red-y for gasflow

Instruction manual red-y smart series

smart meter GSM

smart controller GSC

This manual is valid for instruments with a serial number up to 109 999

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smart flowmodul GSF

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CE

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01 Welcome

With *red-y* you get the latest, most modern CMOS sensor technology. CMOSens™ is a technology label and stands for a modern process in which the sensor and the signal processing are combined on a highly integrated chip.

This manual will familiarize you with the installation and operation of your *red-y*. We therefore ask you to read this manual carefully and to contact your sales partner with any questions or doubts.

We have prepared this manual very carefully in order provide you with appropriate and precise information and instructions. However, no liability is assumed for any errors.

User Benefits

Ultimately, a technology only represents a means to an end. Therefore all of our efforts are aimed at the requirements and wishes of the user of this instrument and his measurement and regulation tasks:

- *Compact, easy-to-install measurement or regulation unit*
- *Normalised input and output signals*
- *Normalised supply voltage*
- *Serial communication*
- *CE approved*
- *Measurement of the gas temperature*
- *Easy maintenance and service*
- *Easy expansion of functionality*
- *3-year guarantee*
- *Top performance in response, dynamics and accuracy*
- *Matching options and accessories*

Service and Quality

We continuously improve the quality of our products and services. Only with use does it ultimately become clear whether the right product has been selected. Thus, we attempt not only to propagate good service and high quality, but to live it every day.

Guarantee

The guarantee for *red-y for gasflow* products extends to material defects and production flaws. The guarantee maximum is the replacement of the equipment at no cost. Claims are omitted in the case of inappropriate use, external effects in general, excessive heat or dropping.

We are always grateful for information on existing defects, for suggestions for improvements, and for critiques.

Tips and Warnings

Before putting the instrument into use, these operating instructions should be read thoroughly. Improper use, errors for lack of understanding and the consequences arising from this, can lead to the destruction of the instrument or even the endangerment of personnel.

The equipment should be put into operation and serviced by appropriately qualified personnel only. The proper handling of the products is an absolute requirement for its trouble-free operation.

Electrostatic discharges can destroy electronic components of this measurement and regulation unit.

This manual aims at a safe operation of *red-y* mass flow meters and controllers.
Each instrument is supplied full of charge with a CD containing the *get red-y* software as well as this manual.

02 A Bit of Theory

Measuring Principle

The principle of thermal mass flow measurement is perfectly suited for the measurement of gas flows. One of the significant advantages is that the measurement is largely independent of pressure and temperature. By contrast to volumetric principles, pressure and temperature do not have to be additionally measured. Although the principle yields mass as a measurement result (e.g. g/min), most devices are calibrated to standard volumes (e.g. ln/min). One possible explanation is the fact that the comparability of the measurement results with other principles is given with this. Since the thermal flow measurement depends on the type of gas, in addition to the specific heat, the standard density (0°C, 1,01325 bar a) for the conversion to standard volume is also used.

With all design options of the measuring principle, there is always a heater and one or more temperature-measurement points and the gasflow draws heat from the heater.

With the *red-y* mass flow meter, a constant heating power ensures a temperature difference that is directly proportional to the gas flow rate. In the flume, a temperature measurement is followed by a heater, and then a temperature measurement again. The figure below illustrates this process. If the flow rate=0, the heater H uniformly distributes the heat, for which the temperature difference T1-T2 equals zero. Two effects occur with the flow rate that lead to a temperature difference: First, the temperature sensor T1 at the entrance detects a lower temperature. This happens because of the cooling of the entering gas, which theoretically drops to the ambient temperature respective of gas. Secondly, the gas flowing over the heater carries heat to the temperature sensor T2, located after the heater, and thus increases this temperature. The temperature difference is in direct proportion to the mass flow.

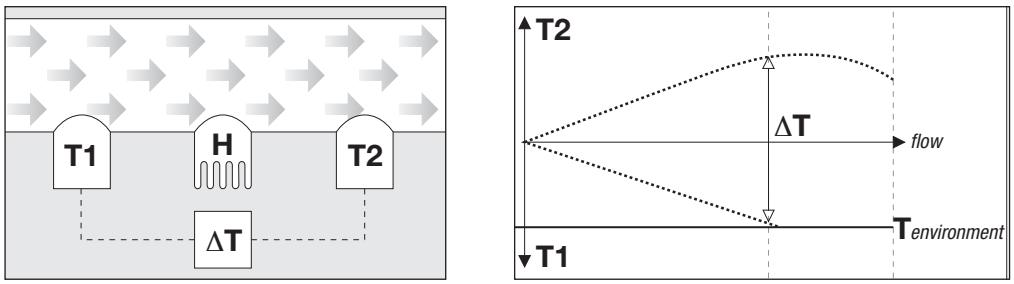


Figure 2: Schematic illustration of how thermal mass measurement functions

CMOS Technology

Red-y measurement and regulation units feature a new basic technology that sets standards for maximum precision sensor systems. The fusion of a semi-conductor chip with sensor technology results in a highly integrated system solution that is impressive for its excellent sensor precision, as well as digital intelligence and reliability.

The most notable advantages to the customer are the outstanding precision of the sensor, the rapid response time and a dynamic measuring range that no system has attained up until now.
Thanks to the compact single chip design, CMOSens™-based sensors are extremely resistant to electromagnetic interference (EMI), a significant technical advantage of this ultra modern sensor technology.

With CMOSens™, the sensor element, amplifier and A/D converter form a unit on the same silicon chip.

The digital intelligence linked with the CMOSens™ sensor permits the emission of a fully calibrated, temperature-compensated output signal. The CMOSens™ 'intelligence' integrated onto the chip thus facilitates an extremely simple processing of the emitted measurement data. CMOS is a standard technology for the manufacture of integrated circuits.

CMOS chips are generally known as 'semi-conductor chips', 'silicon chips' or 'computer chips'. They are widely used in PCs, mobile telephones and many other information technology devices.

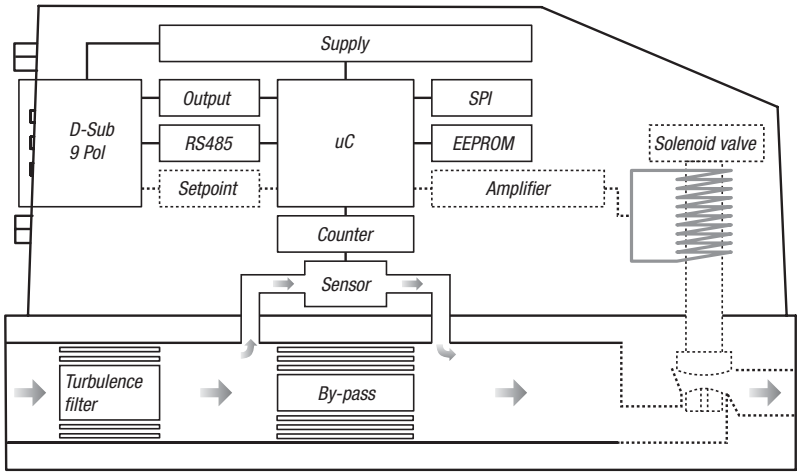


Figure 2: Block diagram of the hardware

03 Technical Informations

General Specifications

Accuracy	
Standard	+/- 1,5% of full scale
Hi-Performance	+/- 0,3% of full scale, +/- 0,5% of reading
Dynamic range	
Standard	3,5 – 100 % within specified accuracy Cut-off < 2% of full scale
Hi-Performance	1 – 100 % within specified accuracy Cut-off
Repeatability	+/- 0,1% of full scale
Longterm stability	< 1% of rate/year
Temperature sensitivity	-
Pressure sensitivity	< 0,2% / bar (typical N2)
Control stability	+/- 0,1% of setpoint
Operating pressure	Up to 10 bar g
Operating temperature	0 – 50°C
Leak integrity	
Inboard/outboard	1 x 10^{-8} mbar l/s He
Control valve	1 x 10^{-6} mbar l/s He
Warm up time	30 min for max. accuracy

Physical Specifications

Materials of construction	
Model code A (Alu)	Aluminum, Stainless Steel
Model code S (SS)	Stainless Steel
Sensor	PBT, Epoxy and Silicon
Seals	FKM, optional EPDM or PTFE
Mechanical connection	Up to 50ln/min G1/4"; up to 200ln/min G1/2" female inlet and outlet optional with fittings
Electrical connection	9-pin sub-D connector (male)
Ingress protection	IP-50

Electrical Specifications

Supply voltage	+ 24 Vdc -5% / +10%
Supply current	
Massflow meter	max. 100 mA
Massflow controller	max. 250 mA
Analog setpoint	
Voltage	0 – 5 V, 1 – 5 V, 0 – 10 V
Current	0 – 20 mA or 4 – 20 mA
Max. load	500 Ohm
Digital communication	RS–485, Modbus RTU protocol
Control parameters	Freely adjustable by digital communication

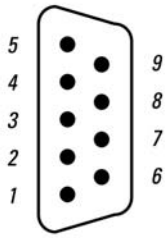
Measurement Ranges

The *red-y* massflow meters and controllers are normally supplied with one of the following standard measuring ranges for air. Optional the instruments are available with a customer specific range and calibrated for a different gas.

Standard ranges

Code	*Range*	*Unit*	*Code*	*Range*	*Unit*
A1	25	mln/min	C2	5	ln/min
A2	50	mln/min	C3	10	ln/min
A3	100	mln/min	C4	20	ln/min
A4	200	mln/min	C5	50	ln/min
A5	500	mln/min	D2	50	ln/min
B2	500	mln/min	D3	100	ln/min
B3	1000	mln/min	D4	200	ln/min
B4	2000	mln/min			
B5	5000	mln/min			

Pin Configuration



1	Ground Analoge Signale	*Common (-)*
2	Ground	*Supply 0 Vdc*
3	Supply + 24 Vdc	*Supply +24 Vdc*
4	Analog output	*Output (+)*
5	Analog setpoint	*Setpoint (+)*
6	RS-485 Output (Y)	*Tx+ RS485 (Y)*
7	RS-485 Output (Z)	*Tx- RS485 (Z)*
8	RS-485 Input (B)	*Rx- RS485 (B)*
9	RS-485 Input (A)	*Rx+ RS485 (A)*

Analog Signals

The analog output signal, linear to the mass flow, is available between pins 4 and 1.
The analog setpoint signal, linear to the mass flow, is applied between pins 5 and 1.

Note

Use separate cables for signal ground pin 1 and power supply ground pin 2 to avoid interference problems.

Voltage signals have to be specified on order, or configured by an authorised sales partner.

The voltage output signal is generated by a 250 Ohm shunt resistor.

Serial Communication

Serial communications with Modbus protocol are a standard feature for the configuration and readout of the instruments.

Note

The power supply for the analog signals and digital communications must have a common ground potential.

Calibration

Each instrument is tested and calibrated on a fully automatic calibration equipment, traceable to european and american standards and the calibration data are stored in the non-volatile memory. As standard the calibration gas is air. Please consult your sales partner for calibrations with other gases.

The configuration and calibration data of each individual instrument are available on request.

Conversion Factors for other Gases

For gases other than air the calibration data are automatically converted to the requested gas. If the measured gas differ from the one the instrument has been calibrated for, the correct output signal can be calculated by means of the relevant conversion factor (see chapter 11).

Note

Depending on the gas measured, conversion factors may introduce considerable inaccuracies.

The reconfiguration to an other gas is more accurate by using the '*get red-y'* software supplied with each instrument. '*Get red-y'* first reads the calibration data from the instrument, converts them to the new gas and reloads them to the instrument.

Pressure Loss

The pressure loss in a thermal massflow meter is very small and depends on the gas, the operating pressure and the actual flow rate. The graphs in chapter 11 'annex' show typical values for different gases at 20°C and 1013 mbara.
The pressure loss for a gas other than air is calculated according to the following formula:

$$\Delta P_{required} = \Delta P \times \sqrt{\frac{\rho_{required}}{1.250}}$$

Note that insufficient tube diameter or unsuitable fittings may cause a high pressure loss.
The pressure loss in a massflow controller mainly depends on the control valve. The control valve must operate with the specified pressure drop for proper operation.
The graphs in chapter 11 'annex' show the typical pressure loss in massflow meters of different sizes and with different gases.

Temperature Compensation

Thermal massflow meters are almost unaffected by temperature and pressure variations of the measured gas. The temperature variations are detected by the sensor. Based on a three dimensional correction table the microprocessor then automatically corrects the output.
The temperature is measured with an accuracy of +/-0.5°C and can be read-out over the serial link.

Pressure Compensation

Each individual instrument is calibrated for the specified working pressure. Changing pressure conditions degrade the accuracy.

Note

The proper function of a flow controller is not guaranteed if the pressure drop is too high or too small.

Response Time

A unique feature of the CMOS-sensor is the extremely fast response time of 5ms. After 10ms the measured value is within its standard accuracy of +/-2%. After 1.2s the maximum accuracy is attained.

Control Caracteristics

The control caracteristics of the *red-y* massflow controllers can be adapted to the application. 3 sets of control parameters are factory programmed for the following control response:

Parameter set U:	*Fast response with overshoot*
Parameter set V:	*Optimal response with slight overshoot (standard)*
Parameter set W:	*Slow response without overshoot*

2 additional sets of control parameters are user programmable should none of the preprogrammed ones be acceptable.

The fast response time of the *red-y* series is design-inherent due to a consequent adoption of the low-mass principle and not the result of any electronic 'speed-up tricks'.

04 Mounting and Installation

General Informations

Check the packing box for damage. Should the packing be damaged, immediately notify the local carrier and inform your sales partner.
Carefully check if the goods correspond to the packing list and that there are no missing or damaged parts.
The *red-y series* are accurate measuring instruments. For best performance carefully read the following recommendations.
Check the instrument label and make sure that the massflow meter/controller suits the application.

Caution
The maximum working pressure must always be lower than specified test pressure.

Mounting

The preferred mounting position is horizontal, up right or hanging. For pressures > 5bar a vertical mounting position may cause an offset.
Avoid the installation in proximity of any source of thermal or electric radiation.
Avoid vibrations and mechanical stress.
Do not install the instrument at the lowest point of the piping to avoid an eventual backflow of liquids.

Piping

The correct piping is very important for the performance of measurement. Therefore carefully check the following points:

The piping must be absolutely clean.

The piping must conform in pressure and corrosion resistance.

Always fix the instrument on the body by means of fixing screws.

Avoid abrupt angles on the inlet. If this is not possible contact your sales partner.

Use appropriate fittings with O-ring seals and do not tighten the fittings holding the instrument by the cover.

Never use liquid sealing as it may flow into the instrument.

Do allow a sufficient upstream buffer volume between the pressure regulator and the instrument, especially with higher flow rates.

Do not use too small diameter piping as this creates a high pressure loss and may impare the performance of the instrument.

Carefully check the piping for possible leaks.

The instruments have a flow rectifier at the inlet. For flow rates > 50ln/min a straight tube of 10 times diameter is recommended.

For critical applications (uninterrupted gas supply) we recommend to install a bypass system to allow service on an instrument.

Electrical Connection

We strongly recommend our standard cables. Please consult your sales partner.
If you install your own cables, carefully read the connection instructions.

The installation has to comply with all relevant safety and EMC regulations.

We recommend the use of an EMC filter if the power supply cable exceeds 3m.

Avoid earth loops.

The power supply voltage must be 24Vdc +-10%.

Use cable of sufficient size to minimize the voltage drop.

Gas Supply

Make sure your gas supply is absolutely clean, i.e. free from dust, oil, water etc.
If necessary install an upstream and eventually a downstream filter to avoid any damage to the instrument.
The capacity of the supply should be at least 2 times of the max. flow range.
Carefully choose your pressure controller and do not install your *red-y* directy to it.
The pressure must be sufficient to cover all pressure losses in the piping, fittings etc.
At very low flows the pressure controller might be oversized and work in an intermittent mode resulting in a strongly oscillating flow.

Do not apply pressure until the electrical connections are made. When applying pressure to the system, increase the pressure gradually and avoid pressure shocks.

If explosive or aggressive gases are to be used, purge the process with dry inert gas like Nitrogen or Argon.

05 Operation and Service

Heat-Up Time

Right when the device is turned on, *red-y* is ready for use. For the most precise measurements, however, *red-y* is ready in 30 minutes (option of external feed). Before turning on, please be sure that the wiring is correct and is installed according to the installation plan, and that the gas connections are also mounted in accordance with the installation instructions of the manufacturer.

Zero Point Check

Without any special specifications for the installation position of the device, the zero point is aligned at operating temperature and horizontal installation position before delivery. If the device is installed vertically, a value can be read out at a zero flow rate according to operating pressure. During the check, be completely sure that no gas is flowing. In the case of a shift in the zero point, please contact your sales partner.

Service

With proper operation, *red-y* does not require any routine service at all. If the measurement value is in a quality-relevant range (e.g. ISO 9001), we recommend a periodic check of calibration. The interval depends strongly on use.

Cleaning in the Case of Contamination

Should there be suspicion of contamination (sudden deviation of measurement value in familiar processes, visible traces in the piping, etc.), try flushing the device with a dry inert gas. Depending on the contamination, it may be necessary to dismantle the device.

Tips

- *Use only designated tools.*
- *Handle the device and individual components with extreme care.*
- *Ensure that the dismantling area is clean.*
- *The guarantee lapses at all events with the dismantling of the device.*
- *Never loosen a torx screw.*
- *Do not touch the electronic circuit board or electronic components under any circumstances.*
- *After the cleaning, you should have the device checked by your sales partner at the first opportunity.*

Dismantling the flow module *(also see sketch on the next page)*

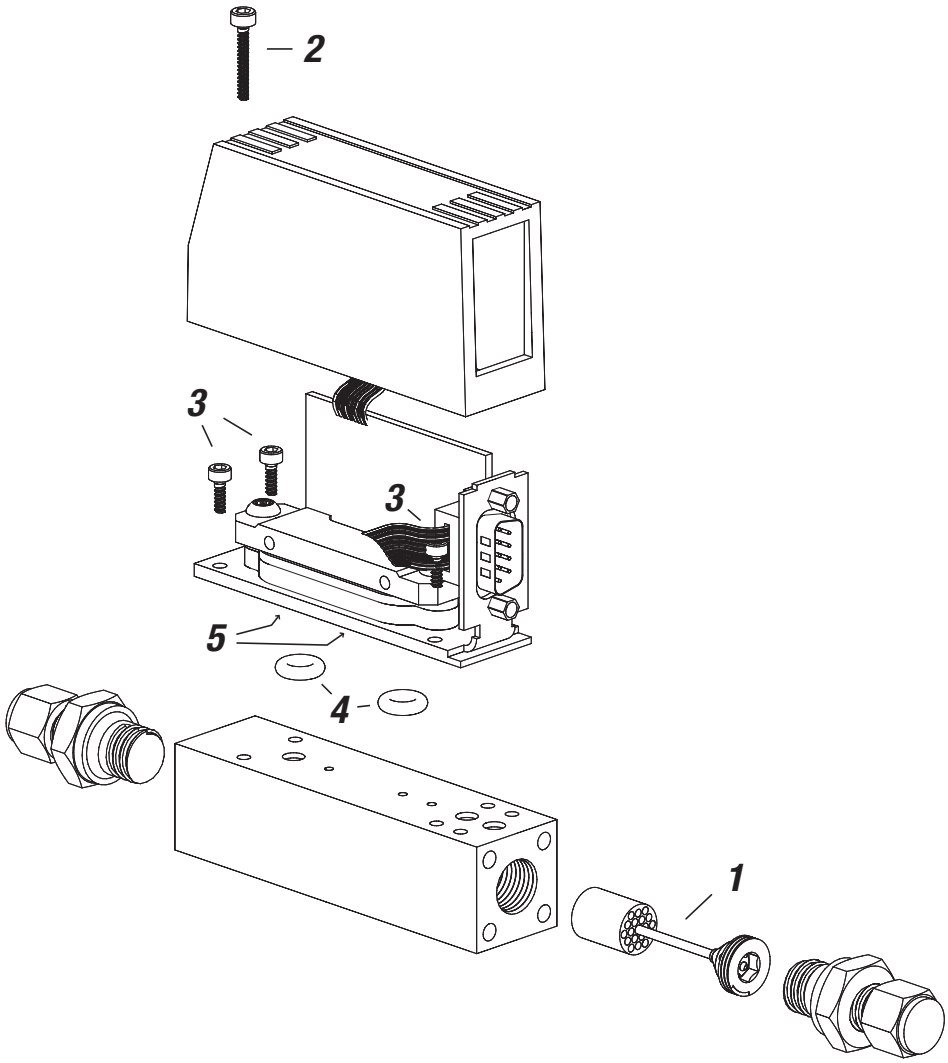
- Dismantle the gas and the electric connections.
- On the feed side, carefully turn out the flow divider together with the flow resistor [***1***]. The construction does not have any O ring seals in this section. You can now clean the complete flow module with a light solvent (e.g. IPA). Please make sure that the drill holes are all absolutely clean, dry and patent.

Dismantling the measuring unit *(also see sketch on the next page)*

- In order to clean the measuring part, first dismantle the central fastening of the electronics casing with an Allen key (4 mm) [***2***]. Slightly lift up the red casing on the screw side and press it towards the electronics plug. The L-shaped sensor carrier is screwed onto the body with four Allen screws (4 mm) [***3***]. Once you have loosened the screws, you can lift the carrier off the body.
  Please note that there are two O ring seals on the bottom side of the sensor carrier [***4***]. Now clean the measuring unit by letting dry gas flow into one of the measuring channel openings sealed by the O rings [***5***] or carefully rinse the channel with a suitable solvent (e.g. IPA). When doing so, hold the complete sensor carrier in such a way that liquid can never penetrate the system.
- After cleaning the system, make sure to rinse it with dry gas until the measuring channel is also completely dry.

Cleaning the body *(also see sketch below)*

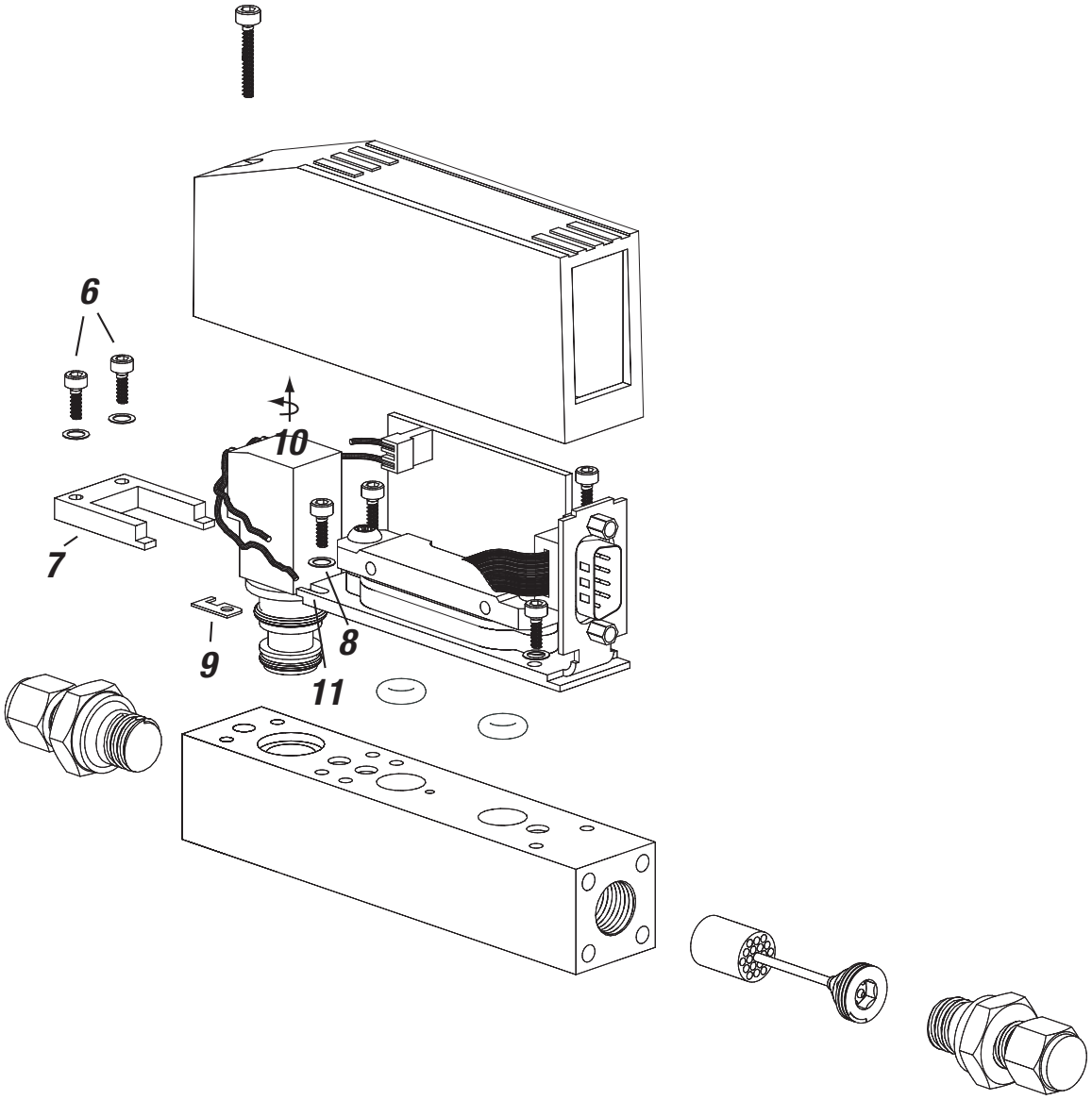
- In case the body is contaminated, dismantle the instrument as described for dismantling the flow module and the measuring unit and clean this also. Please make sure that no residues of cleaning liquids and cleaning cloths etc. remain in the body.
- With the subsequent assembly of the sensor carrier, observe the correct position of the two O ring seals between the sensor carrier and the body under all circumstances [***4***]. Make sure to screw in the flow module [***1***] up to the mechanical stop.
- After correct assembly, rinse the *red-y* once again with dry inter gas.
- By means of empirical values, check the correct function of the cleaned measuring instrument, e.g. by checking the zero point.



Disassembly of the control valve *(also see sketch on the next page)*

- Disassemble the gas and the electric connections.
- Make sure that there is no gas pressure in the pipe system or the instrument itself.
- In order to clean the measuring part, first dismantle the central fastening of the electronics casing with an Allen key (4 mm). Slightly lift up the red casing on the screw side and press it towards the electronics plug.
- Now carefully pull out the valve plug. Make sure you do not touch any electronic components on the circuit board.
- Loosen the two Allen screws [***6***], which hold the U-shaped clamp [***7***] at the valve. After you have removed the screws, you can pull the clamp away towards the gas output.
- Slightly loosen the Allen screws [***8***] so that you can turn the metal part [***9***] diagonally to the outside.

- Carefully pull the valve insert [***10***] upwards. Slight diagonal turning supports the dismantling process.
- Carefully reinstall the new valve insert with the cable outlet towards the electronic circuit board. Please be careful not to damage the O ring seals on the valve insert.
- Assemble the U-shaped retaining clamp with the 2 screws.
- Guide the valve cable into the recess of the sensor carrier. With the metal part, affix the valve cable in this sector.
- Reinsert the valve electronically.
- Please make sure that the valve cable is not squashed in the area of the duct/recess when assembling the electronics casing.
- After assembly of the control valve, it may be necessary to readjust individual control parameters (especially the parameter 'non-linearity N').



Returns

With the return of a measurement or regulation device, use the original packaging if possible, or other appropriate packing. Please inform us of the reason for the return in order to spare any unnecessary callbacks and delays.

Should the device come in contact with dangerous substances, please clean the device carefully, notify us and pack the device tightly.

Please fill out the contamination statement. You will find this in the chapter 11 'annex' or on the enclosed CD.

If you have any further questions, please contact your sales partner.

06 Digital Communication

The digital communication with a *red-y* mass flow meter or controller offers the following advantages:

More informations. *Besides the mass flow you can read the gas temperature, total flow, alarm status, serial number etc.*

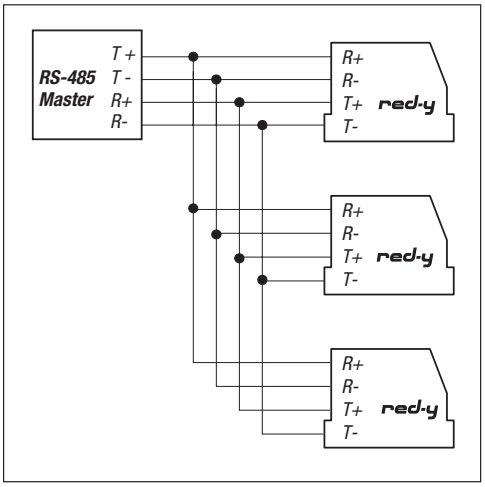
Access to control functions. *Allowing you to adapt the controller behavior.*

Save cost. *Due to a bus structure within a system of several instruments.*

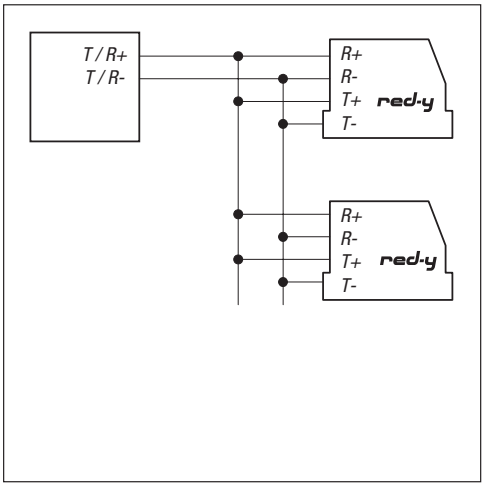
Higher RFI immunity.

Type of Communication

Red-y mass flow meters and controllers work on a serial communication RS-485 with a protocol Modbus RTU. A 2 or 4 wire connection is possible.



4 wire communication



2 wire communication

Using a RS-485/RS-232 converter the instruments can also be connected to a RS-232 port of a PC. The converter should be galvanically isolated.
With a special cable according to the diagram in chapter 9 'accessories' a *red-y* connects directly to the RS-232 port of your PC. This item is also available from your *red-y* sales partner.

Notes

The special cable contains a resistor network to adapt the signal level to the RS-232 port. In some cases it may impair the function of the serial port.

Each red-y must be set to an individual address between 1 and 246 in order to communicate properly with your PC. With the free software 'get red-y' you can check the bus, read and if necessary change the address of an instrument.

Modbus RTU

The Modbus protocol is a communication structure for a master-slave communication between intelligent instruments. It is used world wide and supported by most manufacturers of measurement and control instruments. Orginally it was introduced by MODICON. For further informations see *http://www.modbus.org/*.

For further programming examples please contact your sales partner.

The hardware typically used for Modbus is RS-485, RS-422 or RS-232. A Modbus message from master to slave consists of: Address, command (read or write), data and checksum.

Red-y works on the following communication parameters:

Communication speed	9600 Baud
Startbit	*1*
Databits	*8*
Stopbits	*2*
Parity	*none*
Bit Time	*104,6us*
Character Time (11 Bit)	*1,1458ms*
Max. buffer size	*20 Byte (Data)*

Max. number of units (theortical): *247*

Structure

START	ADRESS	FUNCTION	DATA	CRC CHECK	END
T1-T2-T3-T4	8 BITS	8 BITS	n x 8 BITS	16 BITS	T1-T2-T3-T4

START

A message starts with a pause of min 3.5 character times = ca. 4ms.

ADRESS

Address range:	01..247	
Broadcast to all instruments:	00	=> no answer from the instruments

FUNCTION Overview

Function 03:	Read Holding Registers
Function 06:	Preset Single Register
Function 08:	Diagnostics
Function 16 (10H):	Preset Multiple Registers

DATA

Function 03 Read Holding Register

Reads the data from the following registers of a slave. The number and the starting address of the registers are free.

Query:
Data

Start Adr. Hi	*Start Adr. Lo*	*No. of Points Hi*	*No of Points Lo*
8 Bit	8 Bit	8 Bit	8 Bit

Start Adr: Starting address of registers.
No. Of Points: Number of registers to be read.

Response:
Data

Byte Count	*Data Reg. 1*	.....	*Data Reg. N*
8 Bit	n Bytes	n Bytes	n Bytes

Byte Count: Number of bytes retrieved.
Data Reg. N: Register data.

Function 06 Preset Single Register

Writes data in a register of the slave.

Query:
Data

Reg. Adr. Hi	*Reg. Adr. Lo*	*Preset Data Hi*	*Preset Data x N*	*Preset Data Lo*
8 Bit	8 Bit	8 Bit	8 Bit x N	8 Bit

Reg. Adr.: Register addess.
Preset Data: Register data.

Response:
Data

Reg. Adr. Hi	*Reg. Adr. Lo*	*Preset Data Hi*	*Preset Data Lo*
8 Bit	8 Bit	8 Bit	8 Bit

Reg. Adr.: Register adress.
Preset Data: Register data.

Function 08 Diagnostics

Used is only the Diagnostics function "Return Query Data" (Code 00). This allows to test the Modbus. The addressed slave returns the query without execution. The function is called up with the subfunction 00.

Query:
Data

Subfunction Hi	*Subfunction Lo*	*Data Hi*	*Data Lo*
8 Bit	8 Bit	8 Bit	8 Bit

Subfunction: Call of diagnostic function.
Data: Data.

Response:
Data

Subfunction Hi	*Subfunction Lo*	*Data Hi*	*Data Lo*
8 Bit	8 Bit	8 Bit	8 Bit

Subfunction: Call of diagnostic function.
Data: Data.

Function 16 Preset Multiple Registers
Writes data into multiple registers of a slave. The number and the starting address of the registers are free. However the number of bytes is limited to 20 (address, function, data and CRC check).

Query:
Data

Start Adr. Hi	*Start Adr. Lo*	*No. of Register Hi*	*No of Register Lo*	*Byte Count*	*Data1*	.....	*Data N*
8 Bit	8 Bit	8 Bit	8 Bit	8 Bit	8 Bit	8 Bit	8 Bit

Start Adr.: Starting address of registers.
No. of Register: Number of registers to be written in.
Byte Count: Number of bytes to be transmitted.
Data N: Register data.

Note
The number of bytes to be transmitted is limited to 20 because of the limited storage capacity of the RAM.

Response:
Data

Start Adr. Hi	*Start Adr. Lo*	*No. of Register Hi*	*No of Register Lo*
8 Bit	8 Bit	8 Bit	8 Bit

Start Adr.: Starting address of registers.
No. of Register: Number of registers to be written in.

END
A message is terminated with a pause of min. 3.5 Character times = ca. 4ms.

Parameter
Measured value and setpoint of the mass flow meter or controller are available either as analog signals or directly in engineering units as digital signals. The full functionality is only available in the digital mode.

The following parameters describe the functions accessible by the customer. A series of other parameters are only accessible by the manufacturer.

The following example shows the structure of a parameter:

Parameter name	`Register address`	*Write*	*Authorisation*
		Read	*Authorisation*
Description of the parameters			
Format / interpretation of the parameter			

The following parameter table lists the Modbus registers. In the detailed description you find the register addresses in HEX.

Number types of the different parameters

Type	*Value*	*Description*
uint4	0…7	unsigned integer 4 bits
uint8	0...255	unsigned integer 8 bits
uint16	0…65536	unsigned integer 16 bits: Often used to define two 8-bit values
uint32	0...429496729	unsigned integer 32 bits
int16	-32768…+32767	signed integer 16 bits

Parameter table

Name	Description	E²PROM register
Gas flow	Measured value	0x0000..0x0001
Temperature	Measured value	0x0002..0x0003
Totaliser	Total gas flown	0x0004..0x0005
Setpoint gas flow	Control setpoint of gas flow	0x0006..0x0007
Measured value analog input	Measured value of analog input port	0x0008..0x0009
Valve control signal	Actual value of the valve control signal	0x000a..0x000b
Alarm	Alarm status	0x000c
Hardware error	Indicator for possible malfunction	0x000d
Control function	Selection of the controller mode	0x000e
Instrument address	Sets the Modbus instrument address	0x0013
Measuring range	Calibrated measuring range of the instrument	0x0014..0x0015
Unit of measured value	Engineering unit of measured value	0x0016..0x0019
Name of fluid	Name of the measured gas	0x001a..0x001d
Serial number hardware	Serial number of the electronic module	0x001e..0x001f
Version number hardware	Development stage of the electronic module	0x0020
Version number software	Development stage of the software	0x0021
E²PROM actualisation	Stores the settings in the non-volatile memory	0x0022
Instrument name	Name of the instrument	0x0023..0x0026
Analog output manual	Manual setting of the analog output	0x0028..0x0029
Scanning speed S	PWM scanning speed non linear/linear range	0x002d
Gain factor K_P	Control parameter gain	0x002e..0x002f
Time constant T_N	Control parameter integral time	0x0030..0x0031
Feed forward F	Control parameter feed forward	0x0032
Non linearity N	Control parameter valve offset compensation	0x0033
Soft reset	Resets all parameters to the power-on status	0x0034
Set of control parameters	Selection of predefined control parameters	0x0035
Power-up alarm	Activation of the power-up alarm function	0x4040
Power-up alarm setpoint	Setpoint of power-up alarm	0x4041..0x4042
Totaliser function	Function of the totaliser	0x4043
Totaliser scaling factor	Scaling factor of the totaliser	0x4046..0x4047
Totaliser unit	Engineering unit of the total	0x4048..0x404b
Zero point suppression	Zero point suppression	0x404c..0x404d
Reset hardware error	Reset of the status hardware error	0x404f
Automatic storage E²PROM	Storage mode of the non-volatile memory	0x4050
Backflow detection	Indicates a negative flow	0x4052..0x4053
Signal type analog output	Signal type of the analog measured value output	0x4084
Signal type setpoint	Signal type of the analog setpoint input	0x4085
Delay hardware error	Delay time for the plausibility check at a hardware error	0x4087
Implemented functions	Implemented functions (options) according to the type of instrument	0x4128..0x4129
Calibration data set	Selection of the calibration data set	0x4139

Detailed explanation of parameters

Measured value gas flow	0x0000...0x0001	*Write*	*Not possible*
		Read	*User*
Measured value of the gas flow in mln/min. Scaling according to customer specification, adjustable by manufacturer or sales partner.			
Value ***float32***			

Measured value temperature	0x0002...0x0003	*Write*	*Not possible*
		Read	*User*
Measured value of the gas temperature in °C.			
Value ***float32***			

Totaliser	0x004...0x0005	*Write*	*User*
		Read	*User*

Total gas flow since last reset. Internally totalised in [mln] , may be scaled with an appropriate scaling factor according to the following formula:

$$M_{Gas} = F_{Scalingfactor} * M_{Gas\_mln}$$

Legend

M_{Gas} : Total quantity of gas converted by the scaling factor

$F_{Scalingfactor}$: Scaling factor (Definition according to register Scaling factor of the totaliser)

M_{Gas_mln} : Total quantity of gas in [mln]

Any value can be written in this register (including negative values). The totaliser then starts from this value.

Value ***float32***
The gas total may have any unit if properly scaled.
Preset value: 0 mln. With a scaling factor of 1.0 the unit of the gas total is mln.

Setpoint of gas flow	0x0006..0x0007	*Write*	*User*
		Read	*User*

Setpoint of the controller in mln/min.
To activate the setpoint, the controller mode (register 0x000e) has to be in mode 0 (automatic) or in mode 1 (Modbus).
The controller operates only with this setpoint if the power-up alarm (register 0x4040) is not active.
In this case the value is stored in the non-volatile memory and is still present after a power loss.
With the power-up alarm activated the setpoint will be lost at a power loss.

Value ***float32***

Measured value analog input	0x0008..0x0009	*Write*	*Not possible*
		Read	*User*
Analog setpoint input for the controller. Manufacturer configuration as voltage [V] or current [mA]. The converted input value is always loaded into the register, whether the controller works in analog or digital mode.			
Value ***float32*** *Value float32 voltage or current signal*			

Valve control signal	0x000a..0x000b	Write	User
		Read	User

Contains the actual control value for the valve whether the control value is generated from the controller (automatic mode) or manually set via Modbus.
If the register control mode (0x000e) is defined as mode 10 the control value is immediately loaded into the register. In any other modes the value is stored in a buffer and becomes active when control mode 10 has been activated.
It is possible to adjust directly the position of the control valve. If the value is outside of the normal range the error message ***Data Out Of Range*** is generated.

Value ***float32*** *valve control signal in percent [0...100%]*

Alarm messages	0x000c	Write	Not possible
		Read	User

Indicates the alarm messages in a bit map. The bit pattern depends on the status of the instrument and the detected alarms. If an alarm condition is no longer valid the corresponding bit is automatically erased.

Value ***uint16*** (bits 15...0)

Bit #	*Description*
Bit 0	Indicates a negative flow (flow value < 0)
Bit 1	Indicates a negative flow exceeding the backflow setpoint. The bit remains set until a positive flow is detected.
Bit 2..14	Not used
Bit 15	Hardware error Indicates a hardware error (register 0x000d). This bit is therefore an OR-function of all hardware errors.

Hardware error	0x000d	Write	Not possible
		Read	User

Indicates eventual malfunctions during operation of the instrument. This Information persists even the problem has been solved and has to be reset with the parameter (Reset hardware error).

All alarm messages are reset if the instrument is switched off and activated again at power on if an alarm persists.

Value ***uint16*** (bits 15...0)

The following table explains the individual error bits

Bit #	*Description*
0	*Power-up alarm* If the instrument is switched off with activated Power-up alarm and switched on again, then the active setpoint will be the readjusted power-up setpoint. (see parameter power-up alarm setpoint). This status will only be checked at power-up.
1	*Alarm analog setpoint* Raised if the analog setpoint is outside the valid range. This alarm is only active if the instrument is a flow controller.
2	*Zero point or leakage alarm* Raised If at a valve control signal of 0% (Valve electrically closed) a flow is measured. Possible causes are: An incompletely closed valve, internal leakage or a zero drift. This alarm is only active if the instrument is a flow controller.
3	*No gas / jammed valve alarm* Raised if at a valve control signal of 100% (valve electrically fully open) no gas flow is measured. This alarm is only active if the instrument is a flow controller.
4	*No reaction* Raised if the valve control signal is raised or lowered and no variation of the gas flow is measured. Possible causes are: Jammed valve, changed pressure conditions or valve too small (after a change of gas). This alarm is only active if the instrument is a flow controller.
5	*Sensor communication error* Raised if a communication problem occurs between the sensor and the electronic module. In this case the measurements are probably wrong.
6	*RAM check* Raised if the cyclic RAM check fails. Possible cause: Defective memory.
7	*E^2PROM access check* Raised if access errors to the E^2PROM are detected. In this case the correct function of the instrument is no longer guaranteed.
8	*Totaliser memory corrupted* Raised if the storage of the total value is no longer possible. In this case the totaliser always starts from 0 at power-on.
9	*Invalid contents in E^2PROM or empty E^2PROM*
10	*Current input overload (>25mA)*

Controller Mode	0x000e	Write	User
		Read	User

Selection of the controller mode and the source of the setpoint.

Value ***uint16***
Attempting to write another value results in the error message ***Data Out Of Range***.
The following options are possible:

Value	*Description*
0	*Automatic setpoint selection* The source of setpoint is automatically selected, i.e.: As standard the analog setpoint (voltage or current signal) is active. If a digital setpoint is sent (via Modbus) automatically the *red-y* switches to 'Digital mode' and the analog setpoint is disabled.
1	*Digital setpoint* Activates the digital setpoint via Modbus.
2	*Analog setpoint (standard setting)* Selects the analog signal as setpoint source.
10	*Direct adjustment of the valve signal* Deactivates the automatic control mode. Sets the valve control to the value of register 'valve control signal'. (0x000a..0x000b)
20	*Setpoint 0%* Sets the setpoint to 0%. The serial communication is ready for a new digital setpoint.
21	*Setpoint 100%* Sets the setpoint to 100%. The serial communication is ready for a new digital setpoint.
22	*Valve fully closed* Deactivates the automatic control mode. Sets the valve control to 0% (Valve fully closed).
23	*Valve fully open* Deactivates the automatic control mode. Sets the valve control signal to 100% (Valve fully open).
30	*Test mode analog output* Deactivates the automatic control mode and sets the valve control to 0%. Forces the analog output signal to the value in the register 'Analog output manual' (0x0028).
31	*Test mode for the DAC of the current output*

Instrument address	0x0013	*Write*	*User*
		Read	*User*

Defines the instrument address with which the instrument can be addressed within a modbus structure. Up to 247 different addresses can be assigned in a modbus system.
Attention
In a system, in which several instruments are connected with each other via modbus, all instruments must have different addresses. Otherwise communication errors occur and the system will no longer function.

Value ***uint16*** consist of two uint8
uint8 (bits15..8) are not used (should always be 0)
uint8 (bits7..0) value of the instrument address
Admissible values: 1..247
Default: 247
The error ***data out of range*** is generated when trying to define values outside of the admissible range.

Measuring range	0x0014..0x0015	*Write*	*Not possible*
		Read	*User*

Range of the measurable mass flow in mln/min for which the instrument was calibrated.

Value ***float32*** range of the measurable mass flow

Unit measuring value	0x0016..0x0019	*Write*	*Not possible*
		Read	*User*

Name of the measuring medium in plain text.

Value ***uint16 x 4*** whereby each uint16 consists of two uint8 == char8
Default value 0\ (zero) for all characters
0x0016 contains the first two characters, 0x0019 contains the last two characters. All four registers can be read independently of each other.

Name of medium	0x001a..0x001d	*Write*	*Not possible*
		Read	*User*

Name of the measuring medium in plain text.

Value ***uint16 x 4*** whereby each uint16 consists of two uint8 == char8
Default value 0\ (zero) for all characters
0x001a contains the first two characters, 0x001d contains the last two characters. All four registers can be read independently of each other.

Serial number hardware	0x001e..0x001f	*Write*	*Not possible*
		Read	*User*

Clear and unique serial number of the electronic part of the measuring instrument (print).

Value ***uint32***
Possible range 0..(2 x 10^{32}-1)

Version number hardware	0x0020	*Write*	*Not possible*
		Read	*User*

Different development stages of the print are documented with unequivocal version numbers.

Value ***uint16***

Version number software	0x0021	*Write*	*Not possible*
		Read	*User*

Different development stages of the software are documented with unequivocal version numbers.

Value ***uint16***

E²PROM actualisation	0x0022	*Write*	*User*
		Read	*User*

All settings made via modbus are saved to a volatile memory (RAM). If automatic save (Register 0x4050 storage mode of the non-volatile memory) is activated, the settings are saved immediately when written, also in the non-volatile memory (E²PROM).
There are two different types of settings / parameters:

1. *Settings, which are only saved as long as the instrument runs (connected to the supply). When next turning the instrument on/off, the default values are activated again. These settings are saved in the volatile memory.*
2. *Settings, which are also saved in case of an interruption of operations. These settings are saved in the non-volatile memory E²PROM geschrieben.*

This command permanently saves all settings of all parameters of the second kind in E²PROM. If automatic save (register 0x4050 storage mode of the non-volatile memory) is deactivated, this is the only possibility to permanently save the settings to be stored in E²PROM.

Value ***uint16***

Value	*Description*
0	*Save settings* Writes the settings from the volatile to the non-volatile memory.
>0	*Re-read settings* Reads the settings of the non-volatile memory and writes them back to the volatile memory.

Instrument name	0x0023..0x0026	*Write*	*Not possible*
		Read	*User*

Name of the instrument type / instrument code.

Value ***uint16 x 4*** whereby each uint16 consists of two uint8 == char8
Default value 0\ (zero) for all characters.
0x0023 contains the first two characters, 0x0026 contains the last two characters. All four registers can be read independently of each other.

Analog output manual	0x0028..0x0029	*Write*	*User*
		Read	*User*

The analog power output is manually set to a certain current. The possible range is 0...21,6 mA. Smaller or larger values are clipped according to these limits.
This function lets you check the connected evaluation of the of the analog measuring value.
It is possible to write and read in this register at all times. The value set in this register is first output via the current interface upon activation (register control mode 0x000e =30).
In order to return to the output of the current actual value via the analog current interface, the register (control mode 0x000e) must be reset accordingly.

Value ***float32*** current value in [mA]
Default value 0 mA

Scanning speed S	0x002d	Write	User
		Read	Userr

With a setpoint as of zero, the valve is accessed continuously and linear until a flow sets in. Afterwards, the instrument switches back to 'normal control'.
It is possible to change the speed of this continuous linear scanning process, which is proportional to the value set here.
If a smaller value is set, the scanning process takes longer. On the other hand, the overshoot tendency is lesser with smaller setpoint defaults, vice versa with large values.

Value ***uint16***
uint8 *(bits 15...8)* always zero
uint8 *(bits 7...0)* admissible range [1 – 255]

Gain factor K_P	0x002e..0x002f	Write	User
		Read	User

Gain factor K_P of the PI controller. The logic operation/function of this parameter is described further down in this manual. The following formula shows the meaning of K_P in the PI controller:

$$G(s) = \frac{K_P \times (sT_N + 1)}{sT_N}$$

A larger K_P value makes the controller more exact, faster, more aggressive and more prone to oscillations. A smaller value makes it slower and less sensitive.
The gain factor of the presently selected control parameter set is displayed.

Value ***float32*** *gain factor K_P without unit*
Default: 100
The value must be positive. The error ***Data Out Of Range*** is generated when trying to define values outside of the admissible range.

Time constant T_N	0x0030..0x0031	Write	User
		Read	User

Time constant T_N of the PI controller. The logic operation/function of this parameter is described further down in this manual. The following formula shows the meaning of T_N in the PI controller:

$$G(s) = \frac{K_P \times (sT_N + 1)}{sT_N}$$

A smaller T_N value makes the controller more exact, faster, more aggressive and more prone to oscillations. A larger value makes it slower and less sensitive.
The time constant of the presently selected control parameter set is displayed.

Value ***float32*** *time constant T_N in seconds*
Default: 0,1 s
The value must be larger than 0.0. The error ***Data Out Of Range*** is generated when trying to define values outside of the admissible range.

Feed forward F	0x0032	Write	User
		Read	User

Feed forward share of a controller. The parameters are stated in 8 bit breakdown. The logic operation/function of this parameter is described further down in this chapter.

Value ***uint16***
uint8 *(bits 15...8)* always zero
uint8 *(bits 7...0)* F share of the currently selected controller

Non-linearity N	0x0033	Write	User
		Read	User

Offset compensation share (non-linear part N) of a controller. The parameters are stated with 8 bit breakdown. The logic operation/function of these parameters is described further down in this chapter.

Remark

The N share is only active when the set setpoint is larger than zero.

Value ***uint16***
uint8 *(bits 15...8)* always zero
uint8 *(bits 7...0)* N share of the currently selected controller

Soft reset	0x0034	Write	User
		Read	Not possible

A software reset of the measuring or control instrument takes place if any chosen value is written in this register.
This returns the instrument to the state it had after its last activation.

Attention

The soft reset is first performed after the response to this command was returned to the master.

Value ***uint16***
Any value triggers reset

Selection of the control parameter set	0x0035	Write	User
		Read	User

The controller consists of altogether 5 complete control parameter sets (see the corresponding documentation). Three of these sets were defined by the manufacturer and cannot be changed by the user (so-called manufacturer control parameter sets). Two sets can be changed at wish by the user (so-called user control parameter sets).

One set is used for the current control. This setting can be saved in E^2PROM and is available again with the next activation. This set can be read, changed and re-written via modbus access. Afterwards, the controller immediately works with the modified set.

Function of the pre-defined control parameter sets:
Due to the flow end values, the correspondingly applied control valve and the pressure ratios, these sets receive different values for the parameters P, I, D, F and N. We will discuss the function of the individual parameters later on in this manual. The aim is to provide the controller with the following different properties with the three sets:

U	Fast response time with the corresponding overshooting ***(fast response)***
V	Medium response time with a low overshooting tendency. ***(standard setting)***
W	Slow response time without overshooting ***(slow response)***

Value ***uint16*** consists of two uint8
uint8 (bit 15...8) selects the control parameter set for control and activates it.
The default set is the manufacturer control parameter set V.

Selection	*Type*
0	User control parameter set A
1	User control parameter set B
2	User control parameter set U
3	User control parameter set V (default)
4	User control parameter set W
5...255	not allowed: Data Out Of Range error

Power-up alarm	0x4040	Write	User
		Read	User

Activation of the power-up alarm function
If the alarm is deactivated, the instrument behaves according to its standard or E²PROM settings after an operational disruption or reset.
The following operations are performed in case of an operational disruption or reset if the power-up alarm is activated:

- The power-up alarm setpoint (register 0x4041..0x4042) is used as the new setpoint. The last 'normal' setpoint is overwritten in this process.
- The power-up alarm bit is set to one in the register hardware error (0x000d).

However, these operations are only performed when the control mode (register 0x000e) is set to 1 (digital). Otherwise, only the alarm flag is set.
In each case, the power-up alarm bit remains on 1 until it is explicitly deleted (see description 'Hardware errors').

Value ***uint16***

Value	*Description*
0	Deactivates the power-up alarm
1	Activates the power-up alarm

Power-up alarm setpoint	0x4041..0x4042	Write	User
		Read	User

Defines the setpoint, which is to be set automatically after an operational disruption or a reset of the instrument if the power-up alarm was configured accordingly.
If this value is changed and the instrument is already in power-up alarm mode, the changed alarm setpoint first becomes effective after the next operational disruption or reset.

Value ***float32*** alarm setpoint in mln/min between 0 and end value.

Totaliser function	0x4043	Write	User
		Read	User

Defines the totaliser function. This register is bit-coded.

Value ***uint16*** (bit15..0) whereby each bit stands for a certain totaliser function.

Bit	*Value*	*Description*
0	0	Deactivates the totaliser function
	1	Activates the totaliser function If flow > zero, is totalled
1..15		No function

Totaliser scaling factor	0x4046..0x4047	Write	Not possible
		Read	User

The read-out current integral is multiplied with this factor before the value is output via the modbus.
This way it is possible to select any unit for the totaliser sum.
In local mode, calculation takes place with mln/min. Multiplication with the following factor is required in order to read out the totaliser value in ls/min:

$$F_{Skalierungsfaktor} = \frac{\Phi_{sccm} \cdot 1}{1000} = 1 \cdot 10^{-3}$$

Value ***float32***
Default 1

Totaliser unit	0x4048..0x404b	*Write*	
		Read	

Engineering unit of the totalled totaliser value

Value ***uint16 x 4*** whereby each uint16 consists of two uint8 == char8.
Default 0\ (zero) for all characters
0x4048 contains the first two characters, 0x404b contains the last two characters. All four registers can be read independent of each other.

Zero point suppression	0x0x404c..0x404d	*Write*	
		Read	

The mass flow measured in mln/min can be suppressed downwards with this register. If the mass value is smaller than the value set here, zero is output instead of the measuring value.
This value must be larger than or equal zero. If a negative value is entered, a Data Out Of Range error is generated.

Value ***float32*** unit mln/min
Preset 0 sccm

Reset hardware error	0x404f	*Write*	*User*
		Read	*Not possible*

Resets the alarm statuses of the instrument that occurred during operation. The meaning of the individual error bits are described in the register hardware errors (0x000d).
Error bits cannot be set manually as they are always a consequence of faulty operating states.
If you want to reset an error bit in the register hardware error (0x000d), the corresponding bit is set here in this register (0x404f). If a bit remains on zero, the error bit is also not changed.

Value ***uint16*** (bit15..0) whereby each bit stands for a specific error to be deleted
Bit reset (to zero): the corresponding error bit is not modified
Bit set (to one): the corresponding error bit is deleted

Storage mode E²PROM	0x4050	*Write*	*User*
		Read	*User*

Defines whether the registers that can be saved in E²PROM are automatically saved when writing or not.
If this function is activated, the register is saved in the non-volatile memory with each change of the corresponding registers.
If this function is not activated, changed register contents are only permanently saved if save take place explicitly with the command (register E²PROM actualisation).

Value ***uint16***

Value	*Description*
0	No automatic saving
1	Automatic saving activated

Backflow detection	0x4052..0x04053	Write	User
		Read	User

Defines the limit in percent of the measuring range as of which a negative flow is detected by the sensor. If the negative flow exceeds this mark, the corresponding alarm flag is set (see ModReg: *alarm messages*) and the analog output is set to 10% of the respective maximum range (0.5 V with Vmax=5 V, 2 mA with Imax=20 mA).
In order for the value set here to have an effect, the instrument function *backflow detection* must be previously set in the ModReg: *available instrument functions for users*. The value of this register can therefore also be written and read if this function was not activated.
As the instrument cannot be calibrated for negative mass flows, it is not possible to detect negative flows. Only the sensor characteristics curve is reflected and the characteristics curve is assumed to be symmetric (which is of course not exactly the case).
If invalid values are written in this register, a Data Out Of Range error is generated.

float32 the value is interpreted in percent [%] of the maximum flow value
The admissible value range is [0, 20] %
Default: 20

Signal type analog measuring value	0x4084	Write	Not possible
		Read	User

Defines the output value of the analog measuring value output.

Value ***uint16***
The error message ***Data Out Of Range*** is generated when writing other values.
The following possible defaults are available:

Value	*Description*
0	0...20 mA (0 – 5 V) linear
1	4...20 mA (1 – 5 V) linear
2	4...20 mA acc. to Namur NE43

Signal type analog setpoint	0x4085	Write	Not possible
		Read	User

Sets the format of the analog setpoint input.

Value ***uint16***
The error message ***Data Out Of Range*** is generated when writing other values.
The following possible defaults are available:

Value	*Description*
0	0...20 mA (0 – 5 V) linear
1	4...20 mA (1 – 5 V) linear
2	4...20 mA acc. to Namur NE43

Delay hardware error	0x4087	Write	User
		Read	User

Sets the minimum time in seconds during which a plausibility error has to occur constantly in operation before the corresponding error bit is set in the register hardware error (0x000d).
If normal status returns before the end of this time, the time starts at t=0s again at the next occurrence of the same error.
The following errors are checked for their plausibility during operation:

- *A flow larger than zero is measured despite a set value of 0%.*
- *No flow is measured despite a set value of 100%.*
- *Setpoint was increased, still flow does not increase.*

These three errors correspond to the error bits 2..4 in the register hardware error. So if one of these errors persists longer than the defined time, the corresponding error bit is set.

Value ***uint16*** the value is interpreted in seconds
The admissible input range is: 0...600 seconds
If the value zero is set, the corresponding error bit is set as soon as an error occurs. The maximum delay is approx. 16 ms. Please note that different effects (inertia of the control valve, pressure build-up, etc.) cause an undesired error indication.
Default: 10 seconds

Implement functions	0x4128..0x04129	Write	Not possible
		Read	User

The individual bits of these register represent different functions this instrument has. If a bit is set (1), the corresponding function is available, if the bit is deleted (0), the corresponding function is not available on this instrument.
The functions visible here depend directly on the installed software version. If a new software version is installed, which offers additional / new functions, the corresponding bits are set here.
With the registers *Available instrument functions for users*, you can block or release individual basically available functions for users.
A ***No Wrote Access error*** is generated when attempting to write in these registers.
These two registers can also be read / written individually (2 x uint16)

uint 32 consisting of 32 bits ***(bit 31...0)***

Value	*Description*
0	Controller is available
1	Totaliser is available
2	Backflow detection

Calibration data set	0x4139	Write	User
		Read	Not possible

Up to three different calibration data sets can be saved in the instrument. These may have different pressures, end values or media.

Value ***uint16***
Specifies, which data set is to be used:

Value	*Description*
1	Internal data set (do not use)
2	Standard data set
3	First optional data set
4	Second optional data set

Values outside of 1...4 generate a ***Data Out Of Range*** error.

Different Memories

The controller has three different memories respectively data sources:

- *E²PROM (configuration data, etc.)*
- *RAM (measuring values, etc.)*
- *ROM (fixed-coded data in the program)*

Saving data in the non-volatile memory

Certain register contents are saved in the non-volatile memory (E²PROM). By setting the parameter *storage mode of the non-volatile memory*, you can define whether changes to these registers are saved immediately and automatically, or whether these are initially saved in RAM (volatile memory) first.
With the parameter 'update E²PROM', you save all registers, which can be deposited at all in the non-volatile memory, in E²PROM.

Control characteristics

Control circuit structure

The controller consists of a linear and a non-linear part. The linear part of the controller consist of the following components:

- *Gain factor K_P*
- *Time constant T_N*

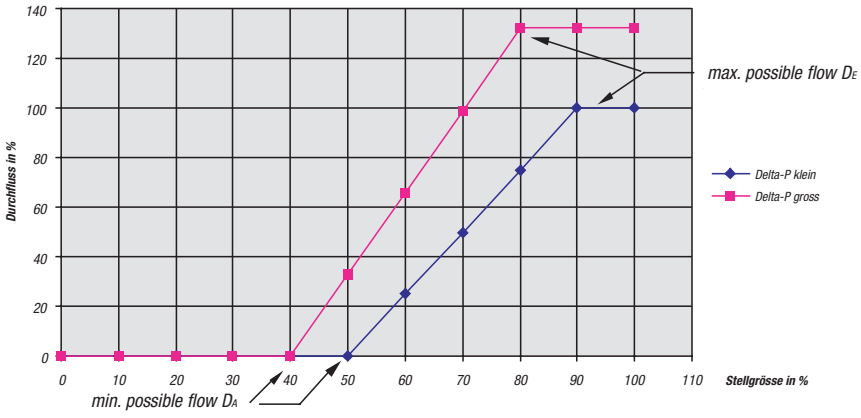
The non-linear part consists of two components:

- *Feed forward share F*
- *Offset compensation share N*
- *Scanning speed S*

Valve characteristics curve

In its work range, the valve characteristics curve has almost linear characteristics. Here, the valve does not use the entire adjustment value range from 0% to 100%. The operating points D_A (minimum possible flow) and D_E (max. possible flow) depend on the inlet pressure and the pressure difference across the valve. As mentioned, the valve behaves linear in the work range. However, because D_A is not located at 0% adjustment value, the valve behaves non-linear when seen as a whole.

Typical Valve characteristics curve



Function of the individual parameters

Non-linearity N

A linear controller (PI) only functions as intended when the distance to be controlled behaves approximately linear in the entire work section. As described above, this is not the case here.
The parameter *non-linearity N* compensates the dead zone in the area 0% to D_A%. This compensation only takes place with a setpoint default larger than zero.
With setpoint defaults larger than zero, a value generated by N is added to the controlling signal generated by the linear control algorithm. Naturally, the value N may never be larger or equal the value D_A in %. Different pressure ratios and temperature changes move the value D_A.

Minimum scanning speed S
With a setpoint jump away from zero, the valve tension has to be increased with a certain speed after reaching the N value. This speed can be influenced with this parameter. The following correlation applies:
The larger the set value, the faster the valve reaches its actual opening point, which increases the likelihood of producing an overshoot with smallest setpoint defaults. Therefore, the value should represent an optimum between the setpoint step height and the opening speed.

Feed forward share F
This share effects that the setpoint has a direct influence on the control value. It does not contribute to the control signal if the setpoint is zero. If the setpoint is larger than zero, this value is directly multiplied with the F share and the result us added to the control value.
If all remaining shares of the controller were set to zero and only the *feed forward share F* used, a direct control of the control valve results. The setpoint would simply control the valve in the range 0% – 100% opening.
Of course, the effect of F strongly depends on the pressure, as pressure changes also change the valve characteristics curve.
This way, one can largely realise a high control speed (F share) with a high control accuracy (slow PI share).

Controller setting
We recommend setting the individual controller parameters according to the following procedure:

1. Non-linearity N
2. Minimum scanning speed S
3. Gain factor K_P
4. Fime constant T_N
5. Feed forward share F

Setting the non-linearity N

1. Connect the controller electrically (warm-up time) and establish the operating conditions (pressure ratios) if possible.
2. With the software *'get red-y'*, you have access to the control parameter sets A and B.
3. Set the control parameters to the following values: S = 0; K_P = 0,001; T_N = 0,02; N = 0
4. Set the setpoint to 5% of the final value.
5. Increase the parameter N in steps of 5 until a flow sets in.
6. Set N to 80% of the detected value. N remains identical for all sets.

Setting the gain factor K_P

1. A setpoint jump from 0% to 50% is defaulted.
2. K_P is increased until the system becomes unstable with this setpoint jump. (non-abating constant oscillation with period T oscillation)
3. K_P is now set to the following value:

Optimised control	*K_P = 150% of the determined value*
Maximum speed	*K_P = 180% of the determined value*
Maximum stability	*K_P = 120% of the determined value*

Setting the time constant T_N
With the determined value for the oscillation period $T_{oscillation}$, the time constant T_N to be set can be calculated as follows:

Optimised control	*T_N = 1/12 of $T_{oscillation}$*
Maximum speed	*T_N = 1/15 of $T_{oscillation}$*
Maximum stability	*T_N = 1/9 of $T_{oscillation}$*

Setting the feed forward share F
We recommend leaving this parameter at zero.

Setting the minimum scanning speed S

1. A setpoint jump from 0% to 5% is defaulted.
2. The minimum scanning speed is increased in steps of 5 until a slight overshoot sets in with the setpoint jump.
3. The detected value can be left for an optimum control speed. For maximum stability, the set value should amount to 70% of the detected value. The following table applies for maximum speed:

Determined value in a range of	*Value to be set*
0 ... 50	200% of the determined value
51 ... 100	150% of the determined value
101 ... 195	130% of the determined value
> 195	255

Backflow Detection

General

A function is implemented as of firmware version 3.1.5, which allows the detection of negative mass flows. This function is intended for measuring instruments and only makes little sense in control operation.

Function description

If this function is activated, the mass flow metre behaves as follows:

Negative flows are detected and the corresponding alarm flags set (with and w/o hysteresis).

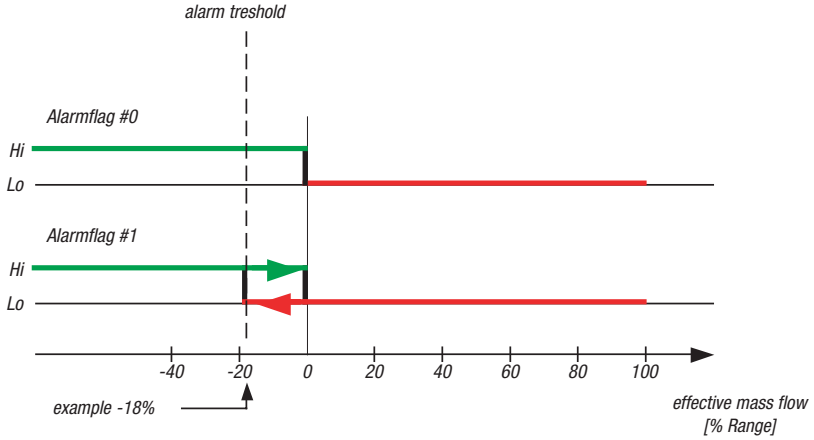
Negative flows are detected and signalled with the analog signal output (with hysteresis).

Setting the alarm threshold

With the ModReg: backflow detection, you can set an alarm threshold in the range from 0% to 20% of the maximum flow (see ModReg reference).

Digital signalling

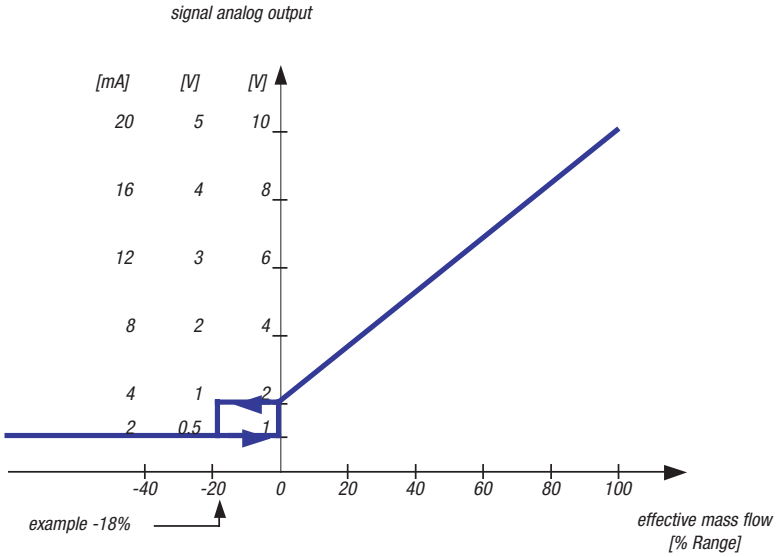
The alarm can be queried with the help of the ModReg: alarm messages. The register shows the current state of the negative mass flow with the two flags #0 and #1.



Here, the alarm threshold that can be adjusted by the user influences the hysteresis behaviour of the alarm flag #1.

Analog signalling

The analog measuring value output is also influenced in addition to alarm flag #1. Signalling with the analog output signal is only possible if a suitable signal format was selected. Possible formats are 4..20 mA, 1..5 V, 2..10 V.



If the condition for setting alarm flag #1 is fulfilled, the analog output is set to half the value of the minimum output value.

Accuracy

The accuracy of the backflow detection (switching threshold of alarm flag #1) directly depends on the symmetry of the sensor characteristics curve as well as the offset trimming.
The sensor is only calibrated for the positive flow range. This inevitably results in an inaccuracy for measuring in the negative range.

07 Software 'get red-y'

'Get red-y' is a configuration software that lets you control and change instrument parameters easily. In addition, you can check your interface cabling with *'get red-y'*, map the bus structure and modify instrument addresses if required.
We provide the software free of charge on the enclosed CD or you can download it at *http://www.red-y.com*. *'Get red-y'* works on IBM-compatible computer systems with the operating systems Windows NT/2000/98.

Installation

After inserting the CD, you can select, which programs or manuals you want to install and/or open. With a manual installation, proceed as follows:
The enclosed CD contains a directory called *'get red-y'*. Open this directory and start the program [setup.exe]. Menus guide you through the installation.

Functions

'Get red-y' provides the following function blocks:

- *Configuration of the serial computer interface*
- *Setting the program language*
- *Scanning and mapping the bus structure*
- *Integrating individual instruments into the bus structure*
- *Reading out the instrument-specific hardware and software versions*
- *Displaying the measuring value, the totaliser and the temperature of a instrument*
- *Setting setpoint values*
- *Resetting the totaliser*
- *Selecting the control parameter sets*
- *Setting the PI control parameters and checking their function mode*
- *Selecting the corresponding calibration data record*
- *Optional data recording*

Direct help

The functions within the program are described in the help menu.

08 Troubleshooting

In the following table, we have compiled possible error situations, their causes and possible remedies. If the error on your measuring or control instrument is not listed, please contact your distribution partner or return the instrument. Please observe the recommendations in the chapter 'Returns'.

If you need to open the pipe system due to the suggested measures, observe all required rinsing processes and the hazard potential of systems under pressure in general.

In the chapter 'Operation and Maintenance', you will find illustrated instructions about disassembling and cleaning the instruments. Observe the proper procedure.

Error	*Possible cause*	*Measures*
Output signal remains at 4 mA or 1 V	*No gas*	Check: - Is the gas supply working? - Are all shut-off valves open? - Are any filters clogged?
	Contamination	Open the pipe system and check it for possible contamination.
No output signal (0 mA or 0 V)	*Electric supply*	Check: - Is the supply connected and OK (+ 24 V DC)? - Are connection cables interrupted? With present digital evaluation: - Does the digital communication still work?
	Evaluation	Make sure whether there is also no signal at the input of your evaluation. Have you installed the shunt resistance (250 Ohm) with 0 – 5 V layout for your evaluation?
	Defect circuit board	In case the digital evaluation still functions, the error description can be specified further for the necessary repair. Send in the instrument as described in chapter 5.
Flow despite a setpoint of zero	*Valve leaks*	The instrument or at least the valve is contaminated. Open the pipe system and check it for possible contamination. Contact your distribution partner. Either send in the instrument for repair or exchange the control valve cartridge.
	Control circuit does not work properly	Separate the connection cables from the instrument and open the casing cover. Then pull out the valve plug, replace the cover and reconnect the connection cable. If the actual value is zero now, check the control parameters. For control purposes, select one of the provided standard sets.
	Wrong control parameters	Check the parameter N and reduce this if required.

	Defect circuit board	Send in the instrument for repair as described in chapter 5.
	Offset though installation position	A zero point offset may occur with vertical installation position and higher pressures.
No flow despite a setpoint lager than zero	*No gas*	Check: - Is the gas supply working? - Are all shut-off valves open? - Are any filters clogged?
	Contamination	Open the pipe system and check it for possible contamination.
	Control circuit does not work properly	Separate the connection cables from the instrument and open the casing cover. Check the correct position of the valve plug. Then reinstall the valve plug and reassemble the casing. If the actual value is zero now, check the control parameters. For control purposes, select one of the provided standard sets.
	Control parameters	Check the control parameters and use one of the provided standard sets for control purposes.
	Defect circuit board	Send in the instrument for repair as described in chapter 5.
Actual value smaller than setpoint	*Gas supply*	Check the gas supply. Does the pressure P1 specified on the type plate correspond to the actual one? Did you observe the recommendations for dimensioning the pipe system?
	Contamination	Open the pipe system and check it for possible contaminations including the installed filters. If you detect contamination, check the instrument as well. If you think the valve is contaminated as well, contact your service representative. Send in the instrument for repair or obtain a new control valve cartridge.
	Control parameters	Check the control parameters and use one of the provided standard sets for control purposes.
Actual value unstable	*Gas supply*	Check the gas supply for constant pressure or any elements that destabilise the system. Did you observe the recommendations for dimensioning the pipe system?
	Contamination	Open the pipe system and check it for possible contaminations including the installed filters. If you detect contamination, check the instrument as well. If you think the valve is contaminated as well, contact your distribution partner.

Control unstable	*Gas supply*	Check the gas supply for constant pressure or any elements that destabilise the system. Especially a too small dimensioned pressure reduction can produce very negative influences. With very small flows with an oversized gas supply, sporadic pressure changes (ON-OFF function pressure reduction) can also lead to unstable pressure characteristics. Did you observe the recommendations for dimensioning the pipe system?
	Contamination	Open the pipe system and check it for possible contaminations including the installed filters. If you detect contamination, check the instrument as well. If you think the valve is contaminated as well, contact your service representative. Send in the instrument for repair or obtain a new control valve cartridge.
	Setpoint default unstable *Control parameters*	Check the setpoint default. Check the control parameters and use one of the provided standard sets for control purposes.
Flow doesn't meet expectations	*Conversion factor not considered*	Check the gas type specified on the type plate. If it does not correspond to the one that is actually used, you have to consider the corresponding conversion factor. You can check the programmed gas type with the software *'get red-y'*.
	Contamination	Open the pipe system and check it for possible contaminations including the installed filters. If you detect contamination, check the instrument as well. In case of contamination in the flow division section, the displayed flow is higher than the actual one, vice versa when the measuring channel is contaminated. If you think the valve is contaminated as well, contact your service representative. Send in the instrument for repair or obtain a new control valve cartridge.
	Leak	Do not use any liquid leak detector liquids for determining leaks inside the instrument. Helium leak detectors or gas sniffers are ideal. If you suspect a leak inside the measuring instrument, contact your service representative or send in the instrument for repair.

Control parameters cannot be changed	*No more communication*	Check the communication.
	Wrong parameter set	Select the correct parameters sets.
Substantial heat build-up on the control casing	*Setpoint default without gas supply*	Try to avoid this state over longer periods if possible. Your instrument might get damaged in the long run.
	Control parameters	Check the control parameters and use one of the provided standard sets for control purposes.

09 Accessories

Cables & Modules

Type	Part Number	Description / Lenght / Use
PDM	**328–2150**	***Power Digital Module (1.5m)*** *Communication cable PC/red-y* *(passive level converter RS232/RS485)*
BAM	**328–2151**	***Bus Analog Module (0.1m)*** *Digital communication combined with pluggable screw terminals for analog signals*
PSM	**328–2152**	***Power Separator Module*** *Power module with power separator for additional power supply PSD*
PAM	**328–2153**	***Power Analog Module*** *Operation with analog signals only (pluggable screw terminals)* *Powered by power supply PSD*
BEC	**328–2160 0.5m** **328–2161 2.0m** **328–2162 5.0m**	***Bus Extension Cable*** *Extension cable for digital communication and analog signals*
BFC	**328–2163**	***Bus Feeder Cable (2.0m)*** *Junction cable PCU/red-y* *Fixing screws om both sides*
BTM	**328–2139**	***Bus Terminator Module*** *Termination resistor for bus communication*
PAC	**328–2164**	***Power Analog Cable (3.0m)*** *Loose ends: For analog operation of the controller*
PDC	**328–2165**	***Power Digital Cable (3.0m)*** *Loose ends: For analog and digital operation of meter or controller with external converter RS232/RS485*

Power Supply

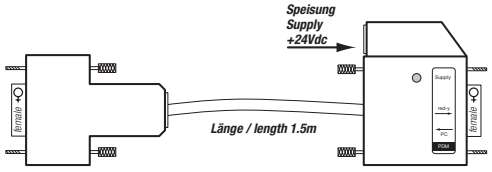
PSD	**328–2234**	***Power Supply Device, Euro-Version*** *Plug-type power supply 24V, 0.3A (8W)* *Secondary side plug: dia. 2.1/5.5mm*
PSD	**328–2233**	***Power Supply Device, Euro-Version*** *Plug-type power supply 24V, 2.2A (53W)* *Secondary side plug: dia. 2.1/5.5mm*

Cables & Modules: Circuit Diagramm/Signal Flow

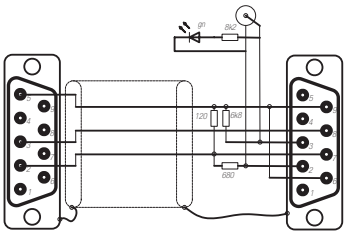
PDM 328–2150

Power Digital Module (1.5m)

Communication cable PC/red-y
(passive level converter RS232/RS485)
Power Supply with PSD



Circuit diagram



Signal flow

Supply

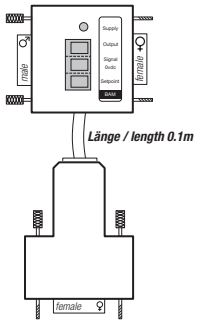
Bus
(digital
Communication)

BAM 328–2151

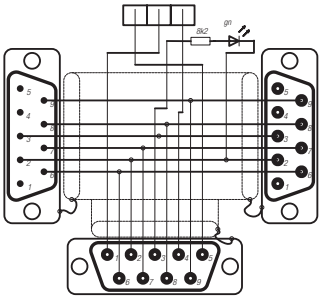
Bus Analog Module (0.1m)

Digital communication combined with pluggable screw terminals for analog signals

Pluggable screw Type Phoenix 3 MCVR 1,5/3-ST-3.81
contact spacing 3.81mm, 3 pole
max. cable cross section 1.5mm²



Circuit diagram



Signal flow

Supply

Bus
(digital
Communication)

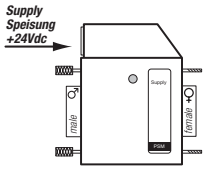
Output

Setpoint

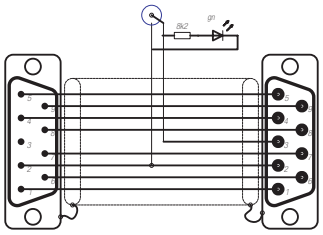
PSM 328–2152

Power Separator Module

Power module with power separator for additional power supply PSD



Circuit diagram



Signal flow

Power

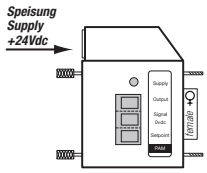
Bus (digital Communication)

PAM 328–2153

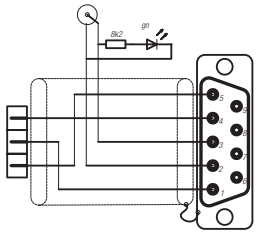
Power Analog Module

Operation with analog signals only (pluggable screw terminals)
Powered by power supply PSD

Pluggable screw Type Phoenix 3 MCVR 1,5/3-ST-3.81
contact spacing 3.81mm, 3 pole
max. cable cross section 1.5mm²



Circuit diagram



Signal flow

Supply

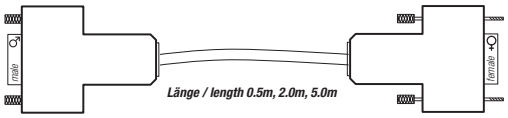
Signal

Setpoint

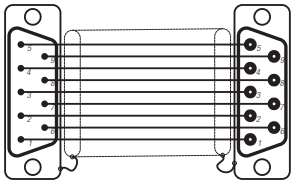
BEC **328–2160 0.5m**
328–2161 2.0m
328–2162 5.0m

Bus Extension Cable

Extension cable for digital communication and analog signals



Circuit diagram



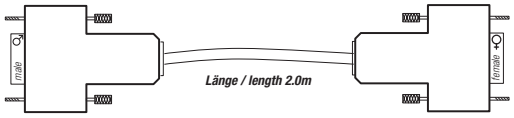
Signal flow

Power
Bus
Output
Setpoint

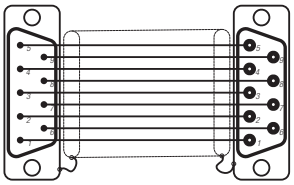
BFC **328–2163**

Bus Feeder Cable (2.0m)

Junction cable PCU/red-y
Fixing screws om both sides



Circuit diagram



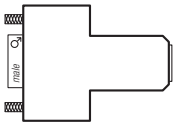
Signal flow

Power
Bus
Output
Setpoint

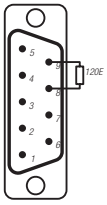
BTM **328–2139**

Bus Terminator Modul

Termination resistor for bus communication

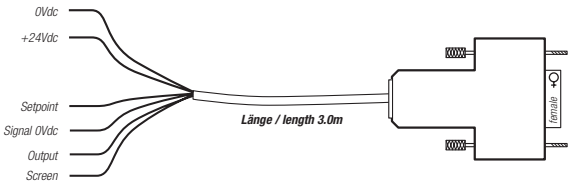


Circuit diagram



PAC 328–2164 Power Analog Cable (3.0m)

Plug-type power supply 24V, 0.35A (8W)
Secondary side plug: dia. 2.1/5.5mm
PVC-Cable, grey 3m, 5x0.25mm², shielded
stripped wire 10cm

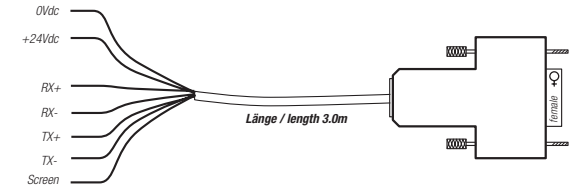


Sub D plug, 9 pole, female

2	0Vdc	brown
3	+24Vdc	white
1	Signal 0Vdc	grey
4	Output	green
5	Setpoint	yellow
	Screen	violet

PDC 328–2165 Power Digital Cable (3.0m)

Plug-type power supply 24V, 1.25A (30W)
Secondary side plug: dia. 2.1/5.5mm
PVC-Cable, grey 3m, 6x0.25mm², shielded
stripped wire 10cm



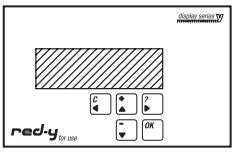
Comms. converter RS232/RS485

Sub D plug, 9 pole, female

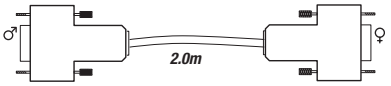
2	0Vdc	brown
3	+24Vdc	white
6	Tx+	green
7	Tx-	yellow
8	Rx-	grey
9	Rx+	pink
	Screen	violet

Connection examples

Connection of one meter or controller



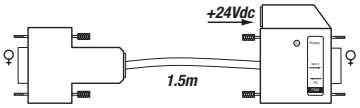
PCU100/800



BFC

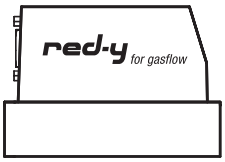
Powered by PCU

PC/RS232



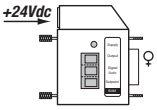
PDM

Powered by PSD power supply



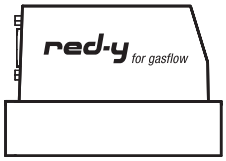
red-y

Operation with analog signals



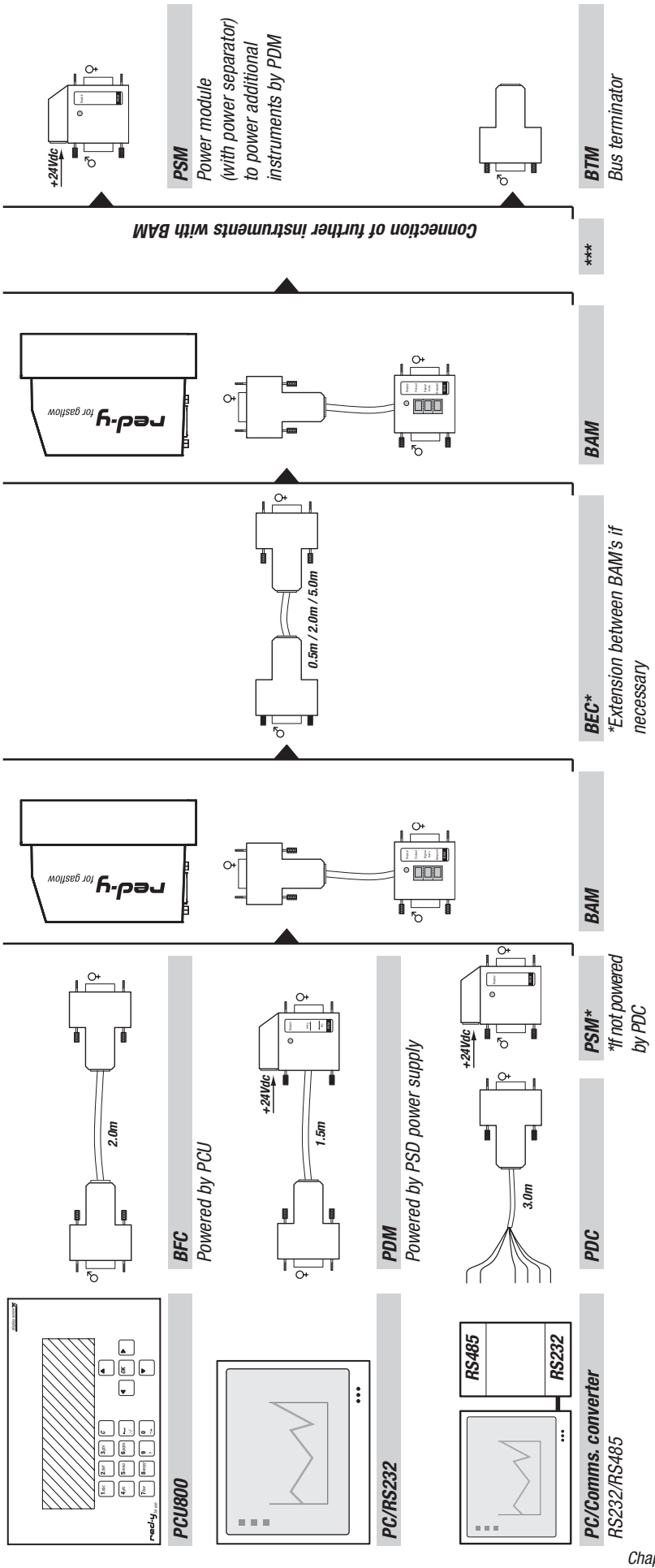
PAM

Pluggable screw terminals (setpoint, signal 0 Vdc, output) powered by PSD power supply



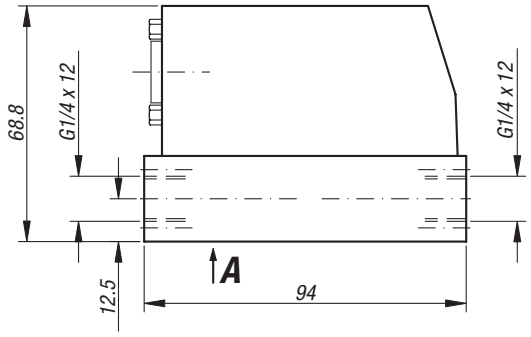
red-y

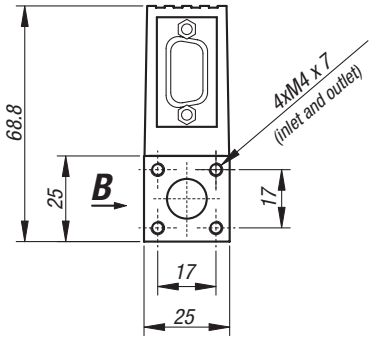
Connection of multiple meters or controllers



10 Dimensions

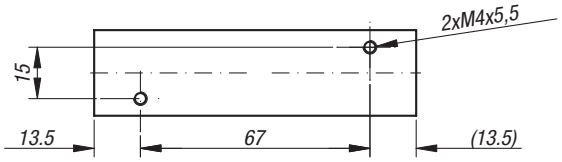
Dimensions smart meter G1/4”



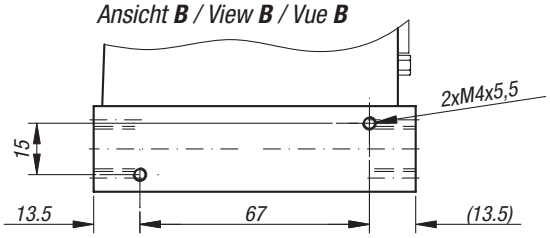


Befestigung / Mounting / Fixation:

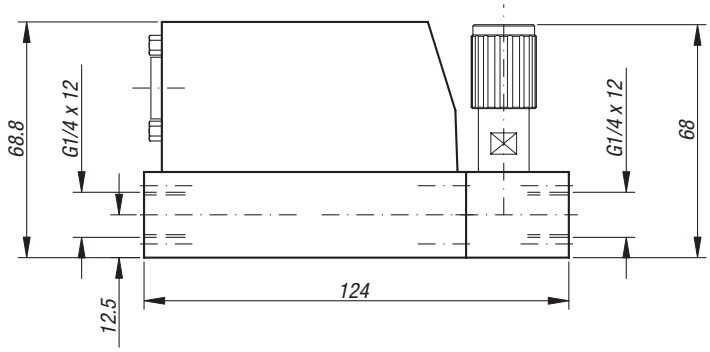
*Ansicht **A** / View **A** / Vue **A***

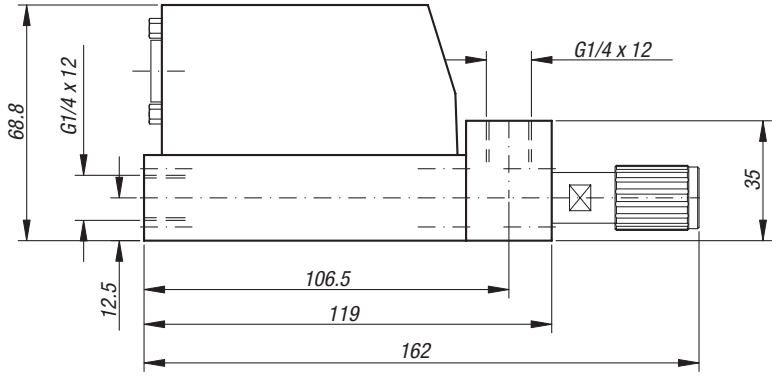


*Ansicht **B** / View **B** / Vue **B***

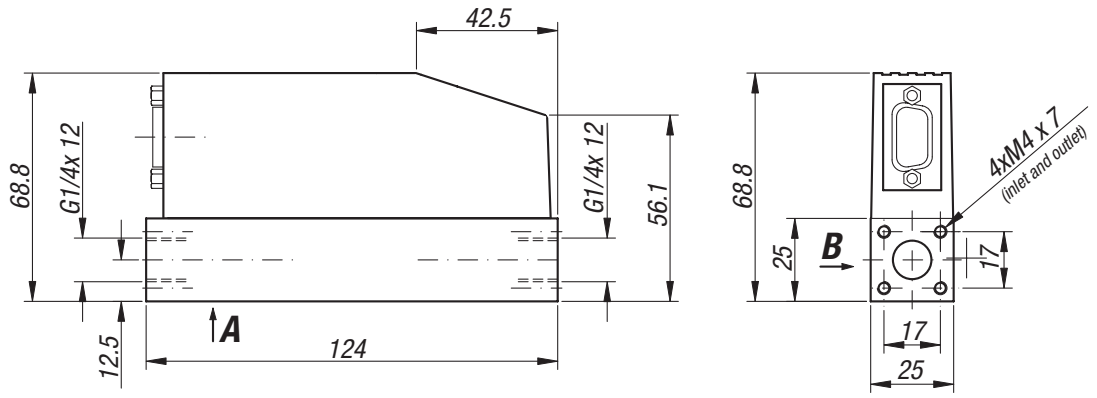


Mit Handregelventil / With manual valve / Avec vanne manuelle:

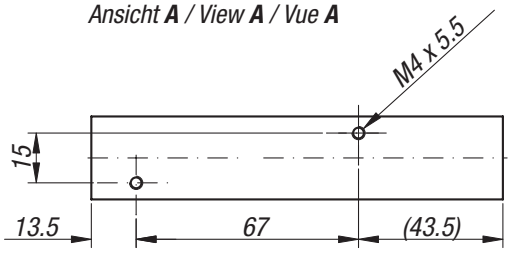




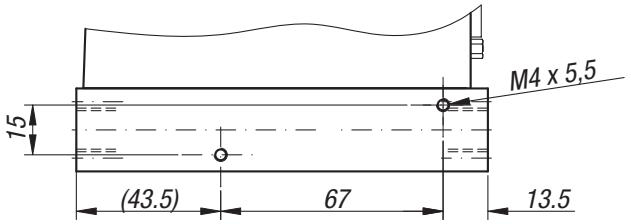
Dimensions smart controller G1/4”



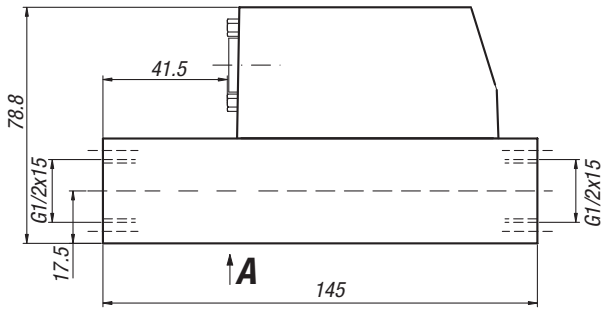
*Ansicht **A** / View **A** / Vue **A***

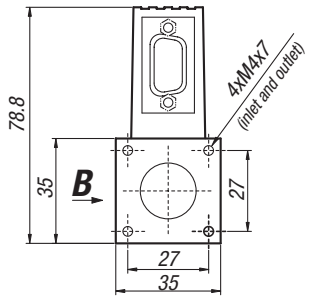


*Ansicht **B** / View **B** / Vue **B***



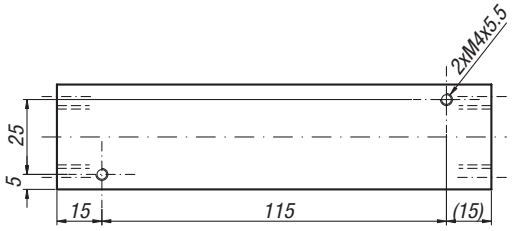
Dimensions smart meter G1/2”



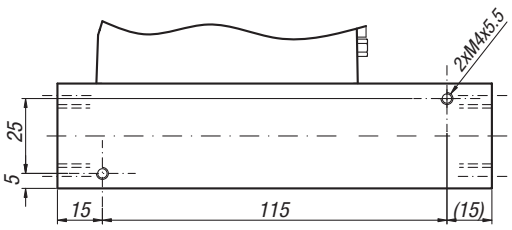


Befestigung / Mounting / Fixation:

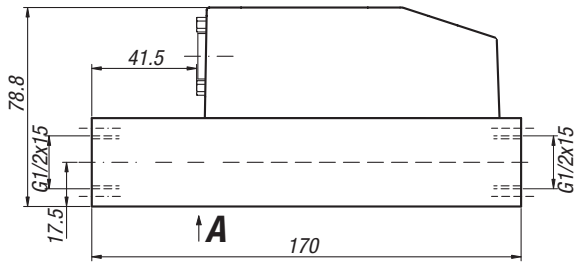
*Ansicht **A** / View **A** / Vue **A***

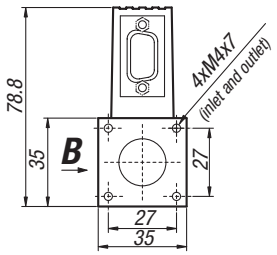


*Ansicht **B** / View **B** / Vue **B***



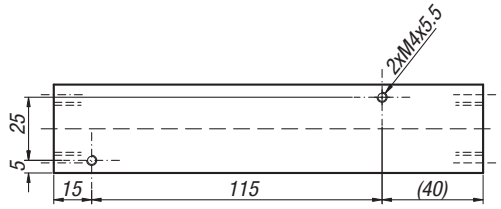
Dimensions smart controller G1/2”



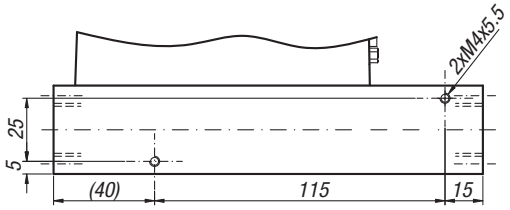


Befestigung / Mounting / Fixation:

*Ansicht **A** / View **A** / Vue **A***

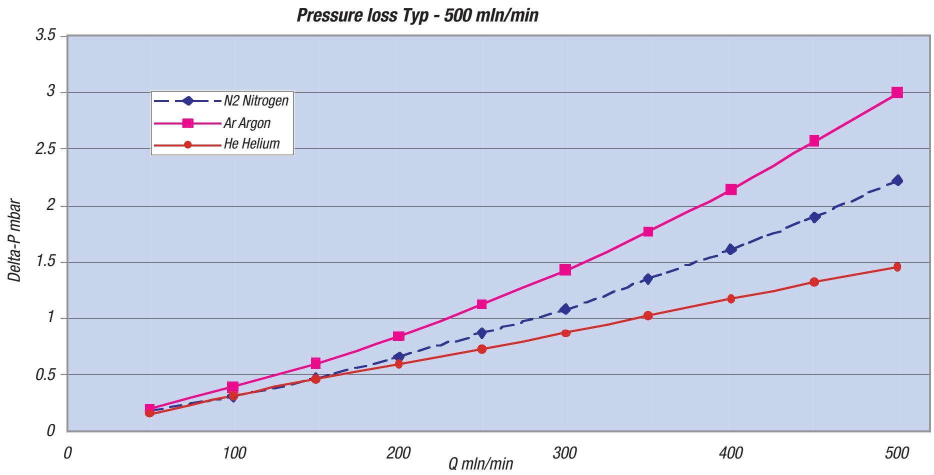


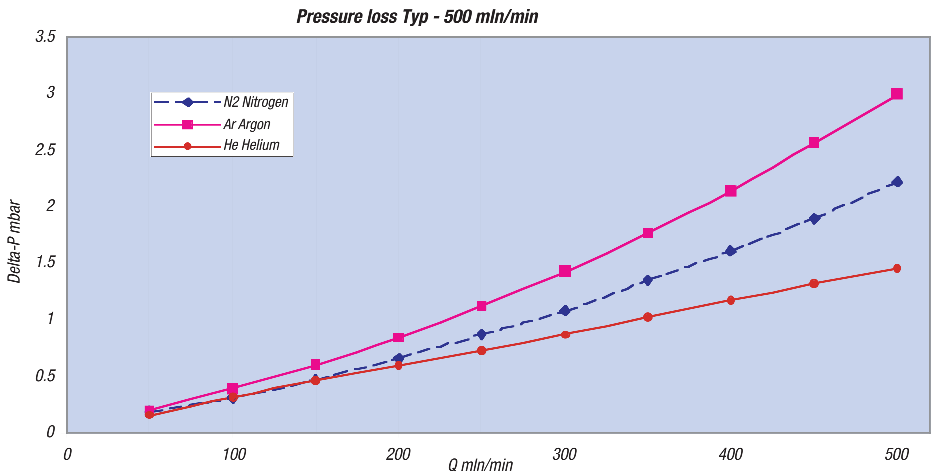
*Ansicht **B** / View **B** / Vue **B***

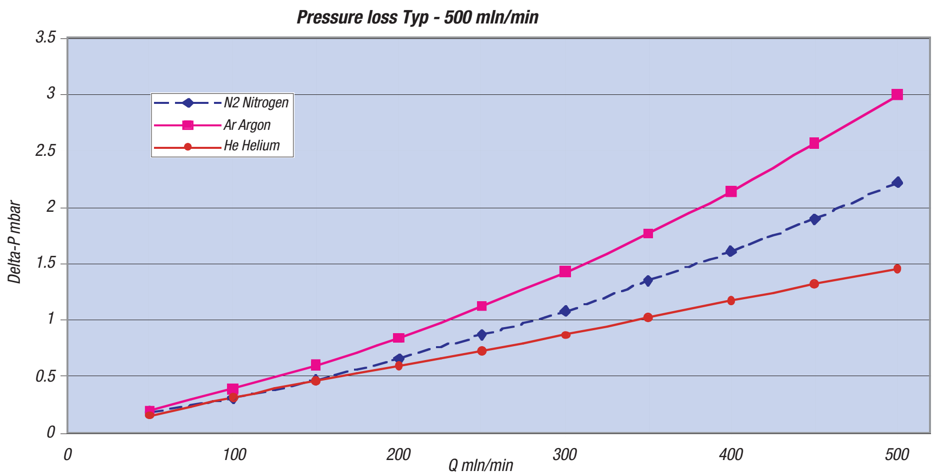


11 Annexe

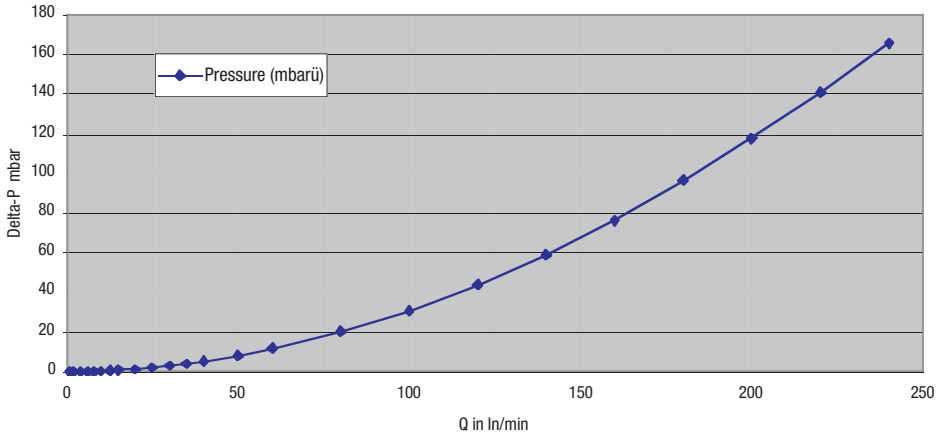
Pressure Loss







Pressure loss - 200 ln/min



Gas Conversion Factors

Name	Chem. Symbol	Density(g/l) 0°C, 1 bar a	Conversion factor	Comments
Air	Air	1.293	0.998	
Oxygen	O2	1.429	0.992	absolutely free from oil & grease
Nitrogen	N2	1.250	1	
Helium	He	0.1785	ca. 9	
Argon	Ar	1.784	1.27	
Carbondioxide	CO2	1.977	0.70	
Hydrogen	H2	0.08991	ca. 10	
Methane	CH4	0.7175		
Propane	C3H8	2.012	0.32	
Nitrousoxide	N2O	1.978		
Sulfur Hexafluoride	SF6	6.626		
Propylene	C3H6	1.915		
Carbonmonoxide	CO	1.25		
Butane	C4H10	2.705		

The conversion factors given are approximative values and should only be used to determine a new range.

Example

New range: 3 ln/min CO2
Conversion factor: 0.70
Equivalent range with air: 3 / 0.7 = 4,28 ln/min

Type Code

Basic Task		G	gasflow	
Series		S	smart series	
Function		M	Meter	
		C	Controller	
		F	Flowmodul meter	
		D	Dualmodul controller	
Measuring Range (Air)		A1	25 mln/min	G1/4", 25x25
		A2	50 mln/min	
		A3	100 mln/min	
		A4	200 mln/min	
		A5	500 mln/min	
		A9	Customer specific	
		B2	500 mln/min	
		B3	1'000 mln/min	
		B4	2'000 mln/min	
		B5	5'000 mln/min	
		B9	Customer specific	
		C2	5 ln/min	
		C3	10 ln/min	
		C4	20 ln/min	
		C5	50 ln/min	
		C9	Customer specific	
		D2	50 ln/min	G1/2", 35x30
		D3	100 ln/min	
		D4	200 ln/min	
		D9	Customer specific	
Class		S	Standard, +/-1.5% of full scale, 1:30	
		T	Hi-Performance +/-0.3% of full scale +/-0.5% of reading, 1:100	
		K	Customer specific, OEM	
Materials Body and Seals		A	Aluminium, FKM *	
		B	Aluminium, EPDM	
		S	Stainless Steel, FKM *	
		T	Stainless Steel, EPDM	
		N	Without Body	
		K	Customer specific, OEM	
Signals	Output Signals	A	Current 4 - 20 mA Namur NE 43	
		B	Current 4 - 20 mA *	
		C	Current 0 - 20 mA	
		D	Voltage 0 - 5 V	
		E	Voltage 1 - 5 V	
		F	Voltage 0 - 10 V	
		G	Voltage 2 - 10 V	
		K	Customer specific	
	Input Signals	A	Current 4 - 20 mA Namur NE 43	
		B	Current 4 - 20 mA *	
		C	Current 0 - 20 mA	
		D	Voltage 0 - 5 V	
		E	Voltage 1 - 5 V	
		F	Voltage 0 - 10 V	
		G	Voltage 2 - 10 V	
		K	Customer specific	
		N	No Input Signal	
Valve	Automatic valve for controller (defined by manufacturer)	21	Nozzle 0.1 mm	
		22	Nozzle 0.2 mm	
		24	Nozzle 0.8 mm	
		12	Nozzle 4.5 mm	
		88	Valve not defined	
		99	Customer specific	
		00	No valve	
Code		**G**	**S**	**C -** **B2** **S** **A -** **A** **N** **05**

** = Standard*

Contamination Statement

With return of devices, please fill out the following statement completely, especially the reason for the return, the type of residue and cleaning in the case of soiling, as well as indication of hazards.

Devices

Type Code: .....

Serial number: .....

Reason for the return:

.....

.....

.....

Type of contamination

Device came in contact with: .....

Cleaned by us with: .....

For the protection of our employees and for general safety during transport, proper cleaning and the use of an appropriate packing are mandatory.

Can you provide any further information on the contamination?

- ☐ inert (no danger)
- ☐ corrosive
- ☐ caustic
- ☐ must not come in contact with moisture
- ☐ oxidizing
- ☐ other hazard

.....

Legal Declaration

We hereby affirm the accuracy and completeness of the above information.

Company: .....

Address: .....

Telephone: .....

Contact person: .....

Date: .....

Signature: .....

On behalf of the entire red-y for gasflow team, we thank you for your understanding.