Field calibration for SCD30

CO_2, humidity, and temperature sensor

Preface

NDIR based CO_2 sensors such as SCD30 are delicate optical systems. Special care has to be taken during handling of the sensors. Mechanical stresses on the optical cavity could change physical properties of the sensor affecting the calibration and thus, resulting in reduced accuracy.

SCD30 features two calibration algorithms to restore full accuracy, in cases where mechanical stress alters physical properties of the sensor.

This document explains how to use the field calibration algorithms ASC (automatic self-calibration) and FRC (forced re-calibration) to restore full accuracy of the SCD30. Implementing these algorithms in a production environment and at end user is discussed separately.

Overview

The algorithms ASC and FRC adapt the calibration of the SCD30, which allows for compensation of the sensors' drift over the entire concentration range. Both algorithms require only a single reference value for the desired manipulation. It is important to note that FRC and ASC do not differ in the applied adaption of the calibration – using the same reference value for ASC and FRC will result in an identical manipulation of the calibration.
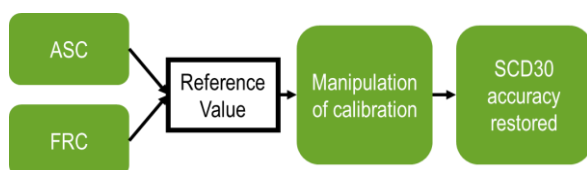

Figure 1: Workflow to restore sensor accuracy by ASC or FRC.

The major difference between ASC and FRC is the source of the reference value. FRC requires an input from the host site whereas ASC generates a reference value autonomously from historical sensor data.

For calibration in a production line, we recommend to apply FRC after assembly of the device. In applications where the end device is placed in well-ventilated buildings, we recommend to activate ASC to account for potential sensor drifts. If conditions at the end user do not fulfill the requirements necessary for ASC (see below), FRC provides means to mitigate deviations.

FRC Field-Calibration Algorithm

In case of forced re-calibration (FRC), the user has to feed a reference value from the host side to SCD30. The value provided by the host is used for updating the calibration to restore full accuracy. The latest reference value is saved in a non-volatile memory on the sensor device and will persist until it is overwritten either by a new reference value that is supplied via FRC or by finding a new reference value by ASC (see Figure 1).

Providing a valid reference value is crucial for correct manipulation of the calibration curve. The reference value can be generated in three ways - from a calibrated reference sensor; by exposing the SCD30 to an environment with controlled CO_2 concentration; or from fresh outside air (= 400 ppm). It is recommended that CO_2 concentration values serving as reference for FRC, be in the range 400 ppm to 2000 ppm.

The effect of FRC takes place immediately. FRC can be executed multiple times at arbitrary intervals. Before applying FRC, SCD30 needs to be operated for 2 minutes with the desired measurement period in continuous mode. Please find below an example demonstrating FRC implementation.

Applying FRC in Production Line

A reliable reference value and correct FRC execution can be ensured by the following method in a production environment, e.g. in the course of an end test process:

Locate the device in an environment with air having a stable CO_2 concentration in the range of 400 ppm to 2000 ppm. This can be accomplished by either

a) Setting and controlling a known CO_2 concentration in a sealed environment with the set CO_2 concentration acting as the reference value for FRC. Or

b) Keeping SCD30 away from CO_2 sources and drains like humans, open windows, and ventilation slots. A calibrated reference in close proximity to the SCD30 gives the reference value for FRC[1].

Operate the SCD30 in the completely assembled end user device in either one of the two above described environments. The measurement period needs to be the same as that used in the end user application. After 2 minutes settling time execute FRC via the digital interface[2].

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[1] Contact your local Sensirion sales representative for a recommended reference device.

[2] See interface description for more details.

Applying FRC at End User

At the end user, a CO_2 reference as described above is usually not available. In that case, fresh air from the outside can be used as a reference. Outside air typically has a CO_2 concentration of 400 ppm. This can be used to apply FRC at end user as follows:

Offer an interactive calibration procedure via the firmware of the end user device for the following steps:

a) The end user has to expose the device to outside air, e.g. by placing it close to an open window or outside. Direct sun light, extreme temperatures, and strong air flow have to be prevented.

b) The user has to confirm the stability of ambient conditions via the user interface, upon which the SCD30 will be operated. The operation mode has to be the same as in normal end user operation mode.

c) After 2 minutes, apply FRC with the reference value 400 ppm via the digital interface.

d) Confirm to end user that calibration procedure is completed.

Applying FRC via Sensirion SEK Evaluation Kit

For testing purposes, the FRC feature can be executed by using the Sensirion SEK EvalKit by going through the following procedure:

a) Connect the SCD30 to the SEK EvalKit and start the ControlCenter software.

b) Open the Setting dialog box of SCD30:
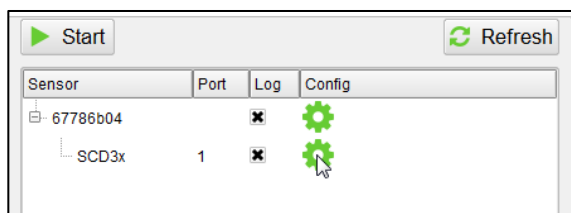
c) Input the reference value in FRC panel:
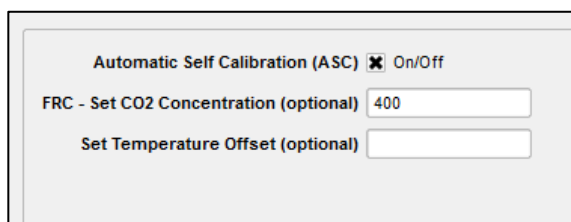
d) Hit OK and confirm FRC implementation.

ASC Field-Calibration Algorithm

The automatic self-calibration (ASC) algorithm autonomously generates a reference value by analyzing the measured CO_2 concentration over a period of time. This reference value is in turn employed for updating of the calibration curve. ASC can be activated and deactivated either via the digital interface or the ControlCenter software for the Sensirion SEK EvalKit. ASC is an optional feature and is deactivated by default. Both the activation status and the latest reference value are saved in an on-board non-volatile memory.

The correct application of ASC requires the SCD30 to be regularly exposed to air with CO_2 concentration = 400 ppm, as is the case in well ventilated buildings over night without human presence. SCD30 needs to be operated in continuous measurement mode, powering down the sensor will delay identification of a new reference value. The reference value will be overwritten either with a new reference value externally supplied via FRC or internally supplied from the ASC (see Figure 1).

ASC working principle

ASC assumes that the lowest CO_2 concentration the SCD30 is exposed to corresponds to 400 ppm. The sensor estimates the most likely reading corresponding to this background level and identifies this as 400ppm. Using this reference value, the very same manipulation is triggered when applying FRC with the reference value of 400 ppm. Generating a reference value not corresponding to 400 ppm induces an erroneous update of the calibration and reduces sensor accuracy. To prevent a faulty self-calibration, ASC employs an internal self-consistency check:

The algorithm will store the seven most recent concentration minima in volatile memory. Recalibration by the ASC algorithm will only be triggered when those seven successive minima of measured CO_2 concentration are within ± 50 ppm. Also, minima need to be separated by at least 18 hours. If the seven successive minima span a range larger than ± 50 ppm, the ASC will not update the calibration. The buffer storing the minima has a depth of seven measurements, the most recent found minima will always replace the oldest minima (first-in first-out). Please find below an example demonstrating ASC application.

Switching ASC on and off at End User

Activate ASC feature via the digital interface[2] before delivery of the end user device.

### Applying ASC via Sensirion SEK Evaluation Kit

For testing purposes, the ASC feature can be switched on and off via the Sensirion SEK EvalKit by going through the following procedure:

Connect the SCD30 to the SEK EvalKit and start the ControlCenter software.

a) Open the Setting dialog box of SCD30

b) Toggle the ASC setting.

c) Hit OK.

Note that the sensor needs to be operated for typical 7 days so that ASC can be applied.
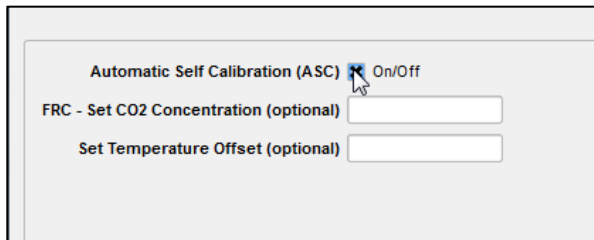
Example: Applying FRC Procedure on Field-Data.

Figure 2 shows the effect of FRC on a sample set of SCD30. Eight sensors were exposed to mechanical stress by handling, shock, and drop testing. The resulting spread in outputs (deviation from a calibrated reference) can be seen in Figure 2 (left) over the range 400 ppm to 10000 ppm. Although most sensors show only minor deviations, two sensors cannot fulfill the specs (dashed lines). Figure 2 (right) shows the accuracy of the same sensors after implementation of FRC in a 400 ppm environment (reference value = 400 ppm). Note that all sensors were in spec over the entire concentration range after re-calibration with a single reference value. ASC will result in the same accuracy given the conditions and assumptions for ASC are fulfilled.
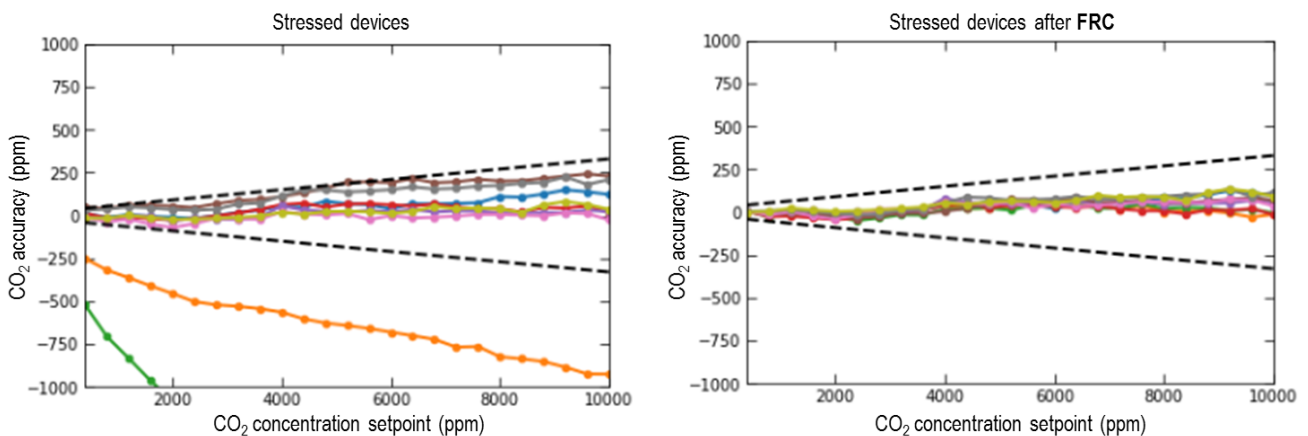

Figure 2 (left): Accuracy of CO_2 concentration measurements at different setpoints for 8 stressed SCD30 sensors. (right): Accuracy from same sensors after applying FRC. Application of FRC restores full accuracy over the whole measurement range.

Example: Applying ASC algorithm on field-data.

Figure 3 shows recorded CO2 concentration data from a stressed SCD30 in a typical office environment over a period of 31 days (blue line). The orange line corresponds to the same data when ASC algorithm is activated. Note that the ASC algorithm here was applied via post-processing. The red dots correspond to the measured minima in the CO_2 concentration.

After collecting seven minima that are mutually separated by at least 18 hours, the self-consistency check verifies that the measured minima lie within a range of ± 50 ppm. After verification, the reference value is determined from the stored minima and used for updating the calibration-offset. This results in a sharp rise of the orange curve, setting the recalibrated values to 400 ppm after the 7th minimum. The green line corresponds to a calibrated reference. It can be seen that readings of the reference and ASC-calibrated readings of the SCD30 show high consistency (within the range < ± 10 ppm). Note that an SCD30 with ASC activated will output the orange line only.
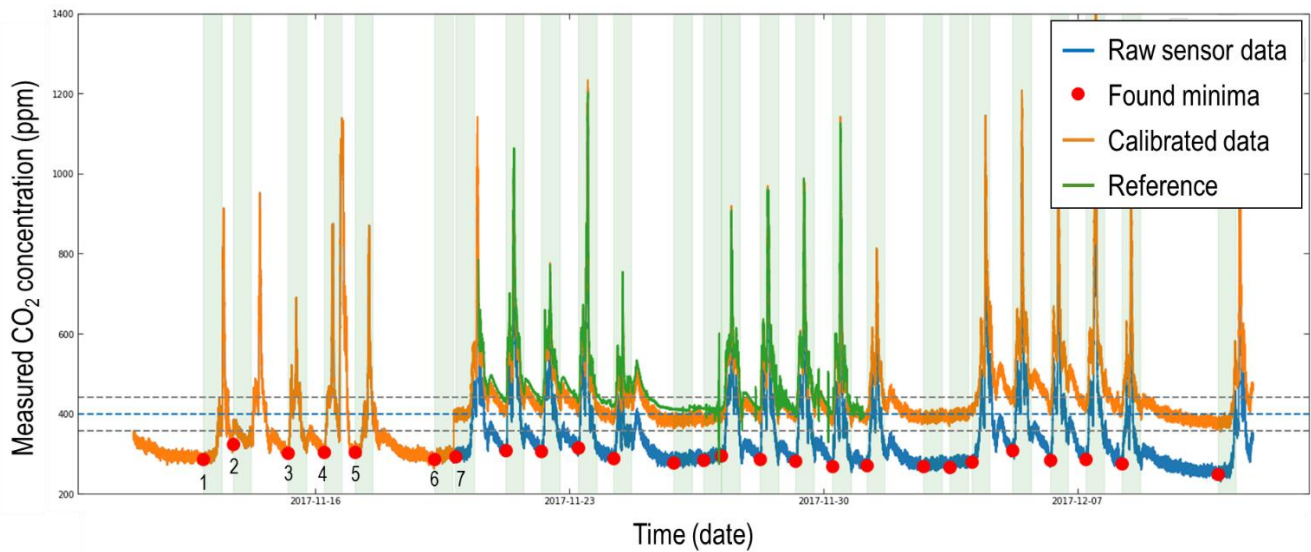

Figure 3: Illustration of ASC calibration algorithm applied to field data. The blue line corresponds to raw sensor data (ASC deactivated), the orange line to the same data with ASC applied. Red dots identify the found minima and green line corresponds to a calibrated reference sensor.

Revision History

Date	Version	Page(s)	Changes
April 2018	0.1	all	Initial version

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