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OPERATION MANUAL

Sensor-Profibus-
Modul 9221

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1 General preliminary remarks

1.1 About this manual

This equipment manual contains important information on the operation, installation and configuration of the Sensor Profibus Module type 9221, IP20 and IP65 versions.

1.2 Important note

Note that the Sensor Profibus module type 9221 must be used in accordance with the instructions, technical data and conditions of use listed in this manual. If handled improperly or used incorrectly, one cannot rule out the possibility of faults, incorrect measurements, effects on or from other equipment and installations or potential risks to life and property. Please note the specific requirements that must be observed for applications in a hazardous area (EExi, ...).

1.3 Unpacking

The unit is packaged for protection against shock during shipment. Carefully unpack the unit and verify that all items are present. Inspect the instrument carefully for damage. If you suspect that the unit has been damaged during shipping, notify the delivery company immediately. The packaging should be retained for examination by a representative of the manufacturer and/or the delivery company. The Sensor Profibus Module 9221 must be shipped only in its original packaging or in a container capable of providing an equivalent degree of protection.

1.4 Deliverables

A standard package includes:
>   1 Sensor Profibus Module
>   1 CD-ROM with configuration software
>   1 manual

2 Description of operation

2.1 Equipment function

The Sensor Profibus Module type 9221 is intended for the acquisition and processing of sensor signals and digital status information and for producing digital signals for the fieldbus level (Profibus).

The Sensor Profibus Module is a user-configurable, single-channel module operated via an RS232 interface (configuration only) or RS485 interface (Profibus-DPV1). The universal Sensor Profibus Module is ideally suited to measuring mechanical variables such as force, torque, pressure, acceleration, displacement and angle. Acquisition and processing of strain-gage, potentiometric and reference signals is straightforward.

Signal conditioning parameters such as gain, offset correction etc., which depend on the sensors used, can be set as required by the user in software. No external amplifier needs to be used. A high-performance A/D converter combined with special ratiometric measurement techniques ensure accurate and high-speed processing of the analog sensor signals.

Functions such as arithmetic averaging, input-signal filtering, zero calibration, MIN/MAX memory and thresholds can be used via the Profibus with a speed of up to 12 Mbaud. Two floating, user-configurable inputs are provided for external control (resetting MIN/MAX buffer, tare and limit status).

The module generates its own stable and precise sensor supply voltage. The calibration and configuration data is saved in an EEPROM to prevent loss in the event of power failure.

The digital signal outputs can be used to transmit two alarm signals if the preset measuring-range limits are exceeded.

The instrument also includes d.c. isolation.

Three LEDs on the instrument provide an immediate indication of the operating status such as bus connection, sensor error or module active. All data can be transferred to the higher-level controller (e.g. PLC) via the integral RS485 communications interface (Profibus DPV1). Up to 127 modules can be connected to the Profibus line (32 in the same segment without repeater, 127 addressable). The communications interfaces are also used for application-specific programming and configuration of the Sensor Profibus Modules, carried out centrally from a PC or PLC via the bus (simultaneous configuration is not possible).

The delivered equipment includes suitable configuration software, which can run on standard commercial PCs under Windows 98 / NT / Me / 2000 and XP. The Profibus DPV1 interface can be used for parameterization and backup, and for remote diagnostics and measured-data acquisition via Profibus. The DIN-rail design in the IP20 version allows quick and easy installation in the control cabinet. An IP65 version is available for particularly harsh environments.

2.2   Applications

The Sensor Profibus Module type 9221 has been specifically developed for high-speed control functions and real-time operations, and therefore covers a huge range of applications. The instrument has been designed to integrate the maximum possible range of analog sensor output signals into complex, networked and distributed automation structures.

Thanks to its secure and reliable transmission protocol, its high transmission rate and its simple design, the module is perfectly qualified for use in both industrial automation engineering and test-bench technology. Exploiting the instrument's quick response time, the extra inputs and outputs (provided in addition to those used for external addressing) can be used for zero-point triggering via proximity switch, for instance, or for rapid alerting when a setpoint value is exceeded.

Industry-compatible connection and installation technologies makes it easier for the user to adapt and integrate the unit in existing mechanical and electrical environmental conditions. The outstanding measuring quality combined with a large number of values used for averaging means it is suitable for use in both development and testing.

The Sensor Profibus Module is only suitable for measurement functions in industry and is not intended for use in medical applications or where humans are at risk.

Specific examples of Sensor Profibus Module applications include:

Complex gear and engine test benches
- Weight measurement in high-rack facilities
- Automotive industry
- Manufacture of custom machinery
- Packaging industry
- Manufacturing technology
- Recording of various mechanical and physical variables in test facilities

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3 Technical data

9221 version	IP 20	IP 65
Input signal		
Strain gage	Bridge resistor: 120 Ω - 5 kΩ Connection type:4 or 6 wire Configurable sensitivities, infinite adjustment strain-gage full bridge: < 1 mV/V ... 40 mV/V Excitation: 2.5 V / 5 V / 10 V Supply current: max. 60 mA Input impedance: > approx. 1 GΩ	
Potentiometer	Terminal resistance: 100 Ω ... 100 kΩ Excitation: 2.5 V / 5 V / 10 V Supply current: max. 60 mA	
Voltage	Reference signal: 0 V ... $\pm$ 10 V Input impedance: > approx. 1 GΩ	
General data		
Supply voltage	20...36 VDC /14...26 VAC	
Measuring error	< 0.03 % of input (5 mV input range and above)	
Temperature drift	< 50 ppm/K	
Power consumption	approx. 6 VA	
Cut-off frequency	approx. 2 kHz (-3 dB)	
Internal fuse	integral reversible overcurrent and overvoltage protection, reverse voltage protection	
d.c. isolation from Profibus	500 V	
Ambient temperature	0 ... + 60 °C	
Storage temperature	-30 ... + 85 °C	
Electromagnetic compatibility	complies with EMC Directive 89/336/EEC	
Case		
Material	Extruded aluminum sect.	Die-cast aluminum
Dimensions (WxHxD)	60x105x120 mm	160x120x80 mm
Weight	approx. 1 kg	approx. 1.0 kg
Degree of protection	IP20	IP65
Installation version	Snap-fit mounting on 35 mm rail to DIN EN 50022	Screw fitting
Connection cross-section	max. 1.5 mm^2 (AWG 16)	max. 1.5 mm^2 (AWG 16)
Electrical connections		
Supply voltage	plug-in screw terminals	PG 7 cable gland
Sensor connection	plug-in screw terminals	PG 7 cable gland
Inputs/outputs	plug-in screw terminals	PG 7/PG 9 cable gland
Serial interface	9-pin sub-min D-connector	9-pin sub-min D-connector
Profibus	9-pin sub-min D-connector	5-pin M12 plug/socket
Signal processing		
A/D conversion	16 bit	
Measurement rate	> 1 kHz	
Resolution	8000 ... 50000 digits, depending on meter configuration	

Profibus	
Baud rate	automatic detection 9.6 kBaud ... 12 Mbaud
Number of devices	up to 32 stations without repeater
on bus	up to 127 stations with repeater
Potential	floating potential
Addressing	Hardware or software addressing
Functions	
Configurable via PC	Mean value, filter, tare, Min/Max buffer,
or Profibus	limits, evaluation status, sensor test
Filter settings	
Cut-off frequency	none; 5; 10; 25; 50; 100; 200; 400 Hz
No filter	1 kHz
Analog output	
Function	Process status, configuration mode
Monitor output	approx. + 8 V max.
Digital outputs	
Limits	2 limit outputs
	1 classification output (too high, too low, OK)
Logic	PLC level, open input, p-switching, 24 VDC,
	floating, maximum output load I_{max} = 400 mA
Digital inputs	
Inputs	2 user-configurable inputs, floating
Logic	PLC level, DIN EN 61131-2, p-switching
Electrical testing of the measuring chain	
By shunt calibration	59, 80, 100 kΩ
Status display	
LED green "on"	Bus connection working OK
LED yellow "flashing"	Module active, normal program execution
LED red / "flashing" red	Error / Evaluation result frozen

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4 Operating instructions for the IP20 version

4.1 Installation / Fixing

The Sensor Profibus Module type 9221 has a snap-fit design for mounting on a standard 35 mm DIN (top-hat) rail to DIN EN 50022. The unit is fixed to the DIN rail via a clip on its rear side. First place the clip on the DIN rail from above and then press the module down onto the DIN rail until the lower edge of the clip snaps onto the DIN rail. For optimum measurement quality the DIN rail must be grounded.
To remove the module, once again push down on the module from above while tilting the lower edge of the clip forwards to release the module from the rail. The module must only be installed by a qualified person.

4.2 Degree of protection

The Sensor Profibus Module type 9221 has IP20 degree of protection. This means that the module is not protected against water ingress, but is protected against ingress of solid particles of diameter $\geq$ 12.5 mm.

4.3 Ambient temperature

The permitted ambient temperature range for the Sensor Profibus Module type 9221 during operation is 0 °C to +60 °C. The unit can be stored at temperatures between -30 °C and +85 °C.

4.4 Front panel / terminal assignments

The following diagram shows the front and rear view of the Sensor Profibus Module with connectors, indicators and configuration and fixing elements. The terminal assignments for the Sensor Profibus Module are given in subsection 6.4.

Front view

Input / Output →

Supply voltage →

Sensor connection →

← Configuration interface (RS232)

← Status LEDs

← Profibus port (RS485)

Rear view

Address setting →

Fixing clip for DIN-rail mounting →
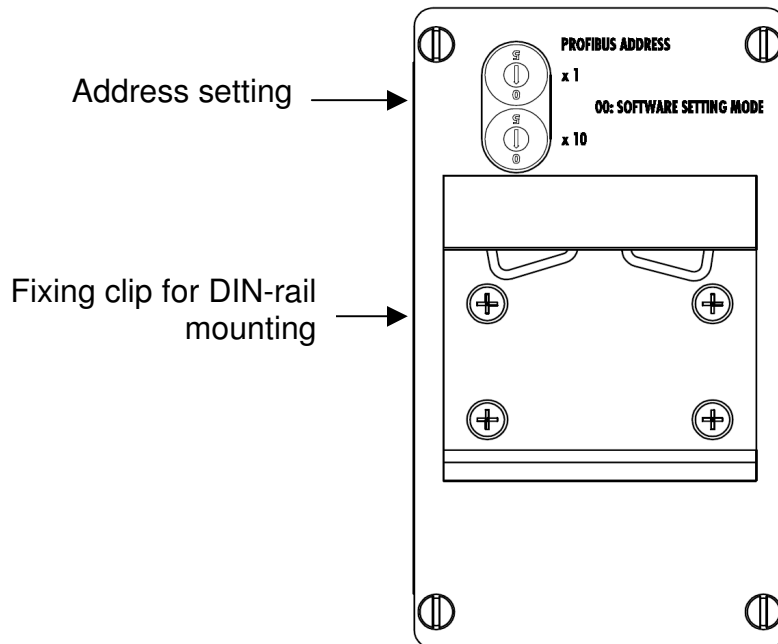
Terminal assignments
Wires are connected via screw terminals on the module. All terminal blocks have a plug-in design, so they can be removed from the module for convenient cable connection. No more than two wires should be connected to one terminal. Ferrules are recommended for connecting stranded wires.
Shielded cables must be used for the voltage-supply lines and signal conductors to avoid interference on sensor signals or in the module.

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5 Operating instructions for the IP65 version

5.1 Installation / Fixing

The Sensor Profibus Module type 9221 has four mounting holes for fixing the module in place. The module must only be installed by a qualified person.

5.2 Degree of protection

The Sensor Profibus Module type 9221 has IP65 degree of protection. The module is therefore protected against ingress of dust and water jets.

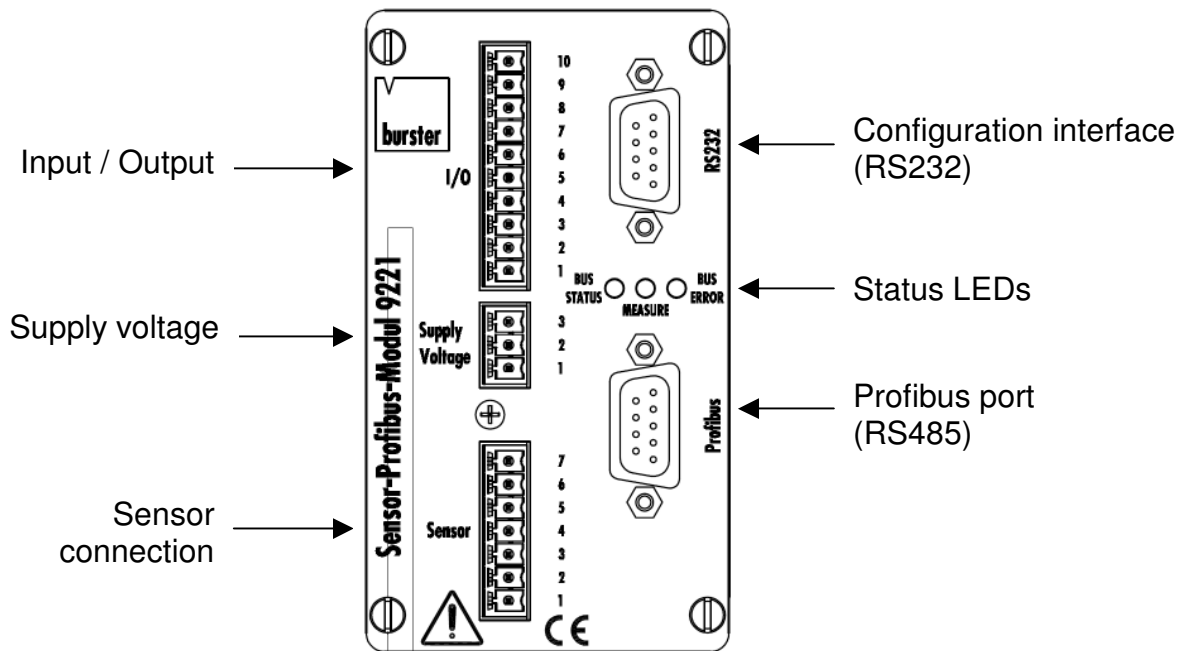## 5.3 Ambient temperature

The permitted ambient temperature range for the Sensor Profibus Module type 9221 during operation is 0 ℃ to +60 ℃. The unit can be stored at temperatures between -30 ℃ and +85 ℃.

5.4 Front panel / terminal assignments

Front panel
The following diagram shows the plan view of the Sensor Profibus Module with connectors, indicators and configuration and fixing elements.

Plan view

Status LEDs

Sensor-Profibus-Modul   9221-IP65

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BUS ERROR — red
MEASURE — yellow
BUS STATUS — green

⚠

CE

Supply Voltage   Sensor   I/O Input   I/O Output   Profibus

Plan view

Mounting holes

Configuration interface (RS232)

Address setting

Profibus terminating resistance

Supply voltage

Sensor connectio

Input   Output   Profibus port (RS485) – B-coded

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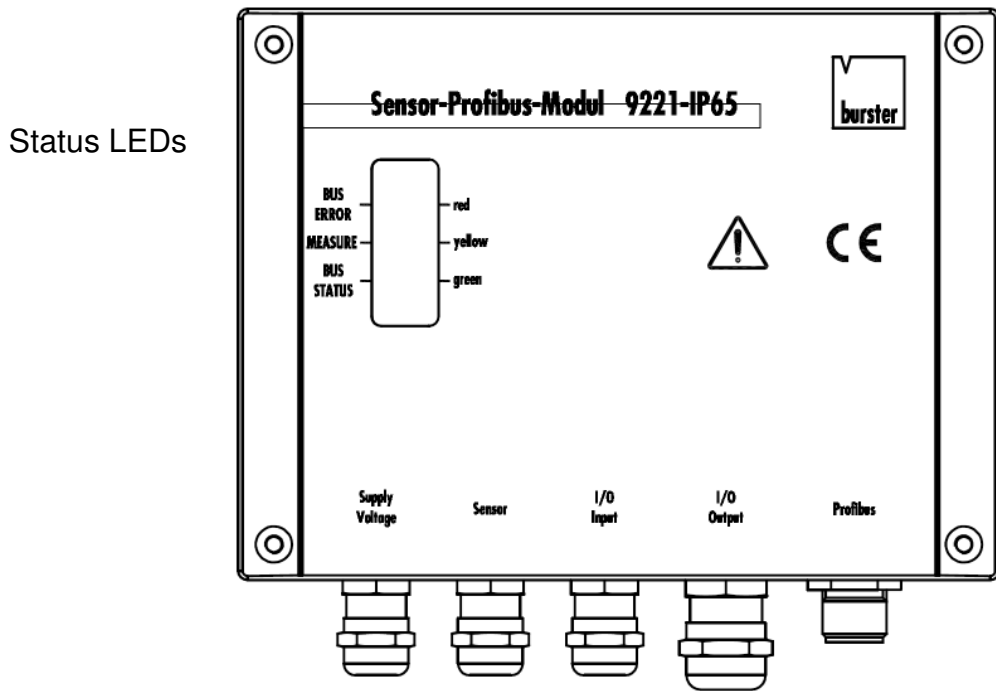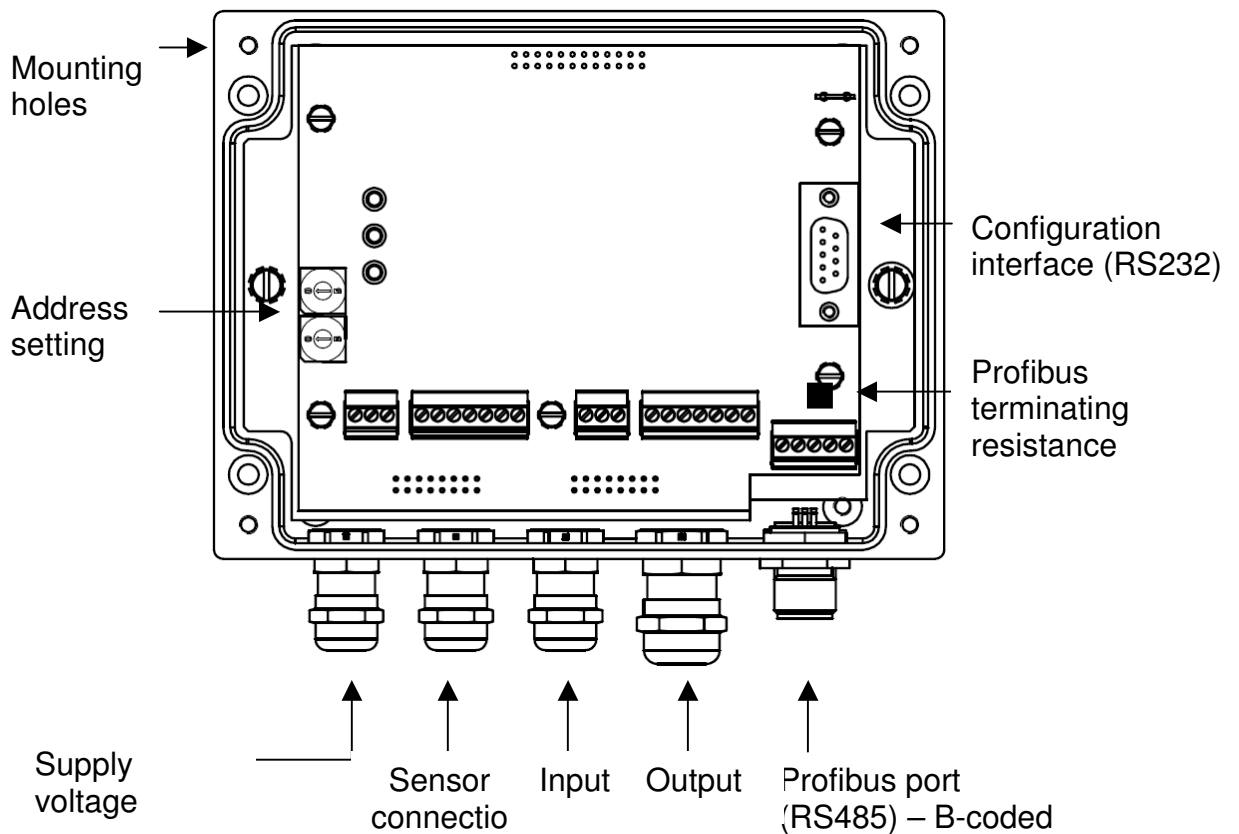
Terminal assignments
Cables are connected via PG cable glands and screw terminals on the module.
All terminal blocks have a plug-in design, so they can be removed from the
module for convenient cable connection.

No more than 2 wires should be connected to one terminal. Ferrules are
recommended for connecting stranded wires.

Shielded cables must be used for the voltage-supply lines and signal conductors
to avoid interference on sensor signals or in the module.

1: +5V
2: A
5: Shield
4: B
3: GND

1 (4): 24 V - PLC supply
2 (5): PLC - Output 1

3: PLC ground
2: PLC - Input 2
1: PLC - Input 1
7. Shield

4: Signal input -
3: Signal input +
2: Sensor +
1: Excitation +
3: Ground 24 V
2: Protective ground
1: 24 V

7 (10): Monitor output ground
6 (9): Monitor output 8V

3 (6): PLC – Output 2
4 (7): PLC – Output 3

5: Sensor -
6: Excitation, ground -

5 (8): Protective ground

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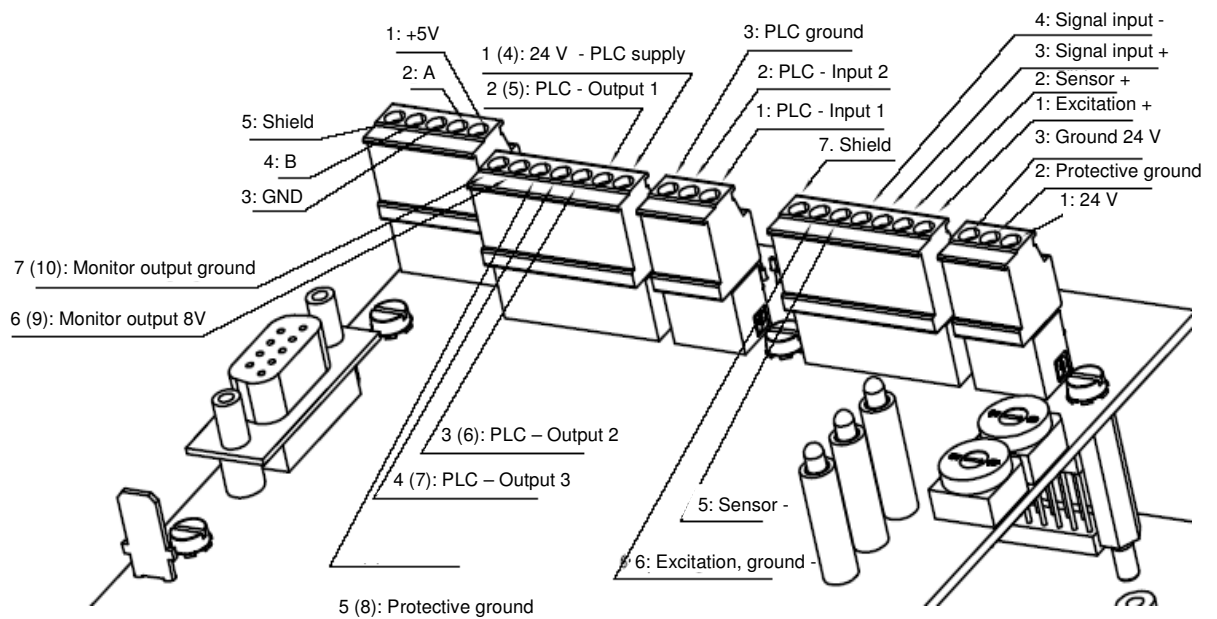
6 Configuring for use and testing

6.1 Block diagram and internal signal processing
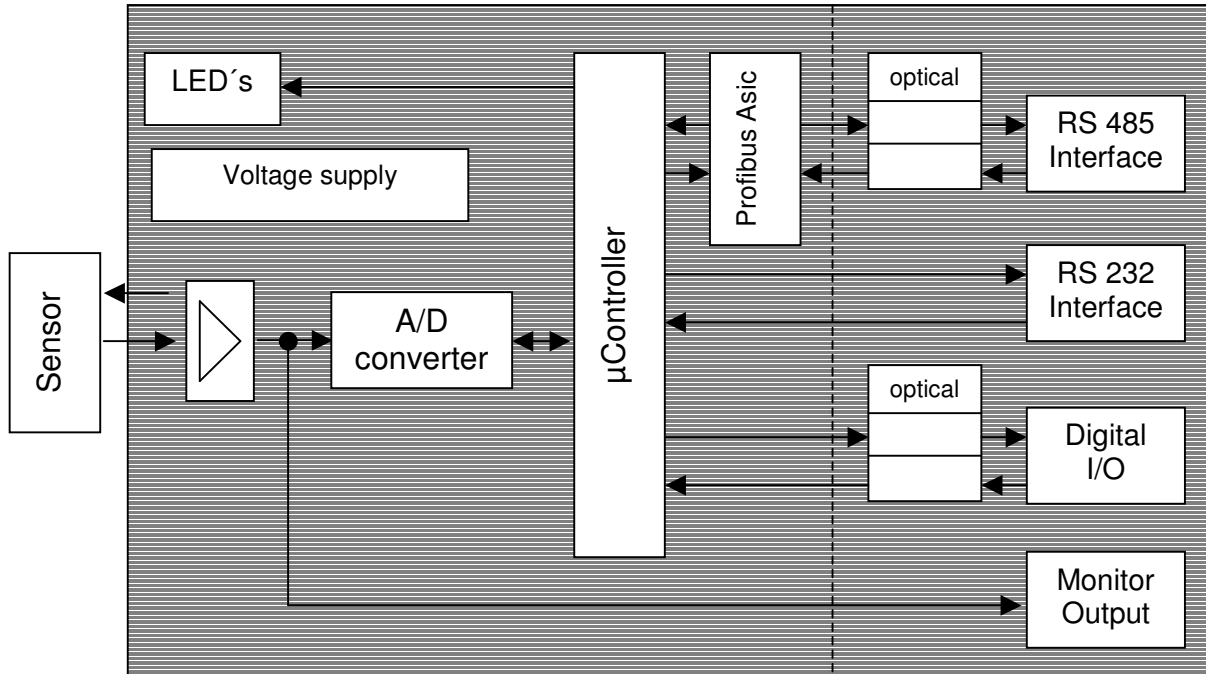
The A/D converter amplifies and converts the signals according to the design and type of the connected sensor. The A/D converter digitizes all incoming signals with a resolution of 16 bits. The analog multiplexer and A/D converter are controlled by the microprocessor. The A/D converter contains an amplifier with various amplifier stages. The gain and the corresponding accuracy and resolution of the measured value depends on the measuring range selected. In addition, there is an option for arithmetic averaging of the measurement signal by the processor.

This can be preset by the user by configuring the Sensor Module accordingly. The processor then linearizes, scales and stores the signal in programmable units ready for bus transmission. In addition, the processor monitors the measured value with respect to user-selectable limits. The configuration settings, linearization and scaling data etc. required by the microprocessor are saved in an EEPROM to prevent loss in the event of power failure.

6.2 Unpacking the unit

Inspect the instrument for damage. If you suspect that the unit has been damaged during shipping, notify the delivery company within 72 hours. The packaging should be retained for examination by a representative of the manufacturer and/or the delivery company.
The Sensor Profibus Module 9221 should be shipped only in its original packaging or in packaging capable of providing an equivalent degree of protection.

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6.3 Before switching on

Before applying the supply voltage to the sensor module, make a final check that the unit is installed correctly and set to the correct voltage. It is essential to check that the unit has been grounded in accordance with regulations and that the supply voltage for all the Sensor modules does not exceed the specified + 36 VDC.

6.4 Terminal assignments

Terminal block 1	Function	Meaning
1	Input	PLC level 1
2	Input	PLC level 2
3	Input	PLC ground
4	Input	24 V – PLC supply
5	Output	PLC level A1 >
6	Output	PLC level A2 <
7	Output	PLC level A3 =
8	Output	Protective ground
9	Output	Monitor output ± 8 VDC
10	Output	Monitor ground
Terminal block 2		
1	Input	+ / ~ supply voltage
2	Input	Protective ground
3	Input	+ / ~ supply voltage / ground
Terminal block 3		
1	Sensor	+ strain-gage excitation / + potentiometer excitation
2	Sensor	+ strain-gage sensor lead
3	Sensor	+ strain-gage signal input / + potentiometer signal input
4	Sensor	- strain-gage signal input
5	Sensor	- strain-gage sensor lead
6	Sensor	- strain-gage excitation / - potentiometer excitation
7	Sensor	Sensor shield

6.5 Supply voltage

The Sensor Profibus Module can be supplied with 20 - 36 VDC (d.c. supply) or with 14 - 26VAC (a.c. supply). The instrument has its own internal protection to safeguard the supply input against overvoltage, overcurrent and polarity reversal.

To avoid unnecessary noise on the supply-voltage line for the modules, a separate voltage supply is recommended for sensors with high current consumption.

The maximum power consumption of the Sensor Profibus Module is 6 VA. The supply voltage must be protected by a fuse (max. 1 A, slow-blowing).

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6.6 Grounding and surge protection

The case of the Sensor Profibus Module must be connected to ground.
The grounding cable can be connected to pin 2 of the supply voltage screw-terminal, or directly via the DIN rail on the rear of the case.

Suitable protective devices must be provided against lightning damage (surge voltages).

6.7 After switching on

After switching on the supply voltage, the LEDs on the front of the Sensor Profibus Module indicate the current operating status of the instrument. The subsection LED – Instrument LED display explains the meaning of the LEDs.

6.8 Configuring addresses and calibration

6.8.1 Address configuration

The address must be specified before a controller or a computer can exchange data with a Sensor Profibus Module via a bus. The following point must be observed when assigning addresses:

- An address must not occur more than once in the bus system.

An address can be assigned via the PC configuration software, Profibus or hardware (rotary switch).

Hardware addressing

Addresses from 01 to 99 can be assigned to the stations on the bus. The address 00 cannot be assigned in hardware to the Sensor Profibus Module. For a module to be addressed via PC software or the Profibus, its hardware-set address must be 00.

Software addressing

Addresses from 00 to 99 can be assigned to the stations.

Note

The hardware-set address can be overwritten by a software address. The hardware-set address is valid again after restarting the device.

6.8.2   Calibration using PC software 9221-P001

The PC configuration program "9221-P001" and a notebook PC can be used for convenient configuration of the instrument via the RS232 socket. The configuration program is held on the CD-ROM supplied with the instrument.
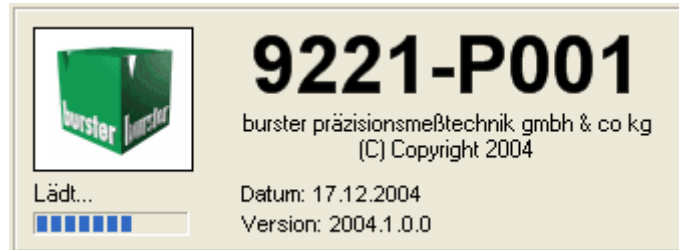
You can use this software to:

- Create instrument configurations offline and online
- Create and reload backups of instrument configurations
- Print instrument configurations
- Perform teach-ins of sensor signals
- Perform graphical test measurements including data storage in Excel files

The configuration software can run on the following operating systems:

- Windows 98/98SE
- Windows ME
- Windows NT 4.0 SP6a
- Windows 2000
- Windows XP

The technical requirements can be found in the file "Readme.txt".

6.9   Calibration and setup

The Sensor Profibus Module can be calibrated using a variety of methods. The instrument settings should be checked after calibration.

- ➢   Calibration using a physical variable
- ➢   Calibration by entering data from the sensor test certificate
- ➢   Calibration using a precision voltage source
- ➢   Calibration using a shunt resistance

6.9.1 Measurements using a strain gage

6.9.1.1 Connection

Strain-gage connection

+ Excitation (1)
+ Sensor line (2)

+ Signal (3)
- Signal (4)

- Sensor line (5)
- Excitation (6)

Shield (7)
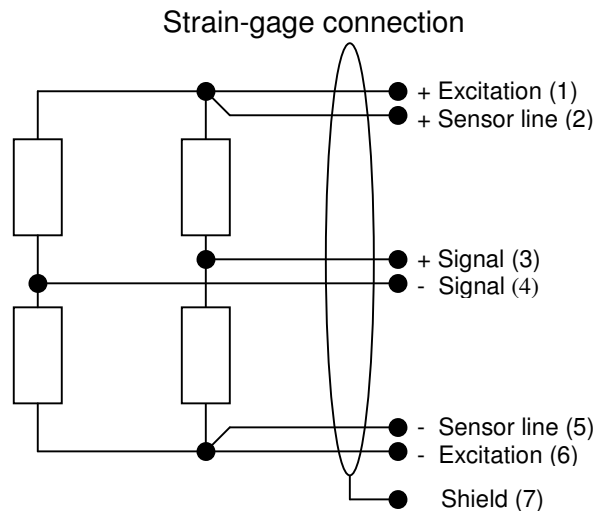
Note:

A measuring chain contains a number of components, each contributing to the overall measurement accuracy of the test setup. One can avoid these accuracy problems by using the standard solution of the 6-wire circuit, or by calibrating as a unit the 4-wire circuit as complete measuring chain.

4-wire connection

In most applications, however, the 4-wire connection is quite adequate. In this case, the sensor lines (Pin 2 and Pin 5) are not connected.

6-wire connection

This connection should be used to achieve the best possible measurement accuracy with strain gages, because the complex effect of resistances, such as the internal excitation lines and connecting elements in the Sensor Profibus Module, do not affect the behavior of the measuring chain. In this arrangement, the measuring lead contains additional "sensor lines" that detect the excitation voltage at the sensor input and feed this information back to the instrument.

6.9.1.2   Sensor excitation, input range and input reference

Sensor excitation voltage

The sensor excitation voltage must be set here, which you can find from the test and calibration certificate for the sensor.

Prüf- und Kalibrierprotokoll
Test- and Calibration Certificate

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ISO 9001

Präzisions-Miniatur-Kraftsensor
Precision Miniature Load Cell

Typ / *Type*		: 8431-100
Serien-Nr. / *Serial no.*		: 986242

Qualitätsprüfungen / *Quality Inspections*

Nennkraft / *Nominal Force*	F_{nom}	: 100 N
Referenzspeisespannung / *Reference Excitation*	U_{Ref}	: 10 V_{DC}
Kennwert / *Sensitivity*	C	: 2,1613 mV/V
Ausgangssignal beim Messbereichsendwert (bei tariertem Nullpunkt). *Output Signal at max. of measuring range (with balanced Zero Output).*		
Kalibriersprung / *Shunt Cal Factor*	C_{Shunt}	: 1,4910 mV/V

Input range

The input range is calculated and selected as follows:
Example calculation for a load cell, type 8431-100:

Input measurement range = Sensor excitation voltage x Sensitivity in ref. test

$$10 \text{ V} \quad \times 2.1613 \text{ mV/V} = \underline{21.613 \text{ mV}}$$

The next higher value must be selected: in this case → **25 mV** ⑦
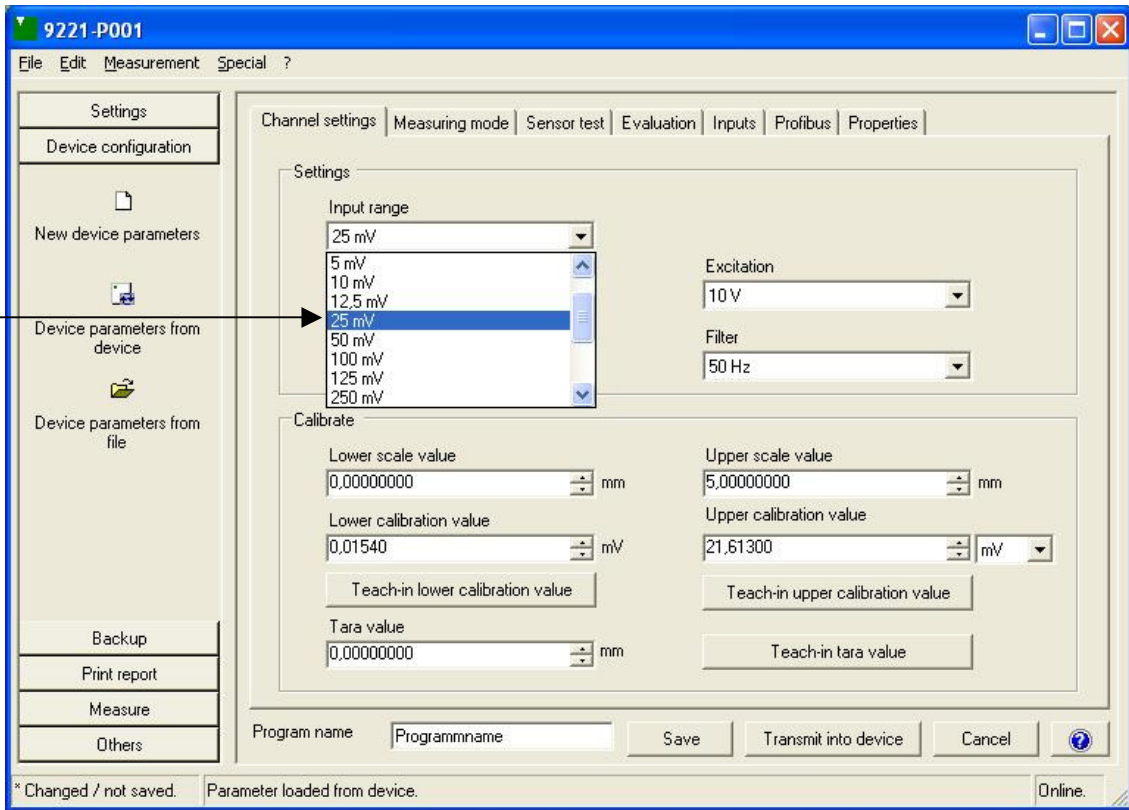
Input reference

"No ground reference" is selected as the measurement signal input reference for measurement using strain gage sensors with Wheatstone Bridge circuit. ⑥

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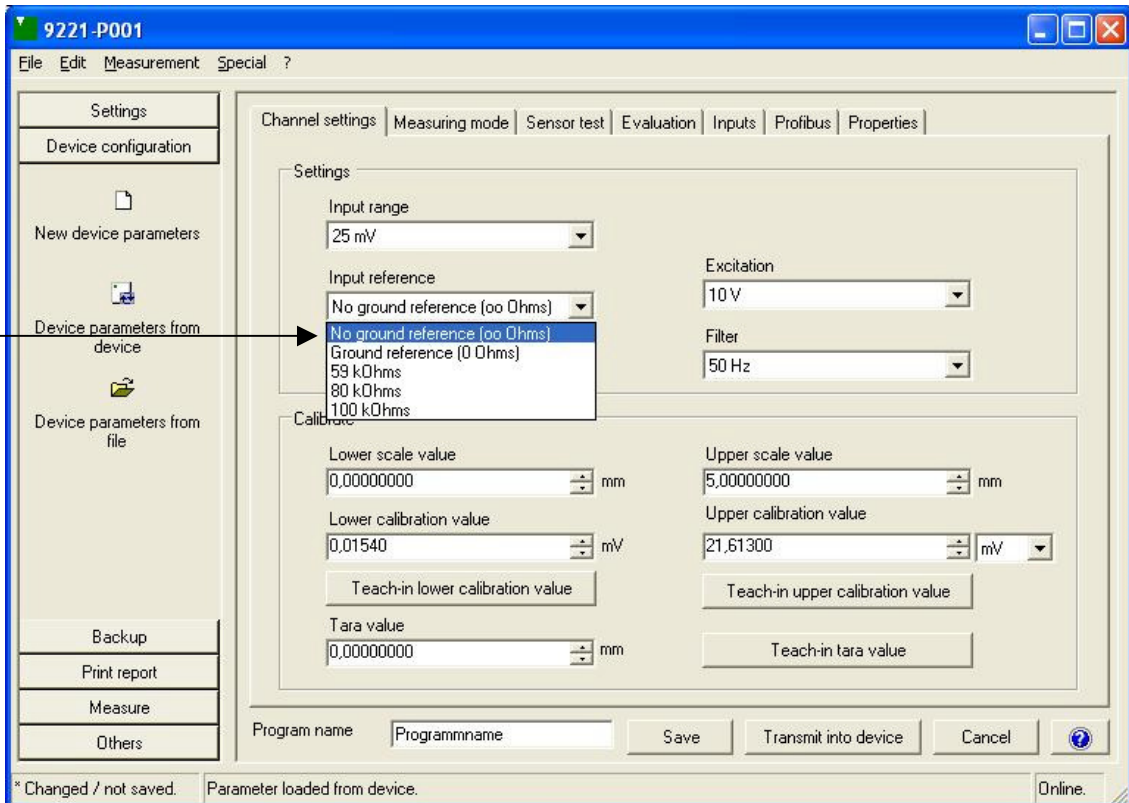
6.9.1.3   Calibration of strain gage sensors

Calibration is necessary in order to specify the relationship between the electrical signals measured by the connected sensors and the measured values to be displayed. A two-point calibration procedure is used here. Normally the sensors have a test and calibration certificate containing details of the electrical signals. The typical certificate might look like the example shown below, where the most important values are labeled.

6.9.1.3.1 Calibration using a physical variable by the teach-in method

This method involves a two-stage online teach-in of sensor data to the Sensor Profibus Module, where two teach-in states are applied sequentially. The first state is the lower scale value, and the second state is the upper scale value.

Example: Remove any load from the load cell and calibrate the zero point F = 0 N. Now press the "Teach-in lower calibration value" button (see Ⓐ). Now apply a known reference weight to the load cell e.g. F = 100 N and set the upper scale value. Now press the "Teach-in upper calibration value" button (see Ⓑ).
This calibration data must now be transferred to the instrument; if required it can also be saved under a user-definable program name.

Force
F [N]

100

0

Teach-IN value 1   Teach-IN value 2

idealized sensor
calibration line

Value in [mV]
measured by
instrument

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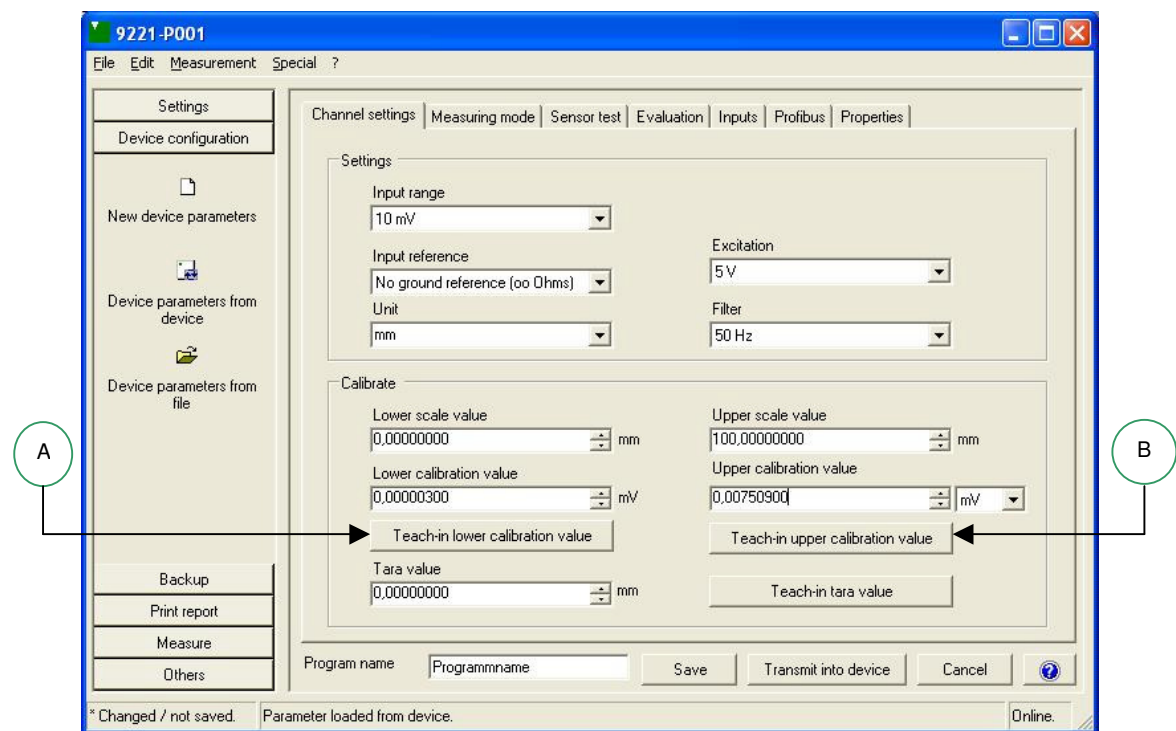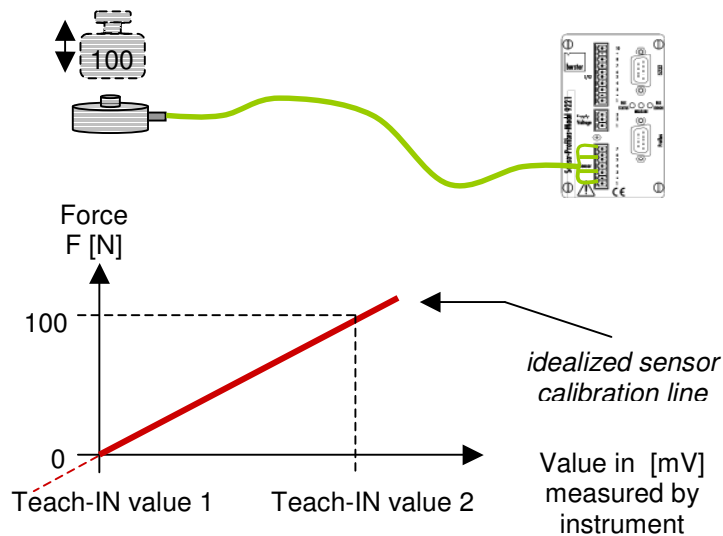
6.9.1.3.2 Calibration using the sensor test and calibration certificate

This method involves using the test and calibration certificate to enter the sensor data directly in the Sensor Profibus Module. All necessary calibration data can be found from the certificate.

About the values:

① ... ③   These values are adopted directly from the test and calibration certificate.

④   This value must be calculated as follows:

Known: Sensitivity in reference direction   = 1.0538 mV/V

Reference excitation voltage   = 5 V

Required: Output signal at 100% load = upper calibration value

Sensitivity in reference direction x reference excitation = upper calibration value
in this case: 1.0538 mV/V x 5 V = **5.269** mV
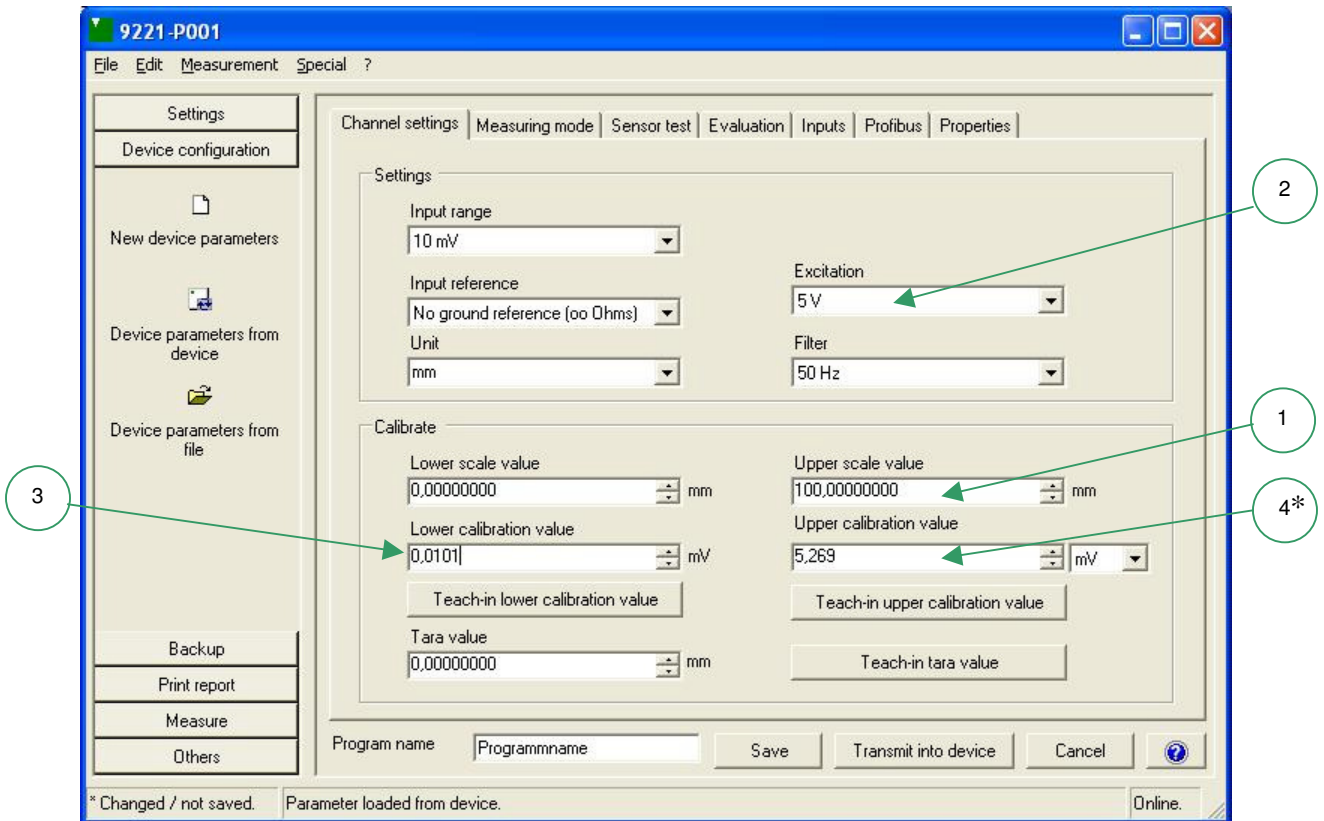
Note:

Please note that when using this type of calibration for strain gage full-bridge sensors and potentiometric sensors, the measurement result also depends on the excitation voltage.

Thus if you wish to verify that the instrument is working properly with sensors that produce a voltage signal, you must measure the sensor excitation voltage using a precision digital voltmeter and then use it to calculate the calibration voltage, or else you should select the "DC-R" setting under "Measuring mode" in order for the excitation correction factors to be included automatically. This measurement method is recommended.
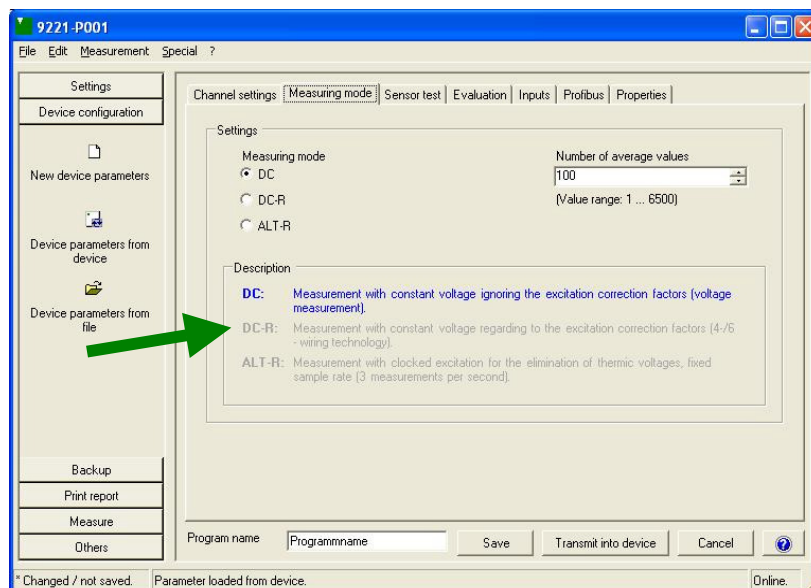
6.9.1.3.3 Calibration using a precision voltage source

This method can be used for all voltage-generating sensors e.g. for strain gages and potentiometric, transmitter and reference-signal sensors. The sensor is simulated by a precision voltage source.

Präf- und Kalibrierprotokoll
Test- and calibration certificate

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ISO 9001

Kraft- Aufnehmer Typ	: 8416- _5100_
load cell type	
Serien Nr.	: _268 965_
serial no	
Nennkraft / Meßfehler	: _100_ N ≤ ± 0,7 %
nominal force / measuring error	
Referenzspeisespannung	: _5_ V_{DC} ± 0,05 %
reference excitation	
Nullsignal ohne Einbauteile	: _0,0101_ mV/V
zero signal without assembly parts	
Kennwert in Vorzugsmeßrichtung	: _1,0538_ mV/V
rated output in preferential measuring direction	
Kalibriersprung *	: _0,8955_ mV/V
calibration step	

1
2
3
4*

By TEACH-IN procedure

+ Signal   - Signal

Precision voltage source
z.B. Typ 4422

The calibration process is identical to that described in "6.9.1.3.1. Calibration using a physical variable by the teach-in method", except that in this case, the "Lower calibration value" ③ and the "Upper calibration value" ④* are simulated by the precision voltage source.

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6.9.1.3.4 Calibration using a shunt resistance

Note:

Shunt calibration is the least accurate technique of the four calibration methods offered. Only select this option if there are no other means available. This method can be used quite satisfactorily, however, for occasional electrical checks of the measuring chain.

Calibration

In this method, a shunt resistance, which can be selected from a menu, is connected across a bridge resistor of the strain gage full-bridge to deliberately unbalance the bridge (calibration offset). Find the value of this shunt resistance and the associated calibration offset from the sensor test certificate and select the value under the menu option "Channel settings" → Input reference" (see ⑥).

The required shunt resistance is listed under Channel settings.
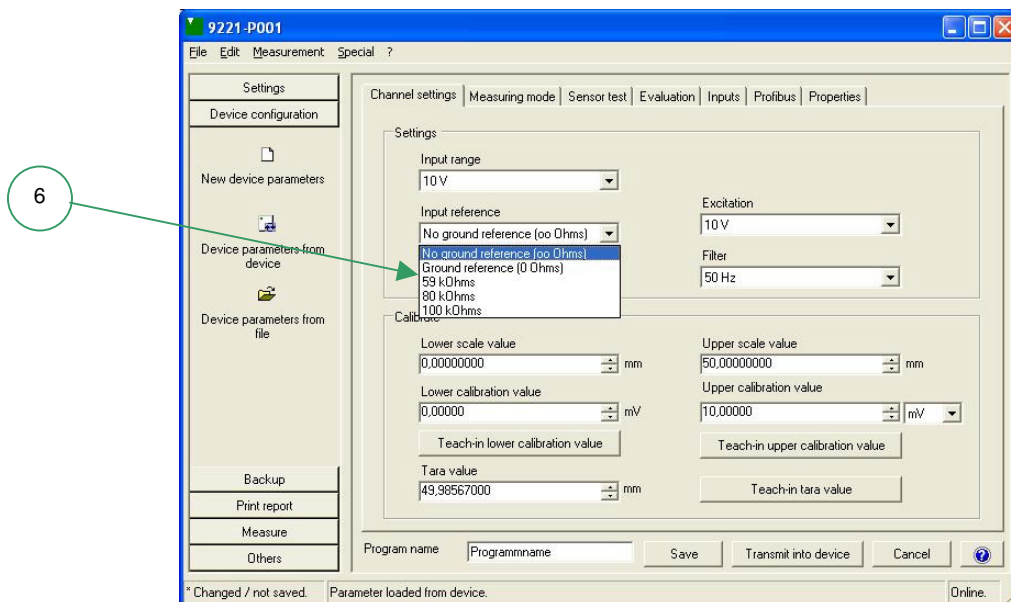
Enter the "Lower scale value" of the sensor measurement range. Usually this will be the zero point of the sensor (e.g. 0.0000). This value is assigned to the "Lower calibration value". This information can be obtained by teach-in or entered directly from the test certificate ③ .

Enter the "Upper scale value" of the sensor measurement range.

Example calculation
Known: Calibration offset   = 0.8955 mV/V
              Calibration resistance = 100 kΩ

$$\text{Upper scale value} = \frac{\text{Upper range value} \; \times \; \text{Calibration offset} \;\;⑥\;\;⑤}{\text{Sensitivity}}$$

$$\text{Upper scale value} = \frac{100 \text{ N} \; \times \; 0.8955 \text{ mV / V}}{1.0538 \text{ mV/V}} = 84.978174 \text{ N}$$

The "Upper scale value" is assigned to the "Upper calibration value" (calibration offset in this case). This calibration data must now be transferred to the instrument; if required it can also be saved.

6.9.2 Measurements using a potentiometer

Calibration is necessary in order to specify the relationship between the electrical signals measured by the connected sensors and the measured values to be displayed. A two-point calibration procedure is used here. Normally the sensors have a test and calibration certificate containing details of the electrical signals. The typical certificate might look like the example shown below, where the most important values are labeled.

Prüf- und Kalibrierprotokoll
Test- and Calibration Certificate

ISO 9001

Potentiometrischer Wegtaster
Potentiometric displacement sensor

Typ / Type : **8712-100**
Serien-Nr. / Serial no. : **8705121581**

Messweg (Elektrischer Nutzweg)	/ Range (useful electrical stroke)	E.N.W.	: **100 mm** + 1 / - 0 mm
Theoretischer elektrischer Weg	/ Theoretical electrical stroke	T.E.W.	: **E.N.W + 1 mm ± 1 mm**
Mechanischer Weg	/ Mechanical stroke	M.W.	: **E.N.W + 5 mm**
Maximal zulässige Speisespannung	/ Maximum applicable voltage	U_{max}	: **≤ 50 V_{DC}**
Anschlusswiderstand	/ Connecting resistance	$R_{E.N.W.}$	: **5 kΩ ± 20 %**
Empfohlener Strom im Schleiferkreis	/ Recommended cursor current	I_c	: **< 0,1 µA**
Fehlergrenze (Linearitätsabweichung)	/ Error limit (Independent linearity)	f_{lin}	: **± 0,1 % v.E. / FS** (innerhalb E.N.W / within E.N.W.)
Isolationswiderstand	/ Electrical isolaton	R_{iso}	: **> 100 MΩ**
Arbeitstemperaturbereich	/ Operating Temperature range	t_A	: **-30 ... 100 °C**
Temperaturkoeffizient	/ Temperature Coefficient	TK	: **< 1,5 ppm/K**
Verstellgeschwindigkeit	/ Displacement speed		: **≤ 10 m/s**
Schutzart (nach)	/ Grade of Protection (according to)		: **IP40** (DIN VDE 0470 / EN 60 529 / IEC 529)
Validiert nach Prüfanweisung	/ Validated according to Inspection Instruction		: **417**

Die Rückführbarkeit der verwendeten Sekundärnormale auf nationale bzw. internationale Normale, entsprechend der Normenreihe DIN EN ISO 9000 ff, ist über Kalibrier- oder Eichscheine gewährleistet. Die verwendeten Normale sind auf Kalibrierlaboratorien rückführbar, die nach ISO/IEC 17025 akkreditiert sind.
The traceability of the used secondary standards to the national respectively international standards, according to DIN EN ISO 9000 ff, is guaranteed by Calibration certificate. The used standards are traceable to calibration laboratories, which are accredited to ISO/IEC 17025.

Das Produkt erfüllt die im Datenblatt angegebenen Spezifikationen.
The device performs the specifications mentioned in the data sheet.

Nach der vorliegenden Erfahrung ist es empfehlenswert, das Produkt im Abstand von etwa 24 Monaten neu zu kalibrieren. / *According to our experience it is recommended to recalibrate this product in intervals of 24 months.*

Anschlussbelegung: Steckertyp / *Connector model*

		9991
Signal	/ *Signal*	
+ Speisung	/ *Excitation*	3
- Speisung /Signal	/ *Excitation*	1
+ Ausgangssignal	/ *Output*	2

Raumtemperatur / *Ambient temperatur* : 23 °C ± 3 K   Rel. Feuchte / *Relative humidity* : 50 % ± 20 %

Datum / *Date* :

Protokoll erstellt durch / *Certificate written by* :

6.9.2.1 Connection

The connector-pin numbering for the potentiometric position sensor is given in the test and calibration certificate.

Drawing showing physical arrangement
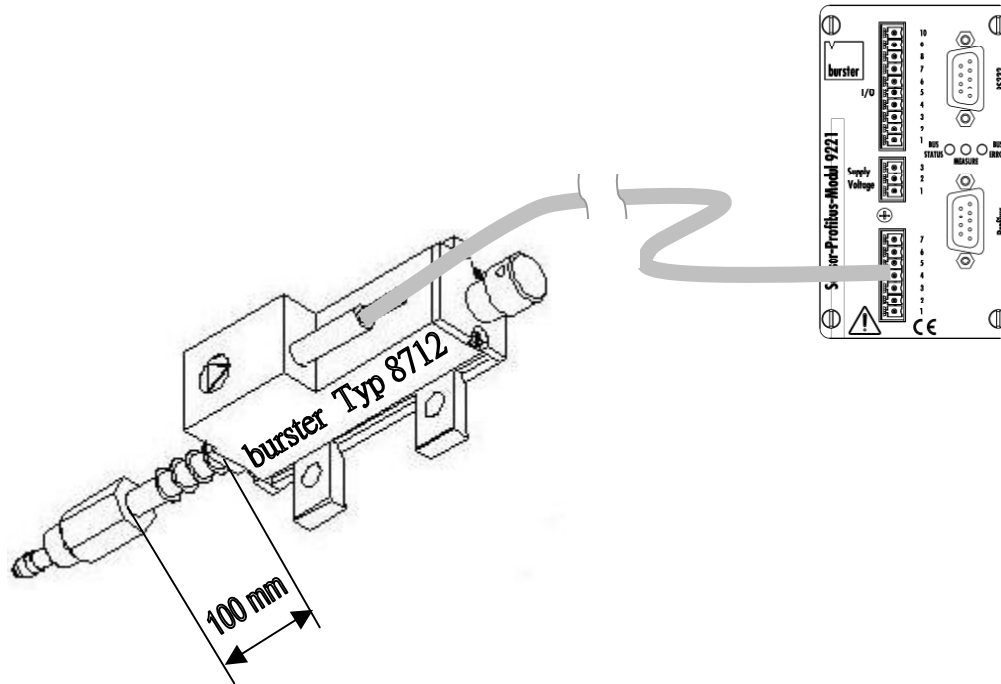
Circuit diagram
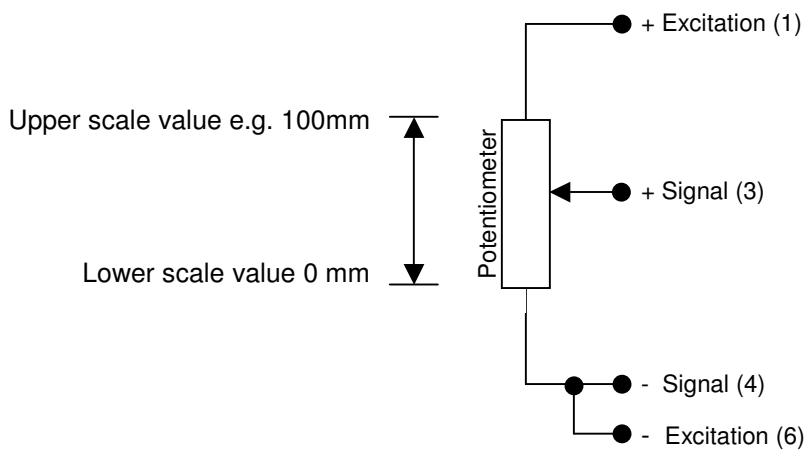
6.9.2.2   Sensor excitation, input range and input reference

Sensor excitation voltage

The maximum admissible sensor excitation voltage for the position sensor is given in the test and calibration certificate. A low excitation voltage, typically 2.5, 5 or 10 volts, is recommended to avoid high lead resistances.

Input range

The maximum measurement signal output from potentiometers to the Sensor Profibus Module is always the supply voltage. So for the input range select the same value as set for "Excitation".

Input reference

Select "Ground reference" as the measurement signal input reference for potentiometric measurements. ⑥

Date: 27.01.06
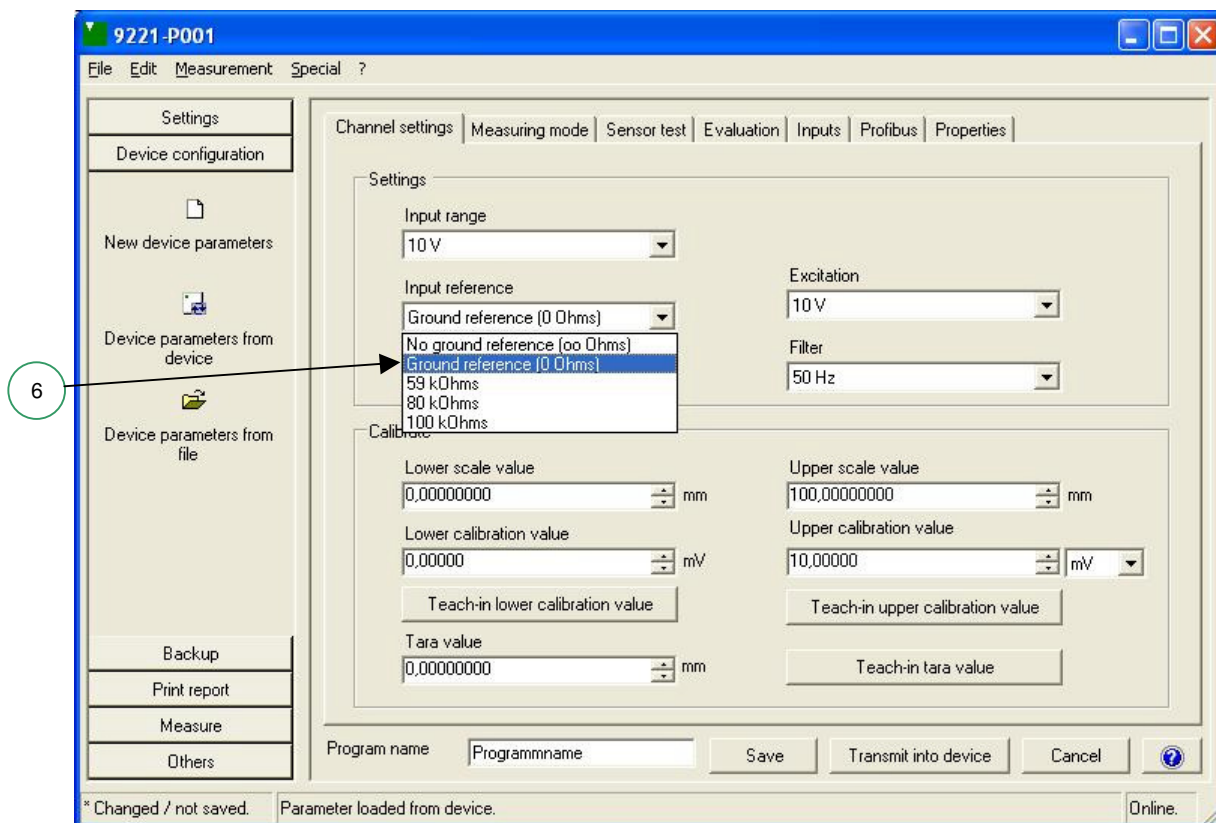
6.9.2.3   Calibration of a potentiometer by the teach-in method

This method involves a two-stage online teach-in of sensor data to the Sensor Profibus Module, where two teach-in states are applied sequentially.
The first state is the lower scale value, and the second state is the upper scale value.

Note: Potentiometric position sensors usually have electrical dead regions at the beginning and end of travel, where the measurement signal does not change despite movement of the sliding shaft.
The monitor output from the Sensor Profibus Module can be used for identifying these dead regions.

The following calibration setup can be used:
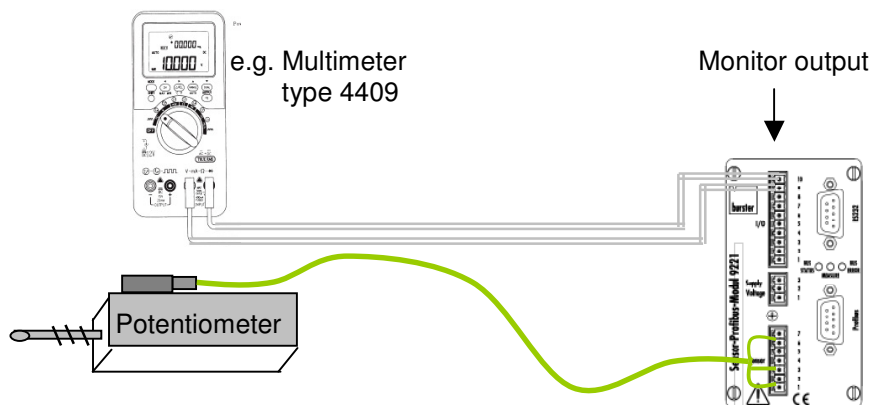
You can use a multimeter (e.g. type 4409) to measure the output voltage at the monitor output. During calibration you should check the voltage change at the lower and upper ends of the measurement range as the sliding shaft is moved. The voltage should be approximately 0 V at the lower range value and approximately 8 V at the upper range value.

Date: 27.01.06

Example calibration:

Displacement measurement using potentiometric position sensor type 8712-100. Adjust the position sensor to give the zero setting 0.00 mm. Now press button (A) "Teach-in lower calibration value". Now move the sliding shaft using a calibrated gage block e.g. S = 100 mm and set the upper scale value. Now press button (B) "Teach-in upper calibration value".
This calibration data must now be transferred to the instrument; if required it can also be saved under a user-definable program name.

Date: 27.01.06
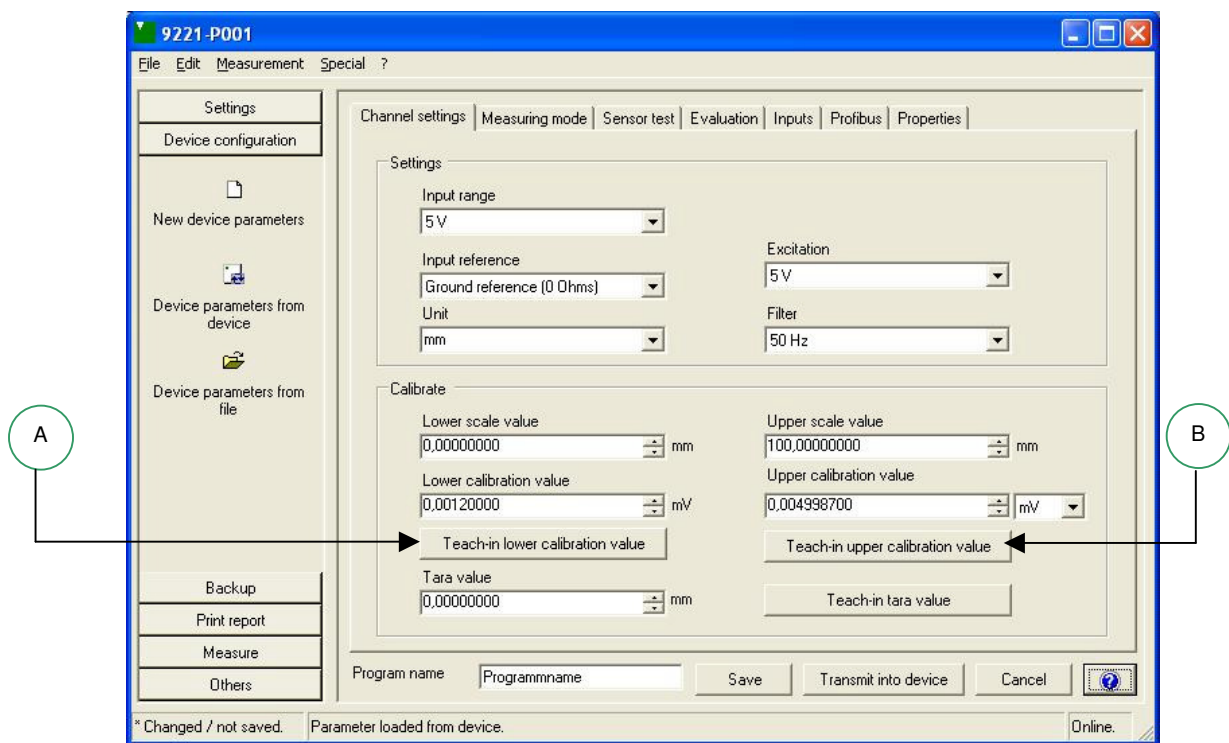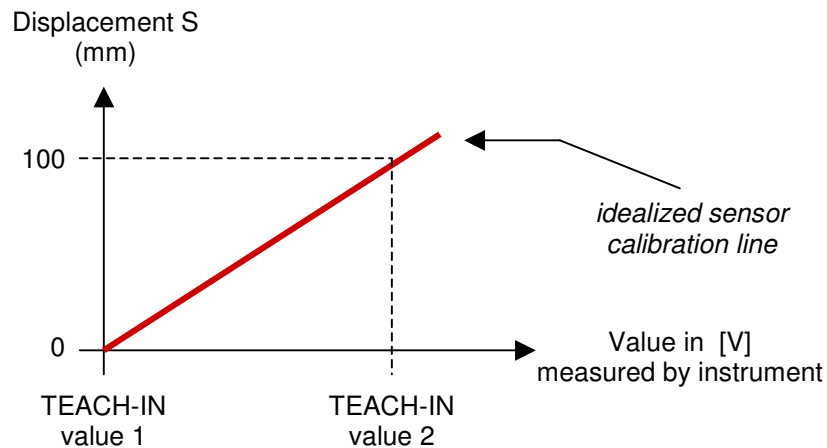
6.9.3 Measurements using a reference signal / transmitter

Calibration is necessary in order to specify the relationship between the electrical signals measured by the connected sensors and the measured values to be displayed. A two-point calibration procedure is used here. Normally the sensors have a test and calibration certificate containing details of the electrical signals. The typical certificate might look like the example shown below, where the most important values are labeled.

Prüf- und Kalibrierprotokoll
Test- and Calibration Certificate

burster

zertifiziert nach
ISO 9001

DC/DC - Wegsensor

DC/DC displacement sensor

Typ / *Type*	: **8740-5001**
Serien-Nr. / *Serial no.*	: **24022374**

Messbereich / *Range*		: **1 mm**
Speisespannung / *Excitation Voltage*	U_{Ref}	: **9 ... 28 V**$_{DC}$
Ausgangsspannung bei Nennmessweg / *Output Voltage* at *measuring range*		: **0 ... 5 V**$_{DC}$
Linearität (LINEARE REGRESSION) / *Linearity (best fit straight line)*		: **< 0,25 % v.E. / FS**

max. Abweichung von der besten Geraden in Prozent des Messbereiches
(DIN 32876 T1 und VDI/VDE/DGQ 2618 Blatt 26)
Linearity is defined as max. deviation from ideal straight line as % of FS

6.9.3.1 Connection

The connector-pin numbering for the potentiometric position sensor is given in the test and calibration certificate.

Drawing showing physical arrangement
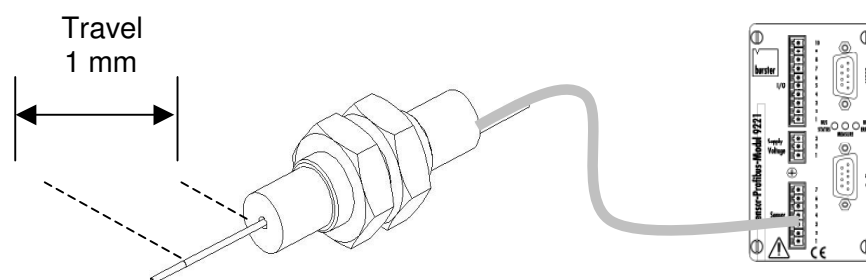
Circuit diagram
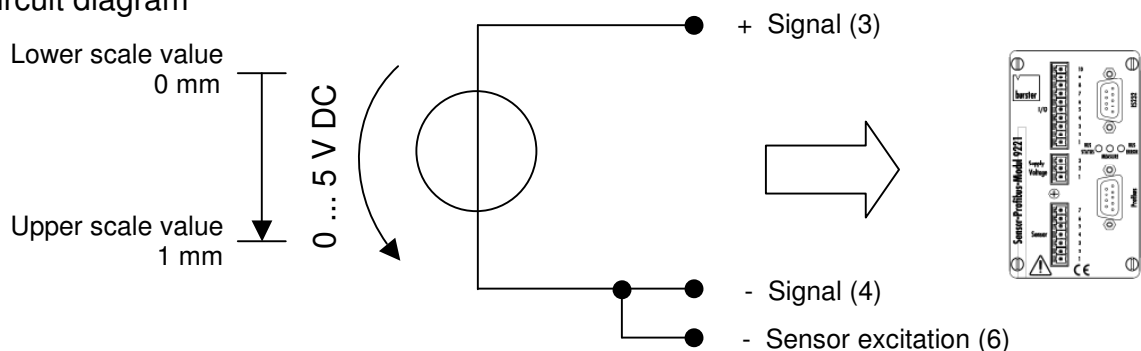
6.9.3.2 Sensor excitation, input range and input reference

Sensor excitation voltage

The sensor excitation voltage for the position sensor is given in the test and calibration certificate. A typical value is 10 volts. If this value is greater than 10 VDC in the test certificate, the transmitter excitation must be provided by an external supply because the Sensor Profibus Module can provide a maximum supply voltage of 10 VDC.

Input range

The measurement signal from the transmitter or reference-signal sensor to be connected to the Sensor Profibus Module must lie in the specified ranges.

Input reference

Select "Ground reference" as the measurement signal input reference for measurements using reference signals or transmitters. ⑥

Date: 27.01.06
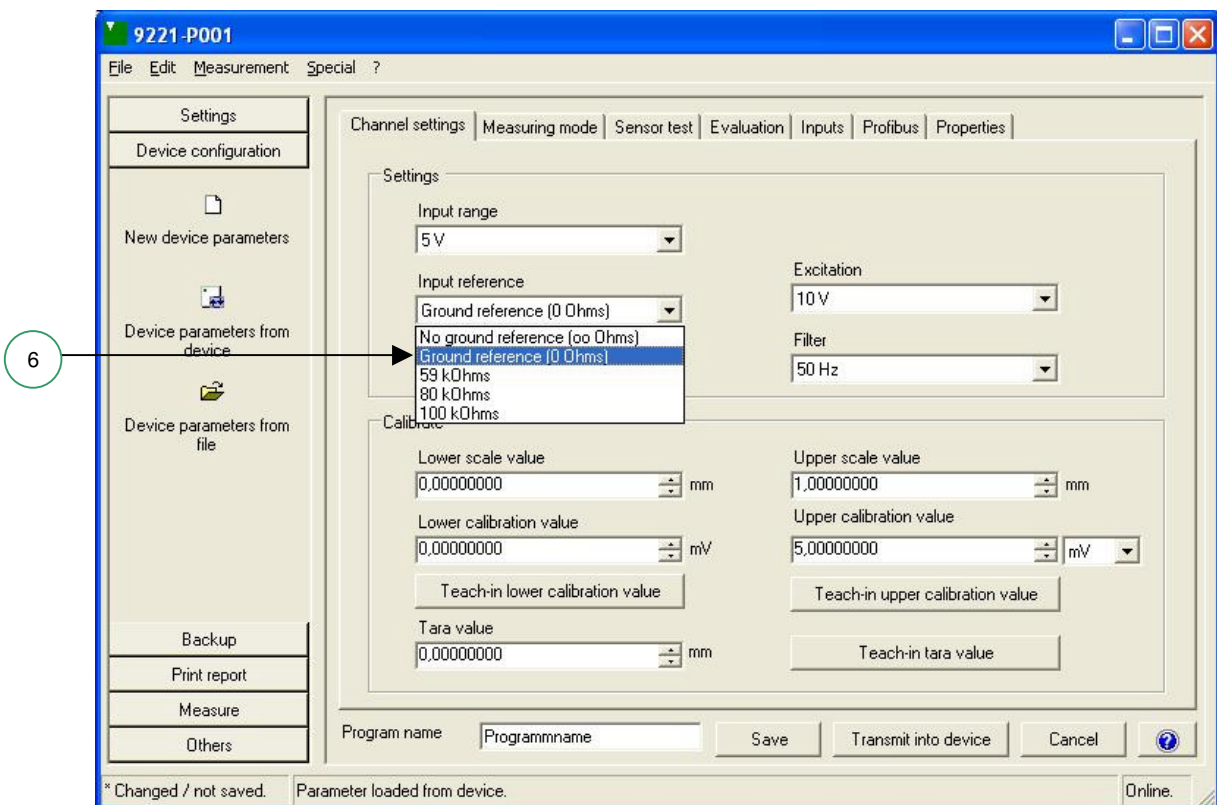
6.9.3.3 Calibration of a transmitter with voltage output

6.9.3.3.1 Calibration using a physical variable by the teach-in method

This method involves a two-stage online teach-in of sensor data to the Sensor Profibus Module, where two teach-in states are applied sequentially. The first state is the lower scale value, and the second state is the upper scale value.

Example calibration:

Displacement measurement using a transmitter e.g. type 8740-5001.

Adjust the position sensor to give the zero setting 0.00 mm. Now press button (A) "Teach-in lower calibration value". Now move the sliding shaft using a calibrated gage block e.g. S = 1 mm and set the upper scale value. Now press button (B) "Teach-in upper calibration value".

This calibration data must now be transferred to the instrument; if required it can also be saved under a user-definable program name.

Date: 27.01.06
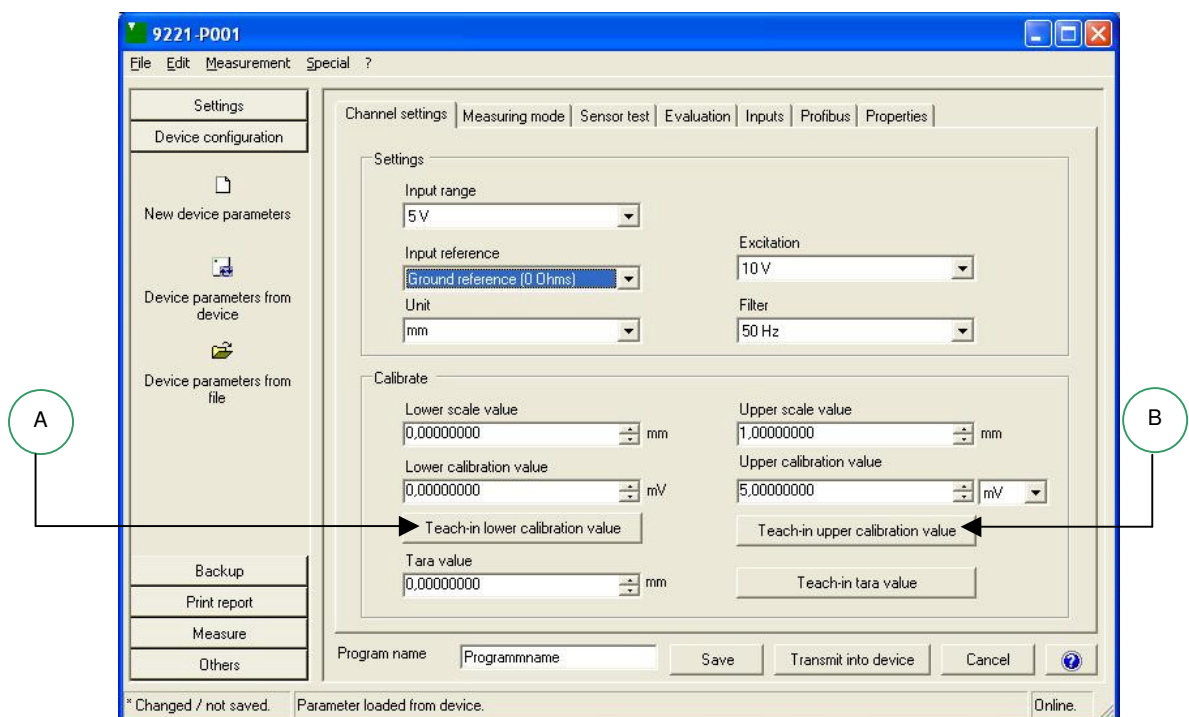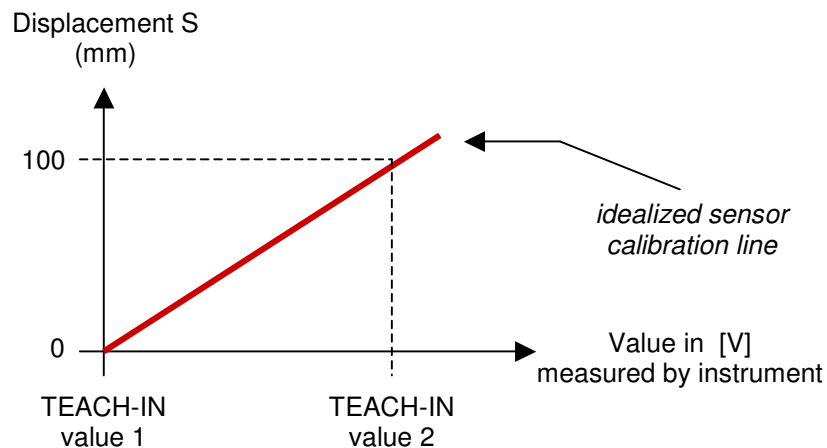
6.9.3.3.2 Calibration using the sensor test certificate
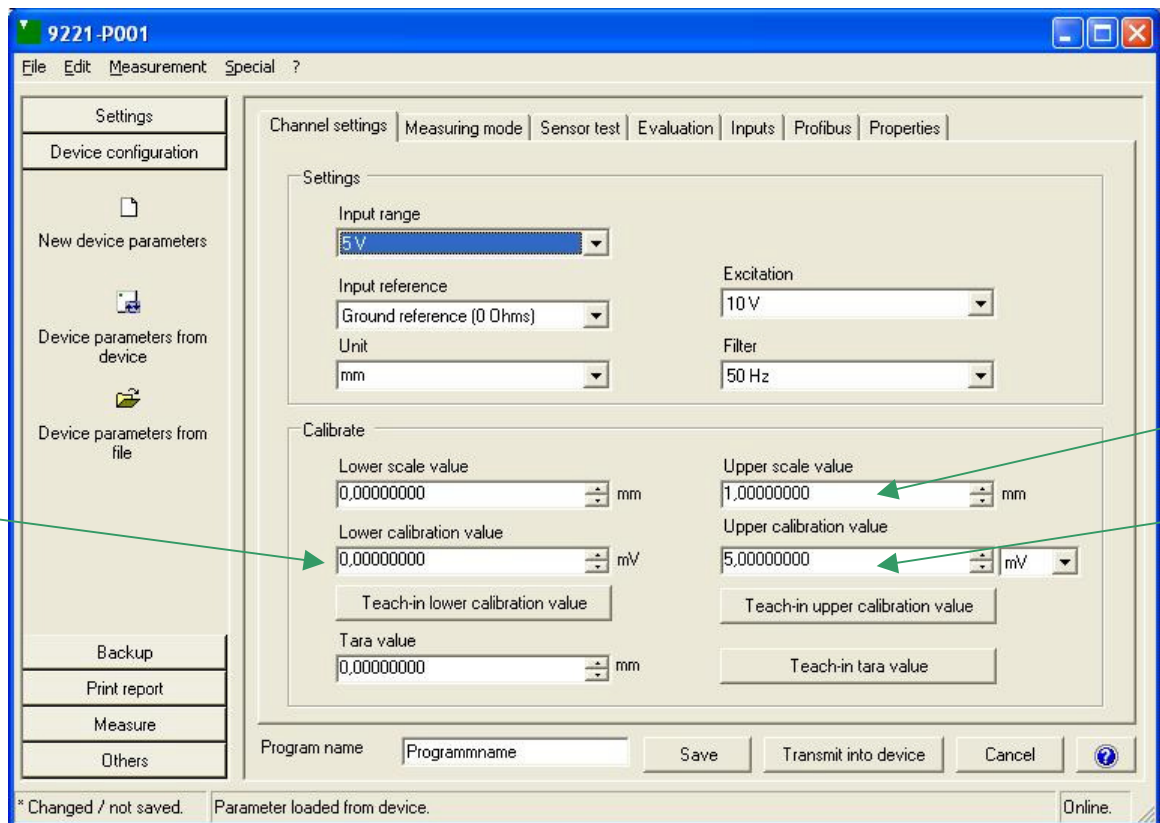
About the values:

① ... ③   These values are adopted directly from the test and calibration certificate.

The calibration was performed as follows:

Electrical range of 0 to 5 V corresponds to a mechanical range 0 to 1 mm.

This calibration data must now be transferred to the instrument; if required it can also be saved under a user-definable program name.

6.10 Signal processing

6.10.1 Measurement rate / Cut-off frequency / Filter

The A/D converter digitizes every single signal at a user-definable rate. The filter cut-off frequencies can be set to 5, 10, 25, 50, 100, 200 and 400 Hz.
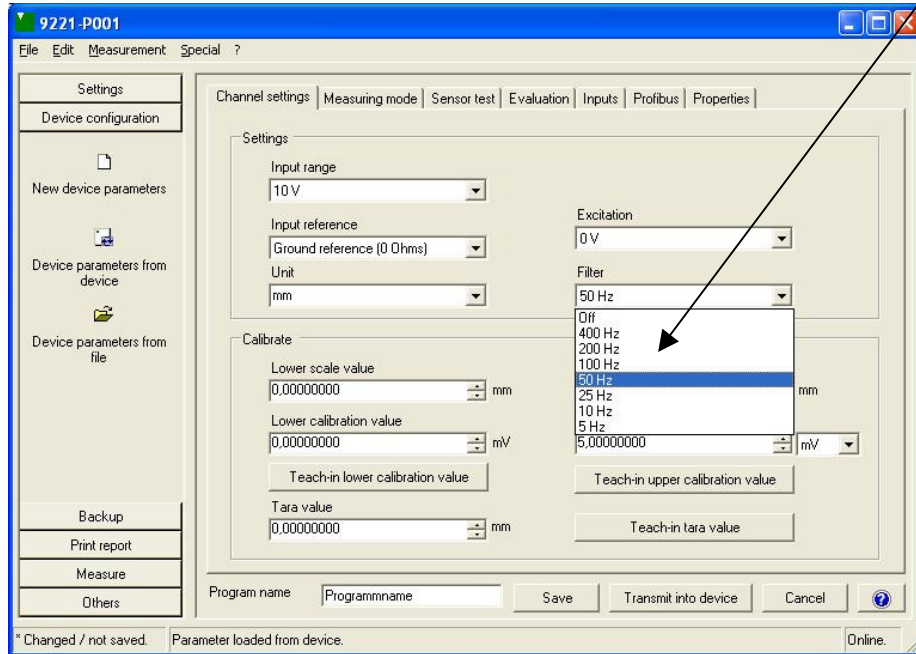
6.10.2 Averaging

The large signal amplification required for small signals inevitably means a higher noise component. In order to increase the measurement accuracy in this case, the user can select to use averaging as part of signal conditioning. This method performs arithmetic averaging over a number of measured values. Although this does reduce the measurement rate, the measurement resolution is increased dramatically. The averaging period, or here the number of values used to find the average, can be set by the user in the range 1 to 6500. Thus the maximum time for a transmitted measurement value can equal 6.5 seconds e.g. when the number of values for averaging is set to 6500.

Date: 27.01.06
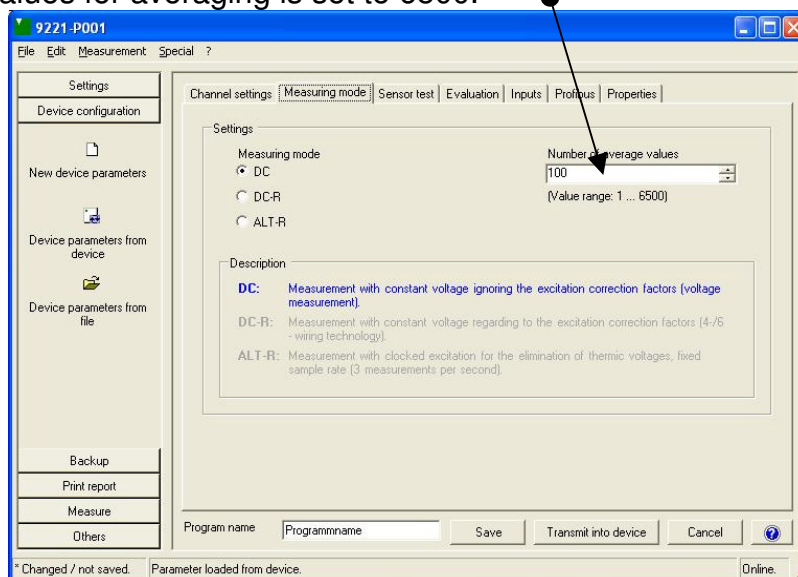
6.10.3 Reference measurement

Using the predefined calibration shunt under "Channel settings" and "Shunt resistance", you can perform a reference measurement here in order to run a sensor test, e.g. for sensors with strain-gage bridges. For this purpose, the strain-gage sensor must be connected. The calibration resistance between the excitation and output, for an unloaded sensor and a calibrated zero point, gives the corresponding output value ① (unbalance). This output value can be compared to the value from the testing and calibration certificate.
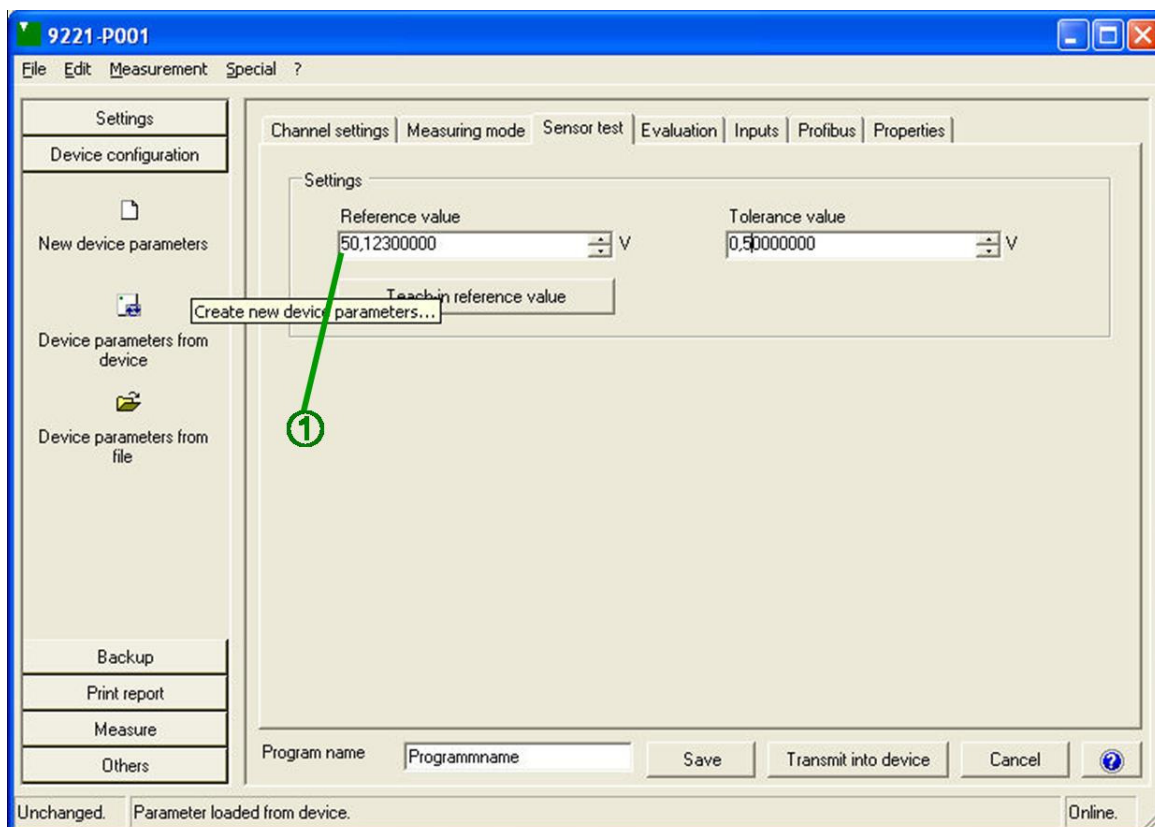
Tolerance value

For entering the tolerance value (+ / -) for the reference value.

Teach-in reference value

If the instrument is connected and the option *Device parameters from device* is selected, you can perform a teach-in of the reference value online ①.

Note: the value is measured directly in the instrument. The previous value, however, is still retained in the instrument. Only after instructing its transfer to the instrument does the new teach-in value actually take effect in the instrument.

6.10.4 Evaluation / Digital outputs (limits)

Status information on the analog input appears at the digital outputs of the Sensor Profibus Module. The status output for each module can be customized by defining threshold values (limits). For instance, user-definable thresholds GW1 and GW2 can be used for alarm or threshold monitoring at the outputs A1 / A2, and the additional output A3 used for a classification.

Example of a classification at output A3:
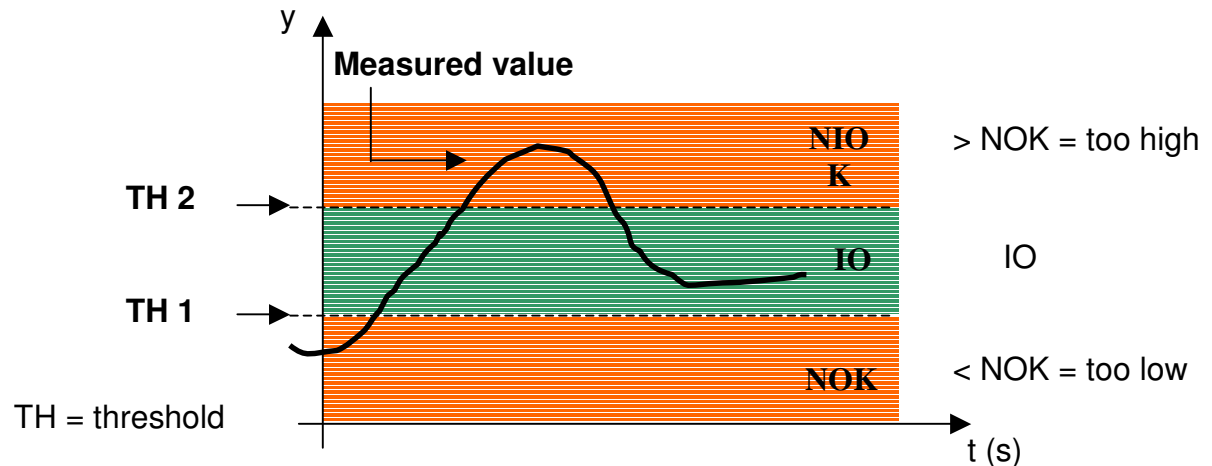
Setting the threshold using PC configuration software 9221-P001

Date: 27.01.06
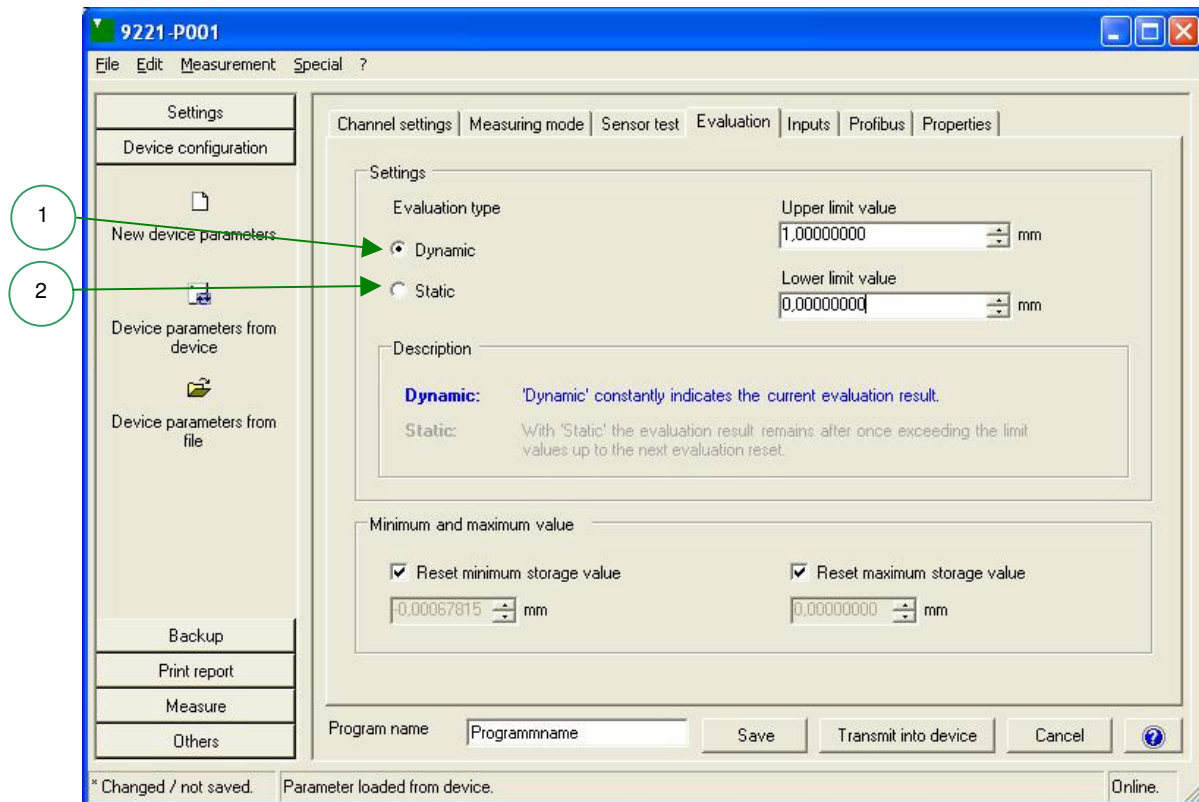
Evaluation type

One can choose between dynamic and static evaluation.

> ① For 'dynamic' evaluation, the present evaluation result is continually displayed.

> ② For 'static' evaluation, the evaluation result obtained once a threshold value is crossed is retained until the next evaluation reset.

6.10.5   Minimum and Maximum value buffer ③

To clear or reset the minimum and/or maximum value buffer, check the corresponding checkbox. After transferring the settings to the device, these values are then reset to the instantaneous measurement value.

Date: 27.01.06
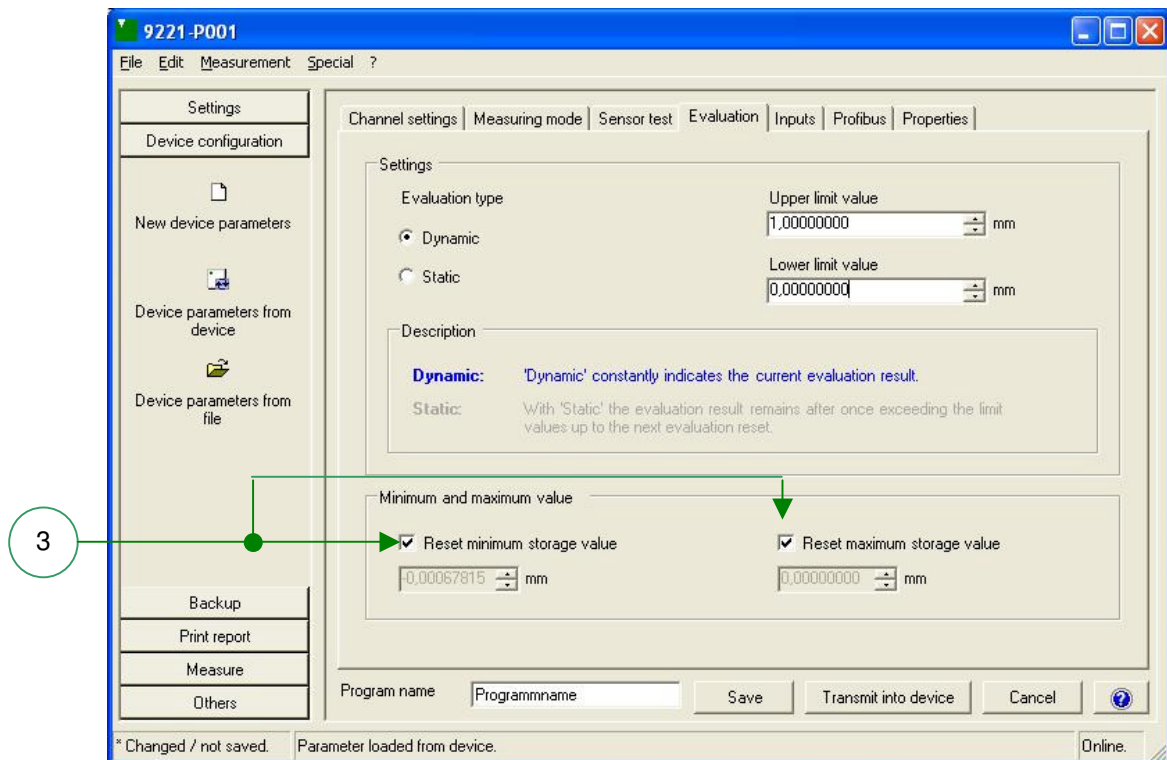
6.10.6   Digital inputs

The following control functions can be performed via the two digital inputs of the Sensor Profibus Module. When a signal is applied to the respective input A / B, the selected function is executed.

> ➢   Perform tare
> ➢   Clear tare
> ➢   Reset evaluation
> ➢   Reset minimum value buffer
> ➢   Reset maximum value buffer
> ➢   Inhibit evaluation, freeze current evaluation result

You can assign just one of these functions or even several at once to the digital inputs.
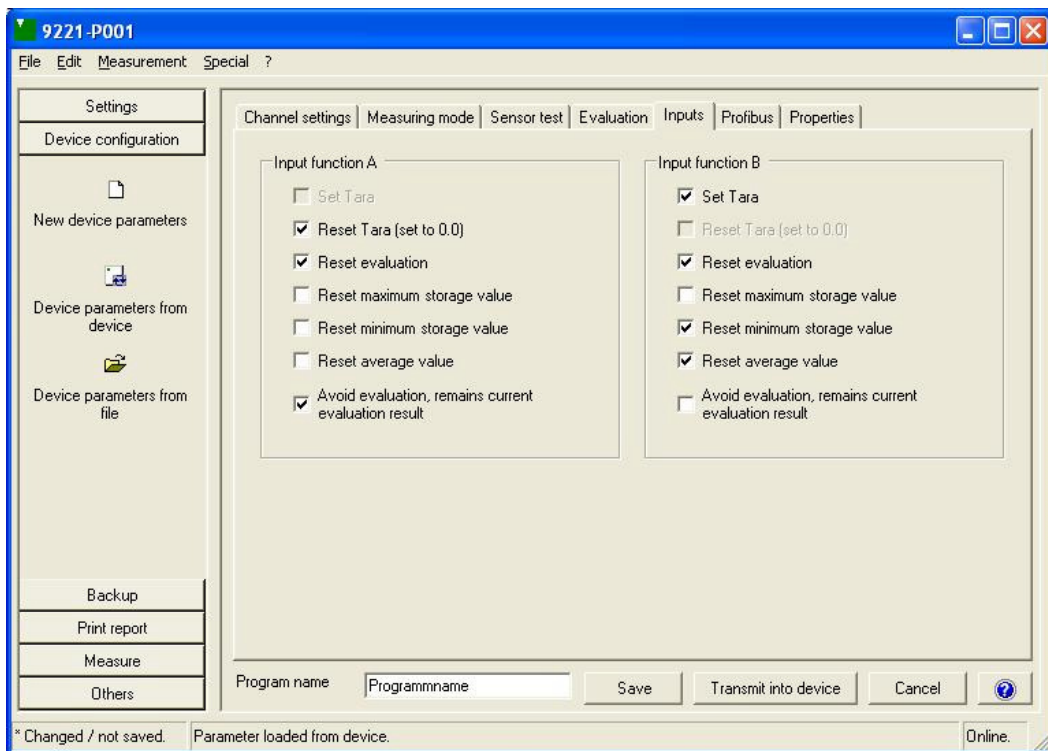
Example terminal assignment:

Input B
Function e.g. tare, reset evaluation, reset max value buffer, reset mean value

Input A
Function e.g. clear tare, reset evaluation, inhibit evaluation
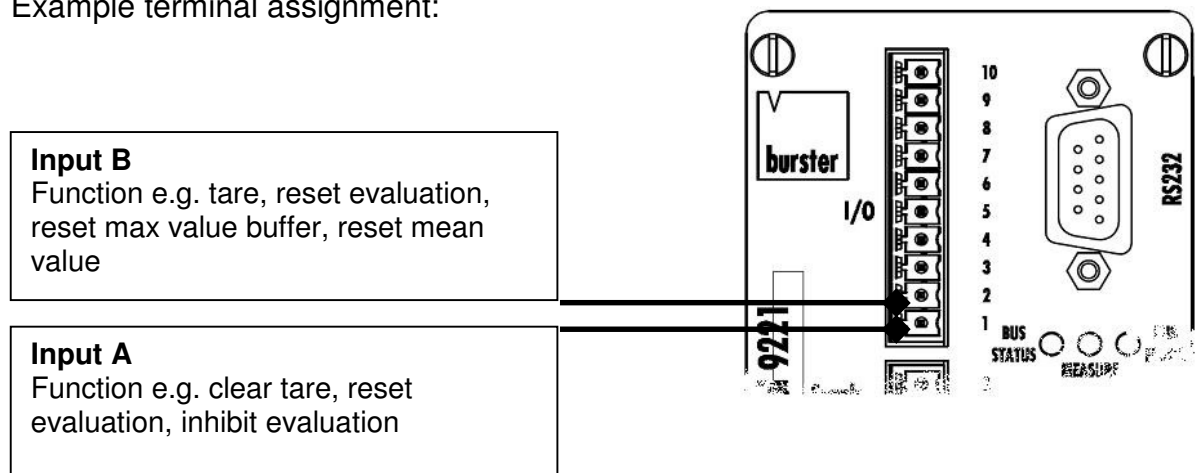
6.11   Monitor output

The monitor output is primarily used for input configuration using a potentiometer. This output must not be loaded nor used for control purposes. If used incorrectly, the Sensor Profibus Module can suffer irreparable damage because this signal is taken from a point directly before the A/D converter.

6.12   Instrument LED display

(1)   Idle LED (yellow)

- *on/off:*   serious error, program execution stopped
- *flashing:*   normal program execution

(2)   PROFIBUS LED (green)

- *flashing rapidly:*   no baud rate detected
- *flashing slowly:*   baud rate detected but no active data transfer
- *on:*   device is configured and involved in data transfer

(3)   ERROR LED (red)

- *off:*   no error
- *on:*   error, e.g. overloaded
- *flashing:*   evaluation result frozen

6.13   Test measurement

In the *Test measurement* submenu you can choose to test out the configured data. The measurement data can be transferred to a PC via the RS 232 interface and exported to an Excel spreadsheet.
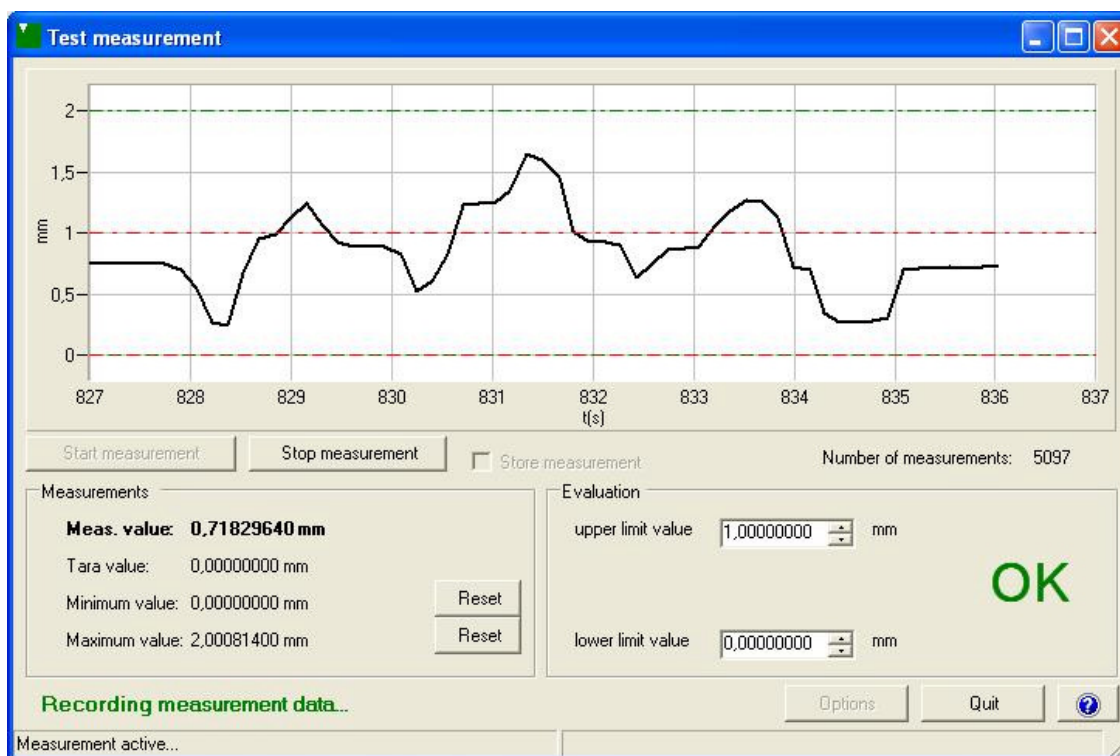
Start measurement

Click on this button to start a test measurement.
First check the "Store measurement" box if you want to save this measurement data in an Excel file; before the measurement starts, another dialog box will open giving you the option of saving the measurement data.

Stop measurement

Click on the "Stop measurement" button to stop the measurement manually.

Measured values

During the measurement process, the instantaneous measurement value, tare value and the minimum and maximum values in the selected cycle step (options) are displayed and updated.
Click on the corresponding "Reset" button to reset the minimum or maximum values during the measurement.

Evaluation

The upper and lower limit values can be set and adjusted during the measurement in the Evaluation section. Under "Options" you can select whether changed limit values should be saved in the instrument after the end of the test measurement, or the previous values restored.
If a dynamic evaluation type is enabled in the instrument, during the measurement the upper and lower limits are evaluated continuously and the resulting evaluation result OK or NOK shown live.

6.13.2   Options

Advanced options are displayed for the test measurement if you click on the "Options" button.
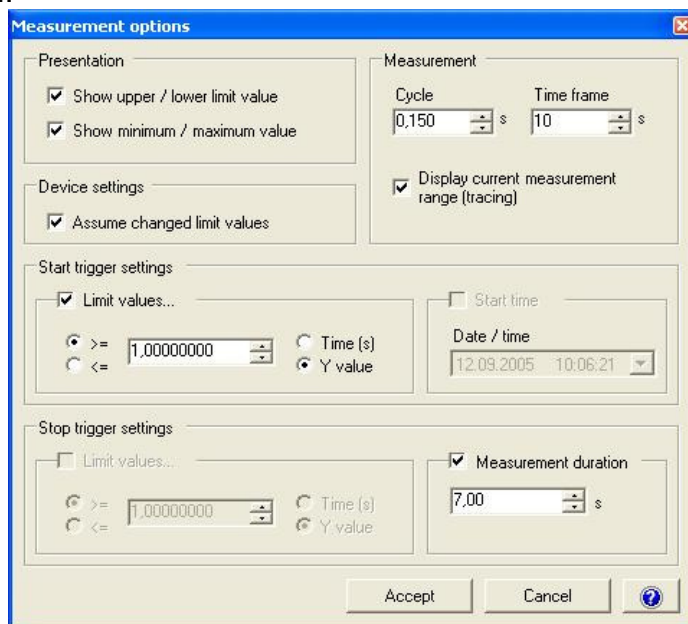
Display

The graphical display of the upper and lower limit values and the minimum and maximum values during the test measurement can be enabled/disabled here. This information is displayed by dashed lines in the graph.

Device settings

You can define here whether to retain or discard at the end of the test measurement any limit values changed during the test measurement.

Measurement

Here you can set for the test measurement the read period for the measured values and the time window displayed in the graphical display.
You can also switch between displaying the graphs as a "continuous trace" or a "complete cycle".

Start trigger settings – Limit values

A threshold (limit) value on the X or Y axis can be defined as a start trigger. Recording of measurements only starts after this threshold value is reached.

Start trigger settings – Start time

A start time for the measurement can be set in the form of a date and time, but make sure that this time does not lie in the past.
When the start time is reached, measurement recording starts.
The current time is shown in the lower part of the dialog window when the Start-time trigger is enabled.

Stop trigger settings – Limit values

A threshold (limit) value on the X or Y axis can be defined as a stop trigger. Measurement recording is stopped when this threshold value is reached.

Date: 27.01.06

Stop trigger settings – Measurement duration

The end of the test measurement can also be set using a measurement period. Enter the measurement period here in seconds.

The settings are activated with the *Accept* button or discarded with the *Cancel* button.

6.13.3   Saving measurement data in an Excel spreadsheet
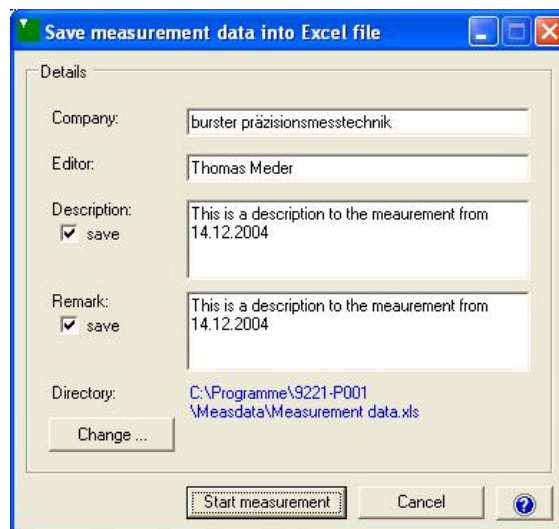
These entries are saved to the Excel measurement file as header data. Here, you have the option of changing the Company and Editor names and entering Description and Remark texts.
The Description and Remark texts can optionally be saved for reuse in another test measurement.

To change the file name and path, click the *Change…* button.
If you don't supply a file name, the Excel file displayed will be automatically generated with a sequential index number.

Finally, start the test measurement with the *Start measurement* button. Use *Cancel* to abort the action.

6.14   Electromagnetic compatibility

The Sensor Profibus Modules comply with the requirements in EMC directives for protecting against generated interference. The instruments also bear the CE mark.

6.15   Behavior in the event of a fault

The module can automatically detect certain faults such as Profibus communications problems, overloading etc., indicated by status LEDs.

7 Profibus configuration

7.1 RS485 interface

The bus interface of the Sensor Profibus Module is a PROFIBUS interface. Compared with conventional RS232 interfaces, PROFIBUS allows a larger number of stations and higher transmission speeds and provides greater interference immunity.

7.2 Bus structure

The bus has a linear structure in which each bus segment has a terminating resistor at each end. Branch segments can be set up using repeaters (signal amplifiers).

7.3 Number of bus stations

The PROFIBUS interface allows up to 32 bus stations to be connected simultaneously in each bus segment. Additional bus segments can be created using repeaters, taking the maximum number of stations to 127.

7.4 Transmission speed

The transmission speed is detected and set automatically by the Sensor Profibus Module.

Note: The permitted line lengths decrease as the transmission speed increases.

7.5 Bus cable, bus connector and bus terminating resistor

Bus cable

A shielded twisted pair having at least two wires with the following electrical specification must be used for bus cabling.

Terminating impedance: 100 ... 130 Ω at f > 100 kHz
Effective capacitance: max. 30 pF/m
Conductor cross-section: min. 0.34 mm^2
Attenuation: max. 6 dB over the entire length
Standard: EN50170
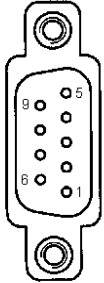
Bus connector

The signal wires A, B and Shield must be present for connections to the bus.
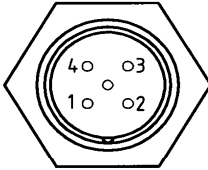
IP20 version

Pin-out for PROFIBUS connection

	Pin Signal	RS485 designation Meaning
	1	- Shield Shield,
Protective Ground		
	3	B / B´
	RxD/TxD-P	Receive/Transmit-Data-P
	5	C / C´
DGND	Data Ground	
	6	- VP Voltage
Plus		
View into	8	A / A´
instrument socket	RxD/TxD-N	Receive/Transmit-Data-N

IP65 version

Pin-out for RS PROFIBUS connection as specified by Profibus

Cable color	Connector pin	Assigned to:
brown	1	+5VDC
white	2	A
blue	3	GND
black	4	B
yellow/green	5	Shield

Date: 27.01.06

Bus terminating resistor

In order to avoid signal reflections on the bus, each bus segment must be terminated at its physical start and end point with a terminating resistor. A terminating resistor is connected between bus wires A and B.
This provides a defined open-circuit potential when no data transmission is taking place on the bus.

Bus terminating resistor in the IP20 version

A terminating resistor is integrated in most 9-pin sub-min D connectors. If the module is connected at the end of the bus line, a terminating resistor must be connected by setting the switch to ON.

Bus terminating resistor in the IP65 version

A built-in terminating resistor is located near the Profibus terminal block. If the module is connected at the end of the bus line, a terminating resistor must be connected by setting both contacts of the DIP switch to ON.

7.6   Shielding

Shielded cables are recommended where there is increased risk of interference e.g. in an industrial environment. The supply cables and signal leads should also be shielded in this case. In general, the shield of each bus circuit should be connected to the protective ground (not DataGround).

7.7   Equipotential bonding

The potential difference between the data reference potentials of each device connected to the bus must not exceed $\pm$ 7 volts. If this cannot be guaranteed, equipotential bonding must be provided. For the bus devices this usually means that the negative terminal of the power supply needs to be looped through from device to device as the equipotential bonding conductor. Since the Sensor Profibus Module has a power supply that is d.c. isolated from the bus, the module does not need to be included in the equipotential bonding system.

7.8   Setting the baud rate

No setting is required for the Sensor Profibus Module because the baud rate is detected automatically. Stubs create numerous problems and should therefore be avoided completely (especially for a high bus speed). See EN50170 standard.

Date: 27.01.06

8 Profibus communication

8.1 Bus interface and GSD file

Bus interface

The bus interface of the Sensor Profibus Module is a PROFIBUS interface.

GSD file

The GSD file for communicating with the PLC can be downloaded from our homepage http://www.burster.de/software.html or found in the 9221-P001 software package under "Device configuration" → "Profibus".

8.2 Bus protocol and data format

The data format and the complete interface complies with the Profibus specification to DIN 19245 or EN50170; the Sensor Profibus Module supports both Profibus DP-V0 and Profibus DP-V1 functionality.

8.2.1 Cyclic communication (DP-V0)

8.2.1.1 Mode summary

Mode	Inputs: 9221→Master (Status)	Length	Outputs: Master→9221 (Control)	Length
1	PLCin Mirror Current measured value	2 2 4 Σ: 8 bytes	PLCout	2 Σ: 2 bytes
2	PLCin Mirror Current measured value	2 2 4 Σ: 8 bytes	PLCout Upper limit Lower limit	2 4 4 Σ: 10 bytes
3	PLCin Mirror Current measured value Tared value	2 2 4 4 Σ: 12 bytes	PLCout	2 Σ: 2 bytes
4	PLCin Mirror Current measured value Tared value	2 2 4 4 Σ: 12 bytes	PLCout Upper limit Lower limit	2 4 4 Σ: 10 bytes

5	PLCin Mirror Current measured value Contents of min value buffer Contents of max value buffer	2 2 4 4 4 Σ: 16 bytes	PLCout	2 Σ: 2 bytes
6	PLCin Mirror Current measured value Contents of min value buffer Contents of max value buffer	2 2 4 4 4 Σ: 16 bytes	PLCout Upper limit Lower limit	2 4 4 Σ: 10 bytes
7	PLCin Mirror Current measured value Tared value Contents of min value buffer Contents of max value buffer	2 2 4 4 4 4 Σ: 20 bytes	PLCout	2 Σ: 2 bytes
8	PLCin Mirror Current measured value Tared value Contents of min value buffer Contents of max value buffer	2 2 4 4 4 4 Σ: 20 bytes	PLCout Upper limit Lower limit	2 4 4 Σ: 10 bytes

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8.2.1.2 Bit coding details

PLCin: Data bytes from 9221 to master

Byte 1:

MSB							LSB
X	TARE active	Sensor test result valid	Sensor test result	Evaluation valid	Evaluation NOK too high	Evaluation OK	Evaluation NOK too low

Byte 2:

MSB							LSB
X	X	X	X	Meas. toggle count MSB	Meas. toggle count bit 2	Meas. toggle count bit 1	Meas. toggle count LSB

Byte 3: (Mirror of 1st control byte)

MSB							LSB
X	Handshake Reset Max value buffer	Handshake Reset Min value buffer	Handshake Reset Evaluation	Handshake Reset Mean value	Handshake Reset TARE	Handshake Perform TARE	Freeze evaluation status

Byte 4: (Mirror of 2nd control byte)

MSB							LSB
State Shunt C	State Shunt B	State Shunt A	Handshake adopt upper limit/ lower limit	Handshake Save setup in EEPROM	State Test method ALT/DC B	State Test method ALT/DC A	Handshake Perform sensor test

NOTES

- *Evaluation results*
  - This is where the actual evaluation results are shown. One needs to be aware of the evaluation type.
  - The "Evaluation valid" signal indicates whether or not the result can be trusted. For instance, if the amplifier is over-driven or the evaluation was prevented, this bit is 0.
- *Sensor test*
  - The validity flag is cleared when a new sensor test is started (see below). As soon as a result from the sensor test is available, the result flag and validity flag are set accordingly.

- *Tare*
  - The TARE active flag indicates that a tare value != 0 is currently included in the result.

- *Meas. toggle count*
  - These bits indicate when a new measured value has been recorded.
  - It is a 4-bit counter, which is incremented every time a new measurement reading is made.
  - Depending on the PROFIBUS cycle time and the averaging period, it may not be possible for every single measurement to be retrieved by the PROFIBUS. If the cycle time is relatively large and only a relatively few values are averaged, then viewed from the PROFIBUS master, the counter will appear to jump in value (e.g. 1-5-9-c-2-6-a-....).
- *Mirror of the two control bytes*
  - Control signals are classified as *action*-oriented and *state-oriented*.
  - Action-oriented:
    A positive edge on the control line concerned is intended to start an action (e.g. tare). Once the action has been started, the control line can return to its initial state. The following handshake procedure is followed to monitor this action.

Master wants to initiate action

Master has detected acknowledgment and wants to terminate handshake

Control bit from master   1   0

Handshake from 9221   1   0

9221 signals that action has been performed

9221 confirms the end of the handshake and is thereby ready for the next action on this channel
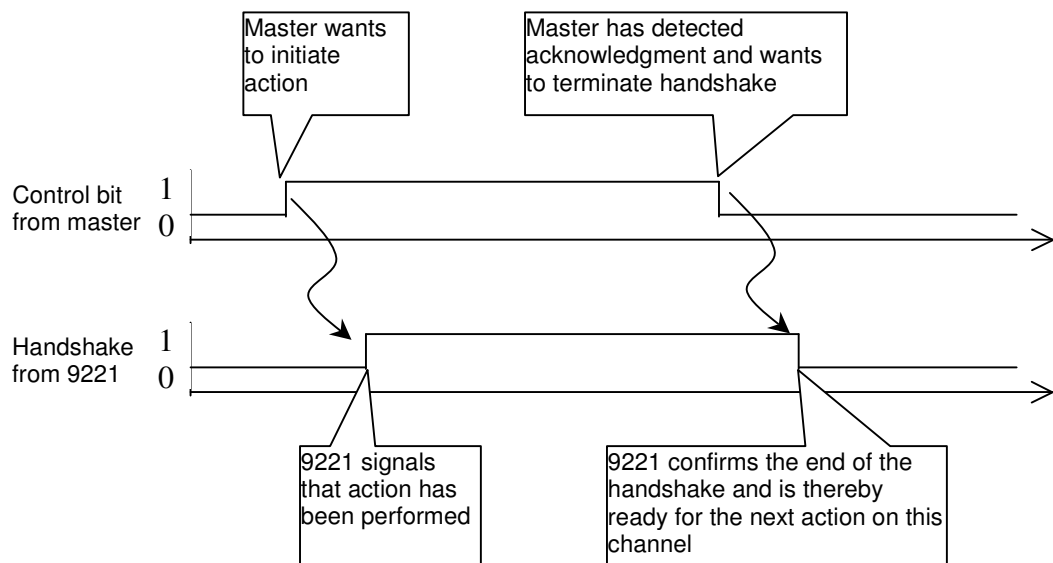
  The relevant bits in bytes 3 and 4 have been labeled with "Handshake".
  - State-oriented:
    In this case the current state of the setting concerned is constantly output. No additional handshake is required.

PLCout: Data bytes from master to 9221

Byte 1:

MSB							LSB
X	Reset Max value buffer	Reset Min value buffer	Reset evaluation	Reset mean value	Reset TARE	Perform TARE	Freeze evaluation

Byte 2:

MSB							LSB
Shunt C	Shunt B	Shunt A	Adopt upper limit /lower limit	Save setup in EEPROM	Test method ALT/DC B	Test method ALT/DC A	Perform sensor test

NOTES

- *Freeze evaluation*
    - This can be used to prevent the evaluation. While this bit is set, the evaluation routine is not executed and the last evaluation result is retained.
    - The red LED flashes slowly as visual indication of this state.
    - In addition, the Evaluation valid flag is reset because the present evaluation is invalid.

- *Perform TARE*
    - A 0-1 edge on this bit starts a tare operation.
    - A measured value is obtained from 500 (*1ms) readings.
    - The current measured value is subtracted from all future measured values.
    - The TARE active flag is set.

- *Clear tare*
    - A 0-1 edge on this bit clears the current tare setting.
    - The TARE active flag is reset.

- *Reset mean value*
    - Averaging of the current measured value is reset.
    - This starts the recording of a completely new measured value.

- *Reset evaluation*
    - Evaluation is reset.
    - Only serves any purpose for the STATIC evaluation type (in this case the NOK evaluation result is set once the measurement goes outside the OK range, and stays sets even if the measured value returns to the OK region in the meantime).
    - The displayed error is cleared and a new evaluation process started.

Reset minimum value buffer / maximum value buffer

- A 0-1 edge on these bits clears the corresponding extreme-value buffer, and then, logically, sets it to the current measured value automatically.

- *Perform sensor test*
  - A 0-1 edge on this bit starts a sensor test.
  - The result is indicated as described above.

- *DC/DCR/ALTR measuring mode*
  - This can be used to change the measuring mode being used.
  - Setting the bits as follows enables the measuring mode shown:

B	A	Measuring mode
0	0	DC
0	1	DCR
1	0	ALTR
1	1	invalid

  - One must first wait for the averaging process to conclude before the instrument starts working in the new measuring mode.
  - This setting is not saved automatically in the EEPROM.

- *Save setup in EEPROM*
  - A 0-1 edge on this bit saves the current device setup in the EEPROM.
  - This means that the setup is still available the next time the instrument is switched on.

- *Adopt upper limit / lower limit*
  - In various PROFIBUS modes, new limits can be transferred to the 9221.
  - These limits are adopted in the instrument by a 0-1 edge on this bit.
  - This bit only serves a purpose in the relevant PROFIBUS modes.
  - This setting is not saved automatically in the EEPROM.

- *Shunt*
  - A shunt resistance / ground reference can be connected by setting the bits here.

C	B	A	SHUNT
0	0	0	open-cct
0	0	1	short-cct
0	1	0	59k
0	1	1	80k
1	0	0	100k

  - This setting is not saved automatically in the EEPROM.

SetParam code bytes,
as defined in gsd file

Mode 1   0xA1, 0x93, 0x93

Mode 2   0xA1, 0xA3, 0xA3, 0x93, 0x93

Mode 3   0xA1, 0x93, 0x93, 0x93

Mode 4   0xA1, 0xA3, 0xA3, 0x93, 0x93, 0x93

Mode 5   0xA1, 0x93, 0x93, 0x93, 0x93

Mode 6   0xA1, 0xA3, 0xA3, 0x93, 0x93, 0x93, 0x93

Mode 7   0xA1, 0x93, 0x93, 0x93, 0x93, 0x93

Mode 8   0xA1, 0xA3, 0xA3, 0x93, 0x93, 0x93, 0x93, 0x93

Note:

By setting the LSB in the last user-param byte, the order of the 4 bytes of a
floating-point number can be reversed if required. Please read the relevant
comments in the gsd file.

8.2.1.3   Byte reference list

Mode 1

Data from master to slave

Byte	Meaning	Section	Comments
0	Output byte 1	**0**	
1	Output byte 2	**0**	

Data from slave to master

Byte	Meaning	Section	Comments
0	Input byte 1	**0**	
1	Input byte 2	**0**	
2	Mirror byte 1	**0**	
3	Mirror byte 2	**0**	
4	Current measured value, byte 1/4		The byte sequence can be changed in the gsd file
5	Current measured value, byte 2/3		
6	Current measured value, byte 3/2		
7	Current measured value, byte 4/1		

Mode 2

Data from master to slave

Byte	Meaning	Section	Comments
0	Output byte 1	**0**	
1	Output byte 2	**0**	
2	Upper limit, byte 1/4		
3	Upper limit, byte 2/3		The byte sequence can be changed in the gsd file
4	Upper limit, byte 3/2		
5	Upper limit, byte 4/1		
6	Lower limit, byte 1/4		
7	Lower limit, byte 2/3		The byte sequence can be changed in the gsd file
8	Lower limit, byte 3/2		
9	Lower limit, byte 4/1		

Data from slave to master

Byte	Meaning	Section	Comments
0	Input byte 1	**0**	
1	Input byte 2	**0**	
2	Mirror byte 1	**0**	
3	Mirror byte 2	**0**	
4	Current measured value, byte 1/4		
5	Current measured value, byte 2/3		The byte sequence can be changed in the gsd file
6	Current measured value, byte 3/2		
7	Current measured value, byte 4/1		

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Mode 3

Data from master to slave

Byte	Meaning	Section	Comments
0	Output byte 1	**0**	
1	Output byte 2	**0**	

Data from slave to master

Byte	Meaning	Section	Comments
0	Input byte 1	**0**	
1	Input byte 2	**0**	
2	Mirror byte 1	**0**	
3	Mirror byte 2	**0**	
4	Current measured value, byte 1/4		The byte sequence can be changed in the gsd file
5	Current measured value, byte 2/3		
6	Current measured value, byte 3/2		
7	Current measured value, byte 4/1		
8	Tared value, byte 1/4		The byte sequence can be changed in the gsd file
9	Tared value, byte 2/3		
10	Tared value, byte 3/2		
11	Tared value, byte 4/1		

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Mode 4

Data from master to slave

Byte	Meaning	Section	Comments
0	Output byte 1	**0**	
1	Output byte 2	**0**	
2	Upper limit, byte 1/4		
3	Upper limit, byte 2/3		The byte sequence can be changed in the gsd file
4	Upper limit, byte 3/2		
5	Upper limit, byte 4/1		
6	Lower limit, byte 1/4		
7	Lower limit, byte 2/3		The byte sequence can be changed in the gsd file
8	Lower limit, byte 3/2		
9	Lower limit, byte 4/1		

Data from slave to master

Byte	Meaning	Section	Comments
0	Input byte 1	**0**	
1	Input byte 2	**0**	
2	Mirror byte 1	**0**	
3	Mirror byte 2	**0**	
4	Current measured value, byte 1/4		
5	Current measured value, byte 2/3		The byte sequence can be changed in the gsd file
6	Current measured value, byte 3/2		
7	Current measured value, byte 4/1		
8	Tared value, byte 1/4		
9	Tared value, byte 2/3		The byte sequence can be changed in the gsd file
10	Tared value, byte 3/2		
11	Tared value, byte 4/1		

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Mode 5

Data from master to slave

Byte	Meaning	Section	Comments
0	Output byte 1	**0**	
1	Output byte 2	**0**	

Data from slave to master

Byte	Meaning	Section	Comments
0	Input byte 1	**0**	
1	Input byte 2	**0**	
2	Mirror byte 1	**0**	
3	Mirror byte 2	**0**	
4	Current measured value, byte 1/4		The byte sequence can be changed in the gsd file
5	Current measured value, byte 2/3		
6	Current measured value, byte 3/2		
7	Current measured value, byte 4/1		
8	Contents of min value buffer, byte 1/4		The byte sequence can be changed in the gsd file
9	Contents of min value buffer, byte 2/3		
10	Contents of min value buffer, byte 3/2		
11	Contents of min value buffer, byte 4/1		
12	Contents of max value buffer, byte 1/4		The byte sequence can be changed in the gsd file
13	Contents of max value buffer, byte 2/3		
14	Contents of max value buffer, byte 3/2		
15	Contents of max value buffer, byte 4/1		

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Mode 6

Data from master to slave

Byte	Meaning	Section	Comments
0	Output byte 1	**0**	
1	Output byte 2	**0**	
2	Upper limit, byte 1/4		
3	Upper limit, byte 2/3		The byte sequence can be changed in the gsd file
4	Upper limit, byte 3/2		
5	Upper limit, byte 4/1		
6	Lower limit, byte 1/4		
7	Lower limit, byte 2/3		The byte sequence can be changed in the gsd file
8	Lower limit, byte 3/2		
9	Lower limit, byte 4/1		

Data from slave to master

Byte	Meaning	Section	Comments
0	Input byte 1	**0**	
1	Input byte 2	**0**	
2	Mirror byte 1	**0**	
3	Mirror byte 2	**0**	
4	Current measured value, byte 1/4		
5	Current measured value, byte 2/3		The byte sequence can be changed in the gsd file
6	Current measured value, byte 3/2		
7	Current measured value, byte 4/1		
8	Contents of min value buffer, byte 1/4		
9	Contents of min value buffer, byte 2/3		The byte sequence can be changed in the gsd file
10	Contents of min value buffer, byte 3/2		
11	Contents of min value buffer, byte 4/1		
12	Contents of max value buffer, byte 1/4		
13	Contents of max value buffer, byte 2/3		The byte sequence can be changed in the gsd file
14	Contents of max value buffer, byte 3/2		
15	Contents of max value buffer, byte 4/1		

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Mode 7

Data from master to slave

Byte	Meaning	Section	Comments
0	Output byte 1	**0**	
1	Output byte 2	**0**	

Data from slave to master

Byte	Meaning	Section	Comments
0	Input byte 1	**0**	
1	Input byte 2	**0**	
2	Mirror byte 1	**0**	
3	Mirror byte 2	**0**	
4	Current measured value, byte 1/4		The byte sequence can be changed in the gsd file
5	Current measured value, byte 2/3		
6	Current measured value, byte 3/2		
7	Current measured value, byte 4/1		
8	Tared value, byte 1/4		The byte sequence can be changed in the gsd file
9	Tared value, byte 2/3		
10	Tared value, byte 3/2		
11	Tared value, byte 4/1		
12	Contents of min value buffer, byte 1/4		The byte sequence can be changed in the gsd file
13	Contents of min value buffer, byte 2/3		
14	Contents of min value buffer, byte 3/2		
15	Contents of min value buffer, byte 4/1		
16	Contents of max value buffer, byte 1/4		The byte sequence can be changed in the gsd file
17	Contents of max value buffer, byte 2/3		
18	Contents of max value buffer, byte 3/2		
19	Contents of max value buffer, byte 4/1		

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Mode 8

Data from master to slave

Byte	Meaning	Section	Comments
0	Output byte 1	0	
1	Output byte 2	0	
2	Upper limit, byte 1/4		The byte sequence can be changed in the gsd file
3	Upper limit, byte 2/3		
4	Upper limit, byte 3/2		
5	Upper limit, byte 4/1		
6	Lower limit, byte 1/4		The byte sequence can be changed in the gsd file
7	Lower limit, byte 2/3		
8	Lower limit, byte 3/2		
9	Lower limit, byte 4/1		

Data from slave to master

Byte	Meaning	Section	Comments
0	Input byte 1	0	
1	Input byte 2	0	
2	Mirror byte 1	0	
3	Mirror byte 2	0	
4	Current measured value, byte 1/4		The byte sequence can be changed in the gsd file
5	Current measured value, byte 2/3		
6	Current measured value, byte 3/2		
7	Current measured value, byte 4/1		
8	Tared value, byte 1/4		The byte sequence can be changed in the gsd file
9	Tared value, byte 2/3		
10	Tared value, byte 3/2		
11	Tared value, byte 4/1		
12	Contents of min value buffer, byte 1/4		The byte sequence can be changed in the gsd file
13	Contents of min value buffer, byte 2/3		
14	Contents of min value buffer, byte 3/2		
15	Contents of min value buffer, byte 4/1		
16	Contents of max value buffer, byte 1/4		The byte sequence can be changed in the gsd file
17	Contents of max value buffer, byte 2/3		
18	Contents of max value buffer, byte 3/2		
19	Contents of max value buffer, byte 4/1		

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8.2.2 Acyclic communication (DP-V1)

8.2.2.1 General information

With PROFIBUS DPV1, a master can use acyclical bus access to access individual device parameters for reading or writing new values for the parameter. To do this, it must be possible to address these parameters precisely so that the master knows how it can access a particular parameter. This information is contained in the slot-index directory, which is a table showing where the various device parameters are located.

The individual device parameters are addressed in two stages: via the *slot* (≈ chapter) and the *index* (≈ entry in this chapter). Another simple analogy is street and house number. The street name on a letter is used to fix the city area and approximate neighborhood, the house number can be used to find exactly the house concerned. The destination can be identified by combining these two pieces of information.

Exactly the same process applies with PROFIBUS DPV1. For example, the entry "Input range of instrumentation amplifier" is located in slot 1 / index 1, This information can be used to access this device parameter. The value of the parameter can be read or its value changed by writing a new value to it. More information is still required in order to be able to read and interpret the addressed value properly:

What sort of variable type is this value? (→how many bytes must be read, how should these bytes be interpreted? (There is no point e.g. reading just 3 bytes of a 4-byte floating point number, because the numerical value cannot be computed from this)).

How many bytes can be read from/written to at this address?

How can this value be accessed? (→ *rw* (read&write): the value can be read, and a new value can also be written,

→ *ro* (read only): the value can only be read, *wo* (write only): the value can only be written).

What are valid values for this entry and what do they mean? (e.g. for slot1/index2 "Excitation" a value of 8 cannot be entered because this excitation voltage does not exist. Even if the value '3' is read, this by itself is of no use: one also needs to know that this '3' means "Excitation = 10 V")

Additional information:

For a slot/index labeled "EVENT!", the action specified in the table is initiated by a write access of any U8-byte to this slot (or index).

Values are transferred in Motorola format (Most Significant Byte first) in hexadecimal notation.

Should this byte order need changing, one simply needs to set the LSB of the 4th byte of the user-param to 1 at parameterization.

Floating-point numbers (float) are transferred as 32-bit floats (4 bytes) as per IEEE-754. They are referred to below as REAL32. Appendix A contains a key to the coding of this number format and a quick guide to converting the 4 bytes into a floating-point number by bit manipulations.

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8.2.2.2 Slot-index directory

Slot	Index	Contents	Type	Access	Len (In bytes)	
0		*General information*				
	1	Software version	STRING15	ro	15	
		Valid values:	*String containing software version, e.g. "V200400BETA28"*			
	2	Serial number	U32	ro	4	
		Valid values:	Serial number e.g. "123456"			
	3	Calibration date	STRING12	ro	12	
		Valid values:	*Date of factory calibration, e.g. "29.03.2004"*			
	4	Error status	U16	ro	2	
		Valid values:	*Bit-coded error statuses* Bit 0 set: AD converter over-driven Bit 1 set: illegal access to protected command Bit 2 set: EEPROM empty or faulty Bit 3 set: Parameter error: incorrect number of bytes Bit 4 set: Parameter error: incorrect range Bit 5 set: logic error in the calibration data Bit 6 set: interface command not implemented			
	5	Load default user settings	U8	wo	1	EVENT!
		Valid values:	*Load default settings from the user area. This does not affect the factory calibration*	*write any byte*		
	6	write user settings to EEPROM / read user settings from EEPROM	U8	rw	1	EVENT!
		Valid values:	*Load user settings from EEPROM into RAM (read access) or write from RAM to EEPROM (write access)*	*write/read any byte*		
1		*Measurement settings*				
	1	Input range of instrumentation amp	U8	rw	1	
		Valid values:	0: Input range 1.25mV 1: Input range 2.5mV 2: Input range 5mV 3: Input range 10mV 4: Input range 22.5mV 5: Input range 25mV 6: Input range 50mV 7: Input range 100mV 8: Input range 125mV 9: Input range 250mV 10: Input range 500mV 11: Input range 1V 12: Input range 1.25V 13: Input range 2.5V 14: Input range 5V 15: Input range 10V			
	2	Excitation	U8	rw	1	
		Valid values:	0: Excitation 0V 1: Excitation 2.5V 2: Excitation 5V 3: Excitation 10V			
	3	Not supported				
		Valid values:	0: Shunt resistance ∞ Ω (open-circuit) 1: Shunt resistance 0 Ω (short-circuit) 2: Shunt resistance 59 kΩ 3: Shunt resistance 80 kΩ 4: Shunt resistance 100 kΩ			
	4	Filter	U8	rw	1	

		Valid values:		0: Off 2: 400 Hz 3: 200 Hz 4: 100 Hz 5: 50 Hz 6: 25 Hz 7: 10 Hz 8: 5 Hz		
2		*Calibration*				
	1	Units	STRING11	rw	11	
		Valid values:	*Units string*			
	2	Upper scale value	REAL32	rw	4	
		Valid values:	*Upper scale value*			
	3	Lower scale value	REAL32	rw	4	
		Valid values:	*Lower scale value*			
	4	Upper calibration value	REAL32	rw	4	
		Valid values:	*Upper calibration value*	*0*		
	5	Lower calibration value	REAL32	rw	4	
		Valid values:	*Lower calibration value*	*0*		
	6	Measure upper calibration value	U8	wo	1	EVENT!
		Valid values:	*Sensor reading currently at input is measured as upper calibration value*	*write any byte*		
	7	Measure lower calibration value	U8	wo	1	EVENT!
		Valid values:	*Sensor reading currently at input is measured as lower calibration value*	*write any byte*		
	8	Compute calibration	U8	wo	1	EVENT!
		Valid values:	*Compute calibration from available data*	*write any byte*		
3		*Measuring mode*				
	1	Set measuring mode	U8	rw	1	
		Valid values:	0: DC 1: DC-R (ratiometric) 2: ALT-R (ratiometric)			
	2	Mean values	U16	rw	2	
		Valid values:	*1..6500*			
4		*Evaluation criteria*				
	1	Upper limit	REAL32	rw	4	
		Valid values:	*Value for upper limit*			
	2	Lower limit	REAL32	rw	4	
		Valid values:	*Value for lower limit*			
	3	Evaluation type	U8	rw	1	
		Valid values:	*Dynamic evaluation type* *Static evaluation type*	*0* *1*		
5		*Input A function*				
	1	Input A function: Perform tare	U8	rw	1	
		Valid values:	*Function not supported* *Function supported*	*0* *1*		
	2	Input A function: Clear tare	U8	rw	1	

		Valid values:	*Function not supported*	*0*	
			Function supported	*1*	
	3	Input A function: Reset evaluation	U8	rw	1
		Valid values:	*Function not supported*	*0*	
			Function supported	*1*	
	4	Input A function: Reset minimum value buffer	U8	rw	1
		Valid values:	*Function not supported*	*0*	
			Function supported	*1*	
	5	Input A function: Reset maximum value buffer	U8	rw	1
		Valid values:	*Function not supported*	*0*	
			Function supported	*1*	
	6	Input A function: Inhibit evaluation, freeze current evaluation result	U8	rw	1
		Valid values:	*Function not supported*	*0*	
			Function supported	*1*	
	7	Input A function: Reset mean value	U8	rw	1
		Valid values:	*Function not supported*	*0*	
			Function supported	*1*	
6		*Input B function*			
	1	Input B function: Perform tare	U8	rw	1
		Valid values:	*Function not supported*	*0*	
			Function supported	*1*	
	2	Input B function: Clear tare	U8	rw	1
		Valid values:	*Function not supported*	*0*	
			Function supported	*1*	
	3	Input B function: Reset evaluation	U8	rw	1
		Valid values:	*Function not supported*	*0*	
			Function supported	*1*	
	4	Input B function: Reset minimum value buffer	U8	rw	1
		Valid values:	*Function not supported*	*0*	
			Function supported	*1*	
	5	Input B function: Reset maximum value buffer	U8	rw	1
		Valid values:	*Function not supported*	*0*	
			Function supported	*1*	

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	6	Input B function: Inhibit evaluation, freeze current evaluation result	U8	rw	1	
		Valid values:	*Function not supported*	*0*		
			Function supported	*1*		
	7	Input B function: Reset mean value	U8	rw	1	
		Valid values:	*Function not supported*	*0*		
			Function supported	*1*		
7		*Evaluation results*				
	1	evaluation result	U8	ro	1	
		Valid values:	*OK*	*0*		
			NOK: too high	*1*		
			NOK: too low	*2*		
	2	Contents of minimum value buffer	REAL32	ro	4	
		Valid values:	*Contents of min value buffer*			
	3	Contents of maximum value buffer	REAL32	ro	4	
		Valid values:	*Contents of max value buffer*			
8		*Sensor test*				
	1	Measure sensor test reference value	U8	wo	1	EVENT!
		Valid values:	*Adopt current measured value as new sensor test reference value*	*write any byte*		
	2	Sensor test reference value	REAL32	rw	4	
		Valid values:	*New sensor test reference value*			
	3	Sensor test tolerance value	REAL32	rw	4	
		Valid values:	*New sensor test tolerance value*			
	4	Perform sensor test	U8	wo	1	EVENT!
		Valid values:		*write any byte*		
	5	Read result from last sensor test	U8	ro	1	
		Valid values:	*OK*	*0*		
			NOK: too high	*1*		
			NOK: too low	*2*		
			Test not performed yet	*3*		
9		*Reset functions*				
	1	Reset evaluation result	U8	wo	1	EVENT!
		Valid values:	*Clear current evaluation result*	*write any byte*		
	2	Reset minimum value buffer	U8	wo	1	EVENT!
		Valid values:	*Delete contents of min value buffer*	*write any byte*		
	3	Reset maximum value buffer	U8	wo	1	EVENT!

		Valid values:	*Delete contents of max value buffer*	*write any byte*		
10		*Tare*				
	1	Measure new tare value	U8	wo	1	EVENT!
		Valid values:	*Use current measured value as tare value*	*write any byte*		
	2	Tare value	REAL32	rw	4	
		Valid values:	*Write/read tare value*			
11		*Measured values*				
	1	ADC value	S16	ro	2	
		Valid values:	*Current uncalibrated measured value in LSB*			
	2	Measured value	REAL32	ro	4	
		Valid values:	*Calibrated measured value*			
12		*Names*				
	1	Station name	STRING20	rw	<21	
		Valid values:	*String containing station name e.g. "Device_35"*			
	2	Program name	STRING20	rw	<21	
		Valid values:	*String containing program name e.g. "Component_12"*			

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8.2.2.3   Representation of floating-point values

Floating-point numbers from measurement results are transferred as 4-byte float values as specified in IEEE-754-1985. The following examples explain how the 4 bytes are interpreted in order to obtain the floating-point values.

What components make up a float number?

A floating-point number represented as a 4-byte float value consists of three elements: the sign bit (*sign*), the exponent (*ex*) and the mantissa (*mant*).

How is a floating-point number constructed from the three components?

The number is composed from this formula:

$$x = (-1)^{sign} * 2^{(ex-127)} * (1.0 + mant)$$

Equation 71.1

- The mantissa is thus saved without the leading "1", hence the term (1.0 + *mant*)
- The exponent is represented with a bias offset, hence the term (*ex*-127)

Examples:

x = -6.0   is represented as   -1.5 * 2^2 , i.e.
              sign bit (*sign*):   1 (negative)
              exponent (*ex*):   129   →   129   − 127   = 2
              mantissa (*mant*):   0,5   →   0,5   + 1,0   = 1.5
              giving:

$$x = (-1)^1 * 2^{(129-127)} * (1.0 + 0.5) = (-1) * 2^2 * 1.5 = -1.5 * 4 = -6.0$$

x = 3.0   is represented as   1.5 * 21 , i.e.
              sign bit (*sign*):   0 (positiv)
              Exponent (*ex*):   128   →   128   − 127   = 1
              Mantisse (*mant*):   0.5   →   0.5   + 1.0   = 1.5
              also:

$$x = (-1)^0 * 2^{(128-127)} * (1.0 + 0.5) = (+1) * 2^1 * 1.5 = 1.5 * 2 = 3.0$$

x = -2.25   is represented as   -1.125 * 21 , i.e.
              sign bit (*sign*):   1 (negative)
              exponent (*ex*):   128   →   28   − 127   = 1
              mantissa (*mant*):   0.125 →   0.125 + 1.0   = 1.125
              giving:

$$x = (-1)^1 * 2^{(128-127)} * (1.0 + 0.125) = (-1) * 2^1 * 1.125 = -1.125 * 2 = -2.25$$

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x = -0.25   is represented as   -1.0 * 2^{-2} , i.e.
    sign bit (*sign*): 1 (negative)
    exponent (*ex*): 125 → 125 − 127 = -2
    mantissa (*mant*): 0.0 → 0.0 + 1.0 = 1.0
    giving:

$$x = (-1)^1 * 2^{(125 - 127)} * (1.0 + 0.0)$$

$$= (-1) * 2^{-2} * 1.0$$

$$= -1.0 * \frac{1}{2^2}$$

$$= -1.0 * \frac{1}{4}$$

$$= -0.25$$

Encoding of the three formula components in the four bytes

1st byte (first byte)							
Bit 7 MSB	Bit 6	Bit 5	Bit 4	Bit3	Bit 2	Bit 1	Bit 0 LSB
S	E_7	E_6	E_5	E_4	E_3	E_2	E_1

2nd byte (second byte)							
bit 7	bit 6	bit 5	bit 4	Bit3	bit 2	bit 1	bit 0
E_0	M_{22}	M_{21}	M_{20}	M_{19}	M_{18}	M_{17}	M_{16}

3rd byte (third byte)							
bit 7	bit 6	bit 5	bit 4	Bit3	bit 2	bit 1	bit 0
M_{15}	M_{14}	M_{13}	M_{12}	M_{11}	M_{10}	M_9	M_8

4th byte (fourth byte)							
bit 7	bit 6	bit 5	bit 4	Bit3	bit 2	bit 1	bit 0
M_7	M_6	M_5	M_4	M_3	M_2	M_2	M_1

- The bit S in the first byte contains the sign bit
- The bits E7 – E0 in bytes 1 and 2 form the exponent
- The bits M22 – M0 in bytes 2 - 4 form the mantissa

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The following 4 bytes were received:

(Byte 1)   (Byte 2)   (Byte 3)   (Byte 4)

(first byte received)   (last byte received)

0x3F   0x40   0x00   0x00

0011 1111b   0100 0000b   0000 0000b   0000 0000b

0   011 1111   0b   100 0000   0000 0000   0000 0000b

S=0   E=0111 1110b   M=100 0000 0000 0000 0000 0000b

S=0   E=0x7E (dec.126)   M=0x400000
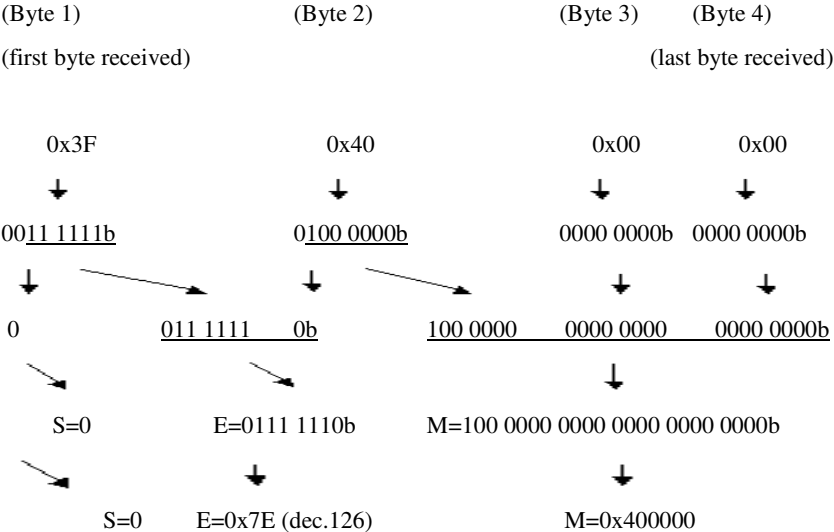
The value in the mantissa field is interpreted as places after the decimal point in the following way:

1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 b

$1 * 2^{-1}$
$0 * 2^{-2}$
$0 * 2^{-3}$
$0 * 2^{-4}$
$0 * 2^{-5}$
etc.

$0 * 2^{-23}$
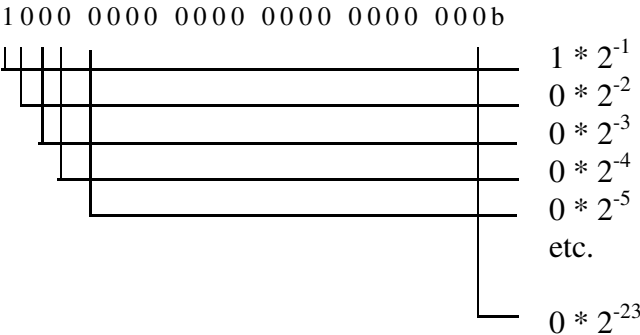
The float value can now be calculated using equation 71.1:

$$x = (-1)^0 * 2^{(126-127)} * (1.0 + 0.5)$$

$$x = 1 * 2^{-1} * 1.5$$

$$x = \frac{1}{2^1} * 1.5$$

$$x = \frac{1}{2} * 1.5 = \underline{0.75}$$

The byte combination 0x3F 0x40 0x00 0x00 equals float value +0.75 .

8.2.2.4   Calculation tip

This calculation can be performed relatively easily by bit manipulation directly at the binary level using the following sequence of operations:
First, as described above, the three components of sign bit, exponent and mantissa must be obtained from the four bytes by copying and masking bits.
Example: As described above, the bytes 0x3F,0x40,0x00,0x00
become
sign=0, exponent=0x7E(126dec), mantissa =100 0000 0000 0000 0000 0000b or (0x400000)

Calculating the exponent value
by subtracting 0x7F (127dec) from the contents of the exponent field
Example: Contents_ExponentField – 127dec = Exponent value
126dec – 127dec = -1

Adding the 1.0 i.e. inserting a 1 and a decimal point in front of the mantissa
Example: Mantissa was 100 0000 0000 0000 0000 0000b
new mantissa is 1.100 0000 0000 0000 0000 0000b

Taking into account the exponent.
A negative exponent shifts the decimal point to the left, a positive exponent to the right. Thus, if an exponent of -3 was calculated, the decimal point is shifted three places to the left; for an exponent of +1 the decimal point moves one place to the right.
Example: Mantissa was: 1.100 0000 0000 0000 0000 0000b
Exponent was: -1
new mantissa with exponent is: 0.1100 0000 0000 0000 0000 0000b

Calculating the integer positions
The integer positions (places in front of the decimal point) are interpreted in a similar way to above as positive powers of two which are added together:
Example: integer position of: 0.1100 0000 0000 0000 0000 0000b
is 0b
$$0*2^0 + [0*2^1 +0*2^2+0*2^3 ...] = \underline{0}$$

Calculating the number of decimal places

Like the integer positions, the decimal positions also represent powers of two, but in this case negative powers.

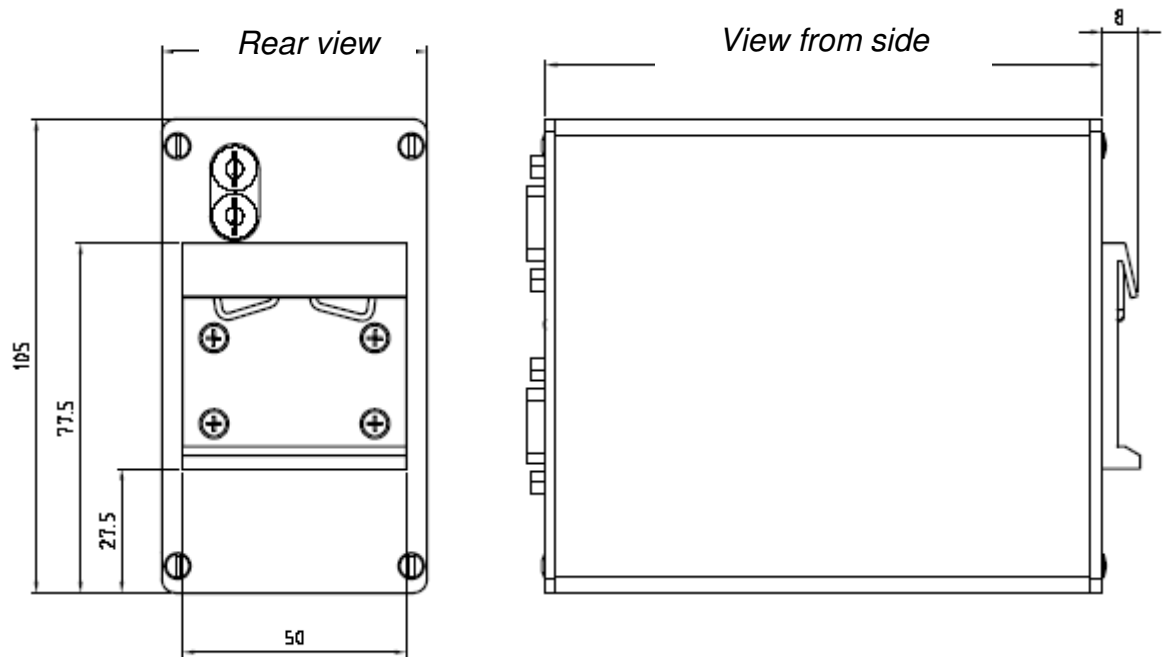*Example:*   decimal position of: 0.1100 0000 0000
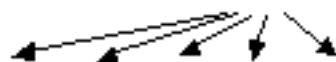
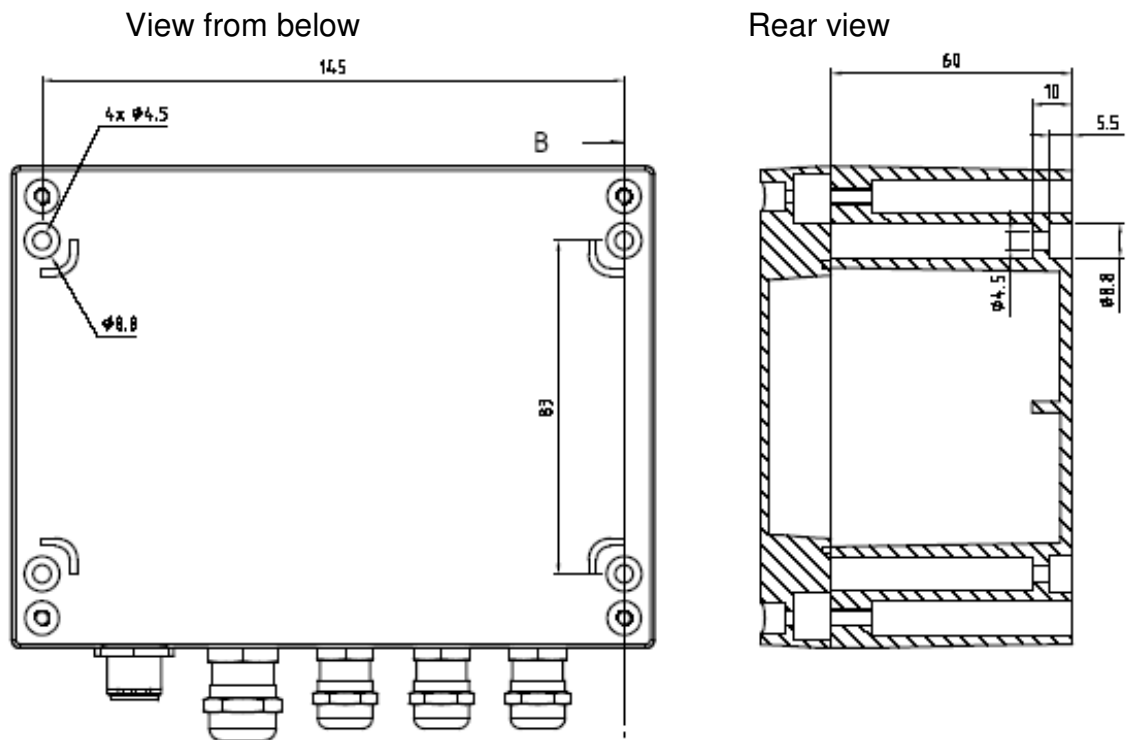0000 0000 0000b

is 1100 0000 0000 0000 0000 0000b

$$1*2^{-1} + 1*2^{-2} + 0*2^{-3} + [0*2^{-4} + 0*2^{-5} + .. =1*0.5 + 1*0.25 + 0*0.125 \,[...] = \underline{0.75}$$

9 Dimensioned drawings

9.1 IP-20 version

Rear view

View from side

9.2 IP-65 version

View from below

Rear view

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View with fixing clips for rail mounting, type 9221-Z001

Side view

View from below

Mounting plate
155x100x5
for clips/IP65
enclosure

Clip fastening

IP65

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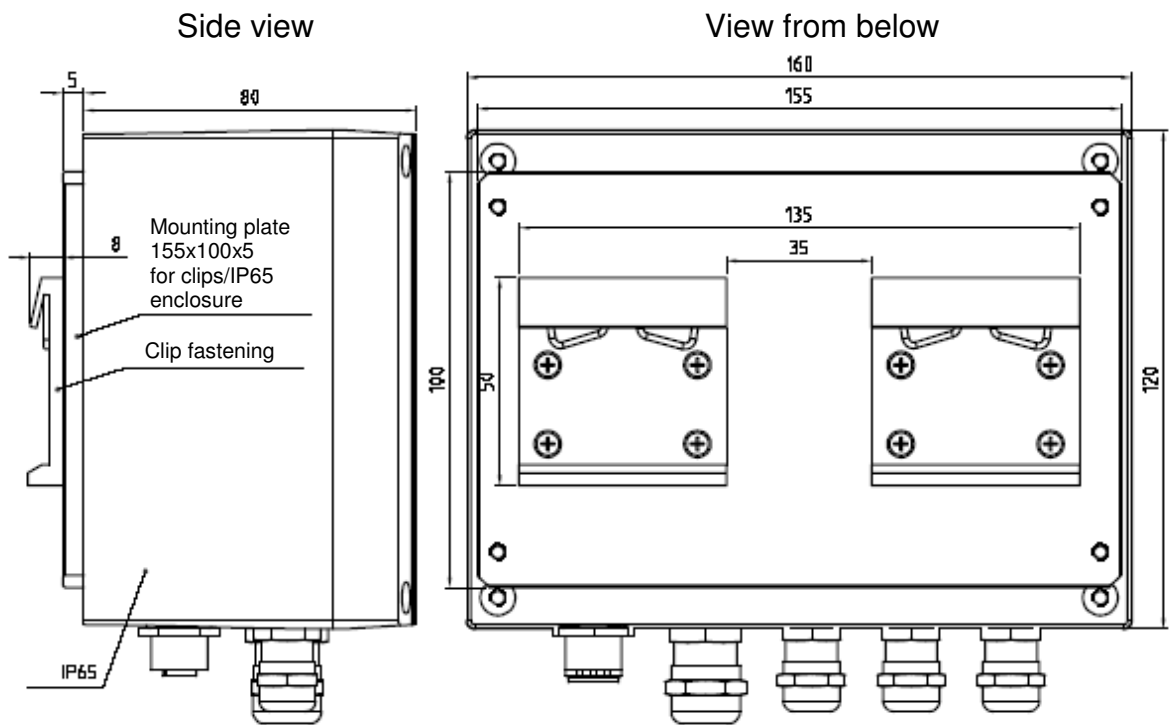
10   Appendix

10.1   Recommendations for use

A few recommendations for use are illustrated briefly below for the Sensor Profibus Module type 9221 so as to obtain the best measurement quality. In addition, the examples should make it easier to use the system in practice.

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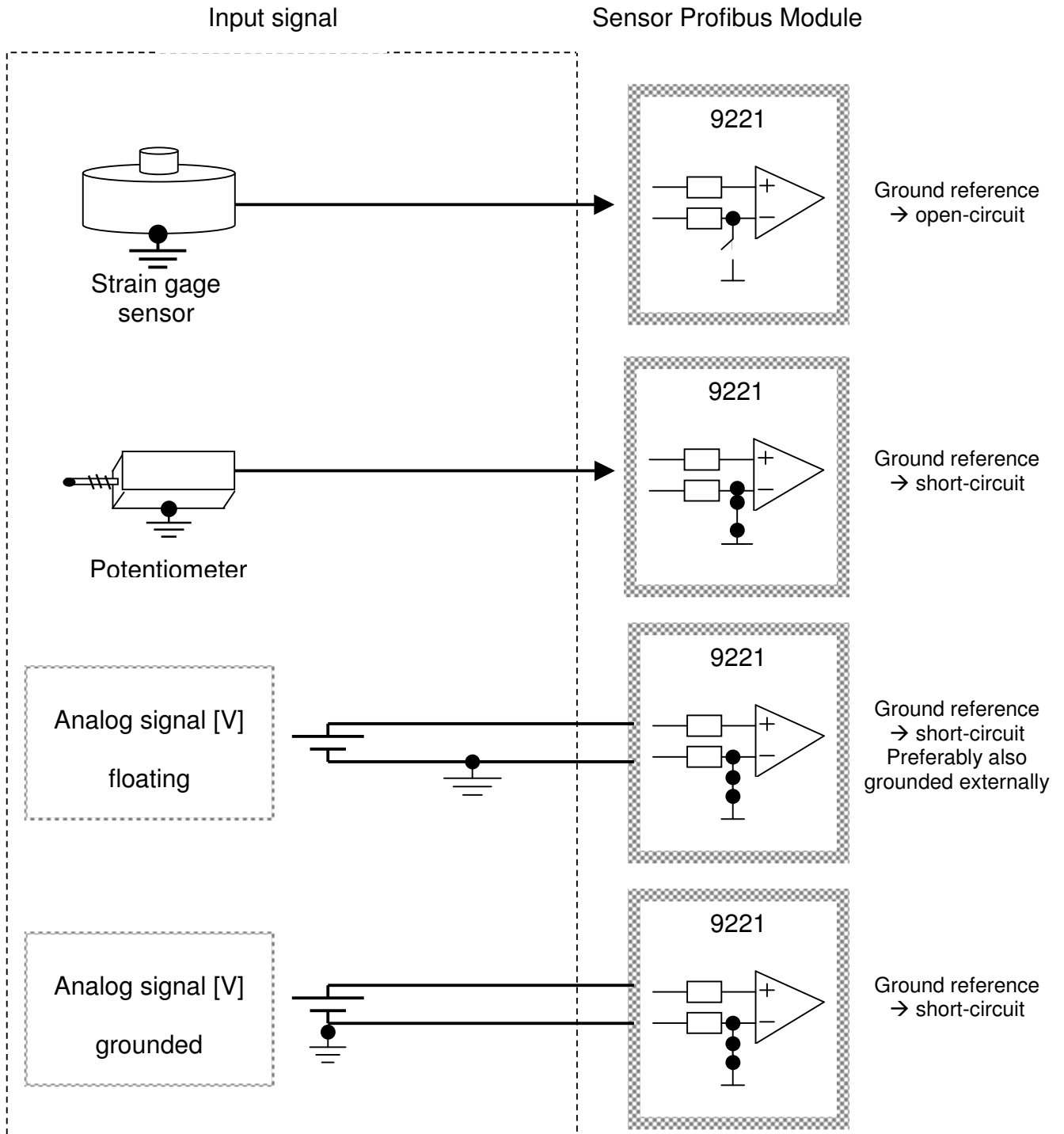
10.2.   Display of measurement results

10.2.1   Introduction

Unlike analog displays of measurement signals in which the measured quantities are represented continuously as electrical signals, only discrete values representing the result of the quantization (digitization) exist when measurement signals are shown on a digital display. Information loss is inevitable as a result of quantization.

In this case, the analog-digital conversion is performed with a bipolar 16-bit ADC (analog-digital converter), which means that 13-digit binary numbers are assigned to the quantization levels obtained by quantization.
A thirteen-digit binary number can represent a range from 0 to 2^{15}-1 = 32767. The relative quantization error for a thirteen-bit digital signal equals
2^{-15} = 1 / 32768 = 0.0031 %. This assumes, however, that the full input range of the ADC is always used.

10.2.2   Dependence of the quantization error on input drive level

Let us assume that a load cell with an upper range value of 50 kN and a sensitivity of 2 mV/V is connected to a Sensor Profibus Module 9221, whose input range is set to 12.5 mV and which supplies the load cell with an excitation voltage of 5 V.

For an applied force of 14 kN, the output signal of the load cell can be calculated as

$$Us = \frac{14kN}{50kN} \cdot 2mV/V \cdot 5V = 2.8mV$$

Hence the input of the Sensor Profibus Module 9221 is driven at

$$\frac{2.8mV}{12.5mV} = 22.4\%$$

This means that the quantization error should be taken into account when assessing the maximum achievable measurement quality, because the displayed value range now only extends from 0 to 7340 (32768 * 22.4 % / 100 %). In this case the relative quantization error now equals 1 / 7340 = 0.014 %.

If one had selected the input range of the Sensor Profibus Module 9221 to be 5 mV , the relative digitization error would be much lower, namely 1 / 18350 = 0.0054 %.

- It is fundamentally important to select the smallest possible input measurement range in order to drive the ADC optimally.
- The input measurement range is *not* based on the upper range limit of the sensor but on the actual output voltage from the sensor for the expected load.

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10.2.3   Increasing the resolution by averaging and filtering

In measurement mode it is also possible to calculate mean values. This improves the resolution by the factor $\sqrt{N}$, where N is the number of single measurements.

Let us assume that the force to be measured is again 14 kN, driving the input at 22.4 %, and mean values are being calculated from N=10 single values. The achievable resolution then equals
(1 / 1834) : 3.16 = 1 / 5795 = 0.017 %.

Of course one cannot increase the resolution indefinitely because physical limits such as noise come into effect. The instrument-dependent ceiling is about 50 000 digits, which is only achieved using suitable measurement facilities under optimum laboratory conditions. Obviously it can still make practical sense to select a value of N = 1000 for quasi-static processes. (max. 6500 are possible).

• The resolution of the transferred measurements does *not* equal the quantization error; this error can be significantly higher and must always be taken into account.

The resolution can also be improved by *enabling a low-pass filter*. The filter is a digital filter, which can be thought of as performing a weighted, smoothing averaging. The lower the cut-off frequency, the more values are averaged, the better the resolution. Of course the same physical limits apply here too.

• The smallest possible cut-off frequency should be selected for optimum measurement quality.

10.2.4   Optimum device configuration

• *Ensure the sensor drives the instrument over its full input range while keeping in mind the actual load on the sensor*

• *Select the smallest possible cut-off frequency or the best possible averaging*

• *Reduce accordingly the number of decimal places to be evaluated*

10.3   Factory settings

Value	Default setting
Units string	"N"
Station name	"Station name"
Program name	"Program name"
Instrumentation amp setting	10 mV range
Excitation setting	2.5 V
Shunt setting	Open (→ strain gage)
Number of averages	100 (→ 10/s)
Measurement function	DC
Input A function	None
Input B function	None
Lower limit	0.0
Upper limit	0.0
Tare value	0.0
Sensor test reference value	0.0
Sensor test tolerance value	0.0
Evaluation type	Dynamic
Filter	50 Hz
Scale: Lower scale value	0.0
Scale: Upper scale value	1.0
Scale: Lower calibration value	0.0
Scale: Upper calibration value	1.0
PROFIBUS-ID	2
Full calibration factor	1.0
Full calibration offset	0.0

These values are set by invoking the command DEFA! and then saving them in the EEPROM using the command SEPR!.

10.4   Maintenance, Customer service and Warranty

10.4.1   Maintenance

The Sensor Profibus Module requires no maintenance by the user. Any repairs that may be needed must be performed only at the manufacturer's premises.

Cleaning

Please do not use any cleaning agents that contain organic solvents or concentrated inorganic constituents.

10.4.2   Customer service

Please supply the serial number and software version when contacting the manufacturer with technical queries. Only then can the manufacturer find out the

technical status of the equipment and hence provide help quickly. The serial number is shown on the rating plate.

10.4.3   Factory warranty

burster präzisionsmesstechnik gmbh & co kg guarantees trouble-free operation of the unit for 24 months after delivery.
Any repairs required during this time will be made without charge.

If the instrument needs to be returned for repairs, please note the following requirements for packing and shipping: if you have a problem with the instrument, please attach a note to the case summarizing the fault.

Damage caused by improper use of the equipment is not covered by the warranty.

The technical data can change at any time without notification.
We also state explicitly that we do not accept liability for consequential damage.

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10.5 Accessories and options

Accessories	Order code
➢ Configuration software (included in deliverables)	*type 9221-P001*
➢ Module power supply, 230 VAC / 24 VDC, 250 mA	*type 9244-Z001*
➢ Data cable for connecting Sensor Profibus Module to a PC	*type 9900-K333*

Accessories for IP-20 version

➢ Connector for PLC interface, 9-pin sub-min D	*Type 9900-V181*

Accessories for IP-65 version

➢ Male coupling connector for PLC interface, 5-pin M12	*type 9900-V225*
➢ Female coupling connector for PLC interface, 5-pin M12	*type 9900-V525*
➢ Snap-fit rail-mounting kit	*type 9221-Z001*

Options	
Calibration of a complete measuring chain	*type 9221-Z001*

This service includes calibration of the Sensor Profibus Module for the sensor ordered with it or for the sensor data provided by the customer (e.g. sensitivity, excitation voltage, or sensor test certificate, Profibus baud rate).

10.6 Contact details for queries

If you have any questions relating to the Sensor Profibus Module type 9221, please contact your representative or go directly to your nearest branch office of burster präzisionsmeßtechnik gmbh & co. kg.

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