Handling, mounting, and soldering guidelines for MEMS devices

Introduction

This document provides preliminary information and general guidelines for handling, soldering, and mounting microelectromechanical systems (MEMS) inertial sensors from STMicroelectronics.

MEMS inertial sensors, such as accelerometers, gyroscopes, and compasses, are highly sensitive devices that require careful handling during manufacturing processes to prevent any issues and ensure that customers receive high-quality sensors that meet their performance requirements.

MEMS devices contain movable microelectromechanical structures. They may exhibit displacement of inertial masses and transient behavior when subjected to acceleration stress, caused by handling, soldering, or mounting operations, or any combination of these. They are different from common discrete electronics components or IC-only devices, where no movable element is present. Therefore, they require a set of special precautions during their usage in customer manufacturing lines, especially when they are handled by:

- Human operators
- High-speed or high-pressure automatic machinery, like pick and place, transfers, seeders, and similar equipment

This technical note describes the precautions recommended by ST for each step of the customer's manufacturing process.

For further information, contact your local STMicroelectronics sales office.

1 Handling and storage of outer box, inner box, base packing (reel and tray)

1.1 Outer box

The outer box is the ST standardized container utilized for shipments that can include different inner boxes.

Precautions in handling the outer box are shown below, indicating:

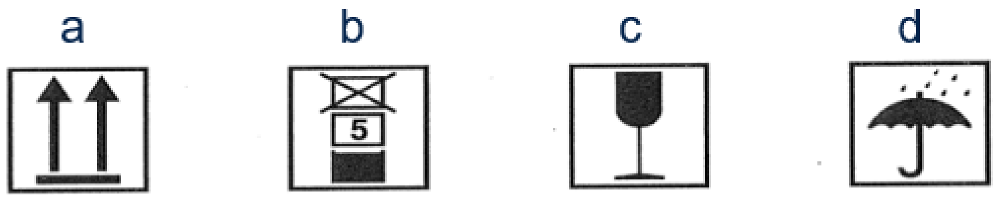
a. The correct vertical orientation of the box

b. To stack a maximum number of boxes on top of each other

c. To handle the box with caution because of a fragile contents

d. To protect the box from water and moisture

Figure 1. **Possible pictograms on outer box**



1.2 Inner box

The inner box is the ST standardized container that contains a defined number of base containers of the same product. The standard inner box labels are depicted in the figure below along with the mandatory information printed on them.

Figure 2. **Example of tape and reel packing inside the inner box**

The following figure shows two examples of the correct or incorrect appearance of the inner boxes.

Figure 3. Examples of correct or damaged aspect of the inner box

	Inner Box	Remarks
GOOD		No defect/anomalies on packing materials
NOT GOOD		Minor dent on the box

1.3 Base packing (reel and tray)

The base packing is the ST standard elementary packing container that contains a defined quantity of product. Typically, the base packing consists of a reel or tray. The contents core of the base packing can vary depending on the thickness of the device.

Figure 4. Example of reel and tray base packing

Figure 5. From reel to inner box

The standard base packing label is depicted in the figure below along with precautions to be taken because of the presence of moisture-sensitive devices. Shelf life and floor life indications are listed as well.

Figure 6. Details of the caution label placed on the base packing

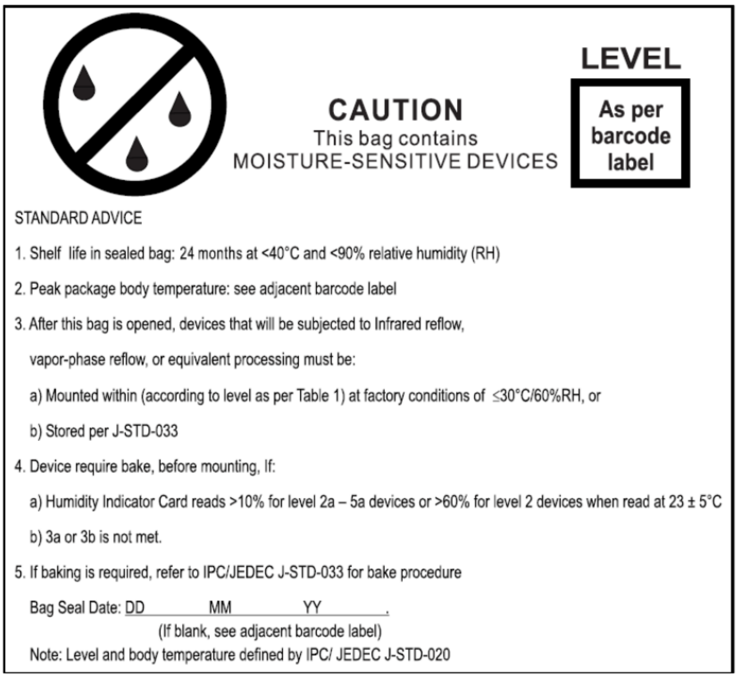
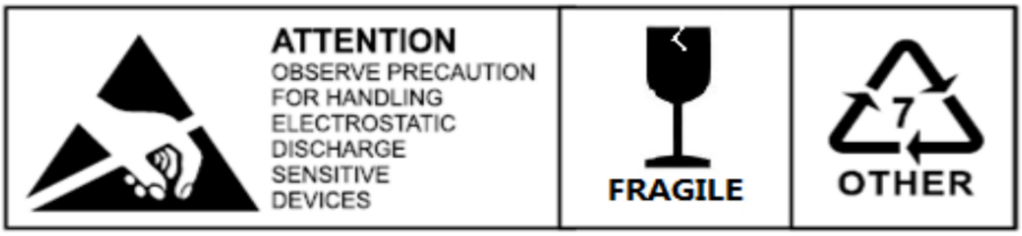


Figure 7. Description of the levels of floor life

LEVEL	FLOOR LIFE (OUT OF BAG) AT FACTORY Ambient ≤30°C/60%RH or as stated
1	UNLIMITED at ≤30ºC/85% RH
2	1 YEAR
2a	4 WEEKS
3	1 WEEK
4	72 HOURS
5	48 HOURS
5a	24 HOURS
6	EXTREMELY Moisture-sensitive devices. Mandatory bake before use: Once baked, must be reflowed within 6 hours.

Figure 8. **Additional pictograms on the base packing**



Note 1 Note 2 Note 3

Note1: Handling Discharge Sensitive Device Symbol
Note 2; Fragile Contents Symbol
Note 3; Material Recycle symbol follow ISO/IEC Standard.

1.4 Handling the reel after bag removal

Handling of reels, when removing them from the carton box and vacuum bag, can be potentially critical for the MEMS devices contained inside. Some best practices and actions should be taken to minimize the risk of sensor damage. Some examples are indicated below:

- Perform a visual inspection of the outer box upon reception.
- Perform a visual inspection of the inner box before opening it.
- Perform a visual inspection of the reel after removing it from the sealed bag.
- De-reel the initial part of the reel just in front of the SMT equipment and avoid accidentally dropping the reel tail on the floor (even if there are no components in the reel tail).
- Avoid any drop or accidental fall, during the entire assembly line process or during transportation.
- In the event of a fall or drop, intended or unintentional, caused by a human being or a machine, track the dropped material (box, reel, or device) and avoid mounting it and delivering to a third party. It is recommended to track any accident (due to mishandling) using a dedicated manufacturing traveler document for reel handling.

1.5 Handling MEMS sensors

Handling MEMS sensors can be potentially critical for the mechanical structure inside.

Some general guidelines to avoid risks are as follows:

- Store MEMS sensors in a clean, dry environment to prevent contamination or damage.
- Avoid touching the sensing elements or leads of the MEMS sensors with bare hands to prevent damage from oil or moisture.
- Use appropriate ESD precautions when handling inertial sensors to prevent damage from electrostatic discharge.
- Use appropriate handling tools. When handling inertial sensors, it is important to use appropriate tools, such as tweezers (preferably made of plastic) or vacuum pick-up tools, to avoid applying excessive force or pressure.
- Avoid bending or twisting the leads. The leads of inertial sensors are fragile and can be easily damaged by excessive force or pressure.
- Train personnel on proper handling techniques to avoid an excessive force or pressure to be applied during placement or testing. This can include training on the use of appropriate handling tools, the importance of a controlled placement process, and the risks associated with bending or twisting the leads.

1.6 Conclusion

MEMS devices during qualification are subjected to:

- Shock tests up to 10000 - 25000 *g*
- Drop (tumble) tests, where accelerations are not deterministic since the falling direction and the interaction with the surface can vary

These shocks are conceived as extreme single-drop falls as required by specific customers, but they are not intended to be sustained along normal manufacturing processes, handling, and PCB mounting operations or shocks occurring during transportation. Users or customers should avoid dropping individually packaged sensors (LGA or ceramic), trays, or reels containing sensors, especially on rigid surfaces (metal, marble, concrete or similar hardness), since accelerations can be in the order of >10x of qualification limits in those cases. The manufacturer shall take into consideration that any impact on the packing (outer/inner box or reel/tray) is considered a major event and that any sign of mishandling could be considered as a potential source of damage for the inertial devices. Therefore, the manufacturer must avoid accidental falls throughout the manufacturing process, regardless of the type of packing.

2 Pick and place guidelines

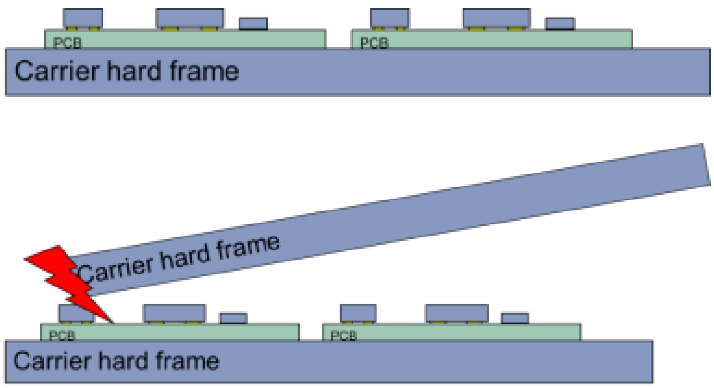
The assembly of the printed circuit boards (PCB) is a fully automated process where high-speed, high-precision machines guarantee the placement of electronic components on the relevant board. These systems normally use pneumatic suction cups, and at the end, a nozzle accurately picks the device from a predetermined area.

This process must be rigorously controlled since the position of the nozzle, the force involved in the pick and place, and the mechanical parameters can damage the structure of the MEMS sensor being picked up.

Some guidelines during the pick and place process are as follows:

- Ensure that equipment can raise an alarm if a false pick or an out-of-control of pick height occurs.
- Avoid any impact of hard material on the PCB area close to the component or on the component itself as depicted in the following example:

Figure 9. Hitting the component or PCB with a hard tool can damage it



- Operator awareness on the possibility of this failure mode
- Remove dangerous tools (screwdrivers, scissors) from the line where not necessary in normal operations.
- Protecting the PCB panel with foam during nonthermal operation and transportation can be an optimal solution even if it impacts line productivity
- Report any accident that occurs on the SMT line.

3 Surface mounting guidelines

3.1 General guidelines for soldering surface-mount MEMS sensors

The following elements must be considered to adhere to common PCB design and good industrial practices when soldering MEMS sensors:

- PCB design should be as symmetrical as possible.
  - Large traces on VDD or GND lines are not required (very low power consumption).
  - No vias or traces below the sensor footprint.
- Solder paste must be as thick as possible (after soldering) to:
  - Reduce the decoupling stress from the PCB to the sensor.
  - Avoid that the PCB solder mask touches the device package.
- Solder paste thickness must be as uniform as possible (after soldering) to avoid uneven stress: final volume of soldering paste within 20% among lands is possible using the SPI (solder paste inspection) control technique.
- Avoid placement of the sensor on the PCB in locations close to hot spots (microprocessors, graphic controllers, batteries, …), close to pushbuttons, screws and/or PCB anchor points since these locations can produce mechanical stress affecting sensor precision.
- High-amplitude resonances (vibrations) of the PCB, both those caused by a source external to the PCB and those originating from another device mounted on the PCB itself, should be avoided.
- Sensors should be placed in positions in which the effects of such disturbing frequencies are minimized, or the component should be placed on a separate board to decouple its effects from the rest of the system.
- As MEMS devices have a mechanical structure with its own resonant and operating frequencies, the use of ultrasonic processes for cleaning and soldering is NOT recommended due to potential damage to the internal MEMS structure.

3.2 PCB design guidelines and recommendations

General recommendations for PCB land and solder mask design are listed below.

- It is recommended to place the solder mask opening outside the PCB land.
- It is strongly recommended not to place any structure on the top metal layer underneath the sensor (on the same side of the board). This must be defined as a keepout area.
- Traces connected to pads should be as symmetric as possible. Symmetry and balance for pad connection help component self-alignment and lead to better control of solder paste reduction after reflow.
- For optimal performance of the device, it is strongly recommended to place screw mounting holes at a distance greater than 2 mm from the sensor.
- If present, the pin #1 indicator must be left unconnected to ensure proper device functionality.
- To prevent noise coupling and thermomechanical stress, following standard industry design practices for component placement is advised.

3.3 Stencil design and solder paste application

The thickness and the pattern of the soldering paste are important for the proper MEMS sensor mounting process.

- Stainless steel stencils are recommended for solder paste application.
- A stencil thickness of 90 - 150 μm (3.5 - 6 mils) is recommended for screen printing.
- The openings of the stencil for the signal pads should be between 70% and 90% of the PCB pad area.
- Optionally, for better solder paste release, the aperture walls should be trapezoidal, and the corners rounded.
- The fine pitch of the IC leads requires accurate alignment of the stencil to the printed circuit board. The stencil and printed circuit assembly should be aligned to within 25 μm (1 mil) prior to application of the solder paste.

3.4 Process considerations

The soldering profile depends on the number, size, and placement of components on the application board. For this reason, it is not possible to define a unique soldering profile for the sensor only. The customer should use a time and temperature reflow profile based on PCB design and manufacturing expertise.

- In order to reduce residual stress on the components, the recommended ramp-down temperature slope should not exceed -3°C/s.
- No solder material reflow on the side of the package is allowed since LGA packages show metal traces on the side of the package.
- If “self-cleaning” solder paste is not used, the board must be properly cleaned after soldering to eliminate any possible source of leakage between adjacent pads due to flux residues.
- The final volume of soldering paste applied to each PCB land is recommended to be within 20% among (all) the PCB land pads.
- Based on the JEDEC 9702 standard, a component shows negligible output variation up to stress intensity of 500 me (microstrain).

3.5 Solder heat resistance and environmental specifications

To meet environmental requirements, ST offers these devices in ECOPACK packages. These packages have a lead-free second level interconnect. The category of second level interconnect is marked on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label.

3.6 PCB layout and recommended distance

The following figures depict some guidelines for PCB layout.

Figure 10. PCB distance and no underfill

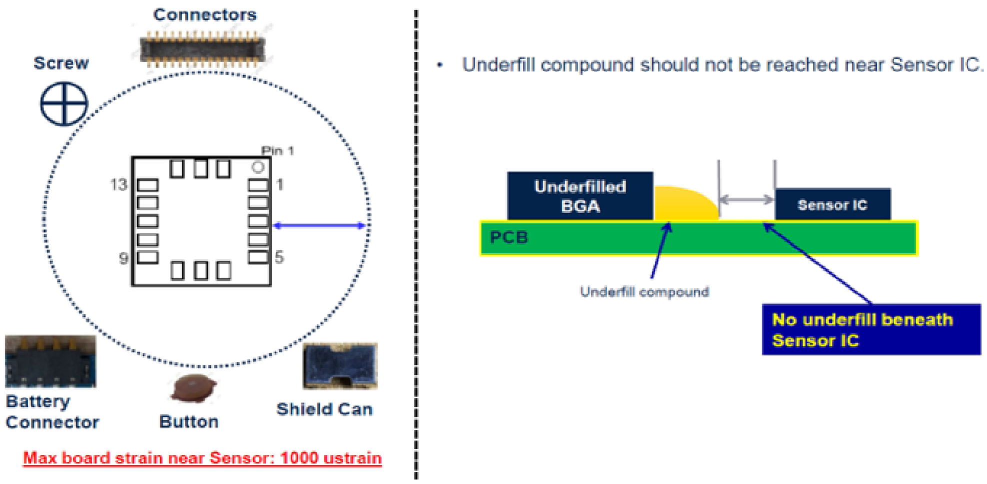


Figure 11. PCB distance under IC

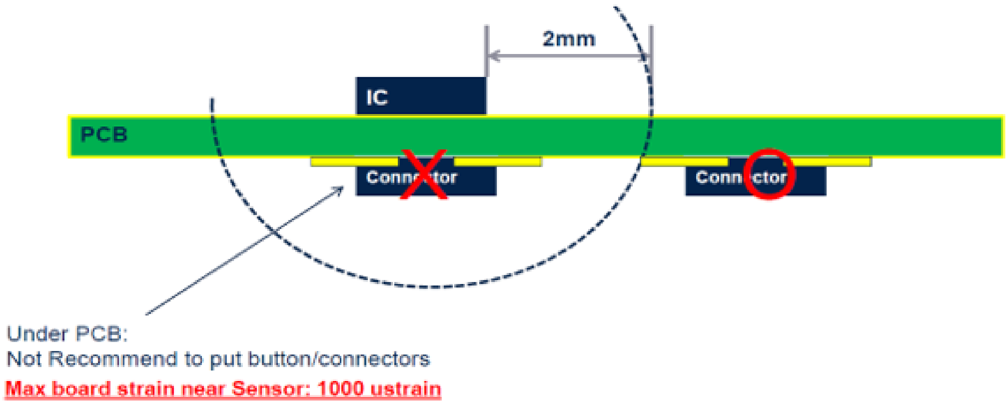
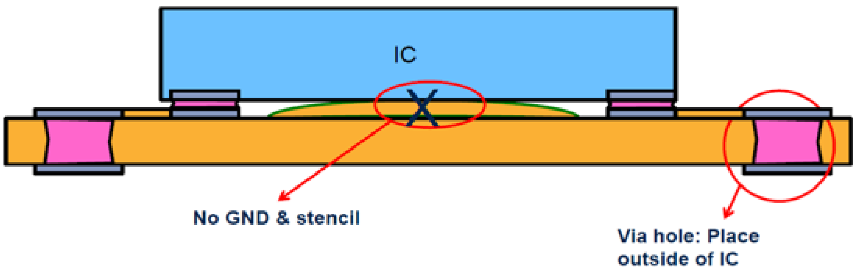


Figure 12. PCB layout: side view



1. Top Layer placement is better than Bottom layer.
2. Via hole should be placed outside of IC
3. Keep out area beneath IC: Peel cut (No GND)

3.7 Mounting recommendations vs. mechanical shock and thermal stress

The following figures depict some mounting recommendations regarding mechanical shock and thermal stress.

Figure 13. Mechanical shock

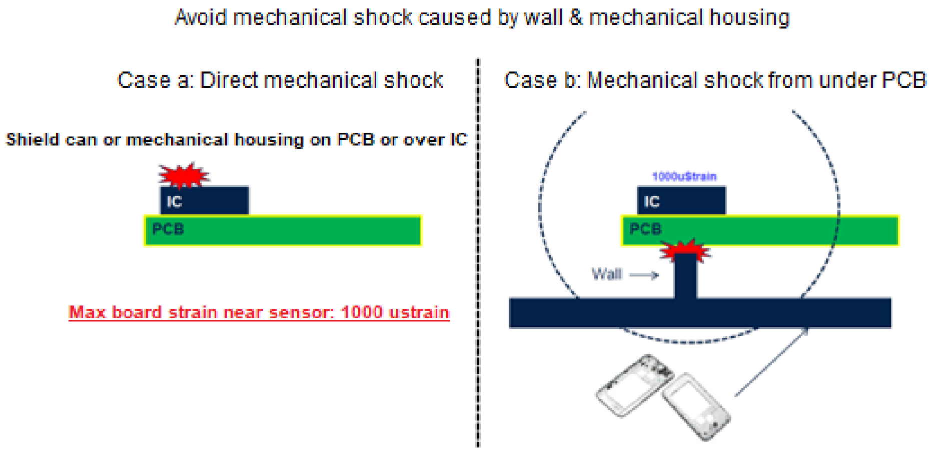


Figure 14. Thermal stress

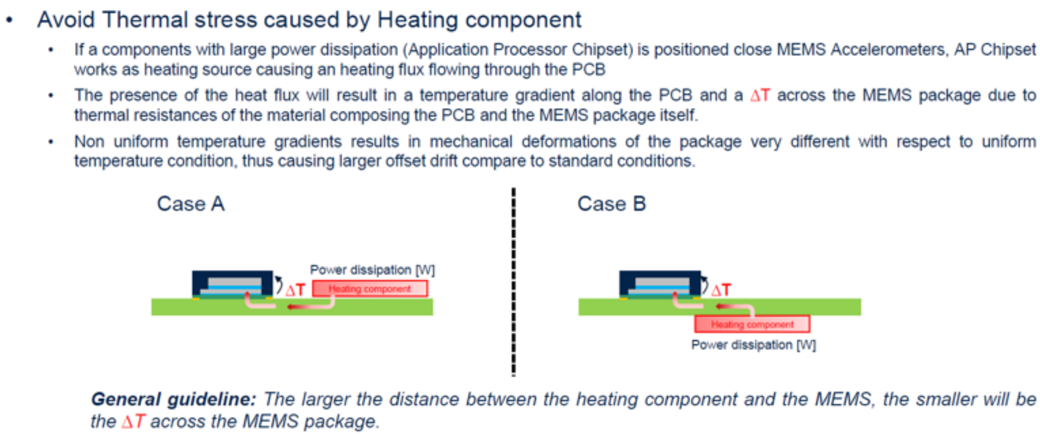
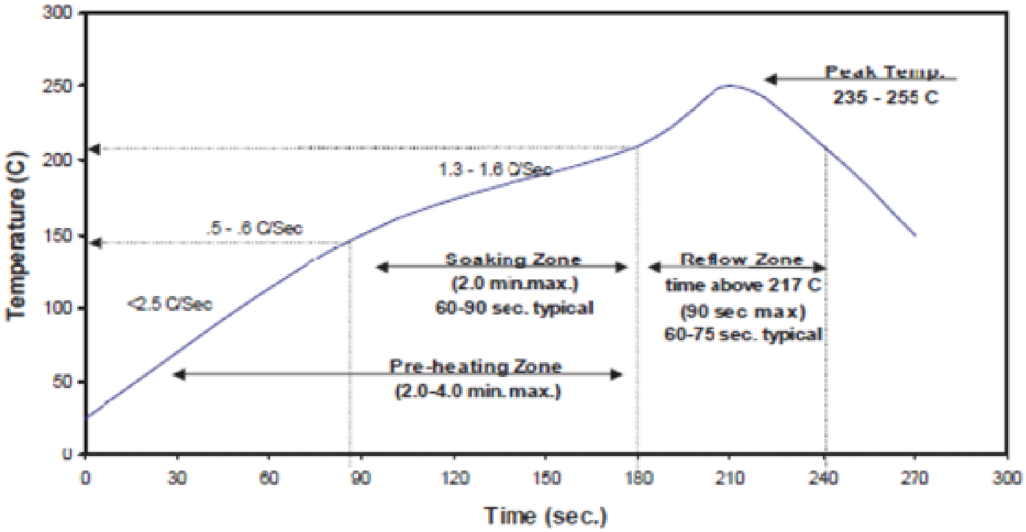


Figure 15. Typical reflow profile



3.8 Ultrasonic baths

Ultrasonic baths, usually performed before and after PCB mounting operations, are allowed but they can potentially damage MEMS devices if the bath energy level is too high and/or one or more resonant frequencies of the device is/are matched and forced.

Appendix A Reference document

Technical note TN0018, entitled "Surface mounting guidelines for MEMS sensors in an LGA package" available on www.st.com.

Revision history

Table 1. **Document revision history**

Date	Version	Changes
06-Jun-2024	1	Initial release

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