Instruction Manual

µ-FLOW & LIQUI-FLOW series
Thermal Mass Flow Meters/Controllers for liquids

Doc. no.: 9.17.161E Date: 16-12-2024

µ-FLOW L01(V12)

LIQUI-FLOW L13(V12), L23(V12)

LIQUI-FLOW L13I, L23I

ATTENTION
Please read this document carefully before installing and operating the product.
Not following the guidelines could result in personal injury and/or damage to the equipment.

Disclaimer

The illustrations in this document serve to provide general notices regarding correct operation. Illustrations are simplified representations of the actual situation and may differ from the actual product.

Bronkhorst® reserves the right to modify or improve its products and documentation without notice.

- Prior to work, check whether a newer version of this document is available on the Bronkhorst website.

Symbols

Important information. Discarding this information could cause injuries to people or damage to the Instrument or installation.

Helpful information. This information will facilitate the use of this instrument.

Additional info available on the internet or from your local sales representative.

Receipt of equipment

Check the outside packaging box for damage incurred during shipment. If the box is damaged, the local carrier must be notified at once regarding his liability. At the same time a report should be submitted to your Bronkhorst representative. Carefully remove the equipment from the box. Verify that the contents of the package was not damaged during shipment. Should the equipment be damaged, the local carrier must be notified at once regarding his liability. At the same time a report should be submitted to your Bronkhorst representative.

- Check the packing list to ensure that you received all of the items included in the scope of delivery
- Do not discard spare or replacement parts with the packaging material

Refer to Removal and return instructions about return shipment procedures.

Equipment storage

- The equipment should be stored in its original package in a climate controlled storage location.
- Care should be taken not to subject the equipment to excessive temperatures or humidity.
- See technical specifications for information about required storage conditions.

Warranty

For information about the warranty, the general terms of delivery, please visit the Bronkhorst website: www.bronkhorst.com/about/general-terms.

General safety precautions

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

Before operating, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables for cracks or breaks before each use.

The equipment and accessories must be used in accordance with their specifications and operating instructions, otherwise the safety of the equipment may be impaired.

Opening the equipment is not allowed. There are no user serviceable parts inside. In case of a defect please return the equipment to Bronkhorst High-Tech B.V.

To maintain protection from electric shock and fire, replacement components must be obtained from Bronkhorst. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be obtained from other suppliers, as long as they are equivalent to the original component. Selected parts should be obtained only through Bronkhorst, to maintain accuracy and functionality of the product. If you are unsure about the relevance of a replacement component, contact your Bronkhorst representative for information.

Contents

1. Introduction

1.1. Scope of this manual

This manual covers the Bronkhorst® instrument model series **µ-FLOW** and **LIQUI-FLOW** mass flow meters/controllers for liquid. It contains general product information, installation and operating instructions and troubleshooting tips.

µ-FLOW L01(V12);
IP40 enclosure

LIQUI-FLOW L13(V12), L23(V12);
IP40 enclosure

LIQUI-FLOW L13I, L23I;
IP65 enclosure

1.2. Intended use

The **µ-FLOW L01** and **LIQUI-FLOW L13(I), L23(I), L13V12, L23V12** is designed to accurately measure and/or control liquid flow rates in a fluid system using the media and operating conditions (e.g. temperature, pressure) that were specified at ordering time.

The liquid(s) in the pressurized system in which the instrument is mounted should preferably be clean and dry. The equipment is suited for general purpose indoor (dry) applications, like laboratories and machine enclosures.

µ-FLOW and **LIQUI-FLOW** instruments are suitable for use at temperatures conditions between 5 and +50 °C and a relative humidity of 10 to 90% RH, unless specified otherwise.

- The L01, L13, L23, L13V12 and L23V12 instruments have an ingress protection of IP40 implying that the electronics housing and electrical connection do not offer any protection against moist environments.
- The L13I and L23I are equipped with an IP65-enclosure, so electronics housing and electrical connection are protected against moist and dusty environments.

To avoid personal injury and/or damage to the equipment only trained and qualified personnel shall perform the installation of the instruments.
The instruments contain electronic components which are sensitive to electronic discharges (ESD). Contact with electronically charged persons or objects could possibly endanger these components or even result in their failure.

The wetted materials incorporated in the **µ-FLOW** and **LIQUI-FLOW** are compatible with media and conditions (e.g. pressure, temperature) as specified at ordering time. If you are planning to use the product (including any third party components supplied by Bronkhorst, such as pumps or valves) with other media and/or other conditions, always check the wetted materials (including seals) for compatibility. See the technical specifications of the product and consult third party documentation (if applicable) to check the incorporated materials.

Responsibility for the use of the equipment with regard to suitability, intended use, cleaning and corrosion resistance of the applied materials against the processed media lies solely with the end user.

Where appropriate, this document recommends or prescribes safety measures to be taken with respect to media usage or working with the described equipment under the specified conditions. The end user is responsible for taking the necessary safety precautions and proper use of appropriate (personal) protective equipment, even if such is not explicitly recommended or required in this document.

The end user is considered to be familiar with the necessary safety precautions, and to comply with the appropriate protective measures as described in the Material Safety Data Sheets of the media to be used in the system (if applicable).

Bronkhorst High-Tech B.V. cannot be held liable for any damage resulting from improper or unsafe use, use for other than the intended purpose or use with other media and/or under other conditions than specified on the purchase order.

See also section Sealing material compatibility.

1.3. Products descriptions

The **µ-FLOW** and **LIQUI-FLOW** instruments are measurement devices for thermal mass flow and control of liquids. They are equipped with a digital electronic multi-bus pc-board and consist of a micro-controller with peripheral circuitry for measuring, controlling and communication. The flow signal is measured, digitized and processed by means of the internal software (firmware). The measured and processed values can be output through the analog interface or through the digital communication line (RS232 or optional fieldbus interface).
For controllers the setting for the actuator is calculated by the firmware. The setpoint can be given through the analog interface or through the digital communication line.

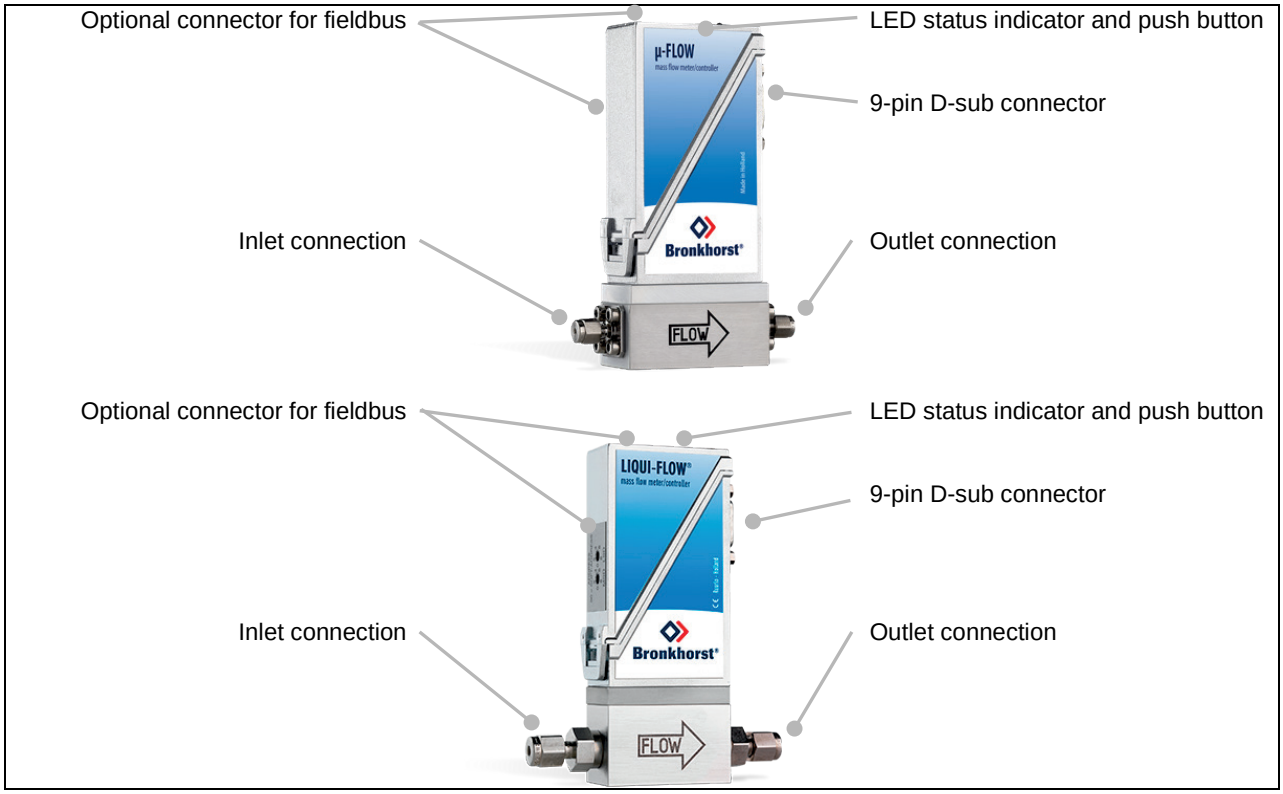
These digital instruments offer great flexibility thanks to the "multi-bus" concept, whereby the instruments can be equipped with an optional fieldbus interface (CANopen, DeviceNet™, EtherCAT®, Ethernet/IP, FLOW-BUS, Modbus (RTU/ASCII/TCP), POWERLINK, PROFIBUS DP, and PROFINET.

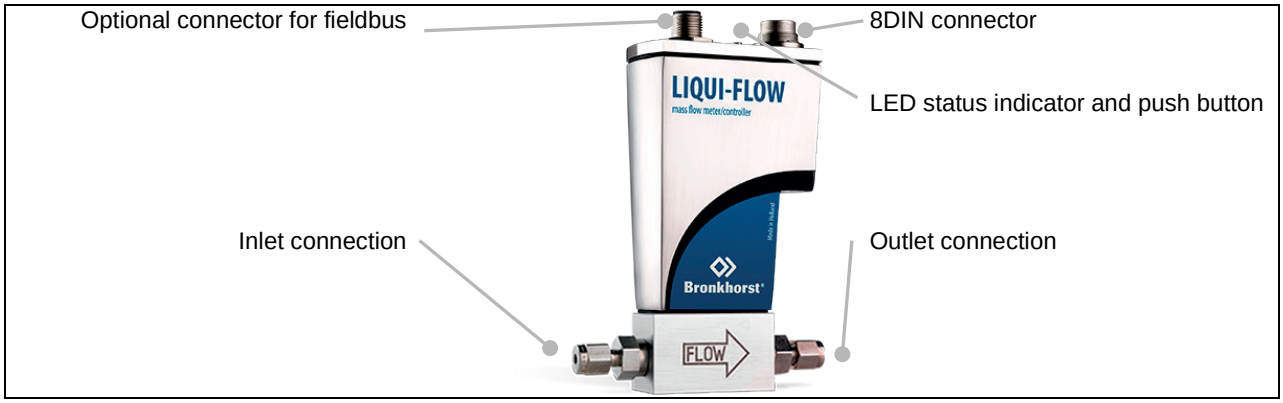
Numerous input/output options can be installed through the programmable 9-pin D-sub or 8DIN connector (see Customized I/O). In addition to the various analog signal options and the standard RS232 communication, there are such options as RS485 communication, digital frequency/pulse output, alarm output/reset, valve purge/close and analog valve output.

The micro switches and LED's on top of the instrument can also be used for manual operation of some options.

Control valves can either be integrally or separately mounted. The standard control valves on Bronkhorst® mass flow controllers are suited for max. 100 bar pressure ratings. These valves are normally closed and available up to Kv-values of 2.37 * 10^{-3}. Normally open valves can also be supplied.

1.4. Product overview





Depending on the ordering details, fittings and/or connectors on your instrument might differ from the images above.

1.5. Calibration

The **µ-FLOW** and **LIQUI-FLOW** are factory calibrated. Periodical inspection, recalibration or verification of the accuracy may be subject to individual requirements of the end user.

Bronkhorst certifies that the instrument meets the rated accuracy. Calibration has been performed using measurement standards traceable to the Dutch Metrology Institute (VSL).

1.6. Maintenance

The **µ-FLOW** and **LIQUI-FLOW** needs no regular maintenance if operated properly, with clean media, compatible with the wetted materials, avoiding pressure and thermal shocks and vibrations. Units may be purged with a clean, dry and inert gas.

In case of severe contamination, cleaning the inside of the device may be required. After cleaning, recalibration of the instrument is recommended.

Inexpertly servicing instruments can lead to serious personal injury and/or damage to the instrument or the system it is used in. Servicing must therefore be performed by trained and qualified personnel. Contact your Bronkhorst representative for information about cleaning and calibration. Bronkhorst has a trained staff available.

1.7. Documentation

The **µ-FLOW** and **LIQUI-FLOW** come with all necessary documentation for basic operation and maintenance. Some parts of this manual refer to other documents, most of which can be downloaded from the Bronkhorst website. Calibration certificates, test certificates and material certificates are included in the scope of delivery or can be provided on request.

The documentation listed in the following table is available on the **µ-FLOW** and **LIQUI-FLOW** product pages under www.bronkhorst.com/products

Type	Document name	Document no.; IP40 enclosure	Document no.; IP65 enclosure
Brochure	µ-FLOW and LIQUI-FLOW brochure	9.60.021	9.60.021
Manuals	Instruction manual µ-FLOW and LIQUI-FLOW (this document)	9.17.161	9.17.161
	Quick Start Guide µ-FLOW and LIQUI-FLOW	n/a	n/a
	Hook-up diagram Analog/RS232	9.16.119	9.16.126

Technical documentation	Hook-up diagram CANopen	9.16.217	9.16.216
	Hook-up diagram DeviceNet™	9.16.122	9.16.129
	Hook-up diagram EtherCAT®	9.16.124	9.16.253
	Hook-up diagram EtherNet/IP	9.16.215	9.16.253
	Hook-up diagram FLOW-BUS	9.16.120	9.16.127
	Hook-up diagram Modbus ASCII / RTU	9.16.123	9.16.130
	Hook-up diagram Modbus TCP	9.16.234	9.16.253
	Hook-up diagram POWERLINK	9.16.236	9.16.253
	Hook-up diagram PROFIBUS DP	9.16.121	9.16.128
	Hook-up diagram PROFINET	9.16.147	9.16.253
	Hook-up diagram custom bus & I/O configurations	9.16.118	9.16.125
	Dimensional drawings model specific	Model specific	Model specific

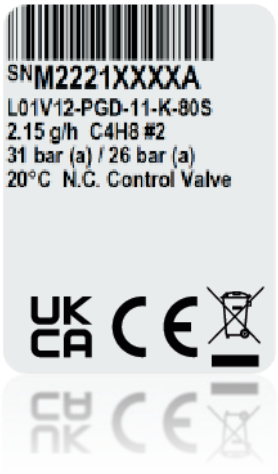
The documentation listed in the following table is available on the **µ-FLOW** and **LIQUI-FLOW** product pages under www.bronkhorst.com/products

Type	Document name	Document no.
General documentation	EU Declaration of Conformaty	9.06.021
Communication interfaces manuals	Manual CANopen interface	9.17.131
	Manual DeviceNet™ interface	9.17.026
	Manual EtherCAT® interface	9.17.063
	Manual EtherNet/IP interface	9.17.132
	Manual FLOW-BUS interface	9.17.024
	Manual Modbus interface ASCII / RTU / TCP	9.17.035
	Manual POWERLINK interface	9.17.142
	Manual PROFIBUS DP interface	9.17.025
	Manual PROFINET interface	9.17.095
	Manual RS232 interface	9.17.027

2. Product specifications

Before installing the **µ-FLOW** and **LIQUI-FLOW**, check that the functional and technical properties of the product match your requirements. If you have a question about the product or if you find the product does not meet the specifications as ordered, do not hesitate to contact your Bronkhorst representative. See section Service for contact information.

The serial number label shows some essential technical specifications of the product as ordered (note that the image does not necessarily reflect the actual specifications of your instrument):



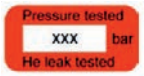
- Serial number
- Type number
- Flow rate
- Medium
- Pressure
- Operating temperature
- Optional: valve type (N.C. - Normally Closed / N.O. - Normally Open)

The model key on contains more detailed information about the technical properties of the product as ordered. Where applicable, follow the directions on any additional labels in order to ensure a safe working environment and to comply with the regulations applicable to the product and its operating environment.

Avoid condensation on the sensor tube. Liquids entering the instrument with a lower temperature than the dew point, may harm the instrument's functionality.

2.1. Pressure rating

Bronkhorst® instruments are pressure tested to at least 1.5 times the specified operating pressure and outboard leak tested to at least 2 * 10^{-9} mbar l/s Helium.



- The test pressure is specified on the device with a red label; if this label is missing or if the test pressure is insufficient, the device must not be used and should be returned to the factory.
- Before installation, make sure that the pressure rating is within the limits of the normal process conditions and that the tested pressure is in accordance with the safety factor of your application.
- Disassembling the device and/or replacing parts will invalidate the test pressure and leak test specification.

2.2. Model key

The model key on the serial number label contains information about the technical properties of the instrument as ordered. The specific properties can be retrieved with the diagrams below.

Code	Instrument type
L01	µ-FLOW meter/controller, ≤2g/h
L13	LIQUI-FLOW meter/controller, ≤100g/h
L23	LIQUI-FLOW meter/controller, ≤1000g/h

Code	Configuration
-	Mass Flow Meter (MFM)
V12	Mass Flow Controller (MFC) NC
~~V21~~	~~Mass Flow Controller (MFC) NO~~

Code	Sensor Code
20D	5...392 mg/h L01
50S	15...713 mg/h L01
60S	26...995 mg/h L01
70S	0.35...1.148 g/h L01
80S	0.56...2 g/h L01
10S	5...50 g/h Lx3
30S	50...500 g/h Lx3
70S	500...1000 g/h Lx3

Type	Range	Par	Configurable input/output (pin 5)
0	0	0	Disabled, 0 Vdc (default)
A	1	V	0...10 Vdc output, controller
B	1	V	4...20 mA output, controller
B	2	V	3.8...20.8 mA output, (TEIP11/Badger) controller
C	3	A	Digital output, min/max alarm
C	4	A	Digital output, counter limit reached
C	5	S	Digital output, enabled by setpoint (for shut-off)
C	0	I	Digital output, high/low switch via remote parameter
F	9	B	Digital pulse output, batch counter
H	1	P	4...20 mA input, external pressure sensor
I	3	C	Digital input, controller mode valve close
I	8	C	Digital input, controller mode valve purge
I	1	R	Digital input, reset counter
I	2	R	Digital input, reset alarm

Supported options, see also pin 5 options table

Inlet	Outlet	Adapters
0	0	None
A	A	3 mm OD compression type
B	B	1/8" Face seal male
C	C	1/16" OD compression type
1	1	1/8" OD compression type
2	2	1/4" OD compression type
3	3	6 mm OD compression type
8	8	1/4" Face seal male
9	9	Other

Code	Sealing material
K	Kalrez/FFKM 6375
M	Metal (L01)
Z	Other

LNNVNN - NNA - A A A - N N - A - A A - A A A

Code	Supply voltage
D	+ 15...24 Vdc

Code	Field bus	Valve type
A	None, I/O	Normally Closed
B	None, I/O	Normally Opened
D	DeviceNet I/O	Normally Closed
E	DeviceNet I/O	Normally Opened
I	EtherNet/IP I/O	Normally Closed
J	EtherNet/IP I/O	Normally Opened
K	CANopen I/O	Normally Closed
L	CANopen I/O	Normally Opened
M	Modbus I/O*	Normally Closed
N	Modbus I/O*	Normally Opened
C	Powerlink I/O	Normally Closed
O	Powerlink I/O	Normally Opened
P	PROFIBUS I/O	Normally Closed
Q	PROFIBUS I/O	Normally Opened
R	FLOW-BUS I/O	Normally Closed
S	FLOW-BUS I/O	Normally Opened
T	EtherCAT I/O	Normally Closed
U	EtherCAT I/O	Normally Opened
V	PROFINET I/O	Normally Closed
W	PROFINET I/O	Normally Opened
X	Modbus/TCP I/O	Normally Closed
Y	Modbus-TCP I/O	Normally Opened

Code	Controller mode
0	Controller disabled (meter only)
A	Controller enabled, analog setpoint
D	Controller enabled, digital setpoint

Code	Integrated comm. mode (pin 1/6)
A	RS232 – ProPar
B	RS485 – FLOW-BUS
C	RS485 – Modbus RTU
D	RS485 – Modbus ASCII

Code	Analog output	Analog setpoint
A	0...5 Vdc	0...5 Vdc
B	0...10 Vdc	0...10 Vdc
F	0...20 mA_{dc} sourcing	0...20 mA_{dc} sinking
G	4...20 mA_{dc} sourcing	4...20 mA_{dc} sinking

* Default: Modbus RTU, optional Modbus ASCII

2.3. Sealing material compatibility

µ-FLOW and **LIQUI-FLOW** instruments are fitted from factory with internal seals compatible with the liquid type(s) as specified at ordering time. Before using other media, always check their compatibility with the applied sealing materials. Check the model key on the serial number label to see which sealing materials have been incorporated in your specific instrument. When in doubt, do not hesitate to contact your Bronkhorst representative for more information.

- Always make sure that the used process gases or mixtures thereof are compatible with the sealing materials the instrument is equipped with.
- Do not exceed the specified maximum operating pressure and temperature. Using the instrument outside the specified operating limits might lead to serious damage and dangerous situations.

2.4. Customised I/O options

Code	Decription
000	Disabled, M8/A2 is pulled down to 0Vdc (default selection)
A1V	0…10Vdc sourcing output, controller Analog signal for pump or external valve steering (control signal only) When the controller output is used for pump or external valve steering (mass flow meters only), make sure to set parameter Valve maximum to 0.3 [A]. For mass flow controllers, the controller output is limited to a value below 10Vdc, due to the maximum valve current restriction.
B1V	4…20mAsourcing output, controller Analog signal for pump or external valve steering (control signal only). When the controller output is used for pump or external valve steering (mass flow meters only), make sure to set parameter Valve maximum to 0.3 [A]. For mass flow controllers, the controller output is limited to a value below 20mA, due to the maximum valve current restriction.
B2V	3.8…20.8mA sourcing output, controller Analog signal for Badger Meter valve with TEIP11 signal converter (control signal only).
C3A	Digital output, min/max alarm During a min/max alarm, M8/A2 is pulled down to 0Vdc.
C4A	Digital output, counter alarm During a counter alarm, M8/A2 is pulled down to 0Vdc.
C5S	Digital output, enabled by setpoint (for shut-off control) M8/A2 is pulled down to 0Vdc at a controller setpoint, e.g. for shut-off valve activation. For factory selected analog control: If parameter Control mode is set for analog control by factory, the minimum setpoint at which the device (shut-off valve) connected to M8/A2 is activated is 1.9%. This prevents possible noise on the analog input activating the device accidentally. For factory selected digital control: If parameter Control mode is set for digital control by factory, the setpoint threshold for activating the device connected to M8/A2 is any value > 0. Note: If the instrument is forced into Valve Safe State, the digital output is not affected, so a (n/c) shutoff valve connected to M8/A2 will not close when the (n/c) controller is in Valve Safe State' Make sure to use 24Vdc power supply corresponding to the shut-off valve specifications.
C0I	Digital output, high/low switch via remote parameter (e.g. for shut-off valve control) M8/A2 is pulled down to 0Vdc when writing value 1 to parameter IO switch status, this is undone by writing value 0. Adevice connected to M8/A2 (e.g. a shut-off valve) can be activated/de-activated by writing parameter IO switch status. Note: If the instrument is forced into Valve Safe State, the digital output is also affected, so a (n/c) shutoff valve connected to M8/A2 will be closed when the (n/c) controller is in 'Valve Safe State'. Make sure to use 24Vdc power supply corresponding to the shut-off valve specifications.
D9E	Digital frequency output, measure Measurement value is translated to a frequency within given frequency range.

	The default frequency range to represent 0…100% flow is 0…10000 Hz. Any other frequency range must be specified on order.
F9B	Digital pulse output, batch counter M8/A2 is pulled down to 0Vdc when a given batch size is reached (during a given pulse length). By default, a pulse is given at each 1x the Counter unit batch value, with a pulse length of 1 second. For instance, when Counter unit is set to 'ln', a pulse is given each time 1 ln has passed through the instrument. An alternative pulse length must be specified on order. Provide a pull-up resistor of 5…10kOhm to create 15…24Vdc at M8/A2 (according to the applicable hook-up diagram).
I3C	Digital input, controller mode valve close Valve closes when M8/A2 is connected to 0Vdc. This option switches between the default Control mode and mode ‘Valve Close’ (value 3). When the default Control mode is digital, the default value is 0 (bus/RS-232), when the default Control mode is analog, the default value is 1 (Analog input).
I8C	Digital input, controller mode valve purge Valve is fully opened when M8/A2 is connected to 0Vdc. This option switches between the default Control mode and mode ‘Valve Fully Open’ (value 8). When the default Control mode is digital, the default value is 0 (bus/RS-232), when the default Control mode is analog, the default value is 1 (Analog input).
I1R	Digital input, reset counter The counter resets when M8/A2 is connected to 0Vdc.
I2R	Digital input, reset alarm The alarm resets when M8/A2 is connected to 0Vdc.

3. Installation

3.1. Mounting

For optimal performance, install the **µ-FLOW and LIQUI-FLOW** in a position free of vibration and away from heat sources. The bottom of the instrument body is fitted with mounting holes; use these mounting holes to fixate the instrument to a firm, rigid base or heavy, vibration free mass, such as a wall, a heavy rig or another stable construction. Contact your local Bronkhorst representative for more information.

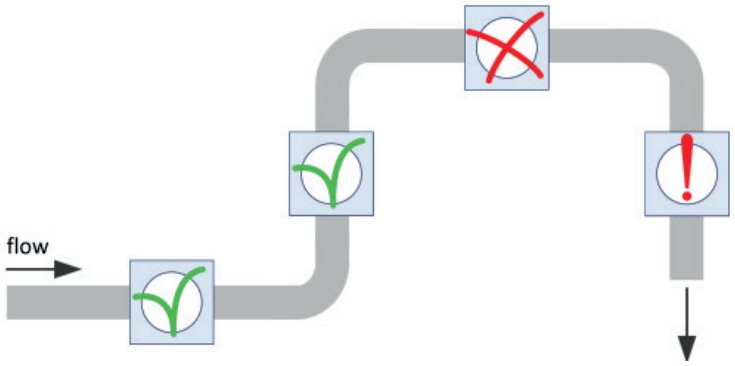
- Always use the mounting holes to fixate the instrument. Consult the dimensional drawing for the exact locations and size of the mounting holes.
- Also make sure that the instrument is not suspended by the piping and take adequate measures to isolate the instrument from vibrations in the piping.

3.1.1. Orientation

Preferably, mount **µ-FLOW and LIQUI-FLOW** in an upright position.

3.1.2. Location in the fluid system

In liquid applications, the presence of gas bubbles in the liquid can cause measurement errors. If there is a risk of expansion of dissolved gas in the metered liquid, the instrument should be mounted in a pipe segment where gas bubbles cannot accumulate. The image below shows the preferable mounting locations.



- The best location is a horizontal pipe segment or a segment where the fluid direction is upward

- Gas might accumulate in a horizontal segment if it is followed by a downward segment. Do NOT mount the instrument in a location like this

- Mounting in a downward pipe segment with an open end is strongly dissuaded, especially if the pipe diameter is 1/2" or more. Gravity might cause the segment to drain; depending on the system dimensions and the viscosity of the metered fluid, this effect might be stronger or weaker
- If the instrument is part of a closed fluid system, mounting the instrument in a downward pipe segment is not preferable, but may be considered if other mounting locations are more problematic.

- To minimize the risk of gas entrapment by cavitation, the preferred location to install a control valve is downstream from the instrument, for a pump the preferred location is upstream.
- Avoid installation in close proximity of mechanical vibration and/or heat sources.
- Use the equipment in an environment with a stable ambient pressure and temperature.

3.1.3. Piping requirements

- For reliable performance, make sure the fluid stream is uncontaminated. If necessary, use an inlet filter to ensure a moisture, oil and particle free stream. Select a filter with a surface area and pore size that minimize the pressure drop.
- If back flow could occur, the use of a check valve is also recommended.

3.1.4. Fluid connections

- Install the **µ-FLOW and LIQUI-FLOW** meter/controller in the process line, in accordance with the direction of the FLOW arrow (see picture below) on the base of the instrument.
- For leak tight installation, follow the guidelines of the supplier of the fittings.

Bronkhorst® **µ-FLOW and LIQUI-FLOW** meters/controllers can be fitted with different fitting types (e.g. compression) or special fitting types on request.

- Check the fluid system for leaks before applying full operating pressure, especially when using hazardous media (e.g. toxic or flammable).
- After using the **µ-FLOW and LIQUI-FLOW** for the first time with low temperature media, re-tighten the fluid connectors in order to prevent leakage.

3.1.5. Mechanical isolation

- Mechanical vibration may travel through piping or a mounting frame.
- Isolate instruments mechanically by mounting them on individual, rigid, stiff bases. Preferably, mount multiple instruments parallel to each other, and use flexible piping if required.

3.2. Electrical connection

- Electrical connections must be made according to the applicable hook-up diagrams, using suitable cables with respect to required supply current, voltage loss, cable and gland diameters and operating conditions.
- When using self-assembled cables, follow the guidelines provided by the connectors' manufacturer.
- For use in fieldbus systems, follow the instructions of the cable supplier for the specific fieldbus system.
- Make sure that the power supply is suitable for the power ratings as indicated on the serial number label (see model key), and that double or reinforced insulation is used for the power supply.
- If a surge protection device is used, make sure its specifications match the power consumption of the application.
- Before powering up, make sure all required cabling is properly connected.
- Before each use, inspect cabling and connectors for damage.

µ-FLOW and LIQUI-FLOW instruments are powered with +15…+24 Vdc or +24 Vdc, depending on configuration or the fieldbus system (if applicable).

To prevent damage as a result of reversed polarity, the use of a 2A fuse in the direct +Us line is recommended.

Always isolate the electrical power before connecting or disconnecting equipment.

The device described in this document contains electronic components that are susceptible to **electrostatic discharge**. In order to prevent damage, proper handling procedures must be followed during installation, (dis)connecting and removing the electronics.

The device carries the CE-mark and is **compliant with the concerning EMC requirements**. However, EMC requirements can only be met using appropriate cables and connector/gland assemblies. Bronkhorst recommends the use of their standard cables. These cables have the right connectors and loose ends (if any) are marked to help prevent wrong connection. When using other cables, cable wire diameters must be sufficient to carry the supply current, and voltage loss must be kept as low as possible. When in doubt, contact your Bronkhorst representative.

When connecting the product to other devices, be sure that the integrity of the shielding is not affected; **always use shielded cabling for signals and communication and do not use unshielded wire terminals**.

3.3. Fieldbus connection

If the instrument is provided with a dedicated fieldbus interface, it can be operated digitally in a fieldbus system, using RS485 communication. In FLOW-BUS, Modbus, CANopen and DeviceNet™ systems, the fieldbus connector can also be used to power the instrument. In other fieldbus systems, the instrument is always powered through the 9-pin D-sub connector on the side or 8DIN power connector on top of the instrument.

Never power the instrument simultaneously from **two different power sources** (e.g. fieldbus and Plug-in Power Supply). Doing so will damage the printed circuit board irreparably.

Always check the total power consumption of your instruments before connecting them to a fieldbus system. Do not exceed the maximum power of the power supply unit.

If you need assistance with setting up a bus configuration, contact your Bronkhorst representative for information.

The operation via analog interface, RS232 interface and an optional fieldbus can be performed at the same time. A special parameter called “control mode” indicates which connection is controlling the instrument: analog or digital (via fieldbus or RS232). Even when using more interfaces at the same time, the reading can be done simultaneously. When changing a parameter value, the last value send by an interface will become valid.

3.3.1. FLOW-BUS

FLOW-BUS is a Bronkhorst® designed fieldbus, based on RS485 technology, for digital communication between devices, offering the possibility of host-control by a Windows computer.

Characteristics:
- Baud rate 187,500 (default) or 400,000 Baud
- +15…24 Vdc supply voltage
- Easy installation and communication with other Bronkhorst® devices
- Automatic node search and bus optimisation (gap fixing)
- RS232 communication (ProPar) with Windows computer (local host)
- Connection of up to 120 instruments on a single bus
- Maximum bus cable length: 600 m

Consult Instruction manual FLOW-BUS interface (document no. 9.17.024) for more information about setting up a FLOW-BUS network.

3.3.2. Modbus

Modbus is a 3-wire, RS485-based fieldbus communication system for parameter value exchange. In this system each instrument/device is equipped with a micro-controller for its own dedicated task. The instrument behaves as a slave, which means all communication (instructions and readout) is initiated by a master device on the Modbus system.

Characteristics:
- Baud rate selectable between 9,600 and 256,000 Baud (default: 19,200 Baud)
- +15…24 Vdc supply voltage
- Connection of up to 247 instruments on a single bus
- Supports RTU and ASCII protocols

Consult Instruction manual Modbus interface (document no. 9.17.035) for more information about setting up a Modbus network.

3.3.3. Other fieldbuses

For other fieldbuses consult the concerning fieldbus manual.

4. Operation

After correct installation and taking all necessary safety precautions, the **µ-FLOW and LIQUI-FLOW** can be used to measure and/or control flow.

4.1. Powering up

To maintain control of the fluid system and ensure a safe situation, it is recommended to turn on power before applying fluid pressure and to switch off power only after the fluid system is depressurized

When applying pressure, avoid pressure shocks and bring the fluid system gradually up to the level of the specified operating conditions; open the fluid supply gently.

For best performance, allow the device to warm up and stabilize for at least 30 minutes before starting measurement and/or control. This may be done with or without media flow.

When powering up, the instrument needs a couple of seconds to start up the electronics and perform a self-test. After successful initialization, the green LED will glow continuously to indicate that the instrument is ready to use.
After powering up, the control valve will act according the last known setpoint. When setpoint is 0, this means the valve closes (normally open) or stays closed (normally closed). The valve stays closed until the instrument receives a new valid setpoint from the active setpoint source.

4.2. First use

- Despite the fact that everything necessary has been done to ensure the cleanliness of the product upon delivery, the presence of some remaining contaminants cannot be ruled out completely.
- In order to prevent undesired reactions, purging the instrument for a minimum of 30 minutes with a dry, inert gas (like Nitrogen or Argon) is recommended before first use. In systems for use with corrosive or reactive media, this is even absolutely necessary.
- During the manufacturing process, the instrument has been tested with water. Purging prior to first use is also recommended to remove any remaining water droplets.

The very first time the instrument is used, adjusting the zero point is recommended. *See* *Adjusting zero point* for background information and instructions.

4.3. Preventing slug flow

Reliable measurement results can only be obtained if the fluid flows through the instrument in a single state, for **µ-FLOW and LIQUI-FLOW** should it be liquid. The following measures can help prevent so called 'slug flow' (two-phase flow):

Before starting measurement and control: remove (dissolved) gas from the system, by flushing the instrument and all fluid lines with the process fluid at a high flow rate

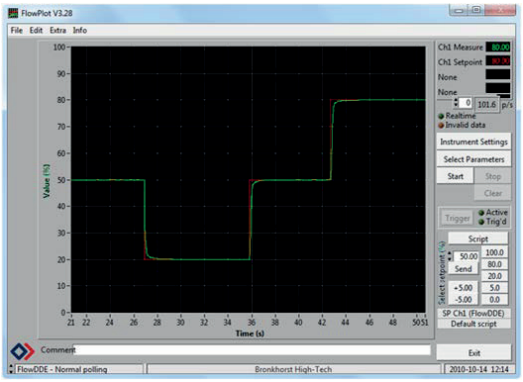
During measurement and control:

- avoid external heating or cooling (can cause gas bubbles in liquid).
- avoid extreme pressure fluctuations (can cause cavitation in liquid).

4.4. Rapid gas decompression / explosive decompression

For instruments used above 10 bar (g):
Bronkhorst recommends a maximum decompression rate of 70 bar/min, according to NACE TM0297.
Exceeding this rate can have negative influence on the lifetime of the sealing materials.

4.5. Mass flow measurement and control



When powering up, the instrument needs a couple of seconds to start up the electronics. As soon as the start-up sequence has finished (green LED glows continuously), the instrument is ready to measure mass flows, however, optimal accuracy is only reached after warming up (see Powering up and powering down).

After powering up, the control valve closes (normally open) or stays closed (normally closed). The valve stays closed until the instrument receives a setpoint from the active setpoint source. The internal PID controller then immediately opens the control valve, until the measured flow rate matches the setpoint. It maintains the resulting flow rate until another setpoint is given.

4.6. After use

- Depending on the properties of the process medium and the (expected) time until the next use, it is advisable to flush the fluid system with a suitable (cleaning) fluid after use.
- If the equipment has been used to process corrosive, reactive or hazardous media (e.g. toxic or flammable), cleaning the fluid system is even absolutely necessary before it is exposed to air.
- If the instrument is not used for an extended period, the fluid system should be dry after use and after cleaning. If not, it should be purged with a dry, inert gas for a recommended minimum period of 30 minutes.

4.7. Powering down

- Prior to powering down the **µ-FLOW and LIQUI-FLOW**, the fluid system should be depressurized.
- When depressurizing, prevent sudden pressure changes, by shutting off the fluid supply gradually.

4.8. Valve safe state

The **µ-FLOW and LIQUI-FLOW** can operate an external control valve, using the analog actuator output signal.

When a controlling instrument is not powered or cannot communicate with the fieldbus network (if applicable), all electrical valves operated by the instrument (whether integrated or external) automatically return to their default state. The default state is closed for 'normally closed' valves (n/c) and fully open for 'normally open' valves (n/o). Taking into account the typical process conditions under which the instrument is used (such as the processed media and ambient conditions; see also Intended use), the default state is generally considered safe.

Check the serial number label or the technical specifications to see which valve type is used on your instrument (if applicable).

4.9. Temperature considerations

Although the **µ-FLOW and LIQUI-FLOW** have excellent temperature stability, the best accuracy is achieved when temperature gradients within and across the instrument are prevented. Observe the following attention points:

- Keep the media temperature as close as possible to the ambient temperature, and above the dew point of the ambient air.
- Do not allow the media temperature to drop more than 10 °C below the ambient temperature or take measures to prevent condensation.
- Always keep the media temperature above the freezing point.
- To prevent simultaneous heating and cooling of different parts of the instrument, make sure the ambient temperature is as stable and evenly distributed across the environment as possible.
- Prevent temperature shocks; heating or cooling should amount to no more than 1 °C per second.

- The **µ-FLOW and LIQUI-FLOW** will show an amount of self heating, due to power dissipation of the electronics. Depending on media and ambient temperature, this effect can be as large as 10 °C. In practice, there will be a balance between media temperature, self heating and ambient temperature.
- Operation in a cool environment can compensate somewhat for the effect of high media temperature.
- Heating and cooling effects also depend on the cooling/heat conductivity of the construction on which the instrument is mounted.

- In normal operation mode, the fluid temperature should stay between 5 °C and 50 °C.
- The ambient temperature can be monitored with digital parameter Temperature.

4.9.1. Preventing condensation

In a moist environment, water condensate may precipitate on the measuring tube if the media temperature is significantly lower than the ambient temperature. Condensed water will influence the measurement and can cause a product failure.

Continuous purging of the housing interior or exterior with a dry, inert gas like Nitrogen can help prevent condensation. Contact your Bronkhorst representative for setting up an optimal purging configuration.

4.9.2. Cleaning temperature

The **µ-FLOW and LIQUI-FLOW** may be cleaned with high temperature fluids. The maximum allowable temperature of the cleaning media depends on the ambient temperature:

- At ambient temperatures below 25 °C, the maximum allowable cleaning fluid temperature is 70 °C for a maximum of 30 minutes.
- At ambient temperatures from 25 °C, the maximum allowable cleaning fluid temperature is 60 °C for a maximum of 30 minutes.

- With cleaning fluid temperatures above 50 °C, the instrument must be powered off during the cleaning cycle.
- After cleaning at high temperature, allow the instrument to return to ambient temperature before turning it on.

4.10. Communication interface

The following table lists the communication interfaces the **µ-FLOW and LIQUI-FLOW** can be equipped with (ex factory):

Connector	Type	Communication standard	Fieldbus/protocol
Main • 8DIN connector • 9-pin D-sub connector	Analog	0…5Vdc 0…10Vdc 0…20mA 4…20mA	n/a
	Digital	RS-232	ProPar
		RS-485	FLOW-BUS Modbus (RTU/ASCII)
Fieldbus	Digital	RS-485	FLOW-BUS Modbus (RTU/ASCII) PROFI-BUS DP
		CAN	CANopen DeviceNet
		Ethernet	PROFINET EtherCAT® EtherNet/IP Modbus TCP POWERLINK PROFINET

Which communication interface(s) the instrument is equipped with, is specified at ordering time:

- In analog mode, the instrument is set to the specified voltage/current range.
- The fieldbus connection only provides the specified fieldbus interface (if ordered).
- A digital interface on the main connector is optional.

The instrument can be monitored and operated through the analog and a digital interface simultaneously, but it only accepts a setpoint from one of both (this is called the control mode; see Special parameters for more information). In analog mode, the analog input and output signals are translated to the digital setpoint and measure parameter respectively. The default control mode (analog or digital) is selected at ordering time.

4.10.1. Analog operation

With analog operation the following signals are available:

- output signal: measured value
- input signal: setpoint (controller only)

Setpoints below 2% of the full scale will be interpreted as 0%.

4.10.2. Digital operation

Digital operation (e.g. via RS-232 or fieldbus) adds extra features to the instrument, such as:

- Direct reading with a readout/control module or host computer
- Diagnostics
- Multi-range functionality
- Device Identification
- Secondary measurement outputs: density and temperature readout
- Adjustable minimum and maximum alarm limits (Alarms)
- (Batch) counter (Counter)
- No limitations on setpoint values below 2 %

4.10.2.1. RS-232 communication

Digital Bronkhorst® instruments can be monitored and operated via RS-232 using the free FlowWare software tools for Windows. These tools provide a graphical interface to the ProPar protocol (used by FLOW-BUS), for monitoring and changing instrument parameters.

The FlowWare toolkit provides functionality for monitoring and operating digital instruments (Bronkhorst FlowSuite, FlowPlot) and selection of the active fluid and configuration of the fieldbus connection (if applicable). For instruments that support the definition and use of multiple fluids, FlowTune™ can be used to define and store fluids in the instrument and select the active fluid.

Digital instrument parameters are made accessible by FlowDDE, a Dynamic Data Exchange server (DDE) that handles communication between the instrument and (dedicated) client software in Windows (e.g. FlowPlot). FlowDDE can also be used by other client applications, such as Microsoft Office or custom made software, built with third party development software like LabVIEW or a SCADA platform.

The FlowWare tools and associated documentation can be downloaded from the product pages on the Bronkhorst website: www.bronkhorst.com/products

For more information about communication through the RS-232 interface, consult the RS-232 manual (document no. 9.17.027).

For communication with a PLC or other controlling device, an 8DIN or 9-pin D-sub cable with a loose end (part no. 7.03.191, 7.03.540, 7.03.541, 7.03.004, 7.03.536 or 7.03.537) can be used. Consult the RS232 hook-up diagram to connect the required signals.

For RS-232 communication at baud rates up to 38,400 Baud the maximum allowable cable length is 10m. For higher baud rates, use a maximum cable length of 3m.

4.10.2.2. Fieldbus operation

For information about parameter access and availability for Bronkhorst® instruments in a specific fieldbus network, consult the according Documentation.

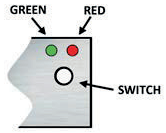
4.11. Hardware interface

The **µ-FLOW and LIQUI-FLOW** offer – depending on the installed digital interface type – the following controls:

- LED indications
- Multifunctional switch
- Rotary switches

4.11.1. LED indications

On top of the housing, the instrument is equipped with two (or three) LED indicators and a multifunctional switch, which can be used to monitor the instrument visually and start several functions manually.



The LEDs on top of the instrument indicate the operational state. The meaning of some indications depends on the specific fieldbus interface of the instrument (if installed).

Position	Colour	Function
Left	●/● (bi-colour)	interface status*
Middle	● (green)	operational mode (Mode/MOD/RUN)**
Right	● (red)	error/warning messages (Error/Err/NET)**

*) The Interface status LED is only used by (Ethernet based) interface types EtherCAT®, POWERLINK and PROFINET.
**) Different interface types use specific names for the different indicator LEDs (indicated between brackets, also see the specific Documentation)

The tables below list the different LED indications:

● **Green**		
Pattern	Time	Indication
off	continuous	Power off or program not running
on	continuous	Normal operation mode
short flash	0.1 sec on, 2 sec off	No communication, valves are in safe/default state
blink	0.2 sec on, 0.2 sec off	Special function mode; the instrument is busy performing a special function
long flash	2 sec on, 0.1 sec off	Configuration mode; the 8DIN connector is set for RS232 communication (ProPar) at 38,400 Baud

● **Red**			
Pattern	Time	Indication	
off	continuous	No error	
on	continuous	Critical error; the instrument needs servicing before it can be used	
short flash	0.1 sec on, 2 sec off	**FLOW-BUS** **PROFIBUS DP** **Modbus** **DeviceNet™** **EtherCAT®** **PROFINET**	Node occupied: re-install instrument No data exchange between master and slave (automatic recovery) Data is being received or transmitted Minor communication error Instrument is not in OP mode No application relation established

blink	0.2 sec on, 0.2 sec off	**FLOW-BUS** **PROFIBUS DP** **Modbus** **DeviceNet™** **EtherCAT®** **PROFINET**	Waiting for communication Not used Not used No bus power Not used Not used
long flash	2 sec on, 0.1 sec off	**FLOW-BUS** **PROFIBUS DP** **Modbus** **DeviceNet™** **EtherCAT®** **PROFINET**	Not used Requested parameter not available Not used Serious communication error; manual intervention needed Configuration error Configuration error (e.g. a requested parameter is not available)
● Green and ● red (alternating)			
Pattern	Time	Indication	
slow wink	1 sec on, 1 sec off	Alarm indication; minimum/maximum alarm, power-up alarm, limit reached or batch size reached	
normal wink	0.2 sec on, 0.2 sec off	Wink mode; by sending a command to the Wink parameter, the instrument flashes its LEDs to indicate its physical location	
fast wink	0.1 sec on, 0.1 sec off	Selected action started (after releasing the multifunctional switch)	

DeviceNet™ instruments have different LED indications, that replace the standard indications described in this section (see below).

4.11.1.1. Interface status

Instruments with an EtherCAT® or PROFINET interface are equipped with a third LED (bi-color; green and red), to indicate the status of the communication interface. This status LED can give the following indications:

Pattern	Time	EtherCAT®	PROFINET
○ off	continuous	Power off or initializing	Interface not (yet) started
● on, green	continuous	Normal operation	Normal operation, application relation established with I/O controller
● blinking, green	0.2 sec on, 0.2 sec off	Pre-operational	Initializing
● blinking, red	0.2 sec on, 0.2 sec off	Invalid state change	Link status OK, no application relation with I/O controller
● single flash, red	0.2 sec on, 1 sec off	Invalid configuration	n/a
● double flash, red	0.2 sec on, 0.2 sec off, 0.2 sec on, 1 sec off	Communication timeout (e.g. communication cable disconnected)	n/a
● on, red	continuous	n/a	No link

Ethernet indicators
RJ-45 connection sockets on instruments with a EtherCAT® or PROFINET interface have two integrated LED indicators, with standard Ethernet functionality:

■ Amber: Ethernet speed

■ Green: Ethernet link/activity

4.11.1.2. DeviceNet™ indications

DeviceNet™ instruments have two bi-color LEDs (green/red) to indicate network and module status. The indications below replace the standard LED indications:

●/● (green/red) Network status (NET; left)

●/● (green/red) Module status (MOD; right)

The tables on the next page list the different LED indications.

Network status		
Pattern	Time	Indication
○ off	continuous	Power off or offline
● on, green	continuous	Online, connected, link OK
● blinking, green	0.5 sec on, 0.5 sec off	Online, not connected; the instrument is online but has no connections to other nodes or is not allocated tpo a master
● blinking, red	0.5 sec on, 0.5 sec off	Connenction timed out
● on, red	continuous	Critical link failure; the device cannot connect to the network

Module status		
Pattern	Time	Indication
○ off	continuous	No power
● on, green	continuous	Normal operation mode
● blinking, green	0.5 sec on, 0.5 sec off	Device is in standby mode or configuration is missing, incomplete or incorrect
●/● alternating	0.5 sec on, 0.5 sec off	Self test mode
● on, red	continuous	Critical error; the instrument needs servicing before it can be used

4.11.2. Multifunctional switch

Some special functions of the instrument can be started manually using the multifunctional switch near the indication LEDs. These functions are available in analog as well as in digital operation mode.

4.11.2.1. Normal operating functions

- In order to access these functions, press and hold the switch while the instrument is in normal operation mode (green LED glowing).
- As long as the switch is held, the LEDs show a repeating sequence of patterns, where each pattern indicates a function.
- All indications in this sequence are continuous.
- Each pattern is shown for a number of seconds; in the table below the column Hold time indicates the time frame within the sequence where the LEDs show the associated pattern.
- To start a function, release the switch when the LEDs show the pattern of the required function.

● Green	● Red	Hold time	Function
off	off	0…1 sec	No action
off	off	1…4 sec	1. In case of a min/max alarm: reset alarm 2. FLOW-BUS: Auto-install to bus - lets instrument obtain free node address if configured node address is occupied Note: min/max alarm (if any) has to be reset before auto install can be performed.

off	on	4…8 sec	Reset instrument; clear all warnings and error messages and restart the instrument
on	off	8…12 sec	Reset instrument; clear all warnings and error messages and restart the instrument
on	on	12…16 sec	Enable FLASH mode for firmware update: • the instrument shuts down and both LEDs are switched off • at the next power-up, the instrument will be active again

See Adjusting zero point for background information and instructions on how to adjust the zero point of an instrument.

Never perform a zeroing procedure before having taken notice of the instructions.

4.11.2.2. Power-up functions

- In order to access these functions, press and hold the switch while powering up the instrument.
- As long as the switch is held, the LEDs show a repeating sequence of patterns, where each pattern indicates a function.
- All indications in this sequence are flashing (0.2 sec on, 0.2 sec off).
- Each pattern is shown for a number of seconds; in the table below the column Hold time indicates the time frame within the sequence where the LEDs show the associated pattern.
- To start a function, release the switch when the LEDs show the pattern of the required function.

● Green	● Red	Hold time	Function
off	off	0…1 sec	No action
off	on	4…8 sec	Restore factory settings (except communication settings)
on	off	8…12 sec	**FLOW-BUS:** Auto install to bus; let the instrument obtain a free node address from the FLOW-BUS system **Other protocols:** No action
on	on	12…16 sec	Activate configuration mode • The 9-pin D-sub connector is set to RS232 communication (ProPar) at baud rate 38400 • In configuration mode, the green LED blinks (2 sec on, 0.1 sec off) • Configuration mode remains active after powering-down and can be deactivated by selecting this function again at the next start-up

4.11.2.3. Control mode - readout/change

Reading control mode

- By briefly pressing the switch 2 times with intervals of up to 1 second in normal operation mode, the instrument shows its current control mode with a series of consecutive LED indication patterns.
- The number of flashes corresponds to the current value of parameter Control Mode (see Special parameters).

Step	Pattern		Indication
1.	Green	● ○	number of flashes indicates the tens of the parameter value
2.	Red	○ ●	number of flashes indicates the units of the parameter value

Examples:

- for value 1 (control mode 'Analog input'), the green LED will flash 0 times and the red LED 1 time
- for value 22 (control mode 'Valve Safe State'), the green and red LED will each flash 2 times

Changing control mode

- By briefly pressing the switch 4 times with intervals of up to 1 second in normal operation mode, the instrument enters a state in which the control mode can be changed.
- This is done in 2 steps, each represented by a LED indication pattern (green or red; see table below).
- The number of flashes corresponds to the available values of parameter Control Mode (see Special parameters).

- At the start of each step, the according LEDs starts flashing fast (0.1 second on, 0.1 second off). By pressing and holding the switch, the associated action is started and the flashing slows (0.5 seconds on, 0.5 seconds off).

Step	Pattern		Maximum flash count	Action
1.	Green	● ○	2	set tens of parameter value
2.	Red	○ ●	9	set units of parameter value

To execute a step, follow these instructions:
- Press and hold the switch (flashing slows)
- To select value 0 (zero), release the switch within 1 second, otherwise:
- Count the number of LED flashes
- Release the switch when the required value is reached
- In case you lose count, keep the switch pressed and wait until the flash count reaches its maximum and restarts

On completion of step 1, the instrument automatically advances to step 2. When both steps have been completed, the instrument returns to its normal operation mode.
If the switch is not pressed within 60 seconds after starting a step, all changes are canceled and the instrument returns to its normal operation mode.

Note that this procedure also sets the default control mode of the instrument (contrary to changing the control mode digitally).

4.11.2.4. Network settings - readout/change

Reading network settings
- By briefly pressing the switch 3 times with intervals of up to 1 second in normal operation mode, the instrument shows its current node address and baud rate with a series of consecutive LED indication patterns:

Step	Pattern		Indication
1.	Green	● ○	number of flashes indicates the tens of the parameter value
2.	Red	○ ●	number of flashes indicates the units of the parameter value
3.	Green and red (simultaneous)	● ●	number of flashes indicates the baud rate

Examples:
- for node address 35, the green LED will flash 3 times and the red LED 5 times
- for node address 116, the green LED will flash 11 times and the red LED 6 times

On DeviceNet™ the node address is called MAC ID.

The number of flashes for the baud rate indication is associated with the following baud rates:

Number of flashes (index)	Baud rate				
	FLOW-BUS	Modbus	PROFIBUS DP	DeviceNet™	Ethernet based
0			Automatically detected		
1	187500	9600	9600	125000	100000000

2	400000	19200	19200	250000	
3		38400	45450	500000	
4		56000	93750		
5		57600	187500		
6		115200	500000		
7		128000	1500000		
8		256000	3000000		
9			6000000		
10			12000000		

Changing network settings

- By briefly pressing the switch 5 times with intervals of up to 1 second in normal operation mode, the instrument enters a state in which the node address and baud rate can be changed (non-Ethernet based protocols only; for Ethernet based protocols (EtherCAT®, PROFINET), network parameters are configured by the fieldbus master and cannot be set on the instrument).
- Changing network parameters with the multifunctional switch is done in 3 steps, each represented by a LED indication pattern (see table below).
- At the start of each step, the according LED(s) start(s) flashing fast (0.1 second on, 0.1 second off). By pressing and holding the switch, the associated action is started and the flashing slows (0.5 seconds on, 0.5 seconds off).

Step	Pattern		Maximum flash count	Action
1.	Green		2	set tens of parameter value
2.	Red		9	set units of parameter value
3.	Green and red (simultaneous)		10*	set baud rate index (number of flashes)

*) maximum count depends on the supported baud rates of the fieldbus. See the baud rate table above for supported baud rates and associated indexes.

To execute a step, follow these instructions:

- Press and hold the switch (flashing slows)
- To select value 0 (zero), release the switch within 1 second, otherwise:
- Count the number of LED flashes
- Release the switch as soon as the required value is reached
- In case you lose count, keep the switch pressed and wait until the flash count reaches its maximum and restarts

On completion of a step, the instrument automatically advances to the next step. When all required steps have been completed, the instrument returns to its normal operation mode.
If the switch is not pressed within 60 seconds after starting a step, all changes in the previous steps are cancelled and the instrument returns to its normal operation mode.

4.11.3. Rotary switches

Using the MSD and LSD switches, the main fieldbus address (Fieldbus 1) of the instrument can be selected, in the range from 1 to 99. MSD (Most Significant Digit) sets the tens, LSD (Least Significant Digit) sets the units. If both switches are set to 0, the node address is selected according to the digital parameter settings (see Network configuration), otherwise the rotary switch setting overrules the digital parameter settings. The switches can be adjusted using a small flat blade screwdriver.

4.12. Adjusting zero point (µ-FLOW only)

The zero point of a Bronkhorst® flow meter/controller (the measurement signal that indicates the absence of a flow) is factory adjusted at approximately 20 °C and atmospheric pressure (ambient conditions), with the instrument positioned upright. Under normal circumstances (i.e. when process conditions are constant), the zero point will remain stable. However, several factors might cause the instrument to develop a zero-stability error over time, causing it to detect a flow when actually there is none. The zero-stability error can be neutralized by re-adjusting the zero point.

- If the ambient conditions or mounting orientation are significantly different from the factory adjustment conditions, zeroing a new instrument is recommended before using it for the first time.
- Always check the zero point after fluid connections and/or electrical connections have been disconnected or if the instrument has been moved.
- If the instrument still detects a (steady) flow while all valves are closed and the fluid system is leak tight, (re-)adjusting the zero point is recommended.

The following factors can affect the zero-stability error (in order of importance):

- fluid type
- fluid temperature
- ambient temperature
- mounting orientation
- (inlet) pressure
- vibrations from the environment
- pressure fluctuations

Zeroing an instrument requires that:

- the ambient conditions (temperature, pressure) match those of the operating environment of the instrument;
- the instrument is filled homogeneously and pressurized with the operational media, according to the typical process conditions;
- there is absolutely no flow through the instrument; preferably, this is achieved by closing a valve immediately (before and) after the outlet of the instrument (control valve, shut-off valve);
- allow the instrument to warm up and stabilize for at least 30 minutes.

Blocking the flow through the instrument is essential; zeroing an instrument while there is still a flow will lead to measurement errors.

Adjusting the zero point of an instrument can be done by the following methods:

- manually (using the multifunctional switch)
- digitally (via RS-232 or fieldbus)
- with the autozero function of a Bronkhorst® readout and control unit (not elaborated here)

Regardless of the preferred method, once started, the zeroing procedure itself can take approximately up to 60 seconds to complete (longer if the output signal is unstable).

4.12.1. Manually, using multifunctional switch

To start the built-in autozero function with the multifunctional switch, follow these instructions:

- Change the setpoint of the instrument to 0 (zero)
- Press and hold the multifunctional switch. After 4 seconds, the red LED ● starts glowing for 4 seconds, after which the green LED ● starts glowing
- At that moment (which is after 8 to 12 seconds), release the switch

The green LED starts to blink fast, indicating that the autozero function is being performed. On (successful) completion, the green LED starts to glow continuously, while the output signal is 0% (parameter Measure = 0).

4.12.2. Digitally

FlowPlot provides an easy way to adjust the zero point of an instrument via RS232; the Auto zero function automatically performs the procedure described here.

To adjust the zero point using digital communication, set parameter values in the following sequence (see section Digital parameters for more information about instrument parameters):

Sequence #	Parameter	Value	Action
1	Setpoint	0	stop flow (close control valve)
2	Init Reset	64	unlock secured parameters
3	Control Mode	9	enable calibration mode
4	Calibration Mode	0	reset calibration mode
5	Calibration Mode	9	start zeroing

The green LED starts to blink fast, indicating that the zeroing procedure is being performed. On completion, the green LED starts to glow continuously, while the output signal is 0% (parameter Measure = 0). At the same time, parameter Control Mode returns to its initial value. If the procedure is successful, parameter Calibration Mode changes to 0 (idle). If the procedure fails, Calibration Mode changes to 255.

After performing the procedure, remember to set parameter Init Reset to value 0 to lock secured parameters.

4.13. FlowDDE

Digital Bronkhorst® instruments can be operated via RS232 using the Bronkhorst® FlowDDE server application. Dynamic Data Exchange (DDE) provides a basic level of inter process communication between Windows applications. Together with a client application, either self-made or with a third party SCADA program, it is possible to create an easy way of data exchange between the flow meter/controller and a Windows application. For instance, a cell in a Microsoft Excel spreadsheet can be linked to the measured value of an instrument; FlowDDE updates the cell automatically when the measured value changes.

FlowDDE uses specific parameter numbers for communicating with the instrument. A DDE parameter number is a unique number in a special FlowDDE instruments/parameter database and not the same as the parameter number from the process on an instrument. FlowDDE translates the node-address and process number to a channel number.

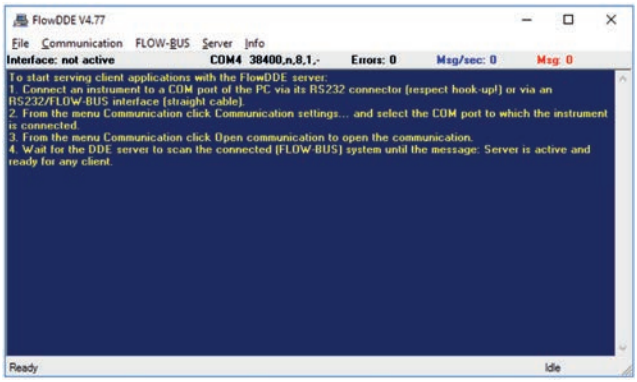
DDE-client applications communicate with the FlowDDE server by using DDE messages. Before messages can be exchanged, a DDE link has to be made. A DDE link consists of three parts: the server, the topic and an item. For separation the characters '|' and '!' may be used, so a DDE link in e.g. Microsoft Excel becomes: Server|Topic!Item.

For standard instrument parameters and the FlowDDE server, these are:
- Server: FlowDDE or FlowDDE2
- Topic: ‘C(X)’ for channel number X
- Item: ‘P(Y)’ for parameter number Y

An example of a DDE link in a Microsoft Excel cell is =FlowDDE|’C(1)’!’P(8)’ to read parameter 8 of channel 1.

When not using FlowDDE for communication with the instrument, parameters are addressed by:
- Node address of the instrument
- Process number on the instrument
- Parameter number on the instrument

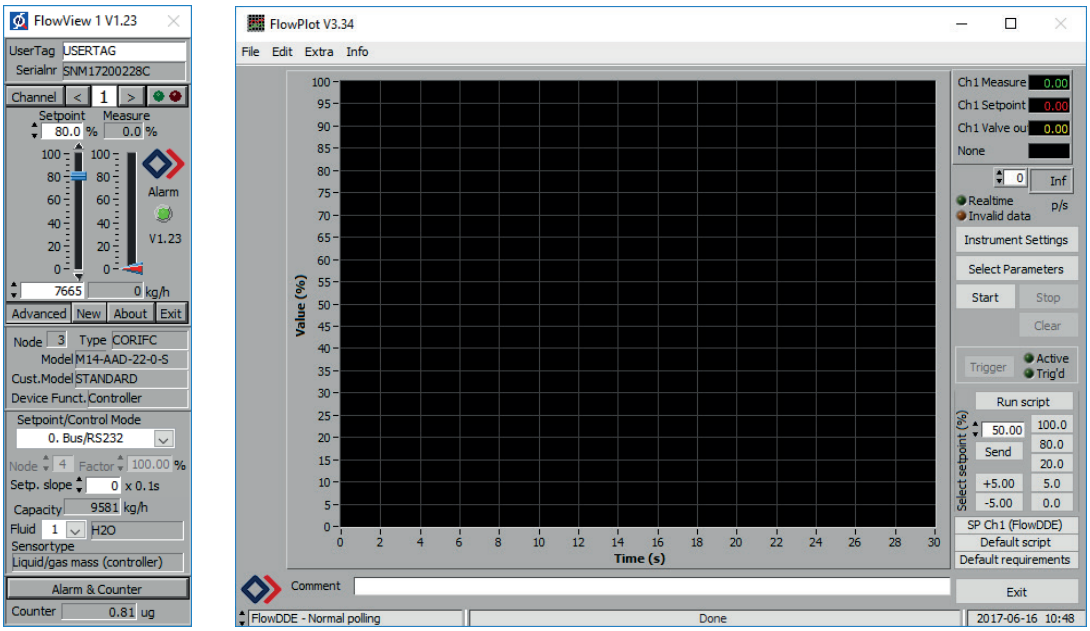
See section Digital parameters for more information about instrument parameters.



For more information about FlowDDE, including setting up a DDE link, consult the FlowDDE Manual (document no. 9.17.067) or the help file in the application.

4.13.1. Software (DDE applications)

Examples of free Bronkhorst® DDE client applications: FlowPlot and FlowView. Other software programs (third party) supporting DDE are for example MS-Office, LabVIEW, InTouch and Wizcon.



Bronkhorst® software applications 'FlowView' (left) and 'FlowPlot' (right)

FlowDDE and other Bronkhorst® applications are available on the support CD or can be downloaded from the product pages on the Bronkhorst website: www.bronkhorst.com/products

5. Digital parameters

Each instrument is controlled internally by a number of digital parameters, most of which can only be accessed using digital communication. Each communication protocol uses its own methods for communicating with instruments and accessing parameters.

5.1. General

This section describes the most commonly used parameters for digital operation of the **µ-FLOW and LIQUI-FLOW**. Descriptions are grouped by category in tables as shown below:

Type	Access	Range	FlowDDE	ProPar	Modbus
[type]	RW 🔧	[x]…[y]	[DDE par]	[Pro]/[Par]	[address]/[register]

In this manual, parameter names are printed in italics (reverted to normal where embedded in italics).

Type
Unsigned char 1 byte unsigned integer (0…255)
Unsigned int 2 byte unsigned integer, MSB first (0…65535)
Unsigned long 4 byte unsigned integer, MSB first (0…4294967295)
Float 4 byte floating point, IEEE 32-bit single precision, MSB first
Unsigned char [x] x byte array (text string)

Access
R Parameter value can be read
W Parameter value can be written
🔧 Parameter is secured and only accepts values if parameter Init Reset is set to 'unlocked' first

Range
Some parameters only accept values within a certain range:
[x] Minimum value of the range
[y] Maximum value of the range

FlowDDE
Parameter number within FlowDDE

FLOW-BUS
Within the FLOW-BUS protocol (ProPar when using RS232 communication), parameters are identified by a unique combination of a process number and a parameter number:
[Pro] Process number
[Par] Parameter number

Consult the RS232 manual (document no. 9.17.027) for detailed information.

Modbus
In the Modbus protocol, parameters are accessed by specifying their unique decimal register number or corresponding PDU address (Protocol Data Unit). The PDU address is the hexadecimal translation of the register number minus 1, e.g. register number 1 corresponds to PDU address 0x0000, register number 11 corresponds to PDU address 0x000A:
[address] Hexadecimal PDU address
[register] Decimal register number

Modbus address blocks are two bytes big. Larger data types use up to 8 subsequent address blocks, resulting in a maximum variable length of 16 bytes. Values longer than the maximum length are truncated.

Other interface protocols
Consult the specific fieldbus manual for accessing parameters using fieldbus communication (see Documentation).

5.2. Special parameters

Init Reset

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	82/64	7	0/10	0x000A/11

Init Reset is used to unlock secured parameters (marked with a 🔑 symbol) for writing. It supports the following values:

Value	Description
64	unlocked, secured parameters can be read and written to
82	locked, secured parameters are read-only

At power-up, Init Reset is always set to 'Locked' (value 82).

Reset

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	R	0…7	114	115/8	0x0E68/3689

This parameter is used to reset the program, counter or alarms.

Value	Description
0	No reset
1	Reset counter
2	Reset alarm
3	Reset counter
4	Reset and disable counter
5	Reset firmware program (soft reset)
6	Reset *Alarm info* error bit
7	Reset *Alarm info* warning bit

The Reset parameter may be disabled by Reset Alarm Enable or Reset Counter Enable. Make sure the value is accepted by sending value 0 first.

Wink

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char [27]	W	0…9*	1	0/0	0x0000/1

*) Modbus only supports value 14592

Sending any text string value between 1 and 9 to this parameter makes the indication LEDs (if present) blink for a couple of seconds. This can be useful in order to identify a specific device in a large fieldbus network.

Control Mode

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned int	RW	0…255	12	1/4	0x0024/37

Control Mode is used to select different control modes of the instrument and determines from which source(s) it accepts a setpoint. The following control modes are available:

Value	Mode	Instrument action	Setpoint source
0	BUS/RS232	Controlling	Fieldbus/RS232
1	Analog input	Controlling	Analog input

2	FLOW-BUS slave	Acting as slave instrument on FLOW-BUS	RS485 only: FLOW-BUS master output x *Slave Factor/100%*
3	Valve Close	Controller disabled, valve closed	
4	Controller Idle	Controller disabled, valve frozen in current position	
7	Setpoint 100%	Controlling, setpoint fixed to 100%	
8	Valve Fully Open	Controller disabled, valve fully opened	
9	Calibration Mode	Calibration mode enabled (factory only)	
10	Analog Slave	Acting as slave of other instrument in analog mode	*Analog Input x Slave Factor/100%*
12	Setpoint 0%	Controlling, setpoint fixed to 0%	
13	FLOW-BUS analog slave	Acting as slave of other instrument on FLOW-BUS, slave factor is set by analog input signal	RS485 only: FLOW-BUS master output x *Analog Input*
18	RS232	Controlling, safe state deactivated	Fieldbus/RS232
20	Valve Steering	Controller disabled, setpoint redirected to *Valve output*	
21	Analog Valve steering	Controller disabled, analog input redirected to *Valve output*	
22	Valve safe State	Force instrument in safe state	

Immediately after power-up, *Control Mode* is set to 'Analog input' or 'BUS/RS232' automatically, depending on the (requested) default setting for analog or digital operation. If *Control mode* is set to value 0, 1, 9 or 18, the instrument returns to its default control mode at the next power-up or reset. Other values are retained after power-up or reset.

5.2.1. Default control mode

IO status

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…255	86	114/11	0x0E4B/3660

The instrument is set to accept a setpoint from either an analog or a digital source. Although this setting can be changed with parameter Control Mode, the instrument usually returns to its default control mode at every power-up or reset. The default control mode can be set with parameter IO Status; to change it, use the procedures as described below.

Changing from digital operation to analog operation:
1. Set parameter *Init Reset* to 64 (unlocked)
2. Read parameter *IO Status*
3. Add 64 to the read value
4. Write the new value to parameter *IO Status*
5. Set parameter *Init Reset* to 82 (locked)

Changing from analog operation to digital operation:
1. Set parameter *Init Reset* to 64 (unlocked)
2. Read parameter *IO Status*
3. Subtract 64 from the read value
4. Write the new value to parameter *IO Status*
5. Set parameter *Init Reset* to 82 (locked)

The procedures described above do not change the value of parameter Control Mode directly. To apply the new default control mode immediately, change the value of parameter Control Mode manually or reset or restart the instrument.

5.3. Measurement and control

Measure

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned int	R	0…41942	8	1/0	0x0020/33

This parameter indicates the flow metered by the instrument. The value of 32000 corresponds to 100%, the maximum measured value output is 131.07%, which translates to 41942.

Setpoint

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned int	RW	0…32767	9	1/1	0x0021/34

This parameter is used to set the required flow rate for the controller. Within the setpoint range, value 32000 corresponds to 100%.

To convert Measure and Setpoint to actual volume flows, use parameters Capacity and Capacity Unit (see Fluid set).

Temperature

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	R	-250…500	142	33/7	0xA138…0xA139/41273…41274

This parameter returns the internal temperature in the instrument housing in °C, which approximates the actual media temperature.

Pressure

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	RW	0…3.4E+38	143	33/8	0xA140…0xA141/41281…41282

In case an external pressure sensor is connected, this parameter returns the actual system pressure in bar(a).
If there is no external pressure sensor, the default value of this parameter is equal to parameter *Inlet pressure*.

5.3.1. Advanced measurement and control

Fmeasure

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	R	-3.4E+38 …3.4E+38	205	33/0	0xA100…0xA101/41217…41218

Floating point variant of *Measure*. *Fmeasure* shows the measured value in the capacity unit for which the instrument is set. The instrument uses parameters *Capacity*, *Capacity 0%, Capacity Unit* and *Sensor Type* to calculate *Fmeasure*.

Fsetpoint

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	RW	0…3.4E+38	206	33/3	0xA118…0xA119/41241…41242

Floating point variant of *Setpoint*. *Fsetpoint* shows the setpoint in the capacity unit for which the instrument is set. Like *Fmeasure, Fsetpoint* is dependent of *Capacity, Capacity 0%, Capacity Unit* and *Sensor Type*.

Setpoint Slope

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned int	RW	0…30000	10	1/2	0x0022/35

The value of this parameter represents the time it would take to adjust the setpoint if it were changed from 0 to 100%. This feature can be used to smooth 'nervous' controller behavior, e.g. to reduce setpoint overshoot or undershoot. The supported range corresponds to 0…3000 seconds. Default value = 0.

Example:
If *Setpoint Slope* = 100 it will take 10 seconds to adjust the setpoint if it is changed from 0 to 100%. A setpoint change of 20% will take (20%/100%)*10 seconds = 2 seconds.

Analog Input

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned int	R	0…65535	11	1/3	0x0023/36

This parameter contains a digital translation of the analog input signal (if applicable).

Valve Output

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned long	RW	0…16777215	55	114/1	0xF208…0xF209/61961…61962

This parameter represents the controller output signal for control valve operation.

5.4. Device Identification

User Tag

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char [16]	RW	-	115	113/6	0xF130…0xF137/61745…61752

With this parameter, the instrument can be given a custom tag name, with a maximum of 16 characters.

Customer Model

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char [16]	RW🔑	-	93	113/4	0xF120…0xF127/61729…61736

This parameter is used to add extra information to the model number information, such as a customer-specific model number.

Serial Number

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char [20]	R🔑	-	92	113/3	0xF118…0xF11F/61721…61728

Instrument serial number for identification.

BHT Model Number

Type	Access	Range	FlowDDE	ProPar	Modbus

Unsigned char [35]	RW	-	91	113/2	0xF110…0xF117/61713…61720

This parameter shows the Bronkhorst® instrument model type information.

Firmware Version

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char [6]	R	-	105	113/5	0xF128…0xF12A/61737…61739

Revision number of the firmware

Identification Number

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…255	175	113/12	0x0E2C/3629

Bronkhorst® (digital) device type identification number.

Device Type

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char [6]	R	-	90	113/1	0xF108…0xF10A/61705…61707

Device type information string; this parameter contains an abbreviation referring to the identification number.

5.5. Alarms

Alarm settings are most easily accessible using FlowPlot or FlowView or a Bronkhorst® readout and control unit.

The built-in alarm functionality can be used to handle different alarm types:
- system errors and warnings
- min/max alarms
- response alarms
- batch alarms
- master/slave alarms

The used alarm type can be set with parameter *Alarm Mode*. When an alarm is activated, the type can be read out using parameter *Alarm Info*. An automatic setpoint change can be set using the parameters *Alarm Setpoint Mode* and *Alarm New Setpoint*. It is also possible to set an alarm delay, to prevent overreaction to small disturbances, using parameter *Alarm Delay Time*. The methods by which an alarm can be reset are controlled by *Reset Alarm Enable*.

Alarm Mode

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…3	118	97/3	0x0C23/3108

Available modes:

Value	Description
0	Alarm off
1	Alarm on absolute limits
2	Alarm on limits related to setpoint (response alarm)
3	Alarm on power-up (e.g. after power-down)

(On DeviceNet™ instruments, only modes 0 and 1 are available).

Alarm Info

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	R	0…255	28	1/20	0x0034/53

This parameter provides information about the event type(s) that triggered an alarm situation. The value is a bitwise summation of the issued alarm types; convert the value to binary to see which types are issued. The following alarm types can be issued:

Bit	Value	Type	Description
0	1	Error	Error flag raised
1	2	Warning	Warning flag raised
2	4	Minimum alarm	*Measure* < *Alarm minimum limit*
3	8	Maximum alarm	*Measure* > *Alarm minimum limit*
4	16	Batch counter alarm	Batch counter reached its limit
5	32	• This bit only: Power-up alarm • If combined with bit 2 or 3: Response alarm	Alarm possibly caused by a power dip Difference between *Measure* and *Setpoint* too big
6	64	Master/slave alarm	Setpoint out of limits (caused by *Slave factor*)
7	128	Hardware alarm	Hardware error

Alarm Delay Time

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…255	182	97/7	0x0C27/3112

This value represents the time in seconds the alarm action will be delayed when an alarm limit has been exceeded. This value also delays the alarm off action if an alarm limit is no longer exceeded.
Default value = '0'.

Alarm Maximum Limit

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned int	RW	0…32000	116	97/1	0x0C21/3106

Maximum limit for *Measure* to activate the maximum alarm situation (after *Alarm Delay Time*). Range 0…32000 represents 0…100% signal. *Alarm Maximum Limit* must be greater than *Alarm Minimum Limit*.
Default value: 0.

Alarm Minimum Limit

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned int	RW	0…32000	117	97/2	0x0C22/3107

Minimum limit for *Measure* to activate the minimum alarm situation (after *Alarm Delay Time*). Range 0…32000 represents 0…100% signal. *Alarm Minimum Limit* must be smaller than *Alarm Maximum Limit*.
Default value: 0.

Alarm Setpoint Mode

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…1	120	97/5	0x0C25/3110

Specifies whether or not to change the setpoint after an alarm situation is activated.

Value	Description
0	No setpoint change (default)
1	Change setpoint to *Alarm new setpoint*

Alarm New Setpoint

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…32000	121	97/6	0x0C26/3111

New (safe) setpoint during an alarm until reset. Range 0…32000 represents 0…100% setpoint.
Default value: 0

Reset Alarm Enable

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…15	156	97/9	0x0C29/3114

Available reset methods for alarms. Up to 4 different methods can be specified; convert the value to binary to see which methods are enabled.
Default value: 15 (all bits/methods enabled)

The following methods are supported:

Bit	Value	Description
0	1	Multifunctional switch
1	2	Externally (deprecated)
2	4	By parameter *Reset*
3	8	Automatically (when alarm conditions no longer apply)

5.6. Counter

Counter settings are most easily accessible using FlowPlot or FlowView or a Bronkhorst® readout and control unit.

Counter Mode

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…2	130	104/8	0x0D08/3337

Available modes:

Value	Description
0	Counter off (default)
1	Counter up continuously
2	Counting up until limit reached (set by *Counter Limit*)

Counter Unit

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char [4]	RW	see table below	128	104/7	0xE838…0xE839/59449…59450

This parameter contains the name of the counter readout unit.
Counter Unit supports the following values:

Mass	Normal volume (1.01325 bar(a), 0 °C)	Standard volume (1.01325 bar(a), 20 °C)	Custom volume (*Capacity Unit Pressure, Capacity Unit Type Temperature*)
ug, mg, g, kg	uln, mln, ln, mm3n, cm3n, dm3n, m3n	uls, mls, ls, mm3s, cm3s, dm3s, m3s	ul, ml, l, mm3, cm3, dm3, m3

Counter Value

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	RW	0…10000000	122	104/1	0xE808…0xE809/59401…59402

Current counter value in units selected with parameter *Counter Unit*.

Counter Limit

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	RW	0…9999999	124	104/3	0xE818…0xE819/59417…59418

Counter limit/batch size in units selected with parameter Counter Unit.
Default value: 0.

Counter Setpoint Mode

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…1	126	104/5	0x0D05/3334

Specifies whether or not to change the setpoint after reaching the counter limit.

Value	Description
0	No setpoint change (default)
1	Change setpoint to *Counter new setpoint*

Counter New Setpoint

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned int	RW	0…32000	127	104/6	0x0D06/3335

New (safe) setpoint when a counter limit is reached until reset. Range 0…32000 represents 0…100% setpoint.
Default value: 0

Reset Counter Enable

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…15	157	104/9	0x0D09/3338

Available reset methods for counters. Up to 3 different methods can be specified. The value is a bitwise summation of the enabled reset methods; convert the value to binary to see which methods are enabled.
Default value: 7 (bits/methods 0, 1 and 2 enabled)

The following methods are supported:

Bit	Value	Description
0	1	Multifunctional switch
1	2	Externally
2	4	By parameter *Reset*

3	8	Automatically (e.g. when *Counter value* is reset)

5.7. Network configuration

Changes made to the network settings will **not** be restored by a factory reset.

Default settings
Network configuration is done ex factory as indicated on the serial number label or in the technical specifications. The table below shows the supported configurations for the available interface protocols (default settings are printed in boldface):

Protocol	ProPar (RS232)	FLOW-BUS (RS485)	Modbus (RTU/ASCII)	PROFIBUS DP	DeviceNet™
Address	**3**	**3**…125	**1**…247	0…**126**	0…**63**
Baud Rate	9600 19200 **38400** 57600 115200 230400 460800	**187500** 400000	9600 **19200** 38400 56000 115200 128000 256000	**(autodetect)** 9600 19200 45450 93750 187500 500000 1500000 3000000 6000000 12000000	**125000** 250000 500000
Parity	**0**	**0**	0, 1, **2**	**2**	**0**

Network configuration for EtherCAT® and PROFINET is done automatically via the Ethernet protocol.

Communication via fieldbus connection (RS485)
Use the following parameters to configure the instrument for communication via the fieldbus connection:

Fieldbus 1 Address

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…255	199	125/10	0x0FAA/4011

Fieldbus 1 Baud Rate

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned long	RW	0…1.0E10	201	125/9	0xFD48…0xFD49/64841…64842

Fieldbus 1 Parity

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…2	335	125/12	0x0FAC/4013

The following values are supported:

Value	Description
0	No parity

1 Odd parity
2 Even parity

Communication via the power supply connection (RS232/RS485)
Use the following parameters to configure the instrument for communication via the 8DIN (power) connection:

- If the 8DIN connector / 9-pin D-sub connector is set for RS485 communication, the instrument will not respond when connected to an RS232 configuration. In that case, use the power-up functionality of the multifunctional switch to enter configuration mode and enable RS232 communication.
- After configuring the required parameters, use the same procedure to leave configuration mode and restore the original communication settings (otherwise, configuration mode remains enabled after power down).

Field Bus 2 Address

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…255	309	124/10	0x0F8A/3979

Field Bus 2 Baud Rate

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned long	RW	0…1.0E10	310	124/9	0xFC48…0xFC49/64585…64586

Field Bus 2 Parity

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…2	336	124/12	0x0F8C/3981

The following values are supported:

Value	Description
0	No parity
1	Odd parity
2	Even parity

5.8. Fluid set

For changing fluid, flow range or operating conditions, using the FlowTune software is strongly advised. FlowTune checks any changes for compatibility of the process conditions with the instrument. When the parameters described in this section are changed manually, no such checks are performed, and the instrument output may become disordered or the instrument may even get damaged if used in conditions the instrument is not suited for. When in doubt, consult your Bronkhorst representative.

Fluid Set Index

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…7	24	1/16	0x0030/49

With this parameter, any of the pre-configured fluids (up to 8) can be selected. Each fluid has its specific (configurable) properties, such as *Fluid Name, Capacity*, etc. Default value: 0 (fluid 1).

Note that the selected value is equal to the fluid number minus 1 (value 0 corresponds to fluid 1, value 1 to fluid 2, etc.).

Fluid Name

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char [10]	RW	-	25	1/17	0x8188…0x818C/33161…33165

This parameter contains the name of the current fluid.

Capacity

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	RW	1E-10… 1E+10	21	1/13	0x8168…0x8169/33129…33130

This parameter sets the maximum readout/control value (100%) for the current fluid in readout units corresponding to *Capacity Unit*.

Capacity Unit

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char [7]	RW	see below	129	1/31	0x81F8…0x81FB/33273…33276

Available units:

Mass	Normal volume (1.01325 bar(a), 0 °C)	Standard volume (1.01325 bar(a), 20 °C)	Custom volume (*Capacity Unit Pressure, Capacity Unit Type Temperature*)
ug/h, ug/min, ug/s, mg/h, mg/min, mg/s, g/h, g/min, g/s, kg/h, kg/min, kg/s	uln/h, uln/min, uln/s, mln/h, mln/min, mln/s, ln/h, ln/min, ln/s, ccn/h, ccn/min, ccn/s, mm3n/h, mm3n/m, mm3n/s, cm3n/h, cm3n/m, cm3n/s, m3n/h, m3n/min, m3n/s, scfh, scfm, scfs, sccm, slm	uls/h, uls/min, uls/s, mls/h, mls/min, mls/s, ls/h, ls/min, ls/s, ccs/h, ccs/min, ccs/s, mm3s/h, mm3s/m, mm3s/s, cm3s/h, cm3s/m, cm3s/s, m3s/h, m3s/min, m3s/s	ul/h, ul/min, ul/s, ml/h, ml/min, ml/s, l/h, l/min, l/s, cc/h, cc/min, cc/s, mm3/h, mm3/m, mm3/s, cm3/h, cm3/m, cm3/s, m3/h, m3/min, m3/s, cfh, cfm, cfs

Because of the maximum string length (7 characters), some unit names are abbreviated. For instance mm3n/m means mm3n/min.

Capacity Unit Type Temperature

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	RW	-273.15… 3.4E+38	245	33/10	0xA150…0xA151/41297…41298

This parameter defines a reference temperature for conversion of the measured mass flow to a volume flow. See also parameters *Capacity Unit* and *Counter Unit*.

Capacity Unit Type Pressure

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	RW	0…3.4E+38	246	33/11	0xA158…0xA159/41305…41306

This parameter defines a reference pressure for conversion of the measured mass flow to a volume flow. See also parameters Capacity Unit and Counter Unit.

5.8.1. Advanced fluid set parameters

Note that the parameters described in this section do not contain any actual measurement values, but only fixed reference values, which can be used for capacity calculations, etc.

Inlet Pressure

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	RW	0…3.4E+38	178	113/13	0xF168…0xF169/61801…61802

Inlet pressure of the current fluid in bar(a).

Outlet Pressure

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	RW	0…3.4E+38	179	113/14	0xF170…0xF171/61809…61810

Outlet pressure of the current fluid in bar(a).

Fluid Temperature

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	RW	-250…500	181	113/16	0xF180…0xF181/61825…61826

Temperature of the current fluid in °C.

Density

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	RW	0…3.4E+38	170	33/21	0xA1A8…0xA1A9/41385…41386

Density of the current fluid in kg/m^3.

Heat Capacity

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	RW	0…3.4E+38	250	113/18	0xF190…0xF191/61841…61842

Heat capacity of the current fluid in J/kg·K.

Thermal Conductivity

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	RW	0…3.4E+38	251	113/20	0xF1A0…0xF1A1/61857…61858

Thermal conductivity of the current fluid in W/m·K.

Viscosity

Type	Access	Range	FlowDDE	ProPar	Modbus
Float	RW	0…3.4E+38	252	113/21	0xF1A8…0xF1A9/61865…61866

Dynamic viscosity of the current fluid in Pa·s.

5.9. Master/slave configuration (FLOW-BUS)

Normally, there is no communication between slave instruments in a fieldbus system. The FLOW-BUS protocol, however, provides a feature to set up a master/slave relationship between two instruments. The typical behavior of a slave instrument is to automatically set its own setpoint relative to the output (measurement value) of its master.

The output value of any instrument connected to a FLOW-BUS network is automatically available to all other instruments without extra wiring. A slave instrument can in turn be a master to other instruments.

To setup a master/slave relationship between instruments, first determine which instrument should be the master and which should be the slave, then set Control Mode of the slave instrument to 'FLOW-BUS Slave' (value 2) or 'FLOW-BUS Analog Slave' (value 13), depending on how the setpoint should be calculated (see parameter Control Mode).

The slave instrument polls the output value of its master periodically and uses the slave factor to set its own flow relative to the master's.

Setpoints from master instruments can be received via FLOW-BUS only.

To prevent damage to the instruments an/or the system(s) they are connected to, be sure to avoid circular references between devices on the same fieldbus. The FLOW-BUS system does not have a protection mechanism.

Master Node

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…128	158	33/14	n/a

Set the master node for the instrument
Note that this parameter only is effective in a FLOW-BUS system via RS485.

Slave Factor

Type	Access	Range	FlowDDE	ProPar	Modbus
Unsigned char	RW	0…500	139	33/1	0xA108…0xA109/41225…41226

The controller output from the master instrument is multiplied by *Slave Factor*/100% to get the slave instrument setpoint. In systems other than FLOW-BUS via RS485, *Slave Factor* is effective only if *Control Mode* is set to 'Analog slave', and the analog output signal of the master instrument is redirected to the input of the slave instrument.

Example:
- master output = 80%
- *Slave Factor* = 50

→ slave instrument setpoint = 80% x 50%/100% = 40%

6. Troubleshooting and service

To track down problems in the fluid system, it is recommended to disconnect the unit from the process line and check it without applying fluid pressure. Dirt or clogging might be detected quickly by loosening fluid connections and performing a visual inspection.

Energizing and de-energizing the equipment can indicate whether there is an electronic failure. After energizing, control behavior can be checked by applying fluid pressure.

If you suspect leakage, do not disassemble the device for inspection, but contact your Bronkhorst representative for service or repairs.

6.1. Errors and warnings

- During operation, the LEDs can indicate errors and/or warnings. See LED indications for an explanation of the LED indications the instrument can give.
- Error and warning information can also be found by connecting the instrument to FlowDDE and FlowPlot. FlowDDE puts all errors and warnings on the console screen; FlowPlot provides several specific alarm and counter indicators. See also section Digital operation (RS232).

6.2. Restoring factory settings

In case changes to the instrument configuration leads to non-recoverable erroneous behavior, the instrument can be reset to the pre-configured factory settings. The easiest way to do this is with the multifunctional switch on top of the instrument.

To restore the factory settings using the multifunctional switch, follow these instructions:

1. Make sure electrical power to the instrument is switched off
2. Press and hold the multifunctional switch, while powering up the instrument. After 4 seconds ,the red LED ● starts flashing (0.2 seconds on, 0.2 seconds off)
3. At that moment (which is after 4 to 8 seconds), release the switch

Changes made to the network settings (bus address, baud rate, parity) will **not** be restored by a factory reset.

Alternatively, factory settings can be restored in FlowPlot (via RS232 communication), or with a Bronkhorst® readout and control unit (BRIGHT, E-8000).

If RS232 communication with the instrument can not be established, use the power-up functionality of the multifunctional switch to switch to configuration mode and enable RS232 communication.

After restoring the factory settings, remember to leave configuration mode and restore the original communication settings (otherwise, configuration mode remains enabled after power down).

6.3. Common issues

Symptom	Possible cause	Action
No (fieldbus) communication	No power supply	• check power supply • check cable connection • check cable hook-up
	Invalid node address	Change node address (see Network configuration)
	Other	Reset instrument and/or restart master. If problem persists, contact Bronkhorst
No output signal	No power supply	• check power supply • check cable connection • check cable hook-up

	Invalid control mode (instrument accepts no setpoint)	Check control mode (see Special parameters)
	No setpoint given or setpoint too low	Give setpoint ≥ 2%
	Control valve in Safe State (normally closed)	Check if control valve is in safe state; solve cause if necessary (see Valve Safe State)
	Inlet pressure or differential pressure too low	Increase inlet pressure
	Piping, filters and/or control valve clogged or blocked	• Flush fluid system with clean, dry air. If problem persists, contact Bronkhorst. • For external proportional control valves: supply 0…15 Vdc and operational inlet pressure to valve and slowly increase voltage. If valve does not open, clean parts and re-adjust valve
	Laminar flow element clogged or blocked	Return equipment to factory
	Sensor failure	Return equipment to factory
Maximum output signal (131%)	Flow too high, valve fully open	Close valve
	PCB/sensor failure	Return equipment to factory
	Valve in 'Safe State' (normally open valves)	Remove cause of 'Valve Safe State' (see Valve Safe State)
Control behavior unstable	Measurement disturbed by vibrations	If possible, avoid installation in close proximity of mechanical vibration
	Inlet pressure unstable	Install pressure regulator or increase buffer volume between controlling instruments (see section Piping requirements)
	Inlet and/or outlet pressure too high or too low	Adjust pressure and/or set instrument pressure in accordance with actual process pressure (e.g. with FlowTune™)
	Wrong process gas selected	Select correct process gas (e.g. with FlowTune™)
	Wrong controller settings	Adjust settings (e.g. with FlowPlot)
	Control valve damaged	Return equipment to factory
No flow (sending a setpoint has no effect)	No fluid supply	Check upstream components for obstruction, e.g.: • fluid lines • valves • filters
	Setpoint too low	Give setpoint ≥ 2%
	Inlet pressure or differential pressure out of bounds	Set inlet pressure to a value within specifications

Symptom	Possible cause	Action
Measured value rises, but never reaches setpoint	Piping, filters and/or control valve clogged or blocked	• Flush fluid system with clean, dry air. If problem persists, contact Bronkhorst. • For external proportional control valves: supply 0…15 Vdc and operational inlet pressure to valve and slowly increase voltage. If valve does not open, clean parts and re-adjust valve
	Inlet pressure too low	Increase inlet pressure
	Outlet pressure too high	Check/decrease outlet pressure
	Process outlet blocked	Check process outlet and downstream piping
Measured value or output signal (much) lower than setpoint	Inlet pressure or differential pressure too low	• Increase inlet pressure • Use instrument in conditions it was designed for
	Process gas condensation	Decrease inlet pressure or increase gas temperature
	• Piping, filters and/or control valve clogged or blocked • Sensor blocked or contaminated	Flush fluid system with clean, dry air. If problem persists, contact Bronkhorst.
	Supplied fluid type does not match configured fluid type	Supply equipment with other fluid or change fluid type in instrument configuration
Measured value or output signal indicates a flow, while there is none	Mounting orientation and/or ambient conditions changed significantly	• Use instrument in conditions it was designed for • Adjust zero point (see Adjusting zero point)
	System leakage	Check the system for leakage. Follow vendor instructions when installing third party components (e.g. adapters, tubing, valves)
Continuous maximum measured value or output signal	Inlet pressure too high	Check inlet pressure
	Valve fully open	• Close valve • Check if control valve is in Safe State (normally open valves); remove cause if necessary (see Valve Safe State)
	Sensor failure	Return equipment to factory

6.4. Service

For current information about Bronkhorst® and service addresses, please visit our website:

www.bronkhorst.com

Do you have any questions about our products? Our Sales Department will gladly assist you selecting the right product for your application. Contact sales by e-mail:

sales@bronkhorst.com

For after-sales questions, our Customer Service Department is available with help and guidance. To contact CSD by e-mail:

aftersales@bronkhorst.com

No matter the time zone, our experts within the Support Group are available to answer your request immediately or ensure appropriate further action. Our experts can be reached at:

+31 859 02 18 66

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NL-7261 AK Ruurlo
The Netherlands

7. Returns

7.1. Removal and return instructions

In case the product needs to be returned (e.g. for calibration, repair), please refer to our website for information on the online product return process (RMA).

- Visit the Bronkhorst website.
- Go to the Service & Support section.
- Follow the on-screen instructions to return the product.

7.2. · Disposal (end of lifetime)

If you are a customer within the European Union and wish to dispose of Bronkhorst® equipment bearing the symbol of a crossed out waste disposal bin, you can return it in accordance with the removal and return instructions . Bronkhorst will then take care of proper dismantling, recycling and/or reuse (wherever possible).
In the covering letter, mention that you are returning the product for disposal.

In countries outside the EU, disposal of electrical and electronic equipment (EEE) may be subject to local or national directives and/or legislation. If applicable, consult local or national authorities to learn how to handle EEE properly in your area.