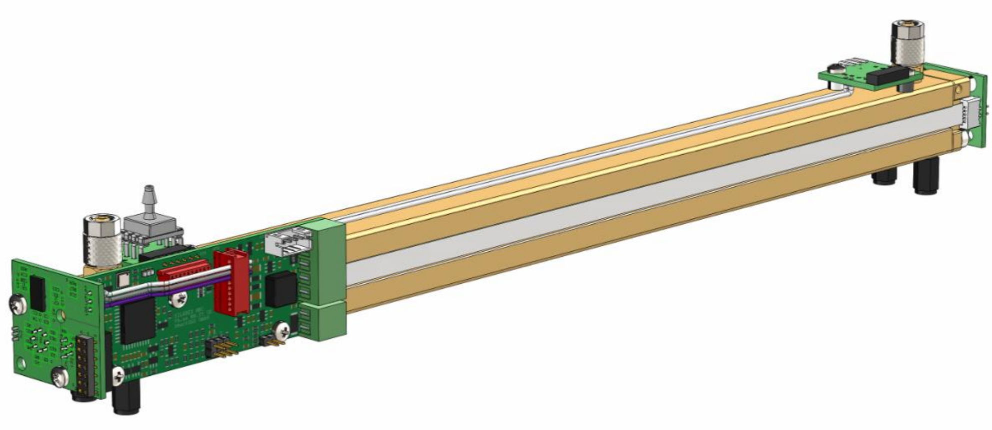
SILAREX

High Performance
Multi-Channel NDIR Gas Sensor

Description of Module and Communication for Firmware Version 2.12



smartGAS MIKROSENSORIK

Contents

1 General

The SILAREX gas sensor is a "high performance", independently measuring gas measurement cell that works with the tried and tested NDIR method. High resolution, measurement accuracy and long-term stability are just some of the features of this newly developed sensor. Thanks to the integrated pressure and temperature compensation as well as its convenient interfaces, the SILAREX sensor is quick and easy to integrate into existing measuring and control systems. Based on the physical measurement method of infrared absorption, SILAREX provides the best conditions for reliable, precise and permanently stable measurements as well as selectivity. Its compact design and low maintenance effort make it ideal for use in difficult conditions.

The present instructions refer to firmware version 2.11 and 2.12 (see Table 7).

1.1 For your safety

Meaning of warning signs

The following warning signs are used in this document to indicate the corresponding warning texts.

CAUTION!

Indicates a potential hazardous situation. If this is not avoided, injuries or damage to the product or environment may occur.

Also warns against improper use.

NOTE

Information on the use of the product

Before connecting and using the SILAREX, ensure that you have read and understood these instructions fully. Please contact our Service department if you have any questions or if anything is unclear. Warning signs indicate important information.

Store these instructions or give them to the device operator for storage if necessary; if you sell this device, hand over these instructions to the purchaser. When installing and operating the device, you must follow the statutory requirements and guidelines that relate to this product!

1.2 Intended use

The SILAREX is a gas measurement cell with independent measurement capabilities and is used to determine gas concentrations in accordance with its specifications. It is not suitable for any other measurement or testing purposes and must not be used in any other way.

CAUTION!

SILAREX 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).

1.3 Loss of warranty / liability / disclaimer

CAUTION!

Opening the sensor as well as manipulating or damaging the device will invalidate the warranty!
The warranty may also be invalidated if aggressive chemicals are used, contamination occurs, liquids penetrate the device or the instructions in this description of the module and communication are not observed!
smartGAS Mikrosensorik GmbH shall not be liable for consequential loss, property damage or personal injury caused by improper handling or failing to observe the instructions in the module and communication description.

2 Measurement cell with hose connections

The SILAREX measuring cell is made of aluminium and gold-plated. It is equipped with hose connections which ensure that the measurement gas passes through the measurement process. The actual measurement cell is located between the gas inlet and gas outlet

2.1 Hose connection / hose material

Hoses must have an inside diameter of 3 mm and an outside diameter of 5 mm to connect to the measuring cell. Make sure that the hoses are firmly connected to the hose connections.
The connection to the pressure transducer for the (indirect) internal cell pressure measurement is produced at the gas outlet by means of a "T" hose adapter.
Please observe the direction of the gas flow, which is indicated by the labels "INLET" and "OUTLET". Mixing up the gas flow could result in measurement values that may show significant deviations from the factory calibration.

Ensure that hoses suitable for measurement are used. Certain applications generate corrosive gases that could cause problems with the hose material.

2.2 Gas flow

The gas flow should be constant and between 0.1 l/min and 1.0 l/min. The gas must
be dry and free from particles.
Corresponding filters can be purchased from smartGAS.

2.3 Mounting / installation site

Mount the Silarex using M3 screws with the four polyamide spacer bolts, which are mounted on the underside of the cell. When screwing the sensor onto the mounting plate, make sure that no stress is applied during the mounting.
When using different spacer bolts (than those mounted at the factory) or spacer sleeves, ensure a minimum clearance of 3 mm to the mounting plate.

NOTE

Do not use the other (free) threads in the sensor for mounting purposes.

3 Electrical connection

The SILAREX is connected using the ST1 and ST2 connectors supplied. The supply voltage and communication is connected using ST1.

Connector ST2 is a power output that can be connected to external peripheral devices (e.g. a gas pump) of up to 200 mA.

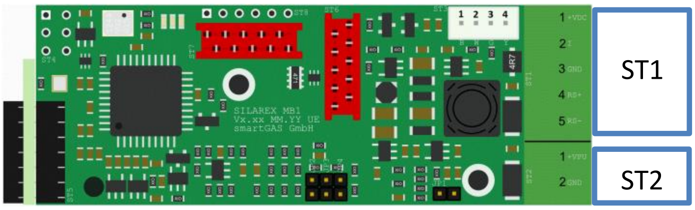


Figure 1: Position of the connectors

Connector ST1

Pin	Assignment
1	+Vcc 12 – 24 V DC
2	NC
3	GND
4	RS485+
5	RS485-

Table 1: ST1 pin assignment

Connector ST2 (power output)

Pin	Assignment
1	5.8 V DC
2	GND
max. 200 mA	

Table 2: ST2 pin assignment

3.1 Current consumption

The following table shows an overview of the current or power consumption. It is strongly recommended to only use adequately dimensioned and voltage-stabilized supply voltages in order to prevent malfunctions due to voltage dips.

Appropriate cable diameters must be used for long supply lines in order to avoid excessive voltage drops over the lines!

Supply voltage	Current consumption
12 V	300 mA
24 V	250 mA

Table 3: Voltage-dependent power consumption

4 LED status display

Three LEDs (green/yellow/red) are located on the Silarex circuit board. These show the current device status according to table Table 4:

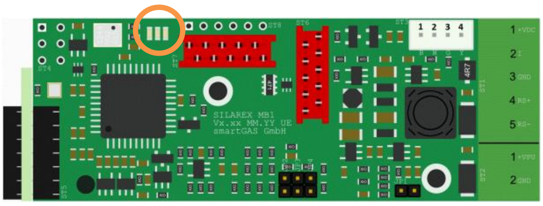


Figure 2: Position of the status LEDs

LD1 (red) O	LD2 (yellow) O	LD3 (green) O	Device status
illuminates	-	-	device error / contact service
-	flashes	-	- warning, - heating control not at setpoint, - measured value falls below or exceeds the guaranteed range
-	-	flashes	warm-up phase (30 minutes)
-	-	illuminates	normal operation

Table 4: LED status display

When the system is switched on, it also performs a brief LED check during which the LEDs light up briefly.

5 Pressure compensation (internal cell pressure)

Owing to the physical properties of the gases, their density changes depending on the pressure. This changes, however, depending on the altitude and weather conditions.

For this reason, a pressure transducer for measuring the internal cell pressure should already be integrated in the Silarex. Hence, the current pressure in the cell is included in the internal calculation of the concentration value.

Automatic pressure compensation in the pressure range of 600 – 1150 mbar takes place. If the value falls below or exceeds this range, a loss of accuracy is to be expected.

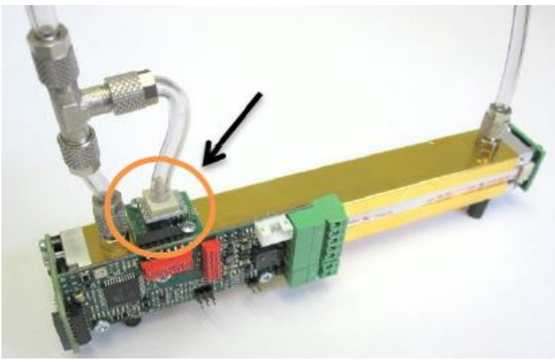


Figure 3: Position of the internal cell pressure sensor

6 Data interfaces

6.1 RS 485 mode

The RS 485 interface is a serial interface that works in 2-conductor mode (half-duplex). Data transmission occurs via symmetrical signals on the RS+ and RS- lines. The reference signal is GND.
The RS485 interface facilitates single master / multiple slave mode, with the sensor acting as the slave. A PC, microcontroller or something similar can be used as the master.
If the users do not have the same zero potential (GND), potential shifts might occur. To prevent these from affecting the terminal devices, the interfaces should be electrically isolated from the rest of the circuit in this case (e.g. by a fast optocoupler).

6.2 Signal profiles

The signals are transmitted differentially at the RS485 interface. RS+ routes the signal unchanged, and RS- in its inverted form – see Figure 4. The data signal is evaluated via the difference between the two signals [RS+] - [RS-].

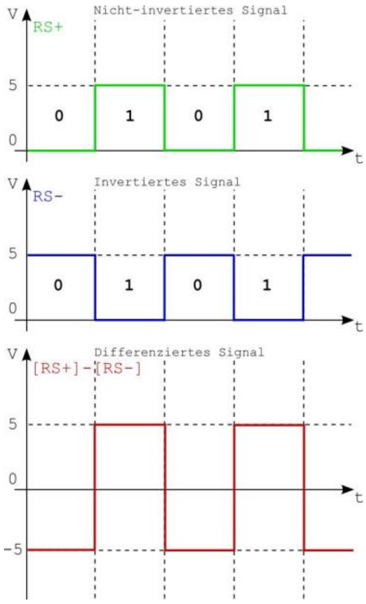


Figure 4: Signal transmission and evaluation on the RS485 data bus

RS485 transmitters provide a voltage difference of at least ±2V under load. The voltage difference can be smaller due to potential damping effects. The sensitivity of the receiver is ±200mV and can evaluate valid signals up to this value:

[RS+]-[RS-]	**> 200mV**	**logical "1"**
[RS+]-[RS-]	**< -200mV**	**logical "0"**
[RS+]-[RS-]	**< 200mV**	**false interpretation of the data is possible.**

6.3 Data exchange between master and Silarex (slave)

Figure 5 shows a possible scenario between master and SILAREX (= slave).
The following times refer to MODBUS ASCII and a baud rate of 2400 Bd.

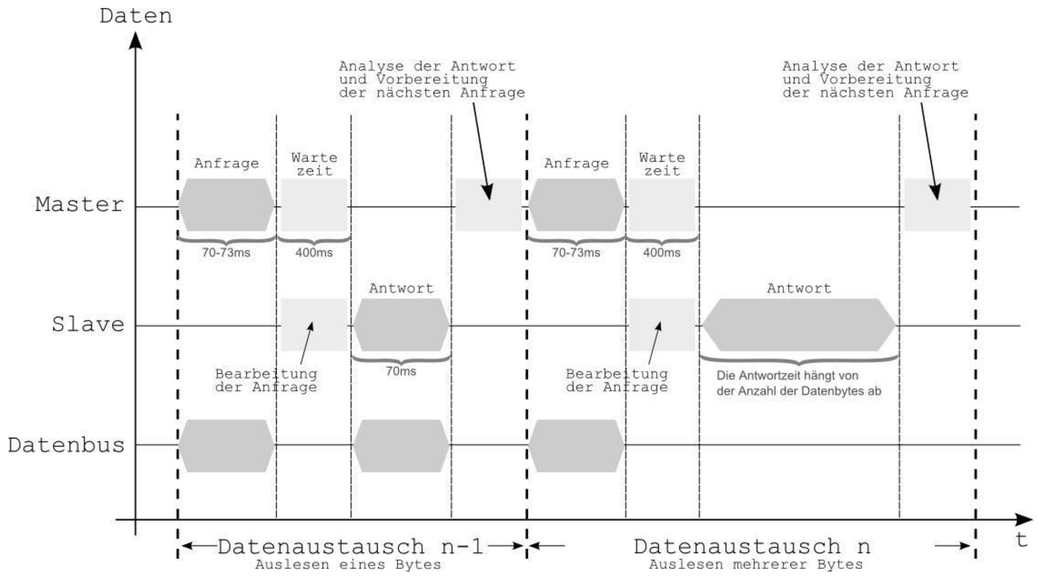


Figure 5: Time diagram – Data exchange between master and SILAREX (slave)

The duration of a query string is 70 - 73 ms. It is therefore possible for a short pause to follow (max. 400 ms). 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 around 70 ms. When multiple bytes are read out, the response phase is extended accordingly.

Basically, it can be said the SILAREX sensor responds to a query within 400 ms. The character string is then sent immediately without a response pause.

CAUTION!

At higher baud rates (> 2400 Bd), significantly faster response times can be expected.

6.4 RS 485 termination (bus terminating resistor)

From a line length of approx. > 30 m, it is advisable to use a terminating resistor to prevent reflections on the signal lines. The bus terminating resistor (150 Ohm) integrated on the Silarex circuit board can be switched on by connecting jumper JP 1.

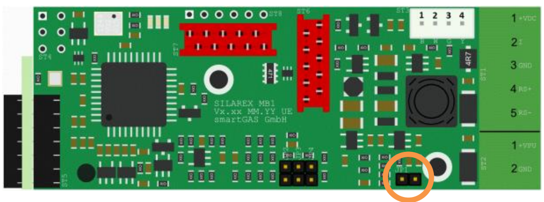


Figure 6: Position of JP1

NOTE

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

6.5 RS 232 mode via RS 485 interface

If only an RS 232 interface is available for data communication, the RS 485 interface can be configured for the RS 232 mode by an external circuit. RS232 mode requires the sensor to be wired as follows:

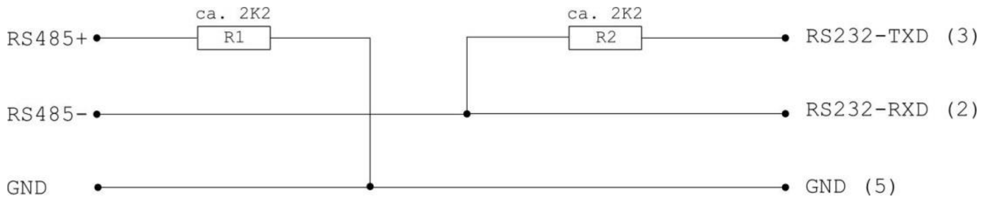


Figure 7: External wiring for RS 232 mode (R1/R2 approx. 2.2 kOhm)

NOTE

Please note the following for the RS 232 mode:

- The transmission rate must not exceed 38400 Bd
- The jumper JP 1 for the termination must not be connected

7 Modbus communication via RS 485 interface

The SILAREX sensor supports the MODBUS protocol in ASCII and 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.

In principle, Modbus communication functions on the basis of a query/response mechanism. The master sends the query to one of possibly several 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

7.1 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 in-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.

Subscriber position	Designation	Address	Baud rate	Role	Termination (bus terminating resistor)
1	SILAREX sensor	22	2400 Bd	Slave	Yes
2	Computer	----	2400 Bd	Master	No
3	Temperature sensor	11	2400 Bd	Slave	No
4	Pressure sensor	33	2400 Bd	Slave	Yes

Table 5: Example - Data bus with multiple subscribers

As Table 5 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.

7.2 Automatic detection of baud rate, framing format and Modbus dialect

The SILAREX software is provided with automatic configuration detection. This means that the sensor automatically detects the baud rate, the framing format as well as the MODBUS dialect used when switched on for the first time in the system.
The framing rates and MODBUS baud rates listed in table 6 harmonise with each another and can be freely combined among each other.

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 6: Freely combinable framing formats / baud rates

NOTE
A framing format of 8 data bits must be used for the communication via MODBUS RTU.

7.3 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:

Dialect	Start	Address	Control	Data	LRC	End
Modbus ASCII	1 character ’:’	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
Commu-nication:	0x3A	0x41, 0x30	0x30, 0x33	0x30, 0x30, 0x30, 0x35 0x30, 0x30, 0x30, 0x32	0x41, 0x36	0x0D, 0x0A

Dialect	Start	Address	Control	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	
Commu-nication:	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 an ASCII terminal; plain text appears on the screen.

In RTU mode, however, each 8-bit byte is handed over unchanged. This inevitably means that UART frames with 8 data bits need to be used in RTU mode. 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.

7.4 Modbus communication device

Figure Figure 8 shows the state diagram of the transmission and receiving devices in principle, regardless of whether it is master or slave:

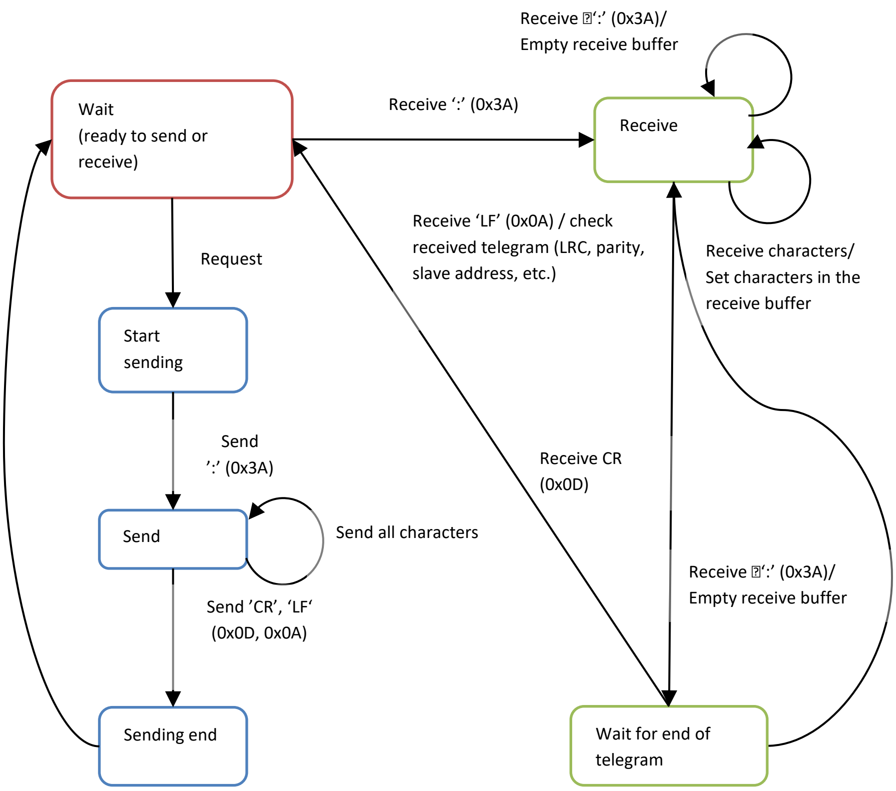


Figure 8: State diagram of a Modbus subscriber (ASCII operating mode)

If an incomplete query is sent to the SILAREX sensor, the sensor does not return a response. The module behaves the same when at least one register in the register area being queried does not exist. Error-free telegrams are processed, others are discarded.

7.5 Modbus address

With the SILAREX sensor, the as-delivered device address (Modbus address) corresponds to the last two numbers of the serial number on the type plate.

NOTE

Example for calculating the Modbus address:

Device address = **#35** decimal → 0x**23** hex

If the serial number ends with "00", the address is always #100 decimal = 0x64 hexadecimal.

The address "0" must never be used!

Figure 9 is a flow diagram that shows how unknown Modbus module addresses can be determined. 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 the serial numbers are queried, it is then possible to conclude which address is assigned to which module.

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

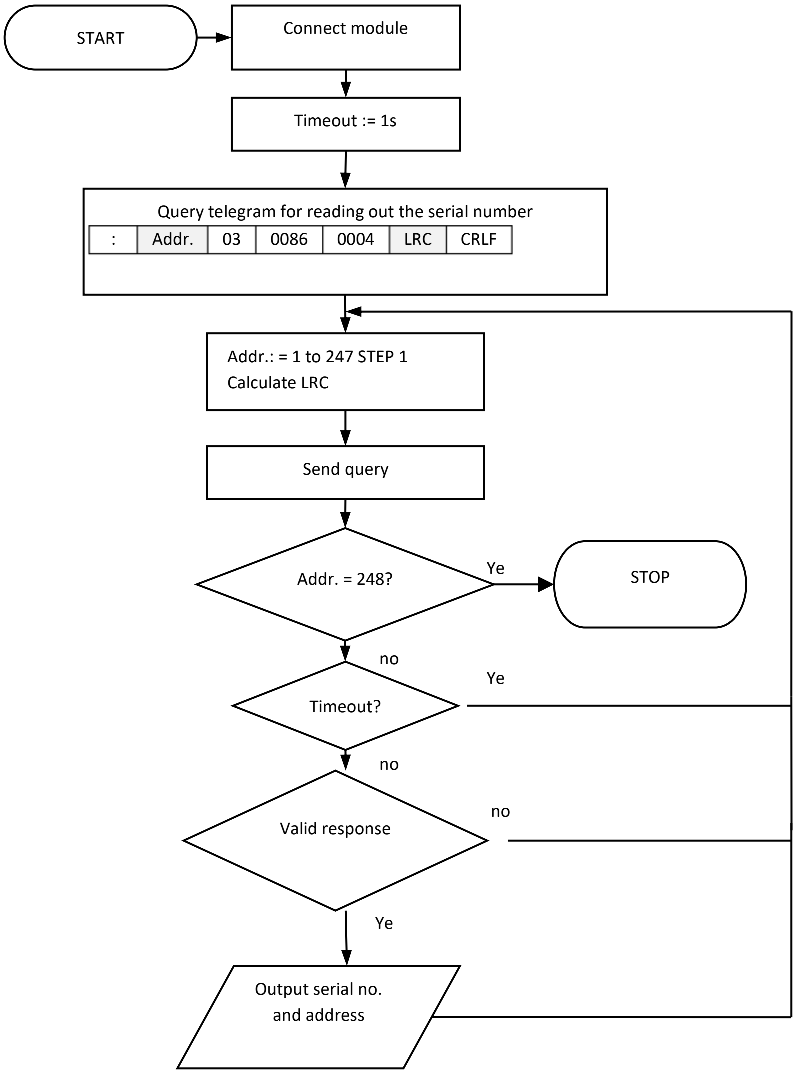


Figure 9: Flow diagram for determining module addresses

7.6 MODBUS control commands

Two command codes (function codes) are sufficient for communication with the SILAREX sensor. These are the following commands:

- **0x03 – Read** (multiple) holding registers and
- **0x06 – Write** (exactly one) register

One register is 16 bits wide and thus consists of 2 bytes:

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

All the SILAREX data that the user can access is shown on registers that are each 16 bits wide.

7.6.1 Control command 0x03 → Read (multiple) registers

This control command allows you to read values from the SILAREX sensor. It is essential that only registers defined in these instructions can be read. Therefore, this must be checked especially when multiple registers are queried.

Request		Response		Meaning of the data (according to ASCII table)
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)	58	'X'
Number of Lo registers	04	Hi register value (129)	20	'3 '
		Lo register value (129)	53	'0'
		Hi register value (130)	46	'0'
		Lo register value (130)	36	'0'
		Hi register value (131)	20	'0'
		Lo register value (131)	20	'3'

Example 1: Reading out the 4 registers for "Device Type"

In this example, four registers of the SILAREX sensor were read starting from register start address 0x0080 (decimal 128). The response consisted of a payload of 8 bytes that can be resolved with the aid of the ASCII table. Example: Response HEX 53 → to ASCII table → letter S

The response is now **"SX300003".** Thus, it is a SILAREX sensor (**SX**) for (**3)** measurement channels and the derivative number (**00003)**.

Request		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	0E	Hi register value (14)	01	456
Number of Hi registers	00	Lo register value (14)	C8	
Number of Lo registers	01			

Example 2: Reading out the "Conc" register (for displaying the gas concentration)

In this example, one register was read starting from the register start address 0x0E (decimal 14). The two data bytes were transmitted combined as a hexadecimal value. If this value (01C8) is converted to a decimal number, the result is a concentration value of 456.

Request		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	23	Hi register value (35)	00	3, means ppm x 1
Number of Hi registers	00	Lo register value (35)	03	
Number of Lo registers	01			

Example 3: Reading out the "Unit" register

In this example, one register was read starting from the register start address 0x0023 (decimal 35). The two data bytes were transmitted combined as a hexadecimal value. If this value (0x0003) is converted to 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 SILAREX sensor that was read has therefore measured a gas concentration of 456 ppm.

7.6.2 Control command 0x06 → Write to (only 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.

Request		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	C0	Lo register address	C0	
Hi register value (192)	00	Hi register value (192)	00	The new address of the module (160)
Lo register value (192)	A0	Lo register value (192)	A0	

Example 4: Writing to the "Modbus_address" register

In this example, a new Modbus address A0 (hex) = 160 dec. was assigned to the SILAREX sensor. Once this communication sequence is complete, the device is only responsive at this new address!

NOTE

The address 0 as well as addresses >247 must not be assigned!

Request		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	20	Lo register address	20	
Hi register value (32)	00	Hi register value (71)	00	The zero point has been reset
Lo register value (32)	01	Lo register value	01	

Example 5: Writing to the IR_zero1 register (setting the zero point for measurement channel 1)

In this example, the zero point of the SILAREX sensor has been reset. This was done by writing the value 1 to register 0x0020 (decimal 32). The device subsequently internally calculated and saved the current correction value for the zero point. Reading out the same register then shows the value of the correction.

NOTE

The zero point must only be set when zero gas and then a stable concentration value are applied.

Request		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	24	Lo register address	24	
Hi register value (84)	27	Hi register value	27	Correction value has been set to 10000
Lo register value	10	Lo register value	10	

Example 6: Writing to the CONC_gain1 register (end point correction comparison)

In this example, a new end point correction was set for the SILAREX sensor. A value of 2710 (hex) = 10000 (decimal). This is also the delivery condition. A value of 11000 would mean, for example, that the concentration value displayed is 10% higher than what is internally measured. This register therefore enables deviations of the SILAREX sensor in the concentration display to be corrected.

NOTE

The end point must only be set in this way when a suitable test gas and then a stable concentration value are applied!

Before the end point is set, the zero point must be set correctly.

7.7 Calculating the checksum

The calculation of the checksum (LRC) specifically for the ASCII (smartGAS) operating mode will now be explained based on an example. How the calculation of the LRC checksum in ASCII standard and CRC checksum in RTU works is described thoroughly in the documentation of the Modbus standard. It is helpful here 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 Conc register from the SILAREX sensor with the address 14 (decimal) = 0E (hex.)

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	0	E	0	3	0	0	0	A	0	0	0	1	---
	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	
Dec.	48	69	48	51	48	48	48	65	48	48	48	49	618

Sum = 618

Checksum = 255 - 618 + 1 = - 362

Modulo sum (256) = - 362 + 256 + 256 = 150 (dec.) → 96 (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: **2303000A000196<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.

8 Register overview

Address	Name	R/W	Function/description
0x05	T_int	R/---	Measured value for internal temperature (x0.1°C)
0x08	T_amb	R/---	Measured value for ambient temperature (x0.1°C)
0x09	P_amb	R/---	Measured value for ambient pressure in hPa (=mbar)
0x0A	P_kue	R/---	Measured value for internal cell pressure in hPa (=mbar)
0x0B	SYS_Status	R/---	Status bit bar, see page 20 for details
0x0E	CONC_1	R/---	Measured value for gas concentration in channel 1 in ppm, vol% or %LEL (Please note unit code CONC_unit1!)
0x11	CONC_2	R/---	Measured value for gas concentration in channel 2 in ppm, vol% or %LEL (Please note unit code CONC_unit2!)
0x14	CONC_3	R/---	Measured value for gas concentration in channel 3 in ppm, vol% or %LEL (Please note unit code CONC_unit3!)
0x20	IR_zero1	R/W	Setting value for zero adjustment of channel 1
0x22	CONC_fs1	R/W	Full Scale Channel 1
0x23	CONC_unit1	R/W	Unit code for gas concentration of channel 1, see page 21 for details
0x24	CONC_gain1	R/W	Concentration calculation of gain for channel 1
0x3C - 0x3F	gas_name1	R/---	Gas name of channel 1 in ASCII form
0x40	IR_zero2	R/W	Setting value for zero adjustment of channel 2
0x42	CONC_fs2	R/W	Full Scale Channel 2
0x43	CONC_unit2	R/W	Unit code for gas concentration of channel 2, see page 21 for details
0x44	CONC_gain2	R/W	Concentration calculation of gain for channel 2
0x5C - 0x5F	gas_name2	R/---	Gas name of channel 2 in ASCII form
0x60	IR_zero3	R/W	Setting value for zero adjustment of channel 3
0x62	CONC_fs3	R/W	Full Scale Channel 3
0x63	CONC_unit3	R/W	Unit code for gas concentration of channel 3, see page 21 for details
0x64	CONC_gain3	R/W	Concentration calculation of gain for channel 3
0x7C - 0x7F	gas_name3	R/---	Gas name of channel 3 in ASCII form
0x80 - 0x83	Device Type	R/---	Device type, max. 8-character text, distributed over 4 registers (e.g.: **SX300003**)
0x84 - 0x85	Software version	R/---	Software version, distributed over 2 registers
0x86 - 0x89	Serial No.	R/---	Serial no., a max. 8 characters long, distributed over 4 registers
0x90 - 0x97	Item No.	R/---	Article number in ASCII format
0x99	Sys_Settings_C	R/W	System settings, explanation see page 20
0xC0	Modbus_Address	R/W	Sensor Modbus address

Table 7: Modbus register table

R= (Read) register can only be read
W= (Write) register can be written

NOTE
All other registers not described here must not be changed under any circumstances.

8.1 Meaning of the individual bits in the status bit bar (SYS_Status):

Faults and error messages can be identified with the aid of the SYS_Status register according to the following table.

Bit	Name	Value → Message
00	DET_ERR	1 → IR detector disturbed
01	TMP_ERR	1 → Temperature sensor disturbed
02	PRS_ERR	1 → Internal cell pressure sensor disturbed
03	STR_ERR	1 → IR emitter disturbed
04	EEP_ERR	1 → EEPROM error
05	----	without function (reserved)
06	----	without function (reserved)
07	WDG_WRN	1 → after watchdog reset
08	Amb_SEN_ERR	1 → Ambient pressure sensor disturbed
09	WARMUP	1 → Silarex is in the warm-up phase
10	HEATER_NOT_IN_RANGE	1 → Control deviation of the cuvette heating is >2K (only if heating is active)
11	OUT_OF_LIMIT_UNDERRUN	1 → Measured value falls below or exceeds the guaranteed range (-20% of the measurement range end value)
12	OUT_OF_LIMIT_OVERRUN	1 → Measured value exceeds the guaranteed range (+40% of the measurement range end value)
13	OUT_OF_RANGE	1 → Measured value calculation outside of the displayable number range (-32768…32767) – Measured value output is limited to the displayable range.
15…14	----	without function (reserved)

Table 8: Allocation of the error messages in the status bit bar SYS_Status

NOTE
The value 0 always stands for the (error-free) normal state.

8.2 Meaning of the individual bits in Sys_Settings_C (customer settings):

The following configuration can be adapted by the customer:

Bit	Name	Value → Message
00	CONC_LIMITS_OFF	1 → Limitation of the measured value to the specification of the sensor is deactivated. The measured values outside of the guaranteed specification range are not necessarily within the guaranteed accuracy.
02…01	PFILTER_SEL	Setting of the downstream low-pass filter 00 → No downstream low-pass filtering 01 → Average value filter moderate (T90 = 7.2s) 10 → Average value filter strong (T90 = 60s) 11 → Adaptive low pass (fast with signal change)

03	PRESS_COMP	1 → Pressure changes in the system are compensated when the measured values are calculated
14…04	----	Without function (reserved)
15	RESTORE_FACTORY_DEFAULT	1 → Restoration of the factory settings for zero and end point of all measuring channels (CONC_1, CONC_2 CONC_3). The bit is self-resetting.

Table 9: Assignment of the settings in the configuration Sys_Settings_C

8.3 Description of the unit code: CONC_unitX:

For each of the three possible measurement channels there is a unit code (e.g. CONC_unit1 register 0x23 for measurement channel 1), which describes the measuring range and the factor by which the measured value given in register CONC_X must be multiplied.

Table 7 shows the allocation of the value read out in the register **CONC_unitX** to the aforementioned factors

Register value	→	Unit
0	→	unassigned, for special applications
1	→	ppm x 0.01
2	→	ppm x 0.1
3	→	ppm
4	→	Vol.% x 0.001
5	→	Vol.% x 0.01
6	→	Vol.% x 0.1
7	→	LEL x 0.01%
8	→	LEL x 0.1%

Table 10: Allocation of register value Conc_unitX to the measuring unit / multiplier

NOTE

Partial quantities of <1 vol.% are mostly specified as a ppm value. The following table shows the relationship of vol.% to ppm:

Vol.%	ppm
100	1,000,000
10	100,000
1	10,000
0.1	1000
0.01	100
0.001	10
0.0001	1

Table 11: Relationship of vol.% to ppm

9 Information on start-up and operation

9.1 Self-test / warm-up time

After the SILAREX sensor is switched on, an internal self-test takes place and the yellow LED flashes briefly. Then a function check of the status LEDs takes place. These light up in the following order:

Red → Yellow → Green

The SILAREX sensor is then in the warm-up phase and the green LED flashes. The sensor now delivers measured values and system errors are evaluated.

NOTE

During the self-test of approx. 3 seconds, correct measurement values are not output.

Each time after switching on, the sensor requires a warm-up phase of 30 minutes until all temperature-dependent elements have reached their operating point.
Only then are all specifications (measurement accuracy etc. according to data sheet) reached.

For SILAREX sensors with a cell heater, it may take longer to reach the system temperature. This depends on the surrounding environmental conditions. If the control deviation is too great (>±2K), the status HEATER_NOT_IN_RANGE is output in the status bar and the yellow LED flashes.

9.2 Setting the zero point

It is advisable to set the zero point

- after reinstallation of the sensor or measuring system
- at regular intervals (must be adapted to the application)
- after repairs/maintenance work on the sensor or measuring system

Before the zero point is adjusted, the sensor must be in operation for at least 30 minutes and a zero gas (e.g. N_2 – 100 vol.%) must flow through the sensor until the indicator for the gas concentration (register Conc_1, 2 or 3) has reached a stable value.

If the aforementioned requirements are met, the value 1 is written in the register IR_zero1 (0x20) and the zero point is thus reset. In the case of multi-channel systems, the process for IR_zero2 (0x40) and IR_zero3 (0x60) must be repeated.

9.3 Setting the end point

Setting the end point (also called final value or span calibration) requires the use of a test gas, which should correspond as accurately as possible to the final value of the measuring range of the sensor to be calibrated.
The same preconditions apply here as when setting the zero point: the sensor must be in operation for at least 30 minutes and test gas must flow through it until a stable value has been set in the register Conc_1, 2 or 3.
If all requirements have been met (which has to be tested by multiple querying of the register Conc_1, 2 or 3), the correction value for the respective measurement channel is written in the register Conc_gain 1, 2 or 3.

9.4 Calculating the correction value for the end point

Let us assume that a sensor indicates a concentration of only 978 ppm (referred to as “Conc_old” here) in channel 1 when a test gas is applied which has the value 1003 ppm (referred to as “Conc_cal” here).

The reading of the Conc_gain1 register yields the value 9985 (referred to as “Gain_old” here).

The new calculation of the correction value for the Conc_gain1 register then takes place as follows:

Conc_gain1_new = Conc_cal x Gain_old / Conc_old
Conc_gain1_new = 1003 x 9985 / 978 = **10240**

The new value of **10240** is now written in the register Conc_gain1 (0x24) and the process is completed!

NOTE
Setting the end point only makes sense if the zero point has previously been set correctly.

9.5 Restoring the calibration parameters to factory settings

When bit 15 is set in Sys_Settings_C (page 20) the factory setting of the calibration parameters for zero and end point of all measuring channels (CONC_1, CONC_2 and CONC_3) can be restored.

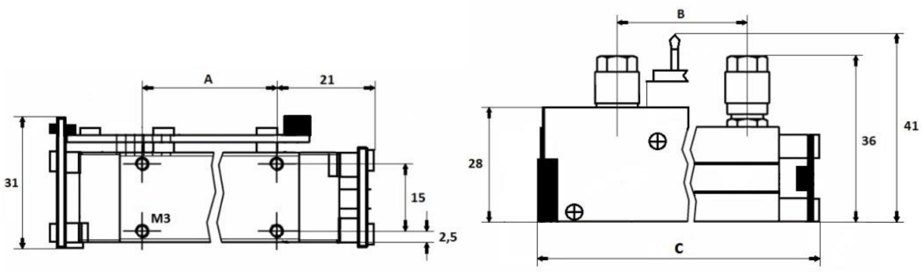
10 Integrated cell heater

The SILAREX sensor is equipped with a cell heater. This stabilises the cell to 42°C. Depending on the ambient conditions, it is possible that the heating output is not sufficient to reach the specified temperature on the sensor. The sensor can then be installed, for example, in a heat-insulating housing. Please contact smartGAS if you have any questions about this.

NOTE
The current temperature on the sensor can be read out via the register and 0x05 (T_int).

11 Mechanical dimensions

(all measurements in mm)



<u>Table of the dimensions </u>(all other dimensions are approximately the same for all device versions)

Cell length →	125 mm	155 mm	305 mm
A →	110	140	290
B →	110	140	290
C →	155	185	335

12 Legal information

The figures and drawings used in this description may differ from the originals; they are provided solely for illustrative purposes.
All information – including technical specifications – is subject to change without notice.
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