Integrating DPS368 into water-resistant systems

About this document

Scope and purpose

This application note gives the reader guidance and recommendations on how to integrate the water protected barometric pressure sensor, DPS368, into water-resistant systems.

Intended audience

This document is addressed to anyone who is either involved in designing water-resistant consumer electronic devices like smartphones, smartwatches, etc., or involved in selecting water-resistant barometric pressure sensors for their product design.

Table of Contents

1 Introduction to DPS368

DPS368 is a water-resistant, consumer-grade, ultra-precise barometric pressure sensor. It is available in an 8-pin PG-VLGA-8 package with dimensions of 2.0 x 2.5 x 1.1 mm^3. The small package size makes the DPS368 ideal for use in mobile applications and wearable devices. The DPS368 pressure sensor has a capacitive MEMS die and an ASIC die, which are covered with a gel for protection against water, dust & humidity, as shown in Figure 1. The DPS368 device enclosure is defined by the gel and the package substrate.

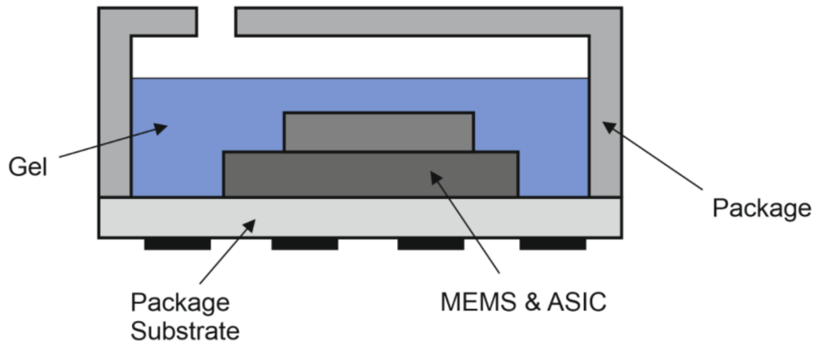

Figure 1 DPS368 package drawing

Please also refer to the datasheet for further details on the properties and characteristics of the water protected barometric pressure sensor DPS368.

1.1 Footprint and stencil recommendation

The PCB pad and stencil aperture recommendations for the DPS368 shown in Figure 2 are based on Solder Mask Defined (SMD) pads. The specific design rules of the PCB manufacturer should be considered for individual design optimization or adaptations.

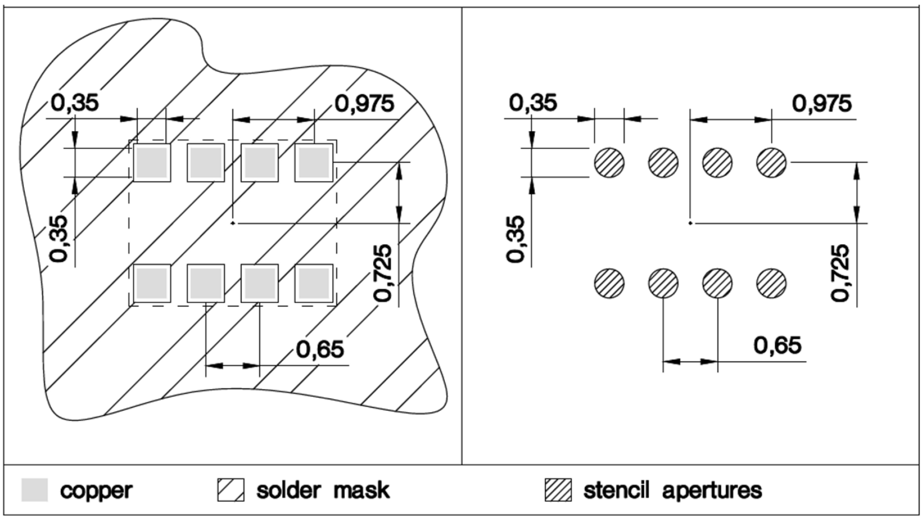

Figure 2 PCB pad and stencil aperture recommendations

2 Recommendations for system integration

Unlike other water-resistant pressure sensors available on the market, the DPS368 pressure sensor has a flat-top package and doesn't have a metallic groove on the top of the package for connection to O-rings directly. Hence the DPS368 sensor package is very small and requires alternative system integration measures. The following section covers recommendation on how to integrate the DPS368 into water-resistant systems. The shown examples are intended as general suggestions for typical scenarios. The actual implementation may vary from one use case to another based on additional integration constrains introduced by the system requirement.

2.1 O-ring sealing with underfill

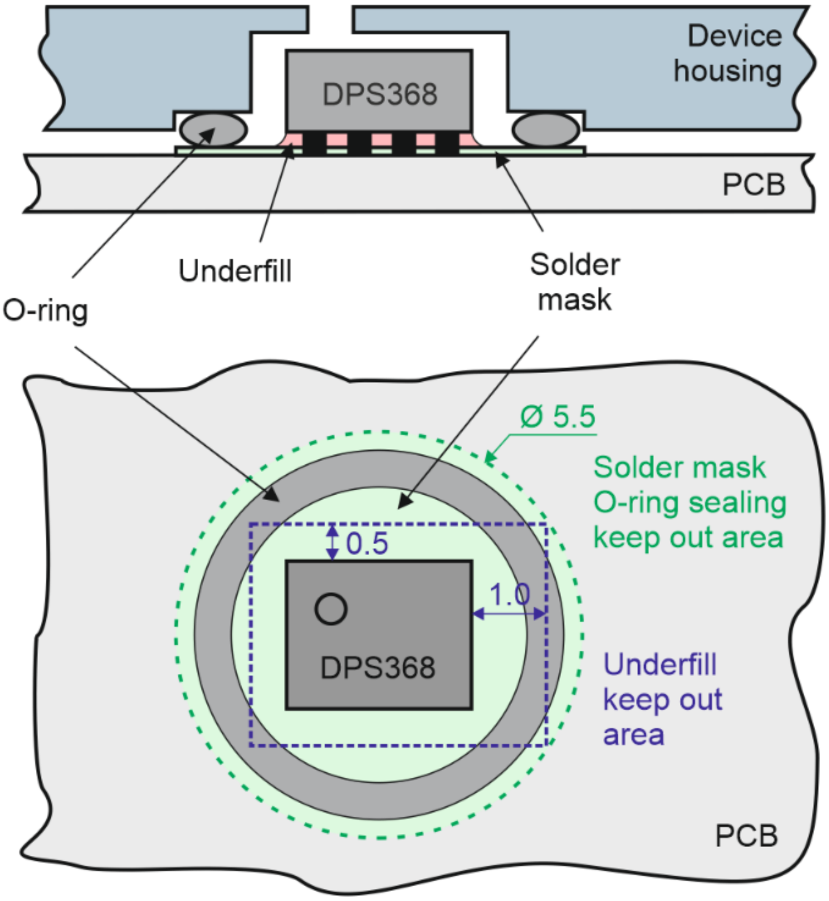

Figure 3 System Integration with O-ring sealing and underfill

Figure 3 shows an example of an O-ring based integration of the DPS368 pressure sensor. The sealing between device housing and PCB is established by a large O-ring encompassing DPS368. The shown O-ring dimensions (diameter = 4.5mm and thickness = 0.5mm) shall be seen as an example. Water tight sealing between O-ring and PCB requires an even layer of solder resist under the DPS368 and the O-ring. No additional device may be placed in the solder mask keep out area marked in green in Figure 3.

Sufficient mechanical force between PCB and device housing is required to ensure a tight sealing between PCB, O-ring and device.

Additional care needs to be taken to ensure water protection of the DPS solder bumps. One possible approach is based on an epoxy based liquid encapsulation technique called underfill. Typically, capillary underfills are provided in syringes (or cartridges) and consist of a formulated mixture of thermoset resins and fillers, see Figure 4.

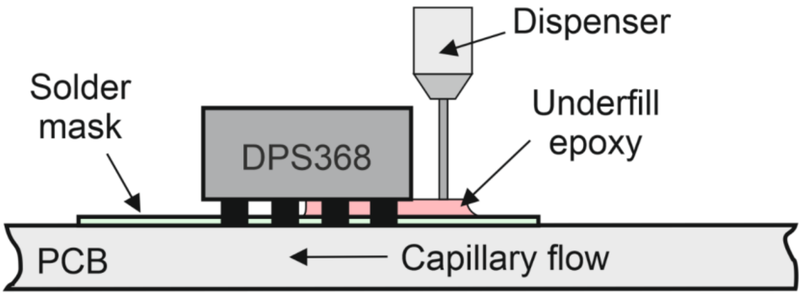

Figure 4 Underfill application

The resins and fillers are tailored to achieve the following properties:

- Good flow under the sensor IC
- Wetting of both the IC back side passivation and the solder mask
- Void-free filling and fillet formation to enable high package reliability
- Physical and mechanical properties such as CTE, glass transition temperature (Tg), modulus, and low moisture absorption

The solder bump height underneath the pressure sensor is an important aspect that influences the impact of the capillary underfill being used. The DPS368 data sheet recommends a minimum solder height of 50um. The 50um are primarily recommended to ensure sufficient mechanical stress decoupling. Slightly high gaps might also be used if required by the selected underfill material. As the bump (or solder ball) height decreases, the smooth flow of the underfill becomes challenging. Traditional filler sizes may be too large for the small dimensions of DPS368. In order to keep the rheology tailored, low viscosity resins should be used. Liquid epoxies are the most common types of thermoset monomers used. There are several options to choose from. One example is 'Bisphenol F' epoxy, a liquid used as a low viscosity resin carrier.

Note, the shown sealing approach relies on the water resistant properties of the solder mask. Care should be taken during the selection of the right solder mask material. Some materials might absorb too much water and swell as a consequence.

2.2 Conformal coating on PCB

An alternative approach to underfill is the conformal coating of the entire PCB board. Water-proof PCB coatings can be used in conjunction with the O-ring sealing as shown in Figure 5.

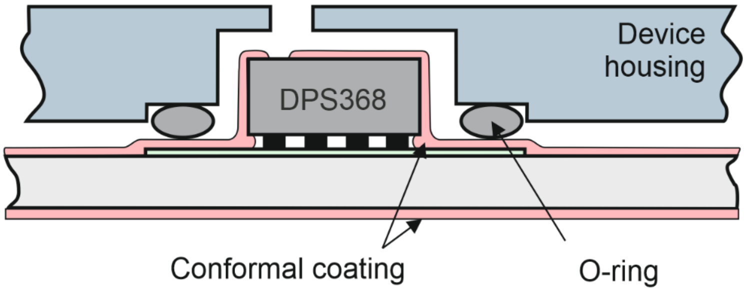

Figure 5 System Integration with O-ring sealing and conformal PCB coating

In some uses cases, exposure of the entire PCB might be acceptable. In such cases an O-ring sealing can be omitted as seen in Figure 6.

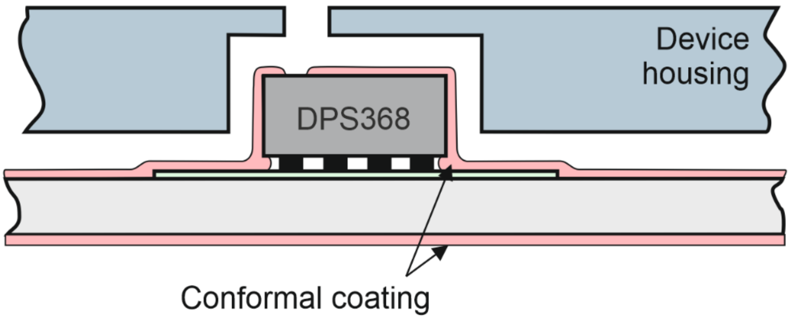

Figure 6 System Integration with conformal PCB coating

The thickness of the coating layer should not exceed 300nm, if the coating is applied over the DPS368 itself as shown in Figure 5 and Figure 6. Thicker coating layers require additional protection of the DPS368 sensor port hole in order to prevent a degradation of the sensor performance. A recommended approach involves sensor port protection with Kapton tape prior to coating. The Kapton tape is removed after the coating has dried out.

2.3 Adhesive Gel based sealing

An alternative to the O-ring based sealing relies entirely on adhesive and water-resistant gel as see Figure 7.

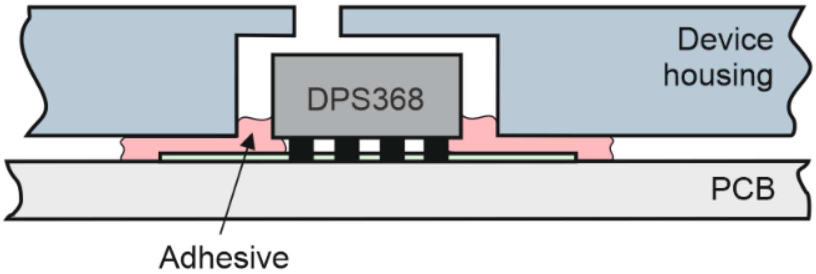

Figure 7 System Integration using adhesive gel

An adhesive gel is be applied on the PCB around the DPS368 sensor prior to device assembly. The adhesive gel acts at the same time as a glue between PCB and device housing as well as a protection of the DPS368 solder bumps. Semicosil 924 is just one example of many other silicon based adhesive gels which might be considered.

2.4 General rules for system integration

The different system integration examples shown in this section can be used as a starting point on how the system can be built around DPS368 in a water-resistant manner. There will be specific challenges involved in each application system and the final design may vary from case to case. However, there are some general rules to keep in mind:

- No mechanical stress should be exerted on the DPS368 package directly. If an O-ring is required for device sealing, it has to be mounted on the PCB surrounding the sensor and not on the sensor itself.
- Protection of the DPS368 solder bumps is required in order to prevent electrical shortage. Recommended measures such as underfill, conformal coating or gel based protection are described in the chapters above.
- Certain applications or environments might require an additional barometric mesh to protect the port hole from being blocked by large particles.
- For a simple water splash protection an additional hydrophobic coating layer might be considered on the device level.

3 Example for system integration

In Figure 8 you can see the integration of DPS368 for an evaluation boards. This board was specifically designed to conduct water-resistant tests efficiently while keeping the sensor powered up and in normal operation mode. The setup can handle water pressure up to 5 bar.

Figure 8 Water-resistant evaluation board

This setup allows water to enter the evaluation board through a tubing adapter. This also enables the measurements to be collected from the sensor while the test is running. The DPS368 sensor pin connections on this PCB are shown in 9 below. The water-resistant sealing in this board is done using O-ring surrounding the sensor, similar to the recommendation shared in Section 2.1.

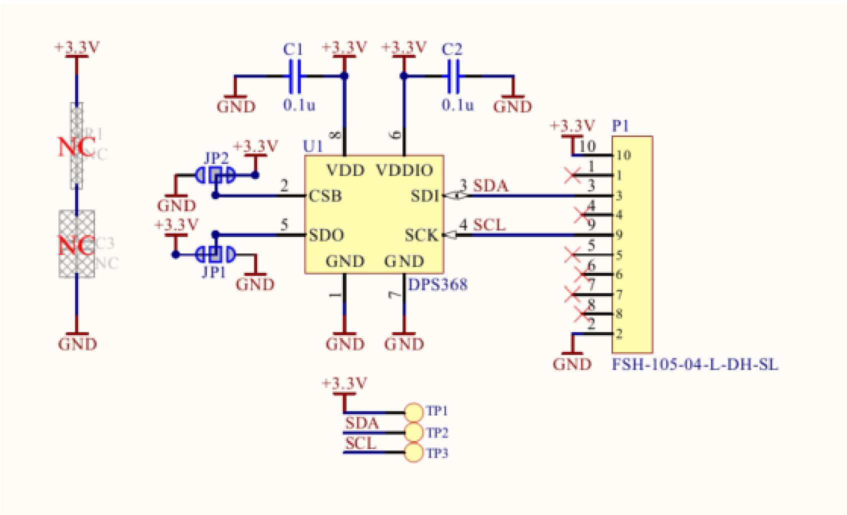

Figure 9 Figure 9. Water-resistant evaluation board schematic

Revision History

Major changes since the last revision

Page or Reference	Description of change

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