



ALTOSONIC 5 Technical Datasheet

Ultrasonic liquid flowmeter for custody transfer

- Suitable for all flow regimes, no Reynolds limitation
- Integrated gas detection
- Significant easier small volume proving



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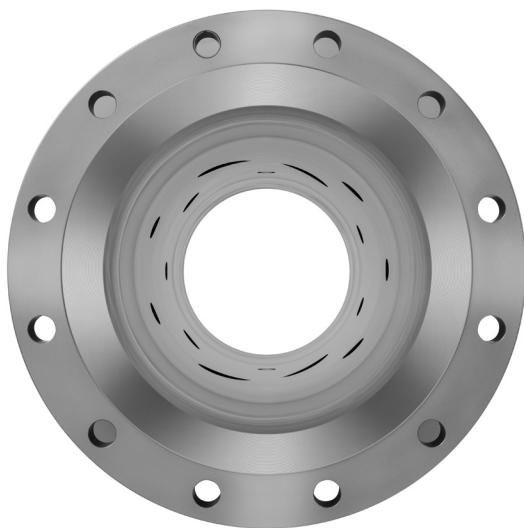
1.1 ALTOSONIC 5 flowmeter for custody transfer

The ALTOSONIC product line for fluids has established itself as the standard in multi-path custody transfer flow metering. The absence of obstructing and moving parts ensures no wear or pressure loss. This in combination with large meter sizes permits simplified configuration of metering systems.

Operation is maintenance free. Due to long-term stability, periodic calibration can be reduced to a minimum which results in drastically cutting costs for on-site equipment and procedures.

In addition, the diagnostics of the flowmeter will ensure a good performance and will prevent malfunctioning of the measurement by providing essential information upon which the operator is able to take preventive action.

This all results in considerable cost savings in both capital (CAPEX) and operational expenditure (OPEX).



Highlights

- All fluids and no Reynolds restriction
 - Widest certified turndown
 - Guaranteed performance in all flow regimes (laminar, transition and turbulent)
 - Multi-product application
 - From light to heavy crudes and LNG
 - Bi-directional flow measurement
- Proven long-term stability
 - No moving parts
 - Longest installed base (1996 - present)
 - No unscheduled downtime due to transducer failure since introduction
- Small footprint
 - Short inlet run
 - Short installation height
- Entrained gas detection (Full Pipe Guarantee)
 - Dedicated diagnostic path
 - Permanent diagnostics
- Compact prover compliance (SVP)

Industries

- Oil and gas
- Petrochemical
- Chemical

Applications

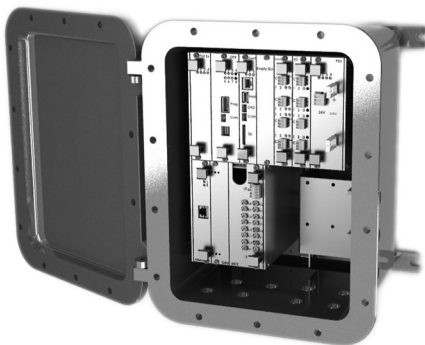
- Offshore oil production
- Onshore oil production
- Crude oil pipelines
- Multi-product pipelines
- Loading and off-loading terminals (crudes, refined products and LNG)
- Refineries

1.2 Options and variants



To be able to cover a wide range of applications, process conditions and ambient conditions, the ALTOSONIC 5 flowmeter consists of a flow sensor and a separate remote signal converter.

The flow sensor, installed in the pipeline, contains multiple ultrasonic transducers for flow measurement and diagnostics. In addition, a vertical mounted transducer pair will ensure that there is no gas on top of the liquid. To avoid influence from flow sensor expansion on the measurement a temperature sensor is integrated to compensate for this effect.



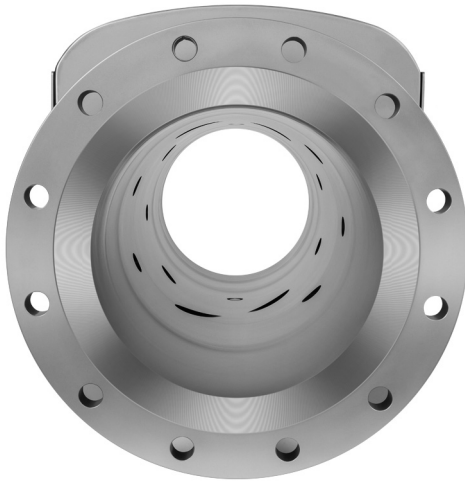
The remote signal converter determines the actual flow based on the information received from the flow sensor. Next to the flow, the signal converter will gather a large amount of diagnostic information such as signal-to-noise ratio, velocity of sound and profile. Based on this diagnostic information, the signal converter is able to determine the health of the measurement. In addition to gathering the information and diagnosing the health of the meter, all this information can be logged internally and is available whenever it is necessary.



Should a local display be required, an optional explosionproof display can be connected to the signal converter. The display can be configured to show any of the process and / or measuring data.

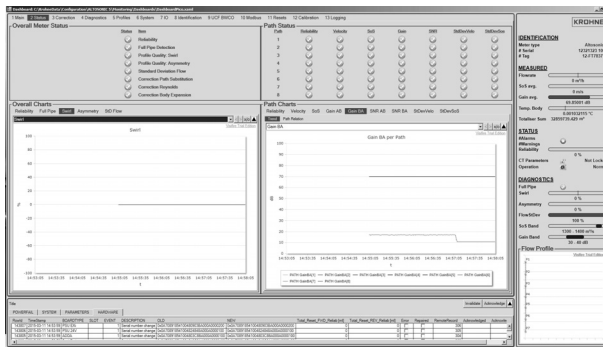


For custody transfer applications the standard flow has to be calculated by correcting for pressure and temperature. This is done by a flow computer. KROHNE offers the internationally recognized and approved flow computer, SUMMIT 8800, to fulfil this task.



Variants

- Standard, for viscosities up to 150 cSt
- High viscosity, for viscosities higher than 150 cSt
- Low temperature, for cryogenic process conditions such as LNG
- High temperature, up to 250°C (482°F)



Standard diagnostics

With the above instruments it is possible to build an excellent measuring system. But what if there is any doubt about the measuring results? Is this due to the measuring system itself or is it due to changing process conditions, such as air in the pipeline? With the Monitoring, Configuration and Diagnostics tool in the flowmeter it is not only possible to determine the cause, but it will also give the user a preventative warning in case of mal-functioning or changing of process conditions.

Example: During operation a thin layer of air occurs on top of the fluid. Assuming this layer displaces 0.1% of the fluid, the reading of the flowmeter will have an additional uncertainty of 0.1%, because an ultrasonic flowmeter assumes the pipe to be hundred percent full. By integrating a vertical diagnostic path the slightest bit of air will be detected and the user will be informed. Full-pipe detection is essential for every custody transfer transaction to guarantee the absence of gas in the pipeline.

1.3 Measuring principle

The ultrasonic liquid flowmeter operates according to the principle of measuring the transit time of an ultrasonic sound wave. The liquid velocity is derived from the difference in transit time of a sound wave travelling in a direction with the flow direction and the sound wave travelling in the opposite direction. The trajectory of the sound wave is called the acoustic path.

1.4 Transit time measuring principle

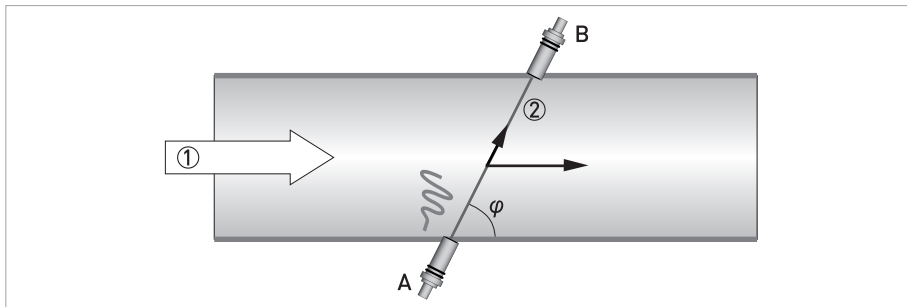


Figure 1-1: Transit time measuring principle

- ① Direction of the flow
- ② Component of velocity in the direction of the chord

In a pipe section two transducers A and B create an acoustic path, which in the above figure, is a single chord. This chord is the distance between transducer A and B and has a length L . The chord intersects with the centre line of the pipe at an angle φ .

Both transducers are capable to transmit and receive an ultrasonic signal. First, one transducer acts as a transmitter and the other as receiver, then the other way around. The transit time of an ultrasonic signal along a measuring chord is influenced by the velocity of the flow (v). If the flow is zero the transit time from transducer A to B is exactly the same as the transit time from transducer B to A (determined by the speed of sound in the liquid).

When the liquid flows with a velocity v and with c being the speed of sound in the liquid: $v \cdot \cos(\varphi)$ is the component of velocity in the direction of the measurement chord.

This component increases or decreases the travel time (time of flight of an acoustic waveform) as it moves from one transducer to the other transducer. The transit time from transducer A to B (t_{AB}) is:

$$t_{AB} = \frac{L}{c + v \cos \varphi} \quad (1)$$

In opposite direction from transducer B to A the transit time (t_{BA}) is:

$$t_{BA} = \frac{L}{c - v \cos \varphi} \quad (2)$$

The velocity of the liquid is derived from formula (1) and (2) as:

$$v = \frac{L}{2 \cos \varphi} \cdot \left(\frac{1}{t_{AB}} - \frac{1}{t_{BA}} \right) \quad (3)$$

An important feature of this method is that the calculated velocity does not depend on the speed of sound in the liquid or liquid properties in general. The velocity as calculated is only a function of the measured transit times t_{AB} and t_{BA} ; the length of the chord and the angle of intersection of the measuring chord are supposed to be known from the design of the flowmeter.

As a “bonus” the speed of sound in the liquid can be derived from formula (1) and (2) as :

$$c = \frac{L}{2} \cdot \left(\frac{1}{t_{AB}} + \frac{1}{t_{BA}} \right) \quad (4)$$

This gives a measured speed of sound value, a valuable tool for diagnostic purposes, as it can be compared with data from other sources.

2.1 Technical data table

- *The following data is provided for general applications. If you require data that is more relevant to your specific application, please contact us or your local sales office.*
- *Additional information (certificates, special tools, software,...) and complete product documentation can be downloaded free of charge from the website (Downloadcenter).*

Measuring system

Measuring principle	Ultrasonic transit time
Application range	Flow measurement of liquids in custody transfer applications
Versions	Standard (ST)
	High Viscosity (HV)
	Low Temperature (LT)
	High Temperature (HT)
Measured value	Actual volume flow
Calculated value	Totalized flow, velocity of sound

Design

General	The ALTOSONIC 5 flowmeter consists of a flow sensor and a signal converter.
Flow sensor	
Construction	The flow sensor has an eight-path design with a central path for turbulent, transition or laminar flow differentiation. It also includes a dedicated vertical diagnostic path for full pipe guarantee.
Nominal diameter	4" ...24" / DN100...600
	Other diameters on request.
Signal converter	
Construction	The remote flameproof signal converter calculates the volume flow and the totalized volume, performs diagnostics and provides data logging functionality.
Functionality	Calculation of totalised volume
	Diagnosis of flow profiles
	Body temperature correction
	Logging of relevant parameters
	Optional display connection

Measuring accuracy

Measuring range	0...15 m/s (bidirectional)
	Reduced bore:
	Reynolds range: no limits (turbulent, transition and laminar flow regimes)
	Certified for custody transfer: 0.2...15 m/s (bidirectional)
	Full bore:
	Reynolds range: > 10000
	Certified for custody transfer: 0.5...15 m/s (bidirectional)
Linearity	0.10%, for Reynolds range > 10000 with a turndown of 30:1 (0.5...15 m/s)
	0.15%, for whole Reynolds range with a turndown of 75:1 (0.2...15 m/s)
Uncertainty	< ±0.027% according to API
Repeatability	according to API chapter 5.8 table B1
Zero stability	< 0.2 mm/s
Certified turndown	75:1

Ambient temperatures

Flow sensor	
ATEX, IECEx, DIV1/ZONE1	Standard: -40...+65°C / -40...+149°F
	Optional: -55...+65°C / -67...+149°F
Storage temperature	-40...+65°C / -40...+149°F
Signal converter	
ATEX	Standard: -40...+55°C / -40...+131°F
	Standard + heating: -55...+55°C / -67...+131°F
IECEX	Standard: -40...+55°C / -40...+131°F
	Standard + heating: -55...+55°C / -67...+131°F
DIV1 / ZONE1 (C/US)	Standard: -40...+55°C / -40...+131°F
	Standard + heating: -55...+55°C / -67...+131°F
Storage temperature	-40...+65°C / -40...+149°F

Process conditions

Process temperature	Standard version: -40...+120°C / -40...+240°F	
	Low temperature version: -200...+120°C / -328...+240°F	
	High temperature version: -40...+250°C / -40...+482°F	
	High viscosity version: -40...+120°C / -40...+240°F	
Viscosity range	All versions: 0.1...150 cSt	
	High viscosity version: 0.1...1500 cSt	
Pressure range	ASME 150...600	
	Pressure rating according to ASME B16.5 (-29...+38°C / -20...+100°F):	
	Class 150 lbs:	Stainless steel: 19.0 bar / 275 psi
		Carbon steel: 19.6 bar / 285 psi
	Class 300 lbs:	Stainless steel: 49.6 bar / 720 psi
		Carbon steel: 51.1 bar / 740 psi
	Class 600 lbs:	Stainless steel: 99.3 bar / 1440 psi
Carbon steel: 102.1 bar / 1480 psi		
Other pressure ranges on request.		
Minimum pressure requirement	For detailed information, refer to <i>Backpressure</i> on page 23.	
Water content	Velocity above 1 m/s: ≤ 6%	
	Velocity above 2 m/s: ≤ 10%	
Solids content	< 5% (volume)	
Air/gas content	< 2% (volume)	

Installation conditions

Installation	For detailed information, refer to <i>Mechanical installation</i> on page 17.
Dimensions and weights	For detailed information, refer to <i>Dimensions and weights</i> on page 14.
Altitude	< 2000 m
Overvoltage category	II
Pollution degree	3

Materials

Flanges (RF)	Stainless steel AISI 316 / 316 L [1.4404] (dual certified)
	Option: Carbon steel ASTM A105 / A350 Gr.LF2
	Other materials / flange types on request
Measuring tube	Stainless steel AISI 316 / 316 L [1.4404] (dual certified)
	Other materials on request
Converter housing	Standard: Copper free aluminum
	Option: Stainless steel 316 [1.4408] for offshore applications
Coating	Standard: KROHNE 1 layer paint system in accordance with ISO 12944-2:2007 Category C3 Medium / C4 Low Color: KROHNE grey (air) CNC 5252 - gloss
	Option: KROHNE 3 layer paint system in accordance with ISO 12944-2:2007 Category C5I High / C5m High Color: KROHNE Grey (air) CNC 5252 - gloss
	Option: Blasted (not coated)

Electrical connections

Power supply	DC: 24 VDC +10%/-15%
	AC: 100...240 VAC, 50/60 Hz
Power consumption	DC: 28 W (with optional heater: 175 W)
	AC: 35 W
Transducer signals	Intrinsically safe flow sensor circuits:
	$U_i = 18 \text{ V}$, $I_i = 210 \text{ mA}$, $C_i = 100 \text{ nF}$, $L_i = 700 \text{ }\mu\text{H}$, $P_i = 1 \text{ W}$
	Intrinsically safe signal converter circuits:
	$U_o = 6.51 \text{ V}$, $I_o = 208 \text{ mA}$, $C_o = 22 \text{ }\mu\text{F}$, $L_o = 1.5 \text{ mH}$, $P_o = 0.34 \text{ W}$
PT100 signal	Intrinsically safe (ia) circuit:
	$U_i = 10 \text{ V}$, $I_i = 10 \text{ mA}$, $P_i = 200 \text{ mW}$
Cable entries	Standard: M20 x 1.5
	Option: 1/2" NPT, PF 1/2

Inputs and outputs

Available options	1x Ethernet			
	4x RS485 serial Modbus master / slave output			
	4x (Basic IO) or 8x (optional, extended IO) IO configurable input/output with: - Alarms - Analog values 0/4...20 mA inputs/outputs - Digital dual pulse, phase shifted (see next line for more details) All circuits: galvanically isolated, rated < 16 V r.m.s. / 22.6 V peak / < 35 VDC			
Digital dual pulse, phase shifted	Maximum frequency: 10 kHz (default setting 2 kHz)			
	Size [inch]	max. flow [m ³ /h]	K-factor [pulse/m ³]	K-factor [liter/pulse]
	4	375	19200.0	0.052083
	6	750	9600.00	0.104167
	8	1750	4114.29	0.243056
	10	2250	3200.00	0.312500
	12	3125	2304.00	0.434028
	14	3750	1920.00	0.520833
	16	4500	1600.00	0.625000
	18	5800	1241.38	0.805556
20	7000	1028.57	0.972222	
24	10000	720.000	1.388889	
MODBUS				
Description	Modbus RTU or Modbus ASCII, Slave, RS485 (galvanically isolated)			
Transmission procedure	Half duplex, asynchronous			
Address range	1...247			
Supported function codes	03, 04, 06, 08, 16			
Supported Baudrate	50, 75, 110, 150, 300, 600, 1200, 2400, 4800, 9600, 19200, 38400 (default), 56000, 64000, 115200, 128000 Baud			

Approvals and certificates

CE			
This device fulfills the statutory requirements of the EC directives. The manufacturer certifies successful testing of the product by applying the CE mark.			
	Please refer to the EU Declaration of Conformity or the website of the manufacturer for full information of the EU directive and standards and the approved certifications.		
Measurement Instrument Directive	2014/32/EU		
Hazardous areas approvals			
		Marking	Certificate
ATEX	Flow sensor	II 2G Ex ia IIC T6...T2 Gb	FTZU 14 ATEX 0131X
	Signal converter	II 2G Ex d [ia] IIB+H2 T5 Gb	FTZU 14 ATEX 0042X
IECEX	Flow sensor	Ex ia IIC T6...T2 G	IECEX FTZU 14 .0020X
	Signal converter	Ex d [ia] IIB+H2 T5 Gb	IECEX FTZU 14.0029X
DIV 1	Flow sensor	Class I, Groups B, C, D, temp class T6...T2	LR 1338-1
	Signal converter	Class I, Groups B, C, D, temp class T5	LR 1338-2
Zone (Canada)	Flow sensor	Ex ia IIB+H2 T6...T2 Gb	LR 1338-1
	Signal converter	Ex ia IIB+H2 T5 Gb	LR 1338-2
Zone, ANSI/ISA (USA)	Flow sensor	Class I, Zone 1, AEx [ia] IIC T6...T2	LR 1338-1
	Signal converter	Class I, Zone 1, AEx d [ia] IIC T5	LR 1338-2
Other approvals			
Ingress protection	IP66 or NEMA Type 4X		
OIML - R117	Flow sensor: TC 8722		
	Signal converter: TC 8548		

2.2 Dimensions and weights

- All dimensions are provided as indication. They can vary slightly with different schedule sizes.
- Values for larger diameters are available on request.

Flow sensor

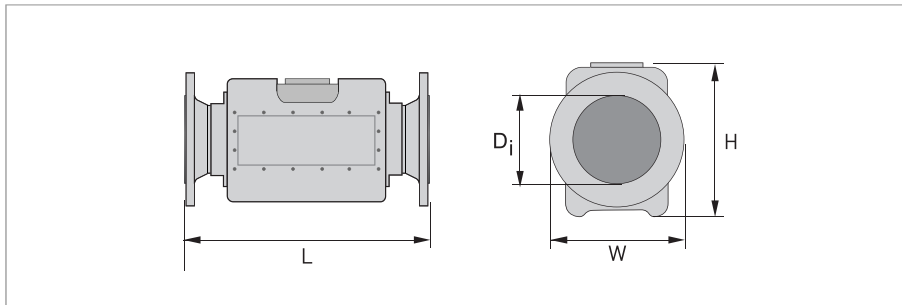


Figure 2-1: Dimensions of flow sensor

ASME 150 lb

Nominal size	Metric					Imperial				
	H [mm]	L [mm]	W [mm]	Di [mm]	Weight [kg]	H [inch]	L [inch]	W [inch]	Di [inch]	Weight [lbs]
4" / DN100	289	500	330	102.26	175	11.38	19.69	12.99	4.026	385
6" / DN150	340	600	380	154.08	310	13.39	23.62	14.96	6.066	682
8" / DN200	408	600	369	202.74	320	16.06	23.62	14.53	7.982	704
10" / DN250	510	900	450	254.56	230	20.08	35.43	17.72	10.022	506
12" / DN300	530	1000	490	304.74	310	20.87	39.37	19.29	11.998	682
14" / DN350	540	1100	540	336.54	460	21.26	43.31	21.26	13.250	1012
16" / DN400	600	1200	600	387.34	600	23.62	47.24	23.62	15.250	1320
18" / DN450	650	1350	635	437.94	860	25.59	53.15	25.00	17.242	1892
20" / DN500	700	1400	700	482.6	960	27.56	55.12	27.56	19.000	2112
24" / DN600	820	1650	820	584.2	1050	32.28	64.96	32.28	23.000	2310

ASME 300 lb

Nominal size	Metric					Imperial				
	H [mm]	L [mm]	W [mm]	D _i [mm]	Weight [kg]	H [inch]	L [inch]	W [inch]	D _i [inch]	Weight [lbs]
4" / DN100	289	500	330	102.26	195	11.38	19.69	12.99	4.026	429
6" / DN150	340	600	380	154.08	325	13.39	23.62	14.96	6.066	715
8" / DN200	396	600	343	202.74	335	15.59	23.62	13.50	7.982	737
10" / DN250	510	950	450	254.56	260	20.08	37.40	17.72	10.022	572
12" / DN300	530	1050	520	304.74	360	20.87	41.34	20.47	11.998	792
14" / DN350	590	1100	590	330.2	440	23.23	43.31	23.23	13.000	968
16" / DN400	650	1200	650	381	690	25.59	47.24	25.59	15.000	1518
18" / DN450	710	1350	710	428.6	900	27.95	53.15	27.95	16.874	1980
20" / DN500	780	1400	780	477.82	1120	30.71	55.12	30.71	18.812	2464
24" / DN600	920	1650	920	574.64	1300	36.22	64.96	36.22	22.624	2860

ASME 600 lb

Nominal size	Metric					Imperial				
	H [mm]	L [mm]	W [mm]	D _i [mm]	Weight [kg]	H [inch]	L [inch]	W [inch]	D _i [inch]	Weight [lbs]
4" / DN100	289	500	330	102.26	205	11.38	19.69	12.99	4.026	451
6" / DN150	340	600	380	148.36	350	13.39	23.62	14.96	5.762	770
8" / DN200	396	650	343	193.7	370	15.59	25.59	13.50	7.626	814
10" / DN250	510	1000	510	242.92	400	20.08	37.40	20.08	9.564	880
12" / DN300	560	1050	560	288.84	480	22.05	41.34	22.05	11.372	1056
14" / DN350	610	1150	610	317.5	650	24.02	45.28	24.02	12.500	1430
16" / DN400	690	1200	690	363.52	810	27.17	49.21	27.17	14.312	1782
18" / DN450	750	1300	750	409.3	960	29.53	51.18	29.53	16.11	2116
20" / DN500	820	1400	820	455.6	1250	32.28	55.12	32.28	17.94	2756
24" / DN600	940	1600	940	547.7	1910	37.01	62.99	37.01	21.56	4211

Signal converter

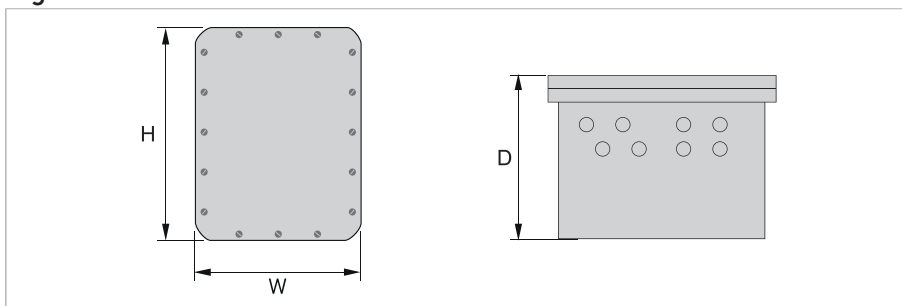


Figure 2-2: Dimensions of signal converter housing

Version	Metric				Imperial			
	H [mm]	W [mm]	D [mm]	Weight [kg]	H [inch]	W [inch]	D [inch]	Weight [lbs]
Aluminium (ATEX / IECEx)	432	332	299	25.4	17.01	13.07	11.77	56.0
Stainless steel (ATEX / IECEx)	432	382	286	75	17.01	15.04	11.26	165.3
Aluminium (DIV 1 / ATEX)	584	432	292	64	22.92	17.01	11.50	141.1

2.3 Flow table

Nominal size	Metric		Imperial	
	Q _{min} [m ³ /h] 0.2 m/s	Q _{max} * [m ³ /h] 10 m/s	Q _{min} [bbl/h] 0.7 ft/s	Q _{max} * [bbl/h] 33 ft/s
4" / DN100	5.6	280	35	1760
6" / DN150	12.6	630	80	3960
8" / DN200	22.6	1130	140	7120
10" / DN250	36	1800	225	11300
12" / DN300	50	2500	315	15700
14" / DN350	70	3500	440	22000
16" / DN400	90	4500	565	28280
18" / DN450	114	5700	715	33850
20" / DN500	140	7000	880	44000
24" / DN600	200	10000	1255	62850

*This table is ment for sizing purposes only, therefore Q_{max} is based on a practical maximum velocity of 10 m/s in the pipeline. However, this is not the physical limitation of the flowmeter. See for certified flowrates OIML-R117 evaluation certificate or contact KROHNE.

Calculations are provided as indication, please ask KROHNE for detailed sizing.

3.1 Intended use

Responsibility for the use of the measuring devices with regard to suitability, intended use and corrosion resistance of the used materials against the measured fluid lies solely with the operator.

The manufacturer is not liable for any damage resulting from improper use or use for other than the intended purpose.

The ALTOSONIC 5 is a highly accurate flowmeter, intended for custody transfer, fiscal, allocation and leak detection applications.

3.2 Installation

3.2.1 Pipe diameters

If an inlet section is delivered for the flowmeter, then ensure that the inner diameter of the inlet section matches the specified connection diameter at the flange of the ultrasonic flow sensor exactly. Contact the manufacturer if the inner diameter deviates.

If the flowmeter is delivered without inlet section, then the flowmeter is calibrated with an inlet section that has the same inner diameter as the upstream pipe of the customer.

The inner diameter of the downstream pipe must be within 3% of the flow sensor.

The welds must be grinded to avoid flow disturbances.

3.2.2 Flow conditioners

An additional flow conditioner can be installed upstream of the flow sensor to minimize the influence of upstream perturbations.

If a flow conditioner is used, then make sure that the flow conditioner, the inlet pipe and the flow sensor are calibrated together.

3.2.3 Inlet and outlet

The inlet and outlet configurations mentioned are intended as general guidelines.

With flow conditioner for unidirectional use

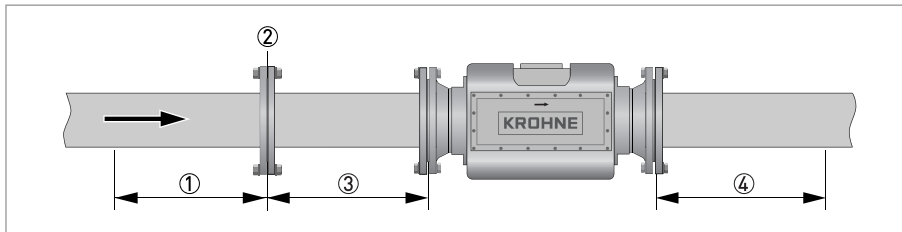


Figure 3-1: Required straight lengths for inlet and outlet

- ① Straight pipe section: minimum 5 DN
- ② Flow conditioner
- ③ Inlet section: 5 DN
- ④ Outlet section: 3 DN

Please note that more straight inlet length will improve overall performance.

With flow conditioner for bidirectional use

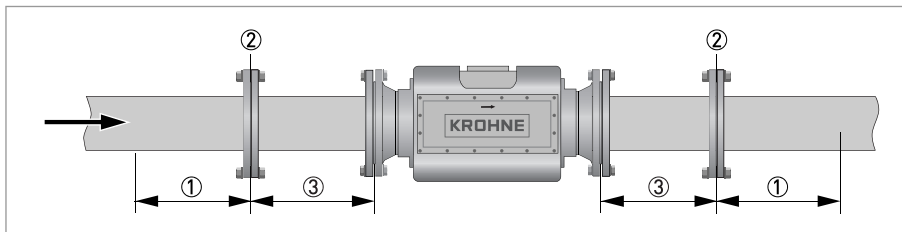


Figure 3-2: Required straight lengths for inlet and outlet

- ① Straight pipe section: minimum 5 DN
- ② Flow conditioner
- ③ Inlet and outlet section: 5 DN

Without flow conditioner

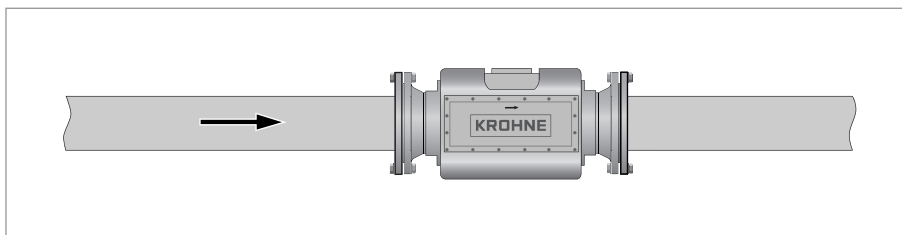


Figure 3-3: Required straight lengths for inlet and outlet

For applications without flow conditioner, the inlet and outlet lengths depend on the upstream piping arrangement and the liquid conditions (temperature, viscosity, flow rate). Please contact KROHNE for assistance.

3.2.4 Mounting position

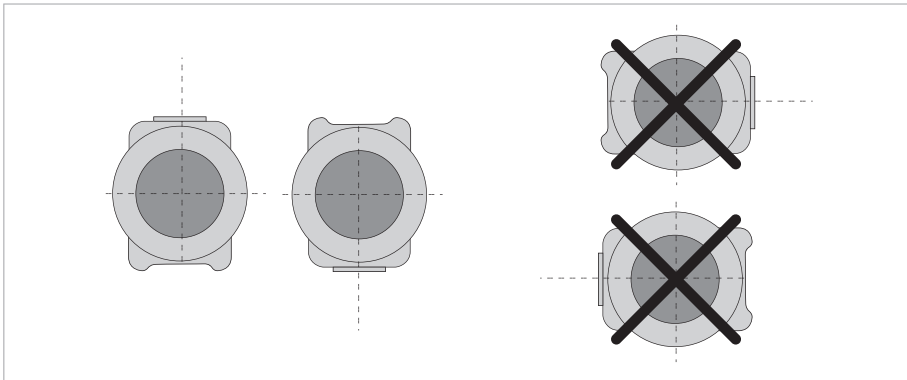


Figure 3-4: Mounting position

3.2.5 Support of the flow sensor

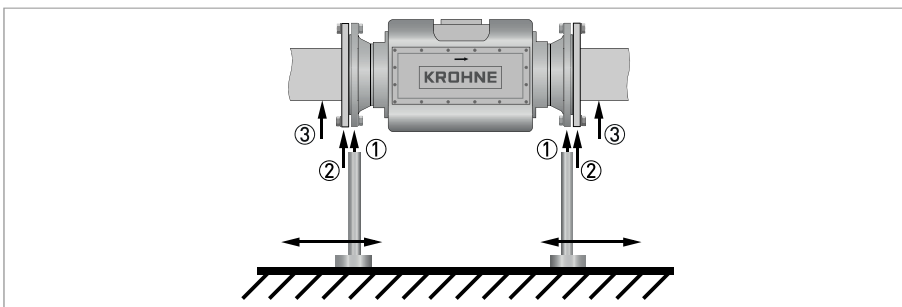


Figure 3-5: Support of flow sensor

- ① Preferred position of supports under flanges of flow sensor
- ② If preferred position is not possible, then use the mating flanges to support the flow sensor
- ③ If both flanges can not be used, then put the supports under the pipeline as close to the flow sensor as possible.

3.2.6 Flange deviation

Max. permissible deviation of pipe flange faces:
 $L_{max} - L_{min} \leq 0.5 \text{ mm} / 0.02''$

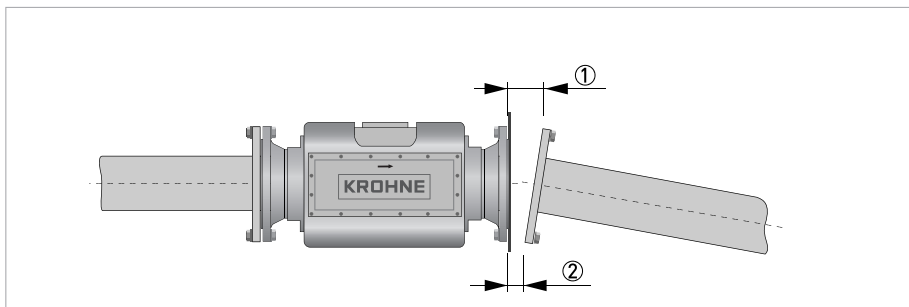


Figure 3-6: Flange deviation

- ① L_{max}
- ② L_{min}

3.2.7 Special considerations

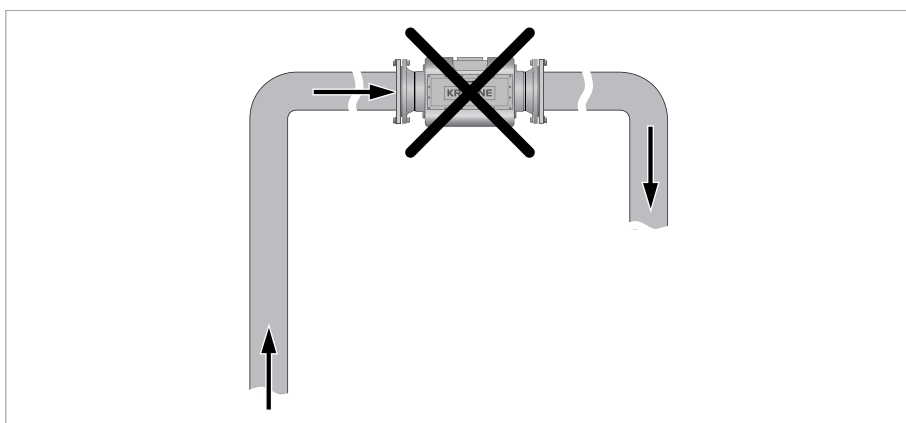


Figure 3-7: Preferrably no installation at highest point

It is advised not to install the flow sensor at the highest point, because gas can collect there. If there is no other possible location, make sure that the pipeline is vented.

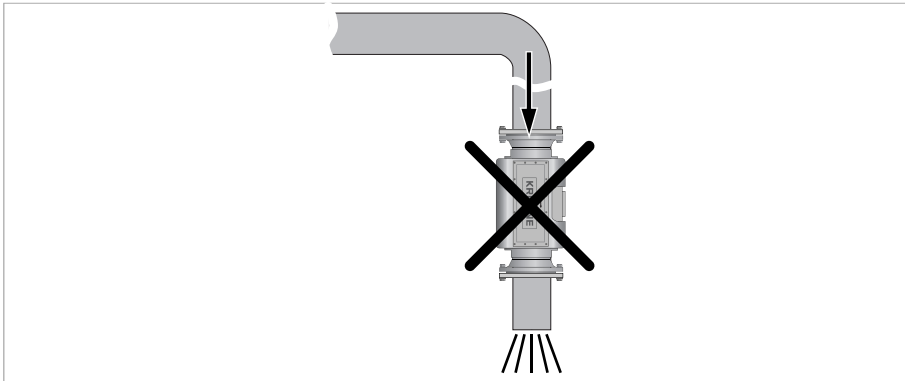


Figure 3-8: No installation in vertical line before free discharge

Do not install the flow sensor in a vertical line, because it is not sure that the pipe remains fully filled and/or is without gas.

The flow sensor can be installed in a vertical line, if there is no free discharge.

3.2.8 Air venting

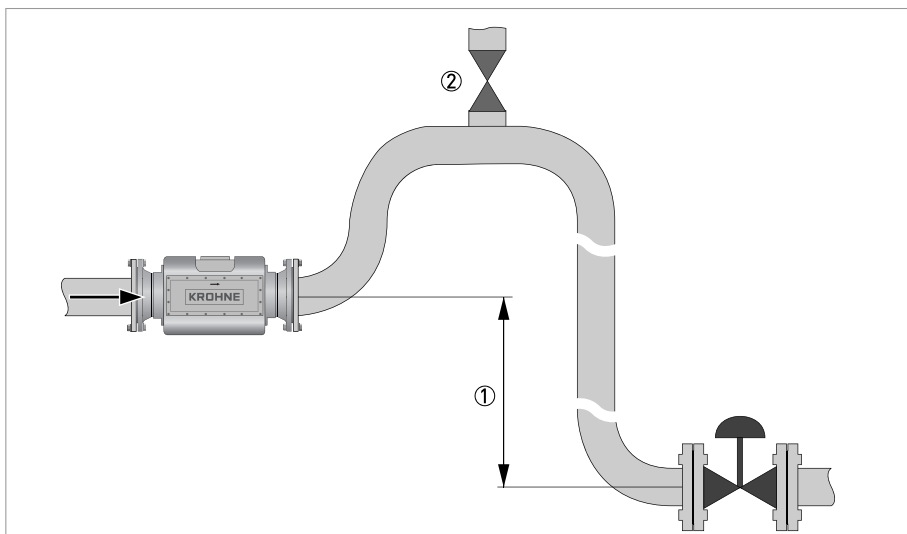


Figure 3-9: Air venting

① ≥ 5 m

② Air ventilation point

3.2.9 Pressure and temperature sensors

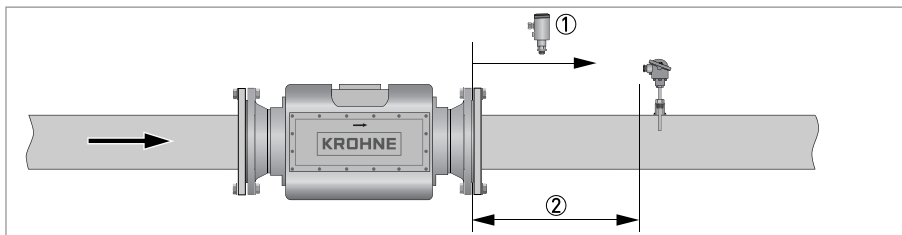


Figure 3-10: Location of pressure and temperature transmitters

- ① Install non perturbing devices such as pressure gauges, drains and vents downstream of the flow sensor
- ② Install perturbing devices such as thermowells at minimum 3 DN downstream of the flow sensor

If a bi-directional flow is used, then the thermowell must be installed during the calibration of the flow sensor to compensate for any flow distortion effects.

3.3 Backpressure

To prevent flashing / cavitation in the flow sensor, it should be installed in such a way that the flow sensor is always fully filled and has enough back pressure. As a guide line, the pressure should not go below the minimum limit as shown in the following graph.

To calculate the minimum required pressure in the pipeline to avoid flashing, you have to know the vapour pressure of the process liquid and add it to the pressure, found in the next figure.

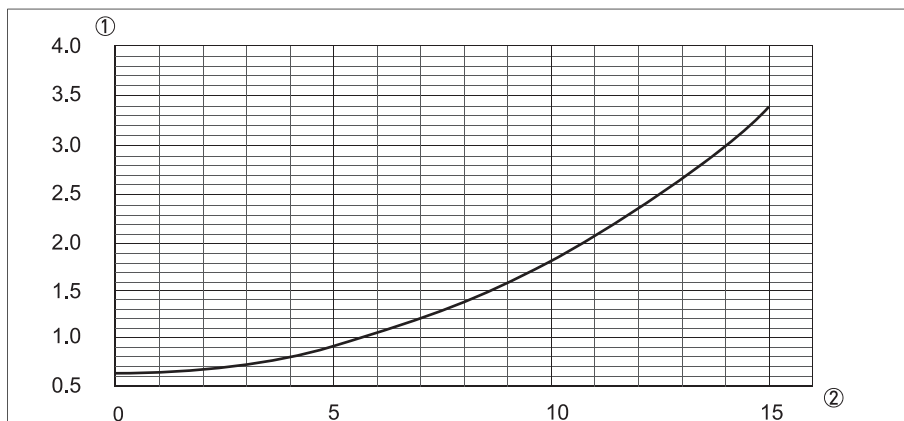


Figure 3-11: Needed pressure above vapour pressure

- ① ΔP [bar]
- ② Velocity [m/s]

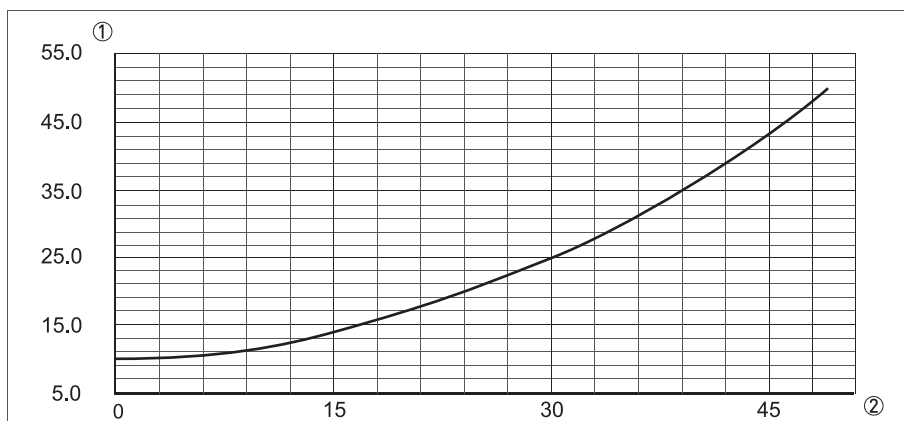


Figure 3-12: Needed pressure above vapour pressure

- ① ΔP [psi]
- ② Velocity [ft/s]

Example for crude oil, at velocity of 10 m/s:

- ① In technical documentation, find the vapour pressure P_v of crude oil. This is 0.7 bar(a).
- ② In the figure above, find the ΔP value at 10 m/s. This ΔP value is 1.8 bar.
- ③ Calculate the minimum required pressure $P_{\min} = P_v + \Delta P$. This will result in $0.7 + 1.8 = 2.5$ bar as a minimum pressure for the pipe line.

3.3.1 Open discharge

Note that with open discharge, there is almost no back pressure, so this can only be used at relatively low flows (maximum 3 m/s). See also next paragraph to gain more back pressure.

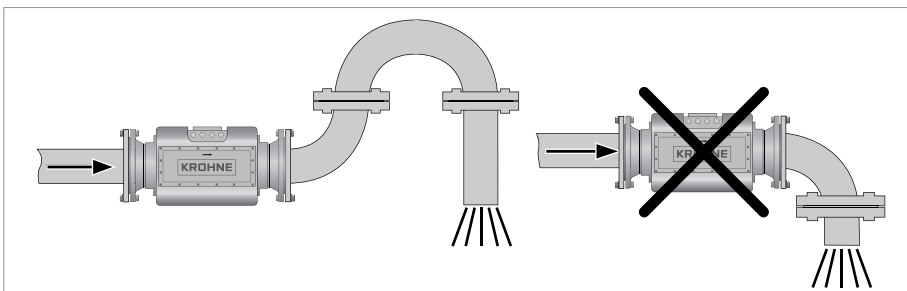


Figure 3-13: Installation in front of an open discharge

3.3.2 Control valve

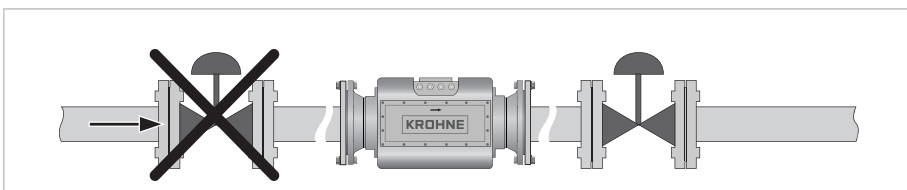


Figure 3-14: Installation in front of a control valve

Downstream of a valve there is low pressure and high flow disturbance. Therefore it is best practice to install the control valve downstream of the flow sensor.

3.3.3 Pump

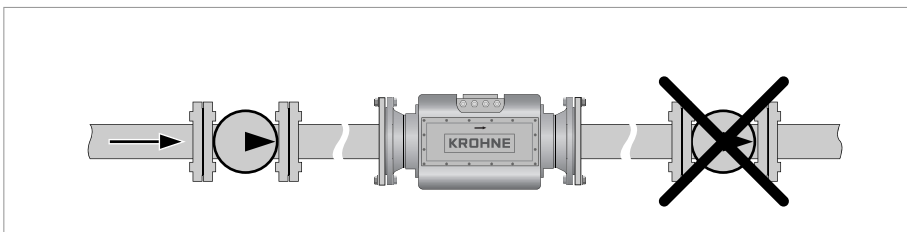


Figure 3-15: Installation behind a pump

Best position for the pump is upstream of the flow sensor. If this is not possible, then install the flow sensor at least 30 DN upstream of the pump.

3.4 Meteorological conditions

In case of extreme sunlight, the signal converter should be protected against direct solar radiation to avoid high temperatures and extend the lifetime of the electronics.

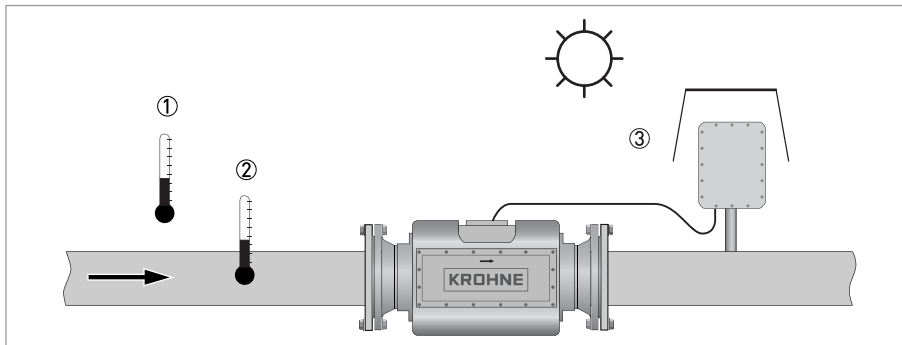


Figure 3-16: Temperatures

- ① Ambient temperature
- ② Process temperature
- ③ Sunshade to protect the signal converter against direct solar radiation

In case of big differences between ambient and process temperatures and especially in combination with laminar flow applications and/or extremely low flow velocities, it is beneficial for best measurement performance to insulate the upstream meter run and use light colored painting to avoid to much heat exchange.

4.1 Overview of electrical installation

An overview of a typical connection diagram is shown below.

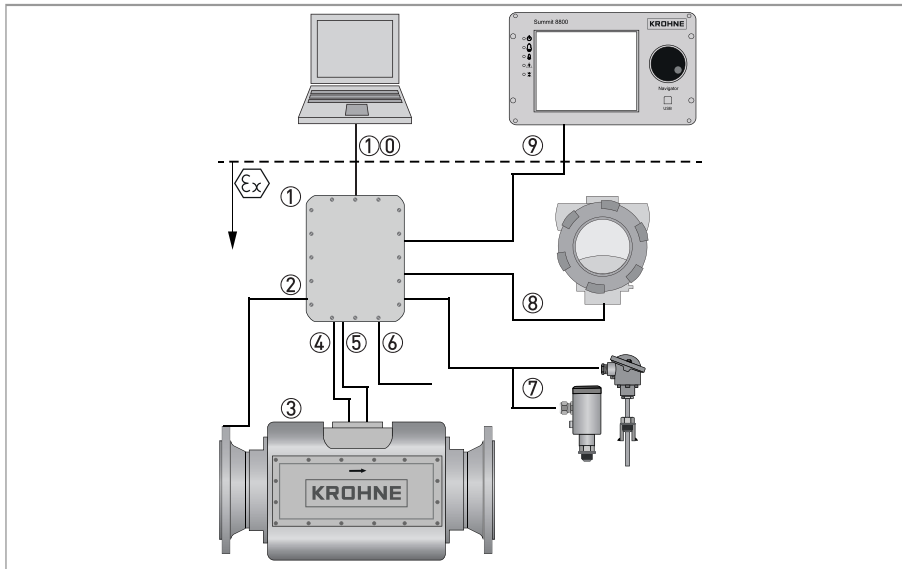


Figure 4-1: Overview electrical connections

- ① Signal converter
- ② Equipotential bonding wire (> 4 mm²)
- ③ Flow sensor
- ④ Connection of PT100 cable for body temperature (supplied with delivery)
- ⑤ Connection of three signal cables of flow sensor (supplied with delivery)
- ⑥ Power supply
- ⑦ Pressure and / or temperature transmitters (optional)
- ⑧ Display (optional)
- ⑨ Flow computer (optional) via:
 - RS485, MODBUS
 - Pulse / frequency
- ⑩ MCD tool (optional, advised)

4.2 Flow sensor connections

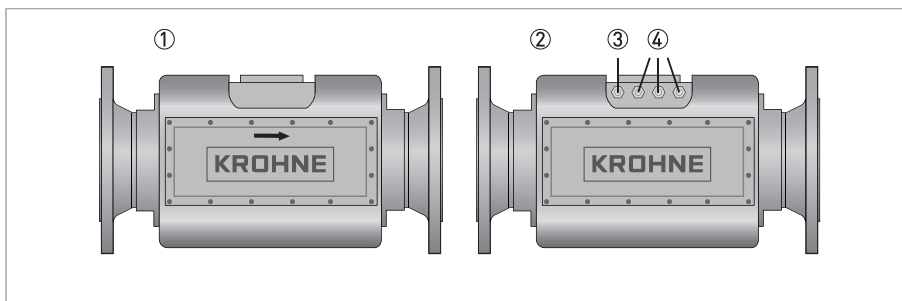


Figure 4-2: Location of cable glands

- ① Front side of the flow sensor
- ② Back side of the flow sensor
- ③ Cable entry for the PT100 cable
- ④ Cable entry for the signal cables

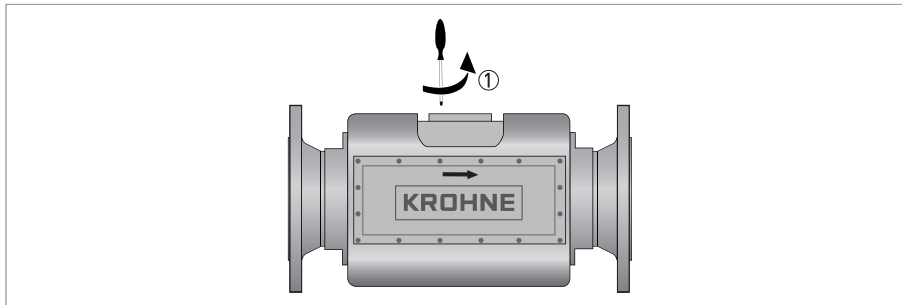


Figure 4-3: Removal of cover

- ① Loosening of screws to remove the cover

Use the factory supplied **sensor signal cables** to make the electrical connection between the flow sensor and the signal converter.

Each cable has six coaxial cables with pre-assembled SMB connectors. Lead the cable through the cable gland and connect it to terminal strip X1 as shown. All cables are numbered in the same way as the connector. Three cables are supplied, which means that two of the pre-assembled coax cables with SMB connectors will not be used.

Use the factory supplied **PT100 cable** to make the electrical connection between the flow sensor and the signal converter. Connect the numbered wires of the cable to terminal strip X2 with the same numbers.

This cable has four wires for temperature measurement. Feed the cable through the cable entry and connect it as shown. All wires are numbered in the same way as connector X2.

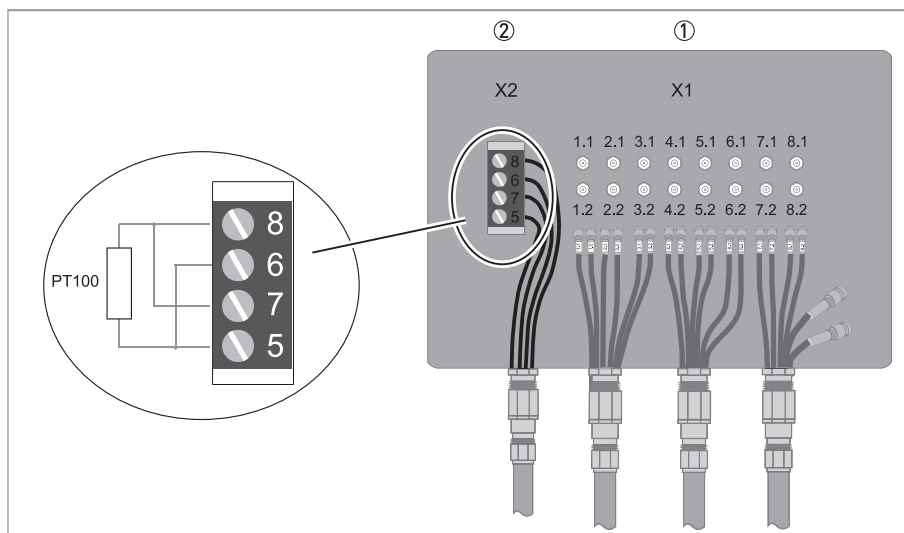


Figure 4-4: Electrical connections of flow sensor

- ① Terminal strip X1 for sensor signal cables.
 ② Terminal strip X2 for PT100 cable.

4.3 Signal converter connections

For the flow sensor and the signal converter that are used in a potentially explosive atmosphere, obey the following rules:

- If the device is used in category 2G, certified cable entry devices **MUST** be used.
- Unused openings **MUST** be closed with certified closing elements.
- To avoid voltage and current addition, the intrinsically safe circuits must be separated and wired to EN 60079-14.

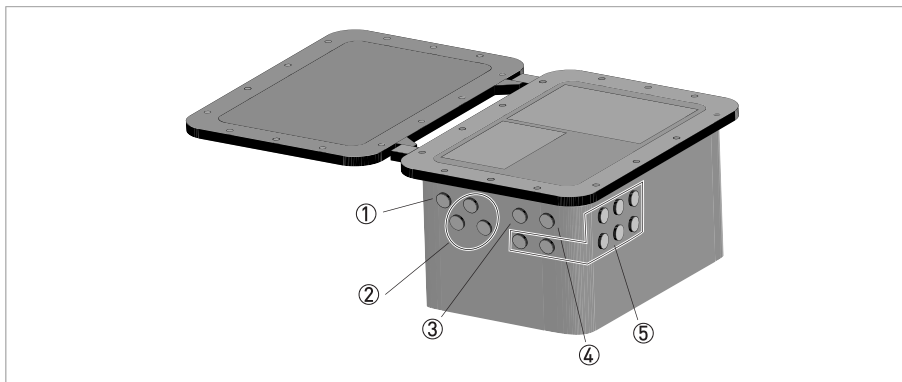


Figure 4-5: Location of cable glands

Number in Figure	Cable entry	Connection
①	PT100 cable, included in delivery	refer to <i>Multiplexer board (MUX) connections</i> on page 29
②	Sensor signal cable, included in delivery	refer to <i>Multiplexer board (MUX) connections</i> on page 29
③	Power supply cable, not included in delivery	refer to <i>Power Supply Unit (PSU) connections</i> on page 40
④	Optional power supply cable for heating	-
⑤	I/O connections	refer to <i>Smart IO board (SMART IO) connections</i> on page 31

Make absolutely sure that only certified cable glands, shielded cables and blind plugs are installed!

4.3.1 Multiplexer board (MUX) connections

The sensors and the body temperature sensor are connected to the MUX.

Use the factory supplied **sensor signal cables** to make the electrical connection between the flow sensor and the signal converter. Note that the cables have stripped cables on both sides, but the lengths of these stripped cables are different. Use the long side for the signal converter and the short side for the flow sensor.

Each cable has six coaxial cables with pre-assembled SMB connectors. Lead the cable through the cable gland and connect it to the card as shown. All cables are numbered in the same way as the connector. Three cables are supplied, which means that two of the pre-assembled coax cables with SMB connectors will not be used.

Use the factory supplied **PT100 cable** to make the electrical connection between the flow sensor and the signal converter. Connect the numbered wires of the cable to the connector with the same numbers.

Please note that the wires of the PT100 cable are numbered differently at the signal converter side and the flow sensor side.

Labels PT100 cable

flow sensor	signal converter
5	F1
6	S1
7	S2
8	F2

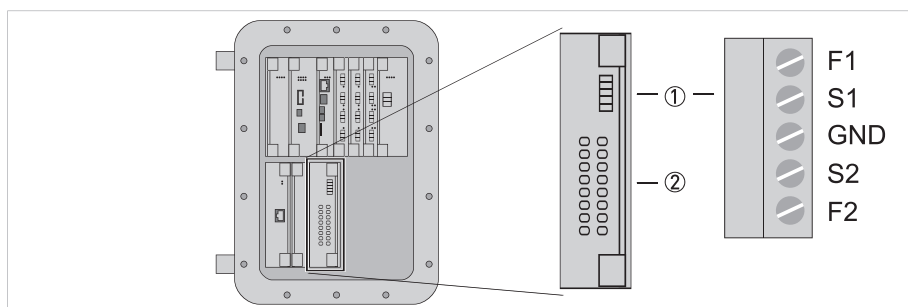


Figure 4-6: Multiplexer

- ① Connections for body temperature correction
- ② Connections of transducers of flow sensor

The GND terminal is not used, do not connect it.

4.3.2 Monitoring Configuration and Diagnostics (COM 1) board connections

The COM 1 board contains the log file on an SD card as well as the configuration stored on an internal flash memory. TCP/IP can be used as Modbus over TCP/IP.

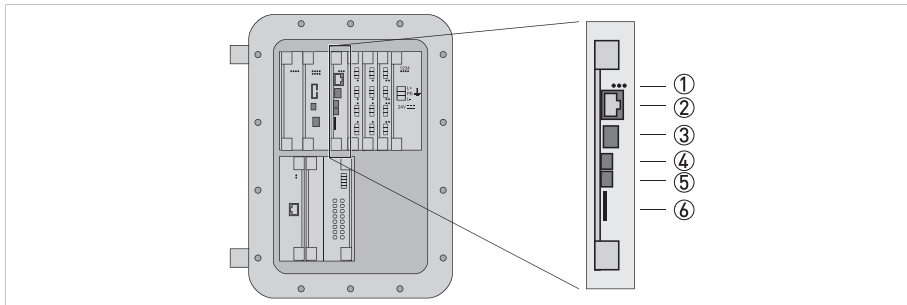


Figure 4-7: ALTOSONIC 5 COM 1 board

- ① Status LEDs, from left to right:
 Red status 1, normally on
 Red status 2, normally blinking
 Green COM 1 power supply OK
- ② Ethernet connection 10/100 Mb
- ③ USB (only for service purposes by KROHNE service engineers)
- ④ mini USB (only for service purposes by KROHNE service engineers)
- ⑤ mini USB for configuration tool (only for short 'normal' USB usage distances)
- ⑥ SD card

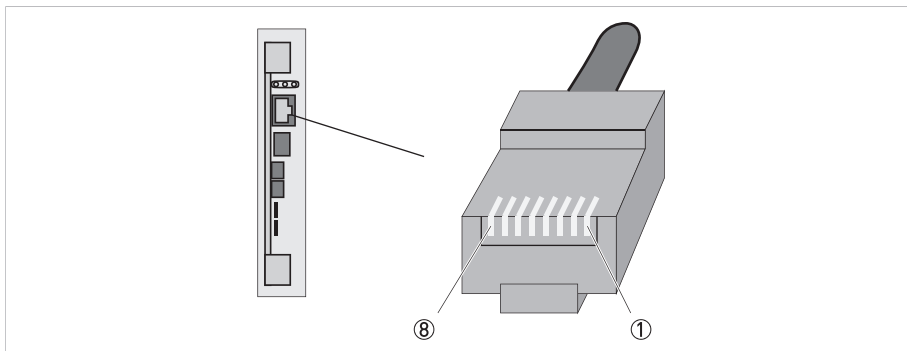


Figure 4-8: Ethernet RJ45 connector pin 1...8

RJ45 Ethernet connection pin	Wire color (T568A)	Wire color (T568B)	Function
1	white/green	white/orange	Transmit +
2	green	orange	Transmit -
3	white/orange	white/green	Receive +
4	blue	blue	Not used
5	white/blue	white/blue	Not used
6	orange	green	Receive -
7	white/brown	white/brown	Not used
8	brown	brown	Not used

4.3.3 Smart IO board (SMART IO) connections

The SMART IO board has multiple configurable IOs. The smart IO can be configured either as digital input/output or analog input/output. All functions use the same connections. The function is defined by the chosen configuration.

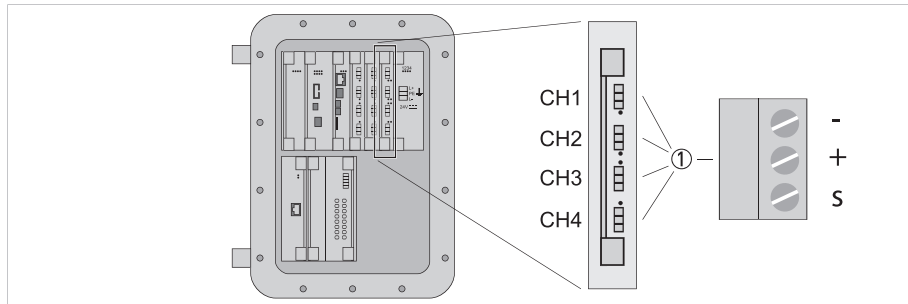


Figure 4-9:

① 4x configurable IO connection

Status lights for each channel

Each channel has two LEDs.

- Green LED: power LED, always on when signal converter is on.
- Red LED: configuration LED, will be on when the channel is set up as a functional output.
- *Passive mode: If a passive external device is connected, an external power supply is necessary to operate the connected devices (U_{ext}). If an active external device is connected, it can be connected directly.*
- *Active mode: The signal converter supplies the power to operate the connected passive devices, observe max. operating data. The maximum quantity of active outputs is limited to four.*
- *Terminals that are not used should not have any conductive connection to other electrically conductive parts.*


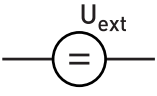
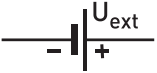
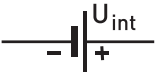
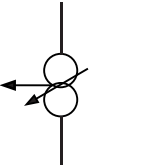
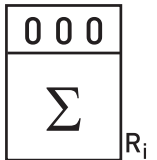
	<p>mA meter 0...20 mA or 4...20 mA and other R_L is the internal resistance of the measuring point including the cable resistance</p>
	<p>DC voltage source (U_{ext}), external power supply, any connection polarity</p>
	<p>DC voltage source (U_{ext}), observe connection polarity according to connection diagrams</p>
	<p>Internal DC voltage source</p>
	<p>Controlled current source with current measurement</p>
	<p>Electronic or electromagnetic counter At frequencies above 100 Hz, shielded cables must be used to connect the counters. R_i is the internal resistance of the counter</p>

Table 4-1: Description of symbols

Inputs and outputs

Inputs and outputs can be configured in the MCD tool as described below. The limits of currents and voltage can be configured in the MCD tool per IO. Limitation of these adjustable values are:

- $U_{int} = 3...23\text{ V}$
- $I_{max} < 25\text{ mA}$

Active frequency output

The active output can be connected to a passive external instrument.

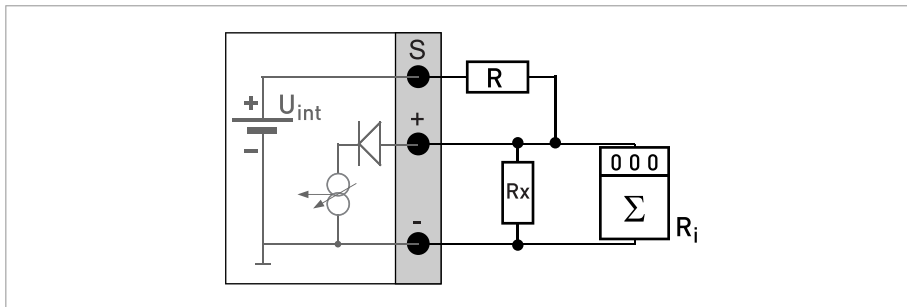


Figure 4-10: Frequency output, active

- Use terminals 'S' (Supply), '+' and '-'
- R: 1...10 k Ω (use resistor R to lower the resistance if the value is too high)
- Additional Rx (1 k Ω) is advised for cables > 200 m.

Passive frequency output

The passive output can be connected to a passive external device with an external power supply or directly to an active device.

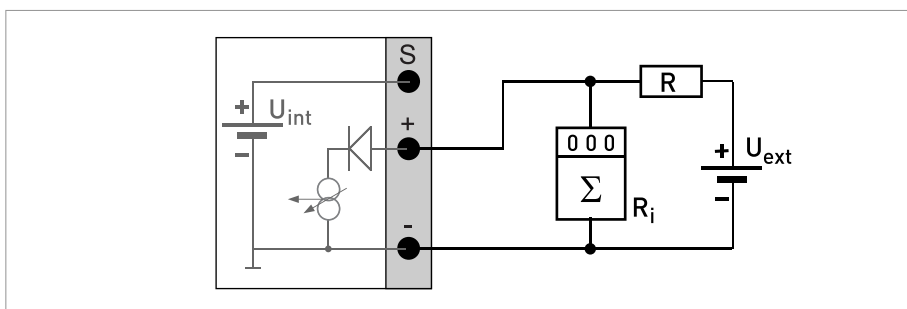


Figure 4-11: Frequency output, passive

- Use terminals '+' and '-'
- $U_{ext} \leq 27\text{ V}$

Active digital input

The active digital input can be connected to a passive external device.

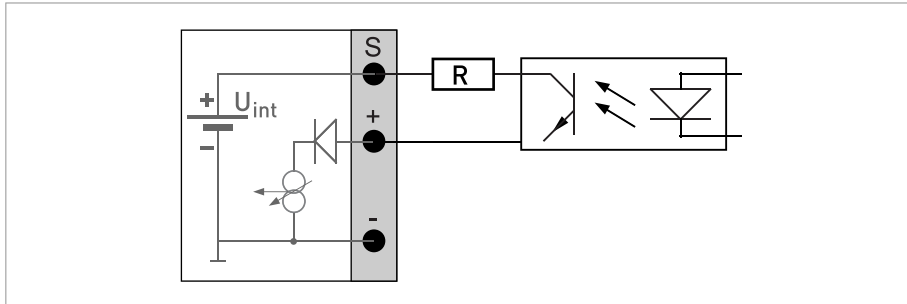


Figure 4-12: Digital input, active

- Use terminals 'S' (Supply) and '+'
- R: 1...10 k Ω

Passive digital input

The passive input can be connected to a passive external device with an external power supply or directly to an active device.

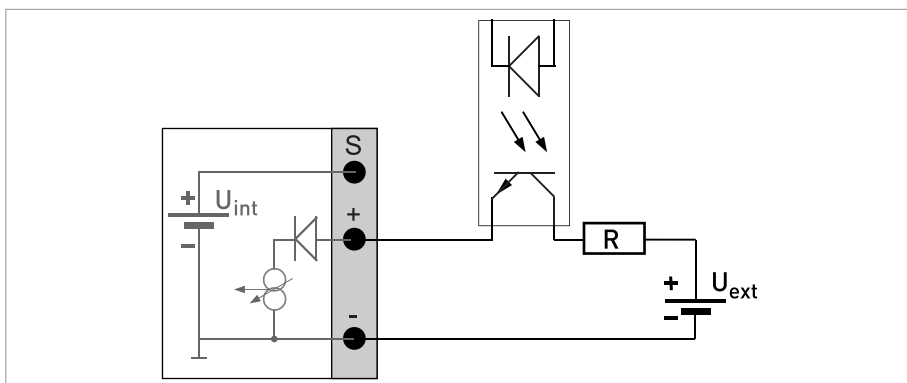


Figure 4-13: Digital input, passive, highside connection

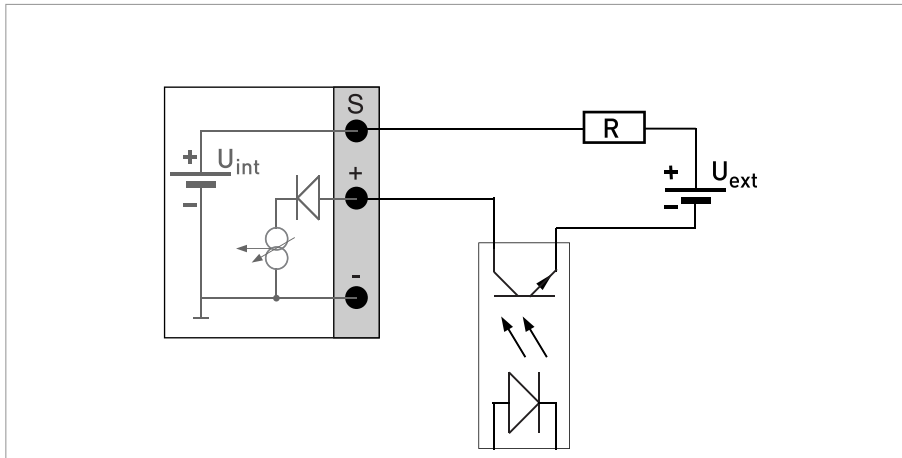


Figure 4-14: Digital input, passive, lowside connection

- Use terminals '+' and '-'
- $U_{ext} \leq 27 \text{ V}$

Active digital output

The active output can be connected to a passive external device.

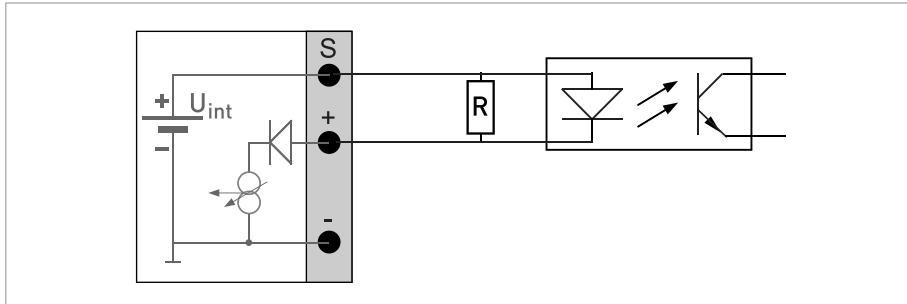


Figure 4-15: Digital output, active

- Use terminals 'S' (Supply) and '+'

Passive digital output

The passive output can be connected to a passive external device with an external power supply or directly to an active device.

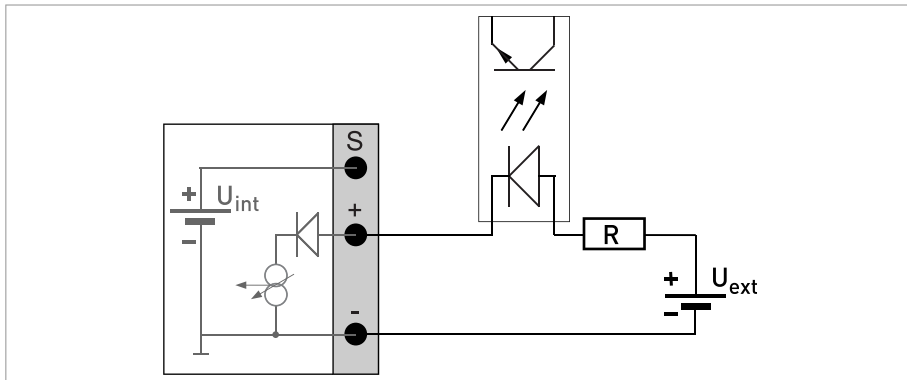


Figure 4-16: Digital output, passive, highside connection

- Use terminals '+' and '-'
- $U_{ext} \leq 27 \text{ V}$

Active analog output

The active output can be connected to a passive external device.

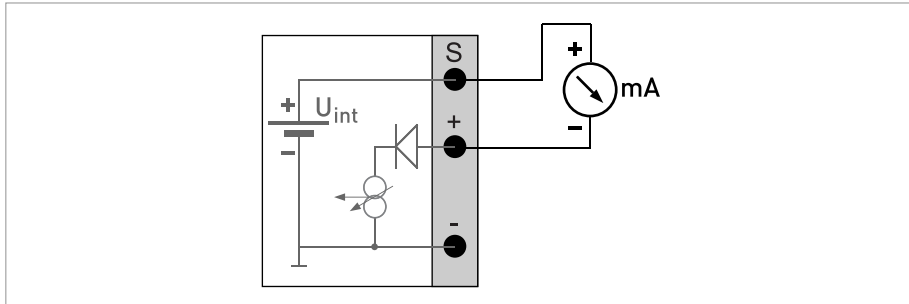


Figure 4-17: Analog output, active

- Use terminals 'S' (Supply) and '+'

Passive analog output

The passive output can be connected to a passive external device with an external power supply or directly to an active device.

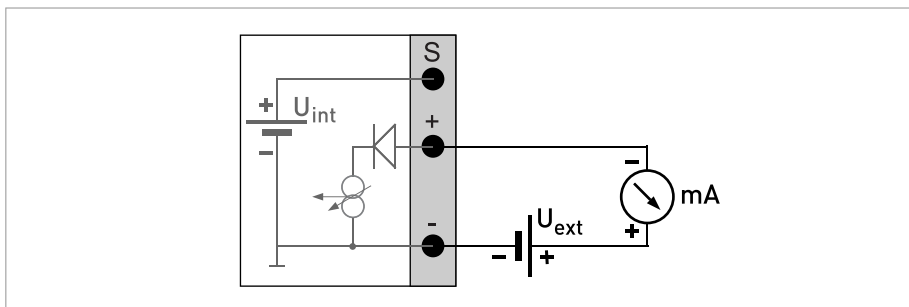


Figure 4-18: Analog output A, passive

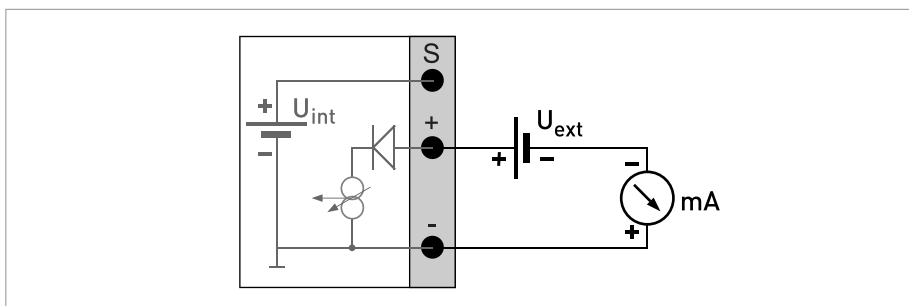


Figure 4-19: Analog output B, passive

- Use terminals '+' and '-'
- $U_{\text{ext}} \leq 27 \text{ V}$

Active analog input

The active input can be connected to a passive external device.

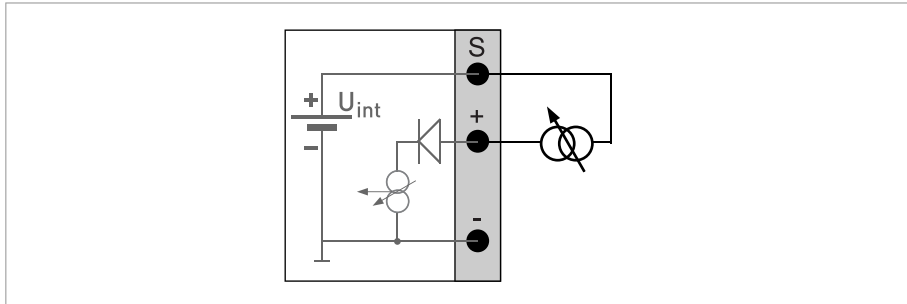


Figure 4-20: Analog input, active

- Use terminals 'S' (Supply) and '+'

Passive analog input

The passive output can be connected to a passive external device with an external power supply or directly to an active device.

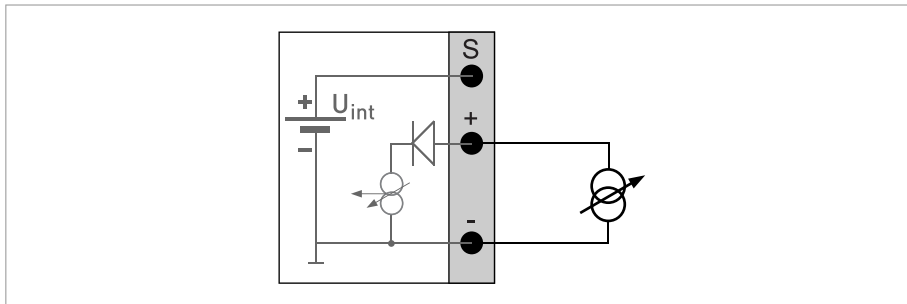


Figure 4-21: Analog input A, passive

- Use terminals '+' and '-'
- $U_{\max} = 27 \text{ V}$

4.3.4 RS485 IO board (COM 2) connections

The RS485 IO board has 4 serial communication channels.

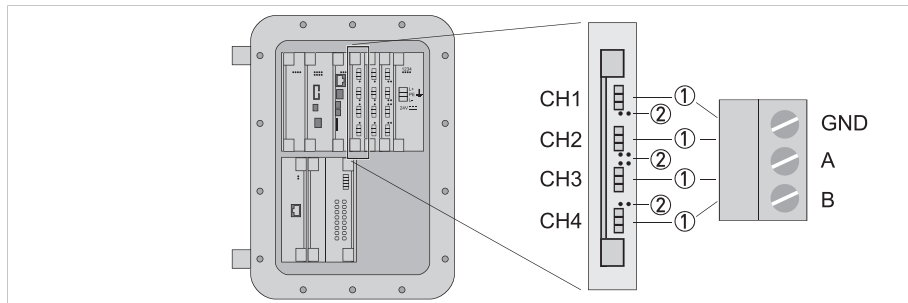


Figure 4-22: ALTOSONIC 5 RS485 IO board

- ① 4x RS485 connection
- ② 8x status LED for RS485 IO board

Status lights for each channel

Each channel has two LEDs.

- Green LED: power LED, always on when signal converter is on.
- Red LED: configuration LED, will be on when the channel is set up as a functional output.

All RS485 channels are galvanically isolated. The standard configuration is as follows:

- CH1: Modbus Master
- CH2: Modbus Slave 1
- CH3: Modbus Slave 2
- CH4: Backwards compatible for Ultrasonic Flow Processor ALTOSONIC V

A terminal resistor should be used if the cable is longer than 10 meter and high speed communication is used. To connect the on-board termination resistor, a jumper must be set, that can be found on the communication board as shown in the next figure.

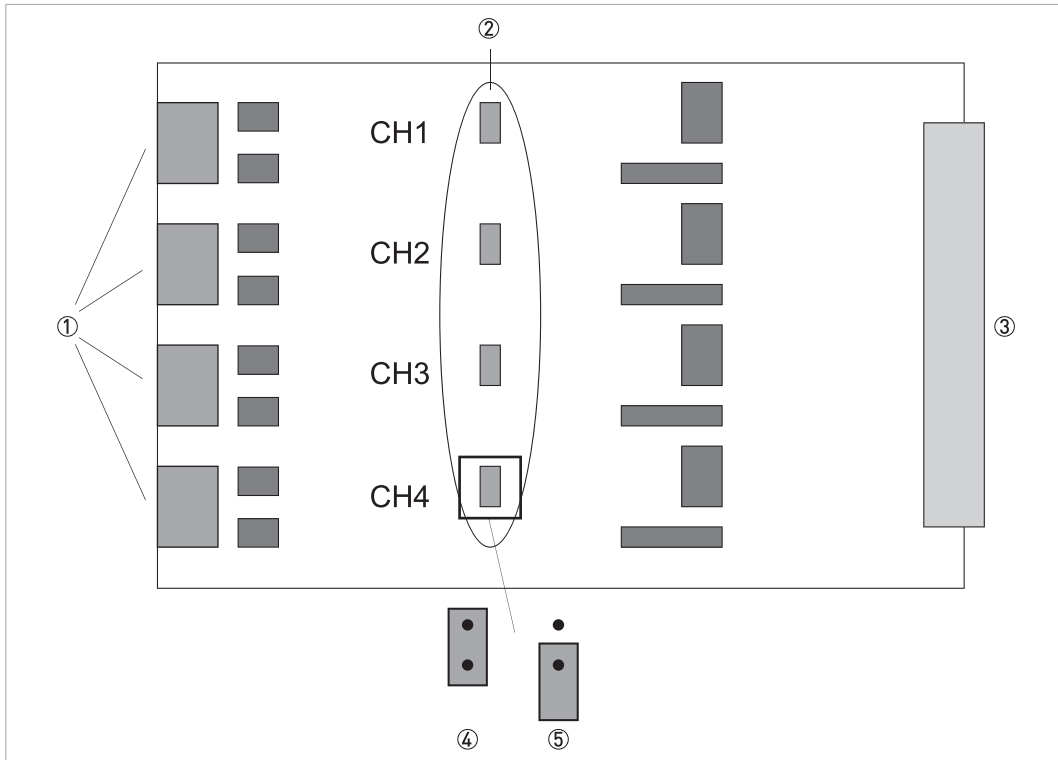


Figure 4-23: Jumpers on Communication board

- ① I/O connectors that are accessible on the front
- ② Jumpers (one for each I/O connector)
- ③ Multipole connector which connects the PCB to the backplane
- ④ Jumper is used: channel is terminated (factory default setting)
- ⑤ Jumper is not used: channel is not terminated

4.3.5 Power Supply Unit (PSU) connections

The PSU supplies isolated power to all cards installed in the signal converter.

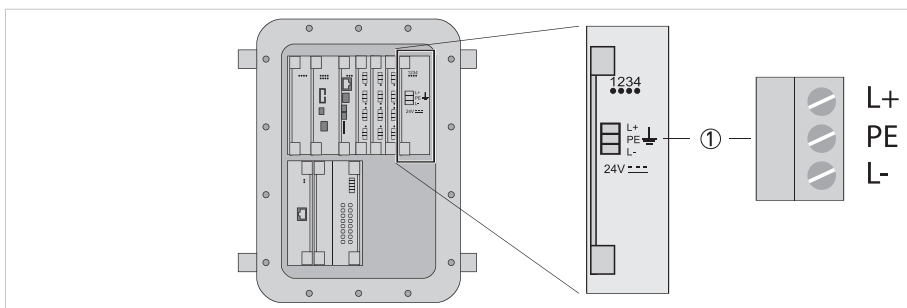


Figure 4-24: ALTOSONIC 5 PSU board

- ① Power Supply connections 24 V DC (+10/-15%)

4.3.6 Digital Processor Board (DPB) connections

The DPB calculates the flow rate, based on the measurement of the flow sensor. Therefore all calculations, filtering and corrections are done in this card.

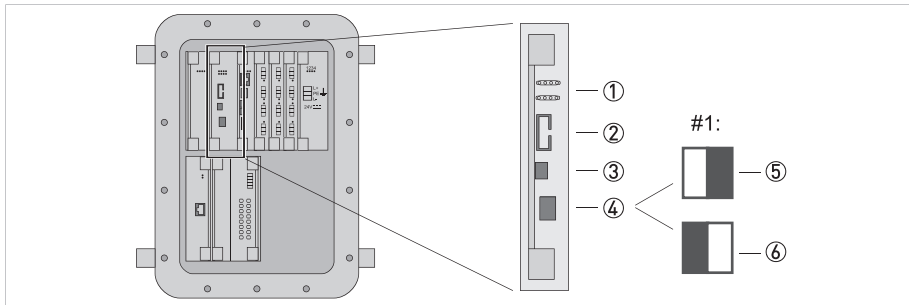


Figure 4-25: ALTOSONIC 5 DPB

- ① 1: green LED: always on, FPGA power ok
- 2: green LED: always on, internal power ok
- 3: green LED: always on, DPB power supply -6 V ok
- 4: green LED: always on, DPB power supply +6 V ok
- 5: red LED: normally blinking, internal clock ok
- 6: red LED: always on, normal operation flow measurement ok
- 7: red LED: always on, data transfer COM1 ok
- 8: red LED: normally off, on when SDRAM is accessed
- ② Internal service connector (KROHNE purpose only)
- ③ Debug interface (KROHNE purpose only)
- ④ Dip switches, from top to bottom:
 - 1: CT parameters. Left position: locked (⑤) ; right-hand position: unlocked (⑥)
 - 2: Not used
 - 3: Not used
 - 4: CT parameters
 - Left position: normal position
 - right position: factory mode

Optionally, the dpswitches can be sealed by a sticker.

4.3.7 Power Supply Unit Intrinsically Safe (PSU Ex) connections

This board has only internal connections and serves as a certified EX(i) power supply for the intrinsically safe part of the signal converter.

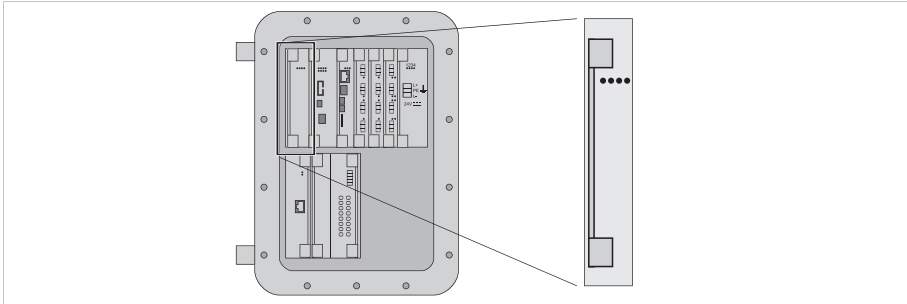


Figure 4-26: Intrinsic safe power supply

- ① 4x Power Supply LED
 - green LED: normally on, +DC/DC ok
 - green LED: normally on, -DC/DC ok
 - orange LED: normally on, +Vmux ok
 - orange LED: normally on, -Vmux ok

4.3.8 Analog Processor Board (APB) connections

The APB is the interface between the Multiplexer and the DPB and is installed in the intrinsically safe part of the signal converter.

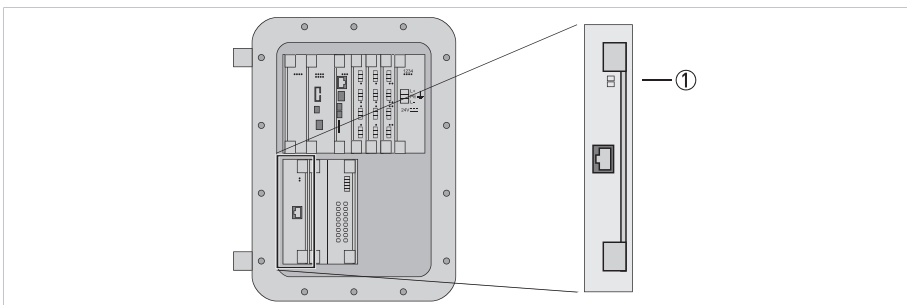
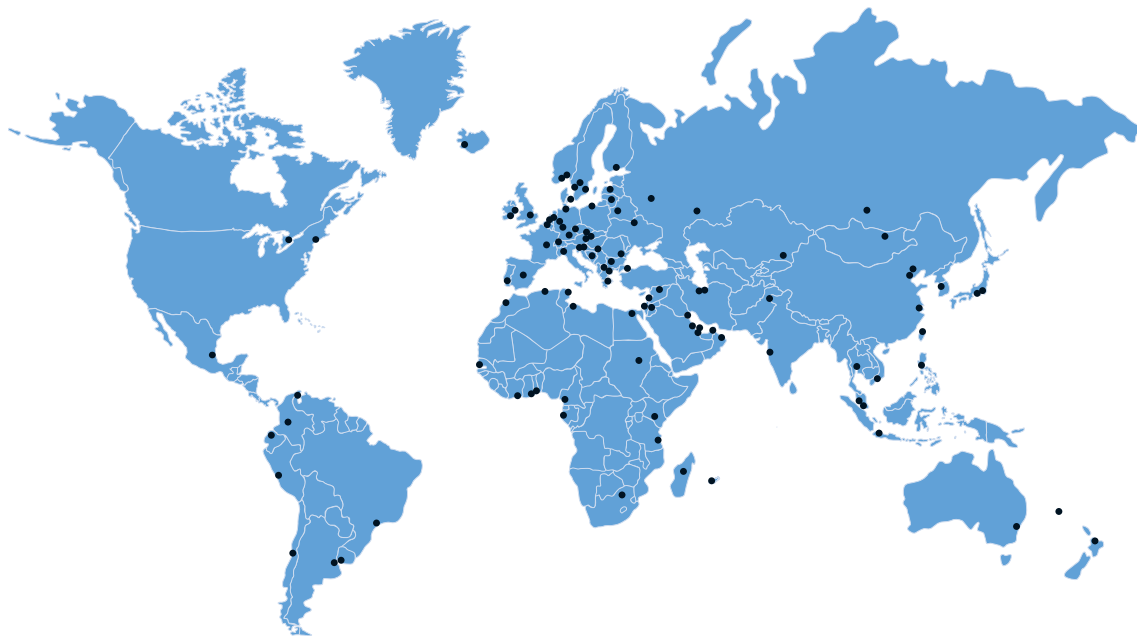


Figure 4-27: ALTOSONIC 5 Analog Processor Board

- ① red LED, normally on
(blinks when in Service mode)
- ② red LED, normally blinking





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