Mechanical Considerations for CCS811

Introduction

The CCS811 is an ultra-low power digital gas sensor solution which combines the CCS801 sensor with an 8-bit MCU (with integrated ADC) for Ethanol (Alcohol) and monitoring indoor air quality including Carbon Monoxide (CO) and a wide range of Volatile Organic Compounds (VOCs).

The CCS811 is assembled into a 2.7mm x 4mm, 10-lead, 0.6mm pitch cavity LGA package. The package consists of a substrate and a moulded lid which contains apertures to allow the unobstructed flow of ambient air through the package to ensure the MOX sensing element is exposed to the analyte gas.

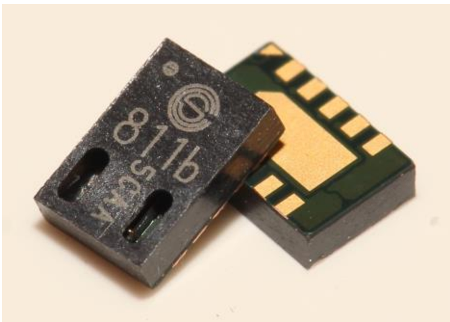


Figure 1 – 2.7mm x 4.0mm Cavity LGA package

The package outline and lead pitch make it ideal for high volume solder mount assembly onto low end PCB technology.

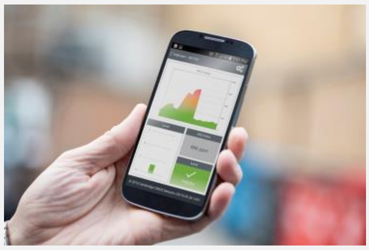
This application note offers guidance regarding mechanical and thermal considerations for using CCS811 during end product development.

Key Benefits

- Ultra-low power consumption for battery operated devices
- High sensitivity and fast heating times
- Small cavity provides reduced dead volume to enhance responsivity
- Exposed pad for mechanical stability and thermal grounding

Applications

- Total VOC sensor for Indoor air quality (IAQ) monitoring
- Alcohol breathalyser



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Mechanical Considerations

The CCS811 gas sensor LGA package has been designed to expose the sensing element to the air within the package cavity. In order to provide accurate measurements the full volume of gas within the package needs to be exchanged with the environmental air under analysis. For this reason, the package cavity is as small as practical to reduce the “dead volume”.

Exchange of air takes place via the package opening(s) so the environmental air, outside the product enclosure, needs to reach the package. Therefore, an exchange of air within the product enclosure and the environment needs to take place. The response time of the sensor is dependent on the efficiency of this exchange which creates some design considerations:

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) parallel to the top of the package
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.

Note: Ideal scenarios for fast response time may compromise accuracy, especially in the case of forced air flow analysis. For example, direct breathing onto the sensing element will exchange environment air quickly (fast response) but will cool the CCS811 gas sensor (poor accuracy). Therefore, the implementation(s) should be designed with the specific user cases in mind.

Ergonomic Considerations

For ambient air quality monitoring there are no ergonomic considerations except to consider how the smart phone may be carried whilst monitoring the environment. For example, aperture positioning should take into account that many users place their phones in protective cases or apply anti scratch films which may cover the aperture.

For exhaled air analysis the user will need to be able to comfortably blow into the aperture. In order to ensure accurate measurement a prolonged blow is necessary, for example, 5 seconds, so the user may want/need to be able to view the phone screen with a countdown timer and/or gas level information.

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Thermal Considerations

The end product may contain various heat sources, for example, 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.

Equally, in the case of exhaled air analysis, for the Alcohol Breathalyzer use case, the forced air flow will cool the CCS811 gas sensor as will the moisture contained within the breath. Therefore, best practice should be employed to provide thermal isolation around the CCS811 gas sensor.

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
- The exposed pad on CCS811 should be bonded to a suitable PCB copper plane to improve device cooling
- Where possible, the CCS811 gas sensor should be mounted on its own PCB/sub assembly or have slots routed in the PCB around the sensor to improve thermal isolation.

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
- If practical, provide a filter membrane to trap moisture and particulates

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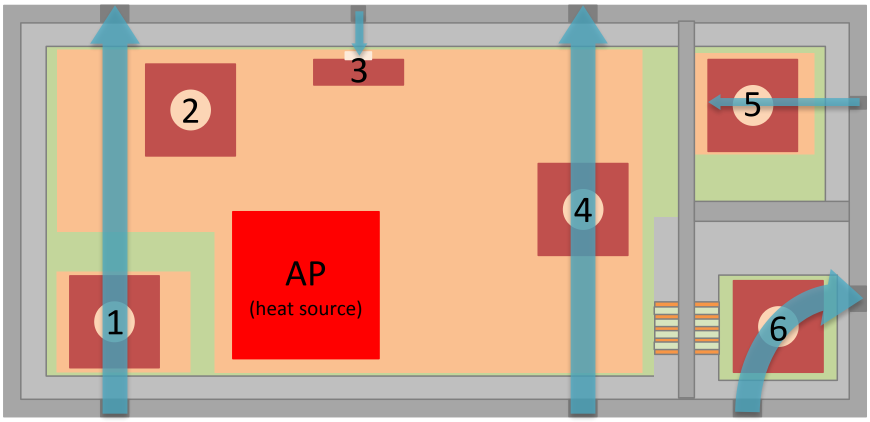
Implementation Examples (for illustration purposes)



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	

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Abbreviations

Abbreviation	Description
CMOS	Complementary Metal Oxide Semiconductor
LGA	Land Grid Array
MOX	Metal Oxide
PCB	Printed Circuit Board
RH	Relative Humidity
SMT	Surface Mount Technology

References

Reference	Description
CC-000619-DS	Datasheet for CCS811
CC-000774-AN	Assembly Guidelines for CCS811

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