

Clip-On Cap/Cable Evaluation Kit

Applicable to following sensors:

SFM3200-AW, SFM3300-AW/D, SFM3400-AW/D

Key content:

- Clip-on cap/cable evaluation kit description
- Clip-on cap/cable use cases
- Technical information on clip-on cap/cable
- Recommended approach for customized solution

Summary

This application note describes the clip-on cap interface for the proximal flow sensors SFM3300-AW/D, SFM3400-AW/D and the expiratory sensor SFM3200-AW. These sensors have in common that they can easily be swapped to allow for cleaning of the sensor (AW-type) or exchanged and disposal (D-type). Both types therefore feature the clip-on interface which allows for user friendly and reliable connection by medical staff.

This application note provides relevant information about the evaluation kit, how to use it for initial feasibility and later implement it in prototypes and the final product. Technical details and guidance are provided for customers looking to implement a customized cap/cable solution for their respiratory device.

1 Introduction

Sensirion's autoclavable, washable and single-use mass flow sensors are optimized for proximal flow measurements in respiratory applications with adults (SFM3300-AW/D), neonates (SFM3400-AW/D) and for expiratory measurements requiring minimal pressure drop (SFM3200-AW).

Since these sensors are exposed to the exhaled media from the patient, they need to be cleaned or replaced regularly, typically carried out by medical personnel. Therefore, these sensors require a user-friendly and reliable interface with a cable which connects them to the respiratory device.

Sensirion's clip-on cap/cable evaluation kit demonstrates the advantages of the proposed clip-on cap/cable solution and offers various possibilities to evaluate the clip-on cap/cable firsthand and with little effort even in the customer's own setup. This application note also provides information for customers on how to design or source a customized solution tailored to their specific respiratory device.

2 Evaluation Kit Clip-On Cap/Cable

Sensirion's evaluation kit cable is shown in **Figure 1** below. The evaluation kit cable is composed of an USB connector, a 2 m cable, and the clip-on cap, which houses a small microcontroller and a pressure sensor.



Figure 1. Evaluation kit cable and SFM3300-AW sensor.

2.1 Clip-On Cap/Cable Functionality

The clip-on cap incorporates a miniaturized PCB with a microcontroller which enables the following features and advantages.

Pressure Sensor in Clip-On Cap

In respiratory applications the patient's breathing pressure often must be measured as close as possible to the patient, typically at a proximal location. In order to avoid having to loop back a thin tube carrying the pressure signal back to the respiratory device (e.g. the ventilator), a fast, high resolution and sensitive pressure sensor has been integrated into the re-usable clip-on cap (Type: AMS 5915-0200-D-B). This allows measuring the pressure proximal to the patient while avoiding additional tubes running back to the ventilator, which delay and attenuate the pressure signal.

The evaluation kit features the clip-on cap with an integrated pressure sensor and a pressure port² which can be connected to the breathing circuit (e.g. the WYE piece) with a short tube.

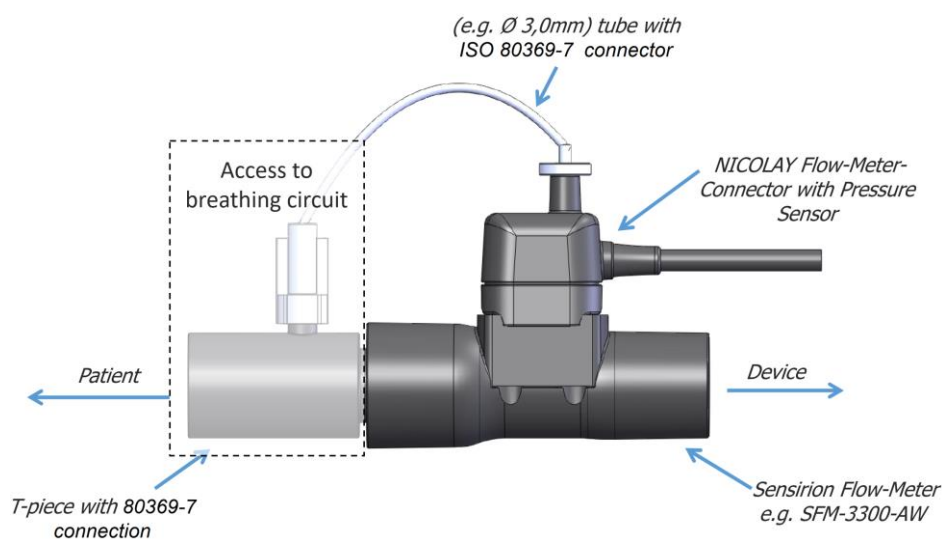


Figure 2. Clip-on cap featuring the pressure port. Flow and pressure readings are returned electrically to the respiratory device.

² Appropriate connector type: 158442 Luer-Tubing Adapter (Male) for Flexible Tubing (<https://www.rct-online.de/en/>)

External Heater

In specific applications it might be necessary to take scenarios of condensation or even icing of the sensor element into consideration. To allow the sensor to operate in such harsh environments, a resistor has been placed on top of the flow sensor PCB which is intended to be used as a heater element. Heating power is limited to 0.5 W and can be directly controlled by communication commands to values between 0 and 100%.

As heating the flow tube induces a thermal gradient over the sensing element, the set external heater power may affect the sensor accuracy. Depending on the heater power applied and the accuracy requirements, additional testing in the specific design-environment is recommended. Generally, it is recommended to only apply sufficient power for the intended scenario, e.g. to avoid condensation, and not to continuously set the heater to 100%.

Sensor Supply Voltage On/Off Capability

Via communication commands to the microcontroller inside the clip-on cap the power supply to the sensor can be switched on and off, to perform a hard reset.

Protocol/Bus Conversion

The sensor's I2C protocol is intended for communication over short cable lengths (<10cm) only and therefore not ideal to connect proximal sensors to a ventilator device with cable lengths typically extending beyond 1m.

In comparison the UART protocol is a much more robust communication protocol and better suited for signal transport over longer distances. For this reason and in order to provide the functionalities mentioned above, a microcontroller is incorporated inside the clip-on cap. This microcontroller reads the flow and pressure signals from the flow and pressure sensor over a short distance via the I2C protocol and transmits the measurement values using RS232 to the USB connector. Inside the USB connector the signal is then transformed into a USB signal.

2.2 Clip-On Cap/Cable Evaluation Kit – Intended Use

The evaluation kit clip-on cap and cable was designed to allow for prototype testing as well as initial integration into customer devices for feasibility testing. While allowing the clip-on cap to accompany the development process as far as possible, several different use cases were considered:

Sensor Evaluation and Initial Testing with Sensirion's Control Center Software

Sensor evaluation and initial testing is straight forward using our quick starter guide:

1. Download install Sensirion's Control Center Software:
<https://www.sensirion.com/en/controlcenter/>
2. Connect the sensor with the cap/connector cable to your computer
3. Start the software and run flow measurements

Proprietary Software on a PC interfacing via USB

The sensor readings can also be integrated into a customer specific application, e.g. a Simulink environment or any other proprietary application. For details on the communication protocol, please refer to the Nicolay cap/cable communication protocol which can be downloaded from the following website:

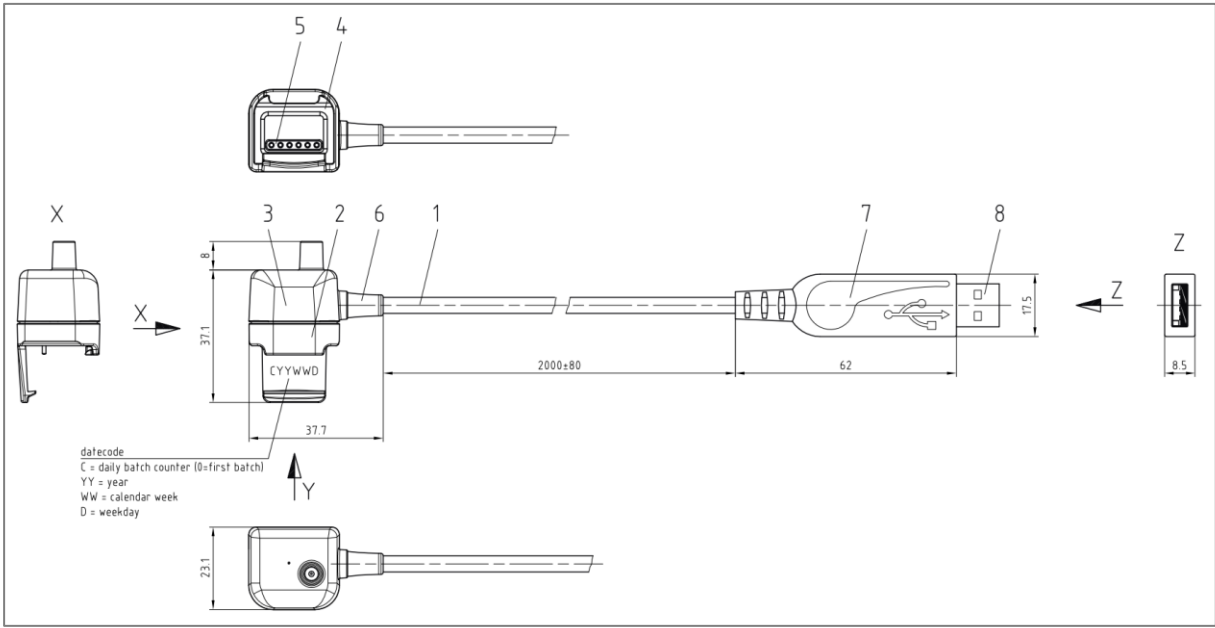
<https://nicolay.de/communication-protocol-flowsensor-cable-with-pressure-sensor>

Installation of the FTDI USB driver might be required and can be downloaded from the following link:
www.ftdichip.com/Drivers/VCP.htm

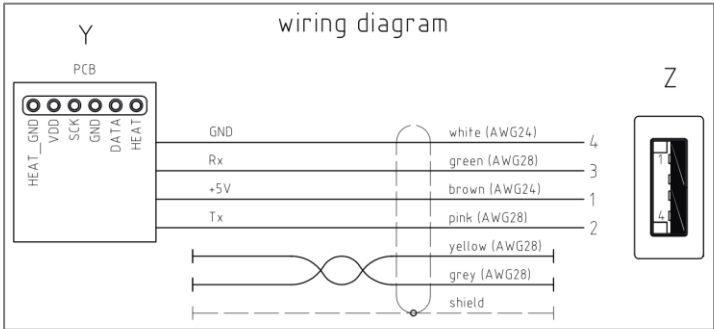
Prototype and interfacing via UART

The sensor can also directly be connected to an electronic circuit board and interfaced with the UART RS232 interface. This requires cutting off the USB connector and follow the wiring diagram of section 2.3 for correctly connecting the cable as well as the outlined communication protocol which is available as outlined in section 2.3.

2.3 Key Characteristics of Clip-On Cap/Cable



-	1	pressure sensor with digital output			AMS 5915-0200-D-B
8	1	USB plug			
7	1	plug-insulation	Hotmelt	black similar RAL 9005	
6	1	strain bend relief	M-PUR	black similar RAL 9005	
5	1	PCB assembled with 6-pin spring-loaded connector			surface Au
4	1	sealing	silicone	black similar RAL 9005	
3	1	cover	PUR	black similar RAL 9005	
2	1	housing	PUR	black similar RAL 9005	
1	1	6-lead shielded cable $\phi 4.5+0.2$	M-PUR	black similar RAL 9005	464478100
<i>pos</i>	<i>quantity</i>	<i>description</i>	<i>material</i>	<i>color</i>	<i>note</i>



Communication Protocol

The communication protocol (Nicolay flow meter connector with pressure sensor) is described in a separate datasheet and provided by Nicolay. The PDF can be downloaded from the following Nicolay website: <https://nicolay.de/communication-protocol-flowsensor-cable-with-pressure-sensor>

2.4 Order Information

The evaluation kit is best obtained from distribution.

- Name: **SEK-SFM3xxx-AW/D Evaluation Kit Cable**
- Order Number: **3.000.518**

For customized solutions, please refer to chapter 3.

3 Recommendation for Customized Cap/Cable Solutions

Sensirion partnered with the company Nicolay for the development and manufacturing of our clip-on cap/cable evaluation kit. Nicolay has production tools readily available (e.g. molding tool for the clip-on interface) and offers various options for customization of the clip-on cap/cable. The sealing inserted into the cap, which seals against the PCB and protects the cap and sensor against spilled water is just one example of Nicolay’s expertise with cables for medical applications.

With many global projects supported with the Nicolay clip-on cap, this solution with the UART communication protocol has been tested and adopted by many customers. For any project going beyond the initial feasibility, Sensirion recommends reaching out directly to Nicolay regarding a clip-on cap/cable solution for our proximal and expiratory sensors. Please note that the customer is responsible for the validation for medical purposes of the cable and its firmware. The contact details are the following:

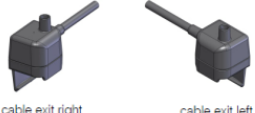



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3.1 Available Options and Inquiry Form

The table below summarizes the most common cap/cable options offered by Nicolay. Please reach out directly to Nicolay to discuss your preferences, requirements, and commercial aspects.

Configuration Options	Customer Selection
Cable length (10cm – 400cm, default 2m)	_____ cm
Select cable exit side 	<input type="radio"/> left <input type="radio"/> right
Cap with or without pressure sensor	<input type="radio"/> with pressure sensor <input type="radio"/> without pressure sensor
Select PCB communication protocol	<input type="radio"/> RS485 <input type="radio"/> RS232
Select device connector interface 	<input type="radio"/> Nicolay mini7 plug <input type="radio"/> Nicolay mini12 plug <input type="radio"/> USB connection <input type="radio"/> Open end cable (pigtail) <input type="radio"/> other: _____
Please indicate order quantity (MOQ = 100pcs)	_____ pcs

4 Own Clip-on Cap/Cable Design

In this chapter details are provided for customers preferring to design their own cap/cable clip-on. Please note that Sensirion does not have a molding tool and solely offers the evaluation kit based on Nicolay's solution. As explained in section 2.1 it is recommended to integrate electronics inside the cap which allow to implement the following functionality:

- Conversion of the communication protocol from I2C to robust long-range protocol (RS485/RS232 etc.)
- Hard reset by switching sensor supply voltage on and off
- Control of the external heater resistor
- Communication with flow and optional pressure sensor

The connector interface of the proximal and expiratory sensors is designed to enable easy and user-friendly connecting and disconnecting of the sensor. Sensirion's proposed connecting method is to utilize a connector-cap which attaches mechanically to the sensor with a clip-on interface and allows electrical connection via spring loaded pogo-pins and the pads on printed circuit board (PCB).

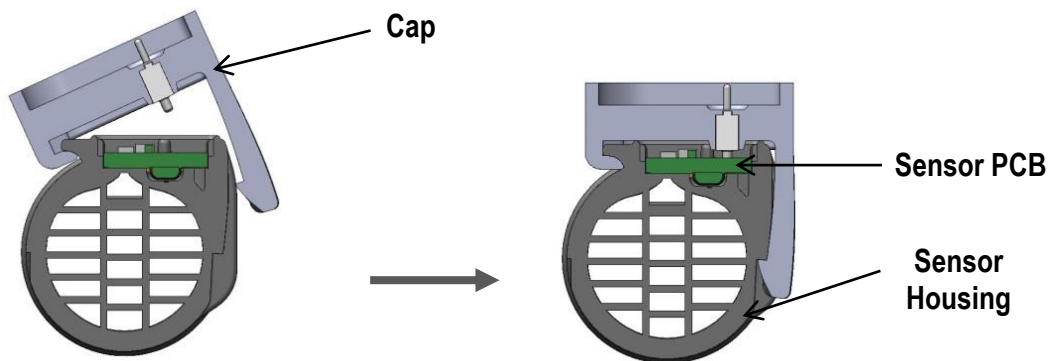


Figure 3. Cross sectional view of clip-on cap and sensor housing

Figure 3 shows a cross sectional view with the drawing plane perpendicular to the flow direction of the flow sensor and an attached cap. The sensor housing is colored dark grey, the PCB green and the connection-cap in light blueish grey. To allow easy and secure fastening and removal of the sensor, the sensor connector interface is designed with a simple snap-fit mechanism. The CAD file of the connector interface can be downloaded from Sensirion at the following link: www.sensirion.com/file/stepfile_sfm_cap

The following figure shows the top view of the sensor's connector interface and the location of the electrical pads. These pads on the PCB are best contacted via spring-loaded pins. The recommended component is the connector Preci-Dip 811-S1-006-10-014101.

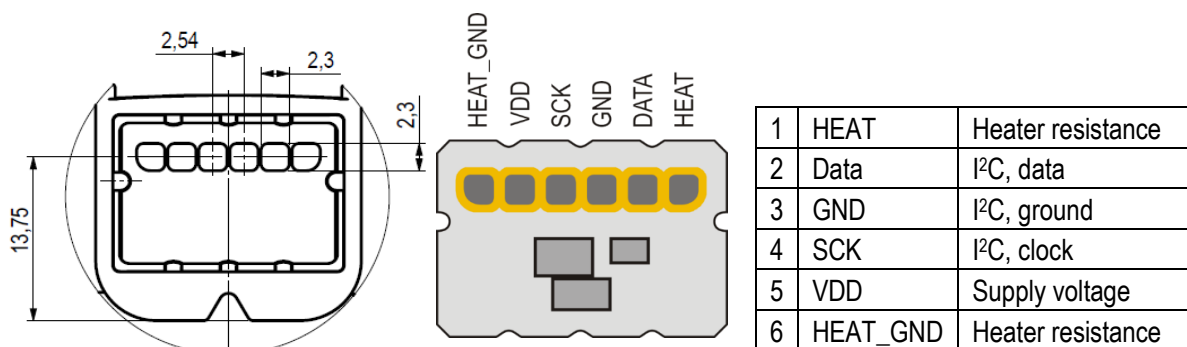


Figure 4. PCB pad layout of sensor

The heater resistor on the top side of the PCB is specified to 51 Ohms and a maximum 0.5 W heating power. Therefore, the supplied voltage drop over the resistor applied with pin 1 and 6 should never exceed 5 V, respectively the current should not exceed 99 mA for full heating power.

5 Revision History

Date	Author	Version	Changes
Jan 2021	LOEH	1.0	Entire new version with description of evaluation kit details. Previous version is now covered in chapter "Own Clip-on Cap/Cable Design".
Sept 2021	PSIM	1.1	Removed preliminary disclaimer
Oct 2024	PSIM	1.2	New contact details at Nicolay

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