



PVM-PD

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PVM-PD User handbook

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1. General

This chapter contains information about the PVM-PD, the format of this manual, and several points to be noted when using the PVM-PD.

1.1 How to use the instruction manual

In order to correctly install and put into operation the PVM-PD with its Sensors and accessories, this manual must first be read very carefully. Further documents relating to components used in conjunction with the PVM-PD must also be read and checked for their compatibility with the PVM-PD. The instruction manual is divided into the following sections:

1. General

This instruction manual should communicate to the user the importance of the functional principles of the PVM-PD and the necessary operational and related conditions for its use. Only by following the guidelines for these conditions will the PVM-PD work in accordance with the given technical specifications. A system overview of the equipment configurations shows all components of the complete system. The parts delivered to the customer must be confirmed to be complete according to the order placed.

2. Technical specifications

The given technical specifications can only be guaranteed when the guidelines for operational and related conditions are adhered to. Possible external influences which may affect the data are clarified in as much detail as possible.

3. Operation

The PVM-PD can only be put into operation after its connection and examination. The user must make themselves familiar with the operation of the PVM-PD via the keyboard and display before commencing measurement. The functions of the keyboard are described and related to the appropriate applications. An overview of the possible causes of errors should enable swift rectification of any errors by the user themselves.

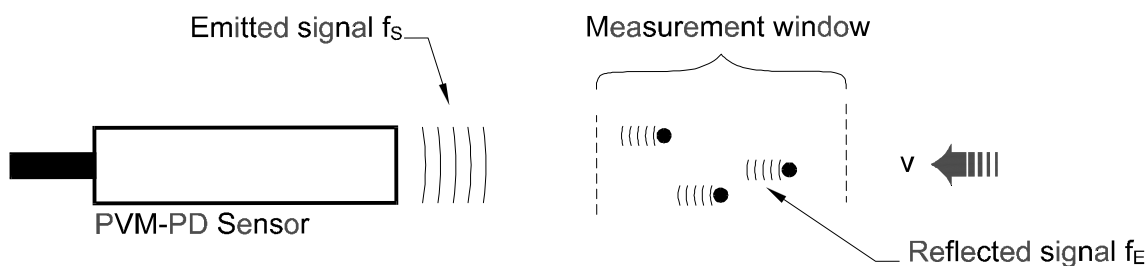
4. Maintenance

Depending on the operational and related conditions the PVM-PD is placed under, maintenance may be necessary. Advice and tips based on experience should be helpful in confirming the maintenance interval and its extent.

1.2 Functional principles of the PVM-PD

The PVM-PD is a battery powered portable measurement unit for recording flow velocity in various streams, pipes and open channels. The flow velocity is determined by pulse Doppler measurement. A piezoelectric crystal element transmitter/receiver sends ultra-sonic bursts of a known frequency into the liquid that is to be measured in rapid succession. Through a time-defined echo evaluation in a time window, the reflected frequency signals can be assigned to a spatial range of the measurement probe. The frequency displacement of the reflected signals caused by the Doppler effect is the value of the flow velocity at this point. The measurement probe measures the flow velocity. Through the frequency-analysing and temperature- compensating evaluation of the received velocity signals with displaced frequency, a velocity measurement with neutral point and long-term stability is achieved.

The ultra-sonic Doppler principal physically assumes the presence of scattered particles in the medium, for example air or solid particles. The scattered particle must be larger than 500µm and the level of solidss should be greater than 100ppm per volume unit.



$$v = \Delta f$$

$$\Delta f = f_E - f_s$$

Δf = Doppler frequency

f_s = emitted frequency

f_E = Frequency displaced by flow velocity

c = sound speed of the measurement medium

1.3 Operational and related conditions

The operational conditions for the PVM-PD are defined by the boundary values of the technical specifications for the sensors and measurement transducers and the measurement medium and the hydraulic conditions:

Limits imposed by the sensors and measurement transducers (see technical specifications):

- Temperature limits according to the technical specifications
- Relative atmospheric humidity (measurement transducer only) lower than 90% (no condensation)
- Electromagnetic interference that breaches CE guidelines on intensity
- Measurement range of the sensor

Limits imposed by the measurement medium:

- Reflective particles required in the medium
The Doppler effect is based on the reflection of the emitted signals. Clear media will not result in any reflection. A flow velocity measurement with Doppler ultra sonic is therefore impossible in such media. The smallest possible particle size (eg bubbles of air or solid particles) and the quantity of particles required for the relevant sensors is given in the technical specifications.
- Tolerance of the measurement medium by the materials used.
Details of durability for the materials used are available from NIVUS. Abrasive media will result in mechanical wear of the sensor. In particular, when there is a high medium velocity and a presence of large solid particles, the sealing compound for the flow velocity sensors can lead to the abrasion, and, in the course of time, the destruction of the sensor.

Limits imposed by hydraulics:

- The straight stretches at profile changes, cracks in the base of the container, bends, gate valves before and after the measurement site are, according to the assembly advice, to maintain the function of the sensors. If these application specifications are impossible, additional measurement errors will occur.
- Changes in the flow (currents/ reverse flows/ turbulent flows) must not occur at the measurement site. The distance from a change in the flow to the sensor must be a minimum of 2 x the width of the channel.
- Minimum depth of flow 2.5 cm
- Minimum distance from the measurement site to the wall of the channel or the surface of the water 1.5 cm.

1.4 Equipment configurations



PVM-PD electronics



Sensor



Charger

2. Technical Specifications

Electronic parts

Casing	Lacquered aluminium casing, approx. 180mm x 110mm x 220mm (W x H x D)
Protection rating	IP 65
Display	4 x 20 character LCD
Operation	6-key
Velocity measurement range	0-4m/s
Temperature boundaries	0 to 50°C (position temperature -5 to 60°C)
Internal battery	Lead storage cell; 12V/ 2Ah; Life span approx. 6 hrs
Connector sockets	1 x sensor; 1 x charger

Rod probe for flow velocity measurement

Emitting frequency (pulsating)	750KHz
Removable telescopic aluminium rod with spirit level	0.7m – 1.6m
Measurement window: Position/ length/ diameter	6cm in the horizontal axis of the sensor/ 3cm/ 1.6cm
Measurement accuracy: (c=1485m/s)	1% of the measurement value or ± 0.01m/s; the larger of the two applies
Smallest particle size for signal reflection	500µm, 100ppm
Operational temperature/ temperature compensation:	0-60°C
Connecting cable	7m with plug connection to electronic parts

CE – check

Interference transmission	EN 50011		
Interference resistance	EN 50082-2	Intensity grade 3	IEC 801.2
			IEC 801.3
			IEC 801.4

3. Assembly and connection

3.1 Sensor

Insert and screw in the plug of the sensor connection cable in the socket of the PVM-PD. At the end of the measurement, the sensor can be unscrewed once more. Close the socket of the PVM-PD with its protective cap.

Placing the sensor in the measurement medium:

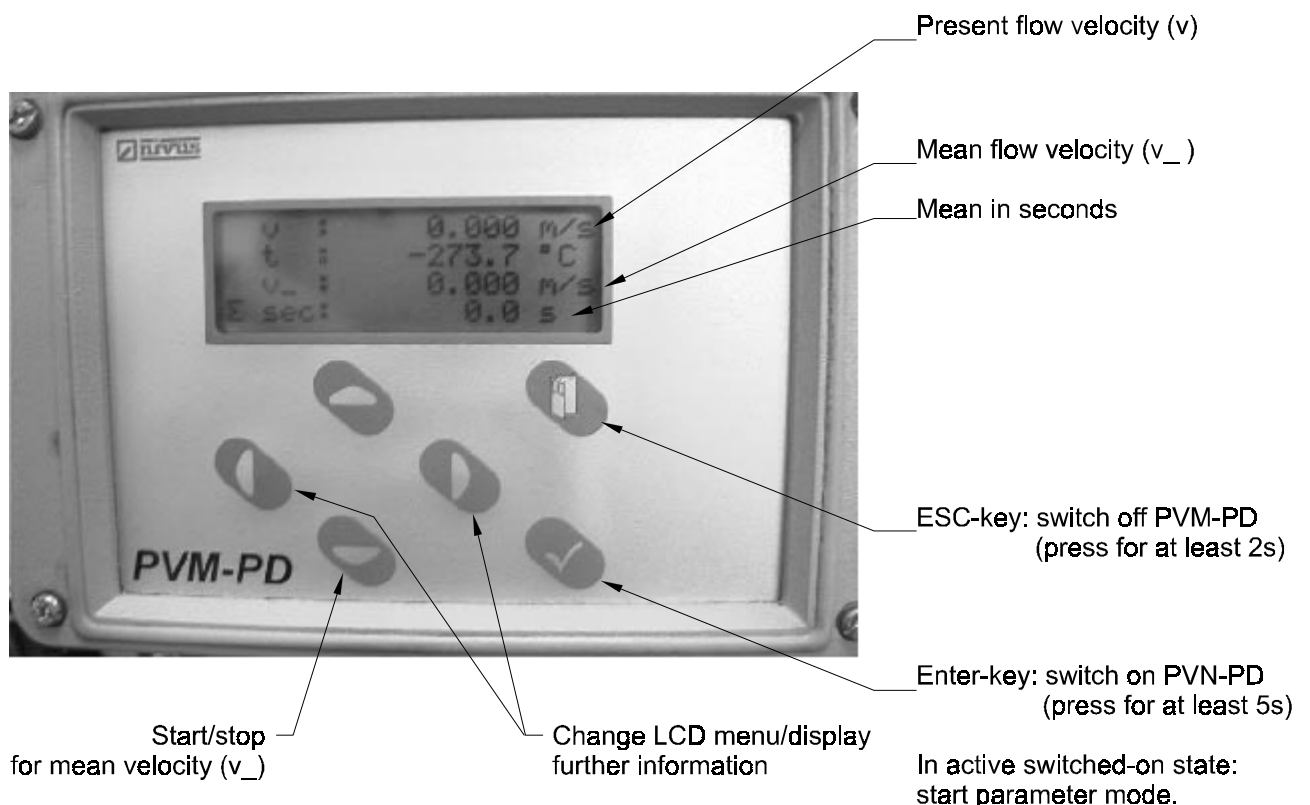
- Lead the probe into the measurement site in profile
- Align the probe parallel to the axis of the canal. To align the probe horizontally, use a spirit level. (WARNING! An angle error of 5° will lead to a measurement error of 0.4%; 10° to an error of 1.5%)

3.2 PVM-PD Electronics

Before putting the unit into operation, charge the battery. Connect the battery charger to its socket. At the end of the charging period (when the red light goes out), remove the charger and close the socket firmly with its protective cap (WARNING! Close the protective cap manually only, otherwise the plastic thread will be damaged). After the connection of the sensor, the PVM-PD is ready for operation.

4. Operation

4.1 Display and keyboard



4.1.1 Switching the PVM-PD on and off

The PVM-PD is switched on as shown in 4.1. It will briefly show the firmware installed. After a few seconds the current temperature and flow velocity. The unit will switch itself off automatically after 8 minutes, or as described in 4.1.

4.1.2 Start/Stop for the calculation of average (mean) velocity

The upper section of the display will show the current velocity continuously. To receive an average (mean) value over a defined period of time, the arrow key must be pushed down. The display of the average (mean) value will continue until the key is released. The standardised velocity (3rd row LCD) and the average (mean) time (4th row LCD) will be displayed until a new average (mean) value is calculated or until the PVM-PD display is switched off.

4.1.3 Further information shown in the display

Through the horizontal arrow key, battery power and the measurement efficiency of the received signals can also be displayed.

Velocity frequency histogram:

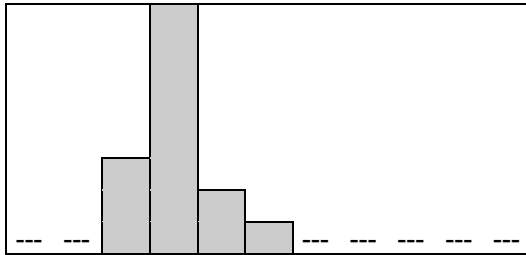
The frequency histogram shows the distribution of the Doppler frequencies emitted. Each bar (peak) represents a frequency group. Up to 11 frequency groups can be displayed at a time. The frequency range is automatically adjusted to fit the range of velocities. Only a qualitative statement about the quality of flow velocity measurement can be made through the distribution and formation of the frequency groups.

Efficiency (E):

The efficiency of the measurement (0-100%) shows the relationship of the evaluated Doppler frequency to the complete spectrum of the measured frequencies. As complex algorithms are used for valuation here, a detailed explanation is not possible. However, it is based on the principle that the higher the efficiency value, the more reliable the displayed flow velocity measurement value. Efficiencies rated at less than 15% will result in the rejection of the measurement value. Even so, there are cases in which a relatively high efficiency of the flow velocity measurement value is incorrectly given out. In this case, the form of the frequency distribution must be taken into consideration. The following histograms should be of practical help in the assessment of histograms:

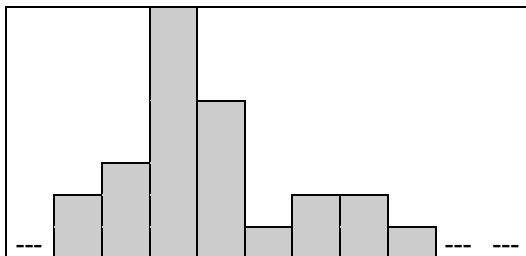
Histogram shapes:

- **Optimum measurement:**



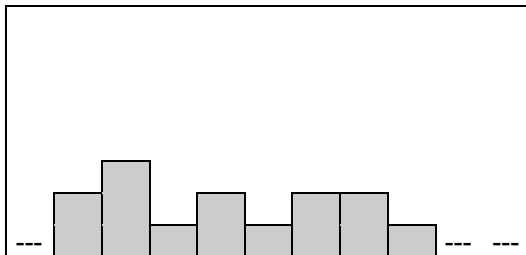
Narrow frequency range. The peak is stable and very high when compared with the other bars.

- **Normal measurement:**



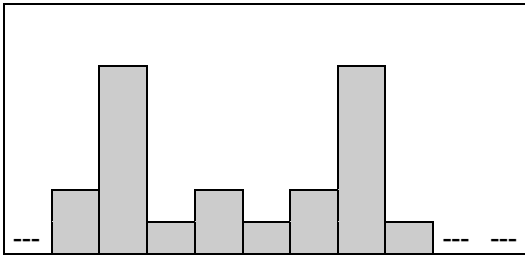
Wide frequency range with stable (alternation max ± 1 bar), high peak. Efficiency > 40%.

- **Measurement with bad reflection quality in the measurement medium:**



Very wide range of frequencies with no stable peak in relation to the other bars. Efficiency < 30%. Eventual creation of a bar with a Doppler frequency that is far below half of the actual Doppler frequency of the flow velocity. In this case the efficiency can be > 30%. Nevertheless, a flow velocity that is essentially too low is displayed. When the level of reflective particles is too low and their size is too small, this can be the cause of poor quality measurement. Reflective particles (eg sand) scattered or air injected into the measurement medium for a short time to see whether this produces a change in the histogram and whether real measurement values are displayed (see also Chapter 2 – technical specifications).

- **Measurement with disturbing influences:**



The peak “jumps” around several frequency groups and a wide frequency range. The calculated Doppler frequency (F) “jumps” very strongly. In spite of an efficiency that is > 40% an incorrect or unstable, fluctuating velocity is calculated. The formation of a whirlpool, stagnant waves, a turbulent water surface or a very shallow water level can all be causes of this kind of histogram. The measurement site is unsuitable.

4.2 Calibration of the sensors

Before commencing measurement, the temperature sensor integrated into the PVM-PD sensor must first become accustomed to the temperature of the measurement medium. When there is a large difference between the temperature of the measurement medium and the temperature on site, this can take several minutes. Immerse the sensor in the medium.

Beware! A temperature difference of 1°C can lead to a measurement error of 0.24%.

The velocity sensor must not be calibrated for water. The neutral point is absolutely stable. If media with a speed of sound that differs from that of water (1485 m/s at 20°C) are measured, it must be taken into consideration in a calibration factor in the setting of the parameters.

4.3 Applications

With the PVM-PD, a localised velocity can be measured in all channels and pipes. In most cases, the present flow should be determined with one or more localised velocity measurements and a separate flow level measurement. Here are several examples of how with one or more flow velocity measurements the mean flow velocity can be defined approximately:

l) **Measurements of maximum flow velocity:**

In many cases the maximum velocity (V_{max}) is situated in approximately 50-70% of the height in the average (mean) axis of the profile. If this is recorded, the mean flow velocity can be calculated by multiplying by 0.86. If this method is used, the error will be around $\pm 5\%$. This method should only be used for a quick check in standard profiles, pipes or rectangular channels with axial symmetrical velocity distribution. Additionally, in partially filled channels/ pipes, > 50% to approx. 20% of the height of the velocity (V_h) can be measured: the average (mean) flow velocity ($V_{_}$) will then be:

$$V_{_} = [V_h + (V_{max} \times 0.86)] / 2$$

- II) Subdivision of the flow cross-section into partial surfaces. This is particularly suited to rectangular channels and for checking Flume measurements. In each partial surface, the flow velocity is measured in the middle. An average (mean) value is created from all the individual velocities. The smaller the partial surface chosen, the more exact the definition of the average (mean) flow velocity. Fluctuating water levels must be taken into account and the flow velocity standardised to one level. With flume measurements, the velocity for example will fluctuate by a change of level between 10% to 4.94%.
- III) Calculation of the average (mean) flow velocity in accordance with VDI / VDE Standard 2640. This enables the exact definition of the average (mean) flow velocity using individually measured, localised flow velocities. The exact procedure exceeds the framework of this instruction manual and can be read about in detail in the Standards.

4.4 Parameter modes

The PVM-PD's parameters are set in the workshop. **For normal operation the user does not have to make any input.** The parameter modes are in menu form with a sub-menu structure (tree). The most part of the menu is not necessary for the PVM-PD. In cases with liquids with a velocity that differ to that of water ($c = 1485 \text{ m/s}$ at 20°C) **Sensors / velocity sensor / correction factor (K)** must be selected and the value previously programmed must be changed.

Example:

C_ Measurement medium	=	1530 m/s	
C_ Water	=	1485 m/s	
K	=	0.9706	$K = \frac{C_{\text{water}}}{C_{\text{Measurement medium}}}$

Should velocities of $> 3.5 \text{ m/s}$ to 5.5 m/s be measured, they can be realised through the following measures:

The sensor should be immersed at an angle of 45° to the direction of flow instead of horizontally (be aware of the position of the measurement window). Activate the service level by selecting **Measurement site / Service level** in the menu and by typing in 2718. Select **Sensors / Velocity sensor / Angle of beam** in the menu and change the value to 45° .

Description of the menu structure for parameter structure:

LCD	Meaning	Definition of symbols
1 st row	Programming status	Parameter setting ° present menu level is 1 st sub-menu level °° " 2 nd sub-menu level °°° " 3 rd sub-menu level S The service level is active
2 nd row	Higher menu level	- - - The present menu level is the highest (main menu)
3 rd row	Present menu level	
4 th row	Number / text input	- - - There are further sub-menus under the present level [x x x] stored numerical value or text > x x x < stored value can be edited

The parameter setting is structured in menu form with various levels:
 The main menu level, which is called up directly after starting the parameter and 3 sub-menu levels.

Measurement site > Measurement mode > Channel data > Save > Sensors > Sampler > Rain measurement > Display > Battery

Choose a main menu with the **—** or **—** key.

Open 1st sub-menu level for this main menu with **—**

Display:
 Parameter setting *
 Measurement site
 Name
 [PVM-PD]

Function	Key(s)
Switch on PVM-PD	---- approx. 5 sec.
Select menu / parameter modes	----
Change menu level	---- change to lower level ---- change to higher level
Open input for numbers / text	----
Alter number; spelling or character	---- or ----
Move cursor or position on menu	---- or ----
Save entry	----
Switch off PVM-PD	Automatically switches off 3 min. after a key was last pressed, or press ---- until "end of parameter mode" is displayed.
Decimal point input	After "0" press ---- 2 times

Editing an input site:

-. / 012...9 (7 special character) ABC...ZÄÖÜ (5 special character) abc...zäöü (special character)
space

4.5 Rectification of errors

Error	Cause / error rectification
PVM will not switch on	Battery empty / recharge Surrounding temperature outside that specified / warm or cool the equipment
No / fluctuating measurement value	Sensor not placed or screwed in correctly / check connections
Heavily fluctuating and too low measurement value	Too few reflective particles in the medium
Heavily fluctuating and too low/too high measurement value	Turbulence in water / choose another measurement site

5. Maintenance

The PVM-PD should be cleaned after every measurement. The sensor can be cleaned with warm water and mild soap. After this, an appropriate disinfectant should be used. The electronics can be cleaned with a damp cloth.

The battery should be charged every 3 months, as it will run out.

The battery will undergo a change. The capacity will become lower. An examination of the capacity can be undertaken by the producer.