ANALYT MESSTECHNIK



OPERATING MANUAL

Aalborg ZFM Digital Mass Flow Meter

Installation, wiring, operation, gas and range set-up, calibration and maintenance of the Aalborg ZFM 17 digital thermal mass flow meter.

AMTC-MN-0016

About this manual

This manual is for everyone who installs, configures, calibrates or maintains an Aalborg ZFM 17 digital mass flow meter. It covers the ZFM 17 only, the model for flows up to 10 sL/min; larger ZFM models have other ranges and fittings and are not described here. It explains how to plumb and wire the meter, read its display, choose the gas, range and units, set up alarms, totalisers and outputs, rescale the meter to another gas, and keep it clean and in calibration.

If the meter is new to you, read Safety (p. 7) first, then follow Installation (p. 12) with the electrical connections (p. 13), Commissioning (p. 17) and Operation (p. 18) in that order. The Specifications (p. 38), the serial commands (p. 47) and the gas conversion factors (p. 53) are reference material.

Some meters have no display. On those, everything the display menus do can be done from a computer with the ZFM Configuration Utility or with serial commands; the push button on the side covers reset, zeroing and totaliser reset (Push button (p. 24)).

Keep this manual for the lifetime of the product. The current revision is on the product page at analyt-mtc.com.

Conventions in this manual:

- Keys, buttons and menu entries are printed like this: **ENT**.
- A menu path such as **Totalizer Settings** › **Totalizer #1** means that you open each entry in turn.
- Commands you send and replies the device returns are set in monospace type, for example `Z`, `N`.

Abbreviations

Abbreviation	Meaning
ADC	Analogue-to-digital converter
ASCII	American Standard Code for Information Interchange, the character set of the serial commands
CPU	Central processing unit, the processor of the meter
CRC	Cyclic redundancy check
DAC	Digital-to-analogue converter
DRC	Dynamic response compensation of the flow signal
EEPROM	Electrically erasable programmable read-only memory
EMC	Electromagnetic compatibility
FFKM	Perfluoroelastomer
FKM	Fluoroelastomer
OLED	Organic light-emitting diode
PI	Process information, the measurement screens of the display
PTFE	Polytetrafluoroethylene
RTS	Request to send, a serial handshake line
RTU	Remote terminal unit, the Modbus transmission mode the meter uses
SAR	Successive approximation register, a type of analogue-to-digital converter
SD	Sigma-delta, a type of analogue-to-digital converter

Abbreviation	Meaning
TD	Transmit data, a serial line
UART	Universal asynchronous receiver-transmitter, the serial interface chip

Safety notices in this manual

⚠ WARNING

A hazardous situation which, if not avoided, could result in death or serious injury.

NOTICE

Practices not related to personal injury — damage to the product, the process or the sample.

Note
Information that helps understanding; never a hazard.

Conventions

- **FS** is full scale, the top of the range the active gas table is set to; **RD** is the reading.
- Flows are standard flows: nitrogen at 21.11 °C, 1013.25 mbar unless stated otherwise. sL/min is standard litres per minute.
- Menu names and screen texts are printed as the meter shows them, for example **`Sensor Zero Calibr.`** Joystick moves are **`UP`**, **`DN`**, **`LEFT`** and **`RIGHT`**; pressing the joystick is **`ENT`**.
- Pin numbers such as “pin 4” refer to the 9-pin D-sub connector (pin assignment (p. 13)).

Document information

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CHAPTER 1

Safety

Read this page before you connect gas or power, and follow the procedures in this manual. Each point is repeated, with its context, in the section where it applies.

Intended use

The ZFM measures the mass flow of clean, dry gases within the pressure, temperature and flow limits given in Specifications (p. 38) and on its label. It does not measure liquids and it does not control the flow.

⚠ WARNING

The ZFM is not designed for life-support applications or any use in which a malfunction of the meter could cause personal injury. In such a use, a malfunction could injure a person. Do not use the ZFM for such applications: anyone who uses or sells it for them does so at their own risk.

⚠ WARNING

A meter that was not cleaned and prepared for oxygen service is a hazard in oxygen applications. Using it with oxygen can cause damage or personal injury. Do not use the meter on oxygen unless it was specifically cleaned and prepared for oxygen service at the factory. Ask Analyt-MTC before you order a meter for oxygen.

Pressure, gas and materials

NOTICE

A pressure above 34.47 bar (500 psia) in the gas line is a hazard to the meter. Higher pressure seriously damages the flow sensor. Keep pressure and temperature within the ratings, with a margin for spikes and surges, and protect high-pressure systems with relief valves or burst discs.

NOTICE

The wetted materials (Materials and connections (p. 39)) do not resist every gas. There is no guarantee of corrosion resistance. A gas that corrodes the wetted materials can damage the meter. Choose a model and seal material that suit your gas: that choice is the responsibility of the user. Ask Analyt-MTC if you are unsure.

NOTICE

Liquids and particles in the gas block the capillary sensor tube and the narrow channels of the flow element. Filter contaminated gases upstream of the meter.

Electrical work and service

NOTICE

A supply above 26 V DC, an external voltage on the 4–20 mA output or a wiring error can damage the meter or make it malfunction. Never apply more than 26 V DC, and never connect an external voltage source to the 4–20 mA output, which powers its own loop. Switch the power off before you connect or disconnect any cable, and check wiring and polarity before you switch it on.

NOTICE

Some of the integrated circuits are sensitive to electrostatic discharge. A discharge can damage them. Wear a grounded wrist strap when you adjust or service the meter.

⚠ WARNING

A meter that has carried toxic, corrosive, infectious or radioactive media can hold residues. Residues endanger the people who open it. Before any meter is cleaned, serviced or returned, purge it and neutralize all residues. Confirm the safety declaration in the service request (Returning a meter (p. 44)).

CHAPTER 2

Product description

The ZFM 17 is a digital thermal mass flow meter for gases up to 10 sL/min. Its gas and full-scale range can be changed on site, so one meter can serve several applications without going back to a calibration laboratory.



Figure 2-1. ZFM 17 with display, aluminium body.

How the ZFM measures

Inside the flow body the gas stream divides. A small share flows through a capillary stainless-steel sensor tube; the rest passes the restrictor flow element (RFE) in the main channel. Both paths keep the flow laminar, so the flow in the sensor tube stays in a fixed proportion to the total flow.

A precision-wound heater coil warms the middle of the sensor tube. Two identical resistance windings sit symmetrically upstream and downstream of it. Flowing gas carries heat from the upstream winding to the downstream one, which becomes warmer and so changes its resistance. The difference between the two resistances is proportional to the mass flow through the sensor tube, and therefore to the total mass flow.

A 32-bit microprocessor turns this signal into the flow reading and drives the outputs. Non-volatile memory holds the hardware settings and all calibration tables.

Gas tables

The meter converts the sensor signal into flow through a calibration table, called a gas table. It has three kinds:

Gas table	What it is	Who can change it
Primary table (P)	The factory calibration with nitrogen. All other tables are derived from it or calibrated against it.	Factory only; never selectable
Main table (M0)	The working table as ordered: your gas and full-scale range, derived from the primary table with empirical conversion curves for each model.	You, by rescaling with the ZFM Configuration Utility (Rescaling the main gas table (p. 29))

Gas table	What it is	Who can change it
User tables (U1–U10)	Ten further tables for other gases or ranges. They read **NOT CALIBRATED** unless calibrations were ordered.	You, by calibrating against a flow standard (User gas table calibration (p. 31))

The main table can be rescaled to nitrogen, air, oxygen, argon, helium or carbon dioxide, at any full-scale value between the minimum and maximum of the meter's range in Table 2-1. Rescaling is supported up to 8 bar. For other gases the meter can apply a conversion factor (K factor) to the reading (K factors (p. 20)).

Flow ranges

Table 2-1 ZFM 17 flow ranges (nitrogen)

Nominal range, sL/min	Full scale can be set from … to …, sL/min
0.0125	0.003125–0.0125
0.05	0.0125–0.05
0.2	0.05–0.2
0.8	0.2–0.8
2.0	0.5–2.0
6.0	1.5–6.0
10.0	2.5–10.0

Ranges are standard flows of nitrogen at 21.11 °C, 1013.25 mbar. For another gas the limits change with its conversion factor; the ZFM Configuration Utility shows the valid limits for the gas you select.

Display, controls and connectors

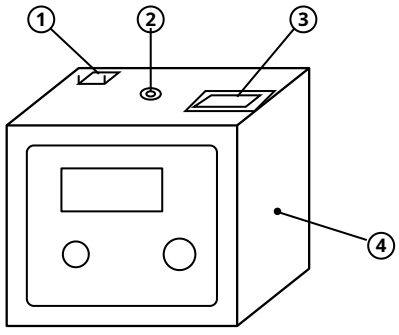


Figure 2-2. Connectors on top of the meter and the push-button hole on its right-hand side.

#	Connector or control
1	RJ45 socket for the Modbus RTU network (option)
2	3.5 mm jack for the RS-232 interface (RS-485 as an option), used for configuration and calibration
3	9-pin D-sub connector for power, analogue output and relay
4	Multi-function push button, behind a small hole in the right-hand side

Meters with a display have a 128 × 64 pixel yellow OLED screen, an **Esc** button and a five-way joystick on the front. Every meter has a two-colour status LED that shows warm-up, alarms and faults (Status LED (p. 24)).

What the meter can do

- Show the flow in percent of full scale, in 45 volumetric or mass units, or in a unit you define (Appendix A (p. 46)).
- Count the delivered gas on two independent totalisers, and give pulses proportional to the flow.
- Raise a low, high or out-of-band flow alarm with delay and latching.
- Switch one solid-state relay on an alarm, a totaliser limit, the pulse output or an event.
- Output 0–5 V DC, 0–10 V DC or 4–20 mA, selectable at the meter.
- Apply conversion factors for 26 stored gases or one factor you enter.
- Zero itself automatically, and monitor its own electronics and sensor through diagnostic events.

Supplied items and accessories

Each meter comes with an electrical connection kit: a 2.5 ft shielded 9-pin extension cable and a screw-terminal block with cover for field wiring. A meter with an RS-232 interface also comes with a 6 ft cable from the 3.5 mm plug to a 9-pin female D-sub; a meter with RS-485 comes with a 6 ft cable from the 3.5 mm plug to stripped wire ends.

The accessories available, such as power supplies, cables and adapters, are listed in Table 11-3 under Accessories (p. 43).

CHAPTER 3

Installation

Unpack and check the meter, choose a stable place for it, then connect it to the gas line in the direction of the flow arrow. Then wire it as described in Electrical connections (p. 13).

Unpacking

1. Before you open the carton, check it for damage. If it is damaged, report it to the carrier at once.
2. Open the carton from the top and check the meter for hidden transport damage. Report any damage to the carrier and send Analyt-MTC a copy of the damage report.
3. Check the contents against the packing list and report anything missing straight away. Each meter comes with an electrical connection kit: a 2.5 ft shielded 9-pin extension cable and a screw-terminal block with cover for field wiring. A meter with an RS-232 interface also comes with a 6 ft cable from the 3.5 mm plug to a 9-pin female D-sub; a meter with RS-485 comes with a 6 ft cable from the 3.5 mm plug to stripped wire ends.

Choosing the location

The meter is calibrated with its flow path horizontal. Keep it within ±15° of that position to keep the original accuracy; in any other orientation you will need to zero it again (Zeroing the sensor (p. 28)) and possibly recalibrate it.

Choose a place free of sudden or frequent temperature changes, high humidity, draughts and vibration, away from hot or corrosive surroundings and strong radio-frequency or magnetic fields.

Pressure and gas quality

NOTICE

A pressure above 34.47 bar (500 psia) in the gas line is a hazard to the meter. Higher pressure seriously damages the flow sensor. Install the meter only in lines that stay within its pressure and temperature ratings, allow a safety margin for spikes and surges, and fit pressure relief valves or burst discs in high-pressure systems.

Only clean gas may enter the meter. A 50 µm filter screen in the inlet protects the flow path, but it is a last line of defence: fit a particle filter upstream of the meter in every installation, and filter contaminated gases so that nothing reaches the sensor.

⚠ WARNING

A meter that was not cleaned and prepared for oxygen service is a hazard in oxygen applications. Using it with oxygen can cause damage or personal injury. Do not use the meter on oxygen unless it was cleaned and prepared for oxygen service at the factory.

Connecting the gas line

The standard meter has 1/4" compression fittings on inlet and outlet; 1/8" and 3/8" compression, 6 mm compression and 1/4" VCR® fittings are options. Leave the fittings in place: remove them only to clean the meter or to recalibrate it for a new range.

1. Inspect the tubing, ferrules and fittings for dust and other contamination, and clean them if necessary.
2. Note the flow arrow on the front of the meter. Gas must flow in the direction of the arrow.
3. Push the tubing into each compression fitting until it rests against the shoulder inside the fitting.

NOTICE

Overtightening can damage the compression fittings beyond repair. Do not overtighten them.

4. Tighten each compression fitting by one and a quarter turns, as the fitting manufacturer specifies.
5. Leak-test the installation before you apply operating pressure.

Electrical connections

Power, the analogue output and the relay share the 9-pin D-sub connector. The digital interface has its own 3.5 mm jack, and the Modbus option an RJ45 socket (Figure 2-2, p. 10).

NOTICE

A wiring error can damage the meter or make it malfunction. Switch the power off before you connect or disconnect any cable or wire. Check the wiring and the polarity of the supply before you switch it on.

9-pin D-sub connector

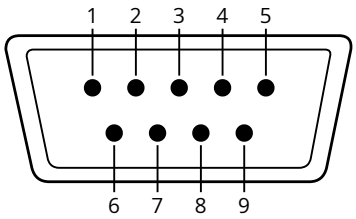


Figure 3-1. 9-pin D-sub connector of the meter (male), seen from the front.

Table 3-1 Pin assignment

Pin	Function	Notes
1	Reserved	Factory use only. Do not connect.
2	Analogue output (+), 0–5 V DC, 0–10 V DC or 4–20 mA	Output only: never apply an external voltage or current. Observe the load limits.
3	Analogue output return (–) for 0–5 and 0–10 V DC	Return for pin 2 when a voltage output is active
4	Power supply (+)	14–26 V DC
5	Power supply common (–)	
6	Analogue output return (–) for 4–20 mA	Return for pin 2 when the current output is active
7	Reserved	Factory use only. Do not connect.
8	Relay contact 1	Solid-state relay, single-pole, normally open. Maximum 48 V (AC peak or DC) and 400 mA.
9	Relay contact 2	

Note

Most D-sub connectors follow the standard numbering, but some mating connectors are numbered differently. Wire by the pin positions in Figure 3-1, whatever numbers your mating connector shows.

Power supply

Connect a regulated, single-polarity 14–26 V DC supply between pin 4 (+) and pin 5 (−). The supply must deliver at least 200 mA and its ripple must stay below 100 mV peak to peak. The meter itself draws at most 100 mA at 24 V DC; if one supply feeds several meters, size it for all of them. Both power inputs are protected by a 300 mA resettable fuse (medium time-lag) and against reversed polarity. If a short circuit or reversed polarity trips the fuse, switch the power off, correct the fault and switch on again; the fuse resets by itself.

NOTICE

More than 26 V DC damages the meter or makes it malfunction. Never apply more than 26 V DC.

Analogue output

The analogue output is linear from 0 to 100 % of the full scale of the active gas table. It is calibrated at the factory for all three signal types; you select the active one at the meter or over the digital interface (Analogue output settings (p. 23)).

Output	Load (+)	Load (−)	Load limit
0–5 V DC	pin 2	pin 3	3000 Ω minimum
0–10 V DC	pin 2	pin 3	5000 Ω minimum
4–20 mA	pin 2	pin 6	500 Ω maximum loop resistance

NOTICE

A load below the minimum on a voltage output can damage the output circuit or make it malfunction, and a loop resistance above 500 Ω on the current output makes it non-linear or faulty. Check which output type is active, and connect only a load within the limit of that type.

NOTICE

The 4–20 mA output is an active, sourcing output that is not isolated. An external voltage source on the output pins can damage the output circuit. Never connect an external voltage source to the output pins.

To keep noise off the analogue signal, run the power and the analogue signal lines in separate cables.

Relay output

Pins 8 and 9 are the contacts of a normally open solid-state relay. When the relay is energized, the contacts close. You choose what switches it — a flow alarm, a totaliser limit, the pulse output, an event or a manual command (Relay assignment (p. 22)). The relay is not energized as delivered.

NOTICE

More than 48 V (AC peak or DC) or 400 mA on the relay contacts can damage the relay. Do not exceed these limits.

Digital interface

The digital interface gives access to every setting and reading of the meter. Standard meters have RS-232; RS-485 is an option. Both use the 3.5 mm stereo jack on top of the meter.

Note

Check which interface your meter has before you connect it. A meter with a display shows the interface type for about two seconds after power-up (Power-up and warm-up (p. 17)); on a meter without display, read it from the last digit of the model number (Reading the model number (p. 42)).

Set the serial port of your computer to:

Baud rate	9600 (default; 1200–115200 selectable, p. 27)
Data bits	8
Parity	None
Stop bits	1
Flow control	None



Figure 3-2. 3.5 mm plug of the communication cable: tip = pin 2, ring = pin 3, sleeve = pin 1.

RS-232

RS-232 needs a crossover connection: the transmit line of the computer goes to the receive line of the meter and vice versa. The supplied cable is wired this way. To make a cable of another length, wire it as follows:

Computer, 9-pin D-sub	Meter, 3.5 mm plug
pin 2 — RX (receive)	pin 3, ring — TX (−)
pin 3 — TX (transmit)	pin 2, tip — RX (+)
pin 5 — signal ground	pin 1, sleeve — digital ground

RS-485 (option)

Several meters with RS-485 can share one two-wire bus, each with its own address (Communication port (p. 27)). Up to 64 devices fit on one bus segment, which may be up to 2000 ft long. A computer with an RS-232 port connects through an RS-232/RS-485 converter.

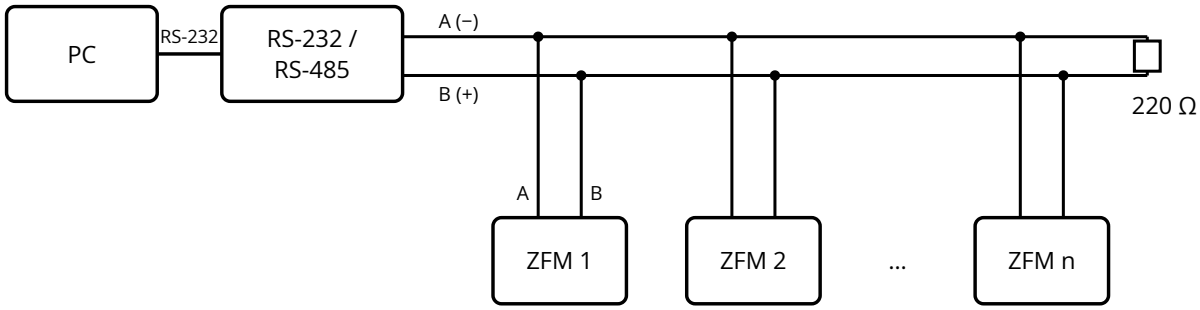


Figure 3-3. RS-485 bus. Every meter connects to both bus lines; a 220 Ω resistor terminates the bus at the last meter.

Bus line	Meter, 3.5 mm plug	Wire colour in the supplied cable
A, T(−) / R(−)	pin 3, ring — TX (−)	white
B, T(+) / R(+)	pin 2, tip — RX (+)	red
Ground, if available	pin 1, sleeve — GND	shield

- Set the converter to two-wire, half-duplex, multidrop operation. Its transmitter must be enabled by the TD or RTS signal, depending on which of the two the converter provides; set its receiver to match, so that the computer does not receive its own transmissions as an echo.

- If the meter is the last device on a long bus segment, connect a 220 Ω resistor between the RS-485 (+) and (−) lines within 6 ft of the meter.

Modbus RTU (option)

The Modbus option adds an RJ45 socket with an isolated RS-485 transceiver; the configuration jack stays available. Settings: p. 27.

CHAPTER 4

Commissioning

Power-up and warm-up

Before the first power-up the meter must be installed and leak-tested (Installation (p. 12)). Keep the gas flow off and switch on the power supply.

A meter with display first shows a banner screen for two seconds, then an information screen for another two seconds (Figure 4-1), and then the first process screen.

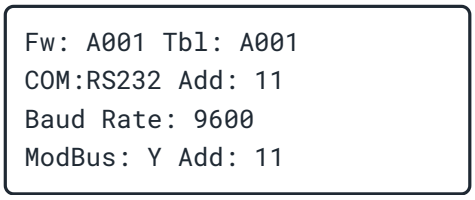


Figure 4-1. Information screen at power-up: firmware and table versions; interface type and RS-485 address (hexadecimal); baud rate; Modbus hardware (Y/N) and Modbus address (decimal). Your values may differ.

1. Let the meter warm up for at least 3 minutes. During this time the status LED is constantly amber, and the flow reading and the output are higher than normal because the sensor has not yet reached its operating temperature. If the power-up event is enabled, an exclamation mark is shown at the top left of the display.
2. After 3 minutes the LED turns constantly green: the meter is ready and the reading settles at zero.
3. For measurements with the specified accuracy, allow at least 30 minutes of warm-up. The gas pressure may be on or off during this time.
4. Switch on the gas flow.

CHAPTER 5

Operation

Read the flow on the display, the analogue output or the digital interface. This chapter explains the process screens, how to move through the menus of a meter with display, the settings, the push button and the alarm and diagnostic events.

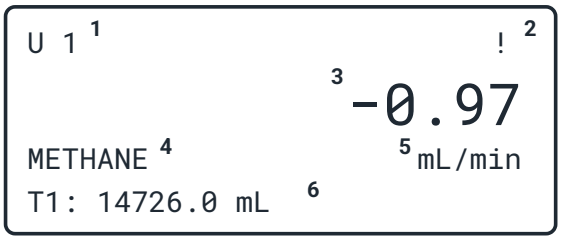
Flow above the range

If the flow rises more than 10 % above the nominal maximum of the meter, the sensor is *swamped*: its reading is neither accurate nor linear. Reduce the flow below 110 % of the range; once it is back in the calibrated range the condition ends by itself.

> **Note**
> While the meter is swamped, its readings are neither accurate nor linear, and the longer it runs above 110 % of its range, the longer it takes to recover. Do not read or record flows while the meter is swamped.

Process screens

The display shows the process information on up to six screens. Move the joystick **UP** to page forward and **DN** to page back; after the last screen the display wraps around to the first. Alternatively the display can cycle through the screens by itself (Display settings (p. 22)). Screens you have switched off are skipped; screen 1 is always on.



1 gas table type (M or U) and number
2 alarm indicator
3 flow reading
4 gas name · 5 flow unit
6 totalizer 1 reading and unit

Figure 5-1. Process screen 1. The content varies with the model and the configuration.

Table 5-1 Process screens

#	Screen	Content
1	Flow and totaliser 1	Flow reading, gas table, gas name, unit, totaliser 1
2	Flow and totaliser 2	As screen 1, with totaliser 2
3	Flow and both totalisers	Flow reading, totaliser 1 and totaliser 2
4	Gas table and interface	Active gas table and gas; its full-scale range; interface type and RS-485 address; K-factor status (D disabled, I internal, U user-defined); analogue output type; Modbus hardware (Y/N)
5	Events	Hours since power-up; flow alarm status; relay assignment; status of totaliser 1, totaliser 2 and pulse output; alarm events and diagnostic events registers (hexadecimal)
6	Diagnostics	Sensor readings in counts, sensor temperature and flow, for troubleshooting with Analyt-MTC support (Checking the zero (p. 28))

Using the menus

Esc switches between the process screens and the setup menus, and takes you one menu level up. In a menu, move the joystick **UP** and **DN** to highlight an item — the list wraps around at both ends — and press the joystick (**ENT**) to open it. The menus described here are those of firmware A001; Table 5-2 shows the top two levels.

Program protection

All settings are protected by a program protection (PP) password. Protection switches on again every time the meter is powered up.

- As delivered, the password is 0, which means protection can be switched off without a password: open **Program Protection**, select **DISABLED** with **DN** and press **ENT**.
- If a password of 1 to 3 digits has been set, the meter asks **Enter PP Password**. Once the right password is entered, protection stays off until the next power-up.

To change the password, switch protection off, open **Change PP Password**, enter the old and then the new password; the meter confirms **New PP Password has been saved**. If the password is lost, contact Analyt-MTC.

Entering values

- **Numbers:** **UP** and **DN** change the digit under the cursor (0–9), **LEFT** and **RIGHT** move the cursor, **ENT** saves the value in the non-volatile memory.
- **Choices from a list:** **UP** and **DN** select, **ENT** saves.

Every value is checked when you save it. A value outside the permitted range is rejected with a message, and the old value stays in force.

Menu overview

Table 5-2 Main menu and submenus (firmware A001)

Main menu	Submenus	Page
Program Protaction (PP)	Enabled / Disabled	19
Change PP Password	Old and new password	19
Device Information	Device ID & FS Flow · **Analog/Com Interface** · Firmware/EE Version (read only)	
EngUnits & K-Factor	Measuring Units · UserDefined Units · K-Factor Settings · User Gas Tbl Density	20
Select Gas Table	M0 and U01 to U10	20
Flow Alarm Settings	Flow Alarm Mode · Low Flow Alarm · High Flow Alarm · Flow Alarm Delay · Flow Alarm Latch	21
Totalizer Settings	**Totalizer #1** · **Totalizer #2** · Pulse Output	21
General Settings	Display & PI Screens · Communication Port · ModBus Interface · Relay Assignment · **Analog Output** · Status LED Settings · Signal Conditioner	22
Alarm & Diagnostic	Alarm Event Menu · Diagnostic Events · **SAR ADC Analog Inp.** · Flow Sensor SD ADC · AnalogOut & POQueue · CPU Temperature/STC	24
Sensor Zero Calibr.	Start Auto Zero Now · View Zero Parameters · Auto Zero Tolerance · DTDAZ Parameters · Manual Zero Adjust.	28

Menu texts are printed as the meter shows them, including the spelling “Protaction”.

Settings

This section goes through the settings in the order of the menus. Each setting can also be made over the digital interface, with the ZFM Configuration Utility or with the serial command named in each section (Appendix B (p. 47)). Switch program protection off first (Program protection (p. 19)).

Engineering units

Open **`EngUnits & K-Factor`** › **`Measuring Units`** and choose the unit of the flow reading (list in Appendix A (p. 46)). The unit applies everywhere: on all process screens, in the data the meter sends and to the totalisers, whose unit follows automatically (a flow in mL/min totalizes in mL). Set the unit before you set alarm, totaliser or pulse values, because several of them are entered in the current unit. Serial command: U.

User-defined unit

If none of the listed units suits you, define your own under **`UserDefined Units`** and then select **`User`** as the unit. It has three parameters:

UD Unit K-Factor	How many of your units make one litre. Default 1.00 (the unit is one litre).
UD Unit Time Base	1 s, 60 s (1 min), 3600 s (1 h) or 86 400 s (1 day). Default 60 s.
UD Unit Use Density	YES for a mass-based unit: the meter then uses the gas density. Default NO.

K factors

A K factor (conversion factor) relative to nitrogen lets a table calibrated for nitrogen read another gas. The meter stores factors for 26 gases (Appendix C (p. 53)) and accepts one factor of your own. Once a factor is active, the meter converts the reading itself; you do not need to recalculate anything. Set the parameters under **`EngUnits & K-Factor`** › **`K-Factor Settings`**; serial command K.

Parameter	Values	Default
K-Factor Mode	Disabled · Internal (stored table) · User-defined	Disabled
Int. K-Factor Index	1–26, the gas number in Table C-1	
User Def'd K-Factor	0.001–999.9	1.000
User Def'd F Density	Density of the gas for the user-defined factor, 0.002–99.9 g/L	1.1637 g/L
N2 Roll Back Mode	Disabled · Enabled	Disabled

- **N2 roll-back** is for a user gas table calibrated with a gas other than nitrogen while you flow a third gas. The meter first converts the reading back to nitrogen with the table's own factor relative to nitrogen, then applies the factor you selected. It works only with user gas tables U1–U10, not with the main table.
- K factors are not applied to readings in percent of full scale.
- With a mass unit and an active K factor, enter the correct K-factor gas density and the density of the flowing gas in the user gas table (**`User Gas Tbl Density`**).

> **Note**
> K factors are approximations. Do not use them where you need an accuracy better than ±5 to 10 %. For better accuracy, rescale the main table to your gas or calibrate a user table with it.

Selecting the gas table

`Select Gas Table` lists the main table M0 and the user tables U01 to U10, each with the name of its gas. Select the table you want with **`UP`** and **`DN`** and press **`ENT`**. Serial command: G.

Every meter is delivered with at least one valid table, the main table M0. User tables that were not calibrated show **NOT CALIBRATED** instead of a gas name.

> **Note**
> A table marked **NOT CALIBRATED** gives wrong readings. Never measure with such a table.

Flow alarm

The flow alarm watches the flow against a low and a high limit and signals on the display, through the status LED and, if you assign it, through the relay. Settings are under **Flow Alarm Settings**; serial command A.

Setting	Function	Default
Flow Alarm Mode	Enabled or Disabled	Disabled
Low Flow Alarm	Low limit, 0–100 % FS in steps of 0.1 %. Must be below the high limit.	
High Flow Alarm	High limit, 0–100 % FS in steps of 0.1 %. Must be above the low limit.	
Flow Alarm Delay	How long the flow must stay beyond a limit before the alarm is raised, 0–3600 s	0 (no delay)
Power-on delay	Time after power-up before the alarm becomes active, so that warm-up does not trigger it, 0–3600 s (serial command A, P)	0 (no delay)
Flow Alarm Latch	Disabled: the alarm clears as soon as the flow is back within the limits. Enabled: the relay stays switched until the alarm is reset.	Disabled

The alarm is raised when the flow is equal to or beyond a limit. The process screen then shows **H** for a high alarm or **L** for a low alarm.

Totalisers

The meter has two independent totalisers. They add up the flow over time and count up only. Their readings are saved every second in non-volatile memory, and every 6 minutes to a separate backup area, so a power failure does not lose them. Settings are under **Totalizer Settings** › **Totalizer #1** or **#2**; serial commands T1 and T2.

Setting	Function	Default
Totalizer Mode	Enabled or Disabled	Disabled
Flow Start	The totaliser counts only while the flow is at or above this value, 0–100 % FS in steps of 0.1 %	
Action Volume	Total, in the current volume or mass unit, at which the totaliser event is raised (for the relay, LED or auto reset). 0 switches the event off.	0
PowerOn Delay	Time after power-up before the totaliser starts, 0–3600 s	0
Auto Reset	Enabled: the total returns to zero as soon as it reaches the action volume — useful for repeated batches	Disabled
AutoRes Delay	Pause after an automatic reset before the next batch is counted, 0–3600 s	0
Reset Totalizer	Sets the total to zero after a YES/NO confirmation	
DP Precision	Reduces the number of decimals of the total by 0 to 5 compared with the flow reading. Example: flow with 3 decimals and setting −2 gives a total with 1 decimal.	

> **Note**
> Configure all totaliser settings before you enable the totaliser. A meter without display resets its totalisers with the push button (Push button (p. 24)). If a totaliser reading must be kept for the life of the meter, its reset can be locked; the lock can be set only from a terminal, with the command T, 1, L, 1 or T, 2, L, 1 (unlocked as delivered).

Pulse output

The pulse output gives one pulse through the relay for every set quantity of gas, independently of the totalisers. Settings are under **`Totalizer Settings`** › **`Pulse Output`**; serial command P. The relay must be assigned to the pulse output (Relay assignment (p. 22)), and the pulses appear on pins 8 and 9.

PulseOutput Mode	Enabled or Disabled (default)
Pulse Flow Start	Pulses are given only while the flow is at or above this value, 0.0–100.0 % FS
[Unit]/Pulse	Quantity per pulse, in the volume or mass unit of the current flow unit
Pulse Active Time	Pulse length, 50–6553 ms

A pulse lasts at least 50 ms and the output gives at most one pulse every 100 ms. Set the quantity per pulse to the maximum flow expressed per second; the output then never pulses faster than once a second. Example: for a maximum flow of 120 g/min (2 g/s), 2 g per pulse gives one pulse per second at full flow, 120 g per pulse one pulse per minute. Keep the pulse length below half the shortest pulse period.

If the flow calls for pulses faster than the output can give them, the pulses are queued and given later, when the flow drops. It is better to increase the quantity per pulse so that no queue builds up.

Display settings

Under **`General Settings`** › **`Display & PI Screens`**; serial command L.

Setting	Function	Default
Display Oper. Mode	Static: you page through the process screens with the joystick. Dynamic: the screens change automatically.	Static
Screen Cycle Time	Time each screen is shown in dynamic mode, 1–3600 s	
PI Screens Config.	Switches screens 2–6 on or off. Select a screen with **`UP`**/**`DN`**, toggle its asterisk with **`RIGHT`** (asterisk = on), save with **`ENT`**.	All on
OLED Brightness	Brightness in normal operation, 256 levels	127
Screen Saver Mode	Disabled · Low Brightness · Vertical Scrolling · OLED Off	
OLED SS Time Out	Time without use of **`Esc`** or the joystick before the screen saver starts	900 s
OLED SS Brightness	Brightness in Low Brightness mode, 127 levels	
Flow Rate Precision	Normal, or Elevated for one more decimal. Switch back to Normal if the last digit becomes unsteady.	Normal

The default brightness of 127 is optimal at room temperature (20 °C). Like any OLED, the display can retain an image that stays on it for too long, temporarily or permanently; the screen saver prevents this. Pressing **`Esc`** or moving the joystick restores the normal brightness and restarts the time-out. A changed screen-saver setting takes effect from the next screen-saver cycle. If nobody reads the display, for example in a closed cabinet, set the screen saver to **`OLED Off`**.

Relay assignment

Under **`General Settings`** › **`Relay Assignment`** you choose what switches the relay; serial command R. The relay is disabled as delivered.

Selection	The relay switches when …
Disabled	never (relay not energized)
Low Flow Alarm	the low flow alarm is active
Hi Flow Alarm	the high flow alarm is active

Selection	The relay switches when …
Flow Range H - L	the flow is between the low and high limits
`Totalizer #1 Event`	totaliser 1 has reached its action volume
`Totalizer #2 Event`	totaliser 2 has reached its action volume
Pulse Output	it gives the flow pulses (Pulse output (p. 22))
Alarm Events	one or more alarm events are active
Diagnostic Events	one or more diagnostic events are active
Manual On	always, regardless of alarms and totalisers

Analogue output settings

Output type

The analogue output settings are under **`General Settings`** › **`Analog Output`**; serial command `AO`. **`Analog Output Mode`** selects 0–5 V DC (load at least 3000 Ω), 0–10 V DC (load at least 5000 Ω) or 4–20 mA (sourcing, loop resistance at most 500 Ω). Move the load to the right pins at the same time (Analogue output (p. 14)).

NOTICE

If the connected load is outside the limits of the new type, the output circuit can be damaged or the reading is wrong. Change the output type only when the load is within those limits. Never connect an external voltage source to the 4–20 mA output.

Calibrating the output

The analogue outputs are calibrated at the factory. Recalibrate them only after parts of the output circuit have been replaced, or when Analyt-MTC support asks you to. The calibration stores a span value for the voltage outputs, and an offset and a span for the current output, from two points at 0 and 100 % FS.

1. Power the meter for at least 30 minutes beforehand. Check which output type is active.
2. Connect a voltmeter to pins 2 (+) and 3 (−) for a voltage output, or an ammeter to pins 2 (+) and 6 (−) for the current output.
3. Open **`Analog Output Cal.`** and follow the prompts: adjust each calibration point with the joystick until the meter reads the target value. **`Esc`** cancels at any time.
4. At the end the meter shows the new offset and span. Press **`ENT`** to save them, or **`Esc`** to leave without saving. A message confirms the result.

Note

Changing the stored output scaling voids the calibration warranty of the meter.

Testing the output

`Analog Output Test` is a troubleshooting aid for use with Analyt-MTC support. It sets the output to a flow you enter, 0.0–110.0 % FS: adjust the value with the joystick and press **`ENT`** to send it to the output; **`Esc`** ends the test, and the output returns to the actual flow.

NOTICE

While the test is active, the output does not show the actual flow, and a control system that acts on it receives a wrong value. Make sure that no control system acts on the output during the test.

Status LED

The two-colour LED shows red, green or amber, steady or flashing. **`General Settings` › `Status LED Settings`** selects which events it shows; serial command `S`.

Mode	Indication
Normal	Auto-zero failure: steady red · Fatal error: steady red, cleared only by a reset (Push button (p. 24)) · Warm-up: steady amber for 3 minutes · Push-button entries: their own pattern, up to 35 s
Flow alarm and totalisers (default)	High alarm: red/off, 1 s · Low alarm: green/off, 1 s Totaliser 1 event: amber/off, 1 s · Totaliser 2 event: amber/off, 2 s High alarm + totaliser 1: red/amber, 1 s · + totaliser 2: red/amber, 2 s Low alarm + totaliser 1: green/amber, 1 s · + totaliser 2: green/amber, 2 s Both totaliser events: amber 3 s / off 1 s · with high alarm: amber 3 s / red 1 s · with low alarm: amber 3 s / green 1 s
Alarm events	Any active alarm event: green/off, 1 s
Diagnostic events	Any active diagnostic event: red/off, 1 s
Configuration interface	Data received: brief red flash; data sent: brief green flash (about 200 ms)
Modbus interface	As above, for the Modbus interface

“red/off, 1 s” means the LED alternates between the two states every second.

Signal conditioner

NOTICE

The signal conditioner (damping, non-linear filter and dynamic response settings) is set at the factory for the best performance of your meter, and other settings degrade it. Do not change it unless Analyt-MTC support asks you to.

Push button

A small push button behind a hole in the right-hand side of the meter (Figure 2-2) starts important actions on every ZFM, with or without display. What happens depends on how long you hold it; the LED shows the stage reached, and the action starts when you release the button.

Held for	LED	Action when released
under 2 s	no change	None — a short accidental press does nothing.
2–6 s	red, flashing every 2 s	None; the meter is ready for an action.
6–12 s	amber, flashing every 2 s	**Reset:** the program restarts with a self-test and all warnings and error messages are cleared.
12–18 s	green, flashing every 2 s	**Auto zero.** Only with absolutely no flow and after at least 30 minutes of power.
18–24 s	steady red	**Totaliser reset mode** for the next 10 seconds (see below).

In totaliser reset mode, press the button once to reset totaliser 1, twice to reset totaliser 2, or three times to reset both, within the 10 seconds. Hold each press until the green LED, which lights while the button is down, goes out again (about 2 seconds); after each valid press the red LED comes on, ready for the next. If no valid press follows within 10 seconds, nothing is reset and the button returns to normal.

Alarm and diagnostic events

The meter records two kinds of events. **Alarm events** concern the settings and the process and are not critical. **Diagnostic events** concern the performance and the hardware of the meter. Both are

shown on a meter with display under **Alarm & Diagnostic**, and are read over the digital interface with the commands AE and DE.

Table 5-3 Alarm events

Code	Event
0	High flow alarm
1	Low flow alarm
2	Flow between low and high limits
3	Totaliser 1 reached its action volume
4	Totaliser 2 reached its action volume
5	Pulse output queue overflow
6	Flow above the limit
7	Password event (attempt to change the password)
8	Power-on event (power-on delay running)

Table 5-4 Diagnostic events

Code	Event
0	CPU temperature too high
1	Sensor compartment temperature too high
2	Sensor heater out of range
3	Sensor resistance out of range
4	2.5 V reference out of range
5	Analogue output alarm
6	Serial communication (UART) error
7	Modbus interface error
8	Memory (EEPROM) read/write error
9	Auto zero failure
A	Fatal error

Each kind of event has three registers, with the codes the display shows:

- **Status** (read only): the events that are active, with their number in the header line. With more than seven events, scroll with **UP** and **DN**.
- **Mask**: which events are monitored at all. An event switched off here is never recorded. As delivered, only the power-on event (alarm 8) and CPU temperature too high (diagnostic 0) are on.
- **Latch**: which events stay in the status register after they end, until you reset it. As delivered, no event is latched: events appear and disappear with their cause.

To change a mask or latch register, select the event with **UP**/**DN**, toggle its asterisk with **RIGHT** (asterisk = on) and save with **ENT**. **Reset AlrmEvents Reg.** and **Reset DiagEvents Reg.** clear the status registers after a YES/NO confirmation; switching the power off clears them too.

Diagnostic screens

Four read-only screens under **Alarm & Diagnostic** show internal values of the meter for troubleshooting. Figures 5-2 to 5-5 show typical displays.

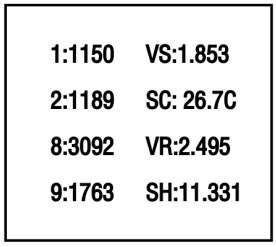


Figure 5-2. **SAR ADC Analog Inp.**: raw or averaged ADC counts and voltage levels of the analogue input circuits.

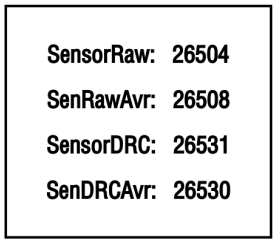


Figure 5-3. **Flow Sensor SD ADC**: raw, averaged and DRC-compensated values of the flow sensor ADC counts.

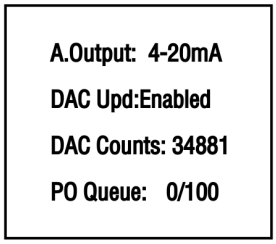


Figure 5-4. `AnalogOut & POQueue`: analogue output setting, DAC counts and the pulse output queue register.

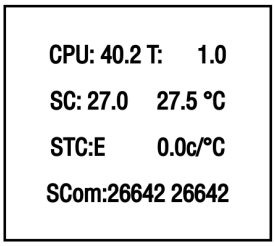


Figure 5-5. `CPU Temperature/STC`: CPU temperature and the parameters of the sensor temperature compensation (STC) algorithm.

The content of these screens varies with the model, the configuration and the operating state of the meter. For troubleshooting with these values, contact Analyt-MTC.

CHAPTER 6

Communication

The meter connects to a computer or programmable logic controller (PLC) through its RS-232 interface, RS-485 as an option, and, as a further option, through Modbus RTU. This chapter gives the port settings. The wiring is in Digital interface (p. 14), the serial commands are in Appendix B (p. 47).

Communication port

Under **`General Settings`** › **`Communication Port`**.

- **Baud Rate Settings:** 1200, 2400, 4800, 9600, 19 200, 38 400, 57 600 or 115 200 baud; 9600 as delivered. The meter and the computer or programmable logic controller (PLC) must use the same rate.
- **RS-485 Bus Address:** two hexadecimal characters, 01 to FF; 11 as delivered. Only meters with RS-485 use an address.

NOTICE

Two devices with the same address on an RS-485 bus collide and cause communication errors. Address 00 is the global address: all devices execute a command sent to it, without replying. Give every device on the bus its own address, and do not assign address 00.

Modbus interface (option)

The Modbus option supports Modbus RTU, through which a computer or PLC reads and writes the meter's registers directly. Ask Analyt-MTC for the register map. Under **`General Settings`** › **`ModBus Interface`**; serial command `MB`.

Setting	Values	Default
Dev. ModBus Address	1–247 (decimal), unique on the Modbus segment	11
Baud Rate Settings	1200–115 200 baud, as for the communication port; the same as the Modbus master	9600
ModBus Com. Parity	None · Odd · Even, as set in the Modbus master	None
ModBus Com. StopBit	1 or 2, as set in the Modbus master	2

NOTICE

Two devices with the same Modbus address on one segment collide and cause communication errors. Give every device on a segment its own Modbus address.

CHAPTER 7

Calibration and verification

You can zero the sensor and check its zero yourself, rescale the main gas table to another gas and range, and calibrate a user gas table against a flow standard.

Zeroing the sensor

The zero is set at the factory. Temperature, pressure, gas type and mounting position can shift it slightly; zero the sensor again only if the meter reads a flow when no gas flows. The automatic zero adjusts the sensor until its reading is within a tolerance of zero counts.

> **Note**
> A zero taken with gas flowing or with a cold sensor makes all later readings wrong. Zero only with absolutely no flow through the meter, and only after the meter has been powered for at least 15 minutes, preferably 30 minutes.

1. Shut off the gas flow into the meter. Disconnect the gas source if you can, so that no gas seeps in.
2. Start the auto zero in one of three ways: in the menu **`Sensor Zero Calibr. › Start Auto Zero Now`**, select **`YES`** and press **`ENT`**; with the push button (Push button (p. 24)); or over the digital interface (Configuration Utility, or command `Z`, `N`).
3. The LED flashes red and green, alternating every 2 seconds, and the display shows **`AUTO ZERO IS ON!`** with the current zero control value (DP) and sensor reading (S). Each adjustment step takes about 8 seconds; the whole procedure takes 2 to 5 minutes.
4. When the sensor reading is within the tolerance — ±7 counts as delivered — the LED returns to steady green and the display shows **`AUTO ZERO IS DONE! OK.`** Press any key.

If the meter cannot bring the reading within the tolerance, the zero has failed: the LED stays steady red and the display shows **`Auto Zero ERROR!`** Check that no gas flows and repeat; if it fails again, see Troubleshooting (p. 36).

The sensor signal is counted from −60 000 to +60 000, with 0 counts as a perfect zero. Do not set the **`Auto Zero Tolerance`** below 7 counts, or the zero may fail. A tolerance above 15 counts makes success more likely but leaves some zero offset. For a closer zero than the automatic one gives, ask Analyt-MTC about the manual zero adjustment.

Checking the zero

On a meter with display, process screen 6 shows the compensated, averaged sensor reading. With no flow, it must be within 0 ±10 counts; if it is not, run the auto zero. On a meter without display, check it with the ZFM Configuration Utility (**`Tools › Zero Adjustment`**).

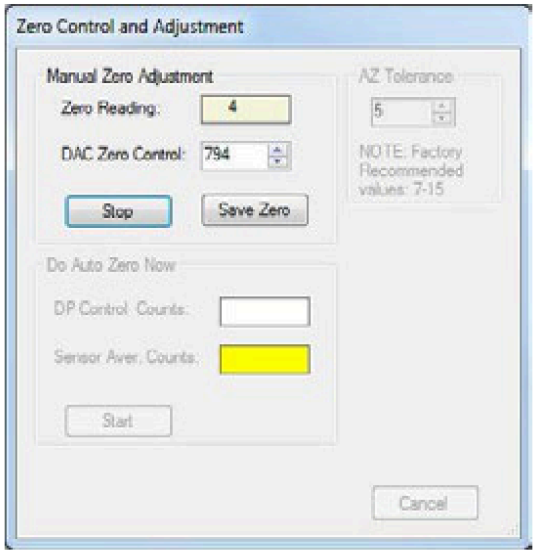


Figure 7-1. Zero check and adjustment in the ZFM Configuration Utility.

Rescaling and calibration

You can move the main gas table to another supported gas and range in a few minutes, without a flow standard. Calibrating a user gas table takes a flow standard and more time, but works for any gas. Both are done from a computer with the ZFM Configuration Utility; nothing needs to be opened or adjusted inside the meter.

> **Note**
> Breaking the factory calibration seals, or changing the calibration tables as described in this chapter, voids the calibration warranty of the meter. The primary calibration table can only be calibrated at the factory. If you would rather not calibrate yourself, Analyt-MTC calibrates ZFM meters for you.

Rescaling the main gas table

Rescaling recalculates the main table M0 from the factory nitrogen calibration for another gas — nitrogen, air, oxygen, argon, helium or carbon dioxide — and another full scale within the limits of the meter (Table 2-1, p. 10). You need the ZFM Configuration Utility, Aalborg's free software, and a connection to the meter's digital interface (Digital interface (p. 14)).

1. Connect the meter to the computer and start the ZFM Configuration Utility.
2. Open **`Tools`** › **`Main Gas Table Rescaling`** and confirm the warning with **`OK`**. The rescaling window shows the model, the serial number, the nominal nitrogen full scale and the flow element configuration of the meter (read only), and below them the current main table with its full-scale range and gas.
3. Select the new gas in **`Fluid Set by Customer`**. The minimum and maximum permitted full scale for that gas are updated.
4. Type the new full scale into **`Full Scale Range`**. It must lie between the limits shown on the left of the window.
5. Enter your initials in **`Rescaled By`**, then click **`Rescale`** and confirm. The software checks the parameters and calculates the new calibration curve, shown together with the primary nitrogen curve.
6. Click **`Upload`** to write the new main table into the meter. A message confirms the upload.

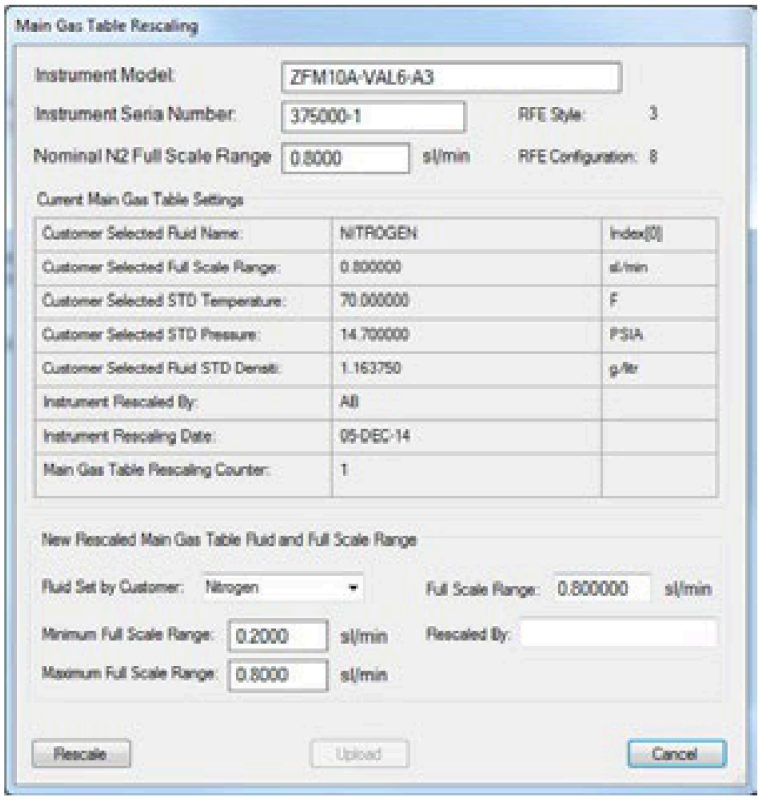


Figure 7-2. Main gas table rescaling: the window with the current main table.

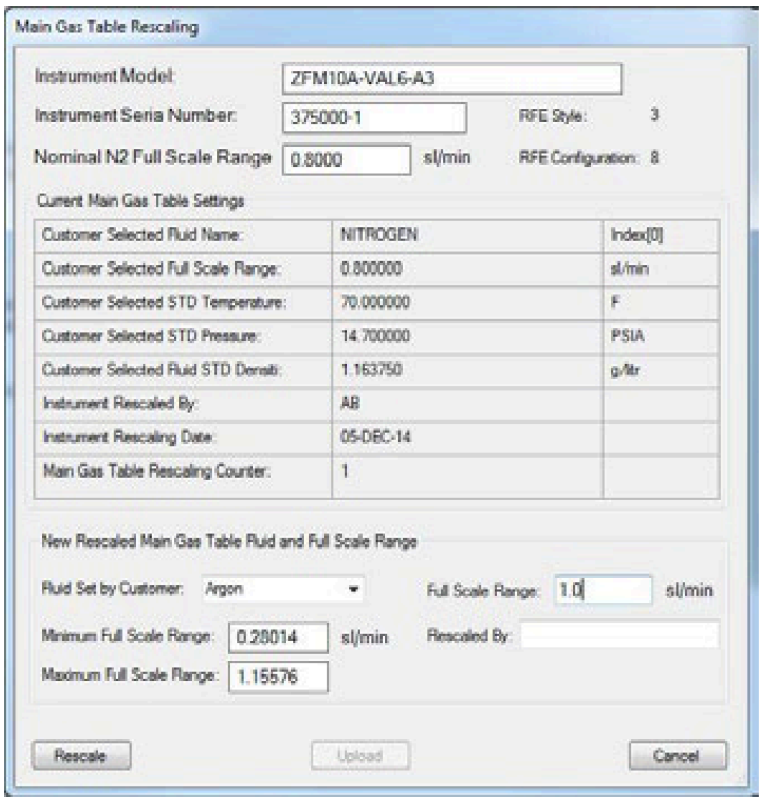


Figure 7-3. Main gas table rescaling: new gas and full scale entered (argon, 1.0 sL/min).

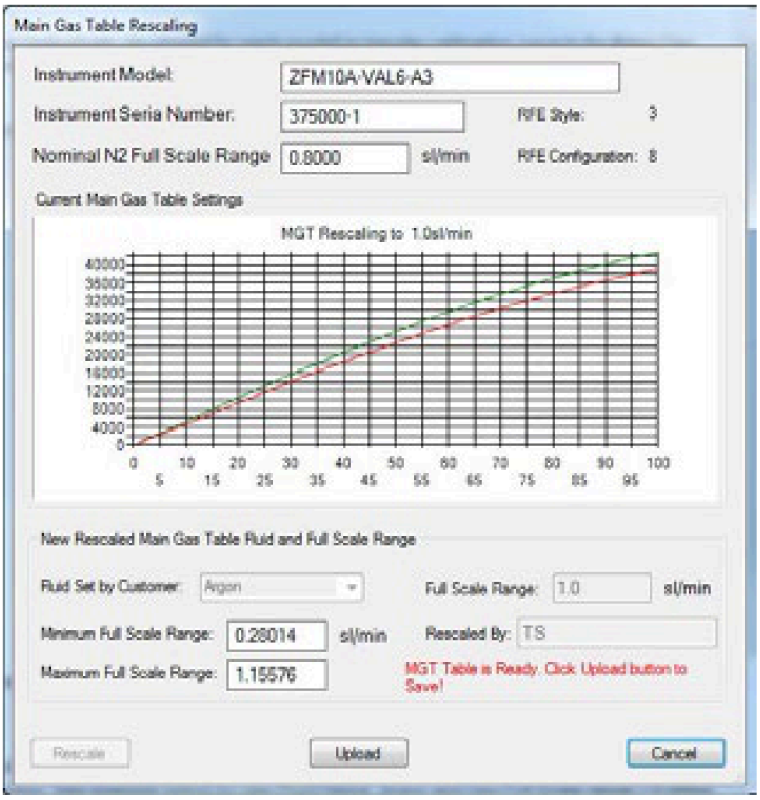


Figure 7-4. Main gas table rescaling: the new calibration curve (red) with the primary calibration curve (green), ready to upload to the meter.

Example: to use a meter for argon up to 1.0 sL/min, select **Argon** as the fluid and enter 1.0 as the full scale.

Calibration practice

Flow meters are usually calibrated with dry nitrogen, and the reading is converted to the actual gas with its K factor (K factors (p. 20)). A reference gas other than nitrogen can approximate the flow behaviour of a gas better, when its thermodynamic properties are close to those of the actual gas; the relative factor is then recalculated (Calculating with K factors (p. 33)).

The standard calibration conditions are dry nitrogen at 21.1 °C (70.0 °F), an inlet pressure of 20 psia (137.9 kPa absolute) and an outlet pressure of 0 psig. The best accuracy is obtained by calibrating at the actual operating conditions: set the gas and ambient temperatures and the inlet and outlet pressures as they are in operation. For calibrations with specific non-toxic, non-corrosive gases at your operating conditions, ask Analyt-MTC.

You need:

- a flow standard at least four times more accurate than the meter;
- a computer with an RS-232 or RS-485 port and the ZFM Configuration Utility;
- a flow regulator upstream of the meter, for example a needle valve;
- a pressure-regulated source of dry, filtered nitrogen or of a suitable reference gas;
- for calibrating the analogue output only, a certified high-resolution multimeter.

User gas table calibration

A user gas table holds a linearization table of 11 points, at 0, 10, 20 … 100 % of full scale. For each point it stores the sensor reading, in counts from 0 to 60 000, that corresponds to that flow. Each of the ten user tables is stored separately. Calibrate a user table only to create a new one, to change its

range or to correct its linearity: the meter was calibrated at the factory for the gas and range on its label.

> **Note**
> All adjustments apply to the user table that is currently active, and the meter starts with the main table M0 active after every power-up. A table that was never calibrated gives unpredictable readings until the calibration is complete. Select the right user table first, and check its number in the header of the calibration panel.

1. Power the meter for at least 30 minutes. Connect it to the computer and start the ZFM Configuration Utility.
2. Select the user table to calibrate: in the software under **`Properties`** › **`Device Settings`**, **`Current Gas Table`**, or at the meter under **`Select Gas Table`**.
3. Check the zero (Checking the zero (p. 28)) and run the auto zero if necessary.
4. Open **`Tools`** › **`User Gas Table`** › **`Linearizer Calibration`** and confirm the warning.
5. For a new table, start at 100 % FS; to correct the linearity, start at any point. Set the flow with the needle valve to the point selected, and compare the meter reading in **`Current Flow Rate`** with the flow standard.
6. If they differ by more than 0.2 % FS, correct the counts value of that point: if the meter reads *lower* than the standard, *decrease* the value; if it reads *higher*, *increase* it. Press **`Enter`** to write the value into the meter, then compare again and repeat until the readings agree.
7. Continue with the next point, 90 %, and so on down to 10 % FS. For all points except 0 and 100 %, the **`Auto Adjust`** button calculates the counts value for you once the reading is within ±2 % FS of the point.
8. When all points are done, click **`Save`** under **`SC Temperature`** to store the average sensor compartment temperature of the calibration in the table. The meter needs it to compensate the reading for temperature.

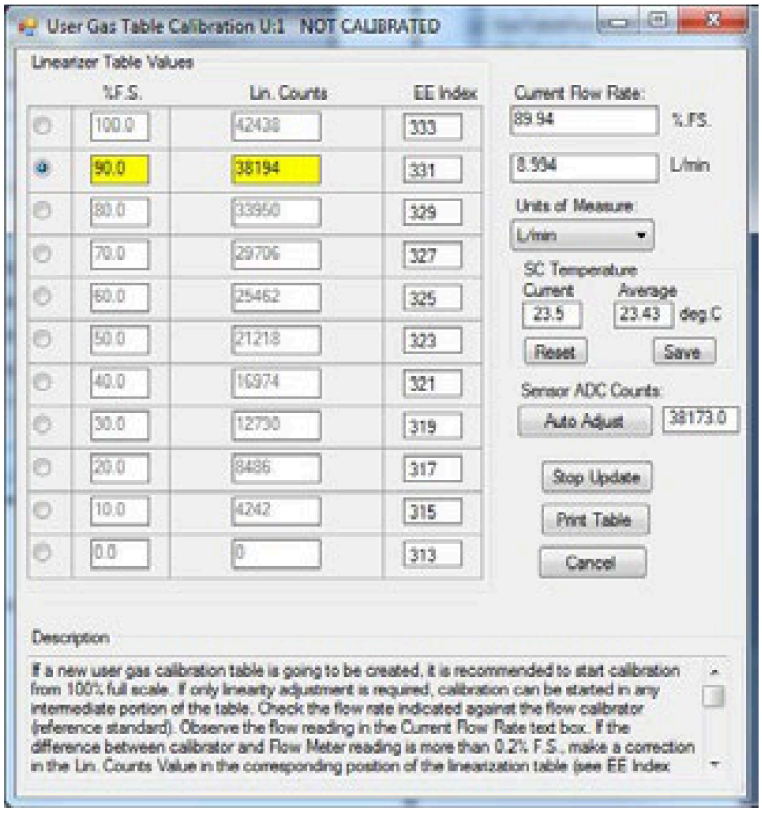


Figure 7-5. User gas table calibration in the ZFM Configuration Utility.

Note
The flow values of the 0 and 100 % points cannot be changed. The counts values must rise steadily from point to point.

Calculating with K factors

When the meter applies a K factor itself, no calculation is needed. To convert a reading by hand, or to derive a factor for a gas that is not listed, use these relations. The K factor of a gas follows from its density d (g/L) and specific heat c_p (cal/g), both taken at the same conditions; for diatomic gases:

$$K_{gas} = 1 / (d \times c_p)$$

As long as the flow range of the meter stays the same, the relative K factor relates the flow of the actual gas to the flow of the reference gas:

$$K = Q_a / Q_r = K_a / K_r$$

where Q_a and Q_r are the mass flows of the actual and the reference gas, and K_a and K_r their K factors. Example: a meter calibrated with nitrogen reads 1000 smL/min; for oxygen (K = 0.9926 relative to nitrogen) the flow is 1000 × 0.9926 = 992.6 smL/min.

CHAPTER 8

Maintenance

A ZFM that sees only clean, filtered gas needs no routine maintenance apart from periodic recalibration. If the flow path becomes blocked, the inlet filter and the flow element of the ZFM 17 can be cleaned as described here.

Keeping the flow path clean

The sensor is a thin capillary tube, and the other flow passages are narrow too. Particles, liquids or gases that crystallize can block them. Use the meter only with clean, filtered gas and never with liquids. A 50 µm filter screen in the inlet protects the flow path; it may need cleaning from time to time.

Have the meter recalibrated at regular intervals by qualified personnel with suitable calibration equipment (Rescaling and calibration (p. 29)). For repair and calibration, send the meter to Analyt-MTC (Service, warranty and contacts (p. 44)).

⚠ WARNING

A meter that has carried toxic, infectious, corrosive or radioactive media can hold hazardous residues. Residues endanger the people who open it. Before you open a meter, purge it completely and neutralize all residues. Work with a grounded wrist strap.

Cleaning the ZFM 17

Before you take anything apart, look into the inlet and the outlet for debris that blocks the flow, and remove it. Continue with the steps below only if the flow path is still blocked. Never take the sensor apart: if flushing with a cleaning fluid does not clear the sensor tube, send the meter to Analyt-MTC.

NOTICE

Taking the meter apart can upset its calibration. After the flow element (RFE) or the flow path has been cleaned, the meter must be recalibrated. Contact Analyt-MTC for cleaning and recalibration.

Inlet filter screen

1. Unscrew the inlet compression fitting from the meter. The 50 µm filter screen is held in the inlet fitting.
2. Unscrew the filter plug from the inlet fitting with a 1/4" hex key. The filter screen becomes visible.
3. Push the screen out through the inlet fitting.
4. Clean or replace the parts as necessary. If you clean them with alcohol, let them dry completely.
5. Reassemble in reverse order, making sure no dust has settled on the O-ring seal.

Restrictor flow element (RFE)

The RFE is a precision flow divider that splits the incoming gas between the sensor and the main flow path in a fixed ratio. Which RFE a meter has depends on its gas and range.

Note

Removing the RFE changes the calibration, and the readings stay wrong until the meter is recalibrated. Once the RFE has been removed, have the meter recalibrated.

1. Unscrew the inlet compression fitting. A retaining ring becomes visible inside the main flow passage.
2. Remove the retaining ring with internal circlip pliers, then the compression spring behind it. The RFE assembly becomes visible.
3. Pull the RFE assembly out of the main flow passage. Clean or replace the parts as necessary; let them dry completely after cleaning with alcohol.
4. Inspect the flow path inside the meter for contamination. If necessary, flush it with alcohol, then dry it thoroughly by passing clean, dry gas through it.

   NOTICE

   Overtightening the inlet fitting deforms the RFE and makes it unusable. Do not overtighten the inlet fitting. Even if you did not remove the RFE, check at least one calibration point after re-installing the inlet fitting.

5. Re-install the RFE assembly, the spring, the retaining ring and the inlet fitting carefully, without twisting or deforming the RFE. Make sure no dust has settled on the O-ring seal.
6. Have the meter recalibrated (Rescaling and calibration (p. 29)).

CHAPTER 9

Troubleshooting

Every meter is checked at several stages of manufacture and calibrated for its gas and conditions before it leaves the factory. If it does not behave as expected, check the common causes first, then look up the symptom in the table.

First checks

- Are all cables connected correctly, and do the pins of your mating connectors match the meter's (pin assignment (p. 13))? Equipment from other manufacturers is often wired differently.
- Is the installation leak-tight?
- Does the power supply meet the requirements, and is it rated for the current of all meters it feeds?
- Is there enough pressure difference across the meter for the gas to flow?

Symptoms, causes and remedies

Symptom	Likely cause	Remedy
No zero reading after 15 minutes of warm-up with no flow	The temperature of the meter has changed since it was zeroed	Run the auto zero (Zeroing the sensor (p. 28)).
Status LED and display stay dark at power-up; the analogue output does not respond to flow	Supply faulty, or polarity reversed	Measure the voltage between pins 4 (+) and 5 (−). If it is outside 14–26 V DC, replace the supply; if it is negative, correct the polarity.
	Circuit board defective	Send the meter to Analyt-MTC for repair.
Display reading or 0–5 V DC output fluctuates widely	Output (pins 2 and 3) shorted to ground or overloaded	Check the external wiring on pins 2 and 3; the load must be more than 3000 Ω.
Display reads correctly, but the 0–5 V DC output does not change (constant, or near zero)	Output circuit damaged	Send the meter to Analyt-MTC for repair.
	Output scaling values corrupted	Restore the original scaling values or recalibrate the output (Calibrating the output (p. 23)).
Display and 0–5 V DC output are correct, but the 4–20 mA output stays constant, around 4 mA	Loop open, or loop resistance too high	Check the wiring on pins 2 and 6; the loop resistance must not exceed 500 Ω.
	Output circuit damaged	Send the meter to Analyt-MTC for repair.
Calibration off by more than ±1 % FS	Zero has shifted	Shut off the gas (preferably disconnect the source, so that nothing leaks in), wait 15 minutes with no flow, then run the auto zero.
Reading above the range, voltage output above 5 V DC while gas flows	Sensor swamped: flow more than 10 % above the maximum	Reduce the flow into the calibrated range or shut it off; the condition ends by itself (Flow above the range (p. 18)).
	Circuit board or sensor defective	Send the meter to Analyt-MTC for repair.
Gas flows, but neither the display nor the output responds	Flow too low for the range of the meter	Check the range on the label and adjust the flow.
	Wrong or uncalibrated gas table, or wrong K factor, selected	Select the right gas table (Selecting the gas table (p. 20)) and switch the K factor off.
	Sensor or circuit board defective	Send the meter to Analyt-MTC for repair.
No gas flows with pressure on the inlet; display and output show zero	Inlet filter screen blocked	Flush or clean the filter screen, or replace it (Inlet filter screen (p. 34)). The calibration can be affected.

Symptom	Likely cause	Remedy
Gas flows, but the output stays near 1 mV and the display reading is negative	Flow direction reversed	Install the meter in the direction of the arrow on its front.
	Back pressure on the outlet and a leak in the system	Find and repair the leak. If the meter itself leaks internally, send it to Analyt-MTC for repair.
Diagnostic event 2 or 3 active	Sensor temperature too low or too high	Keep the gas and ambient temperature within 0–50 °C.
Diagnostic event 0 active	CPU temperature too high (overload)	Switch the power off. Make sure the ambient temperature is below 50 °C, let the meter cool down for at least 15 minutes, switch on again and check event 0. If it returns, send the meter to Analyt-MTC.
Status LED steady red	Fatal error: memory or auto-zero failure	Switch the power off and on. If the LED is still steady red, wait 15 minutes and run the auto zero. If the fatal error returns, send the meter to Analyt-MTC.
Display and analogue output are correct, but the digital interface does not respond	Wrong interface type or wiring	Make sure the computer uses the same interface as the meter (RS-232 or RS-485), with a converter if needed, and check the wiring (Digital interface (p. 14)).
	RS-485 address of the meter differs from the address the computer uses	Set the meter's address to match (Communication port (p. 27)).

If the problem persists, contact Analyt-MTC technical support with the model and serial number of the meter (Service, warranty and contacts (p. 44)).

CHAPTER 10

Specifications

Data for the ZFM 17. The gas, range and calibration conditions of your meter are on its label and calibration certificate.

Measurement

Flow medium	Clean gases only; never liquids
Flow ranges (nitrogen)	Seven ranges from 0.0125 to 10 sL/min full scale; full scale adjustable down to a quarter of the nominal range (Table 2-1, p. 10)
Standard conditions for flow	21.11 °C, 1013.25 mbar
Accuracy, including linearity	±0.5 % of reading + 0.2 % of full scale, based on the actual calibration, at calibration temperature and pressure
Repeatability	±0.15 % FS
Turndown ratio	Up to 133.3:1 at full accuracy
Temperature coefficient	0.05 % FS per °C or better
Pressure coefficient	0.01 % FS per 6.895 kPa (1 psi) or better
Response time	1000 ms time constant; about 2 s to within ±2 % of the final flow, for a step from 0 to 100 % FS
Attitude sensitivity	Up to 0.5 % FS additional deviation, after zeroing again
Calibration conditions	101.4 kPa (14.7 psia) and 21.1 °C (70 °F), unless otherwise requested
Calibration	Calibration certificate for nitrogen as standard; main table can be rescaled to air, carbon dioxide, oxygen, argon and helium without a new calibration. Certificate for another gas ("as found" calibration) and up to 10 additional calibrations, each with certificate: ask Analyt-MTC
Gas tables	Main table and 10 user tables
Warm-up	3 minutes until ready; 30 minutes for the specified accuracy

Operating limits

Maximum gas pressure	34.47 bar (500 psia); see Pressure and gas quality (p. 12)
Pressure drop	At most 0.8 psid at 10 sL/min; the measured value for the ZFM 17 is 130 mm H_2O (0.18 psid, 1.275 kPa)
Gas and ambient temperature	0–50 °C (32–122 °F)
Relative humidity of the gas	Up to 70 %
Leak integrity	1×10^{-9} sccs helium maximum, to the outside
Environment (IEC 664)	Installation category II, pollution degree II

Electrical data

Power supply	14–26 V DC, ripple at most 100 mV peak to peak; supply rated at least 200 mA
Power consumption	At most 100 mA at 24 V DC
Protection	Reverse-polarity protection; 300 mA resettable fuse in the supply inputs
Analogue output	0–5 V DC (load ≥ 3000 Ω), 0–10 V DC (load ≥ 5000 Ω) or 4–20 mA (sourcing, loop ≤ 500 Ω), selectable; linear 0–100 % FS; noise at most 10 mV peak to peak on 0–5 V DC

Relay	1 solid-state relay, normally open, 48 V (AC peak or DC), 400 mA; programmable, also as pulse output
Digital interface	RS-232 (standard) or RS-485 (option), 3.5 mm jack, 1200–115 200 baud; Modbus RTU on RJ45 with isolated RS-485 transceiver (option)
Connectors	9-pin D-sub (power, analogue output, relay); 3.5 mm stereo jack; RJ45 (Modbus option)
Display (option)	128 × 64 pixel yellow graphic OLED with **Esc** button and joystick
EMC	Directive 2004/108/EC as amended; CISPR 11; emission IEC 61000-6-3; immunity IEC 61000-6-1

Materials and connections

Wetted materials, aluminium models	Anodized aluminium, brass, 316 stainless steel, FKM O-rings
Wetted materials, stainless-steel models	316 stainless steel, FKM O-rings
Optional O-ring materials	Buna-N®, EPR (ethylene propylene), PTFE/FFKM
Process connections	1/4" compression (standard); 1/8", 3/8" and 6 mm compression, 1/4" VCR® (options)
Inlet filter	50 µm screen
Weight	0.4 kg (aluminium model); 1.2 kg packed

Dimensions

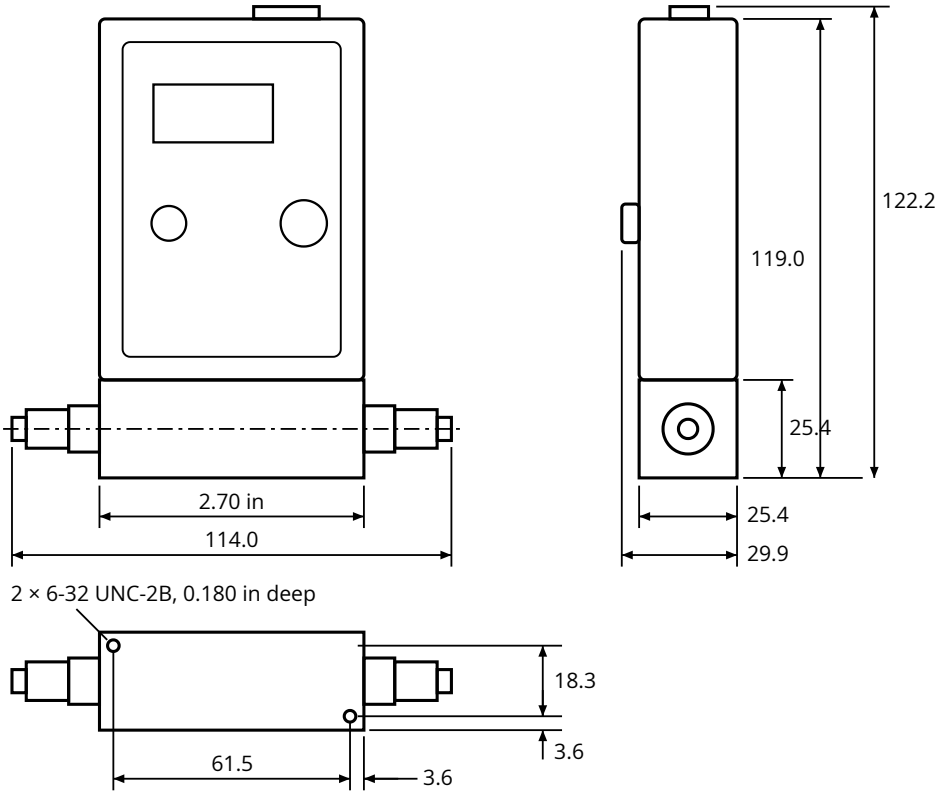


Figure 10-1. ZFM 17 with 1/4" compression fittings, dimensions in mm, body length in inches. Front view (top left), side view (top right) and base with the two mounting threads (bottom). Choosing materials that suit your gas is the responsibility of the user; no corrosion resistance is guaranteed.

Dimensions may change without notice; ask Analyt-MTC for certified dimensions.

Component layout

Component diagrams of the circuit board, top and bottom side.

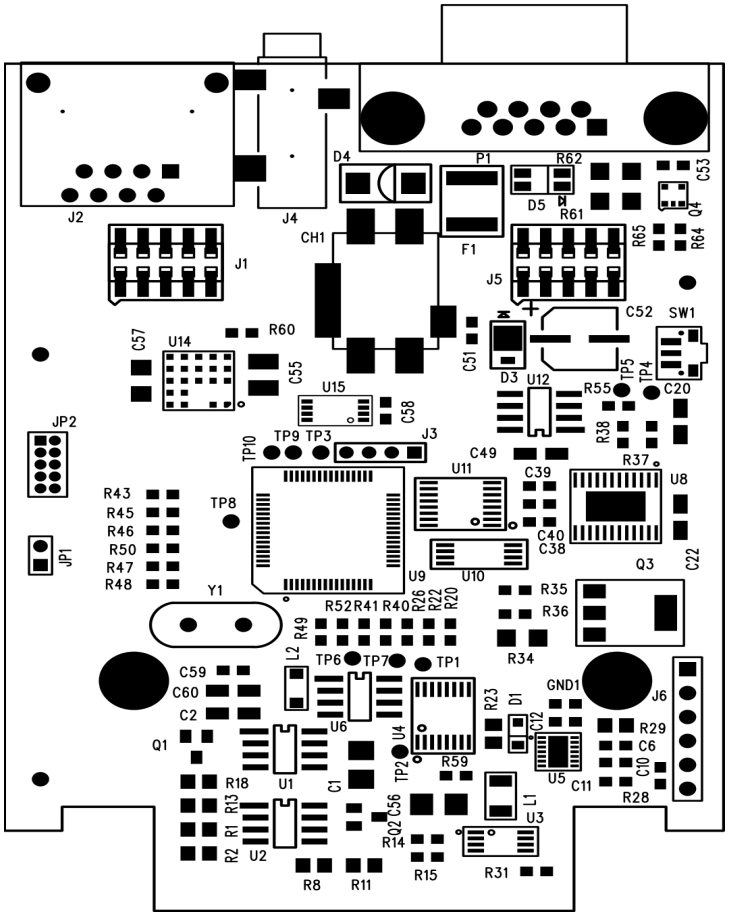


Figure 10-2. Circuit board, top component side.

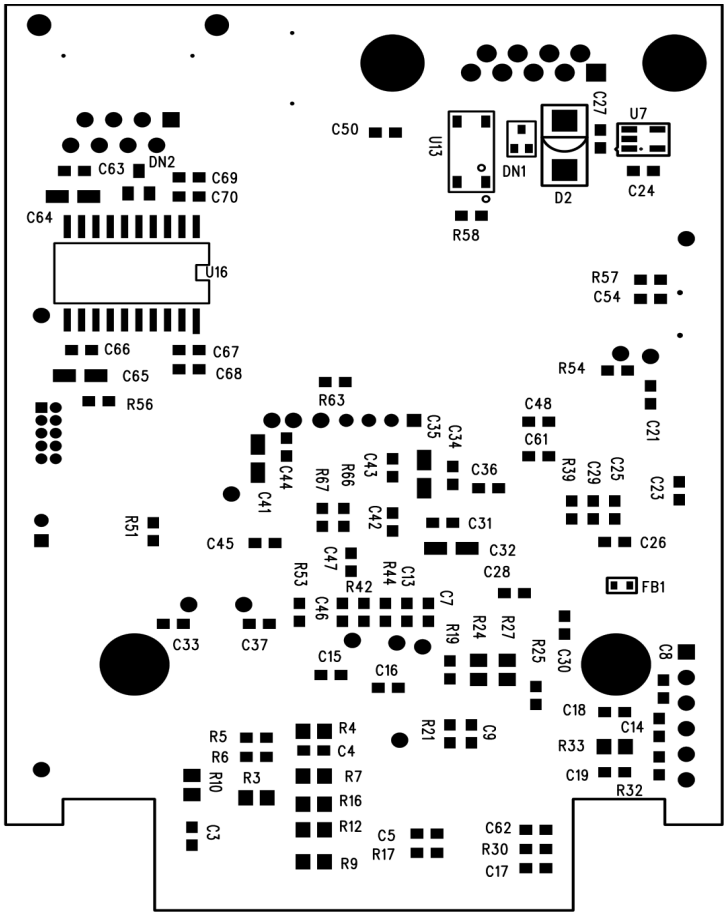


Figure 10-3. Circuit board, bottom component side.

CHAPTER 11

Ordering information

Order from Analyt-MTC with the order codes.

Meters

The meters below are the standard versions; for any other version, contact Analyt-MTC. The standard versions of the ZFM 17 have FKM seals, 1/4 in compression fittings, universal power input, a 0–5 V DC output and an RS-232 interface, with or without Modbus RTU. The model number is explained in Reading the model number (p. 42). Flows refer to 21.11 °C, 1013.25 mbar.

Table 11-1 Meters, standard versions

Model	Nominal ranges, sL/min	Body	Display	Digital interface	Order code
ZFM17A-VAN6-A2	0.0125–10.0	Aluminium	None	RS-232	ZFM17A-N0
ZFM17A-VAN6-A3		Aluminium	None	RS-232 with Modbus RTU	ZFM17A-NM
ZFM17A-VAL6-A2		Aluminium	Display	RS-232	ZFM17A-L0
ZFM17A-VAL6-A3		Aluminium	Display	RS-232 with Modbus RTU	ZFM17A-LM
ZFM17S-VAN6-A2		Stainless steel	None	RS-232	ZFM17S-N0
ZFM17S-VAN6-A3		Stainless steel	None	RS-232 with Modbus RTU	ZFM17S-NM
ZFM17S-VAL6-A2		Stainless steel	Display	RS-232	ZFM17S-L0
ZFM17S-VAL6-A3		Stainless steel	Display	RS-232 with Modbus RTU	ZFM17S-LM

Reading the model number

The model number on the label tells you how your meter is equipped — in particular which digital interface it has, which you need to know before you connect a computer. Example: **ZFM17S-VAL6-A2** is a ZFM 17 in stainless steel with FKM seals, 1/4" compression fittings, a display, universal power input, a 0–5 V DC output and an RS-232 interface.

Table 11-2 Ordering code, for example ZFM17S-VAL6-A2

Position	Codes	Example
Maximum flow (N_2)	17 = 10 sL/min	17
Material	A aluminium · S stainless steel	S
Seals	V FKM · B Buna® · E EPR · T PTFE/FFKM	V
Fittings	A 1/4" compression · B 1/8" compression · C 1/4" VCR® · H 6 mm compression	A
Display	N no display · L display	L
Power	6 universal	6
Output signal	A 0–5 V DC · B 4–20 mA · M 0–10 V DC (can be changed later, p. 23)	A
Digital interface	2 RS-232 · 5 RS-485 · 3 RS-232 with Modbus	2

Accessories

Table 11-3 Accessories

Description	Order code
Power supply, 230 V AC, EU plug, 24 V DC, with DC jack	PS-ZFM-230EU-4
Power supply, 110 V AC, US plug, 24 V DC, with DC jack	PS-ZFM-110NA-4
Power supply, 240 V AC, UK or AU plug, 24 V DC, with DC jack	PS-ZFM-240UK-4 (UK plug) PS-ZFM-240AU-4 (AU plug)
Adapter 9-pin D-sub to 2.1 mm DC jack, for your own power supply	ZFM-APW-BX
Shielded D-sub 9 M/F cable, 5 or 10 ft	CSM9MF-5 CSM9MF-10
Shielded D-sub 9 M/F cable, 15, 25 or 50 ft (4–20 mA output only)	CSM9MF-15 CSM9MF-25 CSM9MF-50
USB to RS-232 converter	35782
USB to RS-485 converter	USB-RS485
Adapter RJ45 to D-sub 9 F, Modbus cable to the USB to RS-485 converter	RBA098F
Modbus: RJ45 Y-adapter, coupler, 100 Ω line terminator, 1-to-4 splitter	ECS803-1 (Y-adapter) TDG1026-8C (coupler) MOD27T (line terminator) JMOD4S-1 (splitter)
Modbus: Cat 5E RJ45 patch cables, 2, 10 or 25 ft	TRD815BL-2 TRD815BL-10 TRD815BL-25
Universal baseplate: bench-top stand for the meter	35780
Rugged transport case	1200-000-110E

CHAPTER 12

Service, warranty and contacts

Analyt-MTC is your contact for everything after delivery: technical questions, calibration, cleaning, repair and warranty. Talk to Analyt-MTC before you send a meter: many problems can be solved by changing a setting.

Contact and support

ANALYT-MTC Messtechnik GmbH

German Headquarters

Klosterrunsstraße 18, 79379 Müllheim
Germany

+49 7631 5545

info@analyt-mtc.de

French Subsidiary

175 Avenue d'Alsace, 68000 Colmar
France

+33 3 89 41 47 78

info@analyt-mtc.fr

www.analyt-mtc.com

Before you contact Analyt-MTC

Have the following at hand so that Analyt-MTC can help you quickly:

- the model number and serial number from the label on the meter;
- the gas and flow range on the label, and the firmware version (shown at power-up, p. 17);
- a description of the fault and what you have already checked (Troubleshooting (p. 36)).

Technical support

Have the model and serial number from the label at hand, together with the gas, the flow range and a description of what you see — including the active alarm and diagnostic events (Alarm and diagnostic events (p. 24)) and what you have already checked (Troubleshooting (p. 36)). The contact details are given above and on the back cover.

Returning a meter

1. **Open a service request.** Open it online in the Analyt-MTC customer portal, portal.analyt-mtc.com, with the model, the serial number and the reason for service: calibration, cleaning or repair. Do not put paper forms in the box: the service request carries everything Analyt-MTC needs.

   WARNING

   A meter that has carried hazardous media can hold residues. Residues endanger the people who unpack and service it. Never ship such a meter without purging and neutralizing it.

2. **Decontaminate the meter.** Purge it and neutralize all residues of toxic, corrosive, infectious or radioactive media. In the service request, state the substances the meter has been in contact with and their hazards, and confirm the safety declaration online. If you are not sure, do not send it.

3. **Pack the meter alone.** Send the meter without power supply, cables, fittings or case unless they are part of the problem; Analyt-MTC is not responsible for accessories sent. Close the inlet and outlet so that nothing enters the flow path, protect the connectors against electrostatic discharge, and pack each meter individually for transport.
4. **Ship it to Müllheim.** Send the parcel to the Analyt-MTC service centre in Müllheim, Germany, never to the Colmar address.

When the meter arrives, it is registered and assessed, and you receive a quote before any work begins: no work is done without your agreement. If you decline the quote, a bench fee and return transport are charged. Every instrument passes a final check before it is returned with its documentation. A standard service typically takes one to two weeks from arrival to dispatch; this lead time is indicative. Express service can be requested in the service request.

Warranty

The warranty terms for your meter are those agreed in your order confirmation. Warranty claims are handled by Analyt-MTC: give it the serial number and a description of the fault before returning the meter. Breaking the calibration seals or changing the calibration tables or the analogue output scaling voids the calibration warranty (Rescaling and calibration (p. 29)).

Disposal

Do not dispose of the meter with household waste. Dispose of it as electrical and electronic equipment under local regulations (WEEE). Remove batteries first where fitted and dispose of them separately.

APPENDIX A

Engineering units

These are the units you can select under **`Measuring Units`** (Engineering units (p. 20)). The totaliser unit follows the flow unit. Units are shown as the meter displays them; the serial command `U` uses the same names (Appendix B (p. 47)). Volumetric units refer to standard conditions, 21.11 °C, 1013.25 mbar. Mass units use the density of the gas.

No.	Flow	Total	Unit
1	%FS	%s	Percent of full scale
2	mL/sec	mL	Millilitre per second
3	mL/min	mL	Millilitre per minute
4	mL/hr	mL	Millilitre per hour
5	mL/day	mL	Millilitre per day
6	L/sec	L	Litre per second
7	L/min	L	Litre per minute
8	L/hr	L	Litre per hour
9	L/day	L	Litre per day
10	m^3/sec	m^3	Cubic metre per second
11	m^3/min	m^3	Cubic metre per minute
12	m^3/hr	m^3	Cubic metre per hour
13	m^3/day	m^3	Cubic metre per day
14	f^3/sec	f^3	Cubic foot per second
15	f^3/min	f^3	Cubic foot per minute
16	f^3/hr	f^3	Cubic foot per hour
17	f^3/day	f^3	Cubic foot per day
18	gal/sec	gal	US gallon per second
19	gal/min	gal	US gallon per minute
20	gal/hr	gal	US gallon per hour
21	gal/day	gal	US gallon per day
22	gr/sec	gr	Gram per second
23	gr/min	gr	Gram per minute
24	gr/hr	gr	Gram per hour
25	gr/day	gr	Gram per day
26	kg/sec	kg	Kilogram per second
27	kg/min	kg	Kilogram per minute
28	kg/hr	kg	Kilogram per hour
29	kg/day	kg	Kilogram per day
30	lb/sec	lb	Pound per second
31	lb/min	lb	Pound per minute
32	lb/hr	lb	Pound per hour
33	lb/day	lb	Pound per day
34	ton/min	ton	Metric tonne per minute
35	ton/hr	ton	Metric tonne per hour
36	Igl/sec	Igl	Imperial gallon per second
37	Igl/min	Igl	Imperial gallon per minute
38	Igl/hr	Igl	Imperial gallon per hour
39	Igl/day	Igl	Imperial gallon per day
40	MnL/min	MnL	Million litres per minute
41	MnL/hr	MnL	Million litres per hour
42	MnL/day	MnL	Million litres per day
43	bbl/sec	bbl	Barrel per second
44	bbl/min	bbl	Barrel per minute
45	bbl/hr	bbl	Barrel per hour
46	bbl/day	bbl	Barrel per day
47	User	User	User-defined unit

APPENDIX B

Serial commands

Every setting and reading of the meter is available over the RS-232 or RS-485 interface with the ASCII commands below. The ZFM Configuration Utility uses the same commands and has a terminal mode for typing them; any serial terminal program works as well. Connection and port settings: Digital interface (p. 14).

Command format

RS-232	`<Cmd>,Arg1,Arg2,Arg3,Arg4<CR>` — example `F<CR>`
RS-485	`!<Addr>,<Cmd>,Arg1,Arg2,Arg3,Arg4<CR>` — example `!11,F<CR>`

- `!` is the start character and `<Addr>` the RS-485 address in two hexadecimal characters (00–FF; 11 as delivered). Use both only with RS-485; leave them out on RS-232.
- `<Cmd>` is the one- or two-letter command; arguments follow, separated by commas. All characters are printable ASCII.
- Every command ends with a carriage return **<CR>**. Line feeds are ignored.
- In the tables, * marks the setting active as delivered and ** a feature that not every meter has.

Examples for a meter at RS-485 address 12 (hexadecimal; 18 decimal):

Sent	Reply	Meaning
`!12,G`	`!12,G 0 AIR`	Active gas table is the main table 0, set to air
`!12,A,R`	`!12,AR:N`	No flow alarm
`!12,F`	`!12,50.0`	Flow is 50.0 in the current unit (here % FS)
`!12,A,C,90.0,10.0`	`!12,AC:90.00,10.00`	High alarm set to 90 % FS, low alarm to 10 % FS

Unknown address. To give a meter whose address you do not know a new one, connect it alone to the bus and send `!00,MW,118,XX`, where XX is the new address (01–FF). Address 00 is the global address: every meter on the bus executes a command sent to it, but none replies. Never assign 00 to a meter.

Reading the meter

Cmd	Arguments	Function	Reply (example)
`F`	—	Flow in the current unit	`25.4`
`PI`	—	Process information: flow, total 1, total 2, flow alarm status (D, N, H, L), alarm events register, diagnostic events register	`25.4,354.2,248.9,N,0x1,0x0`
`DI`	—	Device information: gas table and gas, full scale in sL/min, unit, K-factor mode and value, analogue output mode, Modbus hardware (0 installed, 1 not installed)	`DI:0,NITROGEN,0.8000,ml/min,0,1.0000,0,0`
`G`	—	Active gas table and its gas	`G:0,NITROGEN`
	0–10	Select gas table: 0 main table, 1–10 user tables. The primary table cannot be selected.	`1,ARGON`

Event registers

Cmd	Arguments	Function	Reply (example)
AE	—	Read the alarm events status register	AE:0x0
	R	Reset the status register to 0x0000	AER:0x0
	M [,value]	Read or set the mask register, 0x0000–0x0FFF (all six characters)	AEM:0x11
	L [,value]	Read or set the latch register, 0x0000–0x0FFF	AEL:0x11
DE	as AE	The same for the diagnostic events registers	DE:0x0, DEM:0x101

Alarm event bits

0x0001	0 High flow alarm
0x0002	1 Low flow alarm
0x0004	2 Flow between limits
0x0008	3 Totaliser 1 limit
0x0010	4 Totaliser 2 limit
0x0020	5 Pulse output queue above limit
0x0040	6 Flow above limit
0x0080	7 Password event
0x0100	8 Power-on event

Diagnostic event bits

0x0001	0 CPU temperature too high
0x0002	1 Sensor compartment too hot
0x0004	2 Sensor heater voltage out of range
0x0008	3 Sensor RTD (resistance temperature detector) voltage out of range
0x0010	4 2.5 V reference out of range
0x0020	5 Analogue output alarm
0x0040	6 Serial interface error
0x0080	7 Modbus interface error
0x0100	8 EEPROM error
0x0200	9 Auto zero failure
0x0400	A Fatal error

Flow alarm and relay

Cmd	Arguments	Function	Reply (example)
A	C,high,low	Set the limits in % FS: high 0.1–110.0, low 0.0–109.9; high must be above low	AC:40.10,20.50
	A,value	Action delay, 0–3600 s	AA:5
	P,value	Power-on delay, 0–3600 s	AP:60
	L,value	Latch: 0 off*, 1 on	AL:0
	E / D	Enable / disable* the alarm	A:E
	R	Alarm status: N none, H high (flow ≥ high limit), L low (flow ≤ low limit)	AR:N
	S	Settings: mode, high, low, action delay, latch, power-on delay	AS:E,40.00,20.00,2,0,10
R	D*, AL, AH, AR, T1, T2, PO, AE, DE, M	Assign the relay: none, low alarm, high alarm, range between limits, totaliser 1 or 2 limit, pulse output, alarm events, diagnostic events, manual on. When energized, the normally open contacts close.	R:AL
	S	Current assignment	R:D

Totalisers and pulse output

Cmd	Arguments	Function	Reply (example)
T	1 or 2, then:	Totaliser 1 or 2	
	Z	Reset to zero	T1Z
	C,start,limit	Start flow in % FS (0.0–100.0) and limit volume in the current unit (0 = no limit event)	T2C:2.0,20580.5
	P,value	Power-on delay, 0–3600 s	T1P:10
	E / D	Enable / disable*	T1:E
	R	Read the total in the current unit	T1R:<value>
	S	Settings: mode, start flow, limit, power-on delay, auto reset, auto reset delay	T1S:E,0.5,2045.2,10,0,5
	A,0|1	Auto reset off / on	T2A:1
	I,value	Auto reset delay, 0–3600 s	T1I:2
	B	Restore the total from the backup copy	T1B
	L [,0|1]	Read or set the reset lock: 0 unlocked, 1 locked (a locked totaliser cannot be reset)	T1L:1
P	U,value	Quantity per pulse, in the current unit	PU:10
	T,value	Pulse length, 50–6553 ms	PT:100
	F,value	Start flow, 0.0–100.0 % FS	PF:1.0
	E / D	Enable / disable*	P:E
	Q	Number of pulses waiting in the queue	PQ:<value>
	S	Settings: mode, start flow, quantity per pulse, pulse length	PS:E,1.0,1.666,100

Units, K factors and gas data

Cmd	Arguments	Function	Reply (example)
U	—	Current unit	U:mL/min
	unit	Select a unit by its name (Appendix A (p. 46)); %FS* as delivered	U:L/min
	USER	Select the user-defined unit	USER
	USER,k,t,d	Define the user unit: factor k (> 0) relative to sL/min; time base t: 0 second, 1 minute, 2 hour, 3 day; density d: 1 use, 0 do not use	U:USER,1.5,1,0
K	S	K-factor settings: mode, internal index, user factor, user density	KS:U,1,0.91200,1.16
	D	Mode disabled (K = 1.0)	KD
	I [,index]	Mode internal; index 1–26 (Table C-1)	KI:1,C2H2
	U [,k,d]	Mode user-defined; factor 0.00001–999.9 (the menu accepts 0.001–999.9), density 0.002–99.9 g/L at 21.1 °C and 14.7 psia	KU:0.91200,1.16
	N [,E|D]	N2 roll-back on or off (user gas tables only)	KN:D
C	D [,value]	Density of the gas of the active user table (1–10) at standard conditions, 0.00001–999.9 g/L	CD:1.256
	T	Hours since the last calibration	CT:1024.2
	T,Z	Reset the calibration timer — do this after each calibration	CT:Z

Outputs, LED and display

Cmd	Arguments	Function	Reply (example)
AO	M [,0|1|2]	Analogue output mode: 0 0–5 V DC, 1 0–10 V DC, 2 4–20 mA	AOM:1
	S	Analogue output alarm: N normal, Y abnormal condition detected	AOS:N
S	[mode]	Status LED mode: 0 normal, 1 flow alarm and totalisers, 2 alarm events, 3 diagnostic events, 4 serial interface traffic, 5 Modbus traffic	S:1
L**	—	Display installed: Y or N	
	M [,S|D]	Screen mode static or dynamic	LM:S
	T [,value]	Screen time in dynamic mode, 1–3600 s	LT:5
	S [,mask]	Screen mask 0x0001–0x003F (all six characters): 0x01 screen 1 (cannot be switched off), 0x02 screen 2 … 0x20 screen 6	LS:0x3F
	B [,value]	Brightness, 1–255	LB:127
	P [,mode]	Screen saver: 0 off, 1 low brightness, 2 vertical scrolling, 3 display off	LP:2
	O [,value]	Screen saver delay, 1–36 000 s	LO:900
	C [,value]	Screen saver brightness, 1–128	LC:6
	D [,0|1]	Flow reading precision: 0 normal, 1 elevated	LD:1

For most settings, sending the command without its value reads the current setting instead of changing it.

Auto zero

> **Note**
> An auto zero taken with gas flowing or with a cold sensor makes all later readings wrong. Start an auto zero only with absolutely no flow through the meter, after at least 30 minutes of power. Send Z, W only after an auto zero that succeeded (Z, S returns status D).

Cmd	Arguments	Function	Reply (example)
Z	N	Start the auto zero now	ZN
	S	Status: zero control value, sensor counts, status (N not started, I in progress, F failed, D done)	ZS:721,2,N
	V	Current zero control value	ZV,589
	T [,value]	Zero tolerance, 5–255 counts (7 as delivered)	ZT:7
	W	Save the zero control value and the sensor compartment temperature	ZW

Modbus, memory and error codes

Cmd	Arguments	Function	Reply (example)
MB**	B [,baud]	Modbus baud rate: 1200, 2400, 4800, 9600*, 19 200, 38 400, 57 600, 115 200	MBB:9600
	P [,0|1|2]	Parity: 0 none*, 1 odd, 2 even	MBP:0
	S [,1|2]	Stop bits: 1 or 2*	MBS:2
	A [,address]	Modbus address, 1–247 (11 as delivered)	MBA:11
	D	Counters: messages, CRC errors, slave messages, overrun errors	MBD:1,0,0,0
	R	Reset the Modbus port	MBR:Done
MR	index	Read the memory location 0–285	value
MW	index,value	Write a memory location, 115–285; locations 0–114 are read only	

NOTICE

The memory holds the factory settings of the meter, and some locations are write-protected. A wrong value written with MW can make the meter malfunction. Write to the memory only when Analyt-MTC support asks you to — with the one exception of the address change described above.

Error codes in replies

1	Command not supported, or service access not enabled	6	Command or argument not found
2	Wrong number of arguments	7	Wrong argument value
3	Memory address out of range (MR, MW)	8	Command not permitted
4	Wrong number of characters in an argument	9	Wrong or disabled key for manufacturer data
5	Attempt to change a write-protected memory location		

Factory parameters

The following commands read and set parameters that are adjusted at the factory for each sensor: the signal conditioner (SC: non-linear filter, running average of 1–255 samples, dynamic response compensation), the dynamic temperature-dependent auto zero (Z , D) and the sensor span temperature compensation (TC). Read them freely when Analyt-MTC support asks for the values.

NOTICE

Wrong factory parameters degrade the accuracy and the temperature compensation of the meter. Do not change them unless Analyt-MTC support asks you to.

Cmd	Arguments	Function	Reply (example)
SC	M [,E|D]	Non-linear filter of the flow reading: E on*, D off	`SCM:E`
	R [,value]	Running average, 1–255 samples; 1 = off*	`SCR:1`
	A [,a0,a1]	Filter parameters a0 and a1, 0.01–0.99 each; a1 must be greater than a0	`SCA:0.20,0.80`
	Z [,E|D]	Non-linear filter of the sensor reading used by the auto zero: E on, D off	`SCZ:E`
	C [,0|1|2]	Dynamic response compensation (DRC): 0 off, 1 rising flow only, 2 rising and falling flow*	`SCC:2`
	D [,D0,D1]	Filter parameters D0 and D1, 0.01–0.99 each; D1 must be greater than D0	`SCD:0.20,0.80`
Z	D,M [,E|D]	Dynamic temperature-dependent auto zero (DTDAZ): E on*, D off	`ZDM:E`
	D,T [,value]	DTDAZ temperature difference threshold, 0–20 °C	`ZDT:1.0`
	D,C [,value]	DTDAZ temperature coefficient, −50.0 to 50.0 ADC counts per °C	`ZDC:2.081`
	D,R [,value]	Change of the sensor ADC output per count of the zero control value, 0.1–99.9	`ZDR:13.0`
TC	M [,E|D]	Sensor span temperature compensation: E on, D off	`TCM:E`
	S	Status: mode, threshold (°C), sensor compartment temperature (°C), the same at the last calibration (°C), calculated correction	`TCS:E,1.0,26.1,26.5,0`
	T [,value]	Activation threshold, 0.0–25.0 °C (1.0 °C as delivered)	`TCT:2.0`
	A [,value]	Threshold in ADC counts, 0.0–50 000.0 (36 569 as delivered)	`TCA:39256.0`
	C [,value]	Correction threshold, 0.0–25.0 °C (2.5 °C as delivered)	`TCC:2.5`
	P [,a,b,c]	Parameters a, b, c of the base polynomial	`TCP:0.00000002,0.0011,0.4295`
	Q [,a,b,c]	Parameters a, b, c of the correction polynomial	`TCQ:0.00000003,0.0008,1.1611`

APPENDIX C

Gas conversion factors

K factors relative to nitrogen, with the specific heat c_p and the density d from which they are derived (Calculating with K factors (p. 33)). To use a factor, select it in the meter (K factors (p. 20)): one of the 26 stored gases by its number in Table C-1, or any other gas as a user-defined factor with its density.

Note
K factors are approximations at best, accurate to no better than about ±5 to 10 %. Do not rely on them where you need a better accuracy.

Gases stored in the meter

Table C-1 Internal K-factor table; density at 21.1 °C and 14.7 psia

No.	Gas	K	c_p cal/g	d g/L
1	Acetylene C_2H_2	**0.5829**	0.4036	1.0818
2	Ammonia NH_3	**0.7310**	0.492	0.7076
3	Arsine AsH_3	**0.6735**	0.1167	3.2380
4	Boron trifluoride BF_3	**0.5082**	0.1778	2.8163
5	Bromine Br_2	**0.8083**	0.0539	6.6380
6	Butane C_4H_{10}	**0.2631**	0.4007	2.4141
7	Carbon monoxide CO	**1.0000**	0.2488	1.1637
8	Cyanogen C_2N_2	**0.6100**	0.2613	2.1618
9	Chlorine Cl_2	**0.8600**	0.114	2.9447
10	Carbonyl fluoride COF_2	**0.5428**	0.1710	2.7418
11	Carbonyl sulfide COS	**0.6606**	0.1651	2.4951
12	Carbon disulfide CS_2	**0.6026**	0.1428	3.1626
13	Ethane C_2H_6	**0.5000**	0.420	1.2494
14	Ethylene C_2H_4	**0.6000**	0.365	1.1647
15	Fluorine F_2	**0.9784**	0.1873	1.5780
16	Hydrogen H_2	**1.0106**	3.419	0.0837
17	Hydrogen chloride HCl	**1.0000**	0.1912	1.5147
18	Methane CH_4	**0.7175**	0.5328	0.6656
19	Nitrous oxide N_2O	**0.7128**	0.2088	1.8284
20	Neon Ne	**1.4600**	0.246	0.8379
21	Nitric oxide NO	**0.9900**	0.2328	1.2466
22	Phosphine PH_3	**0.7590**	0.2374	1.4123
23	Propane C_3H_8	**0.3500**	0.399	1.8313
24	Propylene C_3H_6	**0.4000**	0.366	1.7475
25	Sulfur dioxide SO_2	**0.6900**	0.1488	2.6608
26	Xenon Xe	**1.4400**	0.0378	5.4538

Number 27 in the meter's list is the user-defined factor.

Other gases

Table C-2 K factors for further gases; density at 0 °C

Gas	K	c_p cal/g	d g/L
A			
Acetylene C_2H_2	**0.5829**	0.4036	1.162
Air	**1.000**	0.24	1.293
Allene (propadiene) C_3H_4	**0.4346**	0.352	1.787
Ammonia NH_3	**0.7310**	0.492	0.760
Argon Ar	**1.4573**	0.1244	1.782
Arsine AsH_3	**0.6735**	0.1167	3.478
B			
Boron tribromide BBr_3	**0.38**	0.0647	11.18
Boron trichloride BCl_3	**0.4089**	0.1279	5.227
Boron trifluoride BF_3	**0.5082**	0.1778	3.025
Bromine Br_2	**0.8083**	0.0539	7.130
Bromine pentafluoride BrF_5	**0.26**	0.1369	7.803
Bromine trifluoride BrF_3	**0.3855**	0.1161	6.108
Bromotrifluoromethane (Freon-13B1) $CBrF_3$	**0.3697**	0.1113	6.644

Gas	K	c_p cal/g	d g/L
1,3-Butadiene C_4H_6	**0.3224**	0.3514	2.413
Butane C_4H_{10}	**0.2631**	0.4007	2.593
1-Butene C_4H_8	**0.2994**	0.3648	2.503
cis-2-Butene C_4H_8	**0.324**	0.336	2.503
trans-2-Butene C_4H_8	**0.291**	0.374	2.503
C			
Carbon dioxide CO_2	**0.7382**	0.2016	1.964
Carbon disulfide CS_2	**0.6026**	0.1428	3.397
Carbon monoxide CO	**1.00**	0.2488	1.250
Carbon tetrachloride CCl_4	**0.31**	0.1655	6.860
Carbon tetrafluoride (Freon-14) CF_4	**0.4210**	0.1654	3.926
Carbonyl fluoride COF_2	**0.5428**	0.1710	2.945
Carbonyl sulfide COS	**0.6606**	0.1651	2.680
Chlorine Cl_2	**0.86**	0.114	3.163
Chlorine trifluoride ClF_3	**0.4016**	0.1650	4.125
Chlorodifluoromethane (Freon-22) $CHClF_2$	**0.4589**	0.1544	3.858
Chloroform $CHCl_3$	**0.3912**	0.1309	5.326
Chloropentafluoroethane (Freon-115) C_2ClF_5	**0.2418**	0.164	6.892
Chlorotrifluoromethane (Freon-13) $CClF_3$	**0.3834**	0.153	4.660
Cyanogen C_2N_2	**0.61**	0.2613	3.322
D			
Deuterium D_2	**1.00**	1.722	1.799
Diborane B_2H_6	**0.4357**	0.508	1.235
Dibromodifluoromethane CBr_2F_2	**0.1947**	0.15	9.362
Dichlorodifluoromethane (Freon-12) CCl_2F_2	**0.3538**	0.1432	5.395
Dichlorofluoromethane (Freon-21) $CHCl_2F$	**0.4252**	0.140	4.592
Dichloromethylsilane $(CH_3)_2SiCl_2$	**0.2522**	0.1882	5.758
Dichlorosilane SiH_2Cl_2	**0.4044**	0.150	4.506
Dichlorotetrafluoroethane (Freon-114) $C_2Cl_2F_4$	**0.2235**	0.1604	7.626
1,1-Difluoroethylene (Freon-1132A) $C_2H_2F_2$	**0.4271**	0.224	2.857
Dimethyl ether $(CH_3)_2O$	**0.3896**	0.3414	2.055
Dimethylamine $(CH_3)_2NH$	**0.3714**	0.366	2.011
2,2-Dimethylpropane C_5H_{12}	**0.2170**	0.3914	3.219
E			
Ethane C_2H_6	**0.50**	0.420	1.342
Ethanol C_2H_6O	**0.3918**	0.3395	2.055
Ethyl acetylene C_4H_6	**0.3225**	0.3513	2.413
Ethyl chloride C_2H_5Cl	**0.3891**	0.244	2.879
Ethylene C_2H_4	**0.60**	0.365	1.251
Ethylene oxide C_2H_4O	**0.5191**	0.268	1.965
F			
Fluorine F_2	**0.9784**	0.1873	1.695
Fluoroform (Freon-23) CHF_3	**0.4967**	0.176	3.127
G			
Germane GeH_4	**0.5696**	0.1404	3.418
Germanium tetrachloride $GeCl_4$	**0.2668**	0.1071	9.565
H			
Helium[1] He	**1.454**	1.241	0.1786
Hexafluoroethane (Freon-116) C_2F_6	**0.2421**	0.1834	6.157
Hexane C_6H_{14}	**0.1792**	0.3968	3.845
Hydrogen[1] H_2	**1.0106**	3.419	0.0899
Hydrogen bromide HBr	**1.000**	0.0861	3.610
Hydrogen chloride HCl	**1.000**	0.1912	1.627
Hydrogen cyanide HCN	**0.764**	0.3171	1.206
Hydrogen fluoride HF	**0.9998**	0.3479	0.893
Hydrogen iodide HI	**0.9987**	0.0545	5.707
Hydrogen selenide H_2Se	**0.7893**	0.1025	3.613
Hydrogen sulfide H_2S	**0.80**	0.2397	1.520
I			
Iodine pentafluoride IF_5	**0.2492**	0.1108	9.90
Isobutane $CH(CH_3)_3$	**0.27**	0.3872	3.593
Isobutylene C_4H_8	**0.2951**	0.3701	2.503
K			
Krypton Kr	**1.453**	0.0593	3.739
M			
Methane[1] CH_4	**0.7175**	0.5328	0.715
Methanol CH_3OH	**0.5843**	0.3274	1.429
Methyl acetylene C_3H_4	**0.4313**	0.3547	1.787
Methyl bromide CH_3Br	**0.5835**	0.1106	4.236
Methyl chloride CH_3Cl	**0.6299**	0.1926	2.253
Methyl fluoride CH_3F	**0.68**	0.3221	1.518
Methyl mercaptan CH_3SH	**0.5180**	0.2459	2.146
Methyltrichlorosilane $(CH_3)SiCl_3$	**0.2499**	0.164	6.669
Molybdenum hexafluoride MoF_6	**0.2126**	0.1373	9.366
Monoethylamine $C_2H_5NH_2$	**0.3512**	0.387	2.011
Monomethylamine CH_3NH_2	**0.51**	0.4343	1.386
N			
Neon Ne	**1.46**	0.246	0.900
Nitric oxide NO	**0.990**	0.2328	1.339

Gas	K	c_p cal/g	d g/L
Nitrogen N_2	**1.000**	0.2485	1.25
Nitrogen dioxide NO_2	**0.737**	0.1933	2.052
Nitrogen trifluoride NF_3	**0.4802**	0.1797	3.168
Nitrosyl chloride NOCl	**0.6134**	0.1632	2.920
Nitrous oxide N_2O	**0.7128**	0.2088	1.964
O			
Octafluorocyclobutane (Freon-C318) C_4F_8	**0.176**	0.185	8.397
Oxygen O_2	**0.9926**	0.2193	1.427
Oxygen difluoride OF_2	**0.6337**	0.1917	2.406
Ozone O_3	**0.446**	0.195	2.144
P			
Pentaborane B_5H_9	**0.2554**	0.38	2.816
Pentane C_5H_{12}	**0.2134**	0.398	3.219
Perchloryl fluoride ClO_3F	**0.3950**	0.1514	4.571
Perfluoropropane C_3F_8	**0.174**	0.197	8.388
Phosgene $COCl_2$	**0.4438**	0.1394	4.418
Phosphine PH_3	**0.759**	0.2374	1.517
Phosphorus oxychloride $POCl_3$	**0.36**	0.1324	6.843
Phosphorus pentafluoride PF_5	**0.3021**	0.1610	5.620
Phosphorus trichloride PCl_3	**0.30**	0.1250	6.127
Propane C_3H_8	**0.35**	0.399	1.967
Propylene C_3H_6	**0.40**	0.366	1.877
S			
Silane SiH_4	**0.5982**	0.3189	1.433
Silicon tetrachloride $SiCl_4$	**0.284**	0.1270	7.580
Silicon tetrafluoride SiF_4	**0.3482**	0.1691	4.643
Sulfur dioxide SO_2	**0.69**	0.1488	2.858
Sulfur hexafluoride SF_6	**0.2635**	0.1592	6.516
Sulfuryl fluoride SO_2F_2	**0.3883**	0.1543	4.562
T			
Tetrafluoroethane (R-134a) CF_3CH_2F	**0.5096**	0.127	4.224
Tetrafluorohydrazine N_2F_4	**0.3237**	0.182	4.64
Titanium tetrachloride $TiCl_4$	**0.2691**	0.120	8.465
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon-113) CCl_2FCClF_2	**0.2031**	0.161	8.36
Trichloroethylene C_2HCl_3	**0.32**	0.163	5.95
Trichlorofluoromethane (Freon-11) CCl_3F	**0.3287**	0.1357	6.129
Trichlorosilane $SiHCl_3$	**0.3278**	0.1380	6.043
Triisobutylaluminium $(C_4H_9)_3Al$	**0.0608**	0.508	8.848
Trimethylamine $(CH_3)_3N$	**0.2792**	0.3710	2.639
Tungsten hexafluoride WF_6	**0.2541**	0.0810	13.28
U			
Uranium hexafluoride UF_6	**0.1961**	0.0888	15.70
V			
Vinyl bromide CH_2CHBr	**0.4616**	0.1241	4.772
Vinyl chloride CH_2CHCl	**0.48**	0.12054	2.788
X			
Xenon Xe	**1.44**	0.0378	5.858

[1] Value for flows up to 10 sL/min, which covers every ZFM 17 range.

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