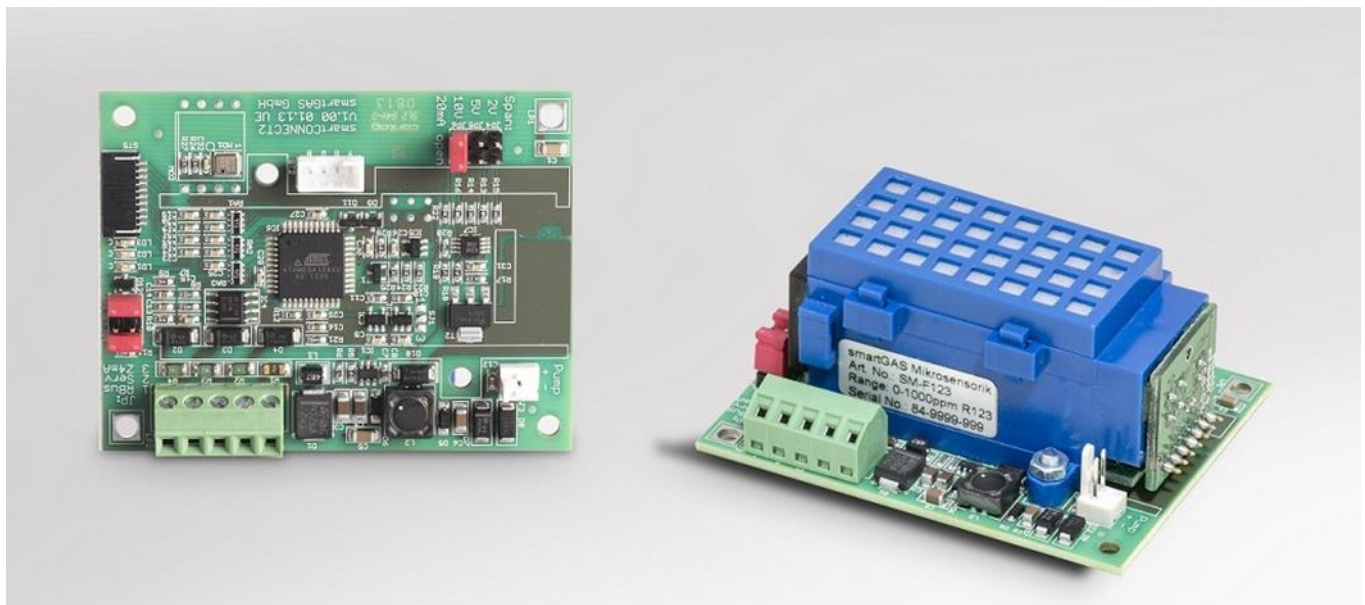
| Time | JP2 Service | JP3 0 / 4 - 20 mA | Action |
|------------------|----------------|----------------------|-----------------------------------|
| At switch-on | Not connected | Not connected | Zero point = 0% FS |
| „ | Not connected | Connected | Zero point = 20% FS |
| „ | Connected | Not connected | Clear zero calibration |
| „ | Connected | Connected | Delete span calibration |
| During operation | Not connected | Irrelevant | Normal operation |
| „ | Connect | Not connected | Determine sensor zero point |
| „ | Remove | Not connected | Transfer zero point to the sensor |
| „ | Connect | Connected | Determine zero/span |
| „ | Remove | Connected | Transfer of zero/span calibration |

6. Technical data

CONNECT INTERFACE

New interface electronics assembly for smartGAS sensors

INNOVATIVE GAS SENSORS



- Operating voltage 12 to 28V DC
- Indication of device status by LEDs
- Analogue interface:
 - 0 (4) – 20 mA (NAMUR NE43)
 - 0-2 V, 0-5 V, 0-10 V
- Digital interface: RS485
- Simple calibration of the analogue interface by means of jumpers
- Zero point calibration of the sensor by means of jumpers
- Integrated ambient pressure compensation (800 – 1150 mbar)
- Internal cell pressure measurement (optional)
- Connection for external peripherals (6 V / 200 mA)
- Dimensions compatible with the smartCONNECT electronics assembly

6.1. Service

Our Service is your expert partner at all times. We guarantee you full satisfaction, long-standing expertise and optimised quality.

Our Customer Service department is available during normal business hours on

Phone: +49 7131 / 797553 – 0

E-Mail: sales@smartgas.eu

<http://www.smartgas.eu/de/kontakt/adresse.html>

accessible.

You can of course also contact us by email or through our website.

Table 12: Our business hours

| Our business hours | |
|-----------------------------|----------------------|
| Monday to Friday | 0800 hrs to 1600 hrs |
| Saturday | Closed |
| Sundays and public holidays | Closed |

6.2. Service

Regular care and maintenance will maintain the longevity and accuracy of your smartGAS products. From perfect handling to optimum care to professional repairs.

The CONNECT INTERFACE assembly has been designed in conjunction with a smartGAS sensor as a monitoring device for guaranteeing safety in potentially hazardous areas. Therefore, any kind of maintenance, parameterisation and all settings on the device are reserved for authorised personnel. Never attempt to dismantle a sensor, manipulate the hardware or modify the software yourself.

Mechanical damage, e.g. caused by improper fastening or handling as well as damage caused by moisture or dirt will invalidate any warranty provided by smartGAS Mikrosensorik GmbH!

6.3. Liability

smartGAS Mikrosensorik GmbH shall not be liable for consequential loss, property damage or personal injury caused by improper handling or failing to observe the safety instructions.

7. Legal information

CONNECT INTERFACE connection and operating manual in English (from SW version 1.16)

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