Company of the Leister Group

MICRO-OPTICS INFRARED SOURCES MASS FLOW DEVICES LASER GAS DETECTION

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Specification

MFM / MFC RS-485 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 all the communication features according to the RS-485 Bus protocol, allowing the customer to quickly connect multiple devices with a single bus wire to their command unit system, establishing a safe and reliable communication.

Mass Flow Meters / Controllers with RS-485 interface

MFM 224X
MFM 225X

Mass Flow Meter
OEM Modules

MFC 2242
MFC 2252

Mass Flow Controller
OEM Modules

MFM 2140
MFM 2150

Mass Flow Meter
Standalone

MFC 2142
MFC 2152

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. This document describes the types with RS-485 interfaces.
Other interfaces available are analog 0…5 V or 4…20 mA and digital RS-232 EIA or RS-232 TTL level (see the MFM / MFC RS-232 Data Communication Document), and also industrial interfaces PROFINET and EtherCAT.

Digital communication is either point-to-point with the RS-232 protocol or is of bus type with the RS-485, PROFINET or EtherCAT protocol allowing digital multipoint communication. Bus communication simplifies the system setup in case of multiple MFM / MFC systems.

The bus serial interface protocol is based on a master slave communication with specific module addresses between the devices 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 pr essure 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.

The MFMs / MFCs RS-485 are factory programmed with a unique standard address. Axetris delivers a communication program interface based on LabView (National Instrument) allowing recognizing each device present in the network, get their actual addresses and change them if necessary.

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

	Type	Analog output	Analog input	Full- or Half Duplex	RS-485 Digital output[1]	RS-485 Digital input
Meter	MFM 2240	N.A.	N.A.	HD	Gas flow Temperature Gas calibration info.	Offset zeroing Channel selection[2]
	MFM 2250	N.A.	N.A.	FD	Gas flow Temperature Gas calibration info.	Offset zeroing Channel selection
	MFM 2140	N.A.	N.A.	HD	Gas flow Temperature Gas calibration info.	Offset zeroing Channel selection
	MFM 2150	N.A.	N.A.	FD	Gas flow Temperature Gas calibration info	Offset zeroing Channel selection
Bidirectional Meter	MFM 2243	N.A.	N.A.	HD	Gas flow Temperature Gas calibration info	Offset zeroing Channel selection
	MFM 2253	N.A.	N.A.	FD	Gas flow Temperature Gas calibration info	Offset zeroing Channel selection
Controller	MFC 2242	N.A.	N.A.	HD	Gas flow Temperature Gas calibration info. PID_out	Set point Valve override Offset zeroing Channel selection
	MFC 2252	N.A.	N.A.	FD	Gas flow Temperature Gas calibration info. PID_out	Set point Valve override Offset zeroing Channel selection
	MFC 2142	N.A.	N.A.	HD	Gas flow Temperature Gas calibration info. PID_out	Set point Valve override Offset zeroing Channel selection
	MFC 2152	N.A.	N.A.	FD	Gas flow Temperature Gas calibration info. PID_out	Set point Valve override Offset zeroing Channel selection

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

MFM and MFC 21xx types with housing and RS-485 EIA Interface (Bidirectional measurement not available)
MFM / MFC 224x: modules without housing and RS-485 Half Duplex Interface
MFM / MFC 225x: modules without housing and RS-485 Full Duplex 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)

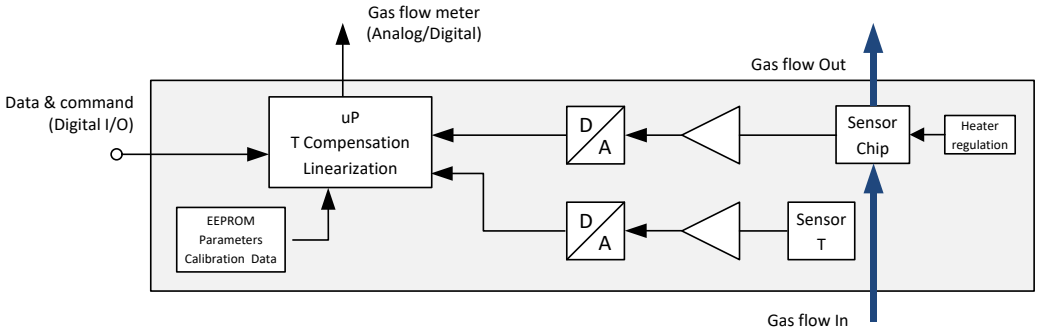


Figure 1 Block diagram of the MFM 2100 and MFM 2200 series mass flow meter

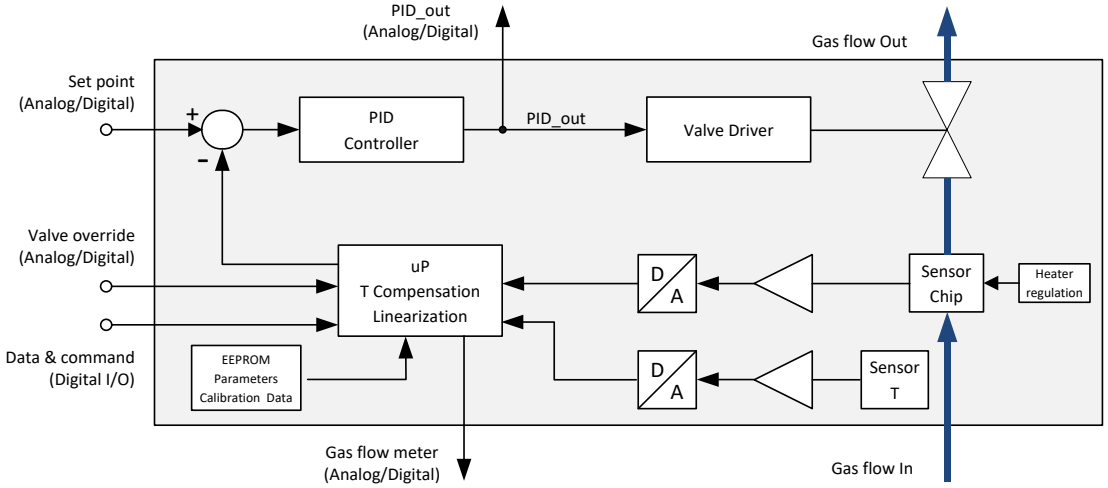
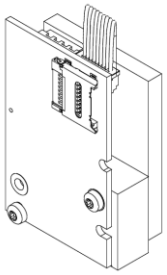
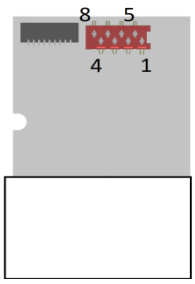


Figure 2 Block diagram of the MFC 2100 and MFC 2200 series mass flow controller

2 Pin assignment for Modules

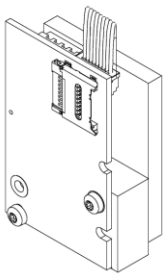
MFM 224X RS-485 Half Duplex

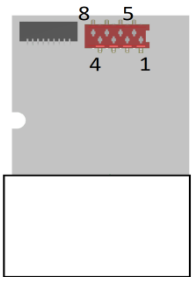




Pin	I/O Type	Description
1	Power	**+ 24 V / ± 10%**
2	Power	GND
3	Digital	Non Inverting Input-Output/ D+
4	Digital	Inverting Input-Output/ D-
5	nc	
6	nc	
7	nc	
8	nc	

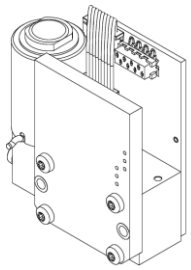
MFM 225X RS-485 Full Duplex

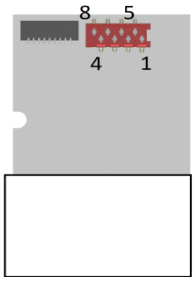




Pin	I/O Type	Description
1	Power	**+ 24 V / ± 10%**
2	Power	GND
3	Digital In	Non Inverting Receiver Input/ R+
4	Digital In	Inverting Receiver Input/ R-
5	Nc	
6	Digital Out	Inverting Transmitter Output/ T-
7	Digital Out	Non Inverting Transmitter Output/ T+
8	nc	

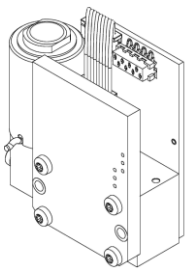
MFC 2242 RS-485 Half Duplex

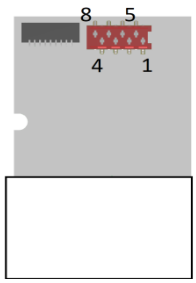




Pin	I/O Type	Description
1	Power	**+ 24 V / ± 10%**
2	Power	GND
3	Digital	Non Inverting Input-Output/ D+
4	Digital	Inverting Input-Output/ D-
5	nc	
6	nc	
7	nc	
8	nc	

MFC 2252 RS-485 Full Duplex





Pin	I/O Type	Description
1	Power	**+ 24 V / ± 10%**
2	Power /Digital	GND
3	Digital In	Non Inverting Receiver Input/ R+
4	Digital In	Inverting Receiver Input/ R-
5	nc	
6	Digital Out	Inverting Transmitter Output/ T-
7	Digital Out	Non Inverting Transmitter Output/ T+
8	nc	

Table 2 Pin assignment
Connector type Micromatch 8-pole

3 Pin assignment for standalone types

3.1 D-SUB connector – 9 pins (standard)

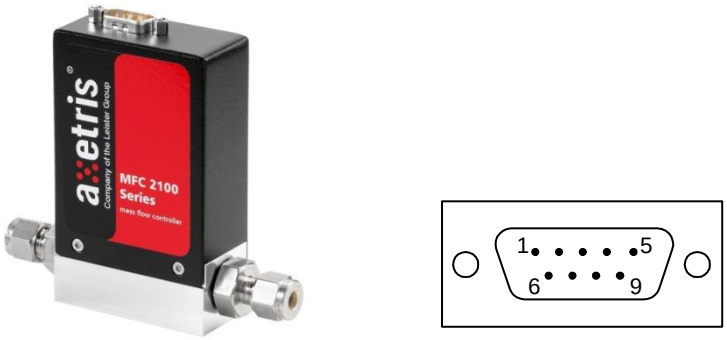


Figure 3 Top view D-SUB 9 poles connector

MFM 2140/ MFC 2142 RS-485 Half Duplex (HD)

Pin	I/O Type	Description
1	Power	+ 24 V / ± 10%
2	Power	GND
3	Digital	Non inverting Input-Output/ D+
4	Digital	Inverting Input-Output/ D-
5	nc	
6	nc	
7	nc	
8	nc	
9	nc	

MFM 2150/ MFC 2152 RS-485 Full Duplex (FD)

Pin	I/O Type	Description
1	Power	+ 24 V / ± 10%
2	Power	GND
3	Digital In	Non Inverting Receiver Input/ R+
4	Digital In	Inverting Receiver Input/ R-
5	nc	
6	nc	
7	Digital Out	Inverting Transmitter Output/ T-
8	Digital Out	Non Inverting Transmitter Output/ T+
9	nc	

Table 3 Pin assignment for D-SUB 9 connector

4 RS-485 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. The digital input / output RS-485 is available for all the Axetris MFMs / MFCs devices. The type of communication, RS-485 Half-Duplex or Full-Duplex is set by the manufacturer at the factory level.

Half-Duplex

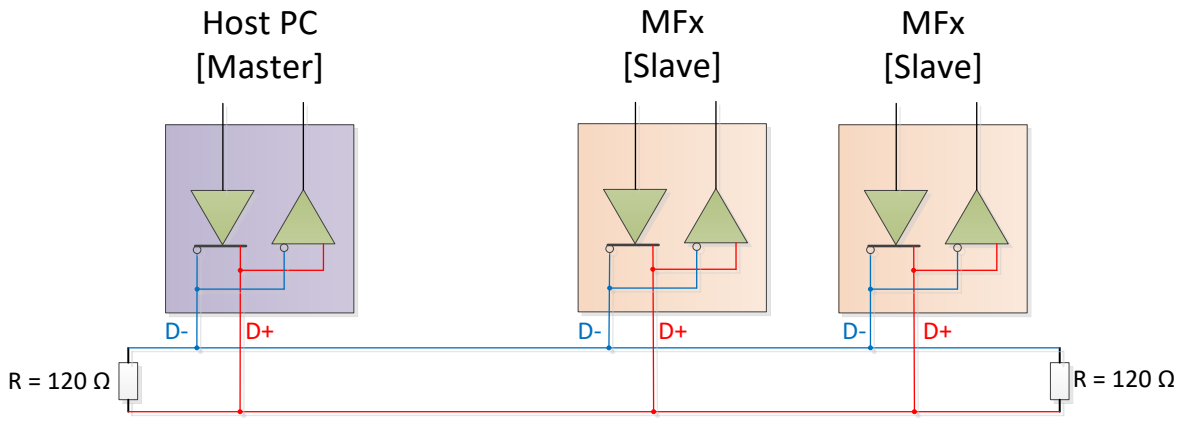


Figure 4 RS-485 bus structure in half-duplex configuration

Full-Duplex

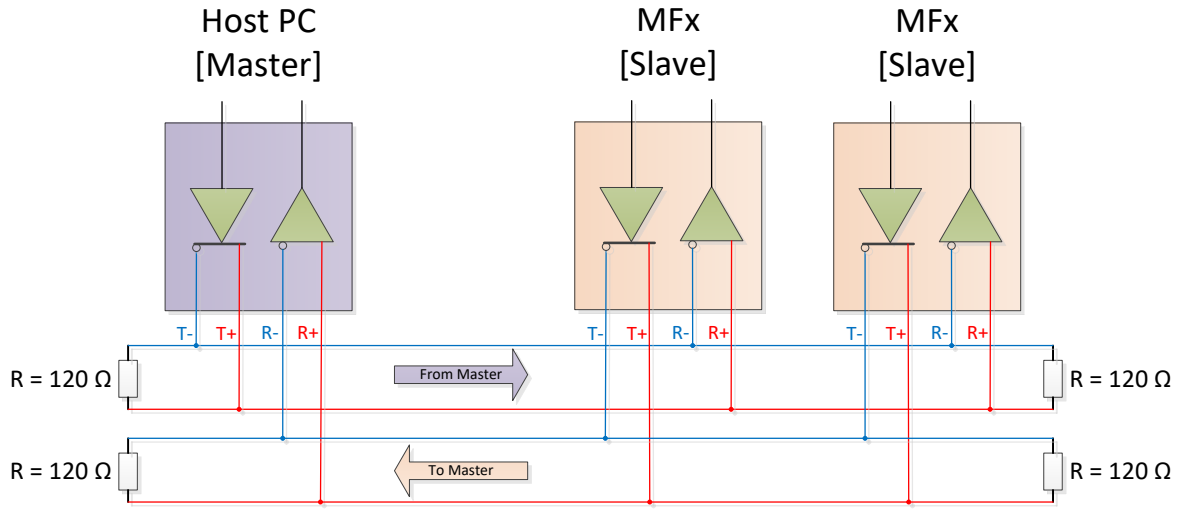


Figure 5 RS-485 bus structure in full-duplex configuration

Minimum node spacing

Adding capacitive load in form of additional devices to the RS-485 bus causes impedance mismatches between the bus media and the load section. Signals passing those mismatched sections are partially reflected back and distort the output driver signal.
In order to ensure a valid voltage level at the receiver (U_{sign} > 0.2 V) the bus requires a minimum impedance match of Z' > 0.4 x Z_0, which can be achieved by keeping a minimum distance between the nodes:

$$d > \frac{C_L}{5.25 \cdot C'}$$

Where d is the minimal distance, C_L the lumped load capacitance and C' the cable capacitance per unit length. The input capacitance of the RS-485 driver is 15 pF. Since the PCB and the connector add some parasitic capacitance as well, C_L should be set to 20 pF which includes some safety margin. C' of a typical twisted pair cable is around 40 pF/m. In that case the minimum node distance would be approximately 10 cm.

Each RS-485 device will wait after turn-on on the master serial communication interface. The device is ready to communicate and to operate (after 3 seconds).

4.2 Meters

- **Meter modules MFM 224X and MFM 225X**
  The OEM, MFM 2240 and MFM 2250 are meters only. Its purpose is to be integrated in a system for mass flow measurement.

- **Meters standalone MFM 2140, MFM 2150**
  The OEM MFM 2140, MFM 2150 are mass flow meter for standalone use (with protective housing).

The RS-485 (EIA 485) hardware and protocol allows bus multipoint connection capability.

Customer mode
The digital communication in customer mode offers additional information (see Chapter 5):

Read Data:
- Gas flow (depending on the request with single or multiple 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

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 these additional possibilities.

4.3 Controllers

The Axetris mass flow controllers contain an advanced internal PID controller with a fast acting solenoid valve. The data output are digitally transmitted using the RS-485 hardware and protocol.
The RS-485 (EIA 485) hardware and protocol allows bus multipoint connection capability.

- **Controller modules MFC 2242, MFC 2252**
  The OEM MFC 2242 and MFM 2252 are ultra compact controller modules. Its purpose is to be integrated in a system for mass flow measurement and control.

- **Controller stand alone MFC 2142, MFM 2152**
  The OEM MFC 2142, MFC 2152 are mass flow meter for stand alone use (protective housing).

Besides the standard way using the flow set point feature, the customer can take the direct control of the valve in digital way. Apart of the digital communication protocol, each device supports analog valve override functionality allowing the immediate closing or opening (purge mode) of the valve. This functionality is useful for security reasons. The analog valve override command is prior to any other command. 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.

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

Read Data:
- Gas flow (depending on the request with single or multiple 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
- Valve driver (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)

Service mode
In service mode, much more digital data is accessible to allow the customer to adapt the device to own needs, e.g. 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.

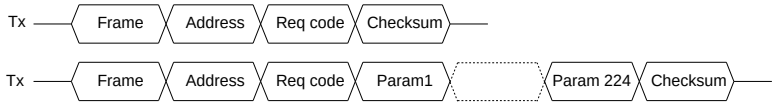
5 Interface specification

5.1 RS-485 serial communication settings

- Baud rate: 57600
- Data: 8 bits
- Stop bit: 1
- Parity: Odd
- Flow control: No handshake
- Levels: EIA 485 (direct connection to the bus line).

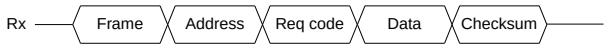
The data communication speed is limited to a request each of approx. 5 [ms]. When writing a data into the EEPROM, the maximum data rate is limited to 100 Bytes/sec. Do not write parameter command when the device is in active control flow mode. No update calculation is performed when writing data to the memory.

5.2 Command format



Each request begins with the frame and sensor address. A one-character code identifying the request follows the address. A checksum has to be added at the end of all 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.

5.4 Analog valve override (input)

The analog valve override feature overrules all other commands. The table hereafter lists the values that are possible to apply and their effects on the flow control.

Table 4: Analog input values for valve override feature:

Parameters	Unit	Min. Value	Max. Value	Resolution	Remark
Valve override	V	0…0.2	4.8…5	-	0 V = close, 5 V = forced open (purge mode > F.S.)

The purge mode forces 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. The last set point value stored in the memory is then used to control the flow.

6 Commands & variables list definition

The following requests and variables are valid for Axetris RS-485 MFDs with software versions SW30.19 and higher.

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 lifetime 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

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

RS-485 specific commands

GENERAL_CALL[3]	0X77	Array with 8 bytes data	WR	WR	
WRITE_ADDRESS[4]	0X78	SerialNumber + SWVersion + NEW RS-485 ADDRESS (5 bytes data)	WR	WR	See chapter 9, FAQ & communication examples
READ_RAWDATA485[5]	0X79	2x144 bytes data	X	RD	Contact Axetris
WRITE_RAWDATA485	0X80	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 Answer: Frame, RS-485Address, Req code, SerialNumber, SWVersion, Checksum.

4 Command: Frame, ActualRS-485Address, Req code, SerialNumber, SWVersion, NewRS-485Address, Checksum.

5 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	uint16	RD	RD	2 bytes (e.g. 3012_{dec} = 30.12)
Offset_zero	0X03	no	Uint8	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 7 for decoding
Gastype	0X06	yes	uint8	RW	RW	Channel selection [1…8]
ADC_Temp	0X0F	no	uint16	RD	RD	Temperature
ADC_AuxIn	0X37	no	uint16	RD	RD	ADC Voltage Aux Input
RS-485Address	0X38	yes	uint8	RW	RW	Bus address RS-485 device [1…200]

Gas flow controller

CtrlNominal	0X14	no	uint16	RW	RW	Set point mass flow
V_OverrideState	0X1E	no	uint16	RW	RW	See chapter 6 for coding - decoding

Calibration and PID parameters

AuxIn_PGA3Gain	0X35	yes	uint8	X	RW	Gain PGA3, auxiliary input
AuxIn_PGAOff	0X36	yes	uint8	X	RW	Offset PGA3, auxiliary input
KFactor[1]	0X07	yes	uint8	X	RW	Factor digital noise filter 1st ord.
CtrlParam_P[2]	0X17	yes	uint16	X	RW	PID controller proportional el.
CtrlParam_I	0X18	yes	uint16	X	RW	PID controller integral element
CtrlParam_D	0X19	yes	uint16	X	RW	PID controller differential el.
CtrlParam_ISumLimit	0X1A	yes	uint16	X	RW	PID contr. integral sum. limit
CtrlParam_ISum	0X1B	no	uint16	X	RD	Actual PID controller ISum.
PID_out	0X16	no	uint16	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:

$$\text{set point} = \frac{110\,[\text{sccm}]}{250\,[\text{sccm}]\,\text{F.S.}} \cdot 65'535 = 28'835_{\text{Dec}} = 0x70A3_{\text{Hex}}$$

See chapter 9 for an example how to code this command in the RS-485 digital bus 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 $(0\ldots65535)_{\text{Dec}}$ = $(0x0000\ldots0xFFFF)_{\text{Hex}}$

The range that allows to directly control the valve externally (PID controller is off) is $(0\ldots4095)_{\text{Dec}}$ = $(0x0000\ldots0x0FFF)_{\text{Hex}}$ = valve close…valve open (in purge mode)

Any value in between is controlling the valve openness. The flow is highly not linear to this direct control value and showing an important offset.

Any value in the rest of the range: $(4096\ldots65535)_{\text{Dec}}$ = $(0x1000\ldots0xFFFF)_{\text{Hex}}$ makes the device to return in the selected mode; analog or digital set point with PID control on.

7.4 Decoding the temperature

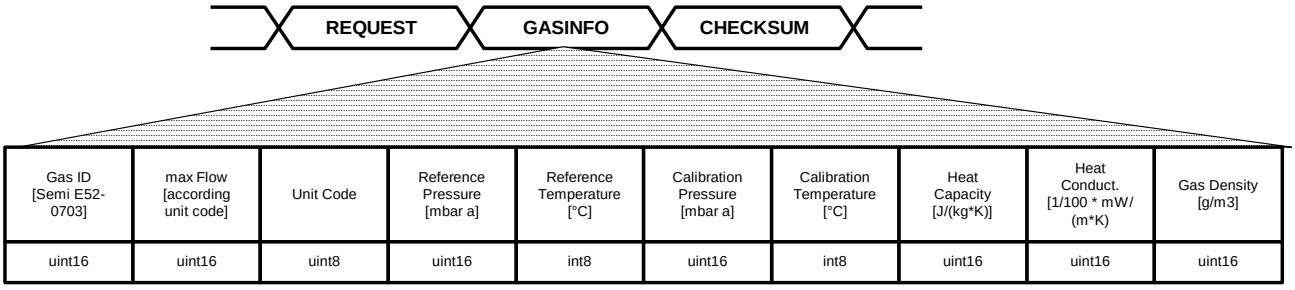
The ADC_Temp variable returns the temperature on two bytes (High value / Low value).

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:

$(-32768\ldots+32767)_{Dec} = (0x8000\ldots0x7FFF)_{Hex}$

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

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

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

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

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… 16]

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 the frame, address of the device and the error code 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.	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	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	
RS485_TRANS_ERROR	0X70	Wrong frame size in RS485 mode	

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.

9 FAQ & communication examples

REMARK: In all the examples, the RS-485 device address is equal to 1 $(0x01)_{Hex.}$

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

The device needs 3 seconds to initiate and then 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 initialisation sets the flow immediately to the analog value that is present at the set point input pin.

- ***How to change the RS-485 address of the device?***

To get the actual address, a general call has to be performed = $0x77_{Hex}$. The address can be change in bus configuration because the individual serial number is also used to decode the command.

Data direction	Hex data	Flow	Remark
Rx	04 01 77 7C	-	A general call with address 0x01 is performed
Tx	08 01 77 04 63 0B CD BF	-	The device sends back the request with the Serial Number ($0x0463_{Hex} = 1123_{Dec}$), the software version ($0x0BCD_{Hex} = 3021_{Dec}$ = 30.21) - checksum

To change the address when several units with same address are present:

Data direction	Hex data	Flow	Remark
Rx	09 01 78 04 63 0B CD 05 C5	-	New address is 0x05
Tx	04 05 78 81	-	The device sends back the request with the new address 0x05 - checksum.

To change the address point to point or when all the units have already different addresses:

Data direction	Hex data	Flow	Remark
Rx	06 01 64 38 05 A8	-	New address is 0x05
Tx	04 05 64 6D	-	The device sends back the request with the new address 0x05 - checksum.

- ***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	07 01 62 14 00 00 7E 07 01 62 14 02 90 10 07 01 62 14 80 00 FE 07 01 62 14 FF FF 7C	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	04 01 62 67		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	04 01 31 36 05 01 32 02 3A	Depends on the flow	Read 1 data Read 2 data (up to 255)
Tx	31 HH LL YY 2x (06 01 32 HH LL YY)	Depends on the flow	YY = Checksum. In case of multiple data, the transfer rate 1 one data each 3.5 ms. Translate the Hex value in Dec value and apply the 6.1 decoding formula to get the actual flow measure

- ***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	05 01 63 06 6F 06 01 64 06 02 73 06 01 64 06 03 74 06 01 64 06 04 75 … 06 01 64 06 08 79	NA	Read which channel is selected Select the channel 2 Select the channel 3 Select the channel 4 … Select the channel 8
Tx	05 01 63 01 6A 04 01 64 69	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	05 01 61 0F 76	NA	Read the temperature
Tx	06 01 61 6F 8C 63	NA	Request code back + value to decode

To decode the temperature use the formula in paragraph 6.4:

6F 8C = 28556_{Dec} = 26.9 [°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	04 01 73 78	NA	
Tx	See here below	NA	Request – 17 bytes – checksum

Tx = 15 01 73 00 0D 00 FA 0A 03 F5 00 08 00 19 04 13 0A 1B 09 0B 03

Decoding:

15 = 21_{Dec} is the number of bytes answered
01 = Address of the device
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
03 = checksum

- ***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	07 01 62 1E 00 00 88 07 01 62 1E 08 00 90 07 01 62 1E 0F FF 96 07 01 62 1E 10 00 98	0 Valve open to 50 % of its max. Valve full open (purge mode) Set point (selected mode)	Valve forced close An opening position is controlled not a flow Digital ouput is max. = 110 % F.S. Any values between 4096 and 65535
Tx	04 01 62 67	NA	Request back

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

Please check your PC COM port setting. Each point of the RS-485 communication 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 cables.

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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