

Datasheet SFM3400-AW & SFM3400-D

Digital Flow Meter for Neonatal/Pediatric Medical Applications

- Flow range: $\pm 33\text{slm}$ (bidirectional)
- Small dead space < 1ml
- Single-use (-D) and Re-use (-AW) version
- Very fast update time (0.5ms)



Product Summary

The SFM3400 sensor series is Sensirion's digital flow meter designed for neonatal/pediatric medical applications. It measures the flow rate of **air, oxygen and other non-aggressive gases** with superb accuracy. The special design of the flow channel results in a **very small dead space**.

Customers have the choice between the single-use SFM3400-D and the multi-use SFM3400-AW with the **ability to withstand autoclave procedures**. Therefore, the SFM3400 series is extremely well suited for proximal flow measurements in neonatal/pediatric medical ventilation and other respiratory applications.

The SFM3400 series has been designed with the use by medical professionals in mind. It features **medical cones** for pneumatic connection to standard breathing circuits and a mechanical interface for **easy and reliable electrical reconnection**. The sensor element, signal processing and digital calibration are on a single microchip assuring **very fast signal processing time, best-in-class accuracy** and **superior robustness** to rough handling and adverse conditions.

The well-proven and patented **CMOSens® sensor technology** is perfectly suited for high-quality mass production and is the ideal choice for demanding and cost-sensitive OEM applications.

Applications

- Proximal flow measurement for infants / neonates
- Expiratory flow measurement for infants / neonates
- Ventilation & Anesthesia for infants / neonates
- Respiratory measurements for infants / neonates
- Metabolic Measurements for infants / neonates

OEM options

A variety of custom options can be implemented for high-volume OEM applications (custom flow rates, calibration for other gases, different body form factor, disposable option etc.). Contact us for more information.

Sensor chip

The SFM3400 flow meter features a fifth-generation silicon sensor chip. In addition to a thermal mass flow sensor element, the chip contains an amplifier, A/D converter, EEPROM memory, digital signal processing circuitry, and interface. Due to seamless integration of signal acquisition and processing on the single silicon die significant performance and cost benefits are achieved.

1.1 Physical Specifications ¹

| Parameter | Condition | Value | | Unit |
|--|---------------------------------|--|--------------------------------------|---|
| Flow Range | | -33 ... +33 | | slm ² |
| | | Typical | Max ³ | |
| Accuracy ⁴ | span <33 slm offset | ± 3 ⁵ ± 0.02 ⁵ | ± 10 ⁶ ± 0.05 | % m.v. ⁷ slm ² |
| Noise Level ^{4, 8} | span <33slm offset | 0.5% ⁹ 0.005 ⁹ | 3.5% 0.025 | % m.v. ⁷ slm ² |
| Accuracy shift for deviation from reference temperature 25°C | span offset | | 1% 0.01 | % m.v./ 10°C slm / 10°C |
| Resolution (14bit) | span offset | 0.06 ⁹ 0.005 ⁹ | 0.2 0.01 | % m.v. ⁷ slm ² |
| Pressure Drop | @ 5 slm @ 10 slm @ 25 slm | 100 / 0.4 ⁹ 250 / 1.0 ⁹ 900 / 3.6 ⁹ | 150 / 0.6 300 / 1.2 1500 / 6.0 | Pa / inH ₂ O Pa / inH ₂ O Pa / inH ₂ O |

1.2 Ambient conditions

| Parameter | Condition | Value | Unit |
|---|---|-------------|-------|
| Calibrated Temperature Range | dry gas | +10 ... +50 | °C |
| Operating Temperature Range ¹⁰ | 10-95% rel. hum. (non cond.) | +5 ... +50 | °C |
| Storage Temperature | 10-95% rel. hum. (non cond.) | -40 ... +70 | °C |
| Shelf Life for SFM3400-D | 15°C - 35°C; 30 - 70 % rel. hum. storage in original packaging | 3 | years |
| Operating Pressure Range | absolute | 0.54 – 1.1 | bar |
| Burst Overpressure | gauge | 0.3 | bar |

1.3 Media compatibility

| Parameter | Value |
|---------------------------|---|
| Calibration ¹¹ | Air |
| Media Compatibility | Air (non-condensing), N ₂ , O ₂ , other non- aggressive gases |
| Wetted Materials -AW | Si, Si ₃ N ₄ , SiO _x , gold, epoxy, PPSU, silicone |
| Wetted Materials -D | Si, Si ₃ N ₄ , SiO _x , gold, epoxy, MABS, silicone |
| RoHS, REACH | RoHS and REACH compliant |

¹ Reference conditions are temperature = 25°C, absolute pressure = 966 mbar, horizontal flow and Vdd = 5V

² slm: mass flow measured in liters per minute at standard conditions (T = 20 °C, p = 1013.25 mbar)

³ For "Max" no sensor measured outside of this limit will be shipped and a CpK of 1.33 is targeted

⁴ For accuracy, noise level or resolution the total value is the sum of the offset and span values

⁵ This value corresponds to a CpK of 0.67 (95% of sensors within the "Typical" limit)

⁶ Dependent on tracheal tube diameter

⁷ % m.v. = % measured value = % of reading

⁸ Noise level defined as standard deviation of individual sensor readings, measured at full sampling rate

⁹ Average value

¹⁰ Do not exceed these operating conditions by heating the sensor excessively with the external heater, see section 4.4.

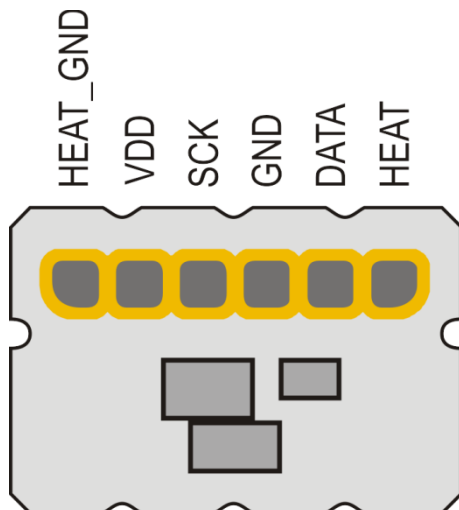
¹¹ Contact Sensirion for information about other gases, wider calibrated temperature ranges and higher storage temperatures

2. Electrical Specifications

2.1 Electrical Characteristics

| Electrical properties | Condition | Value | Unit |
|--|-------------|-------------------------|------------|
| Interface | | I ² C | |
| Default Sensor Address | | 64 (h40) | |
| Update Time | 14 bit | 0.5 | ms |
| Soft Reset Time | | 80 | ms |
| Start-up Time ¹² | Max. | 100 | ms |
| I ² C bus Clock Frequency | Max. | 400 | kHz |
| Supply Voltage | | 5V±5% | V |
| Communication Level | High Low | Min. | Max. |
| | | 2.5 GND | VDD 1.1 |
| Power Consumption ¹³ | | < 50 | mW |
| Electrical Connector | | See section 2.2 and 3.2 | |
| External Heater Power Rating ¹⁴ | Max. | 0.5 | W |
| External Heater Resistance ¹⁴ | Typ. | 51 | Ω |
| Output Signal Resolution ¹⁵ | | 14 | bit |
| Scale Factor Flow | Air, N2 | 800 | 1/slm |
| Offset Flow | | 32768 | |

2.2 Pad Layout



2.3 Conversion to Physical Values

In order to obtain the measured flow in [slm], the measured value needs to be converted using the following formula:

$$flow [slm] = \frac{measured\ value - offset\ flow}{scale\ factor\ flow}$$

Please note that the first measurement performed directly after chip initialization is not valid.

¹² After 4.75V is reached

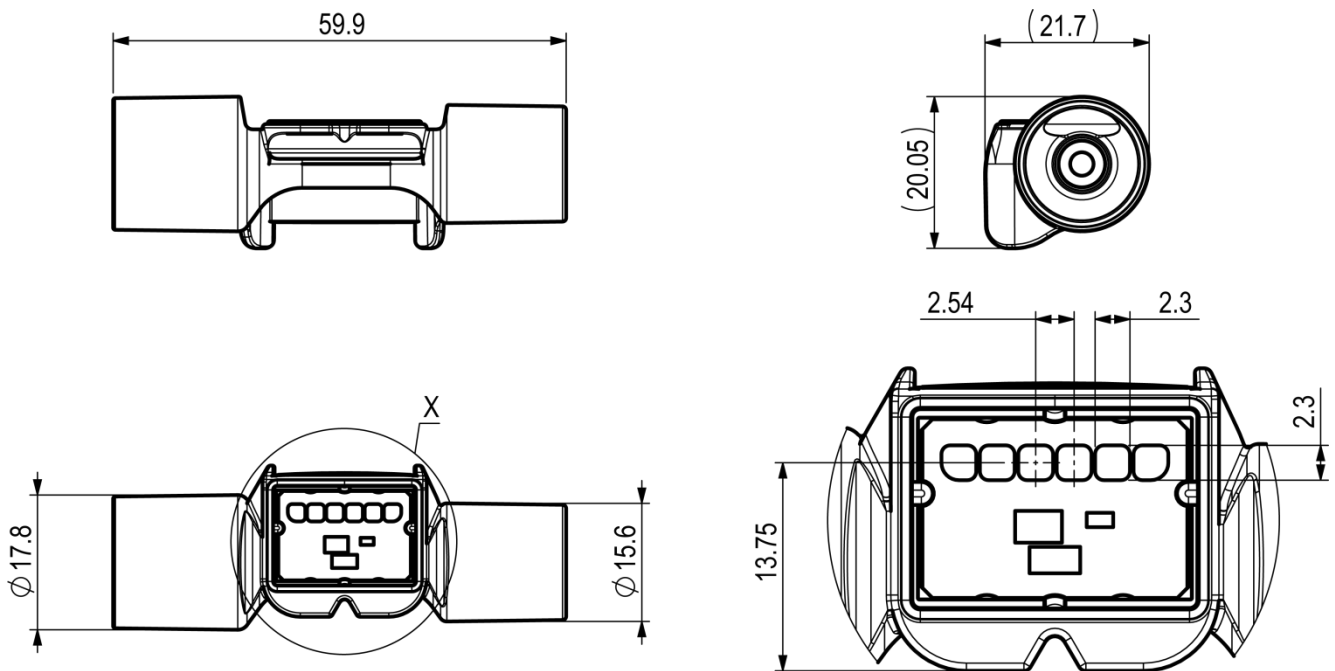
¹³ When the heater resistor on the PCB is not in operation

¹⁴ The heater's purpose is to avoid condensation or icing. One should only apply sufficient power to achieve this purpose. See section 4.4 for more details.

¹⁵ 16 bit with two least significant bits always zero

3. Mechanical Specifications

All dimensions are in millimeters (mm).



3.1 Mechanical fitting

Fittings of the SFM3400 sensor correspond to the international standard ISO5356-1:2004. Details about this type of connection can be found in the description of the standard.

3.2 Mechanical / Electrical Interface

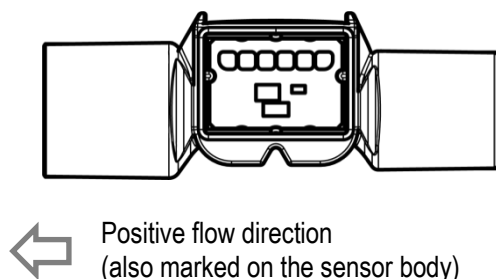
SFM3400 series has been designed for use in an expiratory environment. Therefore, the sensor has been designed for a connector that can be easily connected and disconnected. The connector itself is not provided as a standard product by Sensirion but Sensirion can help with an application note including design recommendations.

| Dimension | Condition | Value |
|----------------------------------|-------------------|------------------|
| Length | | 60 mm (typical) |
| Diameter flow channel | center of sensor | 3.5 mm (typical) |
| Medical connector, distal side | ISO 5356-1 | Cone, 15 mm |
| Medical connector, proximal side | ISO 5356-1 | Socket, 15 mm |
| Dead space | relevant section | 0.9 ml (typical) |
| Weight | without connector | 7.5 g (typical) |

4. Instructions for Use

4.1 Calibration orientation

The sensors are calibrated horizontally as depicted in the following graph:



Positive flow direction is from the male 15 mm cone to the female 15 mm medical cone, so that inspiratory flows are positive and expiratory flows negative.

4.2 Inlet flow conditions

In order to provide good flow conditions, the inner diameter of the connecting tube has to be approximately the same as the inner diameter of the SFM3400 main flow channel.

4.3 Temperature compensation

The SFM3400-AW sensor features digital temperature compensation. The temperature is measured on the CMOSens® chip by an on-chip temperature sensor. This data is fed to a compensation circuit that is also integrated on the CMOSens® sensor chip. Thus, no external temperature compensation is necessary.

4.4 Heater operation

The sensor has an external heater for cases where the gas flowing through the sensor contains high humidity and is warmer than the ambient temperature. In such cases, heating the sensor can help to avoid condensation or icing. Sufficient power should be provided for this purpose, but excessive power must be avoided for two reasons:

- 1) to stay within the operating temperature range,
- 2) to maintain the best accuracy.

Reading out the chip temperature can be used as feedback on the current sensor temperature.

4.5 Cleaning (applies only to SFM3400-AW version)

The SFM3400-AW has been designed to withstand medical cleaning procedures. For details of the test and the results contact Sensirion.

Sensirion AG does not guarantee the stability of the flow sensor using arbitrary methods and/or equipment for autoclaving. Validation of the flow sensor stability for a specific type of procedure and/or equipment is the sole responsibility of the customer.

4.6 ESD

The electronics of the SFM3x00-AW flow sensor chip has been tested for ESD and passed an 8kV contact test. For ESD information about the additional EEPROM (type: 24LC01BT-I/MC) please consult the datasheet of the EEPROM.

4.7 Sensor handling

The SFM3400 sensor is designed to be robust and shock resistant. Nevertheless, the accuracy of the high-precision SFM3400 can be degraded by rough handling. Sensirion does not guarantee proper operation in case of improper handling.

Note: never connect the sensor while connecting part is wet. Especially after cleaning procedure special care is needed to dry the sensor.

Please be aware that SFM3400 has been designed for usage with air and other non-corrosive and non-toxic gases.

If leak tightness is critical in customer application, it remains customer's sole responsibility to leak-test the sensor before usage.

4.8 I²C Interface and communication

Due to I²C interface restrictions, the cable length from the sensor to the microprocessor is recommended to be as short as possible and certainly not above 30 cm. For wires longer than 10 cm it is mandatory to shield the SDA and SCL.

In case data is read from the sensor, the first data byte of the transaction must always be acknowledged by the master.

It must be possible to reset the sensor through a hard reset, i.e. powering off and on the sensor, in case the sensor freezes.

I²C Communication details are given in the application note "GF_AN_SFM3xxx_I²C Functional Description".

There is an additional EEPROM on the PCB to allow storage of customer-specific data. Please see all details in the datasheet of the EEPROM. The EEPROM is of type 24LC01BT-I/MC. No additional validation or modification of EEPROM settings has been performed by Sensirion.

SFM3400-AW only:

There is an additional EEPROM on the SFM3400-AW to allow storage of customer-specific data (like for example usage hours). Please see all details in the datasheet of the

EEPROM. The EEPROM is of type 24LC01BT-I/MC. No additional validation or modification of EEPROM settings has been performed by Sensirion.

5. Ordering Information

Use the part names and product numbers shown in the table below when ordering SFM3400-AW sensors. For the latest product information and local distributors, visit www.sensirion.com.

| Part name | Product Number | Availability |
|---------------|----------------|--------------|
| SFM3400-33-AW | 1-101545-01 | Available |
| SFM3400-33-D | 1-101607-01 | Samples |

Packaging units: 30 items/tray.

Every sensor is traceable by a unique serial number.

Revision history

| Date | Author | Version | Changes |
|---------------|--------|---------|---|
| January 2020 | DAT | 1.1 | Release of SFM3400-D version; |
| February 2021 | DAT | 1.2 | Minor correction, added missing epoxy to the wetted materials list of -AW version |
| January 2022 | PSIM | 1.3 | Note on operating temperature conditions and heater's operation |

Important Notices

Warning, personal injury

Do not use this product as safety or emergency stop devices or in any other application where failure of the product could result in personal injury (including death). Do not use this product for applications other than its intended and authorized use. Before installing, handling, using or servicing this product, please consult the datasheet and application notes. Failure to comply with these instructions could result in death or serious injury.

If the Buyer shall purchase or use SENSIRION products for any unintended or unauthorized application, Buyer shall defend, indemnify and hold harmless SENSIRION and its officers, employees, subsidiaries, affiliates and distributors against all claims, costs, damages and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if SENSIRION shall be allegedly negligent with respect to the design or the manufacture of the product.

ESD Precautions

The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take customary and statutory ESD precautions when handling this product.

Warranty

SENSIRION warrants solely to the original purchaser of this product for a period of 12 months (one year) from the date of delivery that this product shall be of the quality, material and workmanship defined in SENSIRION's published specifications of the product. Within such period, if proven to be defective, SENSIRION shall repair and/or replace this product, in SENSIRION's discretion, free of charge to the Buyer, provided that:

- notice in writing describing the defects shall be given to SENSIRION within fourteen (14) days after their appearance;
- such defects shall be found, to SENSIRION's reasonable satisfaction, to have arisen from SENSIRION's faulty design, material, or workmanship;

- the defective product shall be returned to SENSIRION's factory at the Buyer's expense; and
- the warranty period for any repaired or replaced product shall be limited to the unexpired portion of the original period.

This warranty does not apply to any equipment which has not been installed and used within the specifications recommended by SENSIRION for the intended and proper use of the equipment. EXCEPT FOR THE WARRANTIES EXPRESSLY SET FORTH HEREIN, SENSIRION MAKES NO WARRANTIES, EITHER EXPRESS OR IMPLIED, WITH RESPECT TO THE PRODUCT. ANY AND ALL WARRANTIES, INCLUDING WITHOUT LIMITATION, WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE EXPRESSLY EXCLUDED AND DECLINED.

SENSIRION is only liable for defects of this product arising under the conditions of operation provided for in the datasheet and proper use of the goods. SENSIRION explicitly disclaims all warranties, express or implied, for any period during which the goods are operated or stored not in accordance with the technical specifications.

SENSIRION does not assume any liability arising out of any application or use of any product or circuit and specifically disclaims any and all liability, including without limitation consequential or incidental damages. All operating parameters, including without limitation recommended parameters, must be validated for each customer's applications by customer's technical experts. Recommended parameters can and do vary in different applications.

SENSIRION reserves the right, without further notice, (i) to change the product specifications and/or the information in this document and (ii) to improve reliability, functions and design of this product.

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