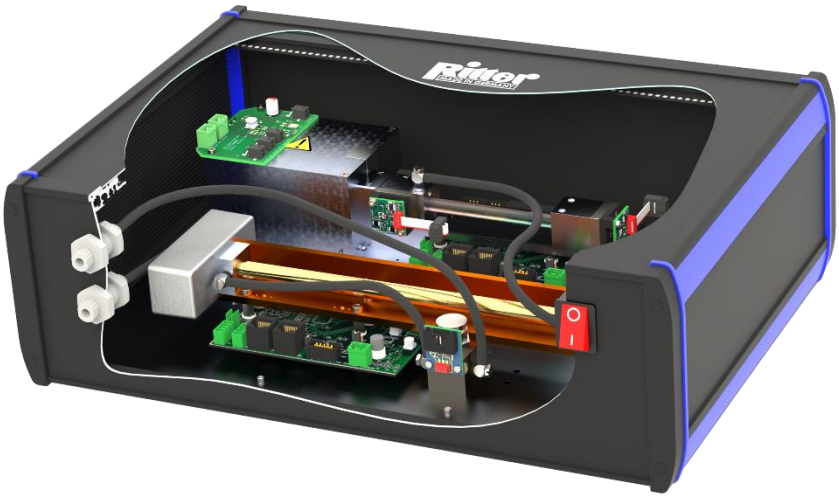

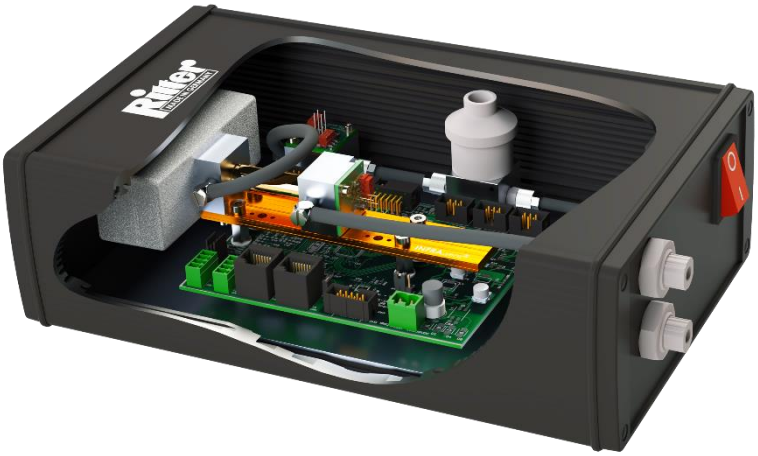

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Divisions:
Plastics engineering & manufacturing
Instruments engineering
Measuring instruments

Content

1. General Information

1.1. This Documentation

This documentation has been prepared with the greatest possible care. However, it is intended **for specialist personnel** who are familiar with the principles of gas measurement technology. Basic questions about measurements of gas concentrations, cross-sensitivities etc. can therefore not be answered with this documentation. Please consult the relevant technical literature in this regard.

1.2. Sensor environment

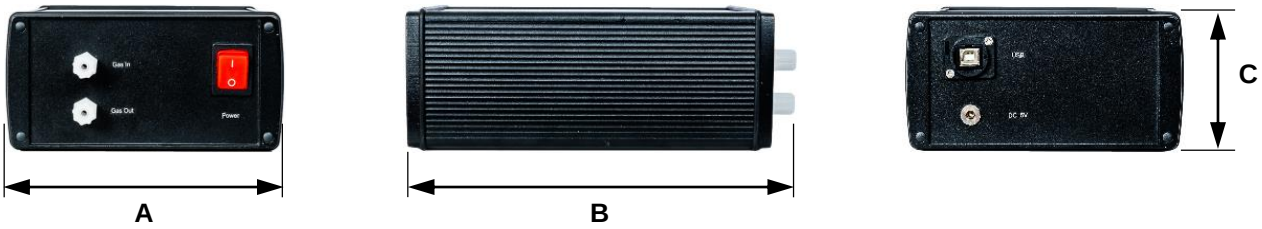
The sensor must not be used in explosive environments or in harsh environmental conditions (e.g. high condensing humidity, strong air currents, aggressive atmospheres, outdoors without housing).

Furthermore, we recommend that the basic requirements are observed with regard to the purification of the gases to be analyzed:

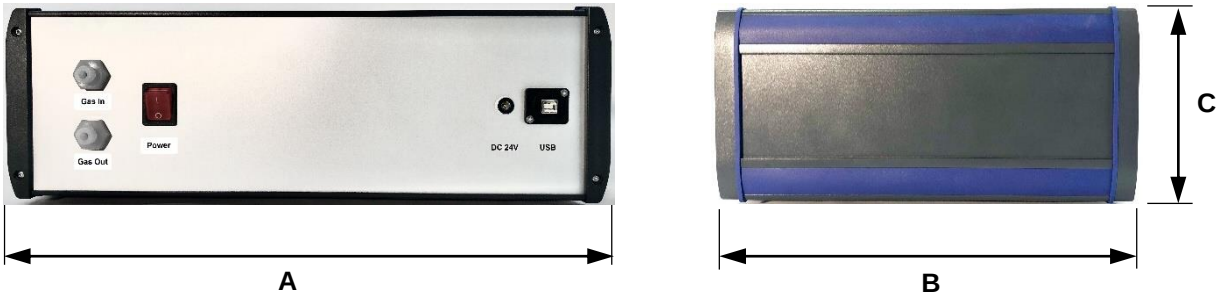
- Reliable particle filtration -inline membrane filter or similar must be checked and maintained regularly.
- Dry sample gas with less than 5°C dew point via electrical cooler and, in the case of heated modules, a condensate trap or similar if necessary.
- Stable sample gas flow between 0.01 ~ 4.0 l/min - pump without pressure fluctuation and without back pressure.

1.3. Casing Types

Type 1



Type 2



1.4. Dimensions

	Type 1	Type 2
A	171 mm	444 mm
B	290 mm [1)]	305 mm
C	86 mm	145 mm
Weight, approx. [2)]	2^{+} kg	6.5 – 8 kg
Connections gas in-/outlet	PVDF screw-type tube connection for tube Ø 4_i / 6_o mm	
Interfaces	Standard: USB Options: RS232, CANbus, CANopen	
Power supply	24 V DC, incl. plug-in power supply unit Input: 100-240 V-AC, 50/60 Hz	

[1)] May be larger with cuvettes for ppm measurement ranges
[2)] Depending on type and number of built-in sensor modules

1.5. Assignment of Sensor Types to possible Sensor Combinations

Part 1: Pre-configured sensors, incl. casing type 1 with gas connection fittings, data interface, plug-in power supply - ready for use

Part 2: Pre-configured sensors, incl. casing type 2 with gas connection glands, data interface, fittings, data interface, plug-in power supply - ready for use

Part 3: Individually combinable sensor modules, composition according to customer specification, delivery incl. housing in suitable size according to number and type of modules - ready for use

Part 4: Casings for sensor modules, assembled according to customer's specification

Part 5: Built-in options mounted inside of the casing

Part 6: Accessories / options

Part 1: Pre-configured Sensors Incl. casing type 1 with gas connection fittings, data port, power supply Ready for use					
Sensor Type: RMS-*xxx*	**Article No.**	**Group of Gases IR**	**Number of Detectable Gases in this Group**	**Group of Gases UV**	**Number of Detectable Gases in this Group**
***xxx* = mono IR1**	**2678**	CO_2 CO N_2O CH_4 C_nH_m* CF_4 SF_6	1		
***xxx* = duo IR2**	**2742**	CO_2 CO N_2O CH_4 C_nH_m* CF_4 SF_6	2		

* Calibration with Propane

Sensor Type: RMS-*xxx*	Article No.	Group of Gases IR	Number of Detectable Gases in this Group	Group of Gases UV	Number of Detectable Gases in this Group
xxx = **trio IR3**	**2743**	CO_2 CO N_2O CH_4 C_nH_m* CF_4 SF_6	3		
xxx = **mono UV1**	**2749**			SO_2 NO_2 O_3 Cl_2 ≤0.5%	1
xxx = **mono UV1 resist**	**2763**			SO_2 Cl_2 ≤30%	1
xxx = **duo UV2**	**2766**			SO_2 ≤0.5% NO_2 O_3 Cl_2 ≤0.5%	2
xxx = **duo IR1+UV1**	**2797**	CO_2 CO N_2O CH_4 C_nH_m* CF_4 SF_6	1	SO_2 NO_2 O_3 Cl_2 ≤5%	1
xxx = **trio IR1+UV2**		CO_2 CO N_2O CH_4 C_nH_m* CF_4 SF_6	1	SO_2 NO_2 O_3 CL_2 ≤0.5%	2

* Calibration with Propane

Part 2: Pre-configured Sensors
Incl. casing type 2 with gas connection fittings, data port, power supply
Ready for use

Sensor Type: RMS-*xxx*	Article No.	Group of Gases IR	Number of Detectable Gases in this Group	Group of Gases UV	Number of Detectable Gases in this Group
xxx = **mono UV1 $H_2S \leq 5.000$ ppm**	**2672**			$H_2S \leq 5.000$ ppm	1
xxx = **mono UV1 $H_2S \leq 1\%$**	**2855**			$H_2S \leq 1\%$	1
xxx = **UVRAS**	**2812**			SO_2 NO_2 NO	3
xxx = **duo IR1 + $H_2S \leq 5000$ ppm**	**2959**	CO_2 CO N_2O CH_4 C_nH_m* CF_4 SF_6	1	H_2S ≤5000ppm	1
xxx = **duo IR1 + [$H_2S \leq 1\%$ / NO]**	**2960**	CO_2 CO N_2O CH_4 C_nH_m* CF_4 SF_6	1	H2S ≤1% NO	1

* Calibration with Propane

Part 3: Individually combinable sensor modules Composition according Customer Specification Delivery incl. casing of suitable size according to number and type of modules Ready for use					
Sensor Type: RMS-*xxx*	**Article No.**	**Group of Gases IR**	**Number of Detectable Gases in this Group**	**Group of Gases UV**	**Number of Detectable Gases in this Group**
xxx = **Mod IR1**	**2813**	CO_2 CO N_2O CH_4 C_nH_m* CF_4 SF_6	1		
xxx = **Mod IR2**	**2814**	CO_2 CO N_2O CH_4 C_nH_m* CF_4 SF_6	2		
xxx = **Mod IR3**	**2815**	CO_2 CO N_2O CH_4 C_nH_m* CF_4 SF_6	3		

* Calibration with Propane

Sensor Type: RMS-*xxx*	Article No.	Group of Gases IR	Number of Detectable Gases in this Group	Group of Gases UV	Number of Detectable Gases in this Group
xxx = Mod UV1	2830			SO_2 NO_2 O_3 Cl_2 ≤0.5%	1
xxx = Mod UV1 resist				SO_2 Cl_2 ≤30	1
xxx = Mod UV1 H_2S ≤ 5.000 ppm	2841			H_2S	1
xxx = Mod UV1 H_2S ≤ 1%	2856			H_2S	1
xxx = Mod UV2	2831			SO_2 NO_2 O_3 Cl_2 ≤5%	2
xxx = Mod UVRAS	2917			SO_2 NO_2 NO	3

Part 4: Casings for Sensor Modules assembled according to Customer Specification			
RMS-Cas-2 (1)	**2817**	Casing type 2	Suitable for multiple modules 444 x 305 x 145 mm
RMS-Cas-3 (1)	**2818**	Casing type 3	Suitable for multiple modules 444 x 305 x 189mm
Part 5 Built-in Options			
RMS-O2 (2) (3)	**2795**	Oxygen Sensor	0 - 25%
	2767		0 - 100%
RMS-O2-resist (3)	**2824**	Oxygen Sensor H_2S resistant	0.5 - 35%
RMS-P (2) (3)	**2771**	Pressure Sensor	800 - 1200 mbar abs. Resolution <1 mbar
RMS-P-resist (3)	**2825**	Pressure Sensor H_2S resistant	0.2 - 3.5 bar abs. Resolution 2 mbar
RMS-H (2) (3)	**2773**	Humidity Sensor	0 - 100% RH
RMS-A/O	**2648**	Analog Voltage Output 0-2V / 0-5V / 0-10V	4 Analog output ports for 4 separate gas concentrations, 16 bit
RMS-CasHeat	**2954**	Thermostatted Casing	Heating and thermo-statting of the sensor casing at 50°C

(1) Casing type depends on the type and number of built-in sensor modules

(2) Not suitable for SO_2, Cl_2, H_2S

(3) Available as supplement to IR or UV sensor only

Casing Type 1

Casing Type 2

Part 6: Accessories / Options			
xxx = **Cal-ZP-N_2**	**2805**	Calibration Gas N_2	For zero-point calibration of all gases
xxx = **Flow-V**	**2806**	Mini Flow Valve	Control of flow rate for calibration gas bottle incl. manometer
xxx = **Cal-CG-Cat1**	**2948**	Calibration with special carrier gas (Ar, H2, He) for gases category 1	Category 1 gases: CO_2, CO < 10Vol-%, N_2O, CH_4, C_nH_m, CF_4, SF_6, O_3, CL_2, NO, NO_2, SO_2 < 10Vol-%
xxx = **Cal-CG-Cat2**	**2949**	Calibration with special carrier gas (Ar, H2, He) for gases category 2	Category 2 gases: CO > 10Vol-%, H_2S, SO_2 > 10Vol-%
xxx = **Cal-ReCal-Cat1**	**2950**	Recalibration for gases category 1	Category 1 gases: CO_2, CO < 10Vol-%, N_2O, CH4, C_nH_m, CF_4, SF_6, O_3, CL_2, NO, NO_2, SO_2 < 10Vol-%
xxx = **Cal-ReCal-Cat2**	**2951**	Recalibration for gases category 2	Category 2 gases: CO > 10Vol-%, H_2S, SO_2 > 10Vol-%

1.6. Calibrations

Depending on the number of gases to be analysed, a suitable calibration gas must be selected. Furthermore, the type of gas also influences the optimal calibration gas. Because of the almost infinite number of possible combinations, the following list should therefore only be understood as a first overview.

1. One gas: Calibration in N_2

2. Two gases:

   a) Binary gas mixture:
   Definition: The sum of the concentrations of both gases is 100%.

   The Calibration takes place in the respective other gas "gas in gas".
   (e.g. CO_2 in CH_4, CH_4 in CO_2)

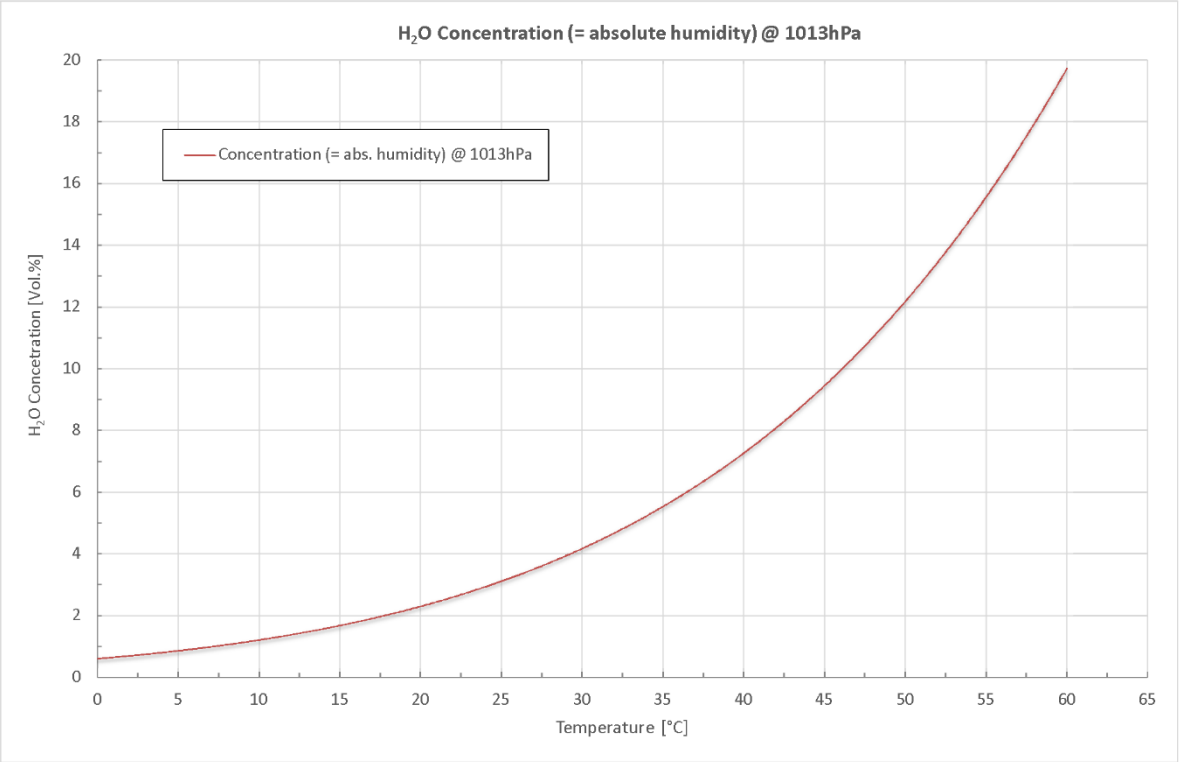
   b) For specific measuring ranges, e.g. CO_2 0-10 Vol.% and CO 0-20 Vol.%, a calibration of one gas at a time is carried out in nitrogen N_2.
   For specific measuring ranges such as CO_2 0-10 vol.% and CO 0-20 vol.%, a calibration of one gas each is carried out in nitrogen N_2. The calibration would be carried out in the above example as follows:
   - CO_2 10 Vol.% + 90 Vol.% N_2
   - CO 20 Vol.% + 80 Vol.% N_2

3. Three and more gases: The carrier gas dependency of the individual gas components must be checked individually. Then, for example, gas 1 and gas 2 can be defined as binary (and calibrated as "gas in gas") and gas 3 can be calibrated in N_2.

1.7. Measurement of Humid Gases

When measuring humid gases, it is essential to prevent condensation of the water vapour inside the sensor. The following diagram shows the maximum water vapour concentration (= absolute humidity) in volume % as a function of temperature at the standard pressure 1013 mbar.
It can be seen from the diagram:

- At room temperature, no condensation occurs up to a maximum humidity of 2 vol.%.
- Condensation occurs at concentrations above the curve shown.



Condensation can be prevented by the following measures:

- Condensate trap or gas cooler in flow direction in front of the sensor. Please note: This will increase the **dead space** in front of the sensor.
- Installation of a heating element with thermostatting in the sensor casing - see para. 8.5. With this heating element, a temperature increase of up to 45°C is possible. Thus, condensation can be prevented up to a water vapour concentration (abs. humidity) of approx. 12 vol.%. **Please note: In addition to heating the sensor, the external gas lines/tubes from the gas source to the sensor unit must also be heated.**

With the optional humidity sensor (see para. 8.3) the relative humidity can be measured in the measuring range of 0 ~ 100% rH. Furthermore, the absolute humidity can be measured as well in g/m³. Both values are displayed in the supplied software.

2. Disadvantages of electrochemical (EC) sensors in comparison to the optical gas sensors »RITTER MultiGas«

- EC sensors become "blind" over time and then display a constant value, usually zero. This suggests misleadingly a stable zero point.
- EC sensors must therefore be replaced preventatively every 0.5 - 2 years, after replacement the sensor must be recalibrated, as the tolerances of EC sensors are relatively high. This causes supplementary additional costs.
- With EC sensors, mutual influence and deterioration occur by different gases, e.g. NO_2 damages the SO_2 sensor and vice versa.
- EC sensors react very strongly to hydrogen. Such sensors are therefore unusable for accurate measurements even at the smallest concentrations of H_2 in the gas mixture.
- In many countries (e.g. in China) EC sensors are forbidden by law with governmental inspection and approval measurements, because they show too low values if they are contaminated or aged. The user then receives "false positive" values.
- The lifetime of the EC cells is already reduced during storage; therefore, the storage should only be a few weeks.
- The response time (t_{90}) is relatively long compared to the optical measuring methods - mostly about 30 sec. Optical systems are in the range < 5 sec.
- Due to the measuring principle of the EC sensors there is always a chemical reaction between the test gas and the sensor. By this reaction, small quantities of the test gas components are converted. For example, CO is converted into CO_2. With low quantities of test gas, measurements beyond the gas sensor can therefore be influenced because fewer CO molecules are present in the gas sample.

3. Preventive / Protective Measures with Gas Measurements

Important: Please specify the desired options when ordering

a) Additional tube connection for flushing of the casing

The gas lines inside the casing and the measuring cuvette are gas-tight by means of O-rings and other gas-tight connections. However, as with all connections, a leakage rate, however slight, cannot be ruled out. With an additional tube connection for flushing of the casing, an accumulation of the measuring gas inside the casing can be prevented.

In the case of **toxic or aggressive gases**, a suction line can be connected via this tube connection, which creates an under-pressure inside the housing thus preventing the gas from escaping from the casing.

In case of **ignitable gases (methane, hydrogen, etc.)**, a pressure or suction line can be connected via this tube connection creating an over- or under-pressure inside the casing thus preventing the accumulation of an ignitable gas mixture.

Please note: H2S can be perceived as an unpleasant smell even in the ppb range. Even with an O-ring seal, micro-leaks can occur, which can be extracted by flushing the housing.

b) Heated and thermostatted casing

By all means, a condensation of the measuring gas inside of the sensor must be prevented. Please refer to the information in para. 1.7 “Measurement of Humid Gases”.

Alternatively, the inside of the sensor casing can be heated and thermostatted at 50°C (standard). The heating not only avoids condensation inside of the sensor but ensures constant measurement results as well.

c) Particle filter

Please make sure by use of a suitable filter that no particles are carried into the sensor. These might block the small orifices of the internal fittings. It is recommended to use filters of 5 micron or smaller.

4. Scope of Supply

No. of Items	Item
1	Document folder including … • Calibration Certificate • Data Sheets • Software Manual
1	Sensor in table top casing
1	Plug-in power supply unit Input: 100-240 V-AC, 50/60 Hz, 0.4 A Output: 24 V-DC, 0.5 A, 12 W or 36 W (H_2S / UVRAS sensor)
1	Data acquisition software (on USB memory card)
1	Connection cable sensor ⇒ computer Standard: USB V2.0 A/B, 1 m Option: RS232, D-Sub socket 9pol. on the unit, connection cable [1x D-Sub male 9pin - 1x D-Sub female 9pin], 2 m
3 m	Viton tubing $Ø_i$ 4 mm / $Ø_o$ 6 mm

5. Setup

1. Unpack all items carefully
2. Install the data acquisition software according to the “RITTER MultiGas Software Manual”. **Don’t start the software at this point in time.**
3. Positioning of the sensor:

   a) The sensor must not be used in explosive environments or in harsh environmental conditions (e.g. high condensing humidity, strong air currents, aggressive atmospheres, outdoors without housing).

   b) If the sensor is used in combination of a RITTER MilliGascounter, the sensor must be positioned (in flow direction) in front of the MilliGascounter if this MilliGascounter is filled with HCl solution. Otherwise, the sensor could be damaged by the HCl vapour coming out of the MilliGascounter.

   c) Place the sensor next to the gas source
   Please note: A tube connection between gas source and sensors that is as short as possible allows a small dead space created by the tubing. In turn, a small dead space enables a fast response time of the sensor.
4. Connect the power adapter to socket “DC 24 V” at the rear side of the sensor and to mains.
5. Connect the data acquisition cable to the respective socket at the rear side of the sensor and to the computer:
   a) USB cable to the socket “USB”
   b) RS232 cable to the socket “RS 232” (option)
6. Connect the gas source to the gas inlet port of the sensor by using the provided tubing as follows:
   a) Remove the screw caps as well as the red rubber caps of the transport lock from the gas inlet and gas outlet.
   b) Slide the screw cap onto the end of the gas inlet tube with the thread of the screw cap facing the tube end.
   c) Push the tube onto the cone in the center of the gas inlet port.
   d) Slide the screw cap to the gas inlet port and screw it hand-tightly in place.
7. If applicable: Connect the gas outlet port of the sensor to other components such as gas sampling bags, exhaust tubing etc.
   - The connection of the tube to the gas outlet port takes place in the same way as described above.
8. Switch-on the power switch at the front side of the sensor casing.
9. Start the software and open the COM port(s) of the connected sensor module(s) according to the software manual.

The »RITTER MultiGas« Sensor is now ready for use.

6. Infrared Sensor

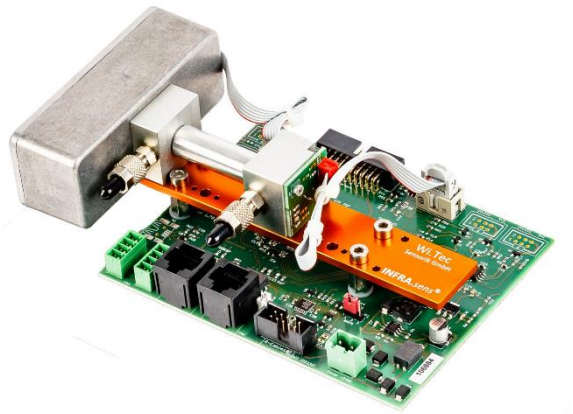
6.1. Description

Gas analysis based on the NDIR technique is an established method to determine the concentrations of gases in complex mixtures. The »RITTER MultiGas« sensors use new optical components for optimal analysis results: Up t
o 3 optical filters analyse the gas which flows through the sensor as one gas stream. The optional oxygen, pressure, and humidity sensors are in-line with the same single gas stream.

The individual internal modules are sealed by means of O-ring connections.

In order to achieve an optimum adaptation to the required measuring range, the lengths of the modular measurement cells (= cuvettes) can be implemented in the range of 5 mm (large measurement range in percentage level) up to 250 mm (small measurement range in ppm level).

Cuvettes with a length ≥ 20 mm are coated with a resistant gold layer in order to improve the reflection properties for



low concentration level detection. Cuvettes used with aggressive gases are gold-coated as well.

The other internal mechanical parts are made out of aluminium, optionally out of stainless steel.

For fast response applications the measuring system delivers a stable result within t_{90} ≈ 3 seconds.

The entire unit can be disassembled for easy maintenance/service.

6.2. Applications

- Biogas / natural gas analysis
- Environmental and Process Measurement
- TOC analysers
- Continuous Emission Monitoring (CEM)
- Elemental analysis
- Industrial gas analysis

6.3. Specifications

General features	
Measurement technology	Innovative NDIR Sensor (non-dispersive infrared sensor)
Detectable gases	CO_2, CO, N_2O, NO, CH_4, C_nH_m *, CF_4, SF_6
Number of simultaneously detectable gases	max. 3 per sensor unit
Measurement ranges	See par. 6.4 or https://www.ritter.de/en/products/sensors#ranges
Flow rate range	5 ~ 300 ltr/h For higher flow rates the sensor can be operated in bypass
Max. gas inlet pressure	300 mbar
Pressure loss (without additional optional sensors)	10 @ 100 / 35 @ 200 / 70 @ 300 [mbar @ ltr/h]

Temperature compensation	Yes
Data acquisition software	Yes
Lifetime of IR radiation source	> 40 000 h
Measurement cuvette	Aluminium, with measurement ranges ≤1% gold-plated inside
Cuvette sealing	Viton O-ring
Internal tubing	FKM / Viton ™ (fluorinated rubber)
Casing	High-quality table-top casing, aluminium
Dimensions	W x H x L 171 x 86 x 290 mm
Weight	approx. 2 kg
Gas connections	PVDF screw-type tube connection for tube $Ø_i$ 4mm, $Ø_o$ 6 mm
Measuring response	
Linearity error	< ± 1% F.S.
Repeatability	± 0.5% F.S.
Long term stability zero	< ± 2% F.S. / week
Long term stability span	< ± 2% F.S. / month
Temperature influence of zero point	< 1% F.S. / 10K
Temperature influence of span	< 2% F.S. / 10K
Cross sensitivity	< 2% F.S.
Pressure influence	< 1.5% / 10hPa of reading
Warm-up time	2 min
Response time (t_{90})	≈ 3 sec
Sampling frequency by software	≤ 10 Hz
Detection limit (3·σ)	See par. 6.5 or https://www.ritter.de/en/products/sensors#limits
Resolution	0.5 x detection limit
Water vapour	No influence with measurements of CO_2 and CH_4
Electrical features	
Power supply	24 VDC, incl. power plug 100~240 VAC, 50/60 Hz ⇒ 24 VDC
Average power consumption	< 1W
Interfaces	standard: USB options: RS232, CANbus, CANopen incl. data transmission cable 1 m
Analogue voltage output (option)	0-2V / 0-5V / 0-10V

Climatic conditions	
Operating temperature	+15 ~ +45 °C
Storage temperature	–20 ~ +60 °C
Operating pressure	800 ~ 1200 hPa (mbar)
Ambient humidity	0 ~ 95% rel. humidity **Condensing inside of sensor must be prevented!**

* Analysis of C_nH_m:
The calibration of sensors for C_nH_m will be performed with propane. Aromatic hydrocarbons are also measured but with a different weighting. This means that the sensitivity of the sensor is significantly smaller with these gases than with other hydrocarbons.

6.4. Table of Standard Measurement Ranges

Full Scale[1)]	CO_2	CO	N_2O	CH_4	C_nH_m[2)]	CF_4	SF_6	H_2O
100 vol. %	x	x	x	x	x	x	x	
50 vol. %	x	x	x	x	x		x	
30 vol. %		x	x	x	x		x	
20 vol. %	x							
10 vol. %	x	x		x	x			
5 vol. %	x	x		x	x			
2 vol. %								x
1 vol. %	x	x		x	x			
5,000 ppm	x	x		x	x		x	
2,000 ppm	x	x	x	x	x			
1,000 ppm	x	x	x	x	x		x	
500 ppm	x	x	x					
300 ppm			x					
100 ppm	x		x				x	
50 ppm	x						x	

1) Measurement range = Zero to Full Scale (FS)
Sensors are calibrated in the same range “Zero to Full Scale (FS)”

2) Calibration with Propane

Other ranges on request

6.5. Table of Detection Limits (= 3 σ) in Percent of Full Scale (FS)

Full Scale	CO_2	CO	N_2O	CH_4	C_nH_m	CF_4	SF_6	H_2O
100 vol. %	< 0.1%	< 0.2%	< 0.1%	< 0.1%	< 0.1%	< 0.2%	< 0.1%	
50 vol. %	< 0.1%	< 0.2%	< 0.1%	< 0.1%	< 0.1%	< 0.2%	< 0.1%	
30 vol. %		< 0.2%	< 0.1%	< 0.1%	< 0.1%	< 0.2%	< 0.1%	
20 vol. %	< 0.1%							
10 vol. %	< 0.1%	< 0.2%		< 0.1%	< 0.2%			
5 vol. %	< 0.1%	< 0.2%		< 0.1%	< 0.2%			
2 vol. %								0,005%
1 vol. %	< 0.1%	< 0.2%		< 0.1%	< 0.2%			
5,000 ppm	< 0.1%	< 0.2%		< 0.1%	< 0.2%			
2,000 ppm	< 0.1%	< 0.3%	< 0.1%	< 0.3%	< 0.5%			
1,000 ppm	< 0.1%	< 0.5%	< 0.1%	< 0.5%	< 0.5%			
500 ppm	< 0.1%	< 0.5%	< 0.1%					
300 ppm	< 0.1%		< 0.1%					
100 ppm	< 0.3%		< 0.3%					
50 ppm	< 0.3%							

Definition of Detection Limit

The Detection Limit is the smallest measurement value which can be obtained with a specific uncertainty. This uncertainty includes the resolution, noise and stability of the gas sensor for a specific gas and specific measurement range. For evaluation of the detection limit value, several single measurements are taken at the identical measurement conditions. With the obtained single measurement results the standard deviation “Sigma” (σ) is calculated. The values given in the table equal the triple amount of Sigma.

6.6. Recalibrations

The following recalibration intervals are recommended for IR sensors:

- Zero-point: Weekly with inert gas, e.g. Nitrogen
  The recalibration of the zero point is described in the software manual.
- End-point (full scale): Every 3 months with suitable calibration gas

7. Ultraviolet Sensors

7.1. Description

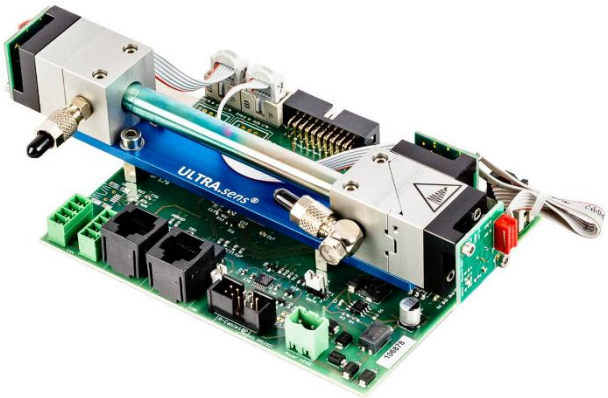
The »RITTER MultiGas« UV sensor is the world's first gas analysis module based on miniaturized UV-LEDs. The stability and lifetime of these UV-LEDs enables high-precision gas analyses down to the ppm range. By using two UV-LEDs two gases can be detected simultaneously. Furthermore, with this approach measuring ranges from ppm to Vol.-% can be realized.

In the spectral range from 200 nm to 500 nm, nitrogen oxides ($NO+NO_2$), aromatic hydrocarbons, hydrogen sulphide, ozone, sulphur dioxide and chlorine can be reliably detected with this new sensor platform.

The entire unit can be disassembled for easy maintenance/service.

The individual internal modules are sealed by means of O-ring connections.

In order to achieve an optimum adaptation to the required measuring range, the lengths of the modular measurement cells (= cuvettes) can be implemented in the range of 5 mm (large measurement range



in percentage level) up to 250 mm (small measurement range in ppm level).

Cuvettes with a length ≥ 20 mm are coated with a resistant gold layer in order to improve the reflection properties for low concentration level detection. Cuvettes used with aggressive gases are gold-coated as well.

The internal mechanical parts are made out of aluminium, optionally out of stainless steel.

For fast response applications the measuring system delivers a stable result within t_{90} ≈ 1-2 seconds.

7.2. Applications

- Biogas / natural gas analysis
- Environmental and Process Measurement
- TOC analysers
- Continuous Emission Monitoring (CEM)
- Elemental analysis
- Industrial gas analysis

7.3. Specifications NDUV Sensor

General features	
Measurement technology	Innovative NDUV Sensor (non-dispersive ultraviolet sensor)
Detectable gases	SO_2, NO_2, O_3, Cl_2
Number of simultaneously detectable gases	max. 2
Measurement ranges	See par. 7.6 or https://www.ritter.de/en/products/sensors#ranges
Flow rate range	5 ~ 300 ltr/h For higher flow rates the sensor can be operated in bypass

Max. gas inlet pressure	300 mbar
Pressure loss (without additional optional sensors)	10 @ 100 / 35 @ 200 / 70 @ 300 [mbar @ ltr/h]
Temperature compensation	Yes
Data acquisition software	Yes
Lifetime of UV radiation source	> 8 000 h
Measurement cuvette	Stainless steel with silicone coating inside
Cuvette sealing	Viton O-ring
Internal tubing	FKM / Viton ™ (fluorinated rubber)
Casing	High-quality table-top casing, aluminium
Dimensions	W x H x L 464 x 189 x 305 mm
Weight	approx. 6.5^{+} kg
Gas connections	PVDF screw-type tube connection for tube $Ø_i$ 4mm, $Ø_o$ 6 mm
Measuring response	
Linearity error	< ± 1% F.S.
Repeatability	± 0.5% F.S.
Long term stability zero N_2	< ± 1% F.S. / 24h
Long term stability span	< ± 1% F.S. / month
Temperature influence of zero point	< 1% F.S. / 10K
Temperature influence of span	< 2% F.S. / 10K
Cross sensitivity	< 2% F.S.
Pressure influence	< 1.5% / 10hPa of reading
Warm-up time	1 min (initial), <60 min for full specification
Response time (t_{90})	1.5 - 15 sec
Sampling frequency by software	≤ 10 Hz
Detection limit (3·σ)	See par. 7.7 or https://www.ritter.de/en/products/sensors#limits
Resolution	0.5 x detection limit
Electrical features	
Power supply	24 VDC, incl. power plug 100~240 VAC, 50/60 Hz ⇒ 24 VDC
Supply current (peak)	<0.4 A
Average power consumption	< 7.5 W
Interfaces	standard: USB options: RS232, CANbus, CANopen incl. data transmission cable 1 m

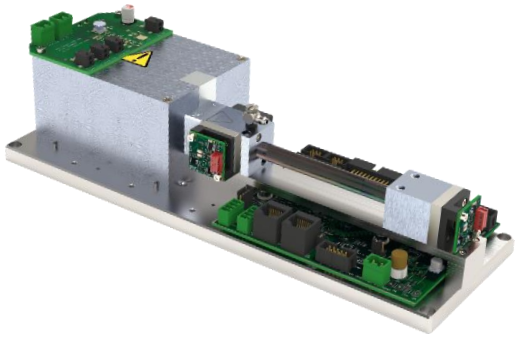
Analogue voltage output (option)	0-2V / 0-5V / 0-10V

Climatic conditions	
Operating temperature	+25 ~ +45 °C
Storage temperature	–20 ~ +60 °C
Operating pressure	800 ~ 1200 hPa (mbar)
Ambient humidity	0 ~ 95% rel. humidity Condensing inside of sensor must be prevented!

7.4. Specifications H_2S Sensor

The H_2S sensor works according to the principle of non-dispersive UV absorption (NDUV).

The measuring wavelength used is in the lower nanometer range, which enables interference-free measurements with water vapour and hydrocarbons. This makes the sensor ideal for use in biogas measurements, as accompanying gases such as NH_3, CO_2, CH_4 and H_2O do not affect the accuracy of the measurements.



General features	
Measurement technology	Innovative NDUV Sensor (non-dispersive ultraviolet sensor) Dual beam
Detectable gases	H_2S, SO_2, CH_4
Number of simultaneously detectable gases	max. 2
Measurement ranges	See par. 7.6 or https://www.ritter.de/en/products/sensors#ranges
Flow rate range	5 ~ 300 ltr/h For higher flow rates the sensor can be operated in bypass
Max. gas inlet pressure	300 mbar
Pressure loss (without additional optional sensors)	10 @ 100 / 35 @ 200 / 70 @ 300 [mbar @ ltr/h]
Temperature compensation	Yes
Data acquisition software	Yes
Lifetime of UV radiation source	> 8 000 h
Measurement cuvette	Stainless steel with silicone coating inside
Cuvette sealing	Viton O-ring
Internal tubing	FKM / Viton ™ (fluorinated rubber)
Casing	High-quality table-top casing, aluminium
Dimensions of module	W x H x L 300 x 100 x 81 mm

Weight of module	approx. 1670 g
Gas connections	PVDF screw-type tube connection for tube $Ø_i$ 4mm, $Ø_o$ 6 mm

Measuring response	
Linearity error	< ± 1% F.S.
Repeatability	± 0.5% F.S.
Long term stability zero N_2	< ± 1% F.S. / 24h
Long term stability span	< ± 1% F.S. / month
Temperature influence of zero point	< 1% F.S. / 10K
Temperature influence of span	< 2% F.S. / 10K
Cross sensitivity	< 2% F.S.
Pressure influence	< 1.5% / 10 hPa of reading
Warm-up time	1 min (initial), < 15 min for full specification
Response time (t_{90})	1.5 - 15 sec
Sampling frequency by software	≤ 10 Hz
Detection limit (3·σ)	See par. 7.7 or https://www.ritter.de/en/products/sensors#limits
Resolution	0.5 x detection limit

Electrical features	
Power supply	24 VDC, incl. power plug 100 ~ 240 VAC, 50/60Hz ⇒ 24 VDC
Supply current (peak)	< 0.4 A
Average power consumption	< 7.5 W
Interfaces	standard: USB options: RS232, CANbus, CANopen incl. data transmission cable 1 m
Analogue voltage output (option)	0-2V / 0-5V / 0-10V

Climatic conditions	
Operating temperature	+5 ~ +45 °C
Storage temperature	–20 ~ +60 °C
Operating pressure	800 ~ 1200 hPa (mbar)
Ambient humidity	0 ~ 95% rel. humidity Condensing inside of sensor must be prevented!

7.5. Specifications UVRAS Sensor

For the detection of NO an EDL (electrodeless gas discharge lamp) is used. In the EDL, N_2 and O_2 are converted to NO and produce a selective UV radiation. With this radiation, a cross-sensitivity-free NO measurement is made possible. This method is called UV resonance absorption spectroscopy (UVRAS).

A combination of both the UVRAS and NDUV technology allows the simultaneous gas analysis of NO, NO_2 and SO_2 in the lower ppm range which is particularly important in flue gas analysis (Continuous Emission Monitoring, CEM).

General features	
Measurement technology	UV resonance absorption spectroscopy (UVRAS)
Detectable gases	NO, NO_2, SO_2
Number of simultaneously detectable gases	max. 3
Measurement ranges	See par. 7.6 or https://www.ritter.de/en/products/sensors#ranges
Flow rate range	5 ~ 300 ltr/h For higher flow rates the sensor can be operated in bypass
Pressure loss (without additional optional sensors)	10 @ 100 / 35 @ 200 / 70 @ 300 [mbar @ ltr/h]
Temperature compensation	Yes
Data acquisition software	Yes
Lifetime of UV radiation sources	LED > 20 000 h (NO_2, SO_2) EDL> 8 000 h (NO)
Measurement cuvette	Stainless steel with silicone coating inside
Cuvette sealing	Viton O-ring
Internal tubing	FKM / Viton ™ (fluorinated rubber)
Casing	High-quality table-top casing type 2, aluminium
Dimensions	W x H x L 464 x 189 x 305 mm
Weight	approx. 6.5^{+} kg
Gas connections	PVDF screw-type tube connection for tube $Ø_i$ 4mm, $Ø_o$ 6 mm

Measuring response	
Linearity error	< ± 1% F.S.
Repeatability	± 0.5% F.S.
Long term stability zero N_2	< 3 ppm / 24h
Long term stability span	< ± 1% F.S. / month
Temperature influence of zero point	< 1% F.S. / 10K
Temperature influence of span	< 2% F.S. / 10K
Cross sensitivities	500 ppm NO_2 < 2ppm 100 ppm SO_2 < 2ppm 100 ppm N_2O < 10ppm 20°C D.P. H_2O < 10ppm
Pressure influence	< 1.5% / 10hPa of reading
Warm-up time	1 min (initial), <60 min for full specification
Response time (t_{90})	1.5 ~ 15 sec
Sampling frequency by software	≤ 10 Hz
Detection limit (3·σ)	See par. 7.7 or https://www.ritter.de/en/products/sensors#limits
Resolution	0.5 x detection limit

Electrical features	
Power supply	24 VDC, incl. power plug 100~240 VAC, 50/60 Hz ⇒ 24 VDC
Supply current (peak)	1.5 A
Inrush current	0.2 ~ 0.7 A
Power consumption (peak)	36 W
Interfaces	standard: USB options: RS232, CANbus, CANopen incl. data transmission cable 1 m
Analogue voltage output (option)	0-2V / 0-5V / 0-10V

Climatic conditions	
Operating temperature	+5 ~ +40 °C
Storage temperature	–20 ~ +60 °C
Operating pressure	800 ~ 1200 hPa (mbar)
Ambient humidity	0 ~ 95% rel. humidity **Condensing inside of sensor must be prevented!**

7.6. Table of Standard Measurement Ranges

Full Scale[1)]	O_3	CL_2	H_2S	NO	NO_2	SO_2
30 vol. %		x				
10 vol. %		x				x
5 vol. %		x				x
1 vol. %		x	x			x
5,000 ppm		x	x	x	x	x
2,000 ppm	x	x	x	x	x	x
1,000 ppm	x	x	x	x	x	x
500 ppm	x	x	x	x	x	x
300 ppm				x	x	x
100 ppm	x	x	x		x	x
50 ppm	x				x	x
10 ppm	x				x	x
1 ppm	x					

[1)] Measurement range = Zero to Full Scale (FS)
Sensors are calibrated in the same range “Zero to Full Scale (FS)”

Other ranges on request

7.7. Table of Detection Limits (= 3 σ) in Percent of Full Scale

Full Scale	O_3	CL_2	H_2S	NO	NO_2	SO_2
100 vol. %						
50 vol. %						
30 vol. %		< 0.1%				
20 vol. %						
10 vol. %		< 0.1%				< 0.1%
5 vol. %		< 0.1%				< 0.1%
1 vol. %			< 0.1%			
5,000 ppm			< 0.1%			
2,000 ppm	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%	< 0.1%
1,000 ppm	< 0.1%	< 0.1%	< 0.2%	< 0.1%	< 0.1%	< 0.1%
500 ppm	< 0.2%	< 0.2%	< 0.3%	< 0.2%	< 0.2%	< 0.1%
300 ppm				< 0.2%	< 0.2%	< 0.1%
100 ppm	< 0.5%		< 0.5%		< 0.5%	< 0.3%
50 ppm	< 0.5%				< 0.5%	< 0.3%
10 ppm	< 0.5%				< 0.5%	< 0.3%

Definition of Detection Limit

The Detection Limit is the smallest measurement value which can be obtained with a specific uncertainty. This uncertainty includes the resolution, noise and stability of the gas sensor for a specific gas and specific measurement range. For evaluation of the detection limit value,

several single measurements are taken at the identical measurement conditions. With the obtained single measurement results the standard deviation “Sigma” (σ) is calculated. The values given in the table equal the triple amount of Sigma.

7.8. Recalibrations

The following recalibration intervals are recommended for UV sensors:

- Zero-point:
  - Concentrations < 300 ppm: Every 48 hours with inert gas, e.g. Nitrogen
  - Concentrations ≥ 300 ppm: Every 24 hours with inert gas, e.g. Nitrogen

  The recalibration of the zero point is described in the software manual.
- End-point (full scale): Every 3 months with suitable calibration gas

8. Options (installed inside of the sensor casing)

8.1. Oxygen Sensor

The oxygen sensor is a sensor module available as option in addition to a RITTER MultiGas NDIR or NDUV sensor. The measured oxygen concentration is displayed in the provided software. The sensor is built into the casing of the RITTER MultiGas sensors.

The following versions are available:

a) For non-aggressive gases

b) For H_2S and similar acid gases

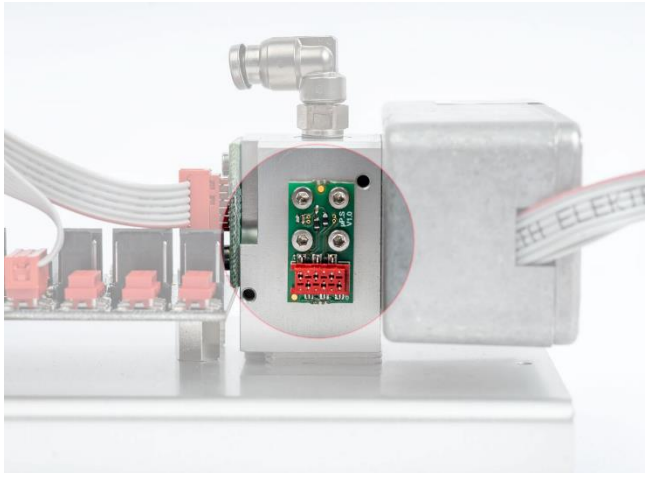
Specifications			
Dimensions [H x W x L]		65.4 mm × 31.7 mm × 56.6 mm	
Weight		70 g	
Tube connector		4/6 mm tube	
Measurement range	0 – 25 Vol.% O_2	0 – 100 Vol.% O_2	0.5 – 35 Vol.% O_2
Application	Biogas, Automotive exhaust gas analyser	Industrial, fully CO_2 resistant	Industrial, fully CO_2 resistant, shows high resistance to acid gases
Medium contact materials	ABS, FKM, PPS, PTFE, stainless steel	ABS, PVC, PPS, PTFE, stainless steel	ABS, PVC, PPS, PTFE, stainless steel
Expected operating life	> 1,000,000 Vol.% O_2 h	~ 1,200,000 Vol.% O_2 h	~ 1,200,000 Vol.% O_2 h
Sensor lifetime	4 years @ ambient air, depending on application	6 years @ ambient air, depending on application	6 years @ ambient air
Measuring response[1]			
Resolution	0.1 Vol.%	0.1 Vol.%	0.1 Vol.%
Response time (t90)	< 3.5 s	< 10 s	< 5 s
Drift[2]	< 1% per month	< 1% per month	< 3% per month

[1] related to Pa = 1013 hPa; Ta = 25°C; RH = 50%; flow = 2.5l/min
[2] averaged across 12 months

Linearity Error		0 - 2 Vol.% O_2: ± 0.1 abs. 2.1 - 100 Vol.% O_2: ± 0.05 rel.	0 - 2 Vol.% O_2: ± 0.1 abs. 2.1 - 35 Vol.% O_2: ± 0.05 rel.
Repeatability[3]		± 1 Vol.% O_2	± 1 Vol.% O_2
Influence of Humidity	-0.03 % rel. O_2 reading / % RH	-0.03 % rel. O_2 reading / % RH	-0.03 % rel. O_2 reading / % RH
Interferences	CO_2: up to 20 Vol.% CO: up to 2000 ppm NO_x: up to 5000 ppm HC: up to 5000 ppm N_2O: up to 500 ppm	< 20 ppm O_2 response to: 100 Vol.% CO 100 Vol.% CO_2 100 Vol.% C3H8 3000 ppm NO in N_2 1000 ppm C_6H_6 in N_2 500 ppm SO_2 in N_2 < 100 ppm O_2 response to: 3000 ppm C_2H_6O 3000 ppm $C_4H_{10}S$ < 200 ppm O_2 response to: 3000 ppm $C_2H_6S_2$ < 400 ppm O_2 response to: 100 Vol.% H_2 < 500 ppm O_2 response to: 2000 ppm H_2S in N_2	< 20 ppm O_2 response to: 100 Vol.% CO 100 Vol.% CO_2 100 Vol.% C_3H_8 1000 ppm C_6H_6 in N_2 2000 ppm H_2S in N_2 < 20000 ppm O_2 response to: 3000 ppm NO in N_2 1000 ppm H_2 in N_2 500 ppm SO_2 in N_2
Climatic conditions			
Operating temperature	0 – 40 °C intermittent 40 – 50 °C	0 – 45 °C	0 – 50 °C
Storage temperature	-20 – 40 °C 5 – 25 °C recommended 40 – 50 °C max. 1 week		5 – 30 °C recommended -20 – 50 °C maximum
Air pressure	650 – 1250 hPa (mbar)	700 – 1250hPa (mbar)	600 – 1250 hPa (mbar)
Ambient humidity	0 – 95% rel. humidity (not condensing)		

[3] @ 100 Vol.% O_2 applied for 5 min

8.2. Pressure Sensor



A change in the gas and/or atmospheric pressure causes a change in the number of molecules per volume and thus a change in gas density. This density change in turn has a significant influence on the result of the concentration measurement by the sensor. By measuring the gas pressure inside of the sample cell (cuvette), the value of the concentration measurement is compensated / corrected.

The pressure sensor enables an increase in the accuracy of the gas analysis measurement by a factor of 15:

- Without pressure sensor: ±1.5% per pressure difference of 10 hPa
- With pressure sensor: ±0.1% per pressure difference of 10 hPa

The pressure sensor is a sensor module available as option in addition to a RITTER MultiGas NDIR or NDUV sensor. The sensor is built into the casing of the RITTER MultiGas sensors. The measured pressure value is displayed in the provided software.
There are two versions available:

a) For non-aggressive gases

Specifications

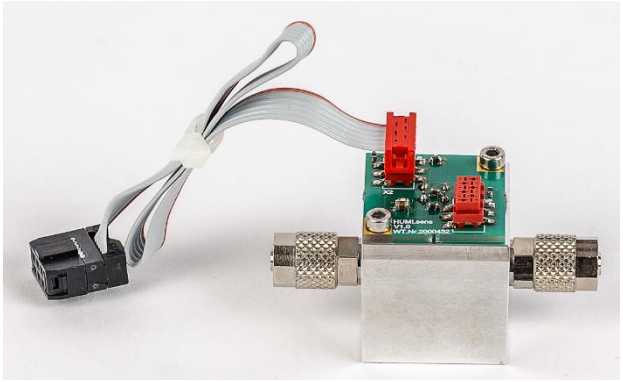
- Measuring range: 800 - 1,200 mbar abs.
- Measurement accuracy ±1% of span (full scale)
- Resolution: <1 mbar
- Response time (t_{90}): 1 s
- Incl. temperature compensation

b) For H_2S and similar acid gases

Specifications

- Measuring range: 0.2 – 3.5 bar abs.
- Measurement accuracy ±1% of span (full scale)
- Resolution: 2 mbar
- Response time (t_{90}): 1 s
- Incl. temperature compensation

8.3. Humidity Sensor



The humidity sensor is a sensor module available as option in addition to a RITTER MultiGas NDIR or NDUV sensor. The sensor is built into the casing of the RITTER MultiGas sensors. The measured humidity values (absolute and relative) are displayed in the provided software.

Specifications

- Polymer humidity sensor
- Measuring range: 0-100% rH
- Measurement accuracy ±2% rH of span (full scale)
- Resolution: ±1% RH
- Response time (t_{90}): 12 s
- Incl. temperature compensation
- Indicated values (in software): absolute [% absH] and relative humidity [% rH]

Display of the measured values of the humidity sensor in the data acquisition software "MARS" and their output as analog voltage signal:

The following measured values of the humidity sensor are displayed in the software in the data logging window (*Data Logging Tab*) as follows:

- Absolute humidity [g/m³]
- Relative humidity [%]
- Concentration [ppm]
- Temperature in humidity sensor [°C]

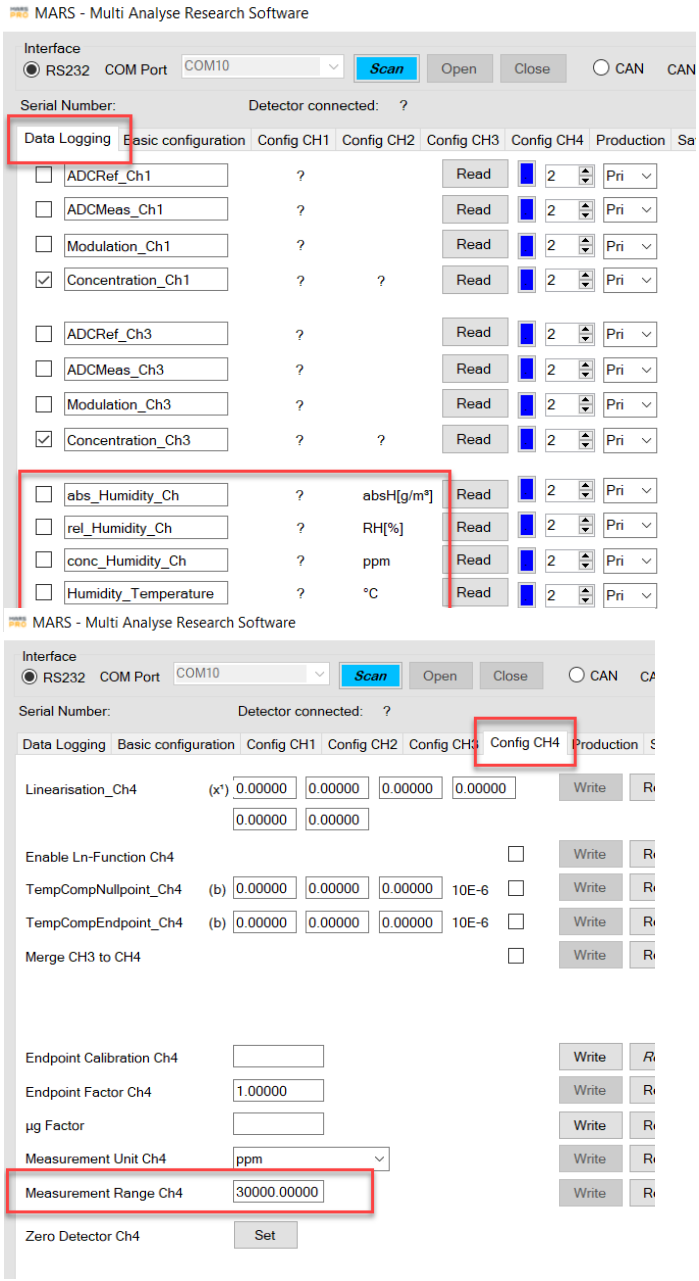
From these values, the measured **concentration** is output as an analog voltage signal on channel 4 (grey wire) for NDIR sensors, and on channel 2 (green wire) for NDUV sensors. (See also table above)

The output voltage value is determined as follows:

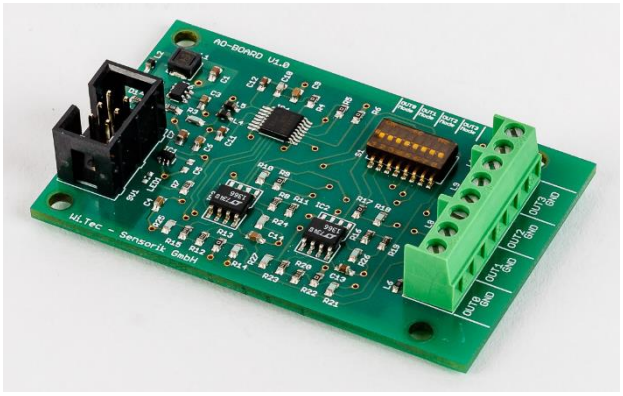
In the software, the measuring range for the concentration value is preset to 30,000 ppm in the Channel 4 configuration window (*Config Tab CH4*). (Can be changed individually)

The measured value of the concentration in the data acquisition window is set in relation to this preset value. This quotient is multiplied by the voltage level of the analog output and output as a voltage value.

Example:
Measured value: 12,000 ppm
Measuring range in *Config Tab CH4*: 30,000 ppm
Quotient 12,000/30,000 = 0.4
Voltage level of the analog output: 0 - 10V
Output voltage: 0.4 x 10V = 4.0V



8.4. Analog Voltage Output



The Analog Voltage Output Module allows the simultaneous output of up to 4 different values at 4 separate channels:

- 4 parallel signal outputs
- The measured values of the oxygen and humidity sensor can only be transmitted alternatively
- Resolution: 16 bit
- Update rate: 1 sec

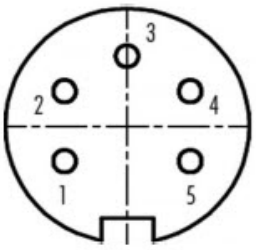
For connection to an analog data acquisition device the analog voltage output port provides alternatively the following voltage levels:

- 0 – 2V
- 0 – 5V
- 0 – 10V

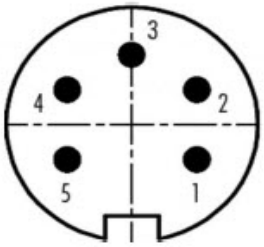
The voltage range is pre-set according to the order and cannot be changed by the user.

Please note the assignments of the respective gas concentration measurements to the respective channels. These assignments are stated in the Calibration Protocol of the sensor unit.

Assignment of contacts to the channels of the gas concentration measurements at the socket and plug of the Analog Voltage Output:



View to socket



View to plug

Contact No.	Assignment to channel	Wire Colors of provided Connection Cable
1	channel 1	white
2	channel 2	green
3	channel 3	yellow
4	channel 4	grey
5	ground	brown

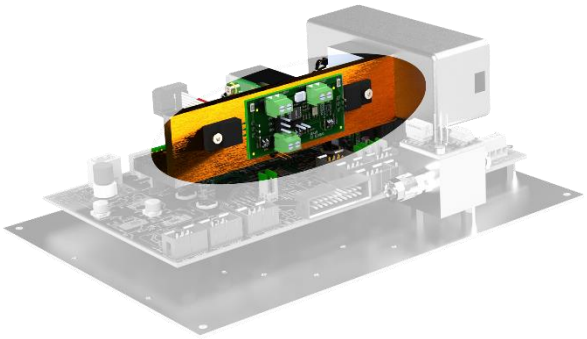
Analogue output signal of **oxygen and humidity sensors**:
(Only one of these two signals can be transmitted alternatively.)

- NDIR sensors: Channel 4 (grey wire)
- NDUV sensors: Channel 2 (green wire)

The connection cable is delivered with open wires to be connected to the analog data acquisition device of the user. The wire colours are listed in the above table.

8.5. Heating and Thermostatting of Sensor Casing

In order to avoid condensation of humid gas inside of the sensor, the sensor and sensor casing can be heated and thermostatted. As standard, the temperature controller is preset to 50°C; lower temperatures are possible on request.



The heating element and temperature controller are mounted at the support of the measurement cuvette.

Features:

- Temperature controller 30-50°C
- Control accuracy ± 0.2 K
- Heating power 12 Watt