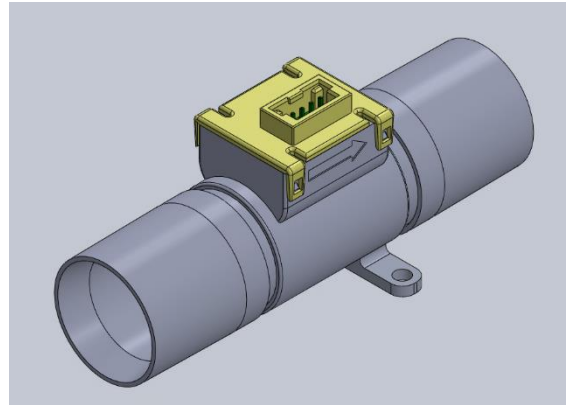## MFM2000 Series

FEATURES

- Low Pressure Drop Flow Sensor
- High Accuracy +/-2.5% Reading @ 1:100 Turndown Ratio
- Calibrated and Temperature Compensated for Clean Air
- Low Power Consumption
- Digital I2C
- Made for Medical Applications
- Calibrated for Clean Air

DESCRIPTION

ACEINNA MFM2000 series is a gas flow sensor with low pressure drop capable of measuring medical gases up to 70SLM. It is configured to be customizable with different flow inlet and outlet configurations.

THEORY OF OPERATION

The flow rate is detected by the MEMS thermal mass flow sensor. The sensor chip, produced in MEMSIC proprietary CMOS compatible technology, is composed of a central heater source (micro heater) and two temperature sensors (thermopiles), which are placed symmetrically upstream and downstream of the micro-heater. If no gas flows over the sensor surface, the symmetric thermopiles measure the same rise in temperature, resulting in the same output voltage of the two thermopiles. If a non-zero gas flows from the inlet to the outlet of the meter, the velocity of a fully-developed laminar air flow unbalances the temperature profile around the heater and heat is transferred from upstream thermopiles to the downstream thermopiles, causing a change in the voltages of the thermopiles. Larger gas flow rates result in larger asymmetry in the profile.

Gas Flow →
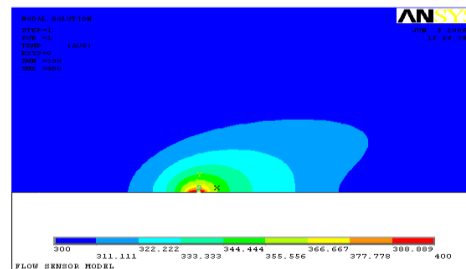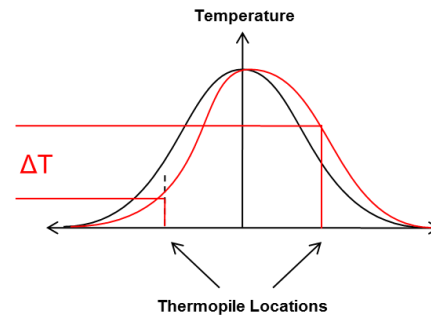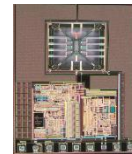
FLOW PERFORMANCE

Measurements performed with air at 23℃, 1 Atm, 50% RH, at 5V DC power supply, unless otherwise specified. Calibration conditions for standard liters per minute slm: 20°C, 1013mbar.

Parameter	Condition	MFM2040	MFM2070	Unit
Maximum Calibrated Flow		70		SLPM
Minimum Calibrated Flow		400		sccm
Calibrated Temperature Range		0 to 50		°C
Operating Temperature Range		-40 to 85		°C
Storage Temperature Range		-40 to 105		°C
Accuracy	25ºC	±2.5 (0.7 SLPM < Flow < 70 SLPM)		% Reading
		±3.5 (0.4 SLPM < Flow < 0.7 SLPM)		
Total Error Band (incl. Temperature)	0-50ºC	±3.5 (0.7 SLPM < Flow < 70 SLPM)		% Reading
		±5.0 (0.4 SLPM < Flow < 0.7 SLPM)		
Resolution		16		Bit
Sampling Time		7.5		ms
Approx. Pressure Drop	Max flow without mesh		80	Pa
	Max flow(with mesh screen)[1]	160		Pa
Operating Pressure Range	Absolute	0.7 to 1.3		Bar
Averaging		10 frames running window averaging		
Wetted Materials		PES (Medical grade: biocompatible; ISO 10993 or USP Class VI), FR4, Silicon Nitrite, Silicon, Epoxy, Gold.		
Standards		RoHS, REACH, ISO10993-10, ISO10993-5,UL94 V0, IEC		

ELECTRICAL SPECIFICATIONS

Parameter	Condition	Min	Typical	Max	Unit
Supply DC Voltage	DC	4.5	5	5.5	V
Power Consumption	@ Recommended Heater Power at zero Flow			7.5	mA
	PD			650	uA
Data format Scaling Factor			2.5		

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[1] Mesh screens helps to reduce flow turbulence created by less than ideal inlet/outlet conditions such as sudden expansion, contractions and elbows.

MECHANICAL SPECIFICATIONS

Specification	Condition	Min	Typical	Max	Unit
Burst Pressure	Over ambient		1		Bar

I^{2}C INTERFACE

Pinout Configuration

Pin	Name	Description
1	SCL	Serial Clock Line for I^{2}C bus
2	VDD	Power Supply
3	GND	Ground
4	SDA	Serial Data Line for I^{2}C bus

Mating Connector

Recommended mating connector: Molex DuraClick™ Series 5023510400

External Interface

SCL and SDA line must be connected to VDD with about 4.7k Ohm pull-up resistor in series, the range of VDD is 4.5-5.5V. Calibration of the MFM2000 is performed at a voltage of 5V.
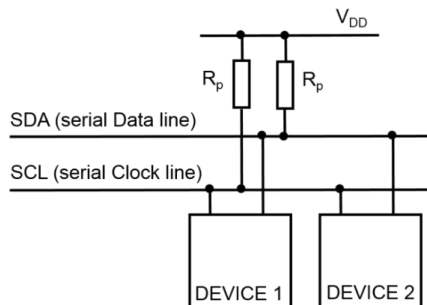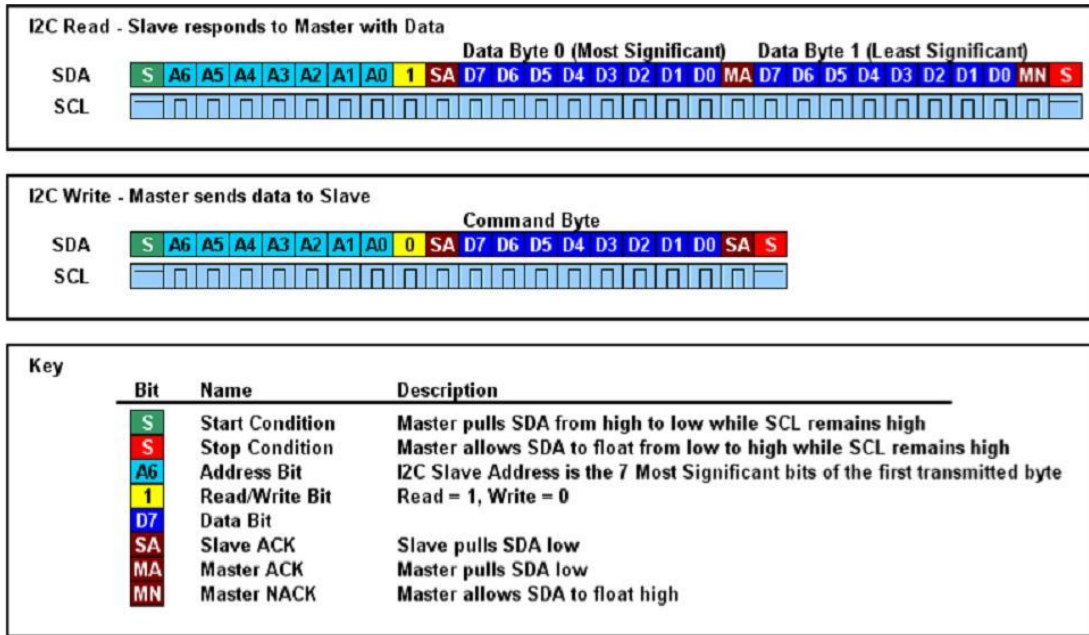

Address

The I^{2}C address is 7 bits long, followed by a write bit (0) or a read bit (1).

Communication

MFM2000's communication interface is Phillips I2C compatible as shown below, the recommended frequency of SCL line is approximately100kHz.

Trigger measurement operation

MFM2000 works in slave mode, it has 7-bit slave address, by default, the salve address is 0x31 for MFM2040, and 0x70 for MFM2070, the following bit is either write bit(0) or read bit(1).

To trigger measurement operation, the master must write a command 0xC1 into sensor to start the measurement, then wait for 10ms, the master can read out 2 bytes differential pressure data from the register 0 followed by 1 byte CRC code.

To read the flow data from register 0, the first byte transmitted must be 0x63 which indicates that master will read from sensor whose slave address is 0x31. Immediately with master generating pulses of 3 bytes, the master can read out the 2 bytes data and 1 byte CRC code.

For example, the slave address is 0x31, the master trigger the measurement first, then read out the data in register 0, there are 3 steps as the following:

(1) Master write into sensor the trigger command 0xC1.

Slave address + write bit	Measurement trigger command
0x62	0xC1

(2) Wait at least 15ms, master should write into slave the register address 0x00, which specify that master will read data from register 0 of slave.

Slave address + write bit	Register address
0x62	0x00

(3) Master reads differential data

Slave address + read bit	16 SCL pulses
0x63	High Byte, Low Byte, CRC Code

Once slave receive the slave address and the read bit (0x63) from master, slave will return the 2 bytes data showed in the table below.

High Byte	Low Byte	CRC Code

With the pulses of 3 bytes is being generated by master, slave will return the 2 bytes differential pressure data and 1 byte CRC code.

Notes:
 a. Slave returns the high byte first, then the low byte, and at last the CRC code
 b. Recommend that each trigger measurement command should be sent after data reading is completed.

Data Format
The output data from slave's register 0 is 2 bytes signed integer data. If the data is multiplied by 2.5, the result will be the flow rate which is from 0 to 70,000 SCCM (70 SLM).

Reset Command
MFM2000's circuit can be reset to initial status by writing reset command 0xFE into device.

Note:
The device will not work normally until 2 seconds after writing reset command. So, do not write any data into device in 2 seconds after writing reset command, or there will be unpredictable error.
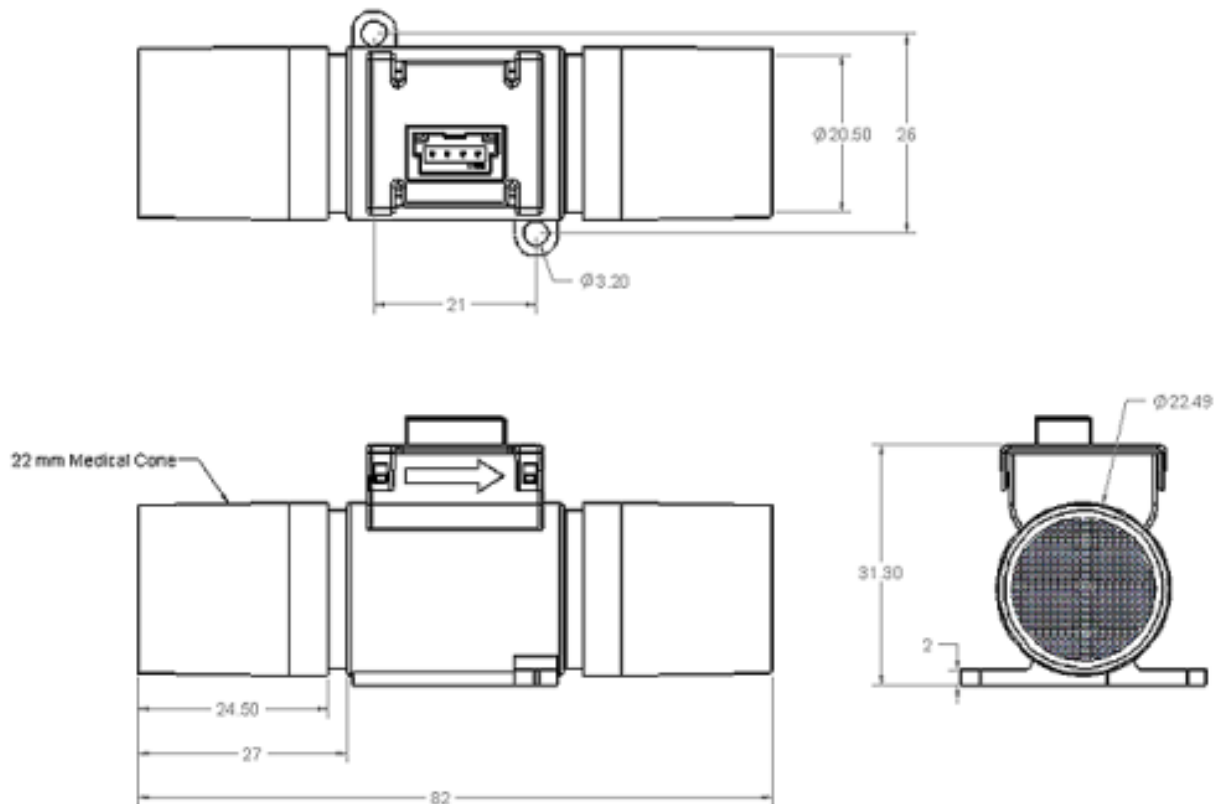
CRC-8 Redundant Data Transmission

MFM2000 use cyclic redundancy checking (CRC) technique for error detection in I2C Transmission. The master appends an 8-bit checksum to the actual data sequence. The checksum holds redundant information about the data sequence and allows the receiver to detect transmission errors. The computed checksum can be regarded as the remainder of a polynomial division, where the dividend is the binary polynomial defined by the data sequence and the divisor is a "generator polynomial". The MFM2000 implements the CRC-8 standard based on the generator polynomial $x^8 + x^5 + x^4 + 1$.

Note:

CRC here is only used for data transmitted from the slave to the master. For details regarding cyclic redundancy checking, please refer to the relevant literature.

In the master's program, must use the 2 bytes differential pressure read out from MFM2000's register 0 and polynomial $x^8 + x^5 + x^4 + 1$ to calculate out one byte result data, then compare the result data calculated by master and the CRC code from MFM2000. If they are not equal, it indicates that there is error in I2C communication, the master must discard the measurement data that time, and trigger the measurement again, then read from MFM2000's register 0 again until the result data and the CRC code are equal.

DIMENSIONS: (UNIT:MM)

Note: Drawing not to scale