VSE.flow®

OPERATING MANUAL

for flow meters of the product line "VSI High Definition Flow Meter"

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IMPORTANT INFORMATION AND LEGAL NOTICES

Dear customer, dear user,

This operating instruction for volume sensors of the **"VSI High Definition Flow Meter"** series by VSE Volumen-technik GmbH (VSE) contains information required to properly install and commission the flow meter for the intended purpose.

Any installation, commissioning, operation, maintenance and testing may only be carried out by trained and authorized personnel. The operating instructions must be read and followed carefully to ensure a trouble-free, proper and safe operation of the flow meter. In particular, the safety instructions are essential.

These operating instructions must be kept safe and accessible for the authorized personnel at all times. At no time should contents of the operating instructions be removed. A missing manual or missing pages must be replaced immediately if lost. The operating instructions can be requested at any time from VSE or downloaded from our website www.vse-flow.com. The operating instructions must be passed on to each subsequent user of the flow meter.

This operating instruction is not subject to any modification service by VSE. VSE reserves the right to make technical changes at any time without notice.

VSE makes no warranties, express or implied, with respect to commercial qualities and suitability for a particular purpose.

VSE accepts no liability for damage and malfunctions resulting from operating errors, failure to observe these operating instructions, improper installation, commissioning or maintenance as well as improper use of the flow meter.

The opening of the flow meter is absolutely not permitted. After an unauthorized opening or rebuilding as well as after a single, incorrect connection of the flow circuits of the flow meter, the warranty as well as the product liability by VSE expire.

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 ensures 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 warranty 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 assured.

All flow meters are tested according to the valid, legally prescribed electro-magnetic compatibility directives 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 protected by a shield?
→ Is there a **connection** of the cable protective shielding via the round plug to the housing of the flow meter?
→ 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 flow meter mounted to be **insulated** to the earth conductor PE (e.g. connection via hoses)? If this is the case, the earth conductor PE has to be connected to the flow meter!
→ Is the cable laid fault-free and the installation secured from input of **interference pulses**?
→ Is the **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
→ Flow meter in special version p_{max} = 700 bar / 10100 psi

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

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INFORMATION ON EU DIRECTIVE 2014/68/EU ON PRESSURE EQUIPMENT

In terms of Article 2, No. 5 of the directive named above, VSE volume sensors are so-called "pressuremaintaining components" and this directive thereby relates to them.
VSE volume sensors must thereby comply with the technical requirements named in Section 4 of the directive in accordance with Article 4, Paragraph (1d), Piping according to Paragraph (1c).
Typically, the fluids measured fall into Group 2 in accordance with Article 13, Paragraph (1b). The volume sensors sold by VSE do not comply with the limit values defined under Article 4, Paragraph (1a).

The technical requirements on volume sensors from VSE are therefore limited to the criteria defined in Article 4, Paragraph (3). That means that the devices must be designed and manufactured in accordance with the good engineering practices prevailing in the member state. We hereby confirm this. The paragraph also states that these units may not bear the CE label named in Article 18.
A CE declaration of conformity is therefore not issued in accordance with 2014/68/EU.
The CE label of our volume sensors refers to Directive 2014/30/EU.

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 "Technical specifications").

> **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.
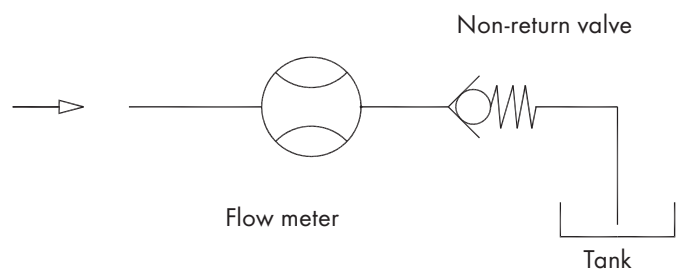

Fig. 1: Flow meter installation with non-return valve

> **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.

VSE supplies subplates for all flow meters of the "VSI" product line; they have various pipe threads and side or rearside connection. 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 Volumentechnik 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 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°.
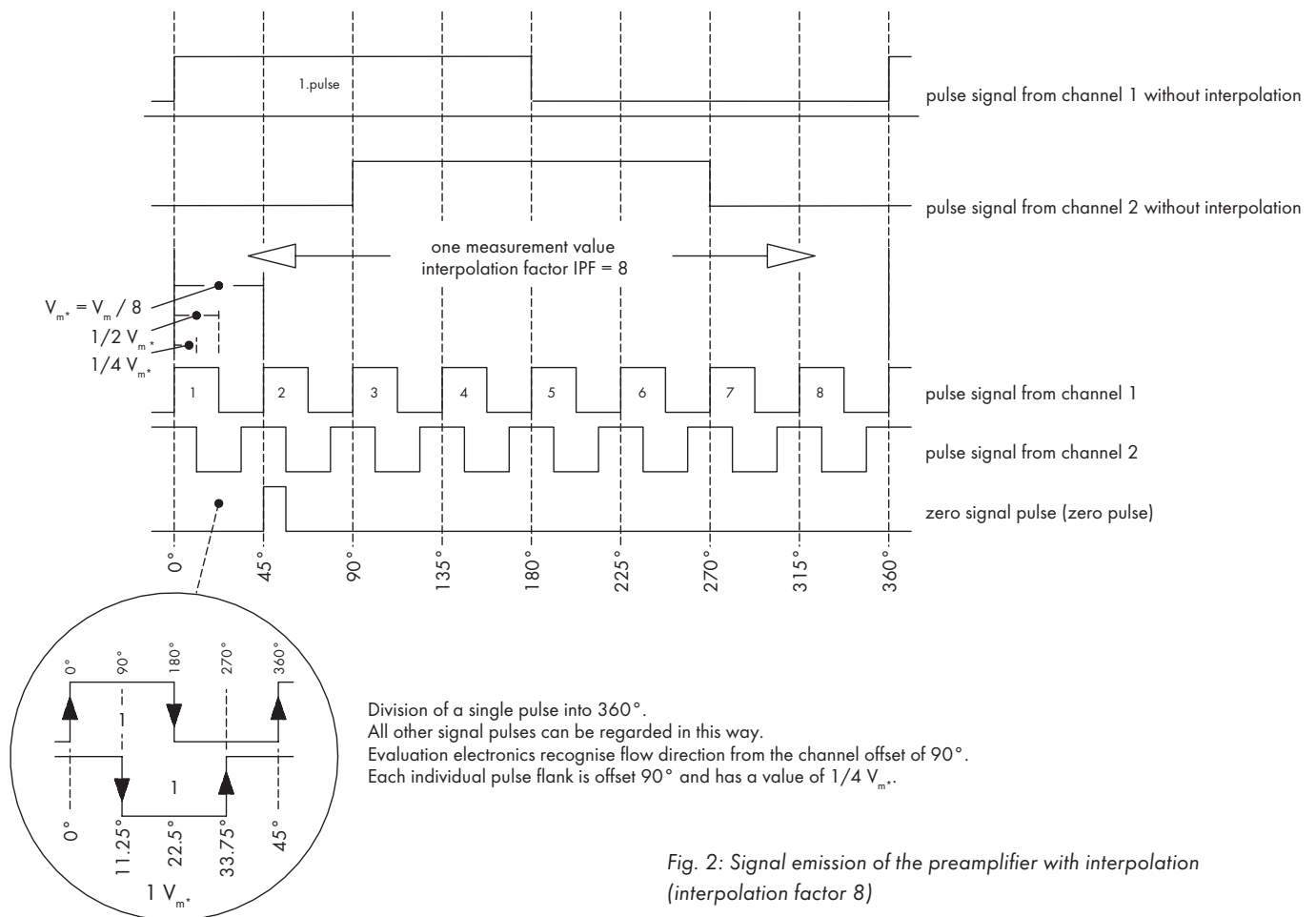Each individual pulse flank is offset 90° and has a value of 1/4 V_m*.

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°.
Hence you can program a resolution of 4 to 64 angular steps per volume measurement V_m (see fig. 3). 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:

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

$f_{max°}$ 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

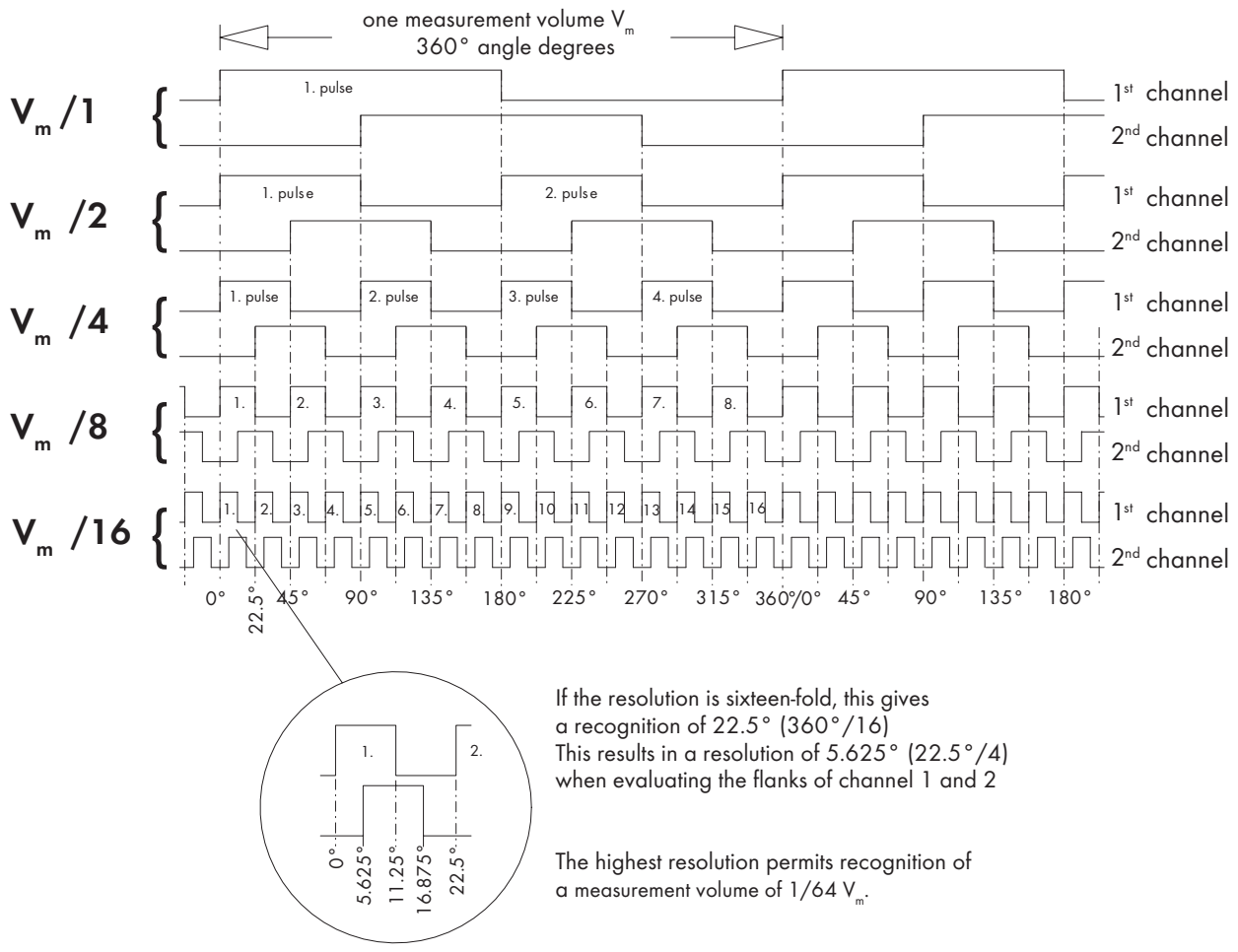At max. flow$_{max°}$ = 40 l/min, the flow meter VSI 1/10... outputs a frequency of $f_{max°}$ = 6666.67 Hz.

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* or the correct K-factor (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* or the K-factor and program this value as parameter into your evaluation electronics.

The maximum flow rates with the corresponding frequencies are listed in columns 4 and 8 of table 4.

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 (=120,000 ml/min = 2,000 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 (= 250,000 ml/min = 4,166.7 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	$V_m =$	0.1 ml/pulse
	(corresponds to the volume measurement V_m at interpolation factor IPF* = 1)		
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)	$f_{max} =$	1 666.7 Hz
	(corresponds to the volume measurement V_m at interpolation factor IPF = 1)		
8. Column:	maximum frequency f_{max}* at programmed interpolation factor (see column 3)	$f_{max}* =$	16 666.7 Hz

CHANGING OF THE INTERPOLATION FACTOR (IPF)

Interpolation setting:

Bridge 1, Bridge 2: Interpolation set-up

IPF: Interpolation factor

Bridge 1	Bridge 2	IPF
HIGH	HIGH	16
OPEN	HIGH	12
LOW	HIGH	10
HIGH	OPEN	8
OPEN	OPEN	5
LOW	OPEN	4
HIGH(ex)	LOW(ex)	3
OPEN	LOW	2
LOW	LOW	1

Free pin header

Example:

Set-up for IPF 3

Bridge "B1"

Bridge "B2"

HIGH   LOW
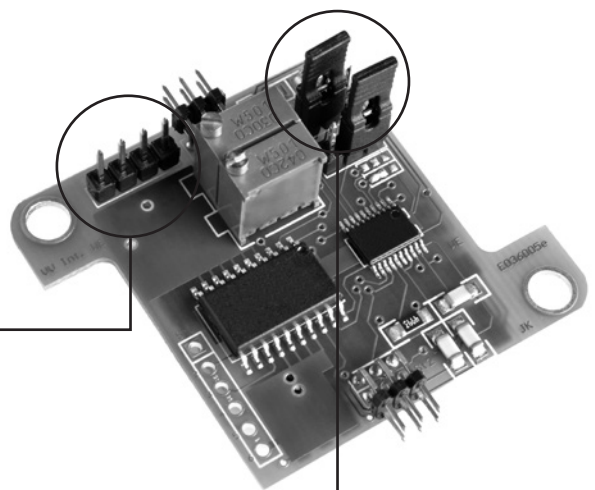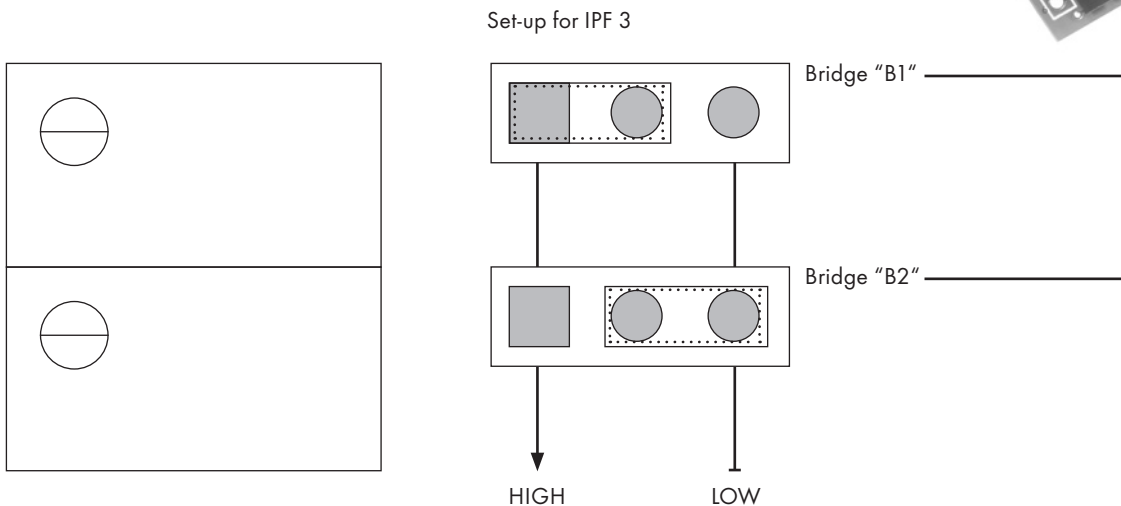
Jumpers which are not used in case of open bridges could be placed
on the free pin header.

DEVIATIONS IN IMPULSE WIDTHS

Due to mechanical tolerances and tolerances in the electronic pick-up system itself there are deviations in the impulse widths when increasing resolution (interpolation). These deviations occur periodically per geargap or within the standard volume measurement.

While the mechanical tolerances are in the μm-range those of the electronic pick-ups are in the nm-range and thus cannot be avoided.

Additionally in fluid technology the flow is subject to strong system pulsations. When using a piston pump for example each stroke of the piston will generate a pulse on the flow.

Caused by the higher resolution the flow is detected in much finer increments and so the measurement is more sensitive to pulsations and flow peaks.

In order to eliminate such disturbing effects of impulse deviations and system pulsations we recommend to use a circular buffer filter in your evaluation.

FUNCTION OF A CIRCULAR BUFFER FILTER

The circular buffer filter CBF calculates a mean value from a specific number of flow measurement values within a loop or a circle respectively.

The CBF works according to the first in – first out principle. This means that the first stored or the longest stored value will be taken from the mean value calculation when a new measurement is made. The new value is placed at the first position of the loop and the remaining values are advanced by one position each. The mean value calculation is carried out with the complete number of measurement values in the loop (see example).

Example circular buffer filter with 16 measurment values
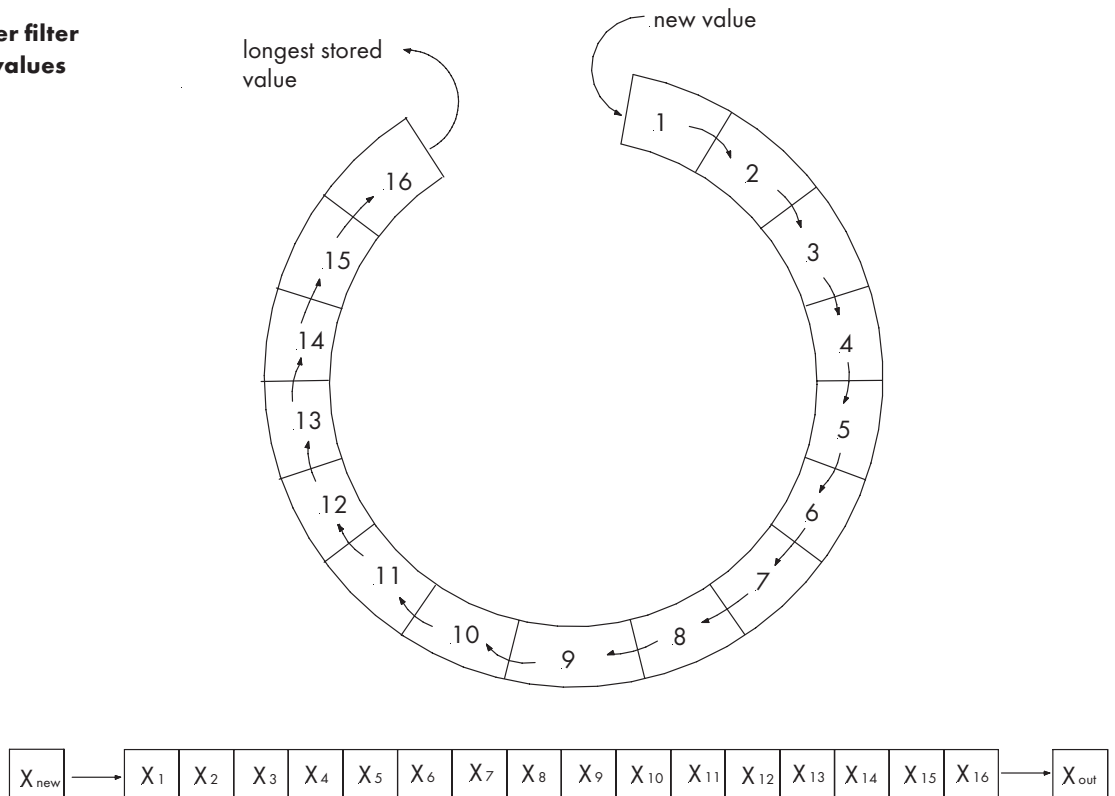
Arithmetic mean value

(example n =16)

$$\overline{x}_{arithm} = \frac{1}{n} \sum_{i=1}^{n} x_i = \frac{x_1 + x_2 + \dots x_n}{n}$$

Mean value calculations results in smoothening of flow oscillations and suppressing flow peaks.

Measuring times

Please note that when using the CBF measuring time will increase due to the means value calculation.

When the fluid circle starts, the CBF must be completely filled until the correct flow value is indicated.

If the flow goes down to zero, it will take a longer time until all storage positions are filled with zero values again.

To reduce the measuring time, a start-up and a programmed stop should be included in the programming.

During the start-up the first read in values should be copied to the remaining storage places to reduce time for the first real measurement indication.

This principle should be used for the standstill of the flow, too.

If several read in values are zero, all remaining storage positions should be filled with "0" (zero) directly to reduce the real measurement time.

Start-Up

| Q_{new} | → | Q_1 | Q_2 | Q_3 | Q_4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | → | Q_{out} |

⇓

| Q_{new} | → | Q_1 | Q_2 | Q_3 | Q_4 | Q_1 | Q_1 | Q_1 | Q_1 | Q_1 | Q_1 | Q_1 | Q_1 | Q_1 | Q_1 | Q_1 | Q_1 | → | Q_{out} |

Reset

0

| 0 | → | 0 | 0 | 0 | 0 | Q_5 | Q_6 | Q_7 | Q_8 | Q_9 | Q_{10} | Q_{11} | Q_{12} | Q_{13} | Q_{14} | Q_{15} | Q_{16} | → | Q_{out} |

⇓

| 0 | → | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | → | Q_{out} |
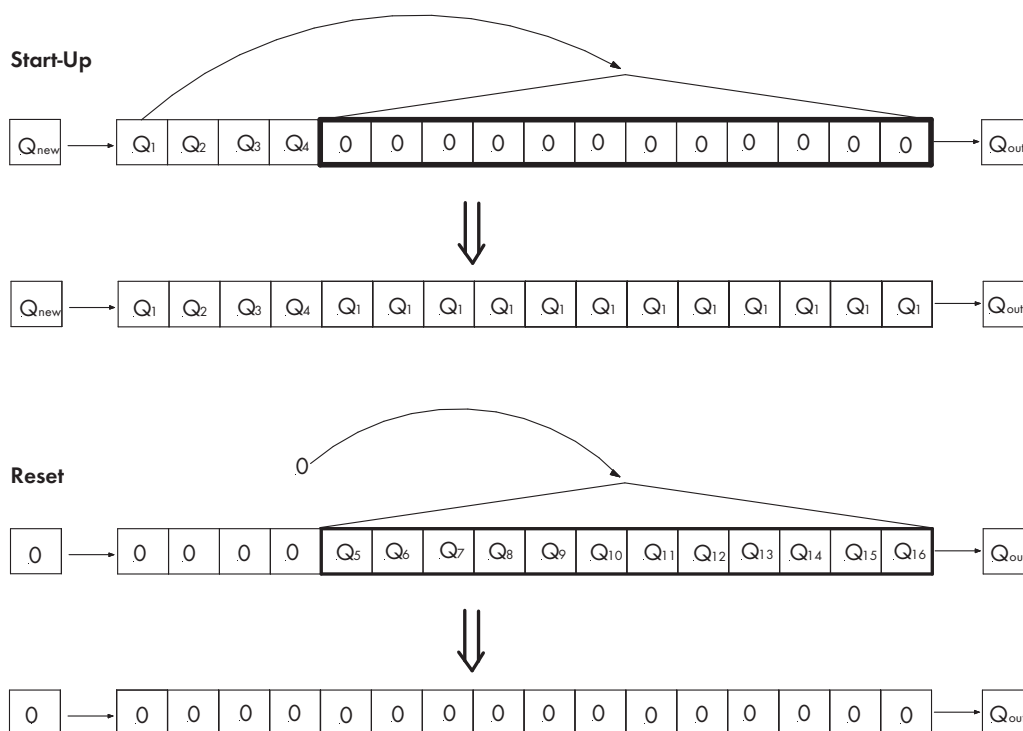
TECHNICAL SPECIFICATIONS OF PREAMPLIFIER

Pick up sensor:	MR sensor
Number of sensors:	Two pick up sensors for generating the sine and cosine signal
Adjustment:	Offset adjustment by 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 pick-up 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 push-pull output stages (channel A, channel B, zero signal Z); driver current approx. 300 mA at 24 V power supply; small saturation voltage up to 30 mA load current; short switching times; reverse voltage protection by integrated free-run diodes against V_b and GND; temperature protection switching with hysteresis; outputs are of high impedance in case of error; ESD protected
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 standard 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 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 should 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.

pin 2
digital signal
1. channel

pin 1
power supply
U_b = 10 – 28 V DC

pin 5
digital signal
zero signal

metal housing connected
with the shielding and the
earth conductor PE

pin 3
power supply
GND ($-U_b$ = 0 V)

pin 4
digital signal
2. channel

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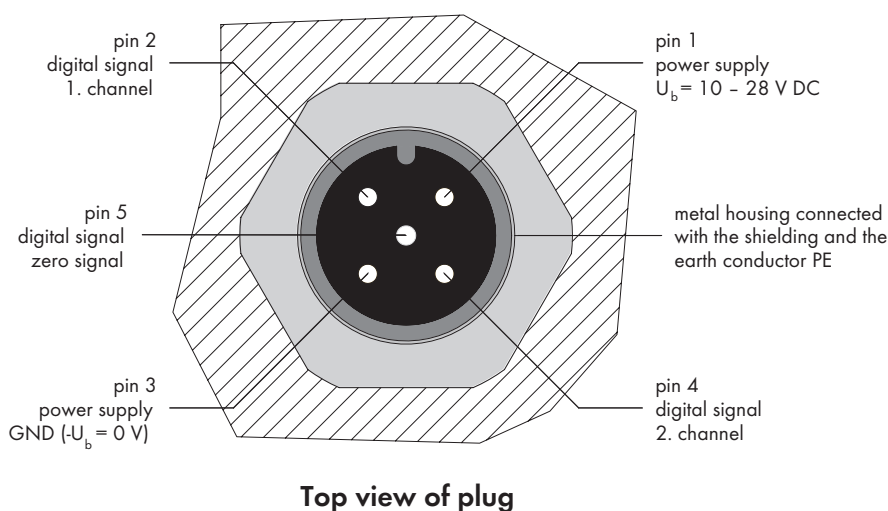
Fig. 4: Flange plug installed in the preamplifier housing of the flow meter

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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 and that it has
a connection to the shielding.

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 which generate high interference pulses, when switched and can interfere with the
functioning of the flow meter, although this complies with the electromagnetic compatibility
directives (especially if the inductive elements are not provided with an adequate protective circuit).

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, EPDM or silicone
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°C ... + 120°C (–40°F ... 248°F)
Ambient temperature	–20°C ... + 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 output 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
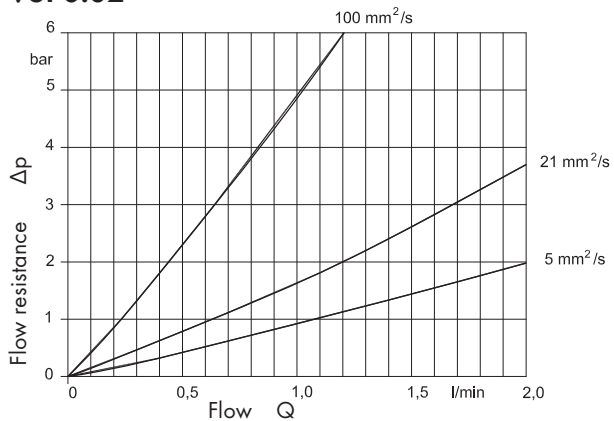
VSI 0.04
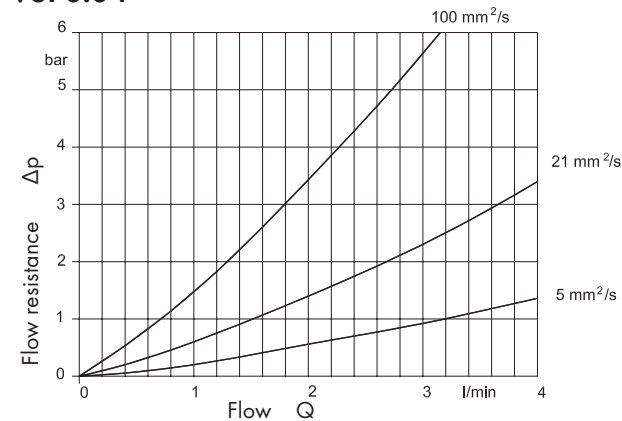
VSI 0.1
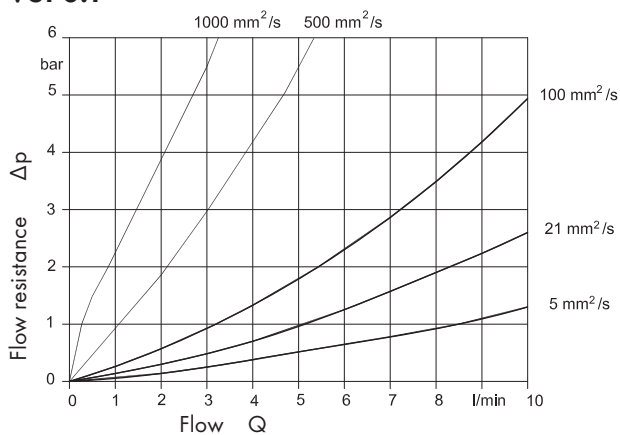
VSI 0.2
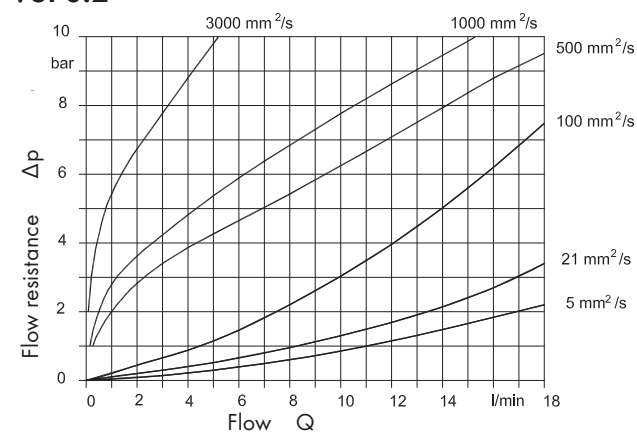
VSI 0.4

VSI 1
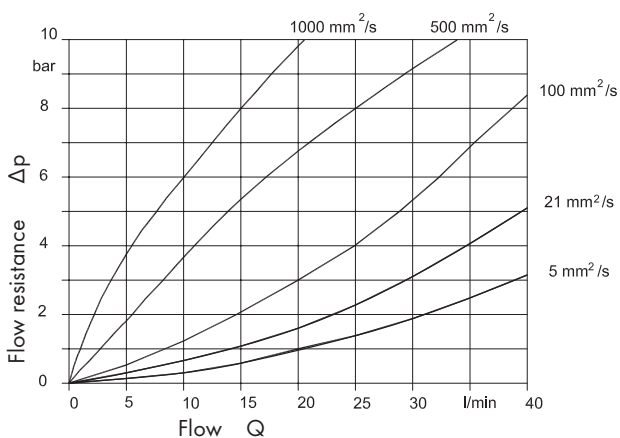
VSI 2
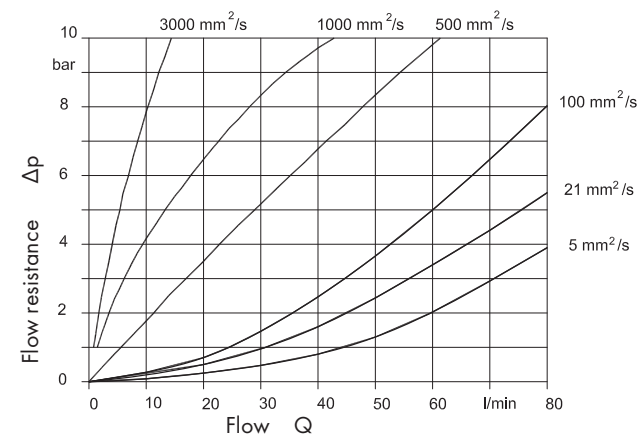
VSI 4
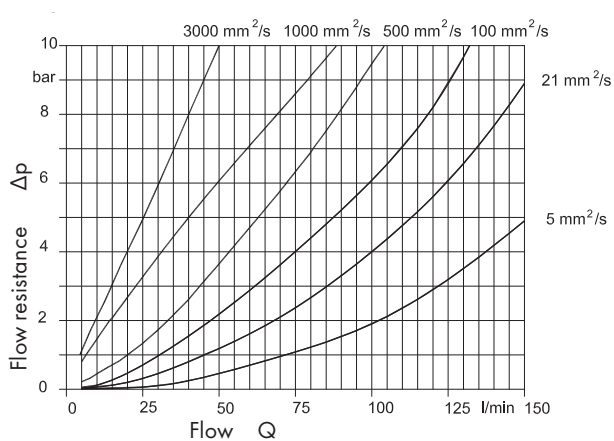
DIMENSIONS VSI 0.02 – VSI 4
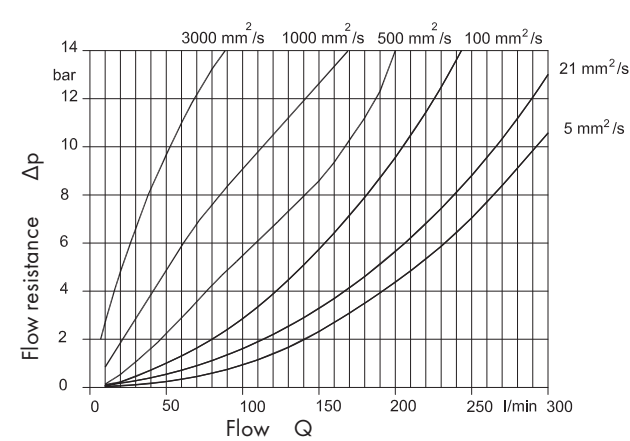
Cast iron version
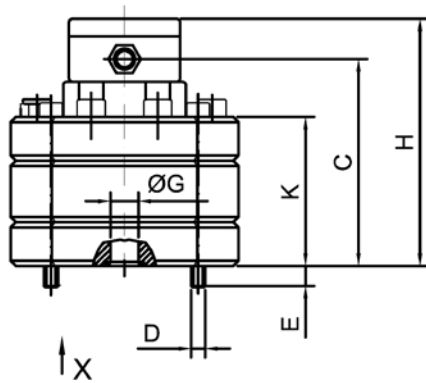
Stainless steel version
Connection diagram
Housing without milled edge

View X

Centring bore hole

Plug position for
VSI 0.02 to VSI 0.4 and VSI 4

Earth

M12 x 1

M12 x 1

Plug position for VSI 1/VSI 2

Centring bore hole
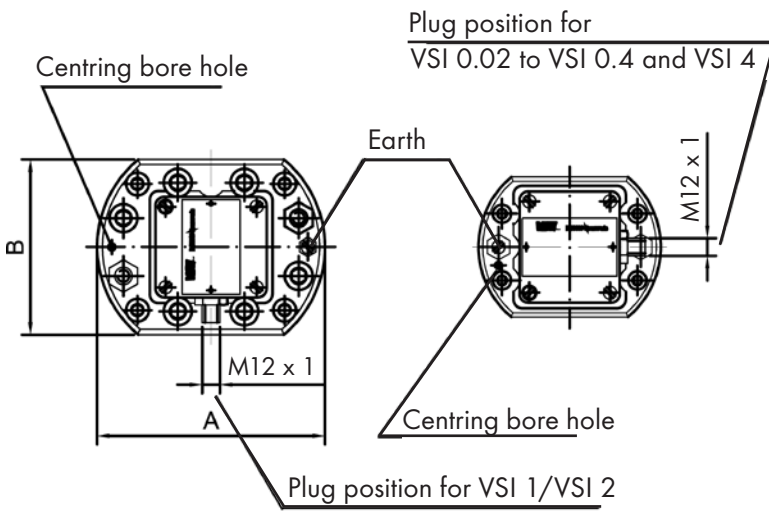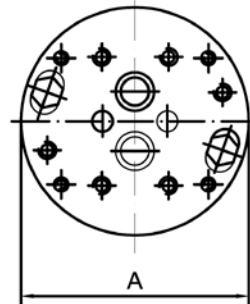
View X

Cast iron version
Connection diagram
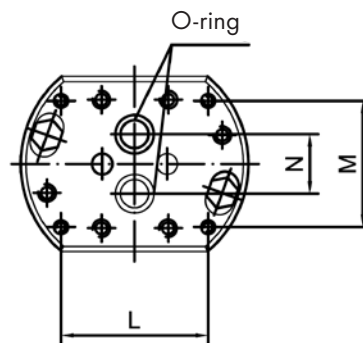
O-ring

Size VSI	A	B	C	D	E	ø G	H	K	L	M	N	O-ring	Weight 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	143	M12	20	30	166	110	46	95	45	36.17 x 2.62	14.7	18.4

Dimensions in mm

DIMENSIONS, SUBPLATES AP.0.2 – 4

Connection position, side

Flow meter

Subplate

Connection drawing
Flow Meter
M../.. for fixing the subplate

Connection drawing
Flow Meter
M../.. for fixing the subplate
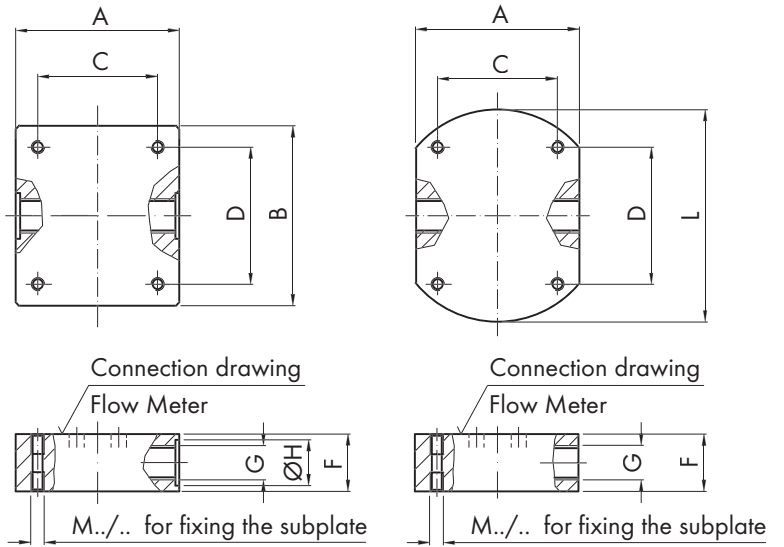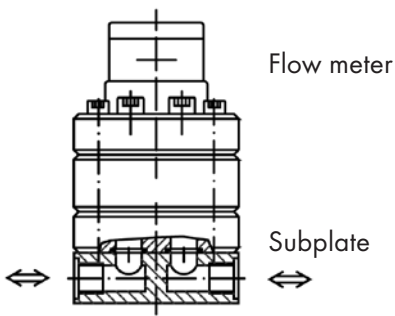
Size VSI	Connection thread G	F	øH	A	B	C	D	E	L	Thread / depth M	Weight kg
0.02 0.04 0.1 0.2	G 1/4"	35	20	80	90	40	70	26	100	M6/12	1.8
	G 3/8"		23					30			
	G 1/2"		28					38			
0.4	G 1/2"	35	28	90	100	38	80	46	115	M8/15	2.7
	G 3/4"	40	33					52			
1 2	G 1/2"	35	28	100	110	72	84	46	130	M8/15	3.6
	G 3/4"	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

Flow meter

Subplate

Connection drawing
Flow Meter
M../.. for fixing the subplate

Connection drawing
Flow Meter
M../.. for fixing the subplate

TECHNICAL SPECIFICATIONS VSI 10 / IPF
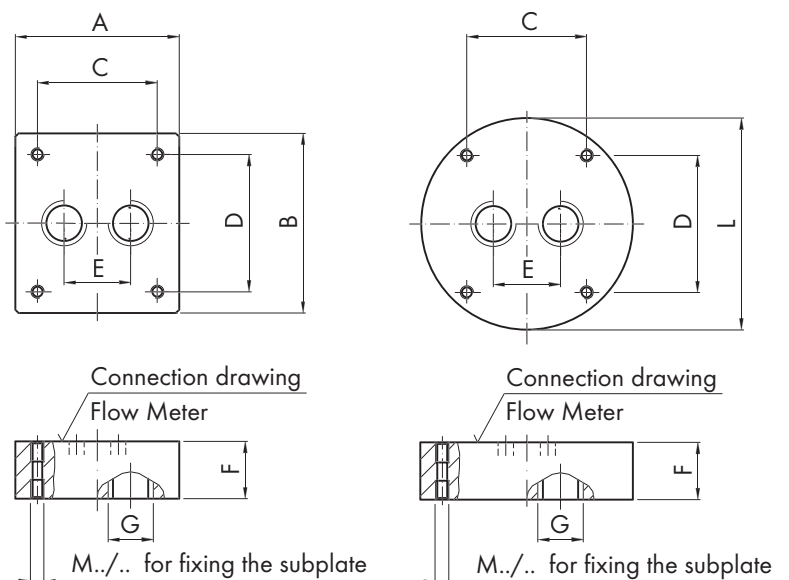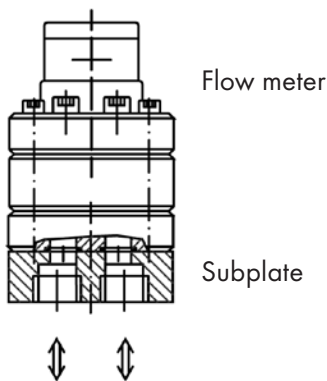
Size	Measuring range l/min	Frequency Hz	Pulse value cm³/pulse	K-factor pulse/litre
VSI 10	1.5 ... 525	7.50 * IPF ... 2625.00 * IPF	3.333 / IPF	300 * IPF

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 mm²/s)
Repetition accuracy	± 0.05% under the same operating conditions
Material	Cast iron EN-GJS-600-3 (EN1563)
Meter bearing	Ball bearings or steel plain bearings (medium-dependent)
Weight	70 kg without subplate
Seals	FPM (standard), NBR, PTFE, EPDM or silicone
Max. operating pressure	420 bar/6000 psi
Medium temperature	–40°C ... + 120°C (–40°F ... 248°F)
Ambient temperature	–20°C ... + 50°C (–4°F ... 122°F)
Viscosity range	5 ... 100 000 mm²/s
Installation position	any
Flow direction	any
Running noise	< 80 db(A)
Power supply version	10 to 28 volts/DC
Pulse output	3 current limiting and short-circuit-proof output 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

58

229

171

136

29

Ø38

M16

X

Bar handle

Lifting eye bolt

84

Earth

M12 x 1

64

84

230

336

Lifting eye bolt

290
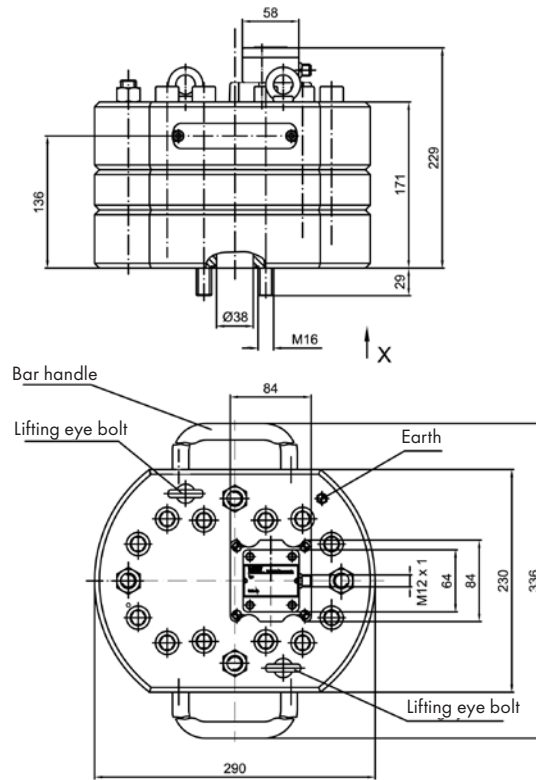
View X

Connection diagram

O-ring
44,12 x 2,62

70

125

64
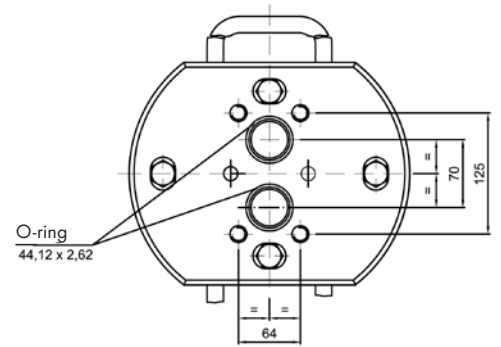
Weight 70 kg

Dimensions in mm

DIMENSIONS, SUBPLATE APG 10.

APG 10 SG0N / 1

180

140

X

View X

M10

170

230

18

80

G 1 1/2

Ø56

Connection surface VSI 10

Weight 21 kg

APG 10 SW0N / 1

180

140

X

View X

79,4

M16 - 27 deep

M10

170

230

18

36,5

100

Ø38

Connection surface VSI 10
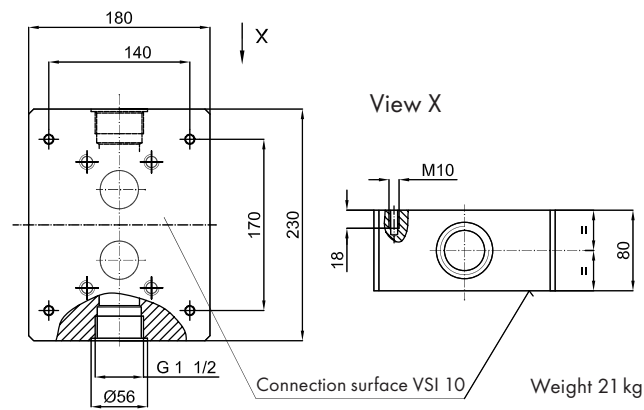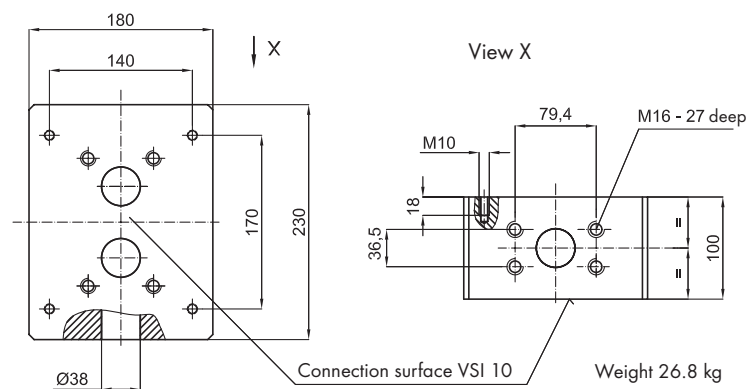
Weight 26.8 kg

Dimensions in mm

Flow meters VSI

Type Codes VSI ... (interpolation)
Interior

Example

VSI 1	/ 4		G	P	O	1	2	V	-	3	2	W	1	5	/ X	. .

Vertical column labels (top to bottom):
- Interpolation
- Material
- Type of connection
- Measuring wheel coating
- Meter bearing
- Meter tolerance
- Seal type
- Sensor pick-up system
- Quantity of pick-up sensors
- Signal output
- Pre-amplifier
- Connection
- Product line
- Power supply voltage

Works-determine to the application (Seal type / tolerance / bearings / coating)

10 ....28 V	Power supply volt.	
X	Modification id. no.	
1	VSE- norm connection (4-pole)	
5	5 pole plug connection	
1	integrated (standard design)	
W	VV int. WE (power supply volt. 10 ... 28 V DC)	
2	2 Sensors	
3	GMR- Sensor	

Seal type:

V	FPM (Viton) standard
P	NBR (Perbunan)
T	PTFE
E	EPDM
B	EPDM - 41B8
S	Silicone

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 (VSI10 = EN-GJS-600-3) EN 1563
E	Stainless steel 1.4305 (V2A)
H	EN-GJS-600-3 (High-Pressure) DIN EN 1563

Interpolation:

	for VSI 0.02 to VSI 4				for VSI 10		
1	1 Imp. pro V_z	$V_m = V_z$ pro Imp		1	3 Imp. pro V_z	$V_m = 10/ 3$ pro Imp
2	2 Imp. pro V_z	$V_m = V_z / 2$ pro Imp.		2	6 Imp. pro V_z	$V_m = 10/ 6$ pro Imp.
3	3 Imp. pro V_z	$V_m = V_z / 3$ pro Imp.		3	9 Imp. pro V_z	$V_m = 10/ 9$ pro Imp.
4	4 Imp. pro V_z	$V_m = V_z / 4$ pro Imp.		4	12 Imp. pro V_z	$V_m = 10/12$ pro Imp.
5	5 Imp. pro V_z	$V_m = V_z / 5$ pro Imp.		5	15 Imp. pro V_z	$V_m = 10/15$ pro Imp.
8	8 Imp. pro V_z	$V_m = V_z / 8$ pro Imp.		8	24 Imp. pro V_z	$V_m = 10/24$ pro Imp.
10	10 Imp. pro V_z	$V_m = V_z /10$ pro Imp.		10	30 Imp. pro V_z	$V_m = 10/30$ pro Imp.
12	12 Imp. pro V_z	$V_m = V_z /12$ pro Imp.		12	36 Imp. pro V_z	$V_m = 10/36$ pro Imp.
16	16 Imp. pro V_z	$V_m = V_z /16$ 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 (cm³)
V_z = the volume between the gear teeth

Subplates AP ...

Example

```
AP  G 1  S  C  0  N / 1
```

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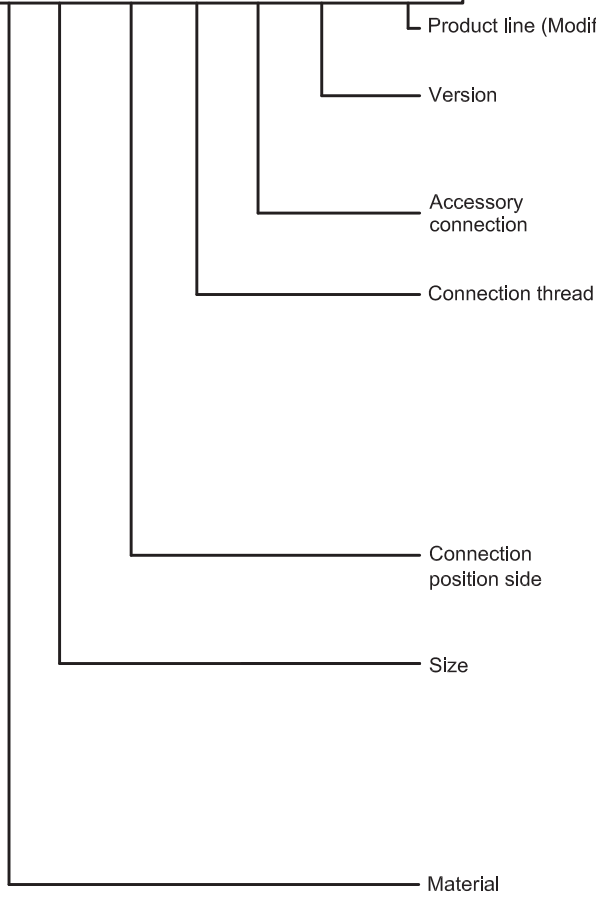
— Version

| 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		0.4	VSI 0.4
	VSI 0.04		1	VSI 1
	VSI 0.1		4	VSI 2
	VSI 0.2		10	VSI 4
				VSI 10

— Material

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

PREAMPLIFIER-BLOCK WIRING DIAGRAM

+ Volts	1	brown
Channel 1	2	white
Channel 2	4	black
Zero	5	grey
0 Volts	3	blue

Evaluation unit

Equipotential bonding

PLUG ASSIGNMENT

Pin 2 — Channel 1

Pin 1 — Supply + Volt

Pin 3 — Supply 0 Volts

Pin 4 — Channel 2

Pin 5 — Zero signal

CONNECTION DIAGRAM

1	+ Volts	(brown)	+U	
2	Channel 1	(white)	K 1	General signal
3	0 Volts	(blue)	0 V	processor
4	Channel 2	(black)	K 2	
5	Channel 5	(grey)	Zero signal	

0 V

NOTES

VSE.flow®