# Dosing with the Continuous Flow Sensor

## Continuous Flow Sensor (CFS)

## Application note

**Introduction**

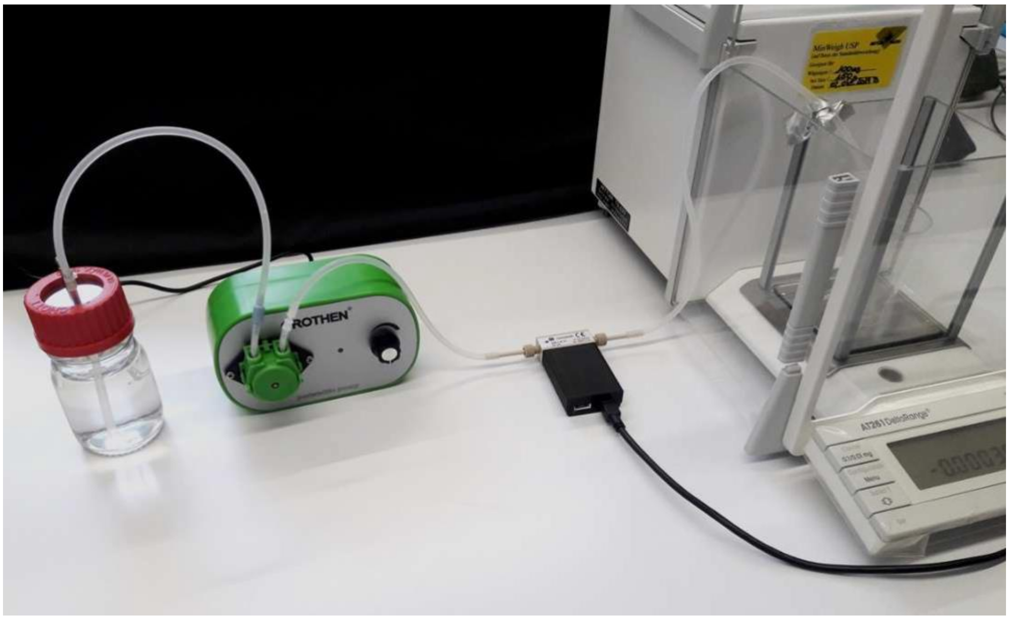
The CFS is a differential pressure Flow Sensor for dosing applications. It is well suited to dispense small amounts of liquid or measure the continuous flow of fluid containing gas bubbles.

**Used Material**

- Continuous Flow Sensor (B2, 10-100 ml/min)
- Simple Peristaltic Pump
- Precision weight scale Mettler Toledo (0.01 mg

**Experiment setup**

The peristaltic pump is connected via 2/4 mm silicone tubing to a water reservoir. A filter with 25 µm mesh size is used to prevent contamination of the sensor. The water is pumped through the sensor and onto the weight scale.



**Connecting the Sensor**

The Continuous Flow Sensor is connected by USB (5V and Data). Also a RS232 connection is possible (for further details consider the user manual of the CFS and the quick start guide). With the command *M_Cont 1* a continuous flow signal is sent by the sensor with an Interval of 1 second.

## Setting the flow to zero

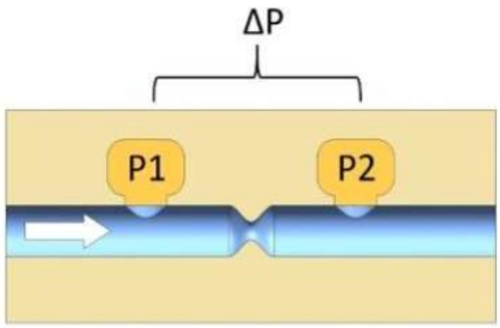



Figure 2: Sensor principle

The CFS measures the flow by evaluating a differential pressure signal generated by two pressure sensors. The pressure sensors values can be accessed by the command M_Press (Answer: P1 976.49 mbar P2 977.322 mbar).
In order to reach a good measurement accuracy the pressure offset between the two sensors has to be set to zero (S_SetZero) before the flow measurement.

*Make sure that the sensor is in its fixed mounting position, filled with liquid and has no flow at the moment of setting zero. Otherwise these factors may lead to a displaced zero point and therewith to measurement errors*

## Threshold settings


Figure 3: Pulse and Threshold

The CFS has a calibrated flow range of 1-15, 3-30 or 10-100 ml/min. Below this calibrated range it can still measure the flow. However the measurement error increases exponentially approaching a flow of 0ml/min. Therefore it makes sense in every application to neglect values below a certain flow threshold.
The plot on the right shows the same flow pulse with and without a threshold of 25 µl/s.
The operator can read and set the threshold manually (S_SetThreshold /S_GetThreshold).

*Note: Threshold settings only apply on the internally sampled flow values of the sensor at 100 Hz. Averaged flow values can be below the preset threshold.*

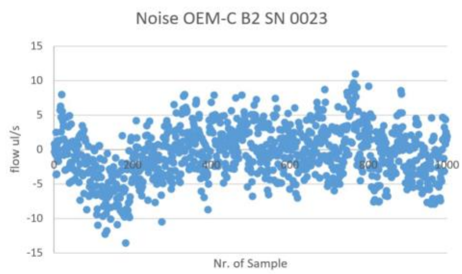



Figure 4: 1000 samples at 100 Hz – no flow

To choose the optimal threshold for an application, the noise of the sensor can be analyzed by setting the threshold to zero and the readout interval to 10 ms (S_SetThreshold 0, S_Interval 10). These settings lead to the raw acquisition data of the sensor (Figure 4). The Threshold should be set at least 5 times higher than the standard noise.In this application the Threshold was set to 5 ml/min (S_SetThreshold 83 (µl/s))

**Flow and fluid calibration**

The CFS uses a physical model to calculate the flow from a differential pressure. Within the flow equation, the values of viscosity and density can be changed using the commands *S_GetFluidCal* and *S_SetFluidCal*. (For example: *S_SetFluidCal 998 1* sets the density to 998 kg/m³ and the viscosity to 1 mPas). Like this, the sensor can be adjusted to higher viscous or denser media. An disregarded density change can influence the flow measurement by 40 % and a viscosity change by up to 5 %.

In case of a remaining linear offset, a multiplier (X) can be set by the command *S_SetFlowCorr X* to correct the flow rate.

Our sensor has the preset fluid density of 997.77 and viscosity of 0.955. *S_GetFluidCal*, which are the Parameters of water at 22° C.
The sensor temperature can be accessed by the command *M_Temp* and it is 21.84° C. So we keep the preset fluid parameters.

**First dosing Volume and Calibration**

We prime the system to fill all tubes with water.
Then we set the weight scale to zero.
Finally, we start the sensor and pump about 6 ml on to the weight scale. The Sensor is set to an interval of 10 s to only produce a few data points (averaged over 10 seconds).

| **Command**: | **Answer:** | | |
|---|---|---|---|
| S_GetThreshold | Threshold 83.00 ul/s | | |
| S_SetZero | Zero 0.180 mbar | | |
| S_Interval 10000 (10 seconds) | Interval = 10000 ms | | |
| | **Run 1** | **Run 2** | **Run 3** |
| M_Cont 1 | Flow 0.000 ul/s | 0.000 | 235.925 |
| | Flow 439.02 ul/s | 242.014 | 428.920 |
| | Flow 194.184 ul/s | 366.307 | 425.300 |
| | Flow 0.000 ul/s | 0.000 | 412.941 |
| Total measured Flow: | 6.33205 ml | 6.08321 ml | 15.0309 ml |
| Weight scale value: | 6.29955 g | 6.12833 g | 15.10086 g |
| Difference (density corrected) | 0.29 % | -0.96 % | -0.68 % |

The measurements don't seem to have a systematic error. Also the accuracy is not dependent on the dosing amount. Therefore the correction factor is left at 1.0
(*S_GetFlowCorr, Ans: FlowCorr 1.0000*) .

**Different readout rates:**

The CFS has a unique internal sampling rate of 100 Hz at any moment. By setting the interval to 10 ms (*S_Interval 10*) the maximum readout rate is achieved.
By setting longer readout intervals of 1000 or 10000 ms, an average is calculated while the sensor is still sampling at 100 Hz.
This fact leads to different sensor signals, depending on the readout rate, while the volume integral stays the same.

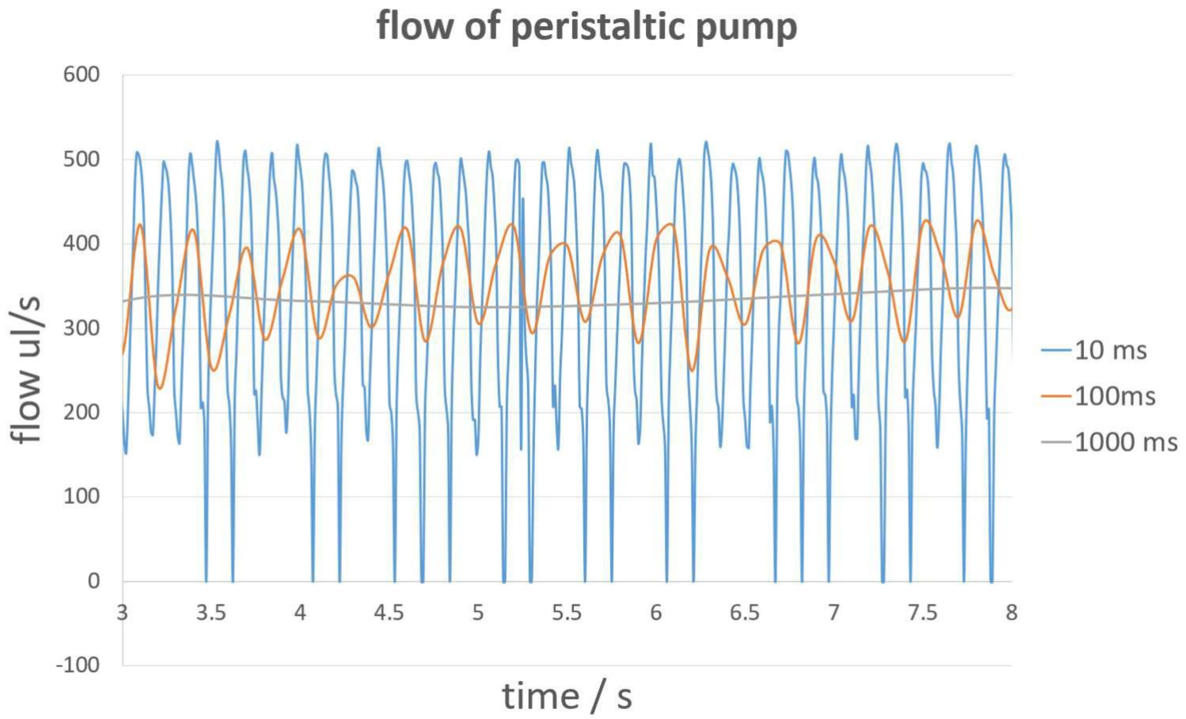



Figure 5: Volume flow at readout intervals of 10, 100 and 1000 ms

## Pumping liquid with air bubbles

To show the CFS's capability to measure liquid containing air bubbles, 10 ml of water were pumped by the peristaltic pump. Then random air bubbles were introduced to disturb the sensor. The readout interval was 1 second.

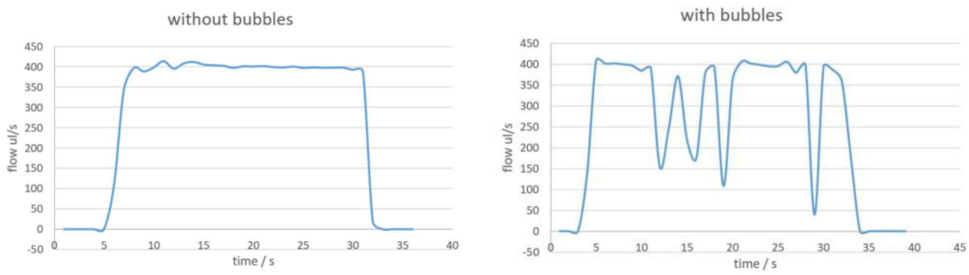



Figure 6: Dispensing with introduced air bubbles

The pumped water was measured on the weight scale and compared to the sensor data:

| | Run 1 | Run 2 |
|---|---|---|
| **Without bubbles:** | | |
| Weight scale | 10.271 g | 10.162 g |
| Sensor | 10.280 ml | 10.217 ml |
| Error (density corrected) | -0.13 % | +0.32 % |
| | | |
| **With air bubbles:** | | |
| Weight scale | 9.8047 g | 10.223 g |
| Sensor | 9.8767 ml | 10.320 ml |
| Error (density corrected) | +0.51 % | +0.72 % |

The two runs containing air bubbles show a slightly higher sensor signal. However, the deviation is below 1%.