Sensors and measuring amplifiers

Operating manual

Stand:	01.09.2024
Version	ba-sensors-v1.5-en
Editor	Holger Kabelitz
Changes	Changelog Seite 12

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Introduction

This document describes the connection and commissioning of force sensors, torque sensors, strain sensors, and other sensors equipped with a strain gauge full bridge. These (passive) sensors are connected to a measuring amplifier that converts the output signal of the Wheatstone bridge, e.g. into an analog output signal ±10V, or 4...20mA, or makes it available in digital form on a digital interface, e.g. USB.

This document describes the pin assignments of typical sensors, as well as the pin assignments of frequently used connectors and the color codes of frequently used connecting cables.

Different connection assignments are possible; in individual cases, the data sheet or test report of the sensor and the measuring amplifier must be consulted.

Connection diagram

Sensors with strain gauge full bridges have at least four connections:

a) the positive and negative bridge supply +Us and -Us,

b) the positive and negative output signal of the full bridge +Ud and -Ud,

c) some sensors also have so-called sense lines +Uf and -Uf to measure and compensate for the voltage drop of the bridge supply over the length of the connection cable,

d) some sensors have a digital data sheet "TEDS" (Transducer Electronic Datasheet), which can be used by measuring amplifiers to adjust the output signal,

e) other possible lines, such as an additional connection for self-testing or shunt calibration, are not covered in this document. To put the sensor into operation, the connections of the sensor must be connected to the connections of the same name on the measuring amplifier. Figure 1 shows the connection plan. Table 1 shows the usual names for the connections.

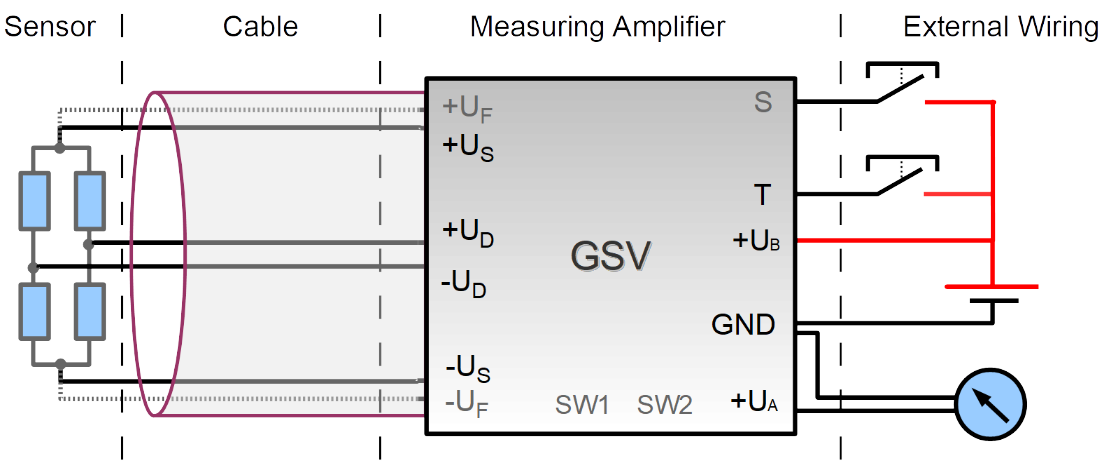

Figure 1: Connection of the sensor to the measuring amplifier

Notes

- Please use a shielded cable for the sensor.
- The shield of the sensor cable is applied to -US or GND or on a provided terminal.
- The wires of + UB and GND, as well as wires of + UA and GND should be installed in pairs.
- The GND terminal has to be assigned twice for some amplifiers.
- A low-noise and stabilized power supply is required. Please use separate power supplies for sensors and actuators.
- For sensors with shielded connectors the shield is only applied at the sensor: the sensor is grounded or connected to GND.

Pin assignment sensor

	Designation Sensor	Designation GSV	Note
$-U_S$	negative bridge supply (-Excitation, -Input)	negative bridge supply	-Us is connected to GND for some amplifiers
$+U_S$	positive bridge supply (+Excitation, +Input)	positive bridge supply	For most measuring amplifiers the positive bridge supply is 5V DC or 2.5V DC.
$+U_D$	positive bridge output (+Output)	positive differential input	The positive signal of the sensor bridge output is connected to the positive differential input of the GSV.
$-U_D$	negative bridge output (-Output)	negative differential input	The negative signal of the sensor bridge output is connected to the negative differential input of the GSV.
$-U_F$	negative sensor cable (-Sense)	negative sensor cable	The sensor cable $-U_F$ of the sensor can be parallel connected with -Us if there is no input at the measuring amplifier.
$+U_F$	positive sensor cable (+Sense)	positive sensor cable	The sensor cable $+U_F$ of the sensor can be parallel connected with +Us if there is no input at the measuring amplifier.

Table 1: Wiring diagram for the connection of the sensor to the measuring amplifier

For measuring amplifiers with connections for sensor cables (6-wire connection) a bridge from $-U_S$ to $-U_F$ and a bridge of + U_S to + U_F can be connected, if the sensor is made in 4-wire technology.

Pin assignment of the measuring amplifier

Measuring amplifiers with analog output usually have a connection for the supply of electrical energy (positive operating voltage +UB and ground GND), as well as a connection for the analog output signal +UA. Depending on the model of the measuring amplifier, a

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separate connection terminal is available for the ground of the output signal and for the ground of the operating voltage, or a common connection is used for both grounds.

Other possible inputs are, for example, "Tara" (T) for automatic adjustment of the zero signal offset and "Scale" (S) for automatic adjustment of the currently applied input signal to 100% of the output signal. Table 2 shows the connection plan of the measuring amplifier.

	Designation	Example	Type
$+U_B$	positive operating voltage	12V DC or 24V DC	input
$+U_A$	analog output	±10 V or 4..20mA or 0...10V	output
T	Tara (zero setting input)	connect the operating voltage for 2 s. Triggering on falling edge	input
S	Scale (autoscale input)	connect the operating voltage for 3 s. Triggering on falling edge	input
GND	ground		Reference potential for operating voltage and output signal

Table 2: Wiring diagram for the connection of the measuring amplifier with operating voltage and with external signal processing.

Color codes for connection cable

Table 3 shows commonly used color codes for the connecting cables of strain gauge sensors.

		Color code Nr.				
	Description	1	2	3	4	5
$+U_S$	positive bridge supply	**brown**	**brown**	**red**	**red**	**green**
$-U_S$	negative bridge supply	**white**	**white**	**black**	**black**	**black**
$+U_D$	positive bridge output	**green**	**blue**	**green**	**green**	**white**
$-U_D$	negative bridge output	**yellow**	**black**	**white**	**yellow**	**red**
$+U_F$	positive sensor cable	**pink**			**blue**	**yellow**
$-U_F$	negative sensor cable	**gray**			**white**	**blue**

Table 3: Color codes for sensor cable

Plug connector

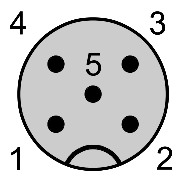

Figure 2: pins of connector M12

TEDS ground is connected to -Us.

5-pin round plug connector, „M12“, Binder, series 713

		Farbcode-Nr		
Pin-Nr	Description	1	2	3
1	$+U_S$ positive bridge supply	brown	brown	red
2	$-U_S$ negative bridge supply	white	white	black
3	$+U_D$ positive differential input	green	blue	green
4	$-U_D$ negative differential input	yellow	black	white
5	TEDS input			

15-pol SubD15HD

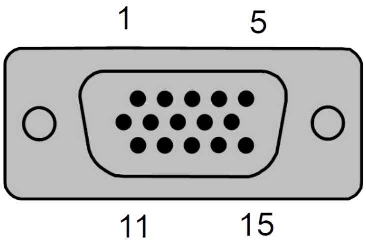

Figure 3: pins of plug SubD15HD

		Farbcode-Nr.		
Pin-Nr	Beschreibung	1	2	3
1	TEDS			
2	$-U_S$ negative bridge supply	white	white	black
3	$+U_S$ positive bridge supply	brown	brown	red
5	$+U_D$ positive bridge output	green	blue	green
7	$-U_F$ negative sense line	grey		
8	$+U_F$ positive sense line	pink		
10	$-U_D$ negative bridge output	yellow	black	white
Shield	Housing	transparent	transparent	transparent

15-pol SubD15

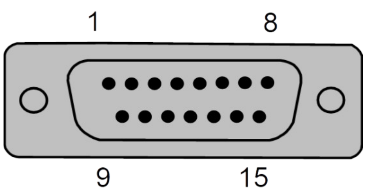

Figure 4: pins of plug SubD15

		Farbcode-Nr		
Pin-Nr	Beschreibung	1	2	3
5	$-U_S$ negative bridge supply	white	white	black
6	$+U_S$ positive bridge supply	brown	brown	red
8	$+U_D$ positive bridge output	green	blue	green
12	$-U_F$ negative sense line	grey		
13	$+U_F$ positive sense line	pink		
15	$-U_D$ negative bridge output	yellow	black	white
Shield	Housing	transparent	transparent	transparent

Sensors with analog output

Sensors with analog output 0...10V or 4...20mA

		Colour code no.			
	Description	1	2	3	4
$+U_b$	Supply voltage 24V DC	brown	brown / 1	brown	brown / 1
GND	Ground	white	white / 2	green	blue / 3
$+U_A$	Output signal 0...10V / 4...20mA	green	blue/ 3	white	white / 2
Tara	Control input for zero adjustment	yellow	black / 4	yellow	black / 4
Scale	Control input for gain adjustment	grey	grey / 5	grey	grey / 5
SW	Threshold output	pink			

Direction of the output signal

The direction of the output signal (e.g. positive output signal at compression load) can be reversed for passive sensors with strain gauges full bridges (e.g. negative output at compression load), by changing the wires + UD and-Ud at the inputs of the measuring amplifier. For sensors with analog output, the direction cannot be reversed. Variants with zero adjustment to 5V resp. 12mA recommended to enable pressure and tension measurement.

Commissioning the measuring system

- Installation of the sensor and the measuring amplifier to the correct positions.
- Connect the sensor to the measuring amplifier according to the wiring diagram in table 1.
- Connect the measuring amplifier with operating voltage and signal processing according to the wiring diagram in table 2.
- Setting of zero of the output signal by triggering the automatic zero setting function "Tara".

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Scaling of the output signal

The relationship between input quantity (e.g., force, torque or strain) and output signal is determined by the following characteristics of sensor and measuring amplifier:

- measuring range of the sensor (e.g. 100N)
- output signal (characteristic value) of the sensor (e.g. 0,9950 mV/V per 100N)
- measuring range (Input sensitivity) of the measuring amplifier (e.g. 2,0000 mV/V)
- Output signal of the measuring amplifier at 100% modulation of the measuring range (e.g. 10,00V)

Example 1, measuring amplifier with voltage output

$$\frac{100\,N}{0{,}9950\,mV/V} \cdot \frac{2{,}0000\,mV/V}{10\,V} = 20{,}10\,\frac{N}{V}$$

Example 2, measuring amplifier with current output

- Output signal of the measuring amplifier at 0% modulation of the measuring range (e.g. 4 mA)

$$\frac{100\,N}{0{,}9950\,mV/V} \cdot \frac{2{,}0000\,mV/V}{16\,mA} = 12{,}56\,\frac{N}{mA}$$

For measuring amplifiers with analog output the maesuring range can be adjusted by setting a jumper on e.g. 1,000 mV/V or 0,5000 mV/V or 0,2000 mV/V.

For measuring amplifiers with digital output signal the scale factor and the unit can be stored in the non-volatile memory of the measuring amplifier.

To calculate the scaling factor the software GSVmulti provides an input mask for teh four characteristic variables of sensor and measuring amplifier. In the non-volatile memory of the measuring amplifier can only be stored the scaling factor and unit, not the input data.

Checking the function

The following properties can be used for checking the function in case of a malfunction.

Property	Value
Operating voltage U_B to GND	e.g. 12V DC or 24V DC
Bridge excitation voltage $+U_S$ to $-U_S$	0 mV (±1 mV)
Sensor resistance $+U_D$ to $-U_D$	e.g. 350 Ohm or 700 Ohm or 1000 Ohm (±5%)
Sensor resistance $+U_S$ to $-U_S$	e.g. 400 Ohm or 800 Ohm or 1200 Ohm (± 20%)
Sensor resistance to sensor housing	>20 MOhm

Shielding / grounding / noise amplitude

Ideally, the measuring range is from 0.. + 2 mV/V dissolved in at least 10,000 readable display steps. This means that the noise amplitude is less than 2mV/V / 10000 = 200 nV/V.

When a sensor with nominal force 100N and 2 mV/V output signal so can be read just barely 0.01N, only the third digit will fluctuate.

Resolution does not mean accuracy: temperature drift or zero point return or creep error display may vary after a few seconds, or after a loading cycle by more than 0.01 N.

Approximately 100,000 display steps are ideally possible with the GSV-8 product. The noise amplitude is approximately 20 nV/V.

The achievable resolution is dependent on the following factors

- Configuration of the measuring amplifier with regard to data rate / analog filter
- Shielding
- Grounding
- Isolation
- grounding concept
- Power supply and power supplies
- Wiring, interference
- Measuring range and mathematical operations

Tip: The software GSVmulti provides in the window "(Y-t Recorder) the ability to see the noise amplitude (max-min) and resolution (Resol.Parts.pp) instead of the actual value (ActualValue)."

Data frequency

The figure 5 shows the resolution of different measuring amplifiers under the ideal conditions at different data rates.

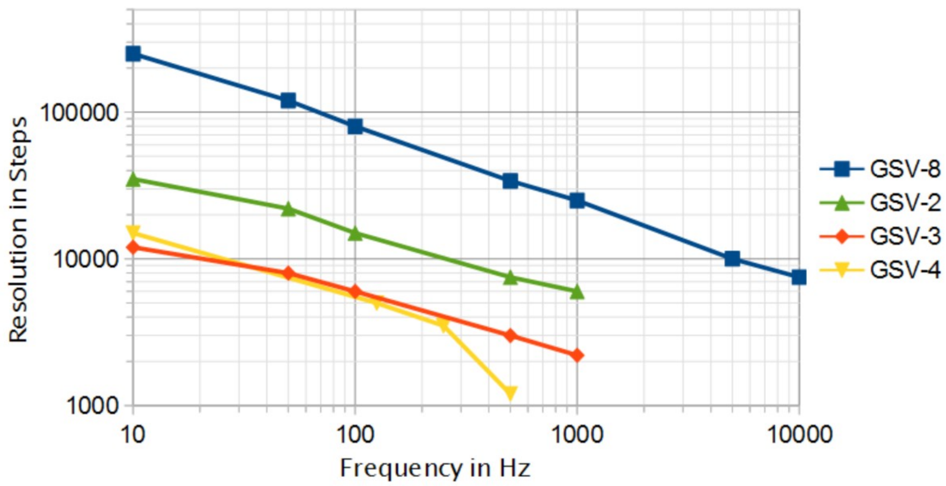

Figure 5: Resolution depending on the set data frequency

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Shielding

For sensors with strain gauges, shielded and partly twisted pairs are used. The screen is placed on the side of the measuring amplifier, e.g. On the housing of the connector (GSV-8, GSV-4) or on GND or on negative sensor power applied.

Grounding

In the case of measuring amplifiers with a USB interface, grounding the USB interface is decisive for the quality of the measuring signal. Use only notebook power supplies with grounding. Possible Action: use the supplied ground connection on GSV-8 and GSV-1USB. Test the quality of signals with power supply and in battery mode.

Isolation

The strain gauge resostors in the sensor are isolated from the sensor housing. Due to a defect (influence of humidity, vibration) the insulation resistance can be impermissibly low (<20MOhm) causing interference and noise.

Grounding concept

Especially with measuring amplifiers with analog output, a star-shaped connection to a common ground connection is crucial in order to prevent so-called ground loops.

Power supply and power supplies

The quality of the power supply and power supplies can affect the quality of the measurement signals. If possible, use the included power supplies for GSV-8 or GSV-1USB or GSV-2TSD-DI. Please use separate power supplies for actuators and sensors to ensure a good quality of the GND cables.

Cable laying, interference

If possible, bus and power cables should not be laid in parallel in a common cable duct to sensor connection cables.

Measuring range and mathematical operations

Multi-component sensors have different measuring ranges for the individual axes. Accordingly, the resolution or noise amplitude on the individual channels is different. In addition, mathematical operations have some influence on the achievable noise amplitude, e.g. For multi-component sensors, because the display for the component Fz additive is calculated from six individual channels.

Changelog

Version	Date	Changes
kb-wiringplan.odt	27.03.12	First german version
ba-sensoren-v1.0.odt	02.01.19	Layout edited; wiring diagram; commissioning;
ba-sensors-v1.0-en.odt	14.01.19	First english version
ba-sensors-v1.1-en.odt	19.03.19	Section about connectors
ba-sensors-v1.2-en.odt	21.03.19	Section about noise amplitude and resolution
ba-sensors-v1.4-en.odt	25.06.21	SubD15 connectors and active sensors added
ba-sensors-v1.5-en.odt	01.09.24	Introduction and connection plan added