ICP-10125 Waterproof Pressure Sensor Integration Guidelines

PURPOSE AND SCOPE

The application note provides a general guideline for the hardware integration of ICP-10125, a waterproof pressure sensor, into a final customer application system. It elaborates more on hardware and electrical specifications along with the mechanical hardware used for the design of a subsystem that can improve performance.

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INTRODUCTION

The ICP-10125 pressure sensor is based on MEMS capacitive technology, which provides ultra-low noise at low power. The pressure sensor can measure pressure differences with an accuracy of 1 Pa. This device only consumes 1 µA at the frequency of 1 Hz. It comes in the 3.55 mm x 3.55 mm x 1.45 mm package with waterproofing gel providing IPx8 waterproofing to 10ATM. It has an operating range of 30 to 110 KPa for pressure sensing and is ideal for wearable fitness monitoring and battery powered IoT applications.

The combination of high accuracy, low power, temperature stability, and waterproofing in a small footprint enables higher performance barometric pressure sensing for sports activity identification and mobile indoor/outdoor navigation. The pressure sensor has an embedded temperature sensor and 400 kHz I2C bus for communication with the MCU for processing data.

SENSOR-SYSTEM SETUP

Many devices such as smartphones and sports watches can use the ICP-10125 pressure and temperature sensor without compromising on reliability and performance. The ICP-10125 sensor can be integrated into various systems by avoiding mechanical and physical parameters that may influence the performance. Figure 1 and Figure 2 show examples of standard integration of the pressure sensor with and without the membrane, which is used to add extra insulation and water resistance. The sensor is not in direct contact with the environment when the membrane is added. Without the membrane, sensor would be prone to collect dust, water, and other debris from the environment, which could cause potential failure.

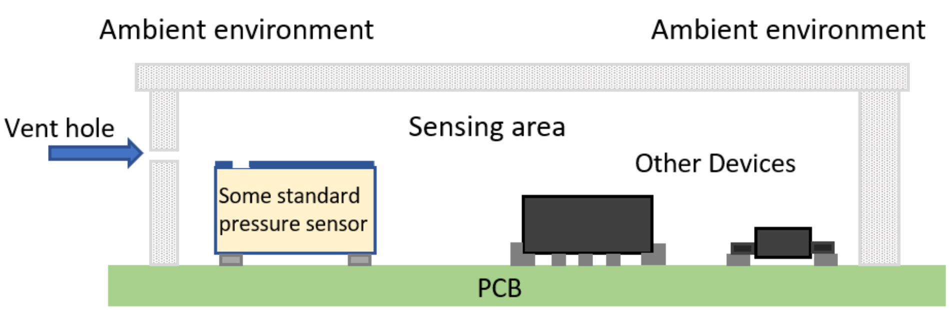

Figure 1. Standard Pressure Sensor Integration

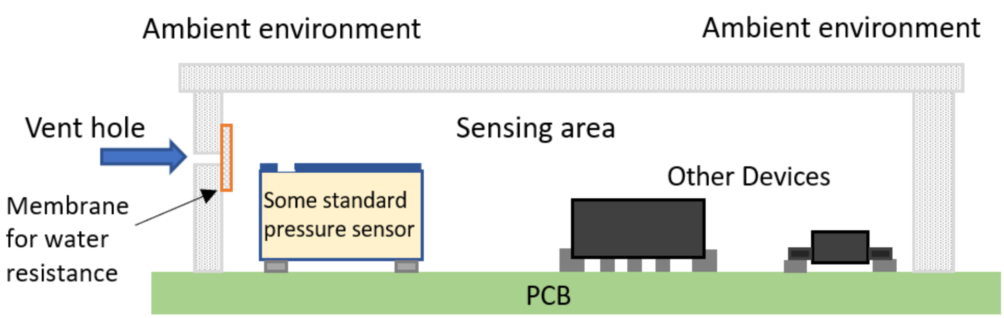

Figure 2. Standard Pressure Sensor Integration with Membrane

The ICP-10125 is a waterproof sensor with a chimney-style package filled with waterproofing gel. The integration of this sensor could allow direct exposure to ambient environment and water without a protective membrane. But sealing the sensor inside the housing through an O-ring is required to protect other electronics from the ambient environment as this sensor can recover from the stress caused by water pressure without damage but other devices in the system might not be able to. The housing around the ICP-10125 should also be designed to maximize the exposure of pressure stress caused by the water and temperature up to the required depth of water.

Figure 3 shows housing where the sensor is placed in a way to get the best exposure to the environment. The vent area is kept large, but the appropriate size should be selected to avoid any mechanical interaction with the sensor. The sensor is placed close to the vent hole. The vent apertures have less depth. This type of setup enhances the performance of the sensor.

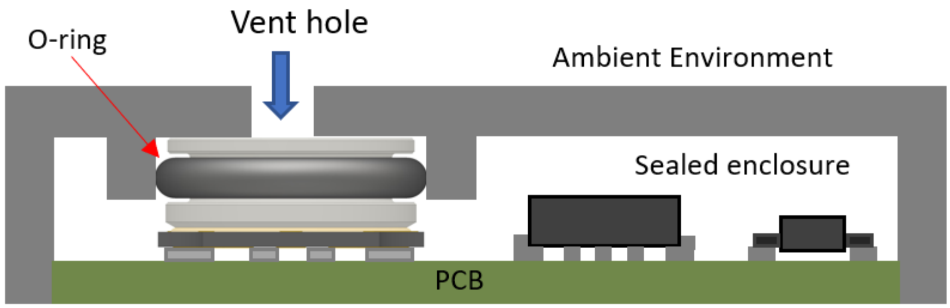

Figure 3. ICP-10125 Sensor Integration and Housing Reference

If the product is designed to sustain harsh environments, extra filter protection can be added to insulate the sensor from dust, debris, or chemical exposure. The gel is very inert and will not be affected from exposure to most chemicals, using a filter would enhance the reliability and life of the product. The choice of filter is critical, as some filter membranes may affect the response of the sensor.

IMPORTANT FACTORS FOR SENSOR SYSTEM DESIGN

Key factors for the sensor system design includes the following:

1. Placement of the sensor on circuit board
2. O-ring selection
3. Mechanical stress
4. Circuit board stress
5. Sensor Handling during PCB Assembly

SENSOR PLACEMENT:

Placement of the sensor on a circuit board with other devices around it can have a direct impact on its performance. A heat generating device can cause thermal stress to the sensor. This stress can cause sensor output to change without change in the pressure and temperature of the environment. Thermal gradients can be caused by heat generating devices such as MOSFETS, power management devices, video cards, etc. through conduction or convection processes. Placement of these devices should be avoided in close proximity to the sensor or insulation techniques must be adapted as shown below:

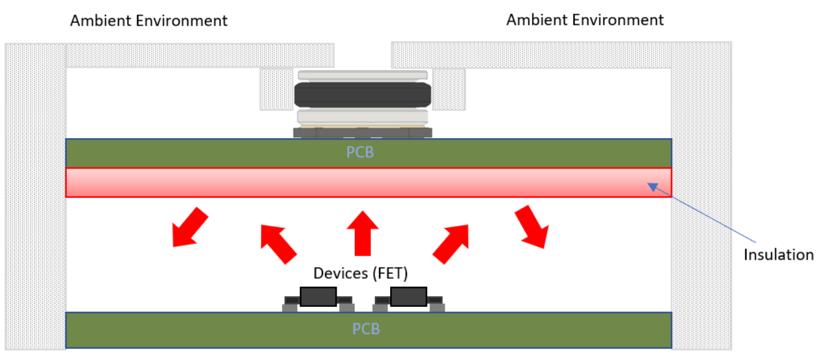

Figure 4. Thermal insulation

Placing heat generating devices far away from sensor and adding a thermal insulator on the PCB is recommended to avoid thermal gradients from reaching the pressure sensor.

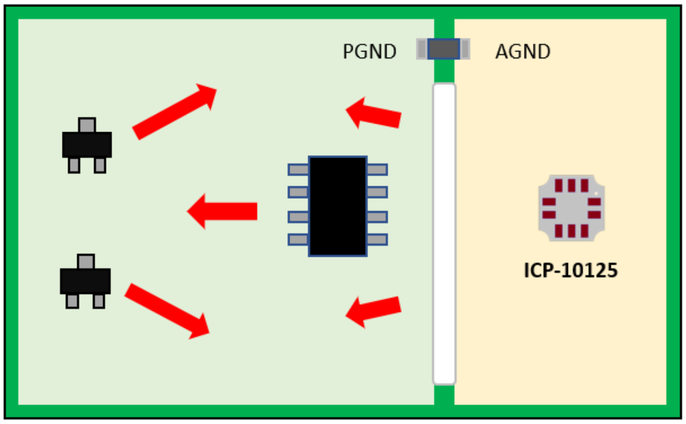

Figure 5. PCB Slot and GND Plane Isolation

Create physical slots on the circuit board to isolate sensor from heat generating devices and use separate GND planes for thermal isolation.

Also avoid placing components which can cause shock or vibration to the ICP-10125 pressure sensor. Since the ICP-10125 is MEMS based, a vibration from another component could deteriorate the performance of the pressure sensor.

O-RING:

An O-ring will be required around the pressure sensor to create a waterproof design and to protect other devices in the system. This could also eliminate the need to have a water-resistant membrane as shown in Figure 2. The O-ring is placed at the groove location as shown in Figure 6.

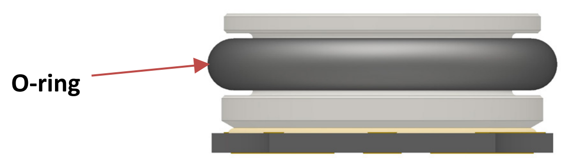

Figure 6. O-ring Installed on the Sensor

1. O-ring has dimensions of 2.5 mm X 0.5 mm. Figure 6 shows an overview of the O-ring. The O-ring thickness is sized in order to fit housing and to apply a sealing force for resisting to 10 bar fluidic pressure according to device specification. Nitrile / NBR is the most common material used for making the O-rings. It is widely used in many applications for fuel and oil resistant system designs. Nitrile compounds are superior to most elastomers because they provide tear, and abrasion resistance. Customer can also choose other material based on their application and housing size. Care should be taken to avoid damage to the O-ring during mounting. Lubrication may be considered if necessary, to facilitate insertion. Below, figure 7, shows the O-ring and sensor body dimensions.

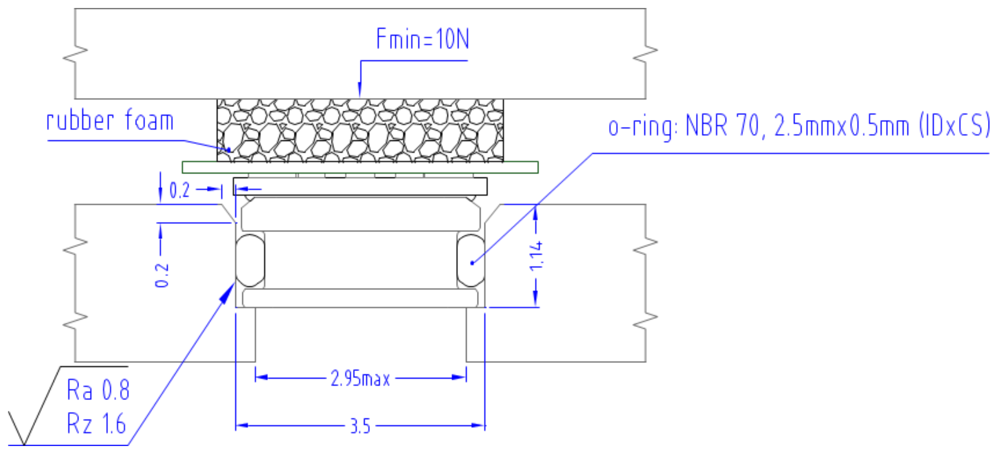

Figure 7. O-ring and Housing Dimensions

MECHANICAL STRESS:

While creating the mechanical design of the sensor housing, ensure it makes enough contact with the O-ring to provide the required level of waterproof sealing, but no mechanical stress is created on the sensor package. This can be achieved by designing chamfered edges as shown in Figure 8.

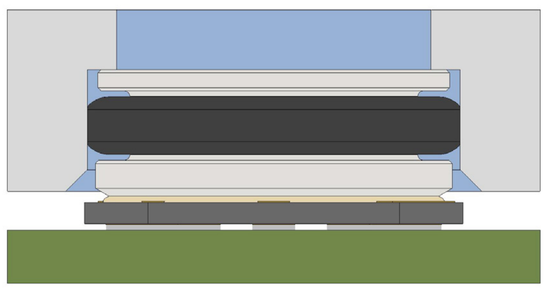

Figure 8. Sensor with O-ring Sealed in Mechanical Housing

Mechanical stress caused by user interaction should also be considered while designing the housing. Different type of devices can have different levels of mechanical stress. For example, a portable phone can go through many free fall events, whereas a wearable device can go through sudden water pressure stress during a user diving event. Therefore, housing design should be created to avoid direct mechanical stress caused by the housing on to the sensor package.

Any type of mechanical interaction with gel should also be avoided. Mating sensor manifold design inside the device, should provide adequate protection to avoid inadvertent contact to sensor gel. This can be achieved with an appropriate housing design. Mounting of the sensor inside the housing design should maintain axial alignment between the part and opening to avoid stresses being applied to the sensor or O-ring damage during use.

CIRCUIT BOARD STRESS:

The ICP-10125 is a MEMS capacitive technology-based pressure sensor device. The PCB material could also play a vital role in sensor performance. A high Tg rating rigid PCB material should be used to avoid contraction and expansion of the PCB while in a cold or hot environment. A flex PCB is also not recommended as it could cause folding/bending related stress to the sensor package.

A solder-mask opening is recommended under the sensor to increase the gap between the PCB and ceramic substrate of the sensor. A copper or exposed pad is not recommended under the sensor. This will avoid stress on to the sensor package caused by the flux or any dust particles or debris collected from environment under the sensor after SMT process. The package layout design is shown below.

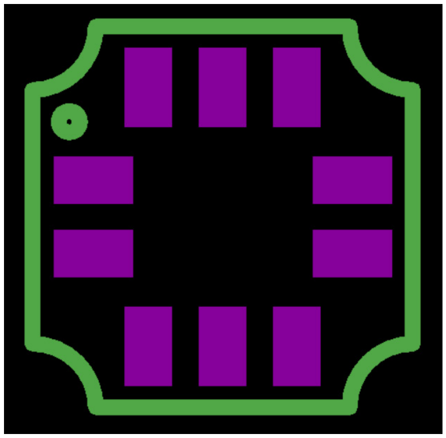

Figure 9. Component Side and Paste-Mask Layer

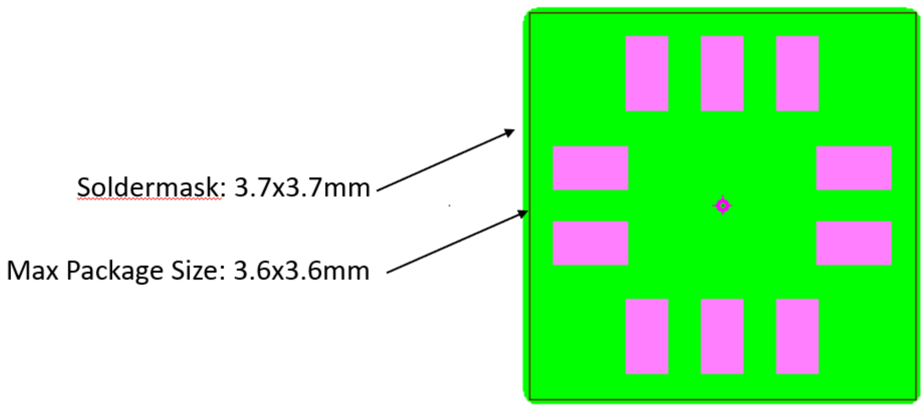

Figure 10. Solder-Mask Layer

For more details on the PCB layout design, see the AN-000140 application note from TDK-InvenSense.

SENSOR HANDLING DURING PCB ASSEMBLY:

Proper sensor handling during the PCB assembly process is very important to keep the sensor gel protected. Some key aspects of sensor handling are mentioned below:

1. Automated pick and place operations and solder are recommended to minimize handling defects. InvenSense recommends a pressure of 55 KPa or more to be used for the pick and place nozzle.
2. Use a pick and place nozzle with an outer diameter that is 3 mm or larger to pick the part from chimney to avoid any mechanical interaction with the gel. An inner diameter of 1.8 mm or more is recommended. The nozzle should be made from stainless steel with high finish quality.
3. Manual builds increase the risk of handling defects. If manual assembly is required, devices should be handled from ceramic instead of chimney to avoid any accidental contact with gel. Accidental contact with gel can possibly render the device inoperable or compromise product reliability. Usage of such device is not recommended.
4. Proper reflow profile should be used as defined in the datasheet.
5. InvenSense devices are shipped in tape and reel. If devices are unpacked from the reel for PCBA purpose and repackaging is required, then adequate pressure should be used on the reeling machine to seal the tape to avoid any physical contact of the tape with the gel. Avoid manual operation for packaging the sensors.
6. Avoid keeping devices unsealed, as the gel is sticky in nature and will contact environmental particles.
7. Devices should be stored dry in compliance with MSL 3 ratings. Baking of devices should be done prior to assembly if left unsealed per MSL3 standard.
8. If there is a special handling or processing needs to be done, please consult your InvenSense representative for support.
9. No-clean solder-paste and flux is recommended.
10. Board washing should be avoided to prevent cleaning residue from accumulating inside the chimney. If board wash is required, measures should be taken to cover the sensor during cleaning to prevent residue accumulation inside the sensor unit or the device path leading to the sensor.
11. Mounting of the sensor inside the device body should be done such that to prevents multiple mechanical interference points. Generally, the only recommended interference fit should be limited to the O-ring region. Direct contact to the pressure sensor elsewhere than the O-ring, that may lead to applied force during normal use should be avoided.

REVISION HISTORY

REVISION DATE	REVISION	DESCRIPTION
03/25/2020	1.0	Initial Draft
05/13/2020	1.1	Minor changes in Mechanical Stress section
07/24/2020	1.2	Added Sensor Handling guideline during PCBA