

# **ALVIM Biofilm Monitoring System**

# **USER MANUAL**

**Model A001S3**

ALVIM - Model A001S3  
Last update: 22 December 2021

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## 1. Introduction

The ALVIM Biofilm Monitoring System is based on a bio-electrochemical Sensor able to detect biofilm growth in aquatic environments, since its first phases.

The ALVIM System represents an effective tool for biocide/cleaning treatments optimization, and for monitoring the effectiveness of these treatments.

For general information about the ALVIM Biofilm Monitoring System architecture, applications and scientific background, please refer to the web page:

<http://www.alvimcleantech.com/biofilmsensor>

## 2. ALVIM System installation

The ALVIM System is composed by:

- one or more Biofilm Sensors;
- a Control Box / power supply unit<sup>1</sup> for powering Sensor;
- a USB/RS485 converter<sup>1</sup>;
- a power supply unit<sup>1</sup> for the 4-20 mA data transmission.

[!] **Attention:** the Sensor and the 4-20 mA power supplies must be isolated



Figure 1: ALVIM Sensor

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<sup>1</sup> Optional

In order to install the System, please follow these steps:

**If you want to communicate with the Sensor via RS485/MODBUS:**

1. Plug the Sensor in the pipeline (see Sensor installation, p.7).
2. Connect ALVIM Sensor to the Control Box through the data/power cable (see ALVIM Sensor wiring, p.9).
3. Connect the USB/RS485 converter to the PC (see Control Box and RS485-USB converter, p.10).
4. Install ALVIM monitoring software and drivers (see Software installation and use, p.11).

Figure 2 gives a general overview of ALVIM System architecture. Please note that, while data/power cable and RS485 cable can cover long distances (up to one hundred meters), USB cable can be used only for short links (2-3 m).

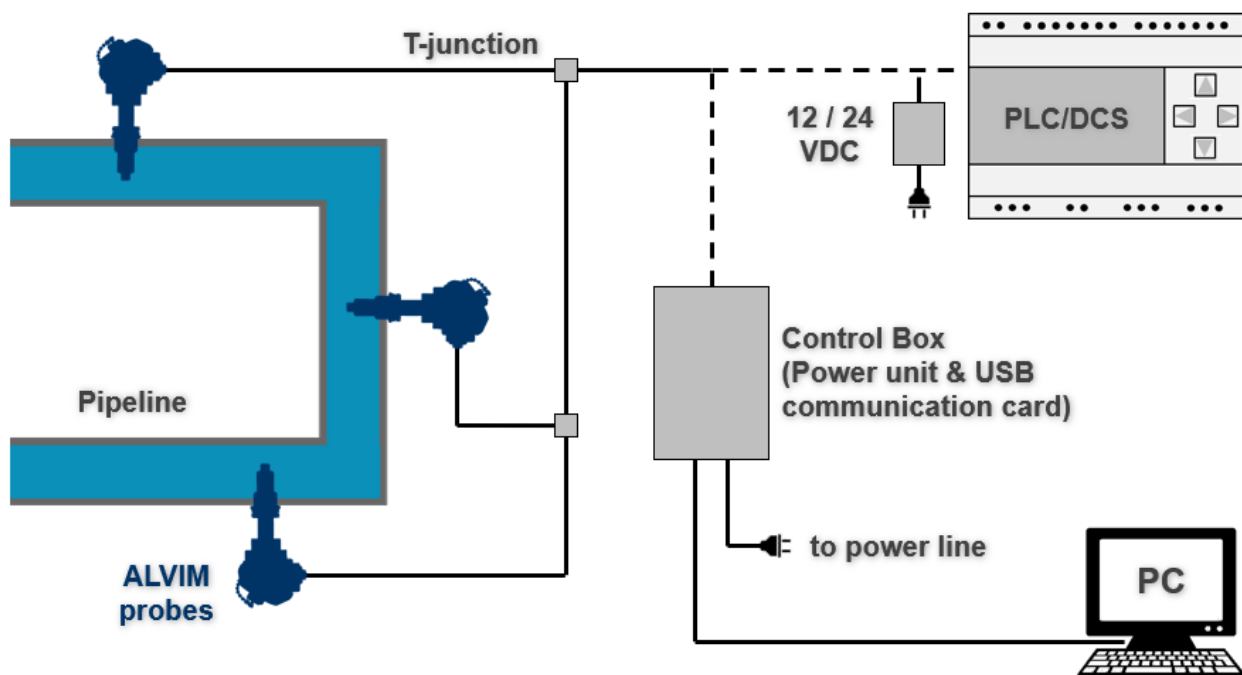


Figure 2: General overview of ALVIM System architecture, for RS485/MODBUS

**If you want to acquire Sensor data via 4-20 mA:**

1. Plug the Sensor in the pipeline (see Sensor installation, p.7).
2. Connect the Sensor to the data acquisition system (e.g. a PLC/DCS) and to the power supply through the data/power cable. Please note that an additional power unit is needed, to generate the 4-20 mA signal (different from the power unit used for the Sensor itself). **For wiring, please refer also to Figure 7.**

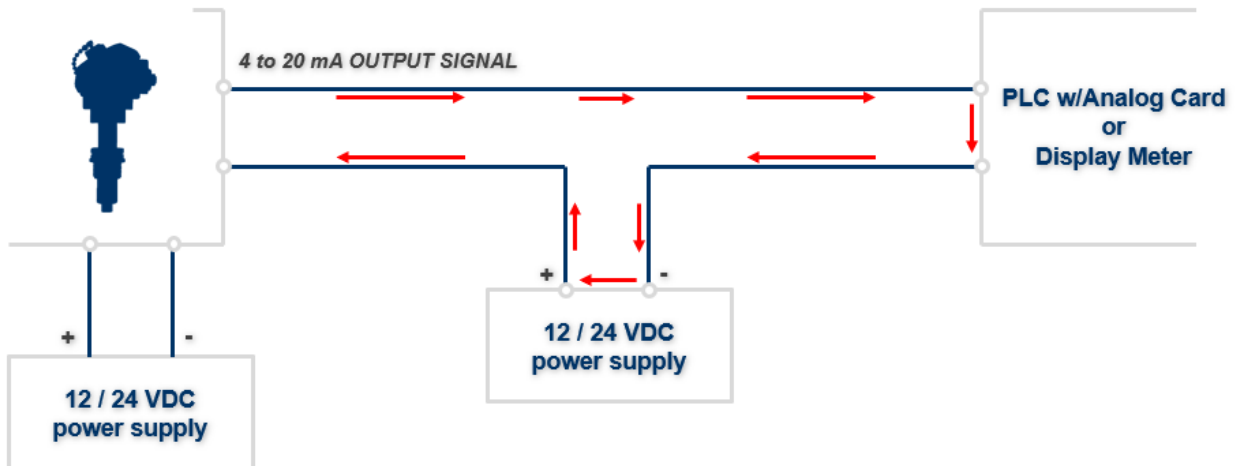


Figure 3: 4-20mA current loop scheme

[?] **Note:** a Sensor can be connected via MODBUS and 4-20 mA at the same time

[!] **Attention:** the Sensor and the 4-20 mA power supplies must be isolated

## Sensor installation

Before installing the Sensors, please take note of the serial number of each one (printed on a label inside the head) and of the position where it is going to be placed. This information is useful for Sensors network configuration (see Software installation and use, p.11) and for identifying the Sensor, if more than one ALVIM probe is going to be installed..

**If you plan to install more than one ALVIM probe, or if the probe is going to be installed in an already-existing MODBUS network, it is suggested to verify the MODBUS addresses of each ALVIM probe before installing it. In this way the risk of network failures due to MODBUS address conflict will be avoided.** To perform this task, please see Software installation and use (p.11) and, in particular, AlvimViewer installation and configuration.

For probes positioning, please follow these suggestions:

- Install the probes in the sections with the highest and lowest flux, to monitor the worst and the best conditions for biofilm growth; if only one Sensor is going to be installed, it is suggested to place it in the section with the lowest flux, because this is expected to be the most suitable condition for biofilm development: in that area the bacterial layer will grow faster, thus the Sensor will provide an early-warning information. However, to get the best results, **it is suggested to install the probes where there is always (or for most time) some flow, even minimum. It is not advisable to install the probes in pipes or tanks where there is, always or for most time, no flow at all.**
- Install the probes in the sections with the highest and lowest temperature, to monitor the worst and the best conditions for biofilm growth (see the temperature range in the ANNEX 1- TECHNICAL DATASHEET); if only one Sensor is going to be installed, it is suggested to place it in the section with the highest temperature (considering the above mentioned range), because this is expected to be the most suitable condition for biofilm development: in that area the bacterial layer will grow faster, thus the Sensor will provide an early-warning information.
- Install one probe at the beginning of the line, just after the point of injection of the chemicals used for the cleaning treatments (if any), and one at the end of the line; in this way the ALVIM System will provide a complete view of line conditions and cleaning treatments effectiveness.

Figure 4 illustrates some options for installing an ALVIM Sensor. **Connection to a bypass is not suggested**, since biofilm growth dynamics can be completely different from those of the main line. If this is the only option, the conditions in the bypass (in particular flow velocity) should be kept as similar as possible to those of the main line.

Where possible, **ALVIM probes should be installed parallel to the ground**, in order to avoid the possible accumulation of both deposit (as it can happen if a probe is installed vertically on the bottom of a pipe) and air bubbles (as it can happen if a probe is installed vertically on the top of a pipe).

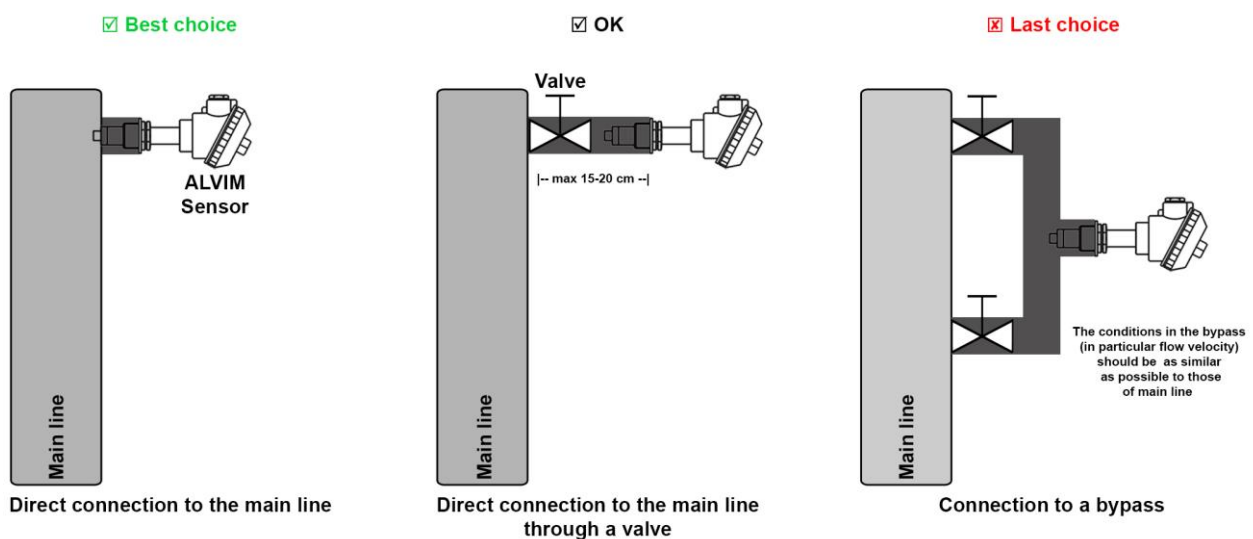


Figure 4: Possible installations of an ALVIM Sensor

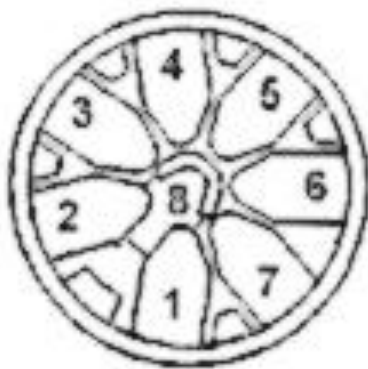


### ALVIM Sensor wiring

In order to connect ALVIM Sensors to the Control Box, please use a 6-wire cable (Note: even if the connector has 8 pins, only 6 of them are used).

Connect the cable through a **straight** connection, using the provided male connectors.

Figure 5 illustrates the pinout of ALVIM connectors (Sensor connectors and Control Box connectors have the same scheme).



1	<b>4-20mA (A)</b> (4-20mA input)
2	<b>VSS (-)</b> (Negative power supply input)
3	<b>RS-485 (A)</b> (Modbus RTU interface) Transceiver terminal 0, V0 Voltage (V0 > V1 for binary 0 [ON] state )
4	N.C. (Not connected)
5	<b>RS-485 (B)</b> (Modbus RTU interface) Transceiver terminal 1, V1 Voltage (V1 > V0 for binary 1 [OFF] state )
6	N.C. (Not connected)
7	<b>4-20mA (B)</b> (4-20mA input)
8	<b>VDD (+)</b> (Positive power supply input)

Figure 5: Connector pins for System wiring

**ONLY FOR RS485/MODBUS COMMUNICATION:** If more than one Sensor is going to be installed using the same cable (bus), a 4-wire cable should be used, creating a T-junction for each Sensor to be connected, as in Figure 2 and Figure 6.

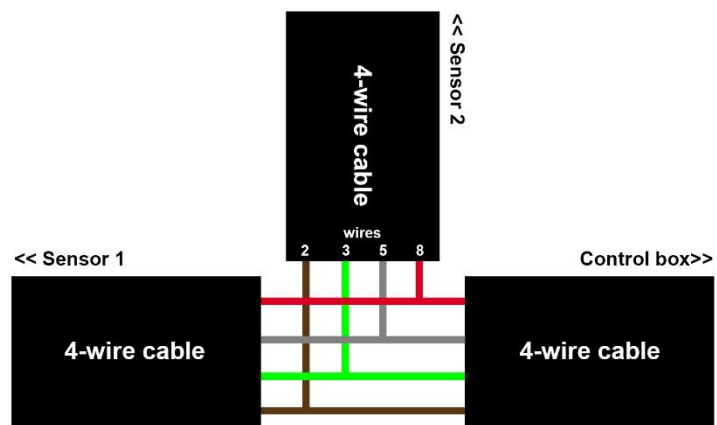


Figure 6: T-junction of 4-wire cables

### Control Box and RS485-USB converter

Figure 7 illustrates Control Box and RS485 to USB converter wiring. In case of long connections or noisy environments, it is advisable to enable the line terminator, short-circuiting BROWN and GREEN wires of the converter (**NOT THE WIRES OF THE PROBE CONNECTOR**).

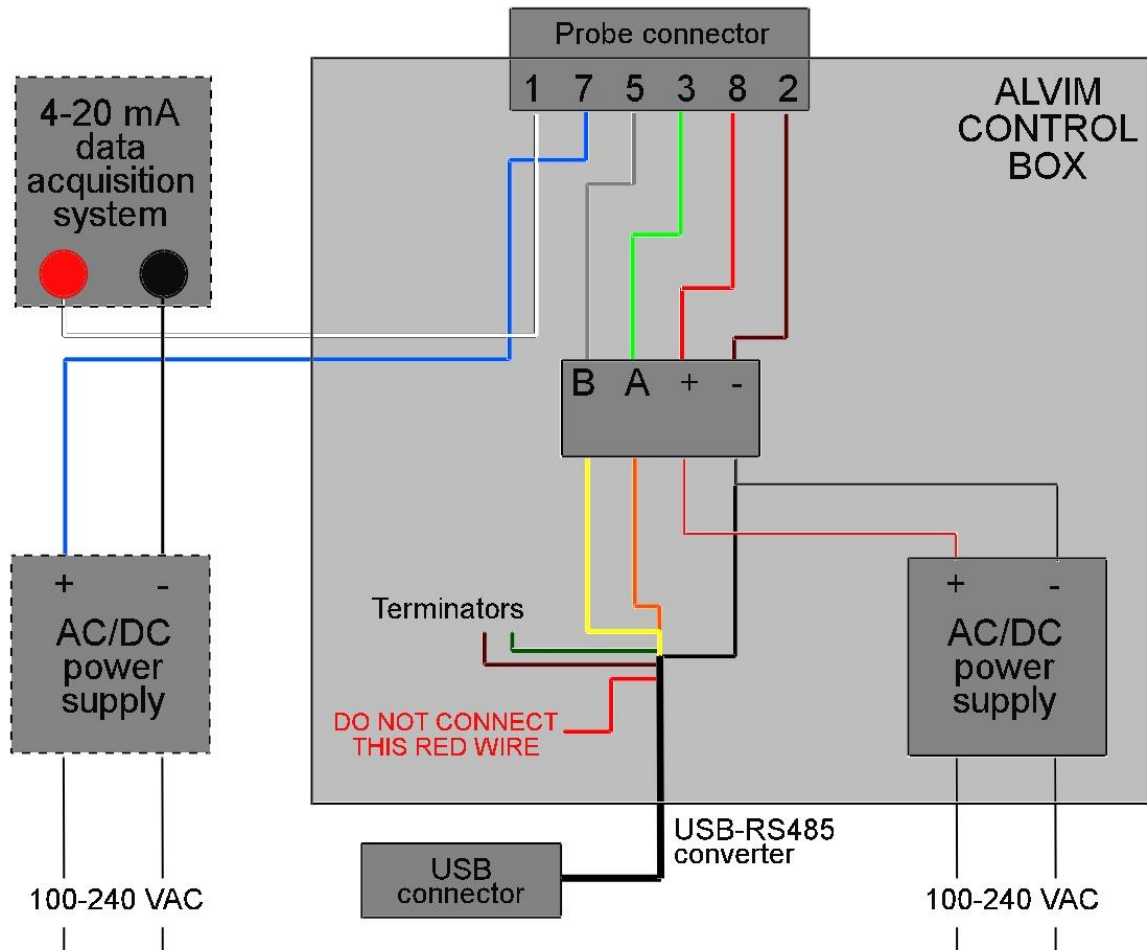


Figure 7: Control Box wiring.  
Data acquisition system and 4-20 mA power supply are optional.

RS485-USB converter leds meaning:

NAME	COLOUR	MEANING
Rx	Green	It blinks when the converter receives data through the RS485 port
Tx	Red	It blinks when the converter transmits data through the RS485 port

For any problem with the converter, verify the following points:

PROBLEM	POSSIBLE SOLUTION
Rx/Tx Led OFF	Verify that the USB port of the PC provides the 5V that are necessary to supply the module
Rx Led steady ON	Verify that the RS485 cables have not been swapped

## 3. Software installation and use

### RS485-USB converter installation

1. **Insert ALVIM USB key in a USB port of the PC.**
2. Connect the RS485-USB converter cable to the PC.
3. The operating system will automatically detect the presence of the device, follow the guided installation. When asked, skip the software search on Windows Update, choose to install from a specific location, and then choose to search the best driver **including removable devices**.
4. Once completed the installation of the serial converter, you will be prompted for the installation of the USB serial port. Follow the same procedure described at point 3.

### AlvimViewer installation and configuration

1. **Insert the ALVIM USB key provided with the Sensor in a USB port of the PC.**
2. Open Windows Explorer, double click on ALVIM USB key icon, then right-click on the file "InstallAlvimViewer.exe" and select "Run As Administrator".
3. Follow on-screen instructions.
4. To start the ALVIM software click on "Start" > "Programs" > "AlvimViewer" > right-click on the icon "AlvimViewer" and select "Run As Administrator".
5. In the AlvimViewer menu, click on "Options" and enter the port number associated with your RS485-USB converter (you can find it in "Start" > "Control Panel" > "System" > "Hardware" > "Device Manager" > "Ports", the converter will be listed as "USB Serial Port") and click on the "Ok" button.
6. In the AlvimViewer menu, click on "Sensor", then:
  - **If you do not know the MODBUS addresses of connected Sensors**, click on "Scan" (Figure 9). Once the scan has been completed, you will see a list of detected Sensors, marked in the Status column as "New". Click on the last of the listed Sensors, enter the desired MODBUS address (between 1 and 247, it has to be different for each Sensor installed), a sensitivity value (see Choice of probe sensitivity level, p. 13), a name (e.g. Sensor1) and, optionally, a description (e.g. Installed at the water intake) for that Sensor. Click on "Insert" to store Sensor configuration data. Clicking on the "Check" button, the value of Sensor Potential (see AlvimViewer installation and configuration, p.13) will appear in the Information Box. Repeat this procedure for each Sensor.
  - **If you know the MODBUS addresses of connected Sensors**, enter the first one in the "Address" field (Figure 9), then enter a sensitivity value (see Choice of probe sensitivity level, p. 13), a name (e.g. Sensor1) and, optionally, a description (e.g. Installed at the water intake), then click "Check". If the address is correct, in the Information Box you will see the value of Sensor Potential (see AlvimViewer installation and configuration, p.13). Click on "Insert" to store Sensor configuration data. Repeat this procedure for each Sensor.



## Choice of probe sensitivity level

The sensitivity of the ALVIM Biofilm Monitoring System can be adjusted to fit different conditions and environments. This can be done only via RS485/MODBUS communication. The sensitivity value, set during ALVIM software configuration (see p.11), ranges between 1 (minimum sensitivity to biofilm growth) and 255 (maximum sensitivity). For the optimal choice of the sensitivity value, please consult with the ALVIM Technical Staff (see p.19).

These general indications can be followed:

Conditions, sensitivity level	Sensitivity value
Seawater, low sensitivity	5
Seawater, medium sensitivity	60
Seawater, high sensitivity	120
Freshwater, medium sensitivity	180
Freshwater, high sensitivity	255
Pure water or membrane systems	255

## AlvimViewer use and interpretation of data

Once the Sensors in the plant have been configured (see p.11), launch AlvimViewer and choose, in the main window (Figure 9), a **data acquisition frequency** (usually 1 point every 30-60 minutes is enough), then click on the "Start" button.

The software will automatically plot collected data; furthermore, in the Box below the graph, it is possible to see last acquired values. If a Sensor is not responding, an alert icon will appear in the "Status" column of this Box.

It is possible to **zoom** in the graph, unchecking "Realtime View" Box, then right-clicking on the graph and selecting "zoom". The x-axis label indicates the time range of the plotted data, and changes with the zoom level.

The "**History View**" Box (Figure 9) allows to plot the data of a selected time period. To view real-time data again, remember to check "Realtime View" Box.

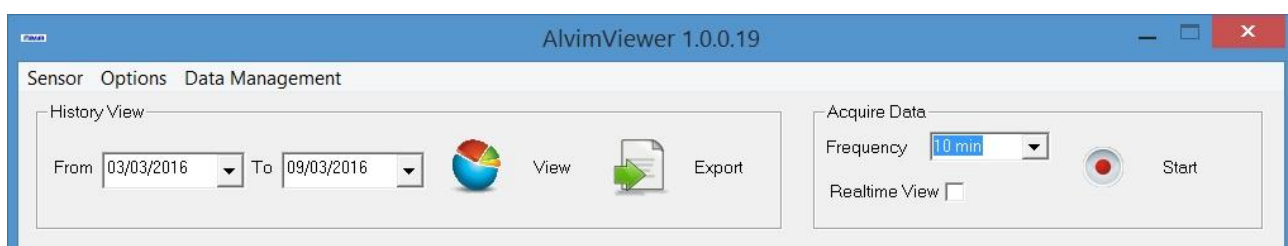


Figure 9: AlvimViewer main window

All the data are stored in a .mdb DataBase, located in the folder:

C:\Program Files\Alvim Viewer\Data

Opening the .mdb file with an appropriate program (e.g. Microsoft Access® or OpenOffice Base), it is possible to view and copy them. To **make a backup of the data** (it is recommended to perform this task periodically), copy the Data folder to a removable device or a remote server. It is also possible to **export in .xls format the data** collected during a chosen period, selecting the period of interest from the “History View” Box, then clicking on “Export”. It is possible to send via Internet a copy of the database to the ALVIM staff (for support and consultancy purposes) choosing, from the ALVIM Viewer menu, "**Remote Backup**" (Note: this function could be disabled in some versions of the software). Please note that this cannot be considered as a backup copy of System data, to be retrieved in case of PC/hard-drive failure. For such a purpose, follow the backup procedure explained in the previous paragraph. Finally, it is possible to delete all the data collected, without losing the configuration of installed Sensors. To make this, from the main menu click on “Data Management” > “Delete Acquisition Data”.

[!] **Attention:** always make a backup of the data before deleting them

Figure 10 gives an example of the evolution of ALVIM Sensor signal with the time. Just after the installation of a new Sensor in a water line, its signal will slowly decrease for some hours (natural conditioning of Sensor's surface), then it will settle on a baseline. **An increase of more than 150 mV (within the space of hours/days from the start of the rise) in the Potential value highlights biofilm growth.** If you are using the 4-20 mA data acquisition, an increase of more than 3 mA (within the space of hours/days from the start of the rise) in the signal highlights biofilm growth. Please note that the time needed for biofilm-related signal increase, initial/final values and growth rate can vary widely, according to environmental conditions, bacterial physiology, etc.

Generally speaking, in seawater systems the **baseline signal** is around 600-800 mV, while in freshwater it is around 450-650 mV. These values should be intended as merely indicative, and can vary due to the specific conditions of the application.

[?] **Note:** 4-20 mA reading corresponds to 300-1200 mV

**A gradual decrease in the signal with respect to the baseline and, in particular, values lower than 400 mV**, can be linked to low levels of oxygen on the surface of the probe. This can be due to:

- low concentration of oxygen in the water (see the minimum concentration indicated in the ANNEX 1 – TECHNICAL DATASHEET, it is suggested to verify oxygen concentration in the water);
- deposit formation on the surface of the Sensor (it is suggested to unplug the Sensor from the process, to verify the presence of any deposit and to clean the probe following the procedure described at p.18).

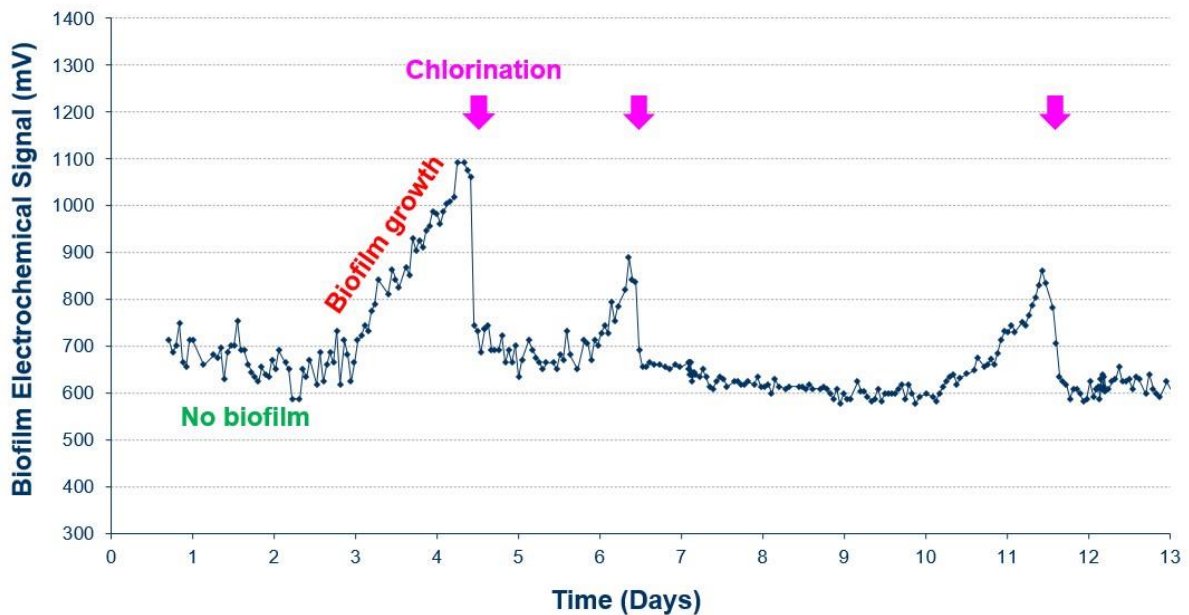


Figure 10: Example of ALVIM Signal evolution<sup>2</sup>

**Sanitation treatments (e.g. biocides) give the best results if applied as soon as biofilm starts to grow.**

Please note that, when the chosen level of biofilm to be monitored (see Choice of probe sensitivity level, p. 13) has been reached, with the consequent signal rise, biofilm signal will not increase anymore, even if biofilm grows further. At this point, cleaning treatments have to be applied, to remove settled bacteria and start monitoring biofilm growth again.

Oxidizing agents (like Sodium hypochlorite and many other biocides) will cause an increase in the signal (proportional to the concentration of the oxidizing agent) while they are present in the water where the Sensor is immersed (see Figure 11). Therefore, the ALVIM System allows to verify both:

- if an oxidizing biocide, when applied, arrives in the point where the Sensor is positioned, and
- if the applied water treatment is effective against the biofilm.

<sup>2</sup> This example refers to RS485/MODBUS data, but the same applies to 4-20 mA signal

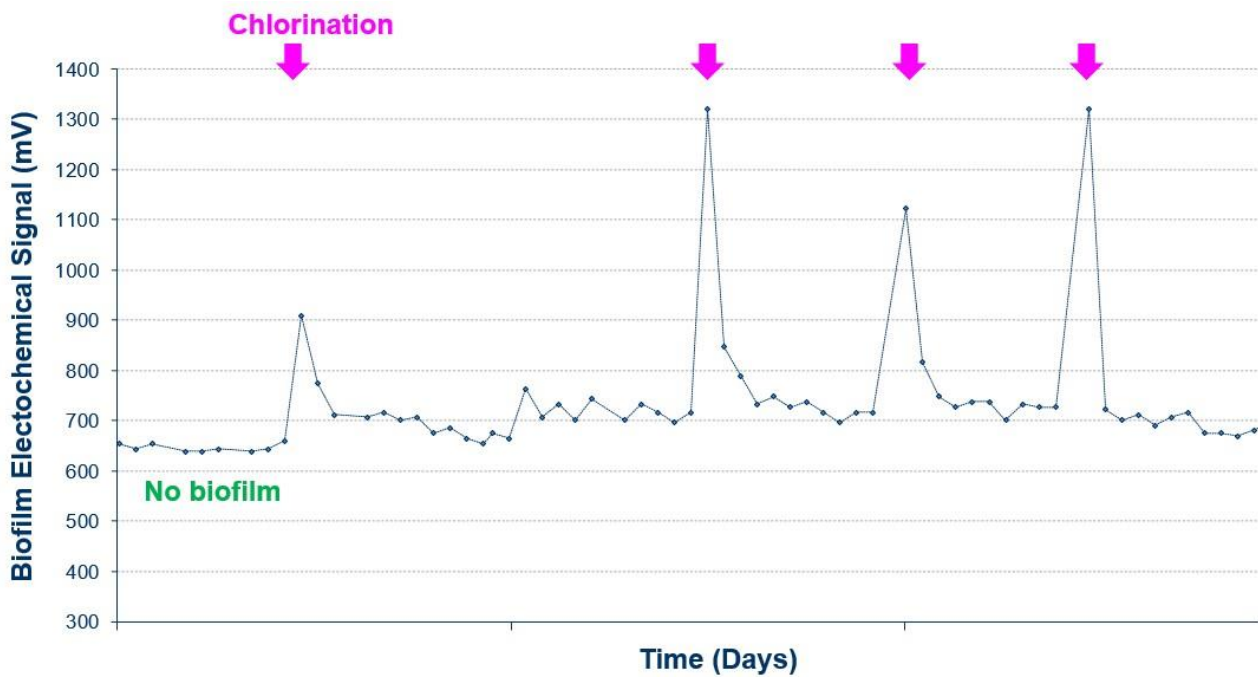


Figure 11: Example of oxidizing agent effect on ALVIM Signal<sup>2</sup>

### Do you want to run a simple trial with the ALVIM System?

If you are going to carry out a lab trial with the ALVIM System, we always suggest to run, at first, a basic test, before introducing other variables. This allows to get confidence with the System, and to better understand how it works. To this aim, we suggest to:

- immerse the Sensor in a tank with a volume of 10 liters or more, filled with natural water (freshwater or seawater) or, if this is not possible, with dechlorinated tap water; to obtain the best results, change 20-30% of the water every 2-3 days, paying attention to keep the Sensor always immersed in water;
- have a constant flow of water (even a minimum flow is enough), by means of a pump; this ensures a sufficient level of oxygen in the whole water bulk;
- keep a stable (ambient) temperature;
- run the testing at least for 10-15 days.

Within some hours from the immersion of the probe, the ALVIM signal should settle on a stable baseline. Then, when biofilm grows, you will see an increase of 150 mV and more in the ALVIM signal, within the space of hours/days from the start of the increase.

**[?] Note:** we suggest to avoid testing the Sensor immersing it in bacterial growth media.

Such kind of media, indeed, can determine a fast decrease in the level of oxygen near sensor surface and, thus, can make impossible to detect biofilm growth.

We also suggest to avoid adding nutrients to the water.



## 4. Data communication

This section explains how the Sensors communicate data and receive commands, and it is needed, e.g., for interfacing ALVIM probes with a PLC. If you plan to use the Sensors just with the AlvimViewer software, or with 4-20 mA data transmission, you can skip this section.

ALVIM Sensor implements MODBUS-RTU protocol in order to communicate and exchange data.

### MODBUS-RTU communication protocol

MODBUS is a master-slave communication protocol able to support up to 247 slaves, organized as a bus or as a star network. The physical link layer, for the ALVIM System, is RS485 with 9600 bps, parity None, 8 data bits, 1 stop bit.

For MODBUS -RTU description, please refer to the official specs:

[http://www.modbus.org/docs/Modbus\\_over\\_serial\\_line\\_V1.pdf](http://www.modbus.org/docs/Modbus_over_serial_line_V1.pdf)

ALVIM Sensor implements a subset of modbus-RTU protocol, precisely:

- read input registers (Function code 0x04) and
- write single register (Function code 0x06).

### ALVIM MODBUS REGISTRY DESCRIPTION AND CODES

#### Read input registers (Function code 0x04)

Register	Access	Description	Min. value	Max. value
0x0001	R/W	Device MODBUS address	1	247
0x0002	R/W	Sensitivity	0x0000	0x00FF
0x0003	R	Sensor Potential analog value (raw)	0x0000	0x0FFF
0x0004	R	Current mirror output value (4-20mA)	40	200
0x0005	R	Sensor Potential analog value (mV)	0	1299
0x0006	R	FactoryID[0]	0x0000	0xFFFF
0x0007	R	FactoryID[1]	0x0000	0xFFFF
0x0008	R	FactoryID[2]	0x0000	0xFFFF
0x0009	R	FactoryID[3]	0x0000	0xFFFF

#### Write single register (Function code 0x06)

Register	Access	Description	Min. value	Max. value
0x0001	R/W	Device MODBUS address	1	247
0x0002	R/W	Sensitivity	0x0000	0x00FF

## 5. Sensor maintenance

ALVIM Sensor is virtually "maintenance-free". It means that, if the cleaning/sanitation treatments applied in the piping system where the Sensor is installed ensure a complete removal of any deposit, the Sensor does not need any additional maintenance. On the other hand, if the applied treatments do not completely remove deposit, a periodic maintenance can be required. In this case, once a month<sup>3</sup> it is suggested to:

- stop the monitoring software;
- disconnect the data/power cable from the Sensor;
- take the Sensor off from the pipeline;
- clean the dipped part of the Sensor with a soft cloth and a surface detergent;
- if any deposit is present on the zinc electrode (see ANNEX 1 – TECHNICAL DATASHEET), clean it with emery paper (it is suggested to use P800 or P1200);
- wash the dipped part of the Sensor with freshwater;
- screw the Sensor again in the pipeline plug;
- reconnect the data/power cable;
- restart the monitoring software.

[!] **Attention:** do not use the emery paper to clean any other part of the Sensor

[?] **Note:** some degradation of zinc electrode with time is completely normal, and it does not affect Sensor functioning

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<sup>3</sup> Typical timing - Maintenance frequency has to be adjusted basing on plant/pipelines/water conditions and characteristics. If the dipped part of the probe appears very dirty after the removal from the pipeline, increase maintenance frequency.

## 6. Contacts / Helpdesk

For further information or support request, please contact:

### ALVIM Srl Helpdesk

Phone: +39 0108566345

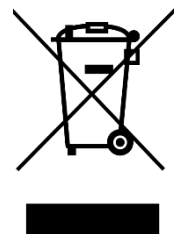
[support@alvimcleantech.com](mailto:support@alvimcleantech.com)

<http://www.alvimcleantech.com>

### NOTES

For disposal, ALVIM products have to be considered as RAEE / WEEE (Waste Electrical and Electronic Equipment), as indicated by the symbol here on the right and, where possible, on the products.

Do not dispose WEEE as urban waste; some substances contained in the electronic equipment can be dangerous for the environment and the human health if the equipment is improperly used or disposed. Collect separately the equipment, or return it to the manufacturer or distributor when you buy a new one. WEEE illegal disposal is subject to sanctions.



## ANNEX 1 – TECHNICAL DATASHEET

### A001S3 Sensor

**Connection to the process**

1" BSPP threaded connector

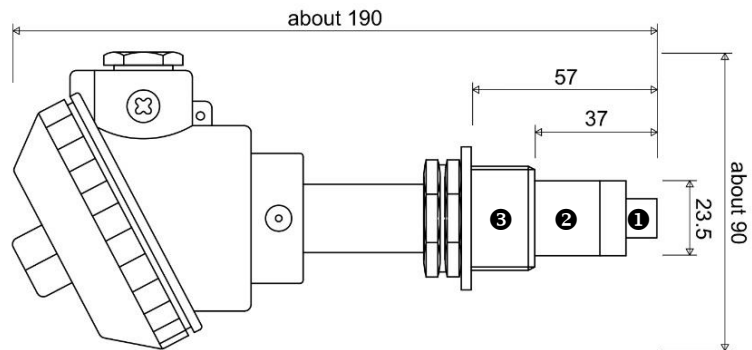
**Materials in contact with the process**

Titanium (working electrode ❶), Zinc (counter electrode ❷), PVC (threaded connector ❸)

**Sensitivity**

1-100% of surface covered by biofilm (i.e. the first bacterial layer)

**Measures (mm)**



**Operating conditions**

Temperature:

-10<T<+60°C  
(to monitor biofilm growth: +2<T<+40°C)

Oxygen:

>1 ppm  
(at the maximum sensitivity level)

Pressure:

<10 bar

Conductivity:

>10 µS/cm

**Power supply**

12 / 24 VDC ±20%, 500 mA

**Data communication**

4-20 mA and RS485/MODBUS RTU

**Wiring**

Standard 6-wire cable, FROR 6x0.5 suggested  
(2 wires used for power supply, 2 for RS485/MODBUS communication, 2 for 4-20 mA data transmission)

**Software - Minimum system requirements (RS485/MODBUS)**

PC with Windows XP/7/8/10, 1 GHz CPU, 512 Mb Ram, 200 Mb of free space on hard drive, RS485 serial interface or USB port (for USB-RS485/MODBUS converter)

*Windows is a registered trademark of Microsoft Corporation in the United States and other countries.*