Application Note

CCS811

Design guidelines

Content Guide

1   Introduction

This application note describes the design guidelines in terms of electronic design, mechanical and thermal considerations for CCS811.

CCS811 is an ultra-low power digital gas sensor solution which integrates a metal oxide (MOX) gas sensor to detect a wide range of Volatile Organic Compounds (VOCs) for indoor air quality monitoring with a microcontroller unit (MCU), which includes an Analog-to-Digital converter (ADC), and an I²C interface.

The integrated MCU manages the sensor drive modes and raw sensor data measured while detecting VOCs. The I²C digital interface significantly simplifies the hardware and software design, enabling a faster time to market.

CCS811 supports intelligent algorithms to process raw sensor measurements to output a TVOC value or equivalent CO2 (eCO$_2$) levels, where the main cause of VOCs is from humans. CCS811 supports multiple measurement modes that have been optimised for low-power consumption during an active sensor measurement and idle mode extending battery life in portable applications.

2 Electronic Design Considerations

The recommended application circuit for CCS811 is shown in Figure 1.

Figure 1: Recommended application circuit for CCS811
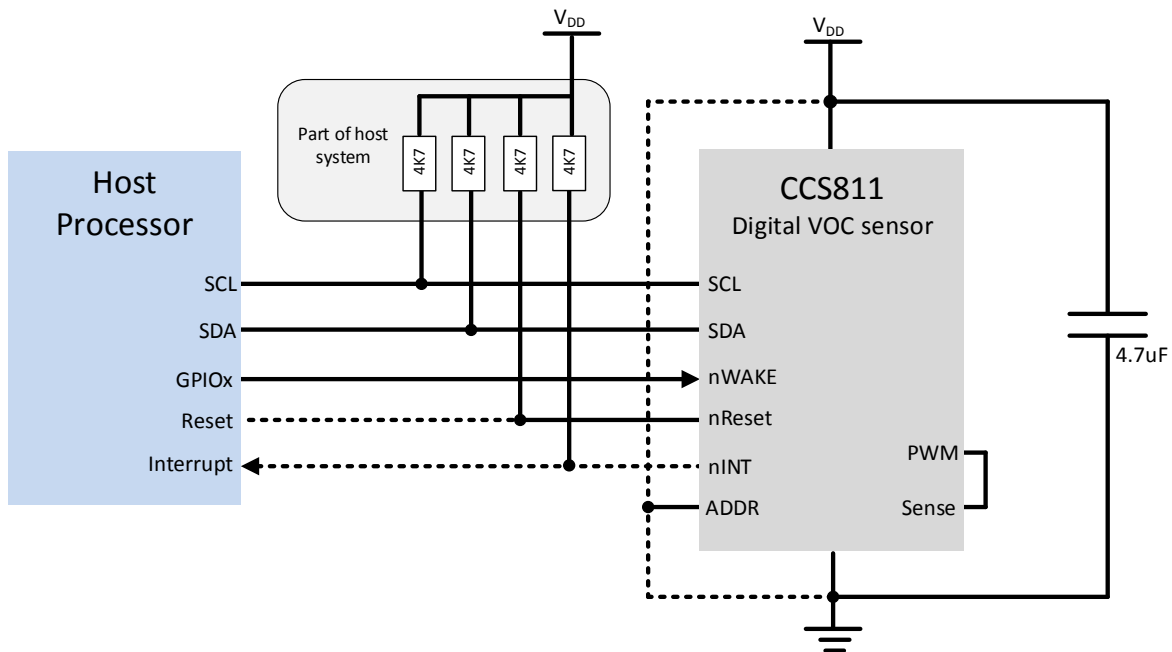
Note(s):

1. The PWM (Pin 4) and Sense (Pin 5) signals on CCS811 must be connected together

2. A decoupling capacitor must be placed close to the supply pin V_{DD} on the CCS811

3. Pull-up resistors are require for I^2C signals SCL and SDA

4. If power is not an issue, nWAKE can be connected to ground if a spare GPIO is not available on the host processor

5. ADDR must be connected to either V_{DD} (logic 1) or ground (logic 0) depending on the required lsb of the CCS811 I²C slave address.

3 Mechanical and Thermal Considerations

3.1 Sensor placement and ambient exchange

The CCS811 gas sensor LGA package has been designed to expose the sensing element to the air within the package cavity. Exchange of air takes place via the package opening(s) so the environmental air, outside the enclosure, needs to reach the package. Therefore, an exchange of air within the enclosure and the environment needs to take place. The response time of CCS811 depends on the efficiency of this exchange which creates some design considerations as follows:

1. The exchange is more efficient if a flow of air is permitted, therefore, inlet and outlet apertures are preferred
2. The air flow path should pass over the CCS811 gas sensor package opening(s)
3. Close proximity of the CCS811 gas sensor to the environment prevents any unnecessary delay
4. Aperture diameter to depth aspect ratios should ideally be 1:1 or greater
5. Any filter membranes should not unnecessarily impede the flow of air
6. Any materials used in the product construction should not adsorb or desorb gases of interest as this will impact the accuracy of the measurement
7. Any cavities formed around the CCS811 gas sensor should be as small as possible to reduce the "dead volume"
8. Existing apertures, for example, USB connectors, speakers, microphones etc. may be utilized for the purposes of exchange.

3.2 Relative Humidity and Temperature Compensation

The CCS811 sensor output will be impacted by environmental factors such as ambient temperature and relative humidity. Air quality results can be compensated for environmental changes by using a relative humidity and temperature sensor with high accuracy and a fast response time such as the ENS210. It is recommended that the ENS210 is placed in the same cavity as the gas sensor, CCS811. Please refer to AN000391 for ENS210 design guidelines.

Sensor data from ENS210 can be written to CCS811 by the host system and used to compensate for relative humidity and temperature changes. Please refer application note AN000369 for more information on the programming guide for CCS811.

3.3   Thermal Considerations

The CCS811 has a fixed power heater drive. This means if it is operated at higher or lower ambient temperatures this could have an impact on the heater temperature. This needs to be considered when designing a product is there can often be many heater sources on PCBs. In a smartphone for example there is the main application processor, connectivity devices, power management ICs and RF amplifiers etc. The CCS811 gas sensor is also a source of heat, all of these components together will cause local fluctuations in the ambient air temperature inside the product.

Therefore, best practice should be employed to provide thermal isolation around the CCS811 gas sensor which creates some design considerations as follows:

Thermal convection

- Baffles to separate other heat source components from the gas sensor should be built into the enclosure
- Similarly, suitable ventilation should be employed

Thermal radiation

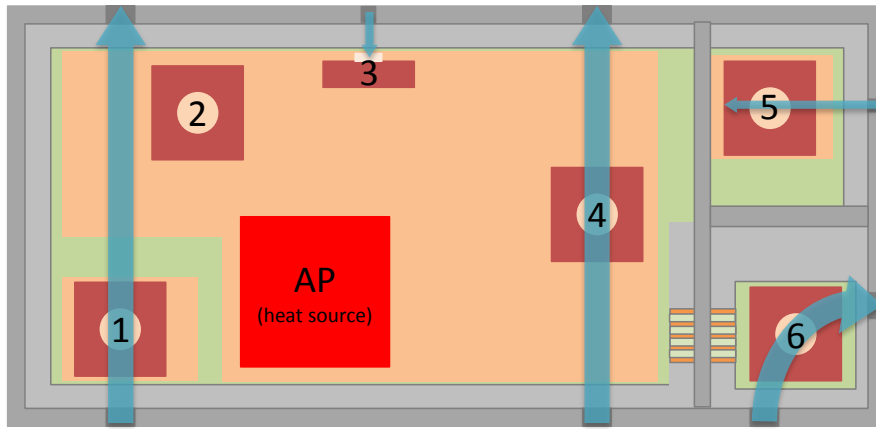- The sensor should be shielded from direct line of sight with radiant heat sources

Thermal conduction

- Maintain maximum possible layout separation between other component heat sources and CCS811 gas sensor
- Copper planes should contain discontinuities between other heat source components and the CCS811 gas sensor

Forced air cooling

- Provide baffles in the flow of air to slow the air before it reaches the sensor
- Offset the package opening(s) from the enclosure aperture to prevent direct cooling

3.4   Implementation Examples (for illustration purposes only)

Sensor ID	Mechanical		Thermal	
	Pros	**Cons**	**Pros**	**Cons**
1	• Large apertures • Sensor close to aperture • Sensor in air flow	• Large dead volume	• Discontinuous copper with heat source	• Close to heat source • Cavity shared with heat source
2	• Large apertures • Sensor close to aperture	• Sensor out of air flow • Large dead volume		• Continuous copper with heat source • Close to heat source • Cavity shared with heat source
3	• Aperture directly over the sensor • Sensor close to aperture	• Aperture over sensor will require filter membrane • Small aperture • Single aperture		• Continuous copper with heat source • Close to heat source • Cavity shared with heat source • Sensing element in direct air flow path
4	• Large apertures • Sensor in air flow	• Sensor far away from aperture • Large dead volume	• Far from heat source	• Continuous copper with heat source
5	• Sensor close to aperture • Small dead space	• Small aperture • Single aperture	• Discontinuous copper with heat source • Cavity separate to heat source	
6	• Large apertures • Sensor close to aperture • Sensor in air flow • Small dead volume		• Separate PCB to heat source • Cavity separate to heat source	•

4   Product assembly and materials

The product assembly and the materials used should be managed based on the criteria outlined in the CCS811 assembly guidelines, please refer to application note AN000367 for more information.

5   References

Document Reference	Description
CCS811_DS_000459	CCS811 Datasheet
CCS811_AN000367	CCS811 Assembly Guidelines application note
CCS811_AN000369	CCS811 Programming and Interfacing guide application note

6 Contact Information

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8   Revision Information

Changes from previous version to current revision 2-00 (2017-Sep-15)	Page
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Correction of typographical errors is not explicitly mentioned.