axetris
Company of the Leister Group

MICRO-OPTICS INFRARED SOURCES MASS FLOW DEVICES LASER GAS DETECTION

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Specification

MFM / MFC RS-232 Data Communication

Introduction

Axetris offers Mass Flow Meter (MFM) and Controller (MFC) modules, as well as standalone Mass Flow Meters and Controllers. All products feature both analog and digital interface input / output capabilities. Therefore Axetris is able to deliver exactly the required device interface that fits the communication system of each customer application.

The goal of this document is to describe in detail all the RS-232 communication features, allowing the customer to quickly connect multiple devices with a single bus wire to their command unit system, establishing a safe and reliable communication. For RS-485 refer to the document MFM / MFC RS-485 Data Communication.

Mass Flow Meters / Controllers with RS-232 interface

MFM 202X
MFM 22XX

Mass Flow Meter
OEM Modules

MFC 2022
MFC 2222

Mass Flow Controller
OEM Modules

MFM 21XX
MFC 21XX
Mass Flow Meter
Mass Flow Controller
Standalone

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Abbreviations, Terms and Definitions

MFM	Mass Flow Meter
MFC	Mass Flow Controller
% O.R.	Percent Of Reading
% F.S.	Percent of Full Scale
sccm	Standard cubic centimetre per minute at reference conditions of 1013 mbar absolute pressure and 0°C temperature.
uccm	User defined standard cubic centimetre per minute at reference conditions of 1013 mbar absolute pressure and 0°C temperature. (Term defined by Axetris)

MSB/LSB	Most Significant Bit / Least Significant Bit
RD/RW	Read / Read and Write
RS-232 EIA	Serial bus standard protocol according to EIA-232
RS-232 TTL	Serial bus standard protocol with TTL level
RS-485	Serial bus standard protocol according to EIA-485 for digital multipoint system communication
RS-485 HD	RS-485 Half Duplex (2 wires)
RS-485 FD	RS-485 Full Duplex (4 wires)

1 General Description

Axetris MFM / MFC modules are capable of communicating by means of analog and digital communication interfaces. The analog input / output is either of voltage type (0…5 V) or current type (4…20 mA).

The serial interface protocol is based on a master slave communication between the device and typically a computer. To respond to the important diversity of applications of such devices, and to deliver the right level of integration complexity, Axetris has developed two levels of communication to fit with the customer's integration.

- The **customer mode** communication level which is the ready-to-use level for high-end applications with standard communication capabilities.
- The **service mode** communication level that allows RD/RW of low level information, such as calibration parameters or filter gains.

All Axetris Mass flow products of the MFM /MFC 2000 series are factory calibrated for a specific gas type, flow range, input pressure range and reference conditions. The devices are fully temperature compensated for a temperature range from 0…50 °C. The parameters for filter and PID parameter are factory set and support almost all common applications. For special conditions they can be tuned and changed by the customer (functionality available on request).

Multi-gas and/or multi-range calibration is possible; the device contains up to 8 channels that can be selected any time with the digital communication protocol. Using other gases and/or other ranges of the ones calibrated in the device is strongly discouraged. False measurements and/or uncontrolled flows will occur in such cases.

To facilitate the communication with the MFMs / MFCs a GUI (Graphical User Interface) interface based on the Labview (National Instrument) program is available. You may consult with the Axetris team in case of need.

Depending on the device type, a meter or a controller, module or standalone, the communication interface features are summarized for the customer mode in Table 1.

	Type	Analog output	Analog input	Digital output[1]	Digital input
Meter	MFM 2020 MFM 2220	Gas flow 0…5 V	-	Gas flow Temperature Gas calibration info.	Offset zeroing Channel selection[2]
	MFM 2120	Gas flow 0…5 V	-	Gas flow Temperature Gas calibration info.	Offset zeroing Channel selection
	MFM 2130	Gas flow 4…20 mA	-	Gas flow Temperature Gas calibration info.	Offset zeroing Channel selection
Meter with PID output	MFM 2X21	Gas flow 0…5 V PID_out 0…5 V	Set point 0…5 V Valve override	Gas flow Temperature Gas calibration info. PID Controller Output	Set point Valve override Offset zeroing Channel selection
Bidirectional Meter	MFM 2X23	Gas flow 0…5 V Gas flow 4…20 mA[3]	-	Gas flow Temperature Gas calibration info.	Offset zeroing Channel selection
Controller	MFC 2022	Gas flow 0…5 V PID_out 0…5 V	Set point 0…5 V Valve override	Gas flow Temperature Gas calibration info. PID Controller Output	Set point Valve override Offset zeroing Channel selection
	MFC 2222	Gas flow 0…5 V	Set point 0…5 V Valve override	Gas flow Temperature Gas calibration info. PID Controller Output	Set point Valve override Offset zeroing Channel selection
	MFC 2122	Gas flow 0…5 V	Set point 0…5 V Valve override	Gas flow Temperature Gas calibration info. PID Controller Output	Set point Valve override Offset zeroing Channel selection
	MFC 2132	Gas flow 4…20 mA	Set point 4…20 mA Valve override	Gas flow Temperature Gas calibration info. PID Controller Output	Set point Valve override Offset zeroing Channel selection

Table 1 Type comparison and product functionality including main communication features in customer mode.

MFx 20xx: Modules without housing and RS-232 TTL level Interface
MFx 22xx: Modules without housing and RS-232 EIA level Interface
MFx 21xx Types with housing and RS-232 EIA Interface

[1] Only main customer mode digital output information is listed in this table. For access to internal data available in the service mode, see chapter 6.

[2] In case of multi-gas, multi-range calibration of the device. Up to 8 channels are available (2 channels are reserved for factory only, 6 channels are reserved for customer's needs)

[3] Only available as MFM 2223

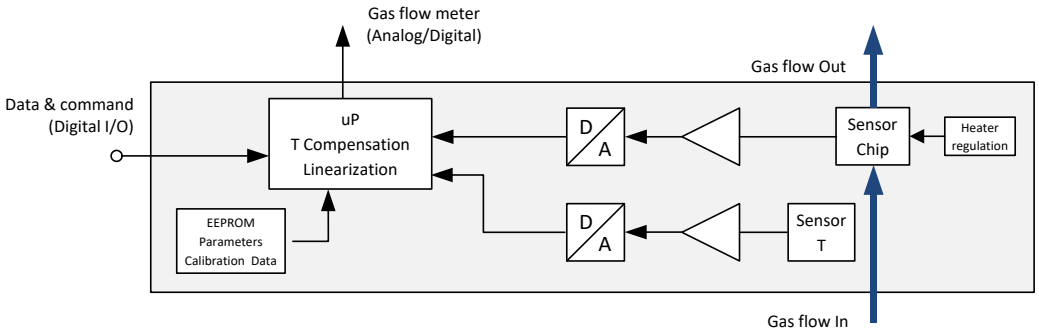


Figure 1 Block diagram of the MFM 2100 and MFM 2200 series of mass flow meter

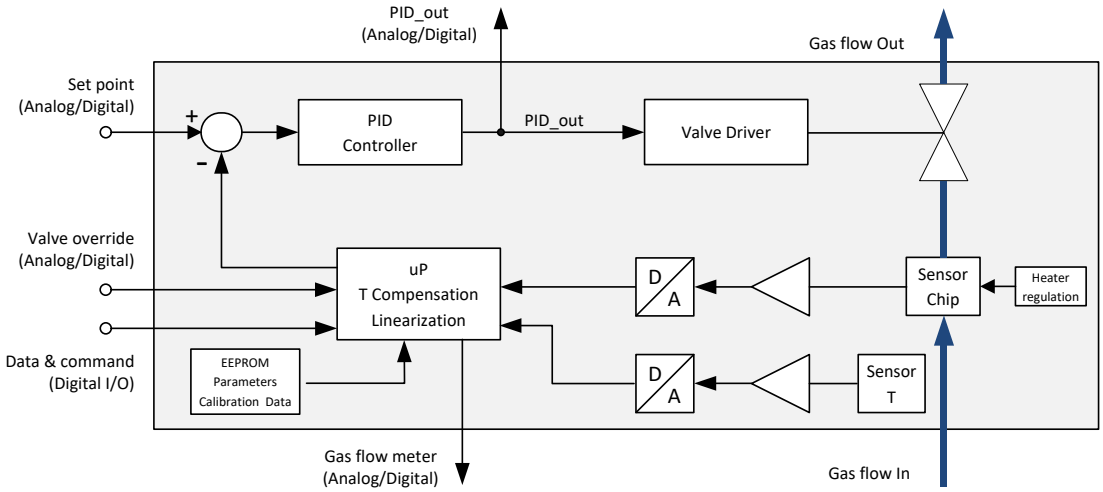
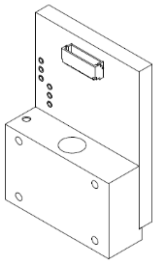
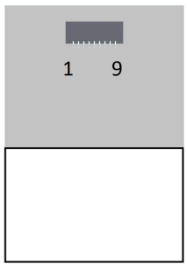


Figure 2 Block diagram of the MFC 2100 and MFC 2200 series of mass flow controller

2 Pin assignment for Modules

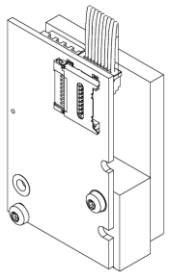
MFM 202X RS-232 TTL / 0…5 V

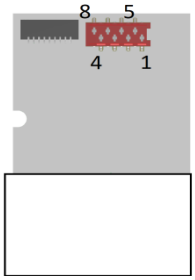




Pin	I/O Type	Description
1	Power	+ **12 V / ± 10%**
2	Power	GND (Power)
3	Digital In	RxD_TTL
4	Digital Out	TxD_TTL
5	Analog	GND (Analog)
6	Analog Out	PID_OUT (MFM 2021)
7	Analog Out	Flow value, 0…5V
8	Analog In	Flow Set-point (MFM 2021)
9	Analog In	Valve Override (MFM 2021)

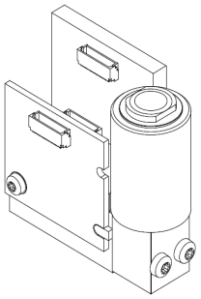
MFM 222X RS-232 EIA / 0…5 V

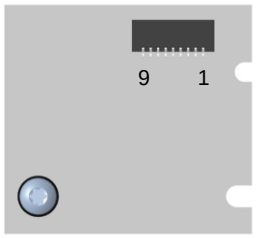




Pin	I/O Type	Description
1	Power	**+ 24 V / ± 10%**
2	Power	GND (Power)
3	Digital In	RxD
4	Digital Out	TxD
5	Analog	GND (Analog)
6	Analog Out	Flow value, 0…5 V
7	nc	
8	nc	

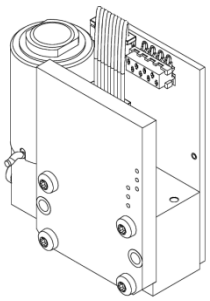
MFC 2022 RS-232 TTL / 0…5 V

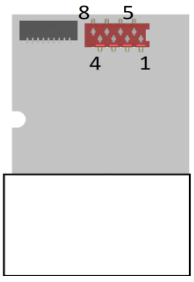




Pin	I/O Type	Description
1	Power	**+ 24 V / ± 10%**
2	Power	GND (Power)
3	Digital In	RxD_TTL
4	Digital Out	TxD_TTL
5	Analog	GND (Analog)
6	Analog Out	PID_OUT, 0…5 V
7	Analog Out	Flow value, 0…5 V
8	Analog In	Flow Set-point, 0…5 V
9	Analog In	Valve Override, 0…5 V

MFC 2222 RS-232 EIA / 0…5 V





Pin	I/O Type	Description
1	Power	**+ 24 V / ± 10%**
2	Power	GND (Power)
3	Digital In	RxD
4	Digital Out	TxD
5	Analog	GND (Analog)
6	Analog Out	Flow value, 0…5 V
7	Analog In	Flow Set-point, 0…5 V
8	Analog In	Valve Override, 0…5 V

Table 2 Pin assignment Mass Flow Meter and Controller modules
MFM 2020, MFM 2021, MFC 2022 connector type JST-SM09B-SR
MFM 2222, MFC 2222 connector type Micromatch 8-pole

3 Pin assignment for standalone types

3.1 D-SUB connector – 9 pins (standard)

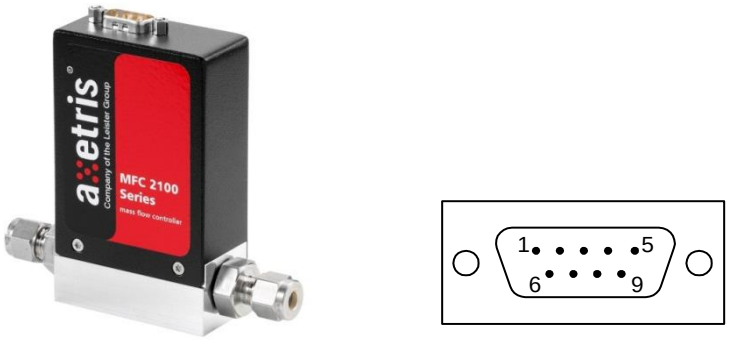


Figure 3 Top view D-SUB 9 poles connector

MFM 2120/ MFC 2122
RS-232 / 0…5 V

Pin	I/O Type	Description
1	Power	+ 24 V / ± 10%
2	Power	GND (Power)
3	Digital In	RxD
4	Digital Out	TxD
5	nc	
6	Analog GND	GND
7	Analog Out	Flow value, 0…5V
8	Analog In	Flow Set-point (MFC), 0…5V
9	Analog In	Valve Override (MFC), 0V close / 5V open

MFM 2130/ MFC 2132
RS-232 / 4…20 mA

Pin	I/O Type	Description
1	Power	+ 24 V / ± 10%
2	Power	GND (Power)
3	Digital In	RxD
4	Digital Out	TxD
5	nc	
6	Analog GND	GND
7	Analog Out	Flow value, 4…20 mA
8	Analog In	Flow Set-point (MFC), 4…2mA
9	Analog In	Valve Override (MFC), 0V close / 5V open

Table 3 Pin assignment for D-SUB 9 connector

4 RS-232 Functional description

4.1 Device input / output configuration

There is no default configuration setup. Due to the many possibilities that are available, the devices are delivered with features which correspond to the customer requirements. Analog input / output is either of voltage type (0…5 V) or current type (4…20 mA). The digital input / output is RS-232. RS-485 is also available (RS-485 Half Duplex MFM 2x40, MFC 2x42 ; RS-485 Full Duplex MFM 2x50, MFC 2x52, see document “MFM / MFC RS-485 Data Communication”). The type of the analog input / output, voltage or current, is set by the manufacturer at the factory level. The way the customer wants to communicate with the device, analog or digital, can be set later at any time with the corresponding digital command. This configuration is stored in an EEPROM forcing the device to start always in the same configuration. There is no reset feature that would bring back the device to a “basic” configuration.

Each device will send the hexadecimal code FF_{Hex} and then 53_{Hex} after turn-on when the device is ready to communicate and to operate (after 3 seconds).

4.2 Meter modules MFM 202X / MFM 222X

The OEM MFM 202X and MFM 222X are meters only. The purpose of the meter modules is to be integrated in a system. According to the needs of the customer, the data output can be read in analog way (voltage only) or digital way using RS-232 with TTL levels (MFM 2020/MFM 2021/MFM 2023) or RS-232 with EIA levels (MFM 2220/MFM 2221/MFM 2223).

The analog output is the gas flow measurement value, and is defined as follows:

Analog Output	V	Linear: 0 V = 0% F.S./ 5 V = 100% F.S.
	mA	Linear: 4 mA = 0% F.S. / 20 mA = 100% F.S

For meters with a bidirectional flow functionality (MFM 2X23), the analog output is defined as follows:

Analog Output for bidirectional meters (MFM 2X23)		
Symmetric Version	V	Linear: 2.5 V = 0% F.S./ 5 V = 100% F.S.
	mA	Linear: 12 mA = 0% F.S. / 20 mA = 100% F.S.
Asymmetric Version	V	Linear: 0.5 V = 0% F.S./ 5 V = 100% F.S.
	mA	Linear: 5.6 mA = 0% F.S. / 20 mA = 100% F.S

The digital communication in customer mode offers additional information such as (see Chapter 6):

Read Data:
- Gas flow (depending on the request with single, multiple or continuous output data)
- Temperature
- Serial number (unique for each device)
- PCB number
- Software version
- Offset value
- Gas type that is currently measured (in case of multi-range and/or multi-gas calibration device). up to 8 ranges for one device can be calibrated.
- Calibrated gas information (gas type, full scale range, calibration conditions…see chapter 6 for more details)

Write Data:
- Channel selection (in case of multi-range and/or multi-gas calibration)
- Offset zeroing

The OEM MFM 2021 is a meter together with an internal PID controller. Besides the analog gas flow measurement value similar to the MFM 2020, a PID analog output 0 to 5 V is present to allow external customer valve control. Consequently to this output feature, an analog input pin allocated to

the valve override command is present to permit immediate shut-off or purge position of the external valve (0 V input – 0 V PID output 100 % close / 5 V input – 5 V PID output 100 % open). This analog valve override command is prior to any other command (analog or digital input). The valve override command is also possible digitally.
For the set point, a cut off limit at 1 % F.S. is available on request and is factory settable only.

Besides the MFM 2020 communication capabilities (see list above), the MFM 2021 digital communication in customer mode offers:

Read Data:
- Set point
- PID_out
- Valve override state
- Selected input mode for the set point (analog or digital)

Write Data:
- Set point
- Valve override
- Input mode for the set point (analog or digital)

Service Mode
In service mode, much more digital data is accessible to allow the customer to adapt the device to his own needs, i.e. device trimming, filter parameters, or even customer calibration for channels 3 to 8 (1 and 2 are accessible only by the manufacturer and are factory calibrated), thus allowing to fully adapt the device to particular customer requirements. See chapter 6, Commands & variables list definition, for more information on those additional possibilities.

4.3 Controller modules MFC 2022, MFC 2222

The MFC 2022 and MFC 2222 are small compact gas flow controller modules including an advanced internal PID controller with a fast acting solenoid valve. Its main purpose is to be integrated into an OEM system. According to the needs of the customer, the data output can be read in analog (voltage or digital modes using RS-232 TTL (MFC 2022) or RS-232 EIA (MFC 2222). Analog voltage input / output is selected as default input when not specified otherwise during ordering. The preferred way to communicate with the device, analog or digital, can be set later at any time with the corresponding digital command. This configuration is stored in an EEPROM making the device starting always in the same configuration.

The analog output is the gas flow measurement value Voltage (0…5 V), They are configured at the factory level. The digital communication in customer mode offers additional information (see chapter 6 how to code – decode the digital data):

Read Data:
- Gas flow (depending on the request with single, multiple or continuous output data)
- Temperature
- Serial number (unique for each device)
- PCB number
- Software version
- Offset value
- Gas type that is currently measured (in case of multi-range and/or multi-gas calibration device). Up to 8 ranges for one device can be calibrated.
- Calibrated gas information (gas type, full scale range, calibration conditions, see chapter 6 for more details)
- Set point
- PID_out
- Valve override state
- Selected input mode for the set point (analog or digital)

Write Data:
- Channel selection (in case of multi-range and/or multi-gas calibration)
- Offset zeroing
- Set point
- Valve override
- Input mode for the set point (analog or digital)

4.4 MFM 2120 / MFC 2122 Standalone types

The MFM 2120 is a standalone meter. Its purpose is to be a ready-to-use gas flow meter with standard gas fittings. According to the needs of the customer, the data output can be read in analog (voltage or current) or digital using RS-232 (EIA 232) with direct connection to the PC. Analog voltage or analog current input / output is selected as default at the factory level when ordering. The way the customer wants to communicate with the device, analog or digital, can be set later at any time with the corresponding digital command. This configuration is stored in EEPROM making the device starting always in the same configuration.

The analog output is the gas flow measurement value. Voltage (0…5 V) or current (4…20 mA) outputs are available. They are configured at the factory level.
The digital communication in customer mode offers additional information (see chapter 6 how to code – decode the digital data):

Read Data:
- Gas flow (depending on the request with single, multiple or continuous output data)
- Temperature
- Serial number (unique for each device)
- PCB number
- Software version
- Offset value
- Gas type that is currently measured (in case of multi-range and/or multi-gas calibration device). Up to 8 ranges for one device can be calibrated.
- Calibrated gas information (gas type, full scale range, calibration conditions…see chapter 6 for more details)

Write Data:
- Channel selection (in case of multi-range and/or multi-gas calibration)
- Offset zeroing

The MFC 2122 is a standalone gas flow controller containing an advanced internal PID controller with a rapid solenoid valve. Its purpose is to be a ready-to-use gas flow controller with standard gas fittings. According to the needs of the customer, the data output can be read in analog (voltage or current) or digital modes using RS-232 (direct connection to the PC). Analog voltage or analog current input / output are set at the factory level when ordering. The way the customer wants to communicate with the device, analog or digital, can be set later at any time with the corresponding digital command. This configuration is stored in an EEPROM making the device starting always in the same configuration.

An analog input is the set point of the gas flow. Voltage (0…5 V) or current (4…20 mA) inputs is available. It is configured at the factory level.
The analog output is the gas flow measure. Voltage (0…5 V) or current (4…20 mA) output is available. It is configured at the factory level.

Besides the analog gas flow control, the customer can take direct control of the valve in an analog or digital way. The analog valve override feature allows immediate close or purge position of the valve. The analog valve override command is prior to any other command (analog or digital input). The digital override command is permitting not only to set the close and purge position but also any intermediate position of the valve.
A cut off limit at 1 % F.S. is available on request and is factory settable only.

The MFC 2122 digital communication in customer mode offers:

Read Data:
- Gas flow (depending on the request with single, multiple or continuous output data)
- Temperature
- Serial number (unique for each device)
- PCB number
- Software version

- Offset value
- Gas type that is currently measured (in case of multi-range and/or multi-gas calibration device). Up to 8 ranges for one device can be calibrated.
- Calibrated gas information (gas type, full scale range, calibration conditions, see chapter 6 for more details)
- Set point
- PID_out
- Valve override state
- Selected input mode for the set point (analog or digital)

Write Data:
- Channel selection (in case of multi-range and/or multi-gas calibration)
- Offset zeroing
- Set point
- Valve override
- Input mode for the set point (analog or digital)

In service mode, even more digital data is accessible to allow customer device setup, device trimming or even customer calibration for channel 3 to 8, 1 and 2 are reserved for Axetris, to fully adapt the device to particular customer applications. See chapter 6, list of requests and variables, for more information on those additional possibilities.

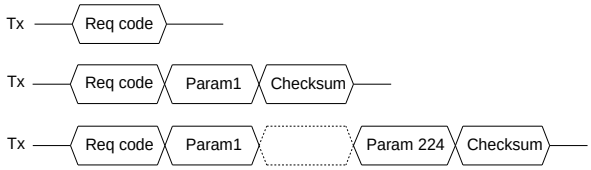
5 Interface specification

5.1 RS-232 serial communication settings

- Baud rate: 57600
- Data: 8 bits
- Stop bit: 1
- Parity: Odd
- Flow control: No handshake
- Levels: TTL Levels for the MFM 2020 / 2021 / 2023 and MFC 2022.
  EIA 232 (direct connection to a PC) for the standalone modules MFM 2120 / MFC 2122

When writing a data into the EEPROM, the maximum data rate is limited to 100 Bytes/sec. Do not write parameter command when the device is active. No update calculation is performed when writing data to the memory.

5.2 Command format



Each request begins with a one-character code identifying the request. If the request to be sent is coded on more than one byte, a checksum has to be added at the end of the command. The checksum is the sum of all the preceding bytes value, including the request byte, truncated to the last 8 bits of the results.

5.3 Response format

The response format is similar to the command format. The response sentence always begins with the repeat of the requested code, followed by data. The sentence ends with a checksum. Note that the STOP request has no response.

5.4 Analog set point and valve override (input)

If the analog input mode is selected, the set point is analog (the current input is only for the standalone MFC 2122). The valve override feature overrules the set point. The table hereafter lists the values that are possible to apply and their effects on the flow control.

Table 4: Analog input values for MFCs 2022 / 2222 / 2122

Parameters	Unit	Min. Value	Max. Value	Resolution	Remark
Set point	V	0	5	0.30518 mV	Values are linearly interpreted between 0V = closed and 5 V = 100 % F.S.
Set point	mA	4	20	976.5 uA	Values are linearly interpreted between 4mA = closed and 20 mA = 100 % F.S.
Valve override	V	0…0.2	4.8…5	-	0 V = close, 5 V = forced open (purge mode > F.S.)

The purge mode is forcing the valve to be full open and the flow is higher than F.S.

The recovery from an analog valve override state is given by any analog value between 0.2 V and 4.8 V. The device is then returned to normal mode with the PID controller on. In the digital mode, it is

the last set point value stored in the memory that will be used to control the flow. In analog mode, the flow will be set to the value present at the analog input pin.

5.5 Analog gas flow and PID_out (output)

The gas flow output is always available independently of the selected mode (analog or digital input). The analog output is either a voltage or a current. Only for the MFC 2022, the analog PID_out is available to drive an external valve provided by the customer. The table hereafter lists the analog values that are readable at the output.

Table 5: Analog output values for MFCs 2022 / 2122

Parameters	Unit	Min. Value	Max. Value	Resolution	Remark
Gas flow	V	0	5	0.30518 mV	Values are linearly interpreted between 0 V = 0 % F.S. and 5 V = 100 % F.S.
Gas flow	mA	4	20	976.5 uA	Values are linearly interpreted between 4m A = closed and 20 mA = open F.S.

Note: 110 % F.S. is reserved for margin. Therefore the maximum voltage output is 5.5 V and the maximum current output is 21.6 mA. Specifications guaranteed up to 100% F.S. (5V)

5.6 Analog readout circuit for 4…20 mA option

In the standalone MFM 2130 / MFC 2132 devices, the 4…20 mA current loop analog output is performed with a specific integrated voltage-to-current converter circuit.

Many design solutions exist to read a current loop output circuit. From the very basic solution with a single load resistor (typically 250 Ω, 4 mA = 1 V, 20 mA = 5 V) to convert current into voltage for reading the value with a DAC, or a proprietary solution, or a specific current-to-voltage converter circuit (i.e. Burr-Brown® RCV420), or a scientific instrument measuring the current, the chosen solution will fit with the system design constraints.

The adequate readout technique is left to the customer's choice according to own preferences and constraints.

6 Commands & variables list definition

6.1 Command to read/write variables

Command name	Hex	Parameters after command
READ_VAR_INT16	0X61	Variable ID
WRITE_VAR_INT16	0X62	Variable ID + Value of 2 bytes (higher bit first)
READ_VAR_CHAR	0X63	Variable ID
WRITE_VAR_CHAR	0X64	Variable ID + Value of 1 bytes (higher bit first)

IMPORTANT: Continuous writing to persistent variables should be avoided if there is no intention to change their value. It will shorten the life time of the EEPROM

See chapter 9 for examples.

6.2 List of commands

Gas flow[1]

Command name	Hex	Parameters	Customer mode	Service mode	Response
SEND_ONE_DATA	0X31	None (single request)	WR	WR	1 Flow value
SEND_N_DATA	0X32	Nx1byte	WR	WR	N Flow values
SEND_CONTINUOUS	0X33	None, terminate with STOP	WR	WR	Flow values (each 3.5 ms)
STOP	0X34	None	WR	WR	None

Device number / configuration ID / gas information / Change mode password

WRITE_SERIAL	0X67	Serial number (16 bytes)	X	WR	Request code
READ_SERIAL	0X68	None	RD	RD	Serial num.
READ_CONFIG_ID	0X76	None	RD	RD	Config. ID
READ_EXT_GASINFO	0X73	None	RD	RD	Gas info. table (17 bytes)
WRITE_EXT_GASINFO[2]	0X74	Gas info. table (17 bytes)	X	WR	Gas info. table (17 bytes)
WRITE_PWD	0X70	Request to change mode	WR	WR	Contact Axetris

Calibration parameters

WRITE_PARAM[2]	0X35	Write interpolation parameters	X	WR	Contact Axetris
READ_PARAM	0X36	Read interpolation parameters	X	RD	Contact Axetris

Sensor raw data

READ_RAW_DATA[3]	0X66	Request to read calib. tables	X	RD	Contact Axetris
WRITE_RAWDATA	0X65	2x144 bytes data	X	X	Contact Axetris

[1] All the RD/WR variables coded with more than 1 byte are MSB first.

[2] Only for customer's channels 3 to 8. Channels 1 and 2 are reserved for the manufacturer.

[3] Only for manufacturer's channels 1 and 2.

6.3 List of variables

Gas flow

Variable name	Hex	EEPROM persistence	Data type	Customer mode	Service mode	Information
Serialnumber_PCB	0X00	yes	unit16	RD	RD	HW identification
SWVersion	0X01	yes	unit16	RD	RD	2 bytes (e.g. 3012_{dec} = 30.12)
Offset_zero	0X03	no	unit8	RW	RW	WR: 0:= none, 1:= activate auto zeroing, 2:= reset RD: 0:= zeroing / reset done, 1:= zeroing ongoing, 3:= Error offset out of range
Offset_value	0X04	yes	int16	RD	RD	See chapter 6 for decoding
Gastype	0X06	yes	unit8	RW	RW	Channel selection [1…8]
ADC_Temp	0X0F	no	unit16	RD	RD	Temperature
ADC_AuxIn	0X37	no	uint16	RD	RD	ADC Voltage Aux Input

Gas flow controller

CtrlNominal	0X14	no	unit16	RW	RW	Set point mass flow
V_OverrideState	0X1E	no	unit16	RW	RW	See chapter 7 for coding - decoding
NomFlowInputSel	0X1F	yes	uint8	RW	RW	Select desired input for set point, 0_{Hex} = digital input, 1_{Hex}= analog input

Calibration and PID parameters

DA_U_Gain	0X0B	yes	unit16	X	RW	DAC gain voltage output
DA_U_Offset	0X0C	yes	unit16	X	RW	DAC offset voltage output
AuxIn_PGA3Gain	0x35	yes	unit8	X	RW	Gain PGA3, auxiliary input
AuxIn_PGAOff	0x36	yes	unit8	X	RW	Offset PGA3, auxiliary input
KFactor[1]	0x07	yes	unit8	X	RW	Factor digital noise filter 1st ord.
nominalU_Off	0x27	yes	Int16	X	RW	Offset of nominal voltage input
NominalU_Gain	0x28	yes	unit8	X	RW	Gain of nominal voltage input
CtrlParam_P[2]	0x17	yes	unit16	X	RW	PID controller proportional el.
CtrlParam_I	0x18	yes	unit16	X	RW	PID controller integral element
CtrlParam_D	0x19	yes	unit16	X	RW	PID controller differential el.
CtrlParam_ISumLimit	0x1A	yes	unit16	X	RW	PID contr. integral sum. limit
CtrlParam_ISum	0x1B	no	unit16	X	RD	Actual PID controller ISum.
PID_out	0x16	no	unit16	RD	RD	PID controller output (12 bits)

[1] KFactor is dedicated to gastype. See chapter 7 for coding – decoding values.

[2] PID parameters are dedicated to gas type.

7 Coding – decoding digital data

7.1 Decoding the digital gas flow output

The digital sensor output is summarized below:

MFM, MFC	Digital flow range	0…11'000	= 0…110% flow
MFM Bidirectional	Digital flow range	-11'000…11'000	= -110%...110% flow

E.g. a digital flow of 8'000 corresponds to 80% of the maximum flow.

In bidirectional MFM devices, the flow value response data type is a **signed** 16-bit integer with values between -11'000$_{dec}$…11'000$_{dec}$ corresponding to -110%...110% flow.

Calculation of the sensor flow with the digital returned value (2 bytes MSB first):

Digital output range = 0…10'000 = 0 % F.S.….100 % F.S.

$$real\_flow = \frac{digital\_flow}{10'000} \cdot max\_flow$$

Example with a 250 sccm F.S. device and a reading value equal to 3400$_{Dec}$:

$$real\_flow = \frac{3400}{10'000} \cdot 250\ sccm = 85\ sccm$$

Due to the headroom, a value of up to 110 % F.S. can be read, corresponding to 11'000$_{Dec}$

Specifications are guaranteed only up to 100% F.S.

Example MFM Bidirectional:

Digital_flow = -400, max_flow = 100 sccm

$$real\_flow = \frac{-400}{10'000} \cdot 100\ sccm = -4\ \ sccm$$

7.2 Coding the digital set point input

Set point of the gas flow with the digital input value:

Digital input range = 0…65'535 = 0 % F.S.….100 % F.S.

$$set\,point = \frac{command\,value}{max\_flow} \cdot 65'535$$

Example with a 250 sccm F.S. device and a set point of 110 sccm:

$$\text{set point} = \frac{110\,[\text{sccm}]}{250\,[\text{sccm}]\,\text{F.S.}} \cdot 65'535 = 28'835_{\text{Dec}} = 0\text{x}70\text{A}3_{\text{Hex}}$$

See chapter 9 for an example how to code this command in the RS232 serial communication protocol.

7.3 Coding – decoding the digital valve override variable

Valve override variable "V_OverrideState" is type uint16.

The two bytes full range are $(0\ldots65535)_{dec}$ = $(0x0000\ldots0xFFFF)_{Hex}$

A value range between $(0\ldots4'095)_{dec}$ allows to directly control the valve position from 0 corresponding to a closed valve to 4'095 corresponding to a fully open valve (purge mode). Any value in between correspond to a valve position, the resulting flow will be a nonlinear function of this value and a consistent offset is necessary to obtain a flow.

Setting the value to 32'768dec (0x8000) enables PID control using either a digital or analog setpoint according to the selected mode.

Other values are not used.

7.4 Decoding the temperature

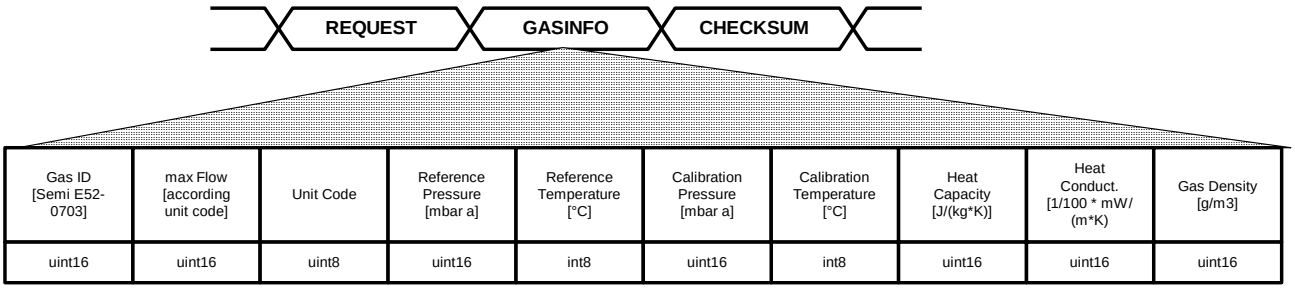
The ADC_Temp variable returns the temperature on two bytes (High value / Low value).

To calculate the corresponding temperature in °C, transform the value from hexadecimal to decimal then use the following formula:

$$\text{Device\_Temp\_}^{o}\text{C} = \frac{\frac{(\text{Temp\_dec})}{65535} - 0.1\overline{6}}{0.01} \quad [^{o}\text{C}]$$

7.5 Coding - decoding Gasinfo RW command

The Gasinfo variable is linked to a channel. Select first the channel with the variable Gastype before read/write the gas information.



Gas ID [Semi E52-0703]	max Flow [according unit code]	Unit Code	Reference Pressure [mbar a]	Reference Temperature [°C]	Calibration Pressure [mbar a]	Calibration Temperature [°C]	Heat Capacity [J/(kg*K)]	Heat Conduct. [1/100 * mW/(m*K)]	Gas Density [g/m3]
uint16	uint16	uint8	uint16	int8	uint16	int8	uint16	uint16	uint16

Gas_ID:

According the Semi E52-0703 standard:

Air	Ar	CO_2	He	H_2	CH_4	N_2	O_2
8	4	25	1	7	28	13	15

Unit Code

Defined by Axetris:

sccm	uccm	ccm	slm
10	11	12	100

7.6 Decoding the offset value

The offset value is limited to ±2 % of the full scale value (F.S.). The offset variable is a signed value (int16) of two bytes.

The two bytes are coded according to 2's complement and the full range is:

$(-32768…+32767)_{Dec} = (0x8000…0x7FFF)_{Hex}$

Calculation of the offset value in sccm for the positive value (0…32767):

$$\text{Offset [sccm]} = \frac{1.1 * \text{Offset\_value} * \text{max\_flow}}{32767}$$

Calculation of the offset value in sccm for the negative value (-32768…0):

$$\text{Offset [sccm]} = \frac{1.1 * \text{Offset\_value} * \text{max\_flow}}{32768}$$

7.7 Coding - decoding the low pass filter value

The variable Kfactor is the value for the 1st order digital noise filter.

$LP_{out} = LP_{acc}$ / Kfactor

Kfactor = [0, 1, 2, 3… 14]

The Kfactor peforms a shift operation. The Kfactor is limited to 14.

8 Transmission errors

If an error occurs during transmission, the device sends back an error and an error code describing the type of error. The error code begins with 45_{Hex} and is followed by the identifying code listed in the following table.

Error of transmission

Error name	Hex	Description	comment
SEND_TIMEOUT	0X01	An internal error occurred and the device could not answer the last request	
SENSOR_BUSY	0X02	A request is send before the last one is finished. The error also occurs when the sensor is in the send continuous mode, and a request different from the STOP command is send	UART related
CHECKSUM_ERROR	0X03	The checksum received by the sensor is wrong	
OVERRUN_ERROR	0X04	The sensor has not enough time to read the received bytes	UART related
FRAME_ERROR	0X08	There is no stop bit	UART related
PARITY_ERROR	0X10	The received parity bit is wrong	UART related
START_ERROR	0X20	There is no start bit	UART related
INVALID_REQ	0X40	1) The request code was wrong 2) The request is not accessible in current access level or gastype	
SENSOR_ERROR	0X50	Error at self test, heater or sensor bridge is defective	
FATAL ERROR[1]	0X60	Initialization of EEPROM data failed at startup	
UNKNOWN_VARID	0XC0	1) The variable identification is unknown 2) The variable with ID is not readable/writeable with this request or the current access level is not sufficient 3) The variable/parameter is out of range	

Remark: All UART related errors (that have the highest priority in case more than 1 error occurs) will be added in case more UART related errors occur.

For example, if FRAME_ERROR (0x08) and PARITY_ERROR (0x10) occur simultaneously, they will be added and the error code will be 0x08 + 0x10 = 0x18.

The total packet will be, in Hex, 45 18 5D

[1] Valid for Axetris Firmware version 30.26 and higher

9 FAQ & communication examples

- ***What happens when switching on the device?***

The device sends on Tx 0xFF and 3 seconds later 0x53 meaning it is ready to communicate and to operate. The mode is the one that was set when the device was switched off. In digital input mode the flow is set to zero. No change occurs until a new set point is transmitted. In analog input mode, the device after sending 0x53 sets the flow immediately to the analog value that is present at the set point input pin.

Data direction	Hex data	Flow	Remark
Rx	None	-	
Tx	FF 53	is zero in digital control mode is equal to set point in analog control mode	0x53 is transmitted 3 sec. later once the device is ready to operate

- ***In which input mode is the device and how it can be change?***

The input mode is set at the factory level according to the ordered configuration. However it is possible to check it or to change the input with the following command:

To check the input mode:

Data direction	Hex data	Flow	Remark
Rx	63 1F 82	-	request – variable ID – checksum
Tx	63	-	The device sends back the request

To change the input mode:

Data direction	Hex data	Flow	Remark
Rx	64 1F 00 83 64 1F 01 84	Last value independently of the previous mode Set point according to analog value present at the input pin	Set the digital input mode Set the analog input mode
Tx	64 64		The device sends back the request

- ***How to write a set point?***

The digital set point range is $(0…65535)_{Dec}$ = $(0x0000…0xFFFF)_{Hex}$ = (0%...100%) F.S.

Data direction	Hex data	Flow	Remark
Rx	62 14 00 00 76 62 14 02 90 08 62 14 80 00 F6 62 14 FF FF 74	0 % F.S. 1 % F.S. 50 % F.S. 100 % F.S.	Zero flow Cut off limit value if present (on request) Flow set at 50 % of the F.S. Flow set at 100 % of the F.S.
Tx	62		The device sends back the request

- ***How to read the actual flow?***

The digital flow measure range (forward only) is $(0…10000)_{Dec}$ = $(0x0000…0x2710)_{Hex}$ = (0...100 %) F.S.

The maximum reading value is 11000_{Dec} = 0x2AF8 = 110 % F.S.

Data direction	Hex data	Flow	Remark
Rx	31 32 02 34 33 34	Depends on the flow	.
Tx	31 XX XX YY 32 HH LL YY 32 HH LL YY 33 XX XX YY None	Depends on the flow	YY = Checksum. Translate the Hex value in Dec value and apply the 6.1 decoding formula to get the actual flow measure 0x33 returns measured flow continuously each 3.5 ms STOP the continuous reading

- ***Which channel is set and how a channel can be selected?***

In case of multi-range and/or multi-gas calibrated device, channel (1 to 8) is selected as following.

Data direction	Hex data	Flow	Remark
Rx	63 06 69 64 06 02 6C 64 06 03 6D 64 06 04 6E … 64 06 08 72	NA	Read which channel is selected Select the channel 2 Select the channel 3 Select the channel 4 … Select the channel 8
Tx	63 01 64 64	NA	Channel 1 is set Request code back

The uncalibrated channels have all parameters equal to zero meaning that if channel is change from a calibrated channel to an uncalibrated channel the flow becomes zero.

- ***How to read the temperature?***

Data direction	Hex data	Flow	Remark
Rx	61 0F 70	NA	Read the temperature
Tx	61 7E 7C 5B	NA	Request code back + value to decode

To decode the temperature use the formula in paragraph 6.4:

7E 7C = 32380_{Dec} = 32.7 [°C]

- ***How to read Gasinfo?***

The Gasinfo is unique for each channel. Select the desired channel before executing a RW command.

Data direction	Hex data	Flow	Remark
Rx	73	NA	
Tx	See here below	NA	Request – 17 bytes – checksum

Tx = 73 00 0D 00 FA 0A 03 F5 00 08 00 19 04 13 0A 1B 09 0B ED

Decoding:

73 = Request code back

00 0D = 13_{Dec} = N_2 gas

00 FA = 250_{Dec} = 250 sccm F.S. flow device

0A = 10_{Dec} = sccm = proprietary unit code

03 F5 = 1013_{Dec} = 1013 mbar absolute for the reference pressure

00 = 0_{Dec} = 0 [°C] = reference temperature

08 00 = 2048_{Dec} = 2048 mbar absolute for the calibration pressure

19 = 25_{Dec} = 25 [°C] = calibration temperature

04 13 = 1043_{Dec} = 1043 [J/(kg • K)] = Heat capacity of the gas

0A 1B = 2587_{Dec} = 2587 [1/100 • mW/(m • K)] = Heat conductivity of the gas

09 0B = 2315_{Dec} = 2315 [g/m^3] = gas density

ED = checksum including the request command that is sent back

- ***How to override the valve?***

The control of the valve can be done directly with digital values. The internal PID controller is then off. Any digital value between $(0…4095)_{Dec}$ takes direct control of the valve, even if the analog mode was set. Any other value out of this range makes the device to come back in the selected mode (digital or analog) with the last set point value for the digital mode and the actual analog value at the input pin for the analog mode. The relation between valve openness and flow is non linear.

Data direction	Hex data	Flow	Remark
Rx	**62 1E 00 00 80**	0	Valve forced close
	62 1E 08 00 88	Valve open to 50 % of its max.	An opening position is controlled not a flow
	62 1E 0F FF 8E	Valve full open (purge mode)	Digital ouput is max. = 110 % F.S.
	62 1E 10 00 8F	Set point (selected mode)	Any values between 4096 and 65535
Tx	62	NA	Request back

- ***My device doesn't communicate?***

Please check your PC COM port setting. Each point of the RS232 settings (see 5.1) must be respected. For example a different Baud rate is not readable by the device. Check the powering of the device. Check the connector and the cable.

10 Caution

10.1 Product damage

- Read all instructions carefully before using the device.
- The MFM anemometric mass flow sensors are not designed to sense liquid flow and damage will result if liquid is passed through the sensor.
- The sensor is not suited for measuring aggressive or corrosive gases. Use only non-corrosive, dry, clean and dry gases. Gas loaded with particles can eventually clog the sensor.
- The appliance must not be used in damp or moist surroundings.
- Use only accessories that are indicated in the instructions for use or are recommended by the manufacturer.
- Failure to comply with these instructions can result in product damage.

10.2 Danger of life

- These sensors employ a heated element.
- The heated element is above the ambient temperature. The sensor must not be used with flammable or explosive gases or mixtures.
- Unprofessional gas handling can cause injury or death. The use of mass flow meters should only be performed by qualified personnel.
- Do not use this product as safety or emergency stop device or in any other application where failure of the product could result in personal injury or death.

11 Important Notice / Disclaimer

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