Cambridge CMOS Sensors

is now

Member of the ams Group

The technical content of this Cambridge CMOS Sensors (CCS) document is still valid.

Contact information:

Headquarters:
ams AG
Tobelbader Strasse 30
8141 Premstaetten, Austria
Tel: +43 (0) 3136 500 0
e-Mail: ams_sales@ams.com

Please visit our website at www.ams.com

CCS811 Clean Air Baseline Save and Restore

Introduction

This application note details this CCS811 Clean Air Baseline save and restore functionality.

The resistance of Metal Oxide (MOX) gas sensors will change in in the presence of target gases such as Volatile Organic Compounds (VOCs). Therefore, in order to determine the level of gas present, the resistance of the sensor must be known when the gas is not present i.e. Resistance in air (Ra), also referred to as the baseline resistance.

Typically algorithms used to determine the presence of a gas are restarted at each power-up so have no previous knowledge of Ra, so if the sensor starts-up in the presence of gas there will be no observed resistance change.

A mechanism has been added to CCS811 to allow a baseline to be saved, when it is known that the sensor has been in a 'clean air' environment. This baseline can then be loaded at a later time to be used by the algorithms to determine the gas presence in polluted air.

When a MOX sensor is turned on the resistance increases (the 'warm-up' period) to a stable maximum and the baseline automatically tracks this maximum resistance. The resistance is highest when there is no gas present if all other conditions are the same; MOX sensors can also be affected by changes in temperature and humidity. This baseline is stored internally and used in calculations to determine the presence of gas.

Over time the baseline of a MOX sensor slowly changes, so internal algorithms are used to track this 'drift' to maintain a good baseline reference. Due to this long-term drift there is not a single baseline that can be stored and used for the whole life of the product. If a MOX sensor is often in an environment with no VOCs there may be no need to save and restore the baseline as this provides a regular update of the baseline.

The CCS811 has no way of retaining the baseline value internally in NVM so this needs to be saved externally by the host system, accessing the relevant registers via the I^2C interface.

Features

- Read the current baseline at any time
- Write a new baseline at any time
- Reset the baseline at any time
- Operates on I^2C digital interface

Benefits

- Start the sensor in a polluted room and get a meaningful reading
- Faster time to useful results
- Flexible sensor applications

Applications

- Stationary indoor sensor deployments
- Starting sensor in polluted room

Overview

The baseline "save and restore" feature is typically used is to save the baseline before turning off the sensor and then restoring it at the start of the next session, after the warm-up period. The baseline needs to be saved from each individual sensor, on the host system, for each mode that the CCS811 will operate in the application. The feature needs to be implemented in a particular sequence to be effective. The operation sequence diagram is shown below in ***Figure 1***

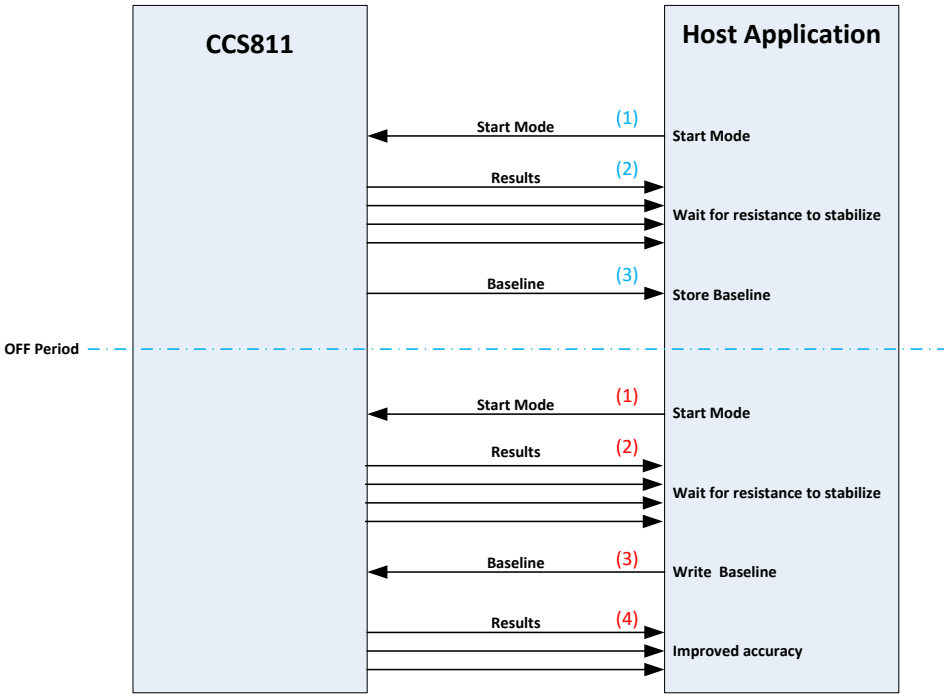


Figure 1: CCS811 Baseline save and restore feature

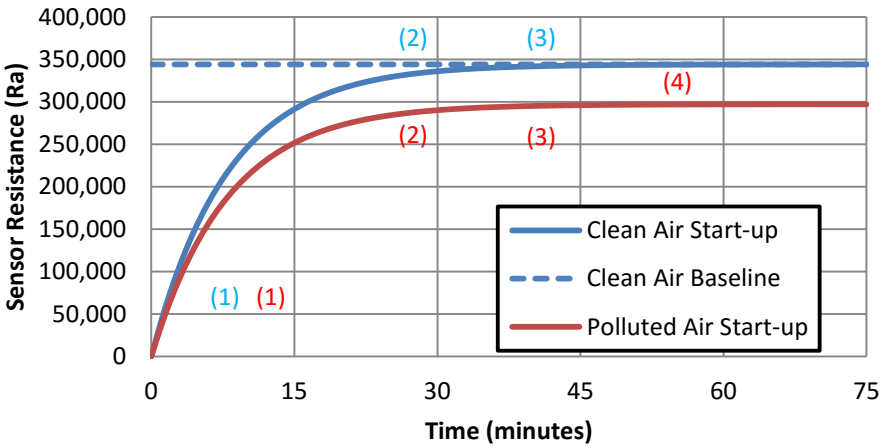


Figure 2: MOX sensor typical warm-up profile

When to Save the Baseline

- CCS811 constantly monitors what it believes to be the clean air baseline. Saving the baseline at any time will preserve the value that the CCS811 algorithms currently calculate to be the best.

- At start-up the resistance follows a 'warm-up' profile and a new baseline should not be saved until the (raw) resistance is stable (either monitor the resistance or wait for the recommended warm-up period). The CCS811 tracks the baseline over days to determine the best current value. If the CCS811 is only run for short intervals (under 24 hours) this mechanism cannot update a restored baseline, so more user/system intervention is recommended.

- Restarting CCS811 will reset the internal baseline to the current environment. If the current environment is known to be 'clean' a restart (or re-write the same mode for continuous operation) will set the baseline in this 'clean' environment and it can then be saved.

- Due to the slow drift that MOX sensors exhibit, the saved baseline will not match the current best baseline if it has not been updated for many days.
    - In the early life of the sensor (up to 500 hours' operation) it is recommended to save a new baseline every 24 - 48 hours.
    - After 500 hours' operation it is recommended to save a new baseline every 5-7 days

- If multiple CCS811 IAQ operating modes are used, the baseline should be stored for each mode (when sensor resistance is stable)

When to Restore the Baseline

- At start-up the resistance follows a 'warm-up' profile and the baseline should not be restored until the resistance is stable. If a baseline is restored before the resistance is stable CCS811 will calculate the gas presence to be too high for a period of time.

- If the CCS811 is switched from low power mode (3) to continuous operation mode (1) without approximately 10minutes 'Idle' (mode 0) period the sensor resistance will also need to settle and then the baseline can be restored.

- The internal baseline takes into account the ENV_DATA that is written to the CCS811. There can be a delay between the environment changing and the system updating the ENV_DATA registers, which can result in a false baseline (especially in conditions where the environment changes quickly, such as moving from indoors to outdoors). In this case, restoring the most recent saved stable baseline will provide the best correction.

I2C Protocol

The register address for the save and restore functionality is address 0x11. The host should read 2 bytes from this register address to get the current baseline to save, or write 2 bytes containing a previously stored baseline for restoring.
The byte order must be preserved.

The Baseline value is not simply a resistance value as it includes some additional factors used by the internal algorithms. It is not in a readable format and should not be modified.

Standard Use Case Example

The save and restore functionality only improves the accuracy of sensors that might start up in a polluted environment and only if a baseline for this particular sensor, in this mode, has been saved before.

Many stationary sensor deployments will see clean air during a 24 hour period and will not need the baseline saving and restoring to improve sensor accuracy. Please note the only down side of not using baseline save and restore in this situation is on the first day the air quality reading may not have the best baseline to calculate with; on the second day the calculated outputs will have a higher absolute accuracy.

To test the air quality of a room start the sensor in the room and once the sensor has stabilised write the previously stored baseline to get the result.

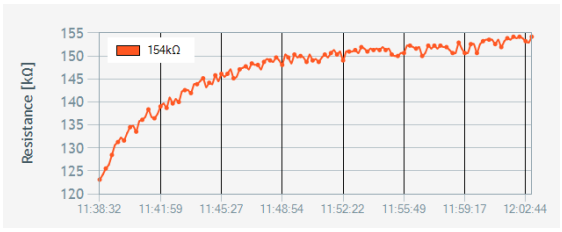
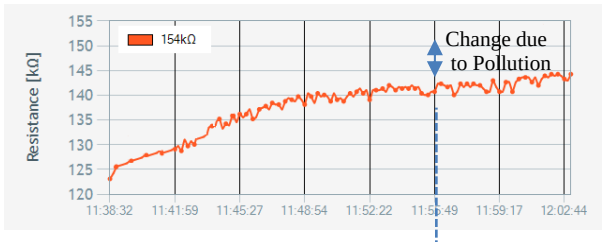
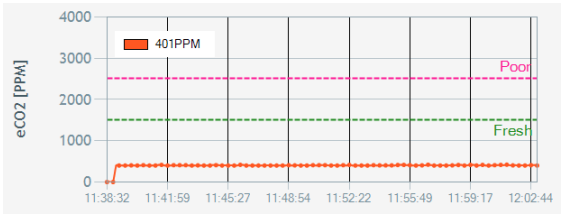
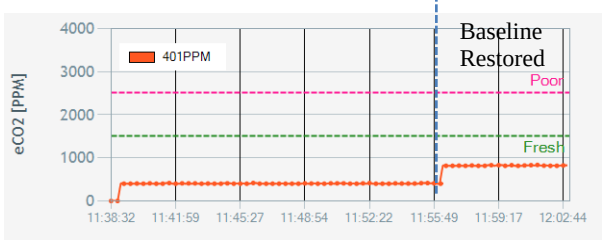
Initial Warm Up	Start Up in Polluted Environment
Wait for the sensor to warm up. Save baseline before device switches off.	Write previously stored baseline to CCS811 once the resistance stabilises. The increase in eCO_2 or TVOC number should be immediately visible.
	
	

Figure 3: CCS811 Baseline save and restore standard operation

Issues to Avoid

- Do not use one baseline setting for all CCS811 devices. The baseline needs to be stored on an individual device by device basis.
- Do not use the first baseline you have read for the lifetime of the sensor. The baseline will move during the lifetime of the sensor. Periodically re-read the sensor baseline e.g. every 24 hours.
- Do not save or restore the baseline while the sensor is still in the process of warming up. The best user experience would be to allow the sensor to stabilise before the baseline is written to avoid initial readings being falsely high. The operation sequence diagram is shown below in ***Figure 4***
- Do NOT just use the baseline save and restore functionality if the sensor is not being regularly used for long term deployments of longer than 48 hours. This is critical to allow the baseline tracking algorithm to work.
    - In this case more user intervention is required to find a good baseline; restart the CCS811 (or re-write the same mode for continuous operation) when you know the environment is clean and the resistance has settled. This can then be saved as a good baseline and restored later, but the value may become invalid over time.

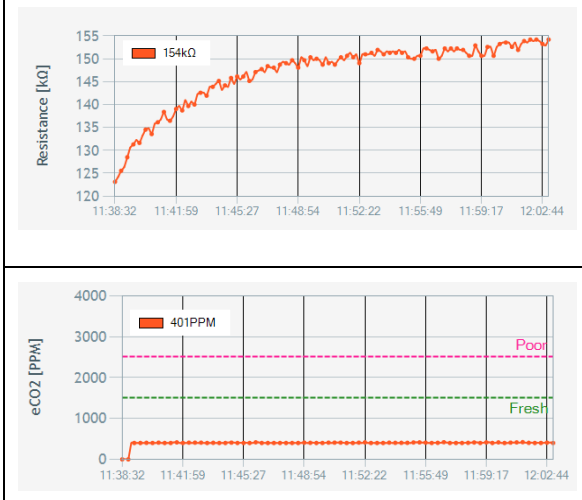
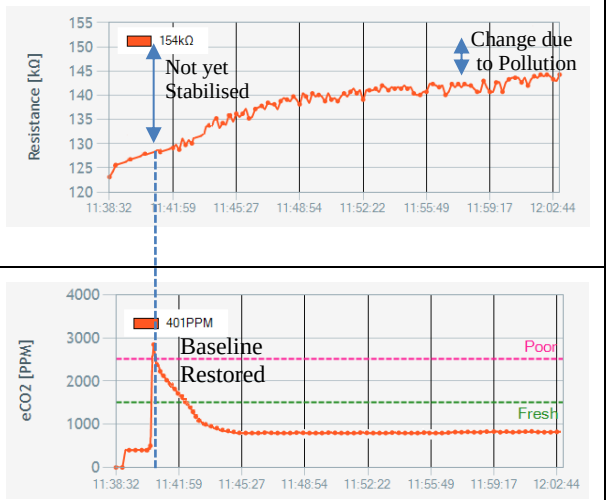
Initial Warm Up	**Saved baseline written early**
Wait for the sensor to warm up. Save baseline before device switches off.	Baseline written before the resistance has stabilised. The eCO_2 spike is due to the baseline resistance being so much higher than the current value.
	

Figure 4: CCS811 Baseline save and restored before sensor warm up finished

Abbreviations

Abbreviation	Description
ADC	Analogue To Digital Converter
CCS	Cambridge CMOS Sensors
CMOS	Complementary Metal Oxide Semiconductor
eCO_2	Equivalent Carbon Dioxide
I^2C	Inter-Integrated Circuit
NVM	Non-Volatile Memory
TVOC	Total Volatile Organic Compound

References

Document Reference	Description
CC-000619-DS	Datasheet for CCS811
CC-000774-AN	Assembly guidelines for CCS811
CC-000783-AN	Mechanical considerations for CCS811
CC-000803-AN	CCS811 Programming and Interfacing Guide

