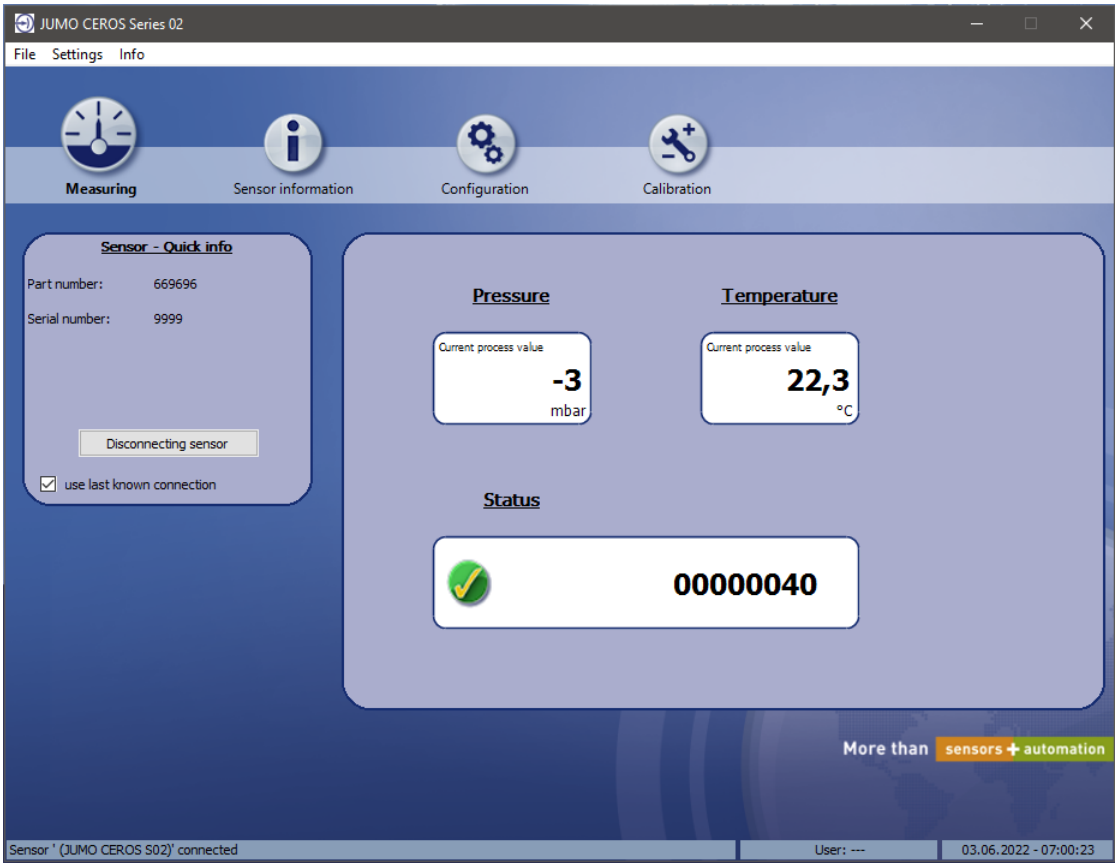
JUMO CEROS Series 02

Digital pressure measuring cells in low energy design



Interface Description

40510409T92Z001K000

V1.00/EN/00731016/2022-06-21

Further information and downloads

qr-405104-en.jumo.info qr-405106-en.jumo.info

Contents

Contents

This document contains all information for the safe and intended use of the product.

Avoid personal injury and property damage

- Ensure you have read and fully understood the document as well as the safety information and warnings
- Store the document in its entirety, in an easily accessible location, and so that it can be read in full at all times
- Contact the manufacturer if you have any questions about the product or document

1.1 Other applicable device documentation

This document is supplemented by the following documents:

Product group	Product name	Document type
405104	JUMO CEROS S02 M	Data sheet (EN), Data sheet (DE)
405106	JUMO CEROS C02 M	Data sheet (EN), Data sheet (DE)

1.2 Trademark information

- Microsoft® is a registered trademark of Microsoft Corp., Redmond, VA 98052-6399, US.
- Windows® is a registered trademark of Microsoft Corp., Redmond, VA 98052-6399, US.

1.3 Symbols and signal words

1.3.1 Warning symbols

NOTICE!

The signal word „NOTICE“ indicates possible material damage.

1.3.2 Note symbols

NOTE!

This symbol refers to **important information** about the product, its handling, or additional benefits.

NOTE!

This symbol is used in tables and indicates that further information is provided after the table.

REFERENCE!

This symbol refers to **further information** in other sections, chapters, or other manuals.

2 I²C communication

2.1 General

The interface description deals with the following topics:

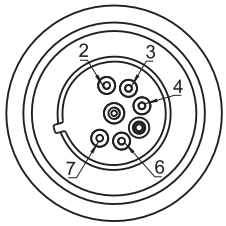
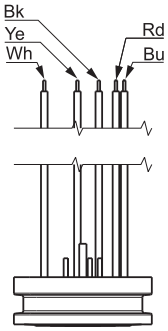
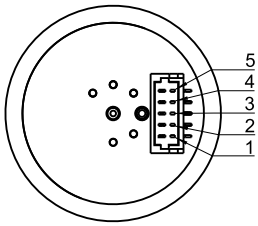
- Communication via the I²C interface
- Correct electrical connection
- Entire design as an I²C bus with master, slave(s) and pull-up resistors
- Digital communication to read out the pressure and temperature value, as well as other device information
- Correct interpretation and conversion of the digital value into a decimal pressure or temperature value
- Configuration possibilities of the digital pressure measuring cell by using the corresponding software

More information on the I²C bus specification and the user manual "UM10204" ⇨ www.nxp.com.

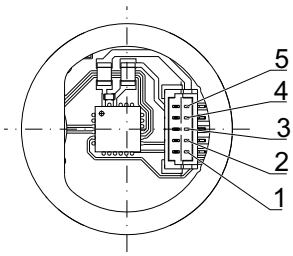
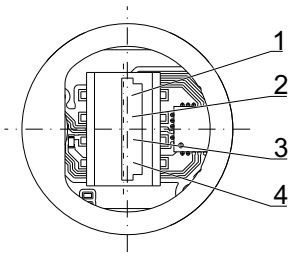
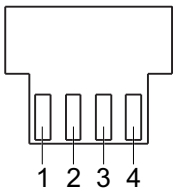
2.2 Interface connection

2.2.1 Pin assignment

JUMO CEROS S02 M

Electrical connection	05 Pins	24 Stranded wires	39 JST connector (type BM05B-SRSS-TB)
			
EOC	2	Ye	5
GND	3	Bk	4
U_B	4	Rd	3
SCL	6	Wh	2
SDA	7	Bu	1

JUMO CEROS C02 M

Electrical connection	39 JST connector (type BM05B SRSS-TB)	42 Edge Connector	Plug-in PCB for Edge Connector
			
EOC	5	-	-
GND	4	4	4
U_B	3	3	3
SCL	2	2	2
SDA	1	1	1

2.2.2 Cabling

NOTICE!

Product damage possible due to insufficient shielding.

The I²C bus is not a field bus and only EMC safe if the interconnections are short or screened by the surrounding housing of the whole application or a suitable cable.

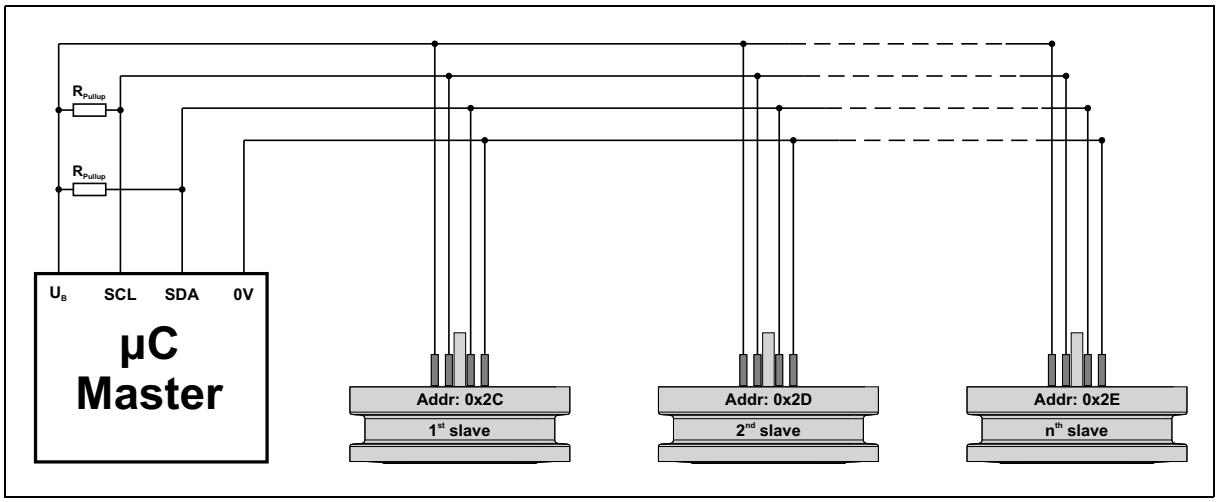
▶ Keep cabling short / not over than a few centimetres.

The digital pressure measuring cell can be connected with a PC/Notebook via PC Interface with Converter USB/I²C 3.3 V ⇨ "Connection to the computer", Page 16.

2.2.3 Entire design of the I²C bus

The following figure shows a entire design by way of example, including a master, three digital pressure measuring cells as slaves and pull-up resistors. The signal wires SDA and SCL are connected by pull-up resistors to U_B. A pull-up resistor in the range of 1 to 10 kΩ is recommended. In order to optimize the data rate or low power consumption, other resistance values are possible.

Scheme of a I²C-bus structure:



2.2.4 Function

I²C is designed as a master-slave-bus. A data transfer is initiated by a master and the slave, which is addressed, reacts on it. Every slave in a bus structure needs a different address to avoid collisions. The address is stored in the memory of the device. For the communication between master and slave the bus needs two signal wires: SCL (Serial Clock) as a clock wire and SDA (Serial Data) as a data wire.

Every device connected to SCL and SDA has an open-collector-output. Combined with the pull-up resistors it results in a wired-AND circuit. Additional series resistors can be placed directly at the devices to get more security.

The I²C bus has a positive logic, what means that a high level at SDA corresponds to a logical '1' and a low level corresponds to a logical '0'.

The transmission protocol of I²C starts with a start bit, the address and a R/W bit (Read/Write) sent by the master. This will be confirmed by the addressed slave with an ACK bit (ACKnowledgement). Dependent on the R/W bit data is written (data to slave) or read (data to master). The confirmation with the ACK bit is sent by the slave when writing and by the master when reading. The last byte of a reading access is confirmed with a NACK bit (No ACKnowledgement) by the master, to show the end of a transmission. The transmission is finished with a stop bit.

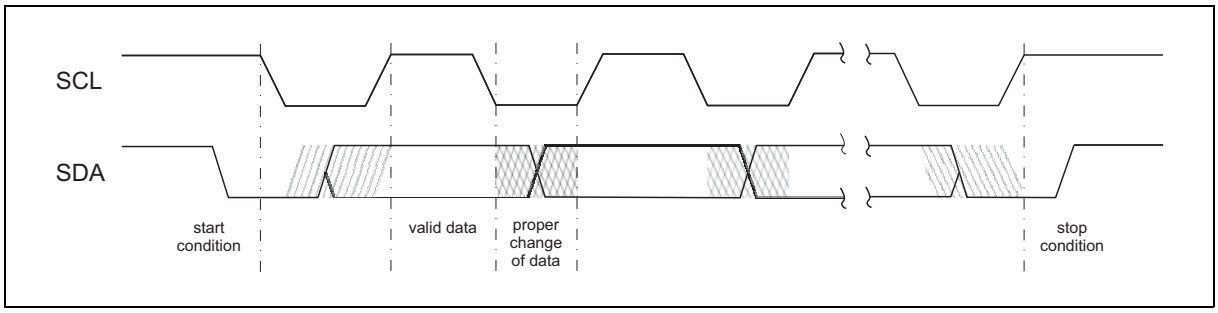
The bit rate of the data transfer is set by the master.

The maximum bit rate, supported by the digital pressure measuring cell, is shown in the following chapter.

2.3 Bit rate

The digital pressure measuring cell works over two sets of bitrates (transfer speed). The maximum clock frequency is 3.4 MHz. Furthermore the maximum bit rate depends on cable length, cable capacity and pull-up resistors. So it is recommended to start with lower bit rates and test the maximum possible bit rate by increasing it.

2.4 Data structure



- **Idle period**

During inactivity of the bus, SDA and SCL are pulled-up to the supply voltage VDDA.

- **Start condition**

Every data frame starts with a start condition. A high-to-low transition on SDA while SCL is at the high level indicates a start condition. Every command must be initiated by a start condition sent by a master.

- **Valid data**

Data is transmitted in bytes (8 bits) starting with the most significant bit (MSB). Each byte transmitted is followed by an acknowledge bit. Transmitted bits are valid if, after a start condition, SDA remains at a constant level during the high period of SCL. The SDA level may change only when the clock signal at SCL is low.

- **Acknowledge**

An acknowledge after a transmitted byte is obligatory. The master must generate an acknowledge-related clock pulse. The receiver (slave or master) pulls down the SDA line during the acknowledge clock pulse. If no acknowledge is generated by the receiver, a transmitting slave will become inactive. A transmitting master can abort the transmission by generating a stop condition and can repeat the command. A receiving master may signal the end of the transfer to the transmitting slave by not generating an acknowledge-related clock pulse at SCL. The digital pressure measuring cell changes to inactive interface mode when processing internal command routines started by a previously sent command.

After every transferred byte (in both directions) the receiver of the byte gives feedback with the acknowledge bit.The slave should always confirm the bytes by an ACK. If the slave does not respond with a LOW level after the 8th bit, the master detects an exception (for example caused by requesting to the wrong slave address). A NACK from the master’s side is not always an exception. It is also needed to terminate a read data frame.

- **Stop condition**

Every data frame ends with a stop condition. A low-to-high transition on SDA while SCL is at the high level indicates a stop condition. A command must be closed by a stop condition to start processing the command routine in the digital pressure measuring cell.

2.5 Addressing

The first byte of every data frame contains the slave address and a R/W bit (Write = 0/Read = 1).

The default slave address (standard adress) of the digital pressure measuring cell transmitters is 0x2C in 7 bit notation. Another address can be set by using the software (⇨ chapter 4.7.1 "Interface", Page 21). The 7 bit address of a I²C device allows 112 bus addresses in general, because 16 of the 128 possible addresses are reserved for special purposes.

It is possible to use up to 112 digital pressure measuring cells on one bus without getting collisions at the maximum. Other devices with other adresses (e.g. temperature sensors) can be added to the bus to, as long as the maximum number of 112 devices is not exceeded.

Examples:

ADDR is 0x2C – data transfer from the master to the slave (write)

0	1	0	1	1	0	0	0
0x2C (address)							0x00 (write)
0x58 (first byte)							

ADDR is 0x7F – data transfer from the slave to the master (read)

1	1	1	1	1	1	1	1
0x7F (address)							0x01 (read)
0xFF (first byte)							

2.6 WRITE Operation

An I²C WRITE operation is initiated by the master sending the slave an address byte including a data direction bit set to '0' (WRITE). The address byte is followed by a command byte, and for applicable commands two additional data bytes (optional). The digital pressure measuring cell's internal micro controller evaluates the received command and processes the related routine. In the following a WRITE command with two data bytes and another WRITE command without data bytes is illustrated.

WRITE Command Byte and 2 Data Bytes

S	6	5	4	3	2	1	0	W	A	7	6	5	0	3	2	1	0	A	15	14	13	12	11	10	9	8	A	7	6	5	4	3	2	1	0	A	S
	Device Slave Address [6:0]									Command Byte [7:0]									Data Byte [15:8]									Data Byte [7:0]									

WRITE Command Byte and no Data Bytes

S	6	5	4	3	2	1	0	W	A	7	6	5	0	3	2	1	0	A	S
	Device Slave Address [6:0]									Command Byte [7:0]									

S	Start/Stop condition	6	Device slave address	W	Read/Write Bit
5	Command Bit	4	Data Bit	A	Acknowledge (ACK)

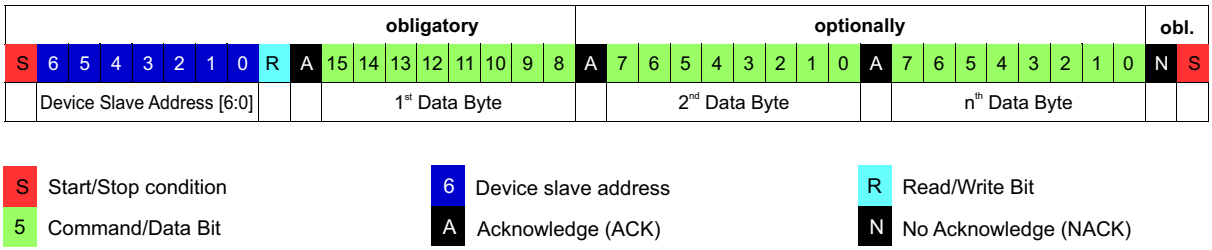
Recommended for your using are only WRITE Commands without following Data Bytes, which are documented in the following chapters.

2.7 READ Operation

A data request from a master to a slave is initiated by sending an address byte including a data direction bit set to ‘1’ (READ). The slave answers by sending data from the interface output registers. The master must generate the transmission clock for the following: SCL, acknowledges after each Data Byte (except after the last one), and the stop condition at the end. A data request is handled by the digital pressure measuring cell’s interface module and consequently does not interrupt the current process of the internal micro-controller.

The content and the length of the Data Bytes from the slave (green marked) depend on the last transferred WRITE command. Independent of the WRITE command is this slave always answering with a status byte in the first Data Byte. Dependend of the WRITE command are optionally some bytes following: there are commands with 0, 2, 3 or 6 following Data Bytes in this slave.

Read n Data Bytes



2.7.1 1st Data Byte

The 1st Data Byte that this slave answers in a READ Operation is always a status byte. This is independent of the last WRITE Operation. This status contains 7 defined bits, which represent the status of the slave or the success of the last WRITE Operation.

Status bit[a]	Value	Meaning
6	0x40	Power On
5	0x20	Busy, last command not ready
4	0x10	Chip is in reserved mode
3	0x08	Chip is in command mode without measuring
2	0x04	Memory CRC-Error
1	0x02	wrong config selected
0	0x01	Saturation while calculating measurement

[a] More than one can be set at the same time

2.7.2 Following Data Bytes

The 2nd to nth Data Byte that this slave answers in a READ Operation are dependent of the last WRITE Operation. The master should therefore remember his last sended command and send as many clock pulses as Data Bytes could be expected.

WRITE command	Number of Data Bytes
Read Register	3 (status + 2 following)
Write Register	1 (status + 0)
Calc Mem-CRC	1 (status + 0)
Get Raw Measure	4 (Status + 3)
Change Mode	1 (status + 0)
Measure + Calc	7 (status + 6)
Select Cfg	1 (status + 0)
Stop + Sleep	1 (status + 0)

Recommended for your using are only the commands Read Register or Measure + Calc, which are documented in the following chapters.

3.1 Receive sensor data

The chart states the combination of address and function in the default settings.

ADDR default	0x2C
W (Write): 0 ⇨ **ADDR | W default**	0x58
R (Read): 1 ⇨ **ADDR | R default**	0x59

3.1.1 Get measure value

1. Request measurement (2 bytes from master)

Bits	S	ADDR | W	A	Meas-Cmd	A	S
sent by	master	master	slave	master	slave	master
type	Start	address + r/w bit	ACK	command	ACK	Stop

You can use different measurement commands (Meas-Cmd) concerning your timing and stability requirements:

Meas-Cmd	Measure + Calc	Proceeding Time
0xAA	1-time	Approx. 4 ms
0xAC	2-time average	Approx. 8 ms
0xAD	4-time average	Approx. 16 ms
0xAE	8-time average	Approx. 32 ms
0xAF	16-time average	Approx. 64 ms

2. Wait by delay the expected proceeding time.
3. Read measurement (1 byte from master, 7 bytes from slave)

Bits	S	ADDR | R	A	Byte 1	A	Byte 2	A	Byte 3	A	Byte 4	A	Byte 5	A	Byte 6	A	Byte 7	N	S
sent by	master	master	slave	slave	master	slave	master	slave	master	slave	master	slave	master	slave	master	slave	master	master
type	Start	address + r/w bit	ACK	status [7:0]	ACK	pressure [23:16]	ACK	pressure [15:8]	ACK	pressure [7:0]	ACK	temp [23:16]	ACK	temp [15:8]	ACK	temp [7:0]	NACK	Stop

The first returned byte is a status byte. byte 2, 3 and 4 make the 24 bit digital count of the actual pressure value in common. Byte 5, 6 and 7 make the 24 bit digital count of the actual temperature value in common.

Pay attention to the status byte:

Status bit	Meaning	Consequence
0x40	Power on	Proceed with next step.
0x20	Busy	Increase delay time before reading.
Any other	Error	Stop process! Show the status error to the user and dont calculate anything with the following bytes!

4. Calculate pressure value

$$P[bar] = \left(\frac{\text{pressure [23:0]} - 2^{24} * 0.1}{2^{24} * 0.8} * MSP[bar] \right) + P_{min}[bar]$$

measuring span (MSP) = measuring range start - measuring range end:

$$MSP[bar] = P_{max}[bar] - P_{min}[bar]$$

P_{max} and P_{min} can be read in the order documents, on the device lable or in the device registers 0x21 (P_{max}) and 0x20 (P_{min}).

5. Calculate Temperature Value

$$T[° C] = \left(\frac{\text{temp [23:0]}}{2^{24}} * MSP [° C] \right) + T_{min}[° C]$$

measuring span (MSP) = measuring range start - measuring range end:

$$MSP[° C] = T_{max}[° C] - T_{min}[° C]$$

T_{max} = 125° C, T_{min} = -40° C

3.1.2 Registry adresses

Sensor identification

Registry	Description
0x00	Sensor identification [15:0] Contact manufacturer!
0x01	Sensor version [15:8] Free [7:0] 0x00 = Piezoresistive sensor (CEROS S02) [7:0] 0x01 = Ceramic thickfilm sensor (CEROS C02)

Sensor specification

Registry	Description
0x20	Measuring range start [15] Unit: 1 = bar, 0 = mbar [14] Prefix sign: 1 = negative, 0 = positive [13:0] Value: 0 to 16383
0x21	Measuring range end [15] Unit: 1 = bar, 0 = mbar [14] Prefix sign: 1 = negative, 0 = positive [13:0] Value: 0 to 16383
0x22	Sensor type [15:1] free [0] Type: 1 = absloute pressure, 0 = relative pressure
0x23 to 0x2D	free

Manufacturing data

Registry	Description
0x2E	[31:16] Part number highword
0x2F	[15:0] Part number lowword
0x30	[31:16] FA number (production order number) highword
0x31	[15:0] FA number (production order number) lowword
0x32	Production location - 010 (dec) for JUMO Fulda
0x33	Production date [15:8] Year [7:0] Calendar week
0x34	Counter number (serial number) 000 to 999
0x35	HW index: 1 byte (use of the low byte) starting with "1", value range (0 to 255)
0x36 to 0x38	Free

4 PC software

4.1 Brief description

The PC software was developed for communication between PC and digital pressure measuring cell.

Using the PC software, the user can adjust the digital pressure measuring cell (offset) and set various parameters within the device.

Communication between PC and digital pressure measuring cell is via PC Interface with Converter USB/I²C, which also provides the operating voltage for the connected pressure cell.

The PC software is designed for online operation. The data to be set are read out from the connected digital pressure measuring cell, displayed, modified by the user and written back into the device.

It is not necessary to save data in a file on the PC, and a printout is also not required.

4.2 Installation

4.2.1 Hardware and software requirements

For operation and the installation of the PC software the following hardware and software requirements have to be met:

- Notebook or Desktop PC with USB interface, OS: Microsoft Windows 7 or newer
- PC Interface with Converter USB/I²C 3.3 V
- Free software "Setup JUMO CEROS Series 02"

4.2.2 Installation via download file

The PC software was developed for communication between PC and digital pressure measuring cell and is available as a free download at qr-405104-en.jumo.info or qr-405106-en.jumo.info.

4.3 Connection to the computer

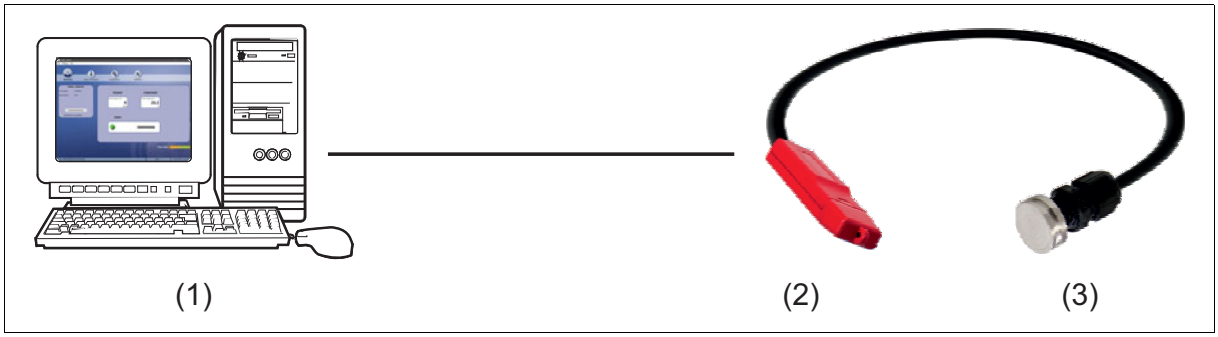
NOTICE!

Product damage possible due to use of incompatible hardware.

To connect the digital pressure measuring cell to the PC/Notebook only use the following (red coloured) PC Interfaces with Converter USB/I²C:

▶ PC Interface with Converter USB/I²C 3.3 V TO39 (Part no. 00764642)

▶ PC Interface with Converter USB/I²C 3.3 V JST (Part no. 00772261)



(1) PC/Notebook – setup software installed

(2) PC Interface with Converter USB/I²C 3.3 V

(3) Digital pressure measuring cell

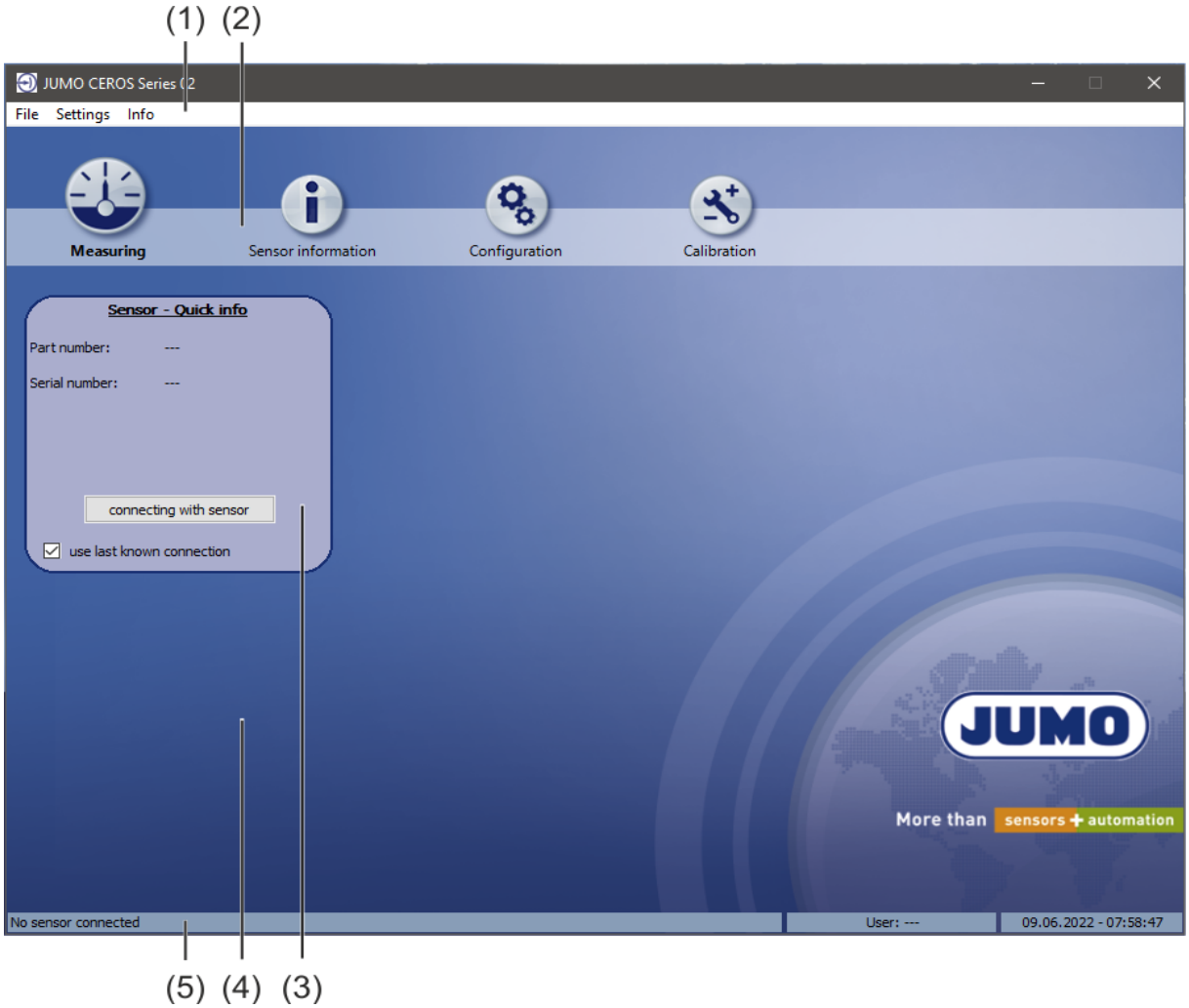
4.4 Program start

Windows Start Menu

1. Make sure the digital pressure cell is connected to the PC/notebook.
   ⇨ chapter 4.3 "Connection to the computer", Page 16
2. Start the PC software via the **Windows Start Menu**.

The start screen of the PC software appears.

Start screen



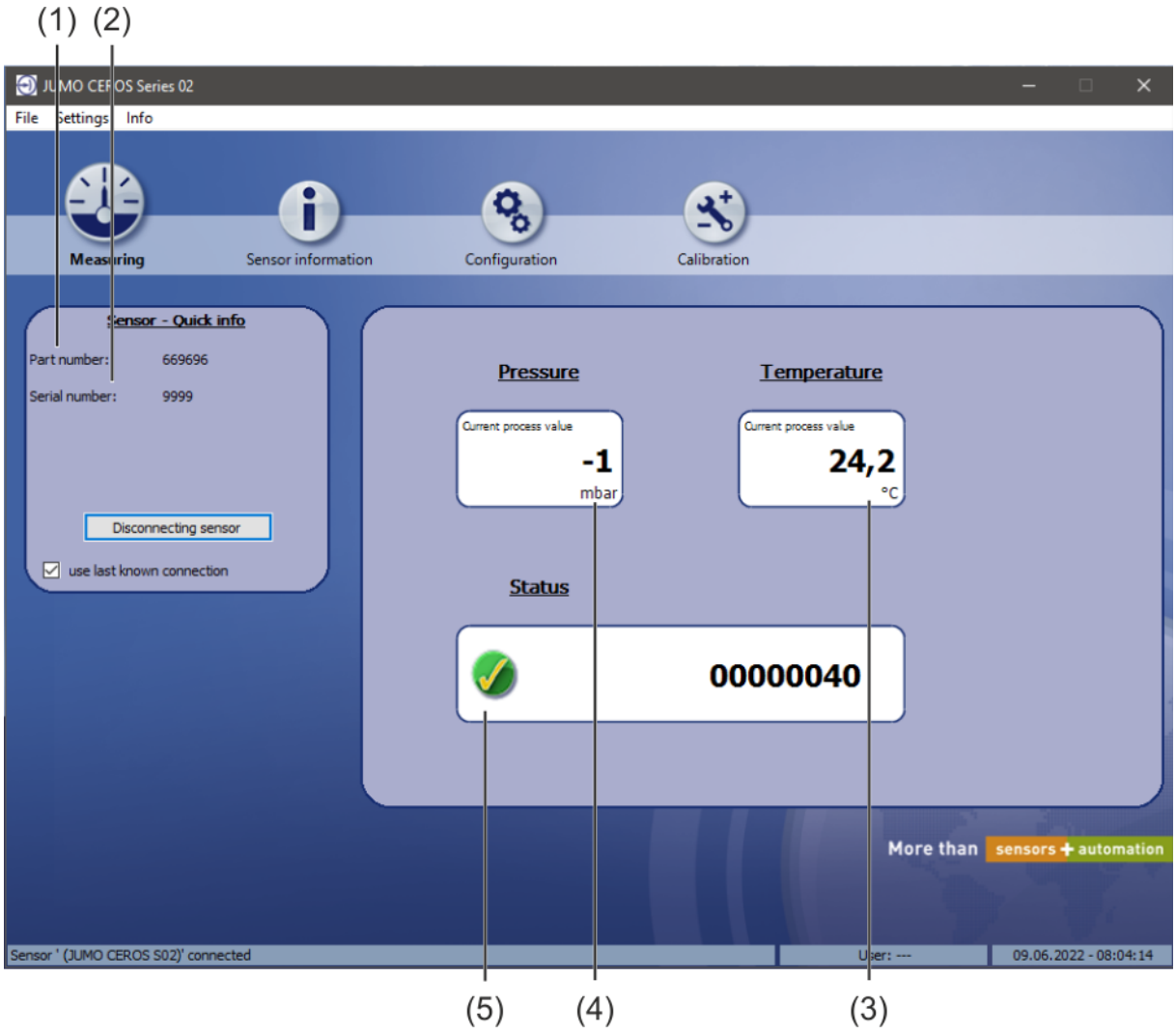
(1) Menu bar
(2) Toolbar
(3) Sensor - Quick info
(4) Dialogue box
(5) Status bar

4 PC software

4.5 Measuring

4.5.1 Connecting with sensor

1. Connect the digital pressure measuring cell to the PC software via the connecting with sensor button in the **Sensor - Quick info** window.



After successfully connecting the digital pressure measuring cell and PC software, **Part number** (1) and **Serial number** (2) of the sensor are displayed in the **Sensor - Quick info** window.

The **Measuring** dialogue box displays the current process values **Temperature** (3) and **Pressure** (4) and in addition, the **Status** (5) indicates the functionality of the digital pressure measuring cell.

NOTE!

If the **Status** shows an error: ⇨ chapter 4.11 "Error messages", Page 25

4.6 Sensor information

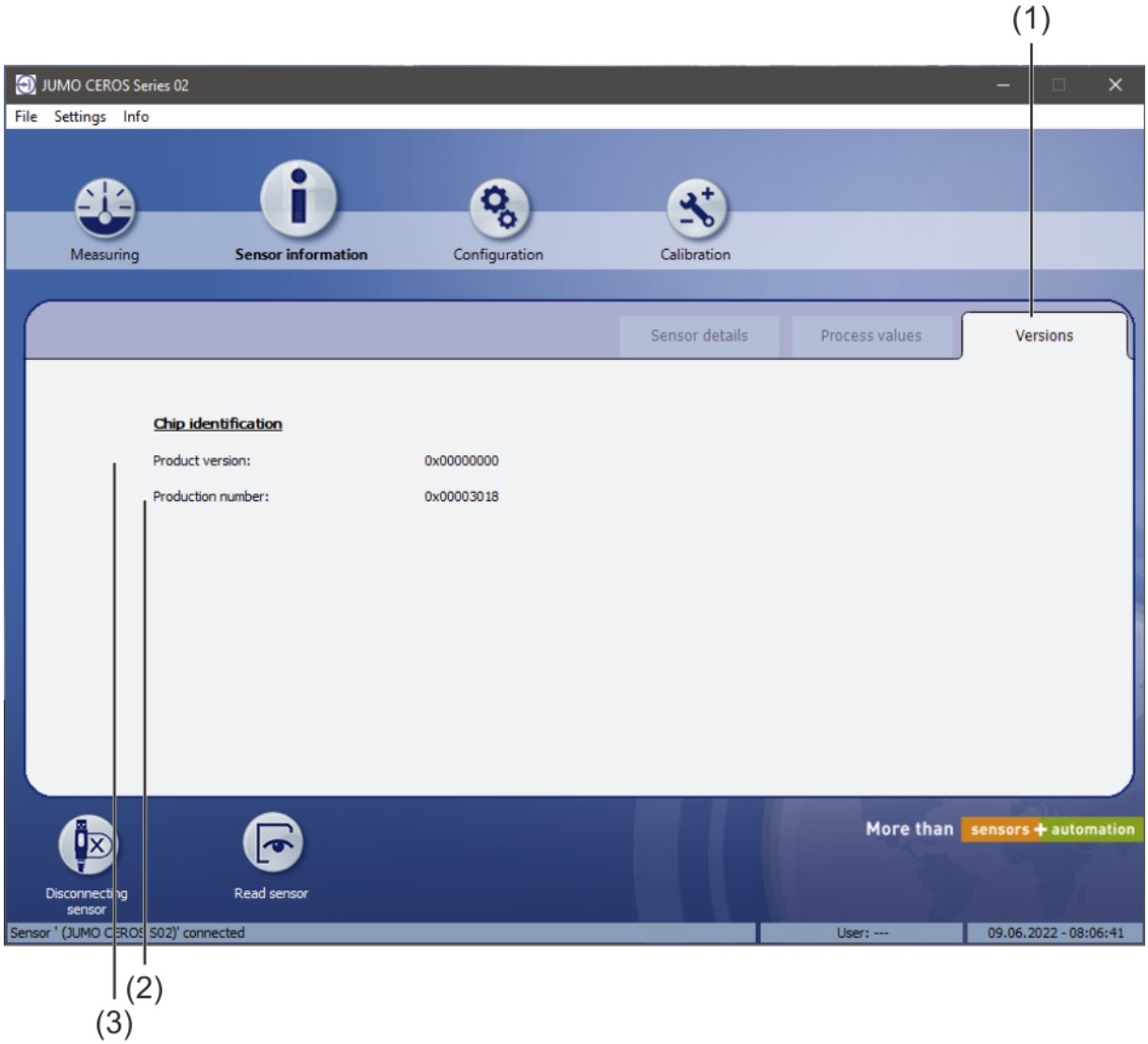
The **Sensor information** dialogue box displays non-editable information about the digital pressure measuring cell. The information is used to uniquely identify the digital pressure measuring cell.

4.6.1 Sensor details

In the **Sensor details** tab (1) **Default settings**, **Manufacturer´s data** and **Sensor details** are displayed.

The **Read sensor** button (2) allows to read the sensor´s configuration, and the **Disconnecting sensor** button (3) removes the connection between digital pressure measuring cell and PC software.

4.6.2 Versions

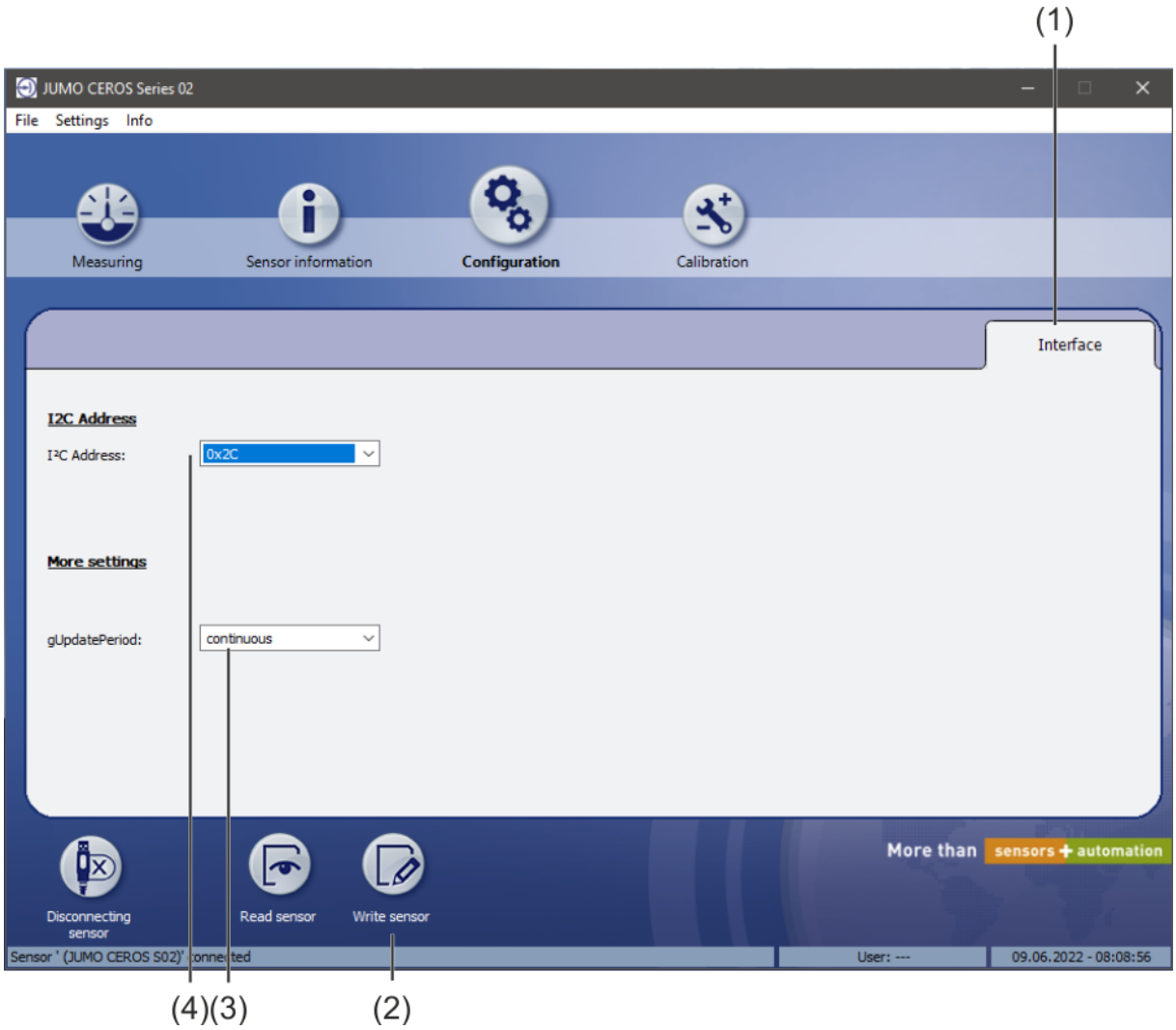


The individual product details **Product Version** (3) and **Production number** (2) are displayed in the **Versions** tab (1) which is used for traceability of the digital pressure measuring cell.

4.7 Configuration

The **Configration** dialogue box displays editable information and sensor data about the digital pressure measuring cell.

4.7.1 Interface



The **Interface** tab (1) displays the **I²C Standard address** (4) and the **gUpdatePeriod** (3).

I²C Standard address

The drop-down menu allows the selection of different addresses.

gUpdatePeriod

The dropdown menu allows to activate a cyclic sleep mode to reduce the average power consumption. The higher the update time the lower the average power consumption.

NOTE!

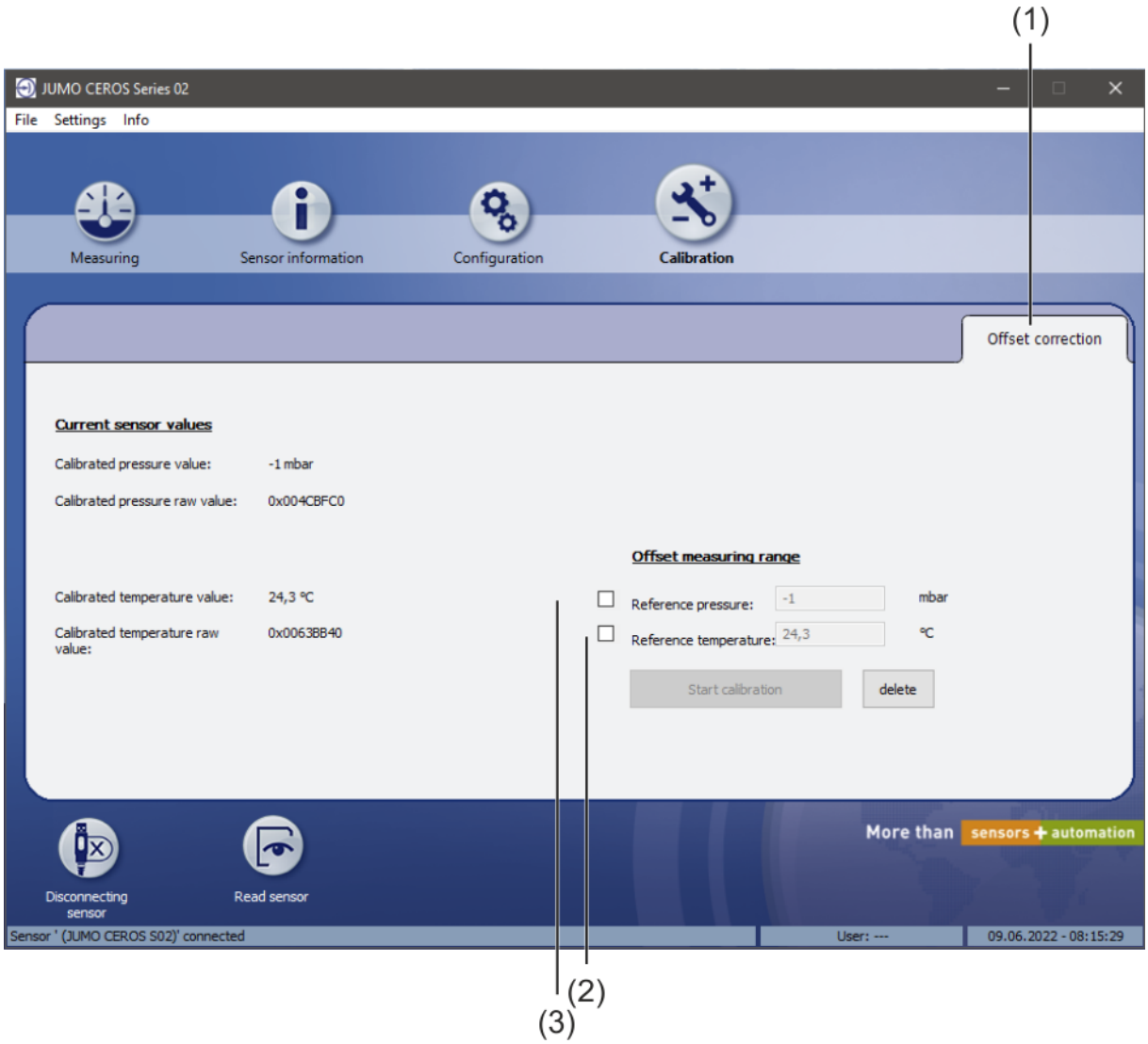
If changes have been made, the data must be transferred to the sensor via the **Write sensor** button (2).

4 PC software

4.8 Calibration

The **Calibration** dialogue box displays **current sensor values** and offers performing an offset correction.

4.8.1 Offset correction



Default there is no offset correction written in the sensor.

In order to increase the accuracy in the operating point, the **Offset correction** tab (1) offers performing offset correction at any operating point by specifying a **Reference pressure** (3) or a **Reference Temperature** (2) and pushing the Start calibration button.

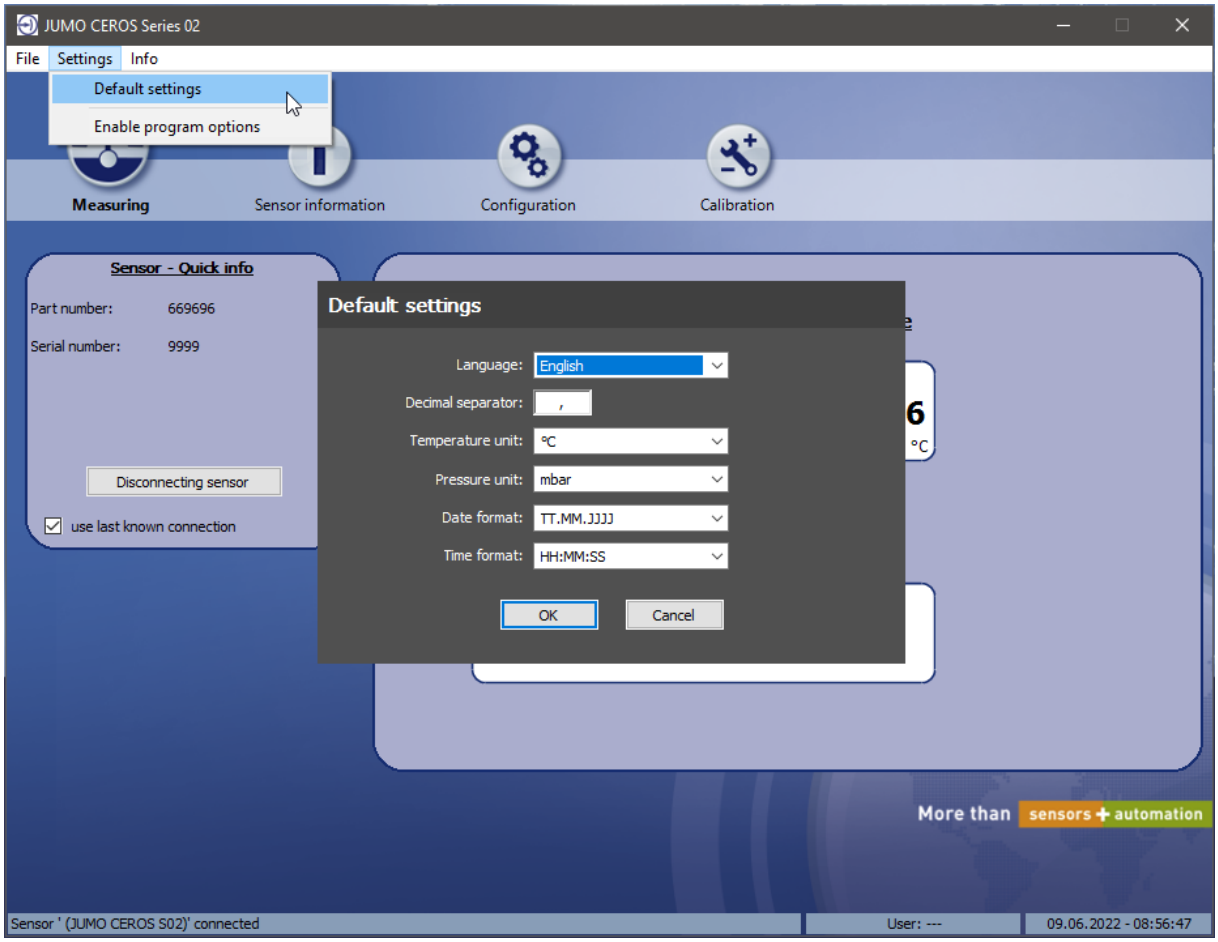
By pushing the delete button the written Offset-correction of the connected sensor will be deleted.

NOTE!

In the simplest case, the offset correction of a relative digital pressure measuring cell is carried out at zero without a calibrator.

4.9 Settings

Via the **Settings** menu the **Default settings** dialogue box can be edited.



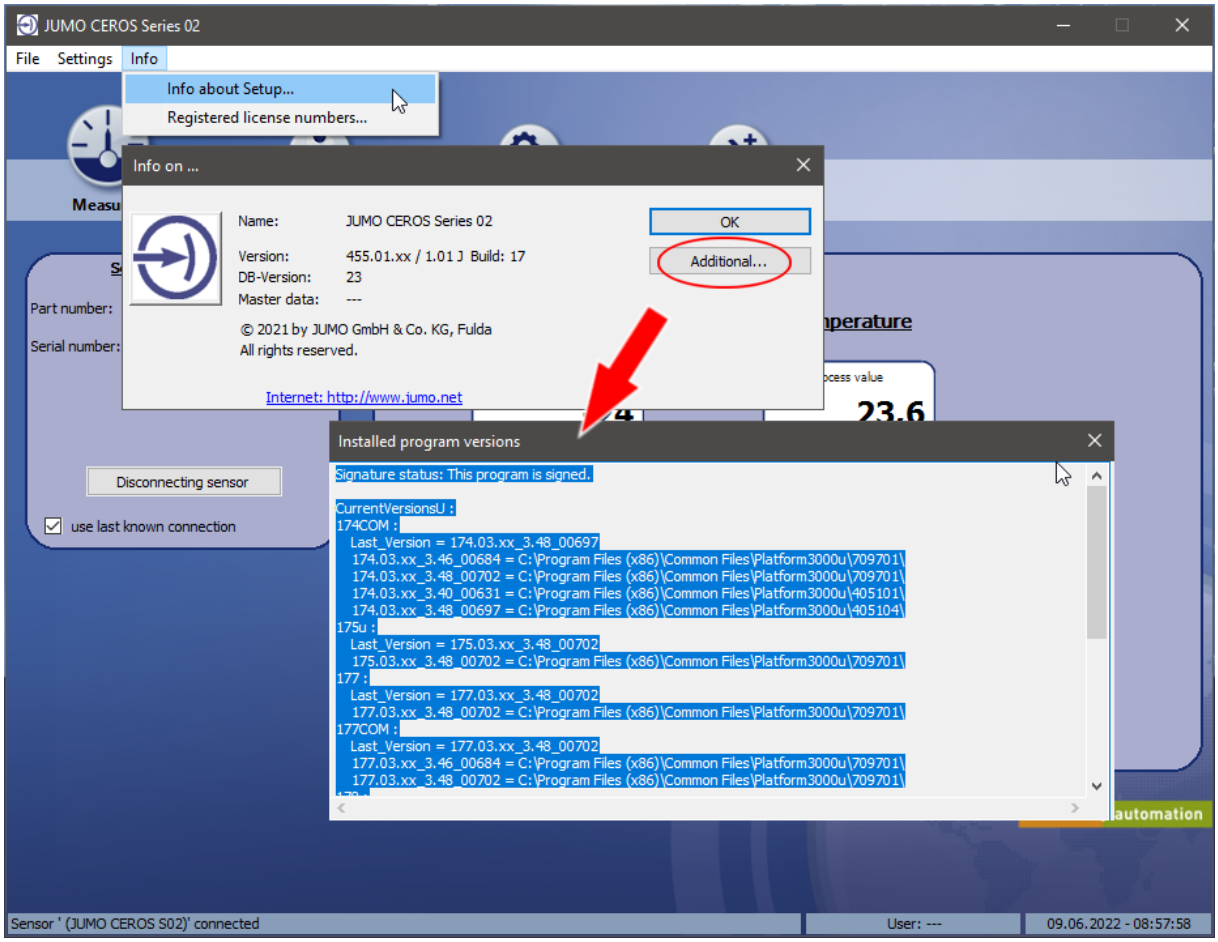
NOTE!

Changing the language will only be effective after a fresh program start!

4 PC software

4.10 Info

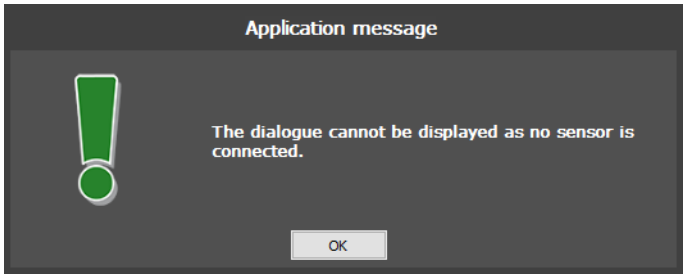
Via the **Info** menu, information about the setup software can be called up.



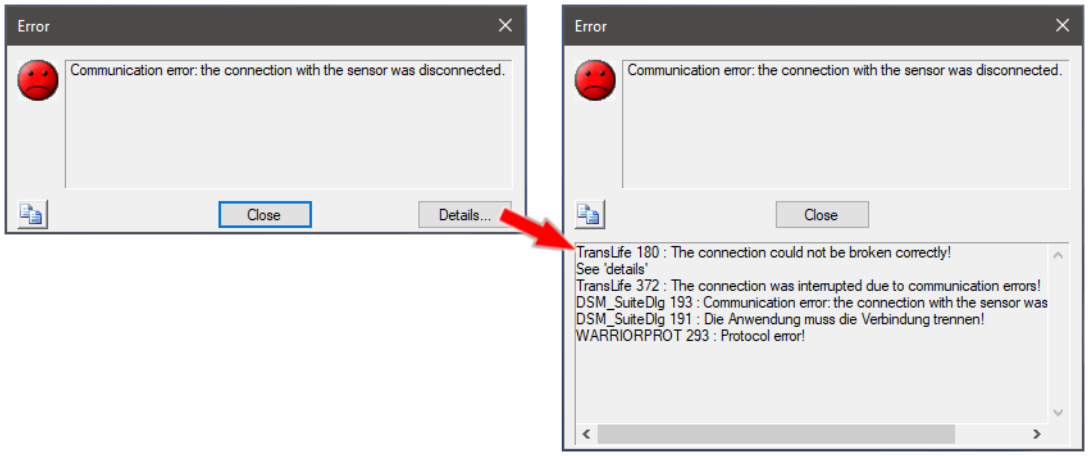
NOTE!

In case of service or maintenance, please have this information ready.

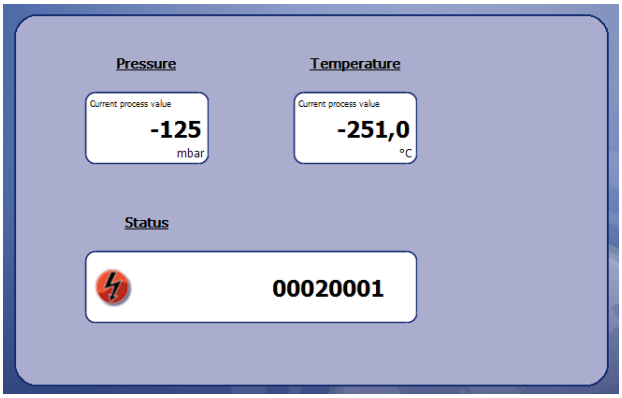
4.11 Error messages



Error cause:	Digital pressure measuring cell is not connected to the computer.
Troubleshooting:	Connect the digital pressure measuring cell with the USB port of your PC/Notebook by using PC-Interface with Converter USB/I²C.
More information:	⇨ chapter 4.3 "Connection to the computer", Page 16



Error cause:	Connection between digital pressure measuring cell to the computer is broken.
Troubleshooting:	Check the correct connection.
More information:	Contact manufacturer.



Error cause:	Sensor error
Troubleshooting:	Contact manufacturer and tell status code

4 PC software

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