OPERATING MANUAL
for flow meters of the product line:
“VSI High Definition Flow Meter“

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Important basic information

Dear customer, dear user,

These installation and operating instructions should provide you with the information you need to properly install and commission the flow meter. The installation, commissioning and testing are to be performed by trained and qualified personnel only. These operating instructions must be read and applied carefully to ensure proper, trouble-free and safe operation of the flow meter. VSE is not liable for any damage incurred resulting from not complying with the instructions in this operating instruction. It is not permitted in any case to open the device.

These operating instructions for the flow meters of the series "VSI High Definition Flow Meter" from VSE must be stored, so that they can be read by the group of authorized personnel at any time. Chapters may not be taken of these instructions at any time. A missing operating instructions manual or missing pages must be replaced immediately. VSE can supply you with new instructions or you can download the operating instructions from the internet (www.vse-flow.com). The operating instructions must be given to each subsequent user of this product.

Legal information

This document is not managed by an updating service of VSE Volumentechnik GmbH.
Changes to this document may be made without notice.

VSE Volumentechnik GmbH does not provide any implicit guarantees of commercial qualities and suitability for a specific purpose.

If the device has been opened, modified or incorrectly connected to the electrical circuits, the guarantee of VSE Volumentechnik GmbH for safe operation is void. VSE Volumentechnik GmbH is not liable in any way for personal injuries or damage to goods resulting from improper installation or improper operating of the flow meter.

• General function description of flow meter

Flow meters made by **VSE Volumentechnik GmbH** measure the volume flow of liquids according to the toothed wheel principle. A pair of very precisely adjusted toothed wheels in the housing constitutes the meter. A signal pick-up system registers meter rotation free of contact and tooth by tooth. In flow meters of high resolution (VSI), each tooth is output as a multiple of digital pulses, depending on interpolation setting.

The gaps within the teeth of the meter wheels, form meter chambers in the areas, in which they are completely enclosed by the housing walls; these chambers digitalise liquid flow depending on their chamber volume.
The liquid flow within one meter rotation of a tooth division is divided by the set interpolation factor. This gives the volume measurement per pulse (V_m) and is defined in cm^3/pulse. It identifies the constructional size of a flow meter (e.g. VSI 1/16).

• General description

Please follow all instructions in this operating manual; only this guarantees trouble-free operation of the flow meters. VSE is not liable for any damage ensuing from not following of these instructions.

Opening the devices during the term of guarantee is only authorised after consultation and approval of VSE.

• Flow meter selection

The correct selection (version) of type and constructional size is crucial for a trouble-free and safe operation of the flow meters. Owing to the great number of various applications and flow meter versions, the technical specifications in the VSE catalogue material are of a general nature. Performance of the flow meter depends on type, size and meter range and on the liquid that is to be measured. Please consult VSE for an exact description.

• Declaration of Conformity

Flow meters of the "VSI" product line are tested for their electromagnetic compatibility and interference transmission in terms of the law on electromagnetic compatibility and correspond to the legal prescriptions enforced by EMC directives. They may not be operated independently and are to be connected via cable to a power source and supply digital electric signals for electronic evaluation. A declaration of conformity is submitted for all flow meters, which you can request if you require.
Since the electromagnetic compatibility of the total measuring system depends on cable layout, correct connection of protective shielding and each single connected device. You must ensure that all components correspond to the electromagnetic compatibility directives and that the electromagnetic compatibility of the total system, machine or plant is guaranteed.
All flow meters are tested according to the valid, legally prescribed electromagnetic compatibility directives EN 55011 and EN 61000 and possess the CE-certification. The EC-declaration of conformity is the CE-label attached to all flow meters.

• General conditions for initial start-up

Before assembly and before initial start-up, you have to note the following properties and aspects of the corresponding characteristics of your system, so that a trouble-free and safe operation is possible.

1. The process fluid

- ➜ Is the flow meter **suitable for the medium**?
- ➜ Is the fluid **viscous or abrasive**?
- ➜ Is the fluid **contaminated** or is there **solid matter** in **the fluid**?
- ➜ Which **granular size** does the solid matter possess and can it **block the meter**?
- ➜ Does the fluid have **fillers** or other **additional material**?
- ➜ Is it necessary to install a pre-switched **hydraulic filter**?
- ➜ Are the **pipe lines clean** and free of assembly residues such as swarf, weld chips?
- ➜ Is the **tank clean** and is it ensured that **no extraneous materials** can get into the pipe line system from the tank?
- ➜ Is the fluid often changed and is **sufficient flushing performed in this case**?
- ➜ Are the pipe lines and the entire system completely **deaerated**?
- ➜ What **cleaning agent** is being used?
- ➜ Are the fluid and the cleaning agent compatible with the **seals**?
- ➜ Are the **seals suitable** for the fluid undergoing measurement **(seal compatibility)**?

2. The hydraulic properties of the system

➜ Is the **max. operating pressure of the system** lower than the max. permitted operating pressure of the flow meter?
➜ Is the **max. fall of pressure Δp** (on flow meter) below the max. permitted fall of pressure?
➜ Does an excessively **great fall in pressure Δp** occur on the flow meter at max. flow (e.g. with higher viscosity)?
➜ Does the flow range of the flow meter (depending on viscosity) correspond to the **provided flow**?
➜ Note that flow range decreases the **greater the viscosity**!
➜ Does the temperature range of the flow meter correspond to the **provided max. temperature** of the medium?
➜ Is the **cross section** of the pipe line large enough and are the falls in pressure in the system not excessive?
➜ Is the **hydraulic connection** (supply and reverse flow) correctly connected and leak-proof?
➜ Has the **pump** sufficient power to operate the system?
➜ A blocking flow meter can stop the whole flow. Is a **pressure control valve / bypass** provided in the system?

3. Electronic evaluation and electrical safety

➜ Have you selected the optimal flow meter and is this equipped with the **appropriate preamplifier**?
➜ Does the **power supply voltage** of the flow meter correspond to the provided voltage?
➜ Is the power supply voltage supplied by the mains or evaluation device sufficiently **steady**?
➜ Does the **output** of the power supply voltage correspond to the required power output?
➜ Has the electric connection been installed based on the enclosed **connection plan**?
➜ Is the **cable protective shielding** correctly connected on both sides on the earth conductor PE?
➜ Is there a **potential difference** between the earth conductor PE on the flow meter and the earth conductor PE on the evaluation device?
➜ Does a correcting lead have to be laid to eliminate the **potential difference** between the flow meter and the evaluation device?
➜ Is the flow meter connected firmly to the **earth conductor PE** (e.g. via the pipe lines)?
➜ Is the meter constructed to be **insulated** to the earth conductor PE (e.g. connection via hoses)? If this is the case, the meter has to be connected with the earth conductor PE!
➜ Is there a **continuous connection** of the cable protective shielding (earth conductor PE) via the housing, of the 4 or 5-pin round plug to the housing of the flow meter?
➜ Is the cable laid fault-free and the installation secured from input of **interference pulses**?
➜ Is the **4 or 5-pin round plug** of the connection cable firmly screwed together with the plug of the flow meter?
➜ Are the wires on the **evaluation device** correctly and properly connected?
➜ Does the entire system correspond to the directives of the electromagnetic compatibility laws (**EMC**)?
➜ Have all local valid regulations, **applicable directives**, guidelines and background conditions of the **electromagnetic compatibility laws** been maintained and observed?
➜ Systems that can lead to personal injury through malfunction or failure are to be equipped with the **appropriate safety devices**. The functioning of these safety devices is to be checked at regular intervals.

• Maximum operating pressure

Before assembling the flow meter, you have to test that the max. operating pressure of the system does not exceed the max. permitted operating pressure of the flow meter. Meanwhile, observe the top pressures that can occur, when operating the system.

The following operating pressures are permitted depending on flow meter version:

➜ Flow meter in grey cast iron version p_{max} = 315 bar / 4500 psi
➜ Flow meter in stainless steel version p_{max} = 450 bar / 6500 psi

Important:
Please consult VSE for all operating pressures > 450 bar / 6500 psi and for special versions.

• Statement to EU-Directive 97/23/EG, Pressurized devices

VSE flow meter are pressurized devices according to article 1, paragraph 2.1.4. of above mentioned directive. Therefore they are subject to the regulations to this directive.

According to article 3, paragraph 1.4, VSE flow meters have to conform with the technical requirements of the guideline. The fluids to be measured are belonging in most of all cases to the class 2, defined in article 9, paragraph 2.2. VSE flow meter do not reach the limit values as defined in article 3, paragraph 1.1.

The technical requirements for VSE flow meters therefore are limited to the parts indicated in article 3, paragraph 3. It means the devices have to be designed and manufactured in conformity with acknowledged engineering, such as practiced in one of the member states. This is herewith confirmed.

Beside this the paragraph declares that these devices must not have a CE-marking according to Directive 97/23/EG. Therefore we do not issue declarations of CE and our products are not labelled acc. to 97/23/EG.

• Flow meter range

The flow meter range specified in the flow meter data sheet (Q_{min} - Q_{max}) refers to the testing fluid "hydraulic oil" with a viscosity of 21 mm^2/s at a temperature of 20°C. For this flow meter range, VSE specifies measurement accuracy of up to 0.3% of the measurement value and a repetition accuracy of 0.05%.

For fluids of lower viscosity (< 21 mm^2/s) measurement accuracy deteriorates, while for fluids of higher viscosity (> 21 mm^2/s) it can improve. Also note, however, that the flow meter range is restricted in case of higher viscosity (see flow meter data sheet).

Important:
Make sure that the specified maximum permitted operating pressure of the flow meter cannot be exceeded, whatever the operating mode of the system. Note the flow meter range that is dependent on the viscosity of the fluid to be measured.

• Assembly of the flow meter

The flow meter should be mounted on an easily accessible location, so that dismantling for cleaning the meter presents no problem. Since flow meters can work in any installation position and flow direction, you can mount it on any location of your system. Take care, when installing the flow meter that liquid always remains in the flow meter, even at system standstill and that it can never run empty. The outflow of the flow meter should therefore always show a certain back pressure, since this clamps the flow meter firmly in the liquid column (the meter supports itself through this on the liquid column) and the pipe line cannot run empty. In critical cases or when the pipe line is at standstill or standby and can run empty, we recommend installing an extra non-return valve in the outflow line.

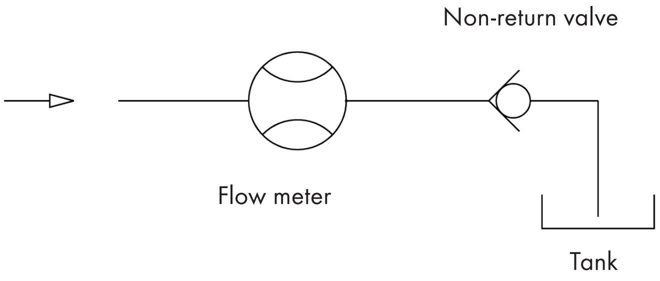


Fig. 1: Flow meter installation with non-return valve

Important:
Make sure that the flow meter is always completely filled both in inflow and outflow and that the outflow has a little back pressure. This prevents the meter being damaged by a sudden and steep increase of flow and at the same time improves measurement accuracy.

Flow meters of the "VSI" product line can be mounted directly onto a block or into the pipe line using four screws. Always select large cross sections for the hydraulic supply and return flow respectively for the entire pipe line system (if possible). This lowers the fall in pressure and the flow rate in the total system.

Block assembly:
The flow meter is directly mounted onto a subplate or manifold, extra components are not needed. The block contains the hydraulic supply and outflow of the flow meter and the fixing bore holes (see flow meter dimension sheet).

VSE supplies subplates for all flow meters of the "VSI" product line; they have various pipe threads and side or rearside connection (see subplates data sheet). Depending on the provided conditions, the installed pipe line, the pipe cross section or pipe thread, the operator can choose the suitable subplate and incorporate this into the system or machine without additional reductions.

The flow meter is screwed onto the block or subplate with four DIN 912 cheese head screws. The screws are to be evenly pre-tensed crosswise with the following torques.

When changing the fastening screws you must take great care that the screws are of property class 10.9 and 12.9.

Table 1: Torque of fastening screws

Flow meter, size (cast iron and 1.4305)	Torque
VSI 0.02; VSI 0.04; VSI 0.1; VSI 0.2	15 Nm
VSI 0.4; VSI 1; VSI 2	35 Nm
VSI 4	120 Nm
VSI 10	250 Nm

Please note the special instructions for mounting sizes VSI 4 and VSI 10 (see appendix)

Important:
When mounting the flow meter, you must take great care that the seals are not damaged and correctly placed in the hydraulic connections of the flow meter. Wrongly installed or damaged seals lead to leakage and to a leaky system, which may have dire consequences.
Please make sure that flow meters with EPDM seals do not come into contact with oil and greases on a mineral oil basis. These fluids can decompose the seals.
The yellow plastic plugs in the hydraulic connections of the flow meter protect the meter against dirt and contamination during storage and shipping. Before mounting the flow meter you have to remove these plugs so that in- and outflow is free and open.

• Cleaning and flushing of pipe lines before initial start-up

Before initial start-up of the flow meter, you must flush and clean the whole system. Contaminated fluid can effect the correct function of the flow meter or seriously damage the meter.

After preparing and connecting up the system pipes, you must first carefully flush and clean the whole pipe line system and the tank. To do this, you have to mount a diversion plate onto the block or subplate instead of the flow meter, so that the fluid can flow through the diversion plate and all extraneous material (e.g. swarf, metal chips, etc.) can be flushed out without obstruction. Use a fluid as cleansing agent, which is compatible with the fluid being used later and which does not cause undesirable reactions. You can consult the suppliers and manufacturers of the fluid or contact VSE for the corresponding information. VSE supplies bypass plates for all VSI-flow meter sizes.

Flow meters are measurement pick-up systems made with high-level precision. They have a mechanical meter consisting of two toothed wheels, which is adapted to the housing with narrow slots. Even the tiniest damage to the toothed wheels and bearings can cause a measurement error. So always make sure that no extraneous material gets into the meter and that the fluid flowing through is always free from dirt and contamination.

After the system has been carefully flushed out and no extraneous material is in the pipe line, you can mount the flow meter and commence the initial start-up.

Important:
Please flush out the pipe lines and the tank thoroughly, to prevent contamination within the flow meter.

• Filtering of liquid

Strongly contaminated fluids or extraneous material in the fluid can block, damage or even destroy the flow meter. Always install a sufficiently large filter for these cases in front of the flow meter to prevent damage to the flow meter. The necessary filtering depends on size, bearing system and model of flow meter.

Table 2: Pre-switched filters

Flow meter size	Filter size for ball bearings
VSI 0.02 / 0.04 / 0.1	10 µm
VSI 0.2 / 0.4	20 µm
VSI 1 / 2 / 4 / 10	50 µm

For information on filter size for flow meters with plain bearings, in special version, or with specially adjusted meter tolerances, please consult ***VSE GmbH****.*

Important:
A blocking flow meter can stop the whole flow. You have to provide a control valve / bypass for the system.

• Flow meters with high definition of volume measurement

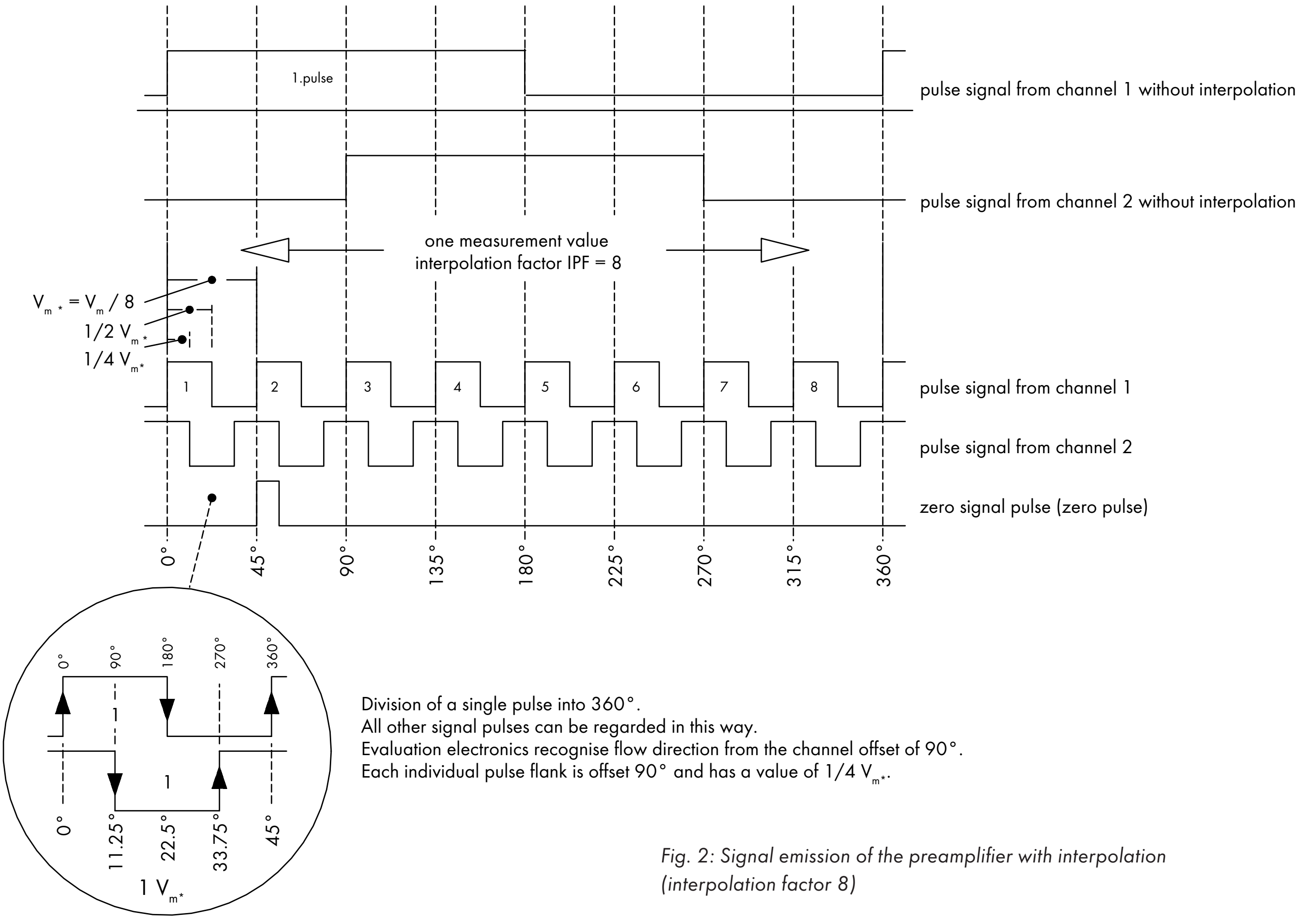
The preamplifiers of the standard version for flow meters of the "VS" product line output a pulse per tooth gap volume V_z, which corresponds to the volume measurement V_m ($V_m = V_z$/pulse.). This takes place in two channels, so that you can attain a maximum resolution of 1/4 V_z for the evaluation of all flanks. A higher resolution is not possible with these preamplifiers.

But since as high a resolution as possible is necessary for precise and exact flow and volume measurements, the volume measurement V_m must be resolved even more than is the case with conventional preamplifiers. VSE has therefore developed the preamplifier with interpolation, with which a selectable resolution of up to 64 flanks (16 pulses) per period can be attained (see table 3). This means that you can resolve the volume measurement V_m with this preamplifier to a maximum of 1/64 V_m. For the evaluation, this means that a part volume of 1/64 V_m from pulse flank to pulse flank (for quadruple evaluation or flank count) is measured, or a full signal pulse is counted as part volume of 1/16 V_m (pulse count) (see fig. 3, interpolation V_m/16).

This individually programmed high resolution enables you to set the volume measurement V_m optimally for each provided case of application. Furthermore, new applications can be availed of with the higher resolution potential.

- ➜ Measuring, controlling and regulating in the lower flow range
- ➜ Measuring, controlling and regulating in zero flow
- ➜ Measuring, controlling and regulating in both flow directions
- ➜ Measuring, controlling, dosing and filling of small volumes

Flow meters with interpolation electronics (VSI) output two digital signals with programmable high resolution that are phase-offset 90° (see fig. 3). In addition to the signal emission, a zero signal emission is provided, which emits a zero signal at each fully registered volume measurement V_m (see fig. 2).



Division of a single pulse into 360°.
All other signal pulses can be regarded in this way.
Evaluation electronics recognise flow direction from the channel offset of 90°.
Each individual pulse flank is offset 90° and has a value of 1/4 V_{m*}.

Fig. 2: Signal emission of the preamplifier with interpolation (interpolation factor 8)

Fig. 2 shows the resolution of the volume measurement V_m with an interpolation factor of 8. This resolves each volume measurement into eight individual part volumes. A pulse on the signal output of channel 1 or channel 2 thus has a value of $V_m* = V_m /8 = 1/8\ V_m$ per pulse. In double evaluation (flank evaluation of one channel) this results in a value of $1/2\ V_m* = V_m/16 = 1/16\ V_m$ and for quadruple evaluation (flank evaluation of both channels) the result is a value of $1/4\ V_m* = V_m/32 = 1/32\ V_m$ per flank. Evaluation electronics can recognise flow direction from signals offset 90°.

The preamplifier of the “VSI” product line has a programmed interpolation factor (IPF) with which you can program new, different resolutions. Hence you can program a resolution of 4 to 64 angular steps (see fig. 4) per volume measurement V_m. The frequency multiplication “f*” lies between 1 and 16 (see table 3).

Table 3: Interpolation factor and resolution

Interpolation factor	Pulse/V_m	Max. resolution (evaluation of signal flanks)	Resolution V_m* (volume measurement V_m*) [ml]	Max. resolution (angle degrees)	Frequency f_{max}*
1	1	4 (quadrupling)	V_m / 4	90°	f_{max} x 1
2	2	8	V_m / 8	45°	f_{max} x 2
3	3	12	V_m /12	30°	f_{max} x 3
4	4	16	V_m /16	22.5°	f_{max} x 4
5	5	20	V_m /20	18°	f_{max} x 5
8	8	32	V_m /32	11.25°	f_{max} x 8
10	10	40	V_m /40	9°	f_{max} x 10
12	12	48	V_m /48	7.5°	f_{max} x 12
16	16	64	V_m /64	5.625°	f_{max} x 16

Only the marked lines are illustrated in the diagram of fig. 3

Column 1: Programmable interpolation factor IPF (programmed in the factory).
Column 2: Pulses per volume measurement V_m.
Column 3: Maximum resolution of the signal flanks. The signal flanks of channels 1 and 2 are evaluated.
Column 4: Volume measurement V_m* resulting from the maximum resolution of the signal flanks.
Column 5: Maximum resolution in angle degrees at resolution of signal flanks.
Column 6: Maximum frequency f_{max}* at maximum flow Q_{max} and programmed interpolation factor IPF

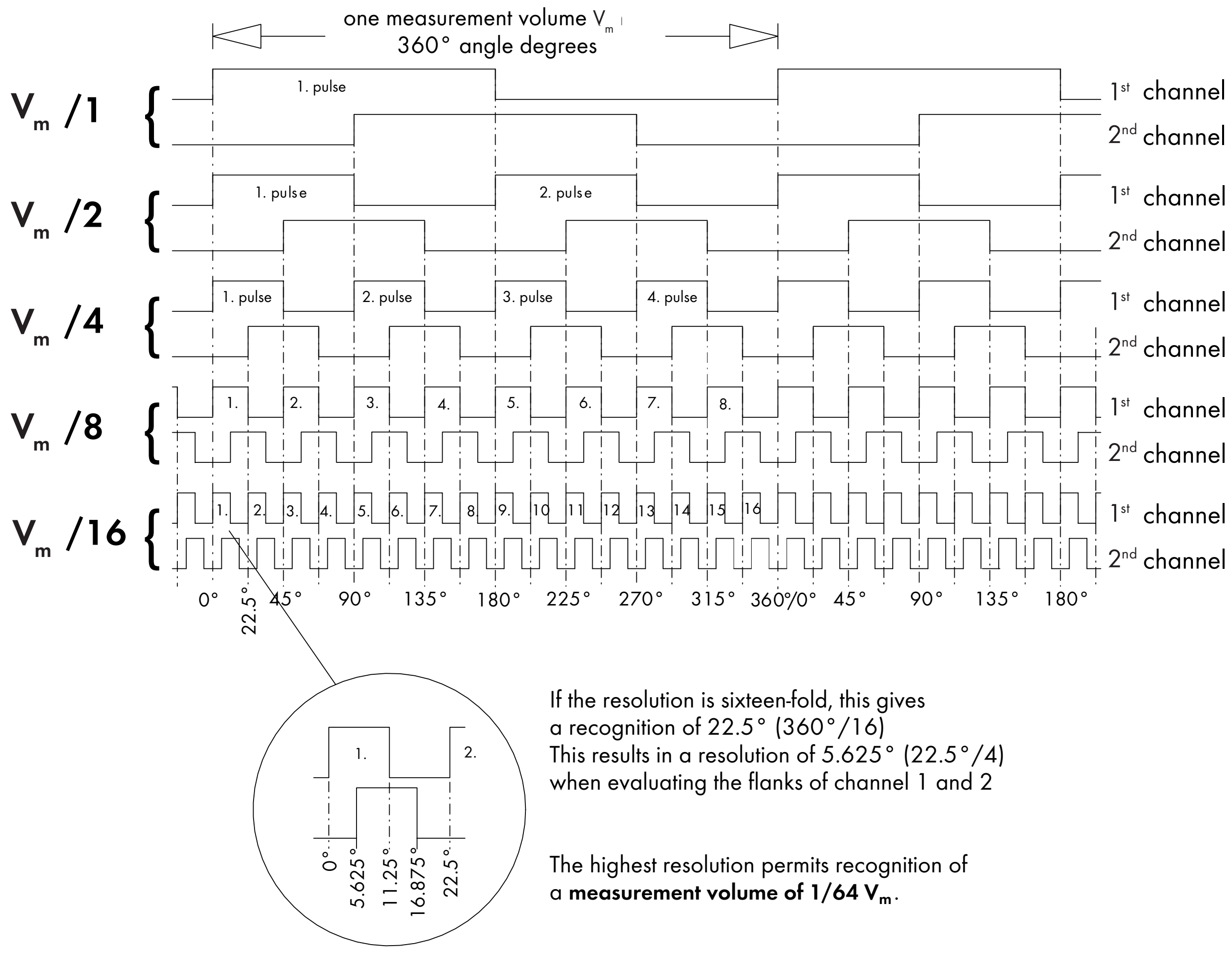
In practice, the maximum flow Q_{max} of the flow meter is seldom run, so that a lower frequency can be calculated. The maximum frequency is then calculated according to the following formula:

$$f_{max°} = \frac{(Q_{max°})*IPF}{V_m} \qquad \textbf{Formula 1}$$

$f_{max°}$	Maximum frequency of the flow meter signals
$Q_{max°}$	Maximum flow attained in the case of application described here
IPF	Programmed interpolation factor
V_m	Volume measurement of the flow meter

Example: Flow meter **VSI** 1/10... max. flow the system can be run on at a maximum
$Q_{max°}$ = 40 l/min = 666.667 ml/sec; IPF = 10; V_m = 1 ml/pulse; $f_{max°}$ = 6666.67 Hz = 6.66667 kHz

At max. flow$_{max°}$ = 40 l/min, the flow meter **VSI** 1/10... outputs a frequency of $f_{max°}$ = 6666.67 Hz.



If the resolution is sixteen-fold, this gives a recognition of 22.5° (360°/16)
This results in a resolution of 5.625° (22.5°/4) when evaluating the flanks of channel 1 and 2

The highest resolution permits recognition of a **measurement volume of 1/64 V_m**.

Fig. 3: Interpolation of the volume measurement V_m

At initial start-up of the system, you have to program the **volume measurement V_m*** (see table 4, column 4) in your evaluation electronics as parameter value (e.g. multiplier). The evaluation electronics then multiply every pulse the flow meter outputs by the volume measurement V_m* and thus calculates the flow and the volume. For flow meters with high resolution, the parameter value **volume measurement V_m*** is dependent on volume measurement V_m (see table 4, column 2) and on the programmed interpolation factor IPF (see table 4, column 3).

Please consult this first of all for the volume measurement V_m* and program this value as parameter into your evaluation electronics.

On table 4 you can view the corresponding volume measurement V_m* (see table 4, column 4) with the real, programmed interpolation factor IPF* (see table 4, column 3). The K-factor in column 5 is a measurement for the resolution per litre.

You then get the maximum frequency f_{max}* (see table 4, column 8) of the signal pulses for the maximum flow Q_{max} (see table 4, column 6) with programmed interpolation factor IPF*. This frequency is dependent on the programmed interpolation factor IPF and increases with rising resolution.

Important:
Test the connected evaluation electronic system as to whether it can process the maximum frequency f_{max}* of the flow meter. Check the data from the following table for the relevant flow meter, or calculate the maximum frequency data f_{max}° with formula 1.

Table 4: Volume measurement and max. frequency at high resolution

Flow meter	Vol. measurement V_m	Interpol. IPF*	Vol. measurement V_m* (ml/pulse)	K-factor* (pulse/l)	Q_{max}	f_{max}	f_{max}* (Hz)
VSI 0.02...	**0.02 ml/pulse**	1	0.02	50 000	**2 l/min (= 2 000 ml/min = 33.33 ml/s)**	**1 666.7 Hz**	1 666.7
		2	0.01	100 000			3 333.3
		3	0.00666667	150 000			5 000.0
		4	0.005	200 000			6 666.7
		5	0.004	250 000			8 333.3
		8	0.0025	400 000			13 333.3
		10	0.002	500 000			16.666.7
		12	0.00166667	600 000			20 000.0
		16	0.00125	800 000			26 666.7
VSI 0.04...	**0.04 ml/pulse**	1	0.04	25 000	**4 l/min (= 4 000 ml/min = 66.67 ml/s)**	**1 666.7 Hz**	1 666.7
		2	0.02	50 000			3 333.3
		3	0.01333333	75 000			5 000.0
		4	0.01	100 000			6 666.7
		5	0.008	125 000			8 333.3
		8	0.005	200 000			13 333.3
		10	0.004	250 000			16.666.7
		12	0.00333333	300 000			20 000.0
		16	0.0025	400 000			26 666.7
VSI 0.1...	**0.1 ml/pulse**	1	0.1	10 000	**10 l/min (= 10 000 ml/min = 166.67 ml/s)**	**1 666.7 Hz**	1 666.7
		2	0.05	20 000			3 333.3
		3	0.03333333	30 000			5 000.0
		4	0.025	40 000			6 666.7
		5	0.02	50 000			8 333.3
		8	0.0125	80 000			13 333.3
		10	0.01	100 000			16.666.7
		12	0.00833333	120 000			20 000.0
		16	0.00625	160 000			26 666.7
VSI 0.2...	**0.2 ml/pulse**	1	0.2	5 000	**18 l/min (= 18 000 ml/min = 300 ml/s)**	**1 500 Hz**	1 500.0
		2	0.1	10 000			3 000.0
		3	0.06666667	15 000			4 500.0
		4	0.05	20 000			6 000.0
		5	0.04	25 000			7 500.0
		8	0.025	40 000			12 000.0
		10	0.02	50 000			15 000.0
		12	0.01666667	60 000			18 000.0
		16	0.0125	80 000			24 000.0
VSI 0.4...	**0.4 ml/pulse**	1	0.4	2 500	**40 l/min (= 40 000 ml/min = 666.7 ml/s)**	**1 666.7 Hz**	1 666.7
		2	0.2	5 000			3 333.3
		3	0.13333333	7 500			5 000.0
		4	0.1	10 000			6 666.7
		5	0.08	12 500			8 333.3
		8	0.05	20 000			13 333.3
		10	0.04	25 000			16.666.7
		12	0.03333333	30 000			20 000.0
		16	0.025	40 000			26 666.7

Flow meter	Vol. measurement V_m	Interpol. IPF*	Vol. measurement V_m* (ml/pulse)	K-factor* (pulse/l)	Q_{max}	f_{max}	f_{max}* (Hz)
VSI 1...	**1 ml/pulse**	1	1.0	1 000	**80 l/min (= 80 000 ml/min = 1 333.3 ml/s)**	**1 333.3 Hz**	1 333.3
		2	0.5	2 000			2 666.7
		3	0.33333333	3 000			4 000.0
		4	0.25	4 000			5 333.3
		5	0.2	5 000			6 666.7
		8	0.125	8 000			10 666.7
		10	0.1	10 000			13 333.3
		12	0.08333333	12 000			16 000.0
		16	0.0625	16 000			21 333.3
VSI 2...	**2 ml/pulse**	1	2.0	500	**120 l/min (=150 000 ml/min = 2 500 ml/s)**	**1 000 Hz**	1 000.0
		2	1.0	1 000			2 000.0
		3	0.66666667	1 500			3 000.0
		4	0.5	2 000			4 000.0
		5	0.4	2 500			5 000.0
		8	0.25	4 000			8 000.0
		10	0.2	5 000			10 000.0
		12	0.16666667	6 000			12 000.0
		16	0.125	8 000			16 000.0
VSI 4...	**4 ml/pulse**	1	4.0	250	**250 l/min (=300 000 ml/min = 5 000 ml/s)**	**1 041.7 Hz**	1 041.7
		2	2.0	500			2 083.3
		3	1.33333333	750			3 125.0
		4	1.0	1 000			4 166.7
		5	0.8	1 250			5 208.3
		8	0.5	2 000			8 333.3
		10	0.4	2 500			10 416.7
		12	0.33333333	3 000			12 500.0
		16	0.25	4 000			16 666.7
VSI 10...	**3.33 ml/pulse**	1	3.33333333	300	**525 l/min (=525 000 ml/min = 8 750 ml/s)**	**2 625 Hz**	2 625.0
		2	1.66666667	600			5 250.0
		3	1.11111111	900			7 875.0
		4	0.83333333	1 200			10 500.0
		5	0.66666666	1 500			13 125.0
		8	0.41666666	2 400			21 000.0
		10	0.33333333	3 000			26 250.0
		12	0.27777777	3 600			31 500.0
		16	0.20833333	4 800			42 000.0

V_m = physical volume measurement (size) of the flow meter (volume per tooth and per tooth gap)
Q_{max} = max. flow (test conditions)
f_{max} = max. frequency at Q_{max} $f_{max} = Q_{max}/V_m$
IPF* = programmable interpolation factor
* = all characters marked with * refer to IPF*
V_m* = interpolated volume measurement $V_m* = V_m/IPF*$; K-factor* = $1/V_m*$
f_{max}* = max. interpolated frequency at Q_{max} $f_{max}* = Q_{max}/V_m*$

Example of flow meter “VSI 0.1/10 ...”

1. Column :	Flow meter, version **VSI** and size **0.1**	VSI 0.1...	
2. Column:	physical volume measurement **V_m** (corresponds to the volume measurement V_m at interpolation factor IPF* = 1)	V_m =	0.1 ml/pulse
3. Column:	Interpolation factor **IPF*** = hardware programmed	IPF* =	10
4. Column:	Volume measurement **V_m***	V_m* =	0.01 ml/pulse
5. Column:	**K-factor***; reciprocal value of volume measurement V_m*	K-factor* =	100 000 pulse/l
6. Column:	maximum flow **Q_{max}** of the flow meter	Q_{max} =	10 l/min
7. Column:	maximum frequency **f_{max}** at interpolation factor IPF = 1 (see column 2) (corresponds to the volume measurement V_m at interpolation factor IPF = 1)	f_{max} =	1 666.7 Hz
8. Column:	maximum frequency **f_{max}*** at programmed interpolation factor (see column 3)	f_{max}* =	16 666.7 Hz

The high-level stages of the preamplifier are fast line drivers for three channels with a characteristic wave impedance adjustment for 75Ω lines. They emit the signals of channel A, channel B and the zero channel Z. The push-pull high-level stages are designed for high driver power of approx. 300 mA on 24 V; they are current limiting and short-circuit-proof by switch-off at excessive temperature. Cap diodes against V_b and against GND protect the emittance against “echoes” through erroneously adjusted lines and against destruction through ESD.

A switching circuit in the high-level stage monitors the voltage supply U_b as well as the temperature and in case of error switches all high-level stages to high impedance. The error output is designed as open collector and likewise short-circuit-proof; it sends an error message to the external electronics if there is a malfunction.

Data transfer with 24 V signals is done as a rule without circuit termination with a wave impedance. An erroneously adjusted circuit termination causes reflections, which can run repeatedly hither and thither if no adjustment is provided on the sender side. If there is a fast sequence of pulses, transmission is interfered with by these reflections.

If there are long connection lines between the preamplifier and the evaluation electronics and also a high resolution, lines with a wave impedance of approx. 40Ω to 150Ω should be used and a corresponding termination impedance connected to the evaluation electronics. An optimal adjustment of the transmission line and the termination wave impedances can permit line lengths of up to approx. 150 ... 200 m.

High interference protection is achieved by a large output amplitude and by the integrated wave adjustment. When the signals on the receiver side are guided through optocouplers, you furthermore get a galvanic separation between sender and receiver side and potential differences can thus be avoided.

The reflection of return signals is prevented in the high-level stage of the preamplifier by an integrated wave impedance adjustment. This adjustment enhances interference-proof performance.

• Technical specifications of preamplifier

Scan sensor: GMR sensor with diplexer; or other scan sensors, which supply a sine and cosine signal;
Number of sensors: Two scan sensors for generating the sine and cosine signal;
Adjustment: Offset adjustment by means of two potentiometers;
Resolution: Programmable in a range of 1 – 64 flanks per volume measurement V_m;
Frequency: Frequency multiplication: programmable in a range of 1 – 16 times the frequency of the scan sensors.
Emission signals: Channel A, channel B, zero channel Z
Channel A and B: Two signal outputs for emitting the digital flow sensor signals; between channel A and channel B there is a channel offset of 90°;
Flow direction: Recognition of flow direction from channel offset of the signals from channel A to channel B.
Zero signal Z: Zero signal, marks the flow of one volume measurement V_m;
Outputs: 3 current limiting and short-circuit-proof high-level stages (channel A, channel B, zero signal Z); integrated adjustment to a 75Ω wave impedance; driver current approx. 300 mA at 24 V power supply; small saturation voltage up to 30 mA load current; short switching times; integrated free-run diodes against V_b and GND; temperature protection switching with hysteresis; outputs are of high impedance in case of error;
The 24 V line drivers are designed for control technology with cable adjustment;
Error messages: Short-circuit-proof output for issuing error messages at excessive temperature or low voltage, low active
Operating voltage: V_b = 8 ... 28 V DC
Current consumption: $I_{no\ load}$ = approx. 40 mA; total current consumption depending on loading of outputs;

• Plug assignment of preamplifier

Fig. 4 shows the plug assignment of the preamplifier. As you can see, this plug has five pins, the outer four assigned exactly as the ones in standard preamplifiers. In addition to the power supply and signal output of channel 1 and 2, there is a fifth pin, which emits the zero signal.
As a rule, only the four outer pins are needed to evaluate the flow meter signals; pin assignment is therefore the same as in previously described preamplifiers. For this reason you can use a normal 4-wired connection cable for the connection of the flow meter. But please make sure that the shielding of the cable is laid on the plug side onto the metal housing of the plug.
The shielding of the connection cable is placed on both sides. The earth conductor PE is connected via the shielding from the evaluation electronics to the preamplifier housing and the meter. The cable shielding should always be laid continuously as far as the flow meter and not interrupted in cross connectors or branch sockets. Lay the connection cable as directly as possible from the evaluating device to the flow meter, since interruptions are always a potential source of error.
The flow meter must be connected electrically with the earth conductor PE. This is normally secured by the earthed pipe lines.

If there are potential differences between the preamplifier housing and the earth conductor PE of the evaluating electronics, you have to lay a correcting earth.

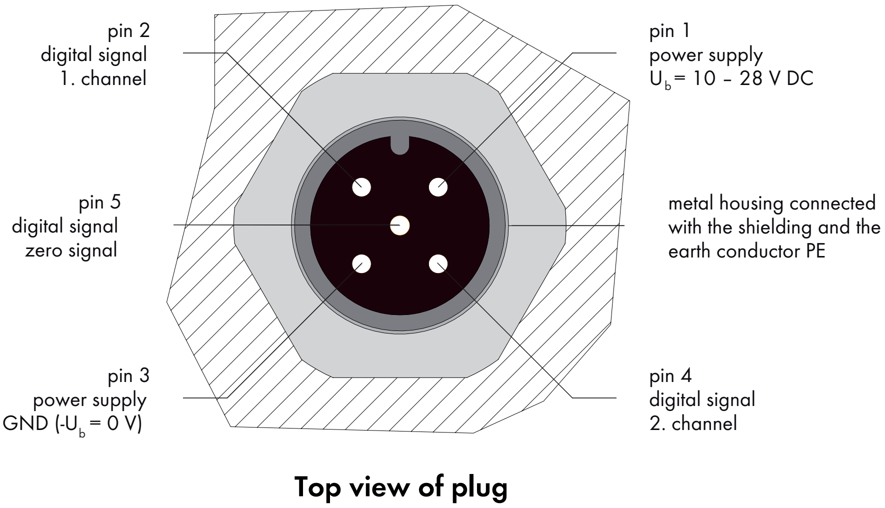


Fig. 4: Flange plug installed in the preamplifier housing of the flow meter

Important:
Only use well-shielded cables for the connection cable, with a wire cross section of ≥ 4 or 5 x 0.25 mm². Please make sure that the housing of the round plug is metallic, that it has a connection for the shielding and that the potential of the earth conductor PE is connected with the cable shielding and the housing of the preamplifier.

Important:
Please make sure that no extra inductive elements are connected in the power supply of the flow meter, such as contactors, relays, valves etc.
These components are potential sources of interference (especially if the inductive elements are not provided with an adequate protective circuit), generate high interference pulses, when switched and can interfere with the functioning of the flow meter, although this complies with the electromagnetic compatibility directives.

• Maintenance

Working life is dependent on operating conditions and thus the specific properties of the devices, limited through wear, corrosion, deposits or age. The operator is responsible for regular control, maintenance and recalibration. Any indication of a malfunction or damage prohibits any further use. On request, we can supply you with a borrowed device for the duration of repair or overhauling. We advice to a yearly control and recalibration.

• Sending back of repairs and sample devices

It is imperative that you enclose an exact description of the complaint, objection or fault, when returning the device so as to ensure a rapid and economic repair of the flow meters and other components. Furthermore, you must include a security sheet, which informs unambiguously, which fluid was run with the flow meter and how dangerous this fluid is.

The maintenance of legal regulations as regards work safety, such as workplace regulations, accident prevention regulations, and stipulations on environmental protection, waste disposal and the water management law, obliges industrial corporations to protect their employees and other persons and environment against harmful effects, when handling hazardous materials. If further safety precautions are still necessary despite careful emptying and cleaning of the flow meter, information on this is imperative and must be included with the returned despatch.

When returning flow meters to VSE Volumentechnik GmbH, please note that inspection and repair will only be performed if the **safety specifications sheet** of the utilised fluid is enclosed and the flow meters completely cleaned and flushed. This protects our employees and simplifies our work.

If this is not observed, the despatch will be returned, chargeable to the recipient.

• Technical specifications VSI 0.02 / IPF – VSI 4 / IPF

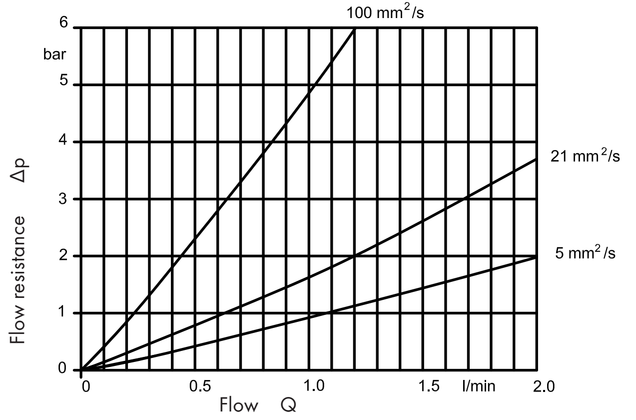
Size	Measuring range l/min	Frequency Hz	Pulse value cm^3/pulse	K-factor pulse/litre
VSI 0.02	0.002 ... 2	1.667 * IPF ... 1666.67 * IPF	0.02 / IPF	50 000 * IPF
VSI 0.04	0.004 ... 4	1.667 * IPF ... 1666.67 * IPF	0.04 / IPF	25 000 * IPF
VSI 0.1	0.01 ... 10	1.667 * IPF ... 1666.67 * IPF	0.1 / IPF	10 000 * IPF
VSI 0.2	0.02 ... 18	1.667 * IPF ... 1500.00 * IPF	0.2 / IPF	5 000 * IPF
VSI 0.4	0.03 ... 40	1.250 * IPF ... 1666.67 * IPF	0.4 / IPF	2 500 * IPF
VSI 1	0.05 ... 80	0.833 * IPF ... 1333.33 * IPF	1 / IPF	1 000 * IPF
VSI 2	0.1 ... 120	0.833 * IPF ... 1000.00 * IPF	2 / IPF	500 * IPF
VSI 4	1.0 ... 250	4.167 * IPF ... 1041.67 * IPF	4 / IPF	250 * IPF

Adjustable interpolation factors IPF: 1; 2; 3; 4; 5; 8; 10; 12; 16

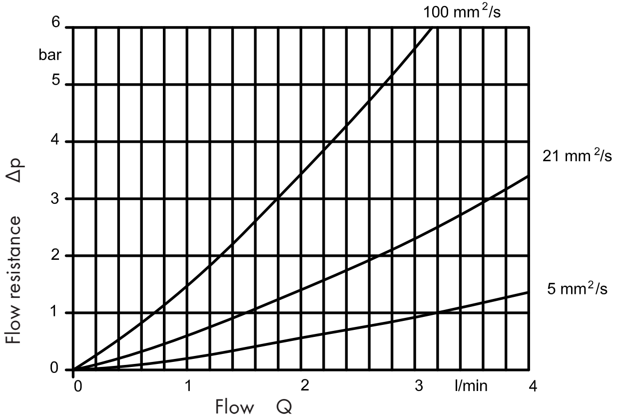
Measurement accuracy	: up to 0.3% of measurement value (with viscosity > 20 mm^2/s)
Repetition accuracy	: ± 0.05% under the same operating conditions
Material	: Cast iron EN-GJS-400-15 (EN 1563) or Stainless steel 1.4305
Meter bearing	: Ball bearings or steel plain bearings (medium-dependent)
Seals	: FPM (standard), NBR, PTFE or EPDM
Max. operating pressure	: Cast iron EN-GJS-400-15 (EN 1563) 315 bar / 4500 psi Stainless steel 1.4305 450 bar / 6500 psi
Medium temperature	: –40 ... + 120°C (–40°F ... 248°F)
Ambient temperature	: –20 ... + 50°C (–4°F ... 122°F)
Viscosity range	: 1 ... 100 000 mm^2/s
Installation position	: any
Flow direction	: any
Running noise	: max. 72 db(A)
Power supply version	: 10 to 28 volts/DC
Pulse output	: 3 current limiting and short-circuit-proof high-level stages low signal: 0 = GND; high signal: 1 = U_b -1
Channel offset	: 90° ± 30° max.
Pulse-width repetition rate	: 1/1 ± 15° max.
Preamplifier housing	: Aluminium
Protection type	: IP 65

• Flow response curves VSI 0.02 – VSI 4

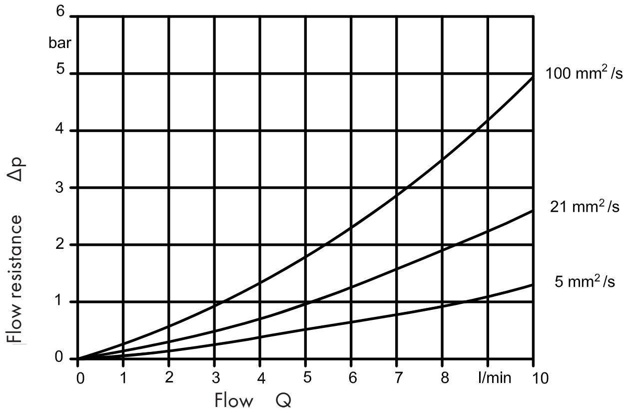
VSI 0.02



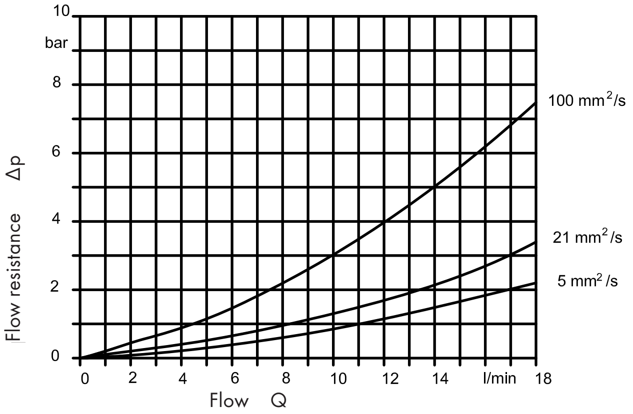
VSI 0.04



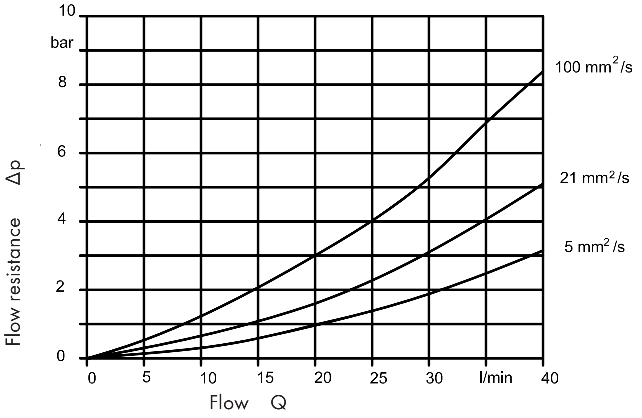
VSI 0.1



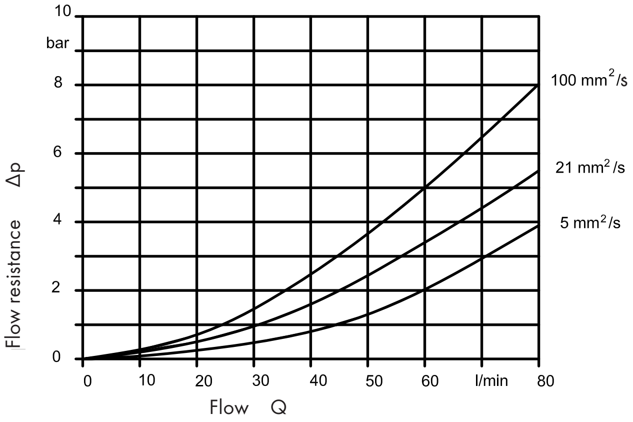
VSI 0.2



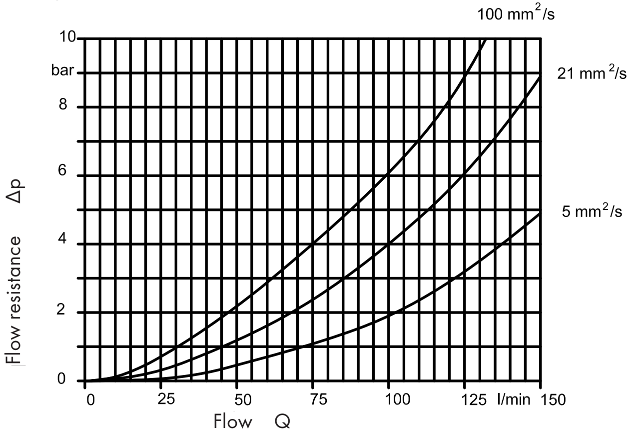
VSI 0.4



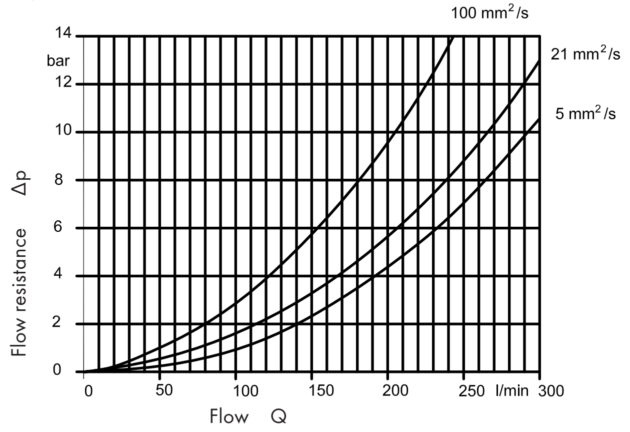
VSI 1



VSI 2

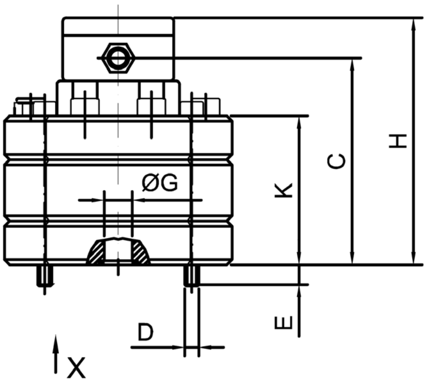


VSI 4



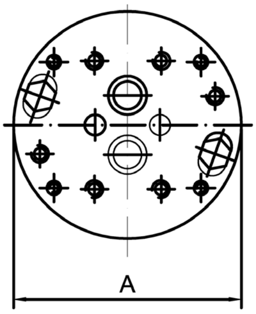
• Dimensions VSI 0.02 – VSI 4

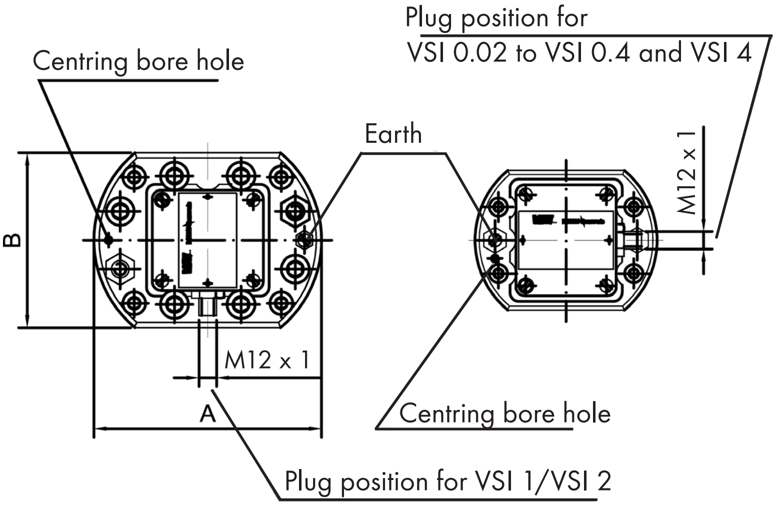
Cast iron version



View X

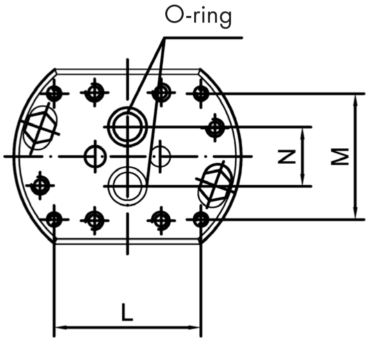
Stainless steel version
Connection diagram
Housing without milled edge





View X

Cast iron version
Connection diagram

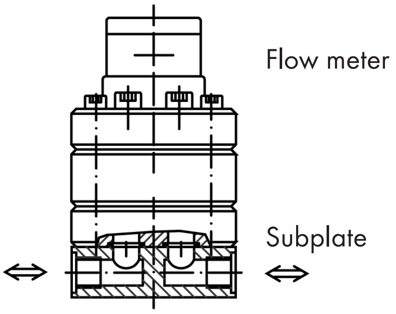


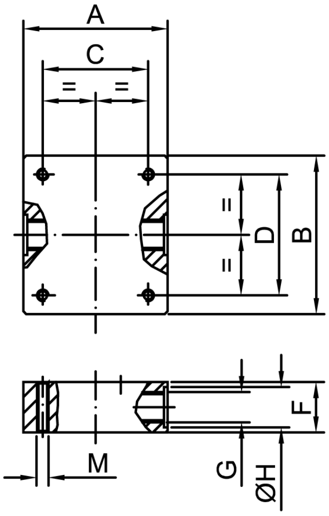
size	A	B	C	D	E	ø G	H	K	L	M	N	O-ring	Weight	
VSI													GCI kg	SS kg
0.02	100	80	91	M6	12.0	9	114	58	70	40	20	11 x 2	2.8	3.4
0.04	100	80	92	M6	11.5	9	115	59	70	40	20	11 x 2	2.8	3.4
0.1	100	80	94	M6	9	9	117	61	70	40	20	11 x 2	2.8	3.4
0.2	100	80	94	M6	9.5	9	117	61	70	40	20	11 x 2	3.0	3.7
0.4	115	90	96.5	M8	11.5	16	120	63.5	80	38	34	17.96 x 2.62	4.0	5.0
1	130	100	101	M8	12.5	16	124	68	84	72	34	17.96 x 2.62	5.3	6.8
2	130	100	118	M8	15	16	141	85	84	72	34	17.96 x 2.62	6.7	8.4
4	180	140	145	M12	20	30	168	110	46	95	45	36.17 x 2.62	14.7	18.4

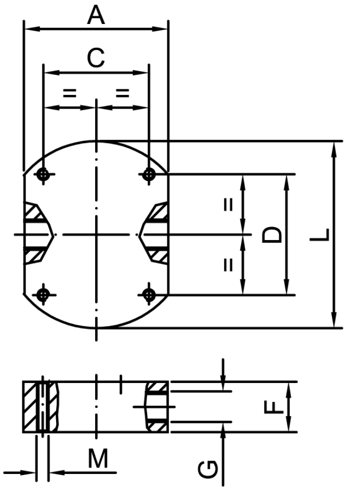
Dimensions in mm

• Dimensions, subplates AP. 02 - 4

Connection position, side



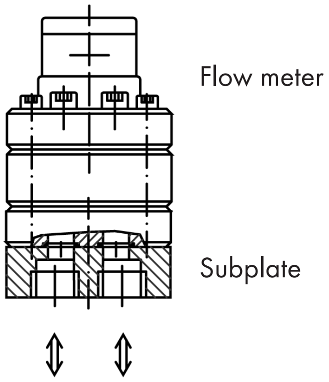


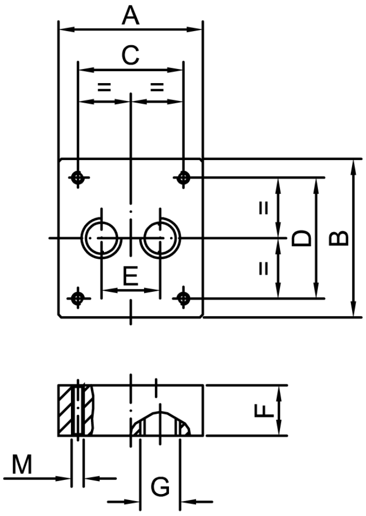


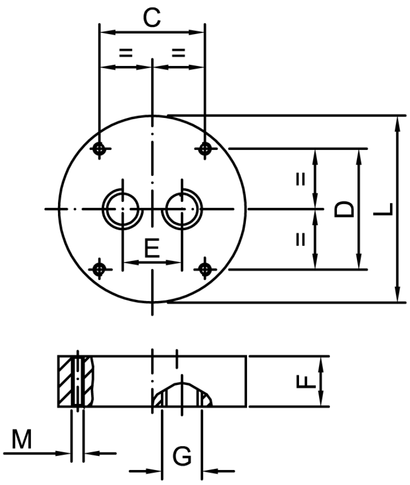
Size VSI	Connection thread G	F	øH	A	B	C	D	E	L	Thread / depth M	Weight kg
0.02 **0.04** **0.1** **0.2**	G 1/4"	35	20	80	90	40	70	26	100	M6/12	1.8
	G 3/8"		23					30			
	G 1/2"		28					38			
0.4	G 1/2"	35	28	90	100	38	80	46	115	M8/15	2.7
	G 3/4"	40	33					52			
1 **2**	G 1/2"	35	28	100	110	72	84	46	130	M8/15	3.6
	G 3/4"	40	33					52			
	G 1"	55	41					55			
4	G 1 1/4"	70	51	120	130	100	110	60		M8/15	7.4
	*G 1 1/2"	70	56				120	72			
	G 1 1/2"	80		140			110		180		12.0

only for AP . 4 U...

Connection position below







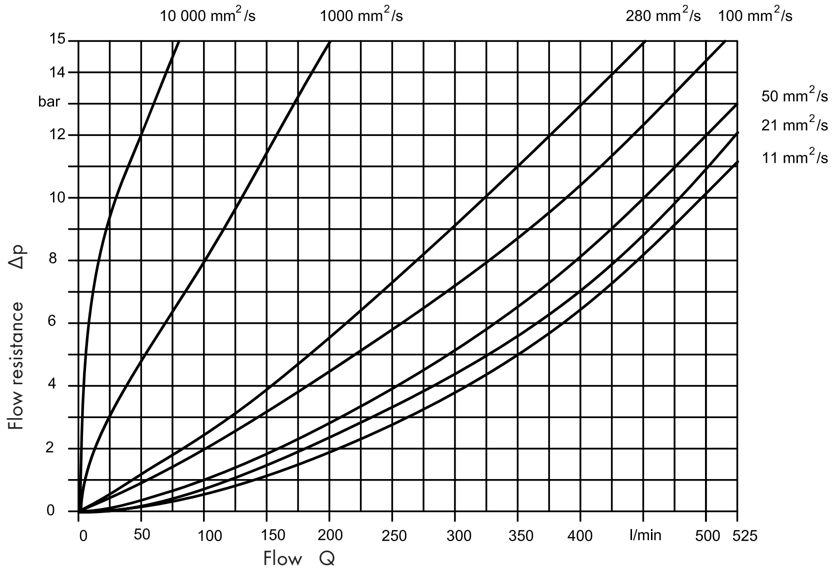
• Technical specifications VSI 10 / IPF

Size	Measuring range l/min	Frequency Hz	Pulse value cm^3/pulse	K-factor pulse/litre
VSI 10	1.5 ... 525	7.50 * IPF ... 2625.67 * IPF	3.333 / IPF	300 * IPF

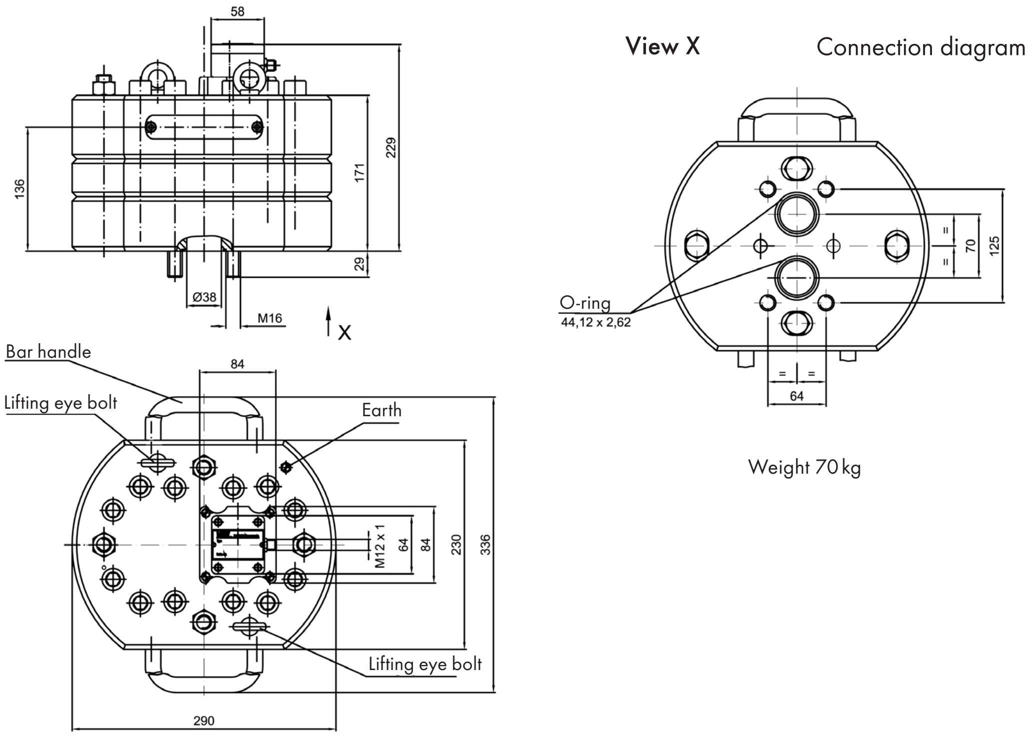
Adjustable interpolation factors IPF: 1; 2; 3; 4; 5; 8; 10; 12; 16

Measurement accuracy	: up to 0.5% of measurement value (with viscosity > 20 mm^2/s)
Repetition accuracy	: ± 0.05% under the same operating conditions
Material	: Cast iron EN-GJS-400-15 (EN 1563)
Meter bearing	: Ball bearings or steel plain bearings (medium-dependent)
Weight	: 70 kg without subplate
Seals	: FPM (standard), NBR, PTFE or EPDM
Max. operating pressure	: 420 bar/6000 psi
Medium temperature	: –40 ... + 120°C (–40°F ... 248°F)
Ambient temperature	: –20 ... + 50°C (–4°F ... 122°F)
Viscosity range	: 5 ... 100 000 mm^2/s
Installation position	: any
Flow direction	: any
Running noise	: db(A)
Power supply version	: 10 to 28 volts/DC
Frequency range	: 0 ... 2625 Hz
Pulse output	: 3 current limiting and short-circuit-proof high-level stages low signal: 0 = GND; high signal: 1 = U_b -1
Channel offset	: 90° ± 30° max.
Pulse-width repetition rate	: 1/1 ± 15° max.
Preamplifier housing	: Aluminium
Protection type	: IP 65

• Flow response curves VSI 10



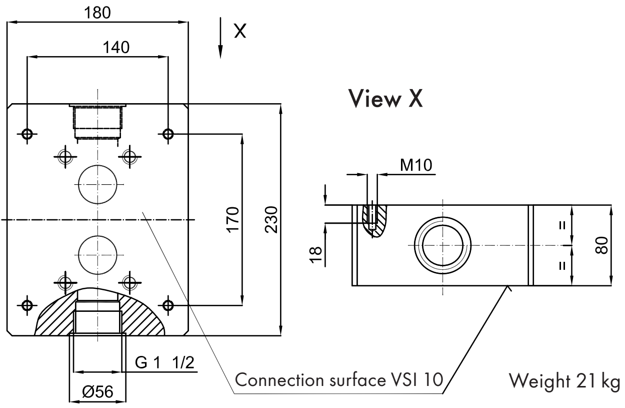
• Dimensions VSI 10



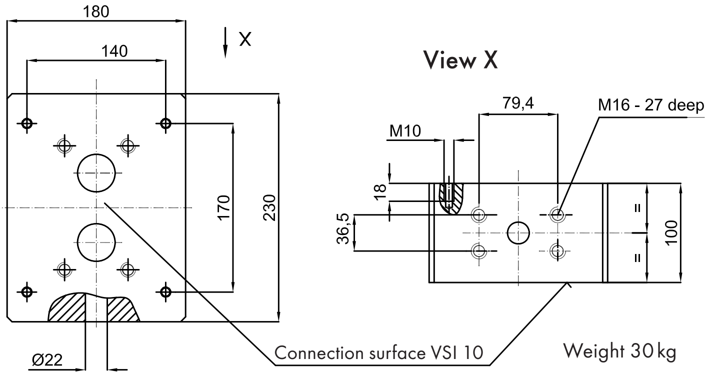
Dimensions in mm

• Dimensions, subplate APG 10.

APG 10 SG0N / 1



APG 10 SW0N / 1



Dimensions in mm

• Type key

Flow meters VSI

Type Codes VSI ... (interpolation)

Interior

Example

VSI 1	/	4		G	P	O	1	2	V	-	3	2	W	1	5	/	X	. .
Size		Interpolation		Material	Type of connection	Measuring wheel coating	Works-determine to the application Meter bearing	Works-determine to the application Meter tolerance	Seal type		Sensor pick-up system	Quantiiy of pick-up sensors	Signal output	Preamplifier	Connection		Product line	Power supply voltage

Power supply voltage

10 ... 30 V	Power supply volt.

Product line

X	Modification id. no.

Connection

1	VSE-norm connection (4-pin)
5	5-pin plug connection

Preamplifier

1	integrated (standard design)

Signal output

W	VV int. WE (power supply volt. 10 ... 30 V DC)

Quantiiy of pick-up sensors

2	2 Sensors

Sensor pick-up system

3	GMR- Sensor

Seal type

V	FPM (Viton) standard
P	NBR (Perbunan)
T	PTFE
E	EPDM

Meter tolerance

1	diminished range
2	normal range (standard)
3	enlarged range
4	range steel plain bearings

Meter bearing

1	Ball bearings
2	Spindle bearings
3	Bronze plain bearings
4	Carbon bearings
5	Steel bearings

Measuring wheel coating

O	No coating (standard)
C	Dynamat coating (C-coating)
T	Titanium coating

Type of connection

P	Plate construction
R	Pipe line connections

Material

G	EN-GJS-400-15 (VSI 10 = EN-GJS-600-3) EN 1563
E	Stainless steel 1.4305 (V2A)

Interpolation

for VSI 0.02 to VSI 4

1	1 Imp. pro V_z	$V_m = V_z$ pro Imp
2	2 Imp. pro V_z	$V_m = V_z$ / 2 pro Imp.
3	3 Imp. pro V_z	$V_m = V_z$ / 3 pro Imp.
4	4 Imp. pro V_z	$V_m = V_z$ / 4 pro Imp.
5	5 Imp. pro V_z	$V_m = V_z$ / 5 pro Imp.
8	8 Imp. pro V_z	$V_m = V_z$ / 8 pro Imp.
10	10 Imp. pro V_z	$V_m = V_z$ /10 pro Imp.
12	12 Imp. pro V_z	$V_m = V_z$ /12 pro Imp.
16	16 Imp. pro V_z	$V_m = V_z$ /16 pro Imp.

for VSI 10

1	3 Imp. pro V_z	V_m = 10/ 3 pro Imp
2	6 Imp. pro V_z	V_m = 10/ 6 pro Imp.
3	9 Imp. pro V_z	V_m = 10/ 9 pro Imp.
4	12 Imp. pro V_z	V_m = 10/12 pro Imp.
5	15 Imp. pro V_z	V_m = 10/15 pro Imp.
8	24 Imp. pro V_z	V_m = 10/24 pro Imp.
10	30 Imp. pro V_z	V_m = 10/30 pro Imp.
12	36 Imp. pro V_z	V_m = 10/36 pro Imp.
16	48 Imp. pro V_z	V_m = 10/48 pro Imp.

Size

VSI 0.02	V_z = 0.02 ml
VSI 0.04	V_z = 0.04 ml
VSI 0.1	V_z = 0.1 ml
VSI 0.2	V_z = 0.2 ml
VSI 0.4	V_z = 0.4 ml
VSI 1	V_z = 1 ml
VSI 2	V_z = 2 ml
VSI 4	V_z = 4 ml
VSI 10	V_z = 10 ml

V_m = Volume (cm ^{3})

V_z = the volume between the gear teeth

Subplates AP ...

Example

AP G 1 S C 0 N / 1

- Product line (Modification id. no.)
- Version

N	Standard version
S	Special version

- Accessory connection

0	without rinse connection

- Connection thread

A	G 1/4	J	1/4 NPT	S	SAE 1/2
B	G 3/8	K	3/8 NPT	T	SAE 3/4
C	G 1/2	L	1/2 NPT	U	SAE 1
D	G 3/4	M	3/4 NPT	V	SAE 1 1/4
E	G1	N	1 NPT	W	SAE 1 1/2
F	G1 1/4	O	1 1/4 NPT	X	SAE 2
G	G1 1/2	P	1 1/2 NPT		

- Connection position side

S	Connection position side
U	Connection below

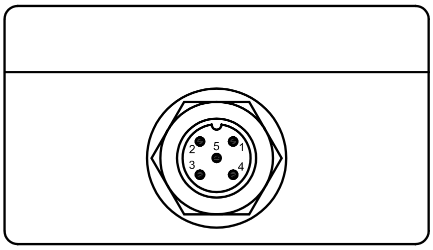
- Size

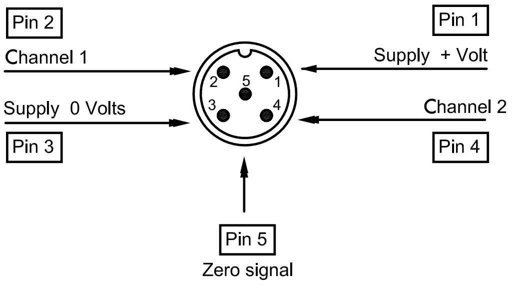
0.2	VSI 0.02 VSI 0.04 VSI 0.1 VSI 0.2
0.4	VSI 0.4
1	VSI 1 VSI 2
4	VSI 4
10	VSI10

- Material

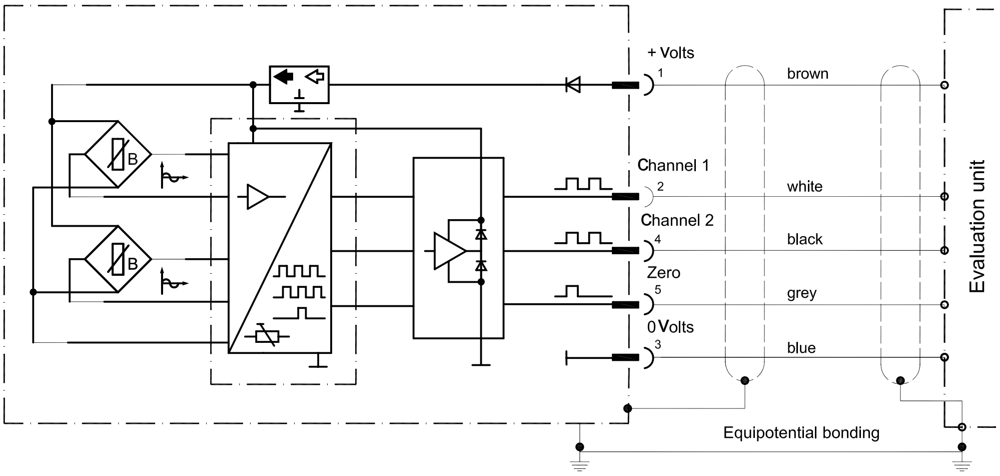
G	EN-GJL-250, EN-GJS-400-15 (DIN EN 1561/1563)
E	Stainless steel 1.4305

• Plug assignment

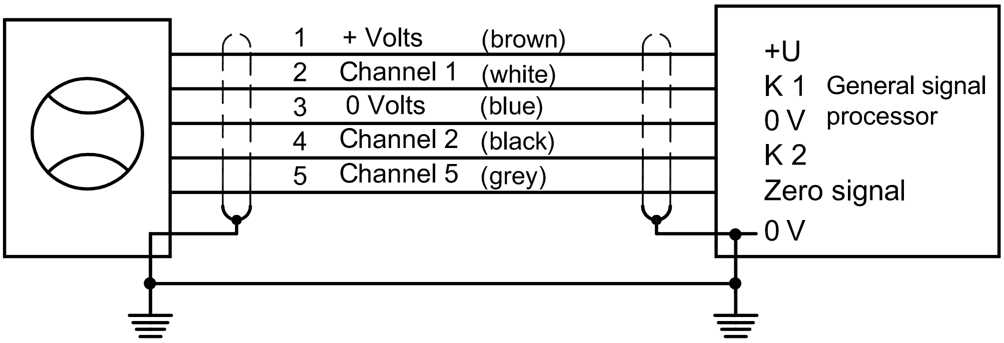




• Preamplifier-block wiring diagram



- **Connection diagram**



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