Operation Manual GSB (Generic Sensor Board)

Electronic Sensor Interface to control SO-zz-xxx

Attention: Please read the manual before initial operation!

1. General

1.1. Technical data

- Microcontroller based interface circuit
- Compatible O_2-sensor types:
  - Standard: SO-zz-xxx (amperometric sensor type)
  - On request: SP-zz-xxx (ampero-potentiometric sensor type)
- External supply voltage: 12Vdc (possible range 6-25Vdc)
- Linear sensor output signal according to O2-concentration:
  - analog 0-5V (V_{out})
  - analog 4-20mA (I_{out})
  - digital via RS232
- Calibration of sensor characteristic and cold heater resistances via DIP-Switch
- Configurable sensor operation parameters (optional via RS232)
- Heater temperature control to compensate ambient sensor temperature
- Sensor connection via plug, screw terminal or directly soldered on the PCB
- several customized options (e.g. threshold switch, enhanced operation parameters, …)

1.2. Layout of GSB – terminal allocation and DIP-switch:

X3 (Power/analog):
1… [Io] 4-20mA output
2… [Uo] 0-5V output
3… [A-] analog GND
4… [+] +12Vdc supply
5… [-] GND supply

X4 (RS232):
1… TXD
2… RXD
3… GND

X1 (General IO)
1… [Vs] option +12V
2… [L] LED output
3… [Gnd] GND
4… [O2] 0-5V output
5… [L1] threshold switch 1
6… [L2] threshold switch 2
7… [L3] threshold switch 3
8… [L4] threshold switch 4

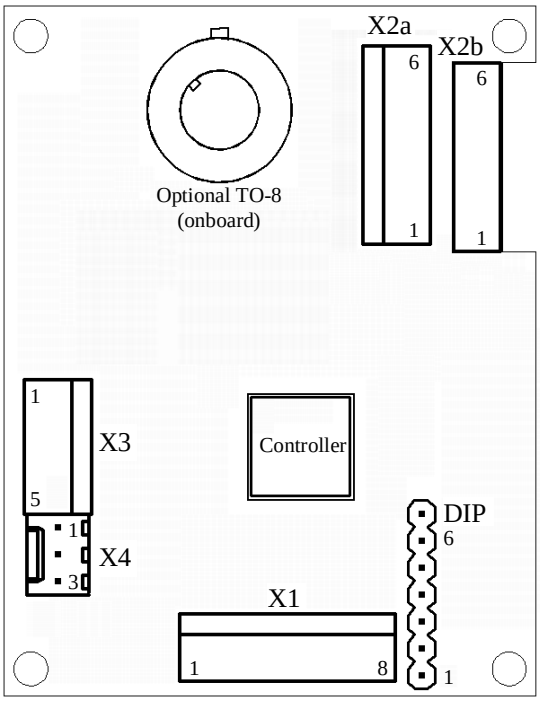


Figure 1 GSB terminal allocation

X2a/X2b Sensor extern:
1… [S-]
2… [S+]
3… [H+]
4… [HS+]
5… [HS-]
6… [H-]

DIP Switch
1… [1] sensor selection Bit 1
2… [2] sensor selection Bit 2
3… [3] sensor selection Bit 3
4… [Cal] calibration switch
5… [Pg] program switch
OFF during normal operation!
6 … not used

2. Configuration and initial operation of the GSB:

Attention: During operation the GSB should not be placed on the conducting antistatic packaging, as this could cause malfunctions.

2.1. Configuration on delivery

There a usually three different GSB configurations on delivery:

A) **Basic configuration:** Standard GSB configuration for basic laboratory measurements
- In this case the first step is to select the sensor measurement range, after that cold heater resistance and sensor characteristic have to be calibrated (see section 2.2)

B) **calibrated system**: The GSB is delivered together with a sensor as calibrated system
- In this case configuration and calibration have been fixed during factory-calibration, so section 2.2 can be skipped
- Startup of GSB and sensor can be simply done by applying power

C) **customized configuration:** GSB-configurations based on customer requests
- Initial operation procedure will be defined based on the customer requirements.

2.2. Configuration and calibration during initial operation – basis configuration

For **basic configuration** the following steps are necessary during initial operation:

0. GSB has to be disconnected from the external power supply
1. Connection of the Sensor (see section 2.4)
2. Selection of the sensor type via DIP-Switch (see section 2.5)
   - Selection of the correct measuring range (96%, 25%, 5%, 2%, 1% or 1000ppm)
   - Attention: DIP Switch „Pg“ has to be OFF, meaning program mode is not active
3. Activation of calibration mode, i.e. DIP Switch „Cal“ has to be set to ON
4. Connection of external power supply 12V and the analog output (see section 2.6)
5. GSB will perform a contact check and will then start the measurement of the cold resistance
   - The ambient sensor temperature should be about 25°C
   - In case of a recent sensor operation, the sensor should have cooled down for about 5 minutes before the GSB is powered on.
   - The GSB checks the cold resistance for about 1 minute, in case of insufficient temperature stability (e.g. sensor is still cooling down) the test time will be increased.
   - At the end of the cold resistance measurement the result will be stored permanently
6. Heat-up: GSB automatically switches to the heat-up sequence (~30 sec)
7. Start of measurement operation is indicated by permanent light up of the LED
8. During calibration the sensor has to be operated at the correct O2-calibration concentration
   - It is recommended to wait ~5 minutes, to achieve accurate calibration conditions
9. The calibration will be permanently stored as soon as the DIP Switch „Cal“ is set to OFF
10. The analog outputs should show the correct calibration result.
11. The sensor is calibrated and ready for measurements

Attention: In general the listed steps have to be done only once, they only have to be repeated if the sensor is changed. Calibration values will be stored in non-volatile memory.

2.3. Standard sequences during GSB start up

If the GSB has been configured and calibrated for the connected sensor, the startup is simply initiated by applying the external power supply.

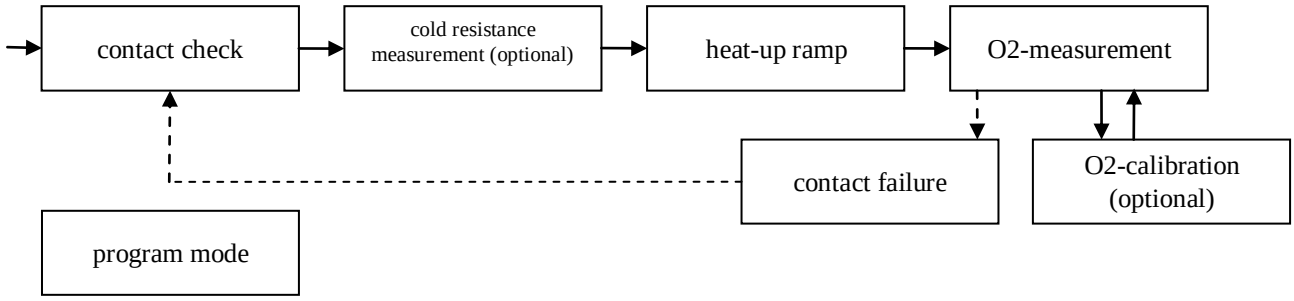


Figure 2 standard sequences during GSB start up

Optional sequences will be activated/deactivated by the position of the DIP-Switch „Cal“

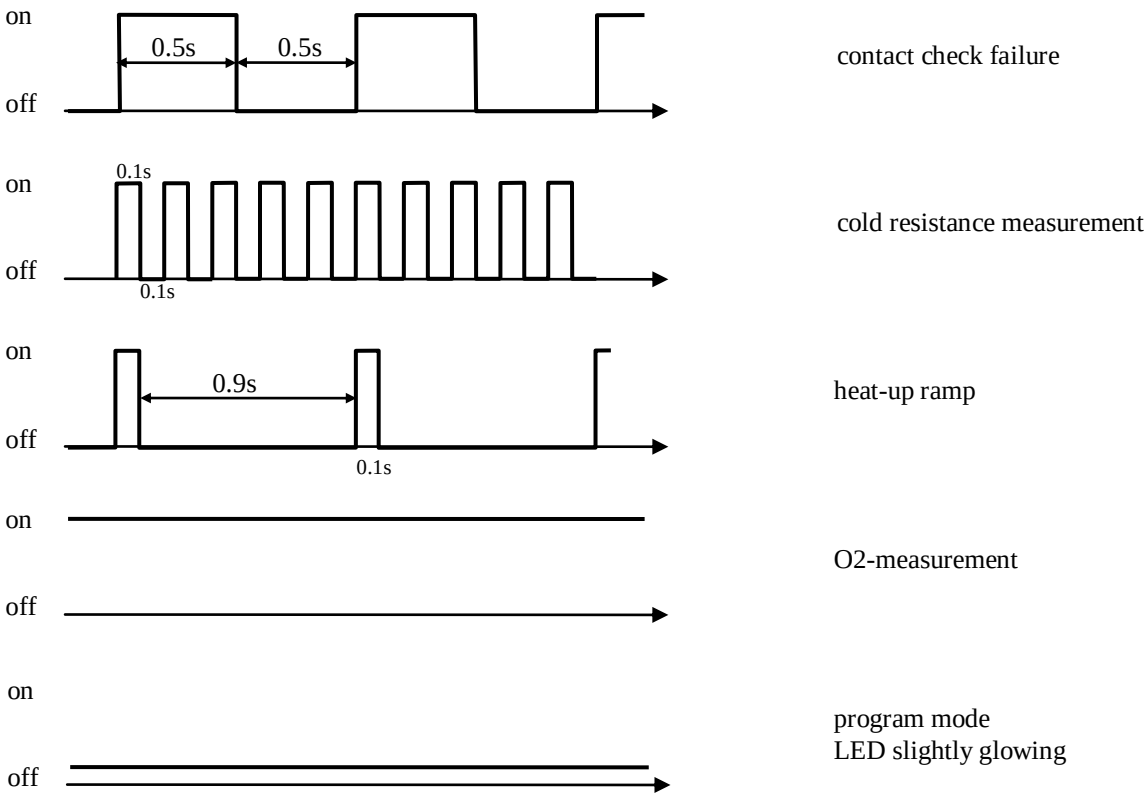


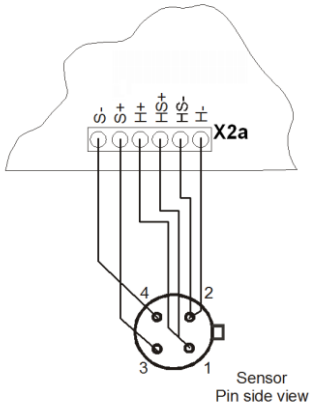
Figure 3 LED indication of standard sequences

Short description of the sequences:

- Contact check
  - Configuration and calibration values are retrieved from non-volatile memory, and a sensor contact check is performed. As long as no sensor connection is detected the GSB remains in the contact check sequence.
- Cold resistance measurement (optional)
  - Will be performed if DIP-Switch "Cal" is ON at the end of the contact check sequence
- Heat up ramp
  - Heater voltage is ramped from ~1,6V to ~3,8V over ~30 seconds
- O2-measurement (usually endless loop)
  - The O2-measurement sequence can be interrupted by
    - Optional O2-calibration if the DIP-Switch "Cal" is set to ON
    - Contact failure if the sensor connection is interrupted
- Program mode
  - Could be activated via DIP-Switch "Pg" during start up or via RS232

2.4. Sensor connection (X2a, X2b or directly soldered to PCB)

Depending on the sensor type configuration, the connection will be done via screw terminal X2a, PCB contact bar X2b or will be directly soldered to the PCB (only TO8). For the sensor operation via wires it is always necessary to use 6 wires, as the heater resistance is measured via 4 wires. The connection via X2a is shown in Figure 4. During connection via X2b correct polarity has to be considered. For soldering of a TO-8 housing it is necessary to ensure a minimum distance of 3mm between PCB and the base of the housing.



Attention: The 4-wire connection of the heater is mandatory!

For sensors with wires, the following colors apply:

black	S-	or	black	S-
red	S+	or	red	S+
white	H+	or	white	H+
white	HS+	or	yellow	HS+
violet	HS-	or	green	HS-
violet	H-	or	blue	H-

Figure 4 pin allocation of sensor

2.5. Selection of the sensor type via DIP-switch

		DIP switch bit			sensor description	GSB full scale	O2-calibration concentration	sensor voltage	heater control
	sensor type	1	2	3					
0	reserved	ON	ON	ON	-	-	-	-	
1	SO-zz-001	OFF	ON	ON	ppm	1000 vol.-ppm	1000 vol.-ppm	0.70 Volt	Rconst
2	SO-zz-010	ON	OFF	ON	1 %	1 vol.-%	1 vol.-%	0.75 Volt	Rconst
3	SO-zz-020	OFF	OFF	ON	2 %	2 vol.-%	2 vol.-%	0.75 Volt	Rconst
4	SO-zz-050	ON	ON	OFF	5 %	5 vol.-%	5 vol.-%	0.80 Volt	Rconst
5	SO-zz-250	OFF	ON	OFF	25%	25 vol.-%	20.9 vol.-%	0.85 Volt	Rconst
6	SO-zz-960	ON	OFF	OFF	96%	100 vol.-%*	20.9 vol.-%	1.60 Volt	Rconst
7	reserved	OFF	OFF	OFF	-	-	-	-	

Table 1 preinstalled sensor settings

*The specified sensor full scale concentration is 96%

The sensor type has to be selected by setting the DIP-Switch (Bit1-3). The setting is basically defined by the measurement range and not by the sensor housing. Standard setting is sensor type SO-xx-250.

2.6. Connecting external power supply and analog outputs

The external power supply has to be connected via terminal X3 (see Figure 5)

- Recommended supply voltage: 12Vdc ± 1Vdc
- Absolute Maximum rating of supply voltage
  - Maximum: 25Vdc
  - Minimum: 6V
- Operation beyond the recommended supply voltage is possible, but absolute maximum ratings should not be violated. Measurement performance and reliability of the GSB have been verified for the recommended supply voltages.

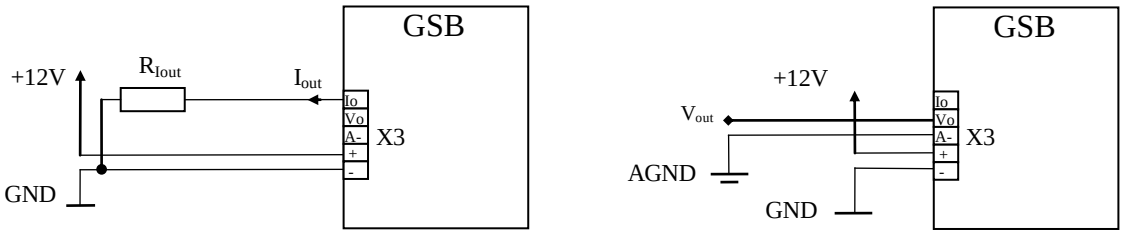


Figure 5 Connection of analog current output or analog voltage output

AGND and GND are internally connected on the GSB, load current over AGND should be avoided.

2.7. Cold resistance measurement

For basic GSB configuration and before the initial operation there is no valid cold resistance value in the non-volatile memory. In such an case even if DIP-Switch „Cal“ is OFF a cold resistance measurement during the first operation will be initiated.

A new cold resistance measurement could also be done independently from an O2-calibration:

0.-4. Same as in section 2.2

5. cold resistance measurement: GSB measures heater resistance at 25°C
   - Approx. 10sec after powering up the GSB, the DIP-Switch „Cal“ should be deactivated [OFF].
   - The Cold resistance measurement will continue nevertheless and the new resistance value will be stored in the non-volatile memory at the completion of the sequence.
6. The GSB will then switch to the heat-up ramp and afterwards into the measurement mode

- **Attention:** A change of the cold resistance calibration usually also affects the calibration of the sensor characteristic

2.8. Heat-up ramp

In the GSB basic configuration the duration of the heat up ramp is approx. 30s. After 1 minute the GSB is usually able to provide the first measurement results. For typical sensor installations it takes about 5 minutes to establish a complete thermal stabilization. Analog Outputs during heat-up:

- Voltage output shows as step from 2.5V down to ~0V, as part of an function test
- Current output is 4mA during the heat-up, also serving as a function test

Customized heat-up sequences on request.

2.9. O2-measurment

Assuming a correct calibration the analog or digital outputs will provide signals representing the measured O2-conecntration. For the calculation of the actual O2-concentration the GSB full scale value $O2_{max}$ (Table 1) will serve as reference value.

Analog voltage output 0-5V / measured output voltage Uo[V]:

$$O2[Vol.-\%] = \frac{Uo[V]}{5V} \cdot O2_{max}[Vol.-\%]$$

Analog current output 4-20mA / measured output current Io[mA]:

$$O2[Vol.-\%] = \frac{Io[mA]-4mA}{16mA} \cdot O2_{max}[Vol.-\%]$$

Digital output (RS232) 0-1000 / readout of digital result O_{RS232}:

$$O2[Vol.-\%] = \frac{O_{RS232}}{1000} \cdot O2_{max}[Vol.-\%]$$

Example - Sensor SO-xx-250 calibrated at 20.9 Vol.-% O2:

- $O2_{max}$=25 Vol.-%
- O2=20.9 Vol.-% will correspond to:
  - Uo=4.18V / Io=17.38mA / O_{RS232}=836
- O2=10,0Vol.-% will correspond to:
  - Uo=2.00V / Io=10.40mA / O_{RS232}=400

measurement overrange:

The analog voltage output allows measurements up to 120% full scale, i.e. 6V
The analog current output allows measurements up to 125% full scale, i.e. 24mA

2.10. O2-Calibration

During the O2-measurement sequence, it is always possible to perform an O2-Calibration. It will be initiated if the DIP-Switch „Cal“ is switched to ON for a short period (~1 second). As long as “Cal” is ON, the sensor should be operated at the correct calibration concentration (Table 1). The O2-measurement will be continued as soon as “Cal” is switched back to OFF. The new calibration value will be stored in the non-volatile memory.

3. RS232 Communication

3.1. RS232 Settings

Baud Rate: 19200
Parity: N
Data: 8 bit (ASCII)
Stop: 1

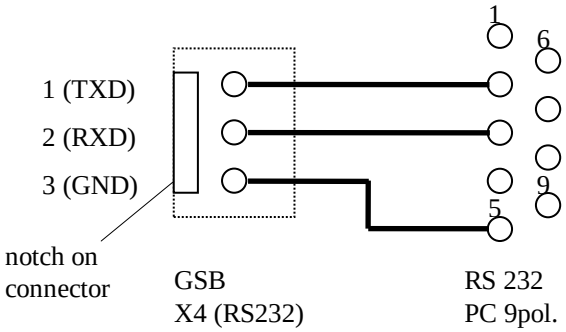


Figure 6 RS232 connection via GSB X4

3.2. Standard commands

All standard commands have a simple protocol:

Req1	Req2	Req3

Table 2 standard command (Request) to GSB has always 3 ASCII-characters and no termination

Resp1 /sign	Resp2 / digit	Resp3 / digit	Resp4 / digit	Resp5 / digit	Resp6 / digit	Resp7 0xD

Table 3 Response from the GSBs always within of 100ms and always 7 characters

- Resp1 /sign contains possible sign
  - Either ASCII „-“ for negative or space for positive sign
- Resp 2-6 /digit contains 5 digits in ASCII
- Resp 7 contains 0xD (CR) as termination

			Command availability during different sequences				
Request	description	Response	contact check	R cold measurement	heat-up ramp	O2-measurement	program mode
Sta	?GSB – Status request	yyyyy … 2-6 (see on the right)	x (2)	x (3)	x (4)	x (5)	x (6)
Prg	Switch to program mode	00001 … if successful	x	x	x	x	
Run	Switch to measurement mode	00001 … if successful					x
Cal	new O2-calibration	yyyyy … cal. current in 0,1uA				x	
O2n	?actual O2-value	yyyyy … 0-1000 (normalized)				x	
Ise	?actual sensor current	yyyyy …current in 0,1uA				x	
Vse	?actual sensor voltage	yyyyy …voltage in mV				x	
Vhe	?actual heater voltage	yyyyy …voltage in mV			x	x	
Ihe	?actual heater current	yyyyy … current in 0,1mA				x	
Tmp	?actual sensor temperature	yyyyy … in °C				x	
Rco	?cold resistance	yyyyy … in mΩ		x		x	

Table 4 Standard commands (requests) - overview

Example for a basic status request „Sta“:

Following ACSII sequence is send to the GSB

„S“	„t“	„a“

GSB is responding within 100ms:

„ „	„0“	„0“	„0“	„0“	„5“	0xD

„00005“ => 5 so the GSB is in sequence „O2-measurement“

3.3. EEPROM-configuration / program mode

The program mode is used to configure the GSB EEPROM, e.g. to modify sensor parameters. The corresponding commands are basically available, but detailed description will not be covered by this manual.

On request, the following possibilities for customized EEPROM-configurations can be provided:

- If the required configuration is already known, the GSB can be delivered with customized EEPROM-parameters. It is also possible to preinstall up to 8 different settings which can be selected via DIP-switch
- If flexible configuration is required for laboratory test, it is possible to provide a simple SW-interface. It would allow the reading and writing of the GSB-EEPROM based on an excel worksheet.
- Also direct programming of the GSB-EEPROM via RS232 can be implemented.

Basic procedure is explained for the reading and writing of the cold resistance value from/to the EEPROM:

EEPROM –write: word-value in address 2 (cold resistance set to 3200mΩ):

„w“	„r“	„t“	„w“	„ “	„2“	„ “	„3“	„2“	„0“	„0“	0xD

GSB Response is returning the write value:

„ „	„0“	„3“	„2“	„0“	„0“	0xD

EEPROM –read: word-value from address 2 (cold resistance):

„g“	„e“	„t“	„w“	„ “	„2“	0xD

GSB Response is the word value from address 2:

„ „	„0“	„3“	„2“	„0“	„0“	0xD

The EEPROM commands are only available in the program mode. If the EEPROM cold resistance is set 0, there will be a forced cold resistance measurement at the next start up.

4. GSB options

On Request, the following GSB-options are possible:

- GSB can be delivered with connected sensor as completely calibrated system
- Integration of the GSB in customer applications
  - Customized connectors (2,54mm grid) to replace the screw terminals
  - For higher volumes: cost optimized GSB, with only the actual required features
  - Customized interface protocols (RS232, SPI)
  - Customized FW to meet special application requirements
- Digital Outputs configured as threshold switches (open collector output up to 30V/50mA)
- SW-Interface for flexible sensor configuration (Excel / RS232-interface)
  - Standard parameters: sensor voltage, measurement range, calibration concentration
  - Enhanced heater control: constant heater- voltage/temperature/resistance/power
  - Enhanced parameters: heat-up time, averaging time, output levels, threshold values, threshold hysteresis, sensor current limitation
  - DIP-switch can be emulated via SW
- Operation with ampero-potentiometric sensors (SP-zz-xxx)
  - This GSB configuration will include some HW-modifications and a special FW-version, i.e. this configuration can then be only used for the operation of ampero-potentiometric sensors
  - Flexible configuration of the amperometric pump cycles
  - also pure potentiometric measurement mode