Data Sheet SFM3000
Low Pressure Drop Digital Flow Meter

- Low pressure drop
- Flow range: +/- 200 slm (bidirectional)
- Accuracy 1.5% m.v. (typical)
- Very fast update time (0.5ms)
- Fully calibrated & temperature compensated
- Zero offset, no drift

Product Summary
The SFM3000 sensor is Sensirion’s digital flow meter designed for high-volume applications. It measures the flow rate of air, oxygen and other non-aggressive gases with superb accuracy. A special design of the flow channel results in the very low pressure drop through the flow body of the sensor making it extremely suitable for very demanding applications, such as medical ventilation and respiratory applications.

The SFM3000 operates from a 5 Volt supply voltage and features a digital 2-wire I^2C interface. The measurement results are internally linearized and temperature compensated.

Applications
- Medical
- Process automation
- Burner control
- Fuel cell control
- Spectroscopy
- Environment monitoring
- Laboratory

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 etc.). Contact Sensirion for more information.

Sensor chip
The SFM3000 flow meter features a fifth-generation silicon sensor chip SF05. 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.

Connection diagram

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1. Sensor performance

1.1 Physical specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Ranges</td>
<td>Air/N₂/O₂</td>
<td>-200 … +200</td>
<td>slm³</td>
</tr>
<tr>
<td>Update Time</td>
<td>14 bit</td>
<td>0.5</td>
<td>ms</td>
</tr>
<tr>
<td>Accuracy 4,5,6,7</td>
<td>span</td>
<td>± 2.5</td>
<td>% m.v.²</td>
</tr>
<tr>
<td></td>
<td>offset</td>
<td>± 0.1</td>
<td>% m.v.²</td>
</tr>
<tr>
<td>Repeatability 4,7</td>
<td>span</td>
<td>± 1</td>
<td>% m.v.</td>
</tr>
<tr>
<td></td>
<td>offset</td>
<td>± 0.05</td>
<td>% m.v.</td>
</tr>
<tr>
<td>Noise Level 4,7</td>
<td>span</td>
<td>± 1</td>
<td>% m.v.</td>
</tr>
<tr>
<td></td>
<td>offset</td>
<td>± 0.1</td>
<td>% m.v.</td>
</tr>
<tr>
<td>Accuracy Shift Due to Temperature Variation 9</td>
<td>span</td>
<td>± 0.75</td>
<td>% m.v./10°C</td>
</tr>
<tr>
<td></td>
<td>offset</td>
<td>± 0.0</td>
<td>% m.v.</td>
</tr>
<tr>
<td>Position sensitivity</td>
<td>non-horizontal position</td>
<td>&lt; 0.05</td>
<td>slm</td>
</tr>
<tr>
<td>Pressure Drop</td>
<td>@60slm</td>
<td>&lt; 100 / &lt; 0.4</td>
<td>Pa / inH₂O</td>
</tr>
<tr>
<td></td>
<td>@200slm</td>
<td>&lt; 600 / &lt; 2.4</td>
<td></td>
</tr>
</tbody>
</table>

1.2 Media compatibility and materials

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration</td>
<td>Air, N₂, O₂</td>
</tr>
<tr>
<td>Media Compatibility</td>
<td>Air (non-condensing), N₂, O₂, non-aggressive gases</td>
</tr>
<tr>
<td>Wetted Materials</td>
<td>PPE+PS blend (medical grade: biocompatible; ISO 10993 or USP Class VI), Si, Si₃N₄, SiOₓ, Gold, Epoxy, Polyurethane, stainless steel (annealed)</td>
</tr>
<tr>
<td>RoHS, REACH</td>
<td>RoHS and REACH compliant</td>
</tr>
<tr>
<td>Sensor Weight with Cap</td>
<td>&lt; 18 gram</td>
</tr>
</tbody>
</table>

1.3 Temperature and pressure conditions

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibrated Temperature Range¹¹</td>
<td>T(environment) = T(gas)</td>
<td>-20 … +80</td>
<td>°C</td>
</tr>
<tr>
<td>Operating Temperature Range¹¹</td>
<td>Non-condensing</td>
<td>-20 … +80</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>Non-condensing</td>
<td>-20 … +80</td>
<td>°C</td>
</tr>
<tr>
<td>Operating Pressure Range</td>
<td>absolute</td>
<td>0.7 – 1.3</td>
<td>bar</td>
</tr>
<tr>
<td>Operating Overpressure</td>
<td>gauge</td>
<td>± 0.2</td>
<td>bar</td>
</tr>
<tr>
<td>Burst Overpressure</td>
<td>gauge</td>
<td>&gt; 1</td>
<td>bar</td>
</tr>
</tbody>
</table>

¹ Unless otherwise noted, all sensor specifications are valid at 25°C with Vdd = 5V and absolute pressure = 966 mbar.
² Other calibration ranges are available for large volume projects
³ In standard liter per minute at 20°C and 1013 mbar
⁴ With ideal inlet and outlet conditions, at VDD = 5V, 25°C, absolute pressure = 966 mbar
⁵ Including offset, non-linearity, hysteresis
⁶ Including offset, non-linearity, hysteresis
⁷ Including offset, non-linearity, hysteresis
⁸ Including offset, non-linearity, hysteresis
⁹ Including offset, non-linearity, hysteresis
¹⁰ Including offset, non-linearity, hysteresis
¹¹ See Section 4.1
¹² Contact Sensirion for information about other gases, wider calibrated and operating temperature ranges
2. Electrical specifications

2.1 Electrical characteristics

<table>
<thead>
<tr>
<th>Electrical properties</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface</td>
<td></td>
<td>I2C</td>
<td></td>
</tr>
<tr>
<td>Default Sensor Address</td>
<td></td>
<td>64 (0x40)</td>
<td></td>
</tr>
<tr>
<td>Soft Reset Time</td>
<td></td>
<td>80</td>
<td>ms</td>
</tr>
<tr>
<td>Start-up Time 12</td>
<td>Max.</td>
<td>100</td>
<td>ms</td>
</tr>
<tr>
<td>Supply Voltage (VDD)</td>
<td></td>
<td>5V +/-5%</td>
<td>V</td>
</tr>
<tr>
<td>I2C Communication Level</td>
<td>High</td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>2.5</td>
<td>VDD</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GND</td>
<td>1.1</td>
</tr>
<tr>
<td>I2C Bus clock frequency</td>
<td>Max.</td>
<td>400</td>
<td>kHz</td>
</tr>
<tr>
<td>Power Consumption</td>
<td></td>
<td>&lt; 50</td>
<td>mW</td>
</tr>
<tr>
<td>Electrical Connector</td>
<td></td>
<td>2 mm pitch, 4 pins in a row</td>
<td></td>
</tr>
<tr>
<td>Output signal resolution</td>
<td></td>
<td>1413</td>
<td>bit</td>
</tr>
<tr>
<td>Scale Factor Flow</td>
<td>Air, N2</td>
<td>140</td>
<td>1/slm</td>
</tr>
<tr>
<td></td>
<td>O2</td>
<td>142.8</td>
<td></td>
</tr>
<tr>
<td>Offset Flow</td>
<td></td>
<td>32’000</td>
<td></td>
</tr>
</tbody>
</table>

12 After 4.75V is reached
13 16 bit with two least significant bits always zero

2.2 Pin layout and mechanical concept of the electrical connection

The SFM3000 is designed for both connector attachment and through-hole technology hand-soldering to a PCB.

2.2.1 Connector attachment

The SFM3000 sensor’s 4-pin 2 mm pitch electrical connector is compatible with Molex DuraClik™ socket (Molex product number: 502351-0400). For this type of connection please order the SFM3000 with a cap (according to the ordering information in Chapter 5). Diverse 4-core flat ribbon cables with crimp fittings can be used for electrical connection.

2.2.2 PCB soldering

Standard selective soldering systems may be used for soldering SFM3000 sensors. Reflow soldering is not feasible and may damage the sensor. The sensor ports must be protected from solder splash and flux during soldering. The characteristics of selective soldering machines vary, so any soldering setup must be tested before production use.

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:

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

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

All dimensions are in millimeters (mm).

3.1 SFM3000 without cover (PCB mount)

3.2 Footprint

Please refer to the mask given below for reliable PCB attachment using the dedicated snap-in feet. Consider using the screw holes of the SFM3000 for a sturdy integration of the sensor.

3.3 SFM3000 with cover

If used with cover, sensor height is 34.4 mm instead of 33 mm. All the other dimensions are the same.
3.4 Mechanical fitting

Fittings of the SFM3000 sensor correspond to the international standard ISO5356-1:2004. Details about this type of connection can be found in the description of the standard. To minimize the risk of connectors being accidentally disconnected, latching connectors can be suggested.

4. Instructions for use

4.1 Calibration orientation

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

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 SFM3000 main flow channel. The inlet tube has to be straight and at least 10 cm in length. The SFM3000 is equipped with meshes on the in- and outlets of the flow channel to reduce turbulences and thus improve the stability. Please refer to the application note “Inlet conditions for the SFM3000 Mass flow meters” for more information.

4.3 Temperature compensation

The SFM3000 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 Sensor handling

The SFM3000 sensor is designed to be robust and shock resistant. Nevertheless, the accuracy of the high-precision SFM3000 can be degraded by rough handling. Sensirion does not guarantee proper operation in case of improper handling. **Note:** avoid applying any mechanical stress to the solder joints of the sensor during or as a result of PCB assembly.

4.5 ESD

The electronics of the SFM3000 sensor consist of a single automotive qualified chip. It complies with the following ESD norms:

- AEC Q 100 002 (4kV HBM)
- AEC Q 100 003 (200V MM)

Although the sensor complies with these norms, it does not mean the sensor is immune against ESD. The sensor is shipped in an antistatic tray to prevent electrostatic discharge. To avoid damage to the sensor, ground yourself using a grounding strap or by touching a grounded object before touching the sensor. Furthermore, store the parts in an antistatic package when not in use.

4.6 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 “I2C Functional Description for SFM3000”.

It is also possible to insert O-rings in the grooves and attach tubes with an inner diameter of 23 mm to the SFM3000.

Cross section of recommended O-ring

\[ d_1 = 19\text{mm} \quad d_2 = 2\text{mm} \]
5. Ordering information

Use the part names and product numbers shown in the table below when ordering SFM3000 sensors. For the latest product information and local distributors, visit www.sensirion.com.

<table>
<thead>
<tr>
<th>Part name</th>
<th>Cap</th>
<th>Product Number 1-100xxx-xx</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFM3000-200-C</td>
<td>With</td>
<td>932-02</td>
</tr>
<tr>
<td>SFM3000-200</td>
<td>Without</td>
<td>934-02</td>
</tr>
</tbody>
</table>

Packaging units: 20 items/tray.
Every sensor is traceable by a unique Serial Number.

Revision history

<table>
<thead>
<tr>
<th>Date</th>
<th>Author</th>
<th>Version</th>
<th>Changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 2013</td>
<td>ANB</td>
<td>1</td>
<td>First release</td>
</tr>
<tr>
<td>February 2014</td>
<td>ANB</td>
<td>2</td>
<td>Updated material to Noryl</td>
</tr>
<tr>
<td>December 2015</td>
<td>ANB</td>
<td>2.1</td>
<td>Updated temperature ranges Clarified max/min pressures Updated product picture.</td>
</tr>
<tr>
<td>July 2016</td>
<td>ANB</td>
<td>2.2</td>
<td>Change of potting material. Product number post-fix updated</td>
</tr>
</tbody>
</table>
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.

See application note “Handling Instructions” for more information.

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.

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