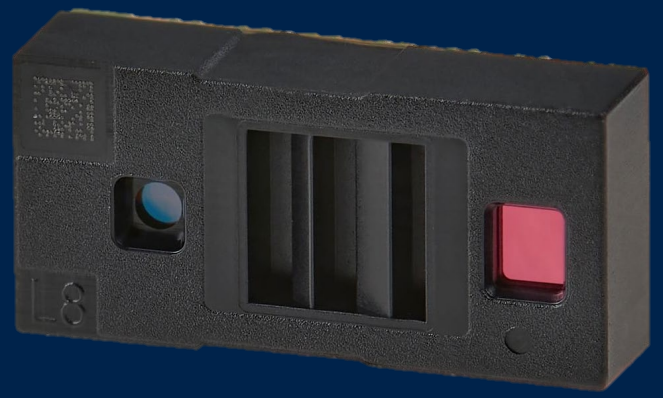
VL53L8 product family

PCB design guidelines and handling
&
PCB rework recommendations



History

Version	Date	Release Notes
1.0	8 June 2022	Initial release
2.0	14 June 2024	Updated slides 19 and 14
3.0		

Products concerned

- Any VL53L8 product version

Purpose

- **This document describes**:
  - Requirements for **SAFE ToF sensor handling**
  - Requirements for **SAFE ToF sensor Liner handling**
  - Requirements for **SAFE PCB assembly**
  - Requirements for **SAFE de-soldering & re-soldering of ToF sensor** from PCB without damage on ToF sensor and on the PCB.
  - Requirements for **SAFE protection of ToF sensor** when handling the de-soldering or re-soldering of another component on same PCB
- **Rework at customers will be required**:
  - To remove a ToF sensor component considered defective. After removal, the component should remain fit for failure analysis.
  - To remove the ToF sensor component to confirm if the soldering is poor.
  - To remove another failed component from the PCB or to confirm local soldering process is poor.

Document coverage

Covered by this document

- PCB layout rules for ToF soldering to board
- MSL3 Storage/Handling Guidelines (inc. datasheet extract)
- Mechanical Handling at Customer Manufacturing Process
- Soldering Process Guidelines (inc. datasheet extract)
- Manual Rework procedures
- Safe manual re-soldering
- Troubleshooting

Covered by Datasheet (for reference)

- Product marking
- Inner box labelling
- Packing
- Pb-free solder reflow process
- Recommended solder pad dimensions
- Storage temperature conditions
- Package information (ecopack^{tm})

PCB layout rules for ToF soldering to board

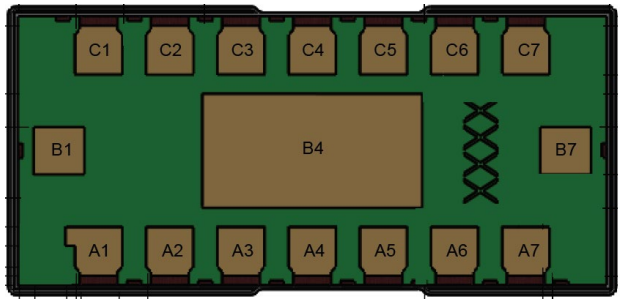
General guidelines for PCB mounting for optical sensors

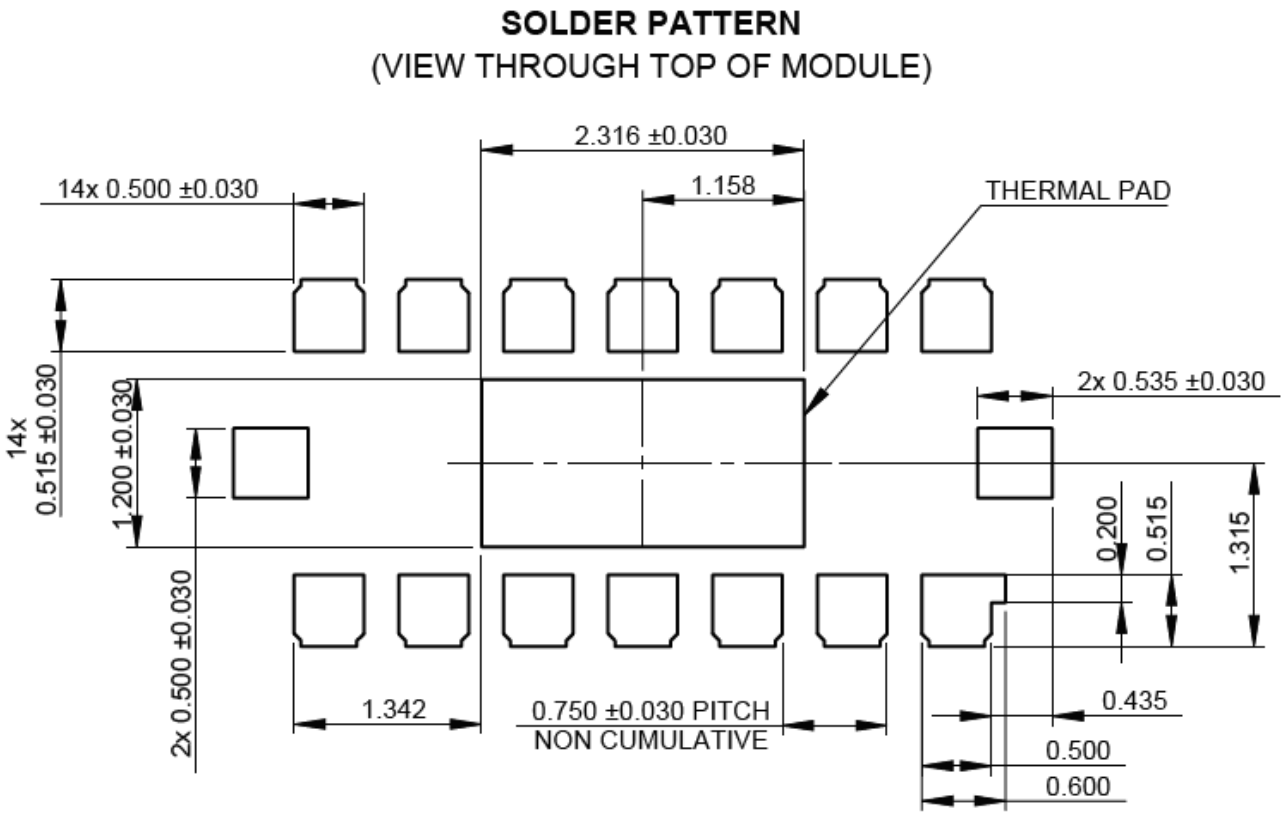
- The following four elements must be considered in order to adhere to common PCB design and good industrial practices when soldering optical sensors:

1. PCB design should be as symmetrical as possible
   - Large traces on VDD / GND lines are not required (very low power consumption)
   - no vias or traces below the sensor footprint
2. Not Connected pins i.e. DNC pins indicator must be left unconnected to ensure proper device functionality.
3. It is recommended to open solder mask external to PCB land;
4. The area below the sensor (on the same side of the board) must be defined as keep out area. It is strongly recommended to not place any structure in top metal layer underneath the sensor:
   - No vias or traces below the sensor footprint.

VL53L8 Pad type

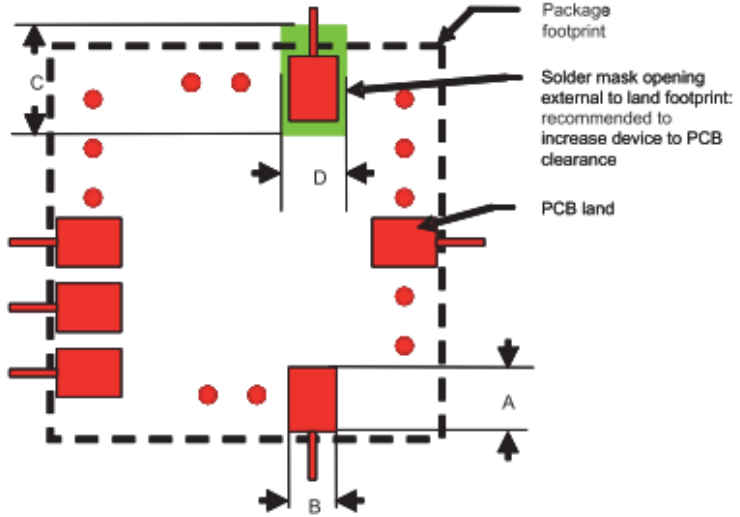
- Pad type: **NSMD**





Dimensions (View thru package)

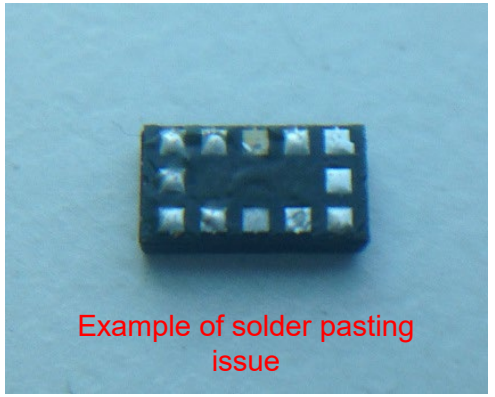
PCB Layout guidelines VL53L8



- PCB land design and connecting traces should be designed symmetrically.
- For LGA pin spacing greater than 200 µm:
  - A = PCB land length = LGA solder pin length + 0.1 mm
  - B = PCB land width = LGA solder pin width + 0.1 mm
- For LGA pin spacing equal to or less than 200 µm:
  - A = PCB land length = LGA solder pin length
  - B = PCB land width = LGA solder pin width
  - C = Solder mask opening length (when applicable) = PCB land length + 0.1 mm
  - D = Solder mask opening width = PCB land width + 0.1 mm
- For the thermal pad (B4):
  - It is recommended to create multiple pads with vias to GND as opposed to one large pad to improve solder reflow.

Solder paste dispensing recommendations

- Stainless steel stencils are recommended for solder paste application.
  - A stencil thickness of 90-150µm(3.5 6mils) is recommended for screen printing.
  - Stencil openings for the signal pads to be between 70% and 90% of the PCB pad area.
- 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 25µm (1mil) prior to application of the solder paste.
- 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
  - Recommended Solder paste type: Any solder paste of type **SAC305**
- Solder paste must be as thick as possible (after soldering) in order to:
  - Reduce the decoupling stress from the PCB to the sensor
  - Avoid that the PCB solder mask touches the device package
  - Recommended Solder paste thickness and size 20 to 50microns


Example of solder pasting issue

MSL3 Handling, Packing, Shipping and Use of Moisture, Reflow, and Process Sensitive Devices Guidelines

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Background

- The vapor pressure of moisture inside a plastic package increases rapidly when package is exposed to the high temperature of solder reflow.
  - In standard ICs, this pressure can cause:
    - Internal delamination of the plastic from the die;
    - Die cracks;
    - Bond damage/lifting;
    - External package cracks (“popcorn” effect).
- In ToF sensors, this pressure can also cause additional plastic deformation of device package, leading to sensor offset drift.

ToF sensors are MSL level 3 compliant devices

- ToF sensor is PCB/Flex MSL level 3 device and shall be handled as a non-hermetic package and dry mounted on x as per JEDEC-STD-033C requirements.

Table 4-1 Reference Conditions for Drying Mounted or Unmounted SMD Packages (User Bake: Floor life begins counting at time = 0 after bake)

Package Body	Level	Bake @ 125 °C +10/-0 °C		Bake @ 90 °C +8/-0 °C ≤5% RH		Bake @ 40 °C +5/-0 °C ≤5% RH	
		Exceeding Floor Life by >72 h	Exceeding Floor Life by ≤72 h	Exceeding Floor Life by >72 h	Exceeding Floor Life by ≤72 h	Exceeding Floor Life by >72 h	Exceeding Floor Life by ≤72 h
Thickness ≤4 mm	2	5 hours	3 hours	17 hours	11 hours	8 days	5 days
	2a	7 hours	5 hours	23 hours	13 hours	9 days	7 days
	3	9 hours	7 hours	33 hours	23 hours	13 days	9 days
	4	11 hours	7 hours	37 hours	25 hours	15 days	9 days
	5	12 hours	7 hours	41 hours	24 hours	17 days	10 days
	5a	16 hours	10 hours	54 hours	24 hours	22 days	10 days

Handling precautions

Refer to the HANDLING section ToF sensor datasheet for related product information

Shock precautions

Sensor modules house numerous internal components that are susceptible to shock damage. If a unit is subject to excessive shock, is dropped on the floor, or a tray/reel of units is dropped on the floor, it must be rejected, even if no apparent damage is visible.

Part handling

Handling must be done with nonmarring ESD safe carbon, plastic, or teflon tweezers. Ranging modules are susceptible to damage or contamination. The customer is advised to use a clean assembly process until a protective cover glass is mounted.

Compression force

A maximum compressive load of 25 N should be applied on the module.

Moisture sensitivity level

Moisture sensitivity is level 3 (MSL) as described in IPC/JEDEC JSTD-020-C.

If devices are stored out of the packaging for greater than 168 h, the devices should be baked before use. The optimum bake recommended is at 90°C for a minimum of 6 hours.

Sensor storage on the shelves requirements

- Storage condition is critical to liner quality
  - To obtain best performance, use this product within 18 months from date of delivery and store under normal conditions of 16° to 27°C (60° to 80°F) and 40 to 60% relative humidity in the original packaging.
  - This is important particularly for sensor with a liner material covering the sensor emitter and collector/receiver cavities as well as air vents.
  - Please refer to JEDEC JSTD-020

MSL3 Handling prior to PCB assembly

- The packing uses a Moisture Barrier Bag (MBB). A Humidity Indicator Card (HIC) and drying desiccant are included in the MBB.
- Shelf life of devices in a sealed bag is 12 months at <40degC and <90%RH
- After opening MBB, the HIC should be checked immediately: devices require baking before board mounting if the HIC is >10% when read at 23degC+/-5degC.
- After MBB is opened, devices should go through reflow for board assembly within 168hours at factory conditions of <30degC/60%RH. If both of these conditions are not met, baking is required.
- In case factory conditions are not constantly monitored to be compliant with <30degC /60%RH, it is suggested to do reflow within 48 hours.
- If baking is required, devices should be baked according to following table:

Bake@ 90degC, <5%RH	Bake@ 40degC, <5%RH
>6 hours	13 days
Only applies to sensor NOT TO THE REEL due to potential outgassing	

- The above baking condition must not be applied to low temperature carrier like Tape and Reel
- Care must be taken on carrier outgassing risk therefore the baking of optical camera inside T&R is not recommended even at 40°C

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MSL3 Handling of unused devices

- Any unused devices after Moisture Barrier Bag (MBB) has been opened for more than 168 hours or not stored at <10%RH should be backed before any subsequent reflow.
- In case factory conditions are not constantly monitored to be compliant with <30degC /60%RH, it is suggested to bake the devices if not mounted within 48 hours after MBB opening.
- Re-baking should be done according to the following table:

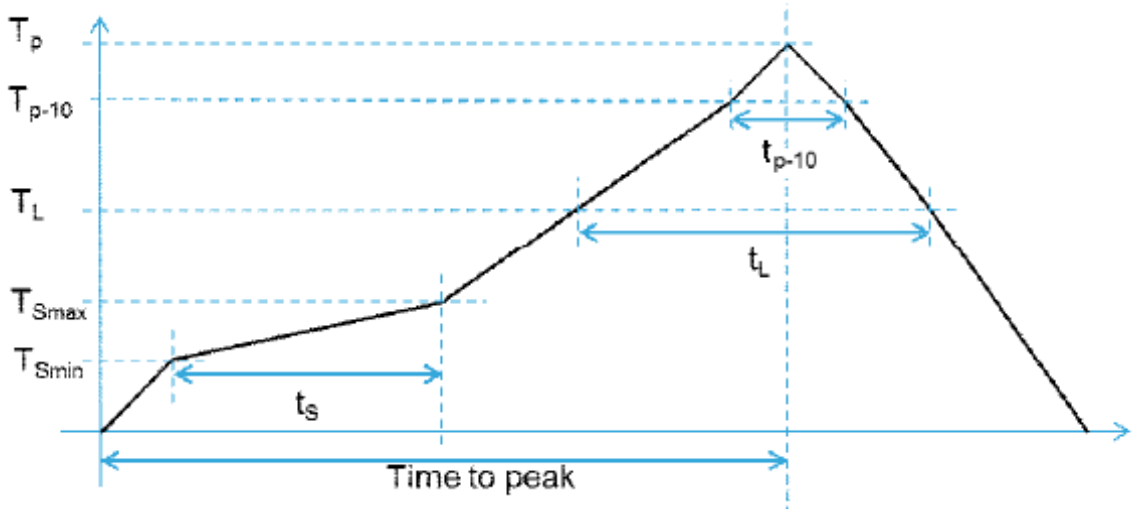
Bake@ 90degC, <5%RH	Bake@ 40degC, <5%RH
>6 hours	13 days

- Unused devices can be stored according to one of the following procedures:
  - Baking + dry-packing before storage
  - Baking just before next PCB assembly

ToF soldering summary

- **ST can guarantee 3x reflow soldering**
  - **ToF sensor products are JEDEC Level 3 compliant:** All components in the ToF sensor module are designed and qualified to withstand 3x lead free reflow (up to 260°C).
- **ST can NOT guarantee 4x reflow solderings**
  - If the customer application requires ToF sensor to withstand 3 reflow soldering during manufacturing, in case of rework, ToF sensor device should be de-soldered and replaced by another ToF sensor for re-soldering on PCB and phone calibration will be required again.
- **ST recommends PCB soldering at 240°C (or lower) as per below Datasheet extracts. However, ST's ToF sensor products are not compliant with Vapour Phase soldering method.**

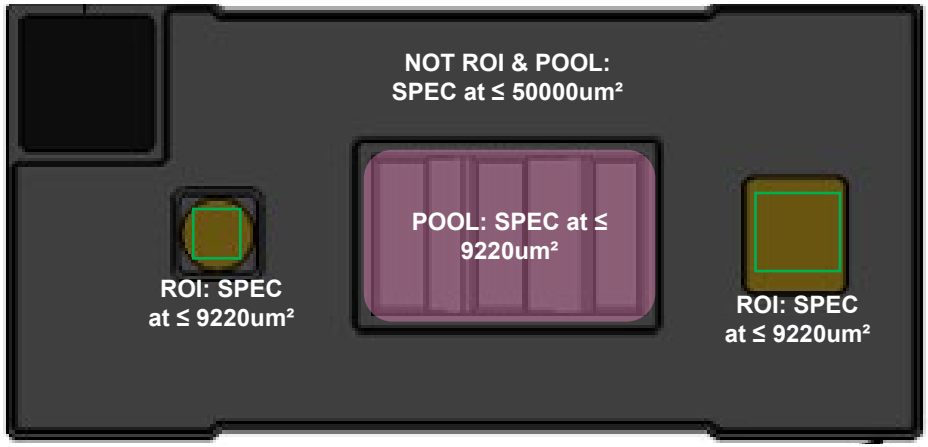
Parameters	Recommended	Maximum	Units
Minimum temperature (T_S min)	130	150	°C
Maximum temperature (T_S max)	200	200	°C
Time t_s (T_S min to T_S max)	90-110	60-120	s
Temperature (T_L)	217	217	°C
Time (t_L)	55-65	55-65	s
Ramp up	2	3	°C/s
Temperature (T_{p-10})	—	235	°C
Time (t_{p-10})	—	10	s
Ramp up	—	3	°C/s
Peak temperature (T_p)	240	260	°C
Time to peak	300	300	s
Ramp down (peak to T_L)	-4	-6	°C/s



Production environment cleanliness
Dust requirement

- It is recommended to mount ST's ToF sensors in a **class 1000 environment** (if the version without liner is requested).
  - ST's customers regularly use their supply chain to assemble our sensor on a small PCB or FPC where cleanliness may be not matching class 1000 requirement **but** :
- Choice cleanliness environment control is customer decision,
  - Long ranging distance applications require very clean assembly/testing environment before sensor is sealed in a dust proof in final application.
  - Short ranging applications will be less sensitive than long ranging application for dust.
- When dealing with any PCB or FPC on which a ToF sensor is attached and it is required to perform some dry cleaning, it is required special care to avoid particle deposition on critical optical areas. The current design is not suitable for wet cleaning or coating.

- **Dust size specification**, the IPC specification for ToF sensor about called Foreign Material (FM) is:
  - **ROI** (inside green area) and **POOL** (pink area): FM in the center of Glasses, for both emitter and receiver: **SPEC is at ≤ 9220um²**
  - **Not ROI**: FM on the Glasses but outside of the ROI (outside of Glass center), for both emitter and receiver: SPEC is at 50,000 µm².



Handling at Customer Manufacturing Process

Manufacturing Process at ODM/OEM

- **Process steps requiring particular attention in standard manufacturing.**
  - **4 particular process steps (pink color)** in the below diagram require special care for cleanliness
  - Manual handling (include manual soldering) not recommended by ST to avoid contamination on optical path & clogging vent holes. The function of the vent hole is to eliminate the risk of package pop corn during the reflow process. It hasn't any link with the product optical performances.

SMT Process

PCB loading → Solder Paste Printing → IC mounting (LPS22HB) → Reflow → PCB unloading

❖ *Process requiring attention where ToF sensor contamination can happen due to cleanliness challenge*

Optional Process

PCB Washing

Conformal Coating, Underfil

Process after SMT

PCB Cutting → Functional Test → OQC Inspection

E=Emitter optical area
C=Collector/optical sensing array

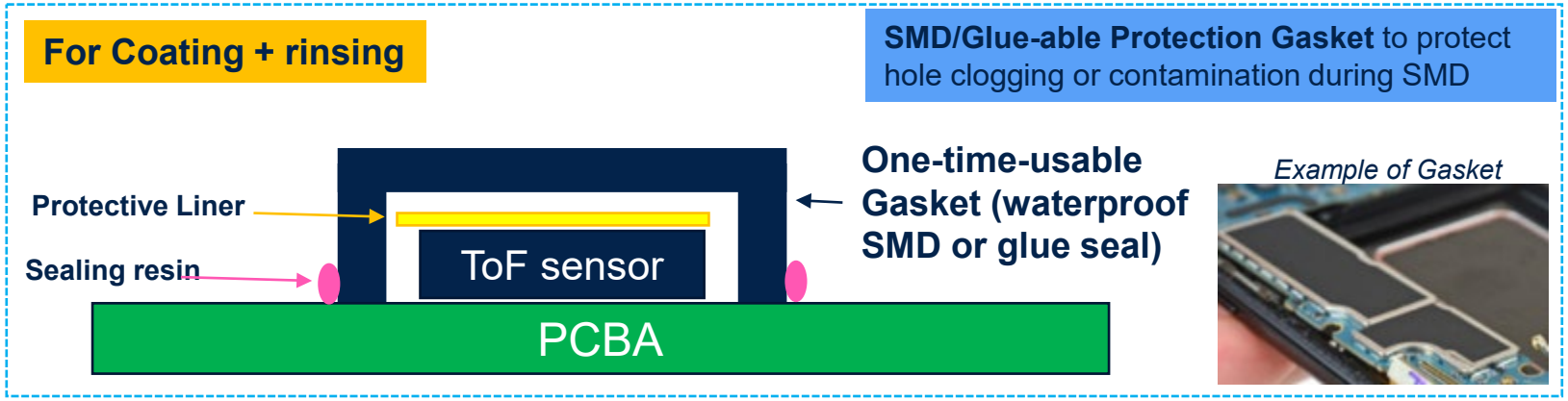
Manufacturing Process
Issues & corrective actions

- Optical path (glass) contaminations (& Holes clogging) can happen in any process step during assembly manufacturing.
- Optimization of assembly process to handle ToF sensors (different requirements than ALS or other lower end IR sensors)

	Failure mode	Root cause	Corrective action
Reflow	✓ Contamination on E/C ✓ Vent Holes clogging	✓ Dust & Flux by soldering in reflow	✓ Regular reflow oven cleaning ✓ Use a liner
Manual Soldering/PCB Rework	✓ Contamination on E/C ✓ Vent Holes clogging	✓ Particle/contamination ✓ Hand / Finger touch to IC	✓ Attention during handling ✓ Hot plate with soldering (than hot air gun) ✓ Blow dry clean air on E/C ✓ Use a liner
PCB Washing	✓ Mechanical Damage ✓ Contamination on E/C	✓ Mechanical stress ✓ Particles, contaminants and chemicals on water	✓ Not recommended. ✓ If needed, Protective CAP might be useful.
Coating	✓ Contamination on E/C	✓ Coating on Optical areas	✓ No recommend. ✓ If needed, Protective CAP might be useful.
PCB Cutting	✓ Contamination on E/C	✓ Particle/contamination from PCB	✓ Optimization of cutting process for minimize of particle ✓ Use a specific liner to protect the parts
Functional Test	✓ Contamination on E/C	✓ Dust from unclean room ✓ Grease or sweat in hands during handling	✓ Attention during handling ✓ Blow dry clean air on E/C

PCB coating + rinsing cleaning
ToF specific recommendations

- **PCB coating** involves the deposition of a layer with poor optical properties.
- **ST's requirements for PCB coating**
  - For coating of a PCB on which a ToF sensor is attached to, it is required to add a soft Teflon gasket or a SMD type hard shell gasket and perform a waterproof sealing around the ToF sensor.
  - The gasket is to be kept during the rinsing flow.



DISCLAIMER: The above recommendations are for reference only. This is the integrator/CMI responsibility to propose a workable solution when coating/cleaning is applied to ST's sensors during assembly process to ensure the process does not impact optical performances (by adding residues in optical paths) or functional performance (liquid stuck inside cavity or on top of critical optical areas.

PCB Dry cleaning process
ToF sensor recommendation

- **Dry cleaning** is often used to blow air onto PCB on optical/pressure sensors.
- **Basic recommendations**
  - **Dry cleaning**: Requires use of a neutral & clean gas that is blown vertically with a laminar flow from top to bottom inside the factory and under higher air pressure than outdoors so dust does not accumulate on PCB and sensors.
  - **Environment**: Clean room of class 1000 for non liner version or use liner version. Temperature within product specification (<70C)

DISCLAIMER: The above recommendations are for reference only. This is the integrator/CMI responsibility to propose a workable solution when coating/cleaning is applied to ST's sensors during assembly process to ensure the process does not impact optical performances (by adding residues in optical paths) or functional performance (liquid stuck inside cavity or on top of critical optical areas.

Manual Rework procedures

Failure Analysis Returns Do Not Desolder Sensor

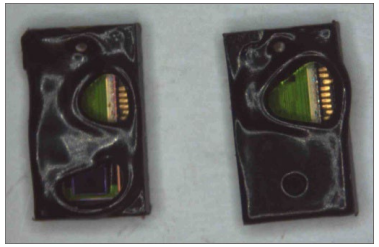
- It is preferable to return both **non desoldered** device and good parts for FA. If Customer desoldering for FA care must be taken to not exceed 260°C for a limited time (hot plate recommended).
- Customer is responsible for handling, tool calibration and methods in accordance with this document requirements.
- **Failure analysis Return**
  - Even if the package is not deformed but the reflow soldering exceeded 260°C, it may affect the sensor electrical behaviour (SPAD performance and others).
  - **For deformed device (de-soldering temperatures of >275°C)**
    - **Risk of altered optical performances of ToF sensor. Parametric testing not guaranteed for failure analysis**
    - **Responsibility: ST can not guarantee Failure analysis conclusions if device deformed**
  - **For melted device (de-soldering temperatures of 300°C and above)**
    - **ToF sensor functionally damaged**
    - **Responsibility: ST will not agree to perform failure analysis of a melted device**

PCB Rework compliance for MSL3

- Prior to removing the device soldered to a PCB, the board must be baked.
- It is recommended that during removal localized heating should be used.
- The replacement device should not exceed the specified floor life of 168 hours.
- In case factory conditions are not constantly monitored to be compliant with <30degC/60%RH,
  - it is suggested to perform device replacement within 48hours.

Safe rework summary

- **ToF sensors are optical packages** such as a camera module with lens, it can not be handled as a standard IC for de-soldering.
- **Industry facts**
  - Since **lead free solder paste (tin alloy) melt between 217°C-221°C**, higher temperature purpose is solely to facilitate heat transfer.
  - ST is not aware of any reflow profile used in production in the Mobile Industry to go over 260°C.
- **Safe Requirements for rework**:
  - **Safely de-solder ToF sensor from any PCB**
    - **Targeted 260°C (real temperature) on ToF sensor. Max 275°C (real temperature)**
  - **Safe protection** of ToF sensor during removal of other components around.
    - **Maximum Real temperature of 260°C on ToF sensor.**
  - **Safe re-soldering**
    - **Manual re-soldering: Maximum Real temperature of 260°C on ToF sensor plastic cap.**
    - **Standard Reflow soldering profile applied: Maximum Real temperature of 260°C**



Example of
de-soldering at 350**°C**

Rework responsibilities

- This is the responsibility of ST's customer during PCB rework to respect maximum Real temperature as described here:
  - **Safe de-soldering ToF sensor from any PCB: Maximum Real temperature of 275°C on ToF sensor measured on plastic cap topside.**
  - **Safe protection** or ToF sensor during removal of other components around: **Max 260°C (real temperature on ToF sensor plastic cap)**
  - **Safe Manual re-soldering: Maximum Real temperature of 260°C on ToF sensor measured on plastic cap topside.**
  - **Standard Reflow soldering profile applied: Maximum Real temperature of 260°C on ToF sensor measured on plastic cap topside.**

- This is the responsibility of ST's customer to ensure all tools, equipment are going to guarantee above temperature requirements and are calibrated.
  - 5% error on thermometer means to set the Hot air blow such as the maximum temperature reported by the thermometer is 0.95%*max temperature.
  - 10% error on thermometer means to set the Hot air blow such as the maximum temperature reported by the thermometer is 0.90%*max temperature.

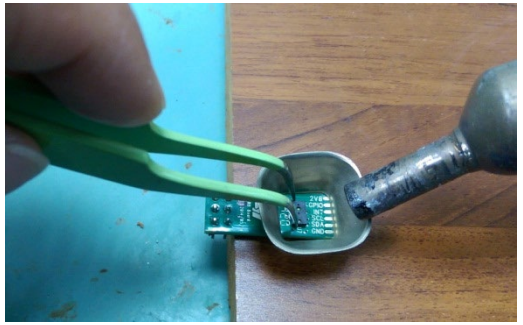
ToF sensor module

Temperature prerequisites to de-soldering and re-soldering

- **ST can guarantee 3x reflow solderings**
  - **ToF sensor is JEDEC Level 3 compliant:** All components in the ToF sensor module are designed and qualified to withstand 3x lead free reflow (up to 260°C).
- **ST can NOT guarantee 4x reflow solderings**
  - If the customer application requires ToF sensor to withstand 3 reflow soldering during manufacturing, in case of rework, ToF sensor should be de-soldered and replaced by another ToF sensor for re-soldering on PCB and phone calibration will be required again.
- **ST recommends:**
  - **De-soldering at 260°C (or lower)**
    - ST has made experiments up to 275°C peak temperature re-soldering which confirms no module deformation at this temperature. **Over 275°C, risk of functional issues.**
  - **Automated PCB re-soldering at 245°C with ST's recommended reflow profile.**
  - **Manual PCB re-soldering at 260°C max.**

Safe de-soldering techniques

Safe De-soldering flow *with protection cube*



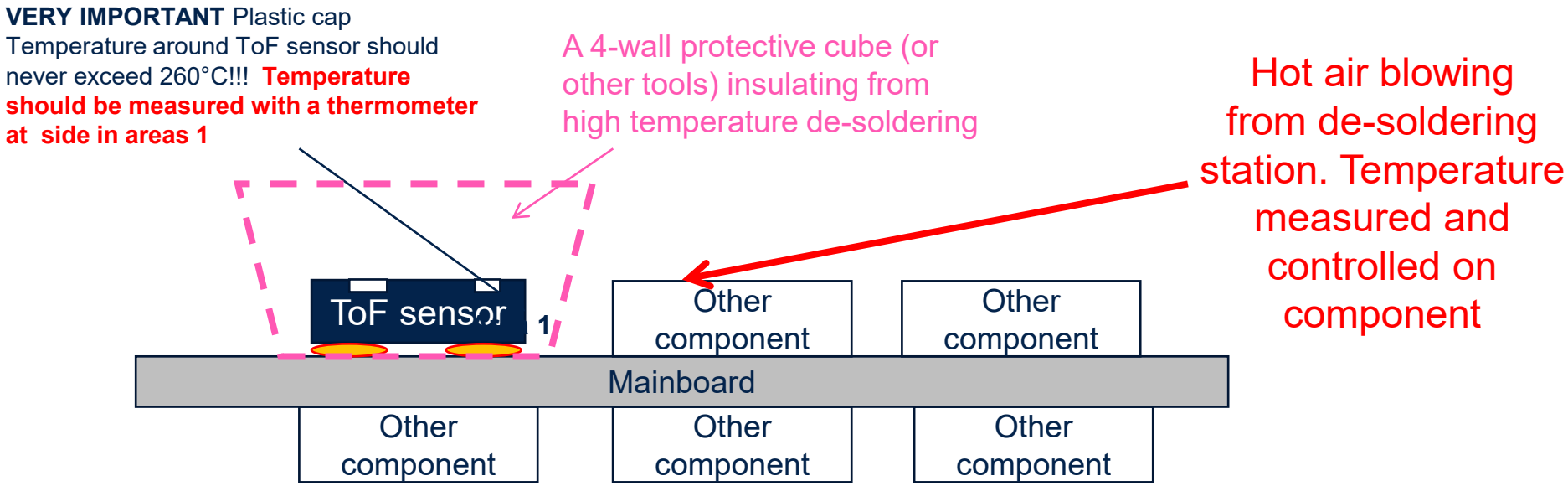
A de-soldering air blowing station causes heating due to both convection and irradiation and is known to have a poor temperature control and regulation that will be dependent on the specific manufacturer.

1. Fixing PCB with ToF sensor on rework station/base board
2. Placement of protection cube on PCB around the ToF sensor
3. Place a thermometer probe above the ToF sensor plastic topside. Choose a well calibrated thermometer (+/-5% accuracy).
4. Set hot air temperature to 250°C and increase/decrease until thermometer indicates 260°C.
5. The distance between gun and ToF sensor should be around 1~2 centimeters with an angle of 45°C. Control temperature to 260°C.
6. After less than 60 seconds, ToF sensor can be removed from PCB with tweezers.
7. Safety handling

Protecting ToF sensor during other component(s) de-soldering

De-soldering of a different component **on same side** as ToF sensor

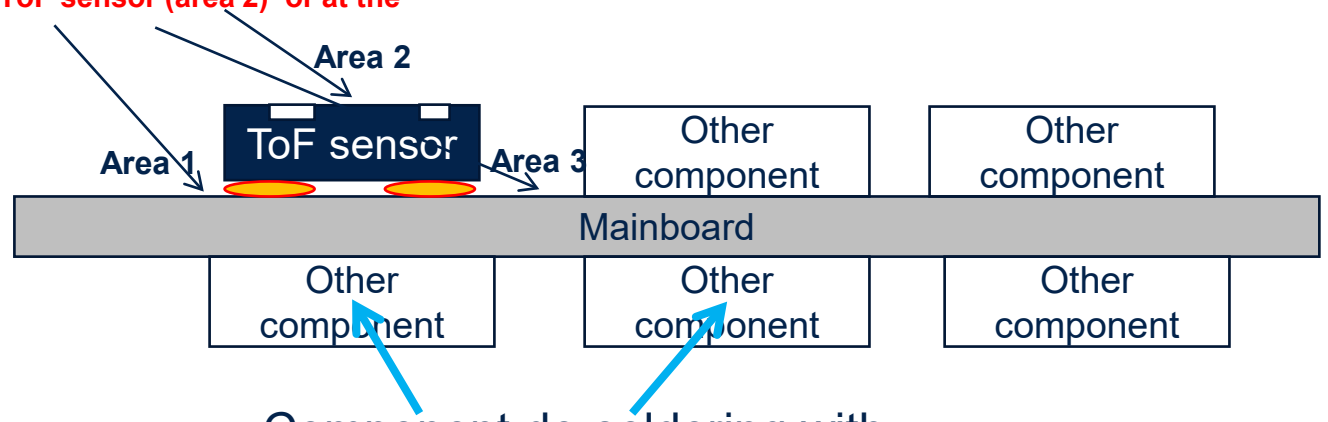
- If during rework, it is required to de-solder a component on same side as the ToF sensor, it is required that the temperature of ToF sensor is monitored to **ensure it is maximum at 260°C. This corresponds to the device Real temperature.**
- A 5% error on thermometer means to set the Hot air blow such as the maximum temperature reported by the thermometer is 0.95%*max temperature.
  - As an example: For 260°C maximum temperature at ToF sensor, it means for a 5% accurate thermometer, maximum temperature measured on the side of the ToF sensor (area 1) should be 0.95*260=247°C.



De-soldering of a different component **on opposite side** as ToF sensor

- If during rework, it is required to de-solder a component on opposite side (on PCB) of the ToF sensor, it is required that the temperature of the ToF sensor is monitored to **ensure it is maximum at 260°C. This corresponds to the device Real temperature.**
- A 5% error on thermometer means to set the Hot air blow such as the maximum temperature reported by the thermometer is 0.95%*max temperature.
  - As an example: For 260°C maximum temperature at the ToF sensor , it means for a 5% accurate thermometer, maximum temperature measured on the side of the ToF sensor (area 1) should be 0.95*260=247°C.

VERY IMPORTANT Plastic cap Temperature around ToF sensor should never exceed 260°C!!!
Temperature should be measured with a thermometer around ToF sensor (area 2) or at the PCB (in areas 1 or 3)

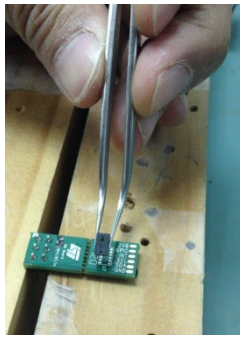


Component de-soldering with
Hot air blowing from de-soldering station.

Safe manual re-soldering

Basic Manual re-soldering rules for ToF sensors

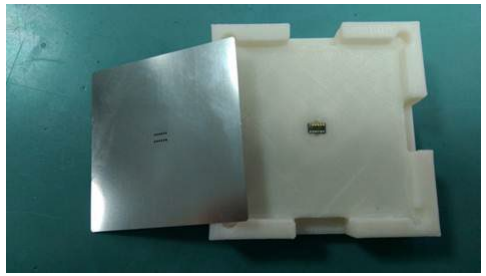
- ToF sensor are optical devices. Careful handling during.
- Safe Manual re-soldering: Maximum Real temperature of 260°C on ToF sensor measured on plastic cap topside.
  - **Recommended manual re-soldering at 250°C** to account for soldering station and thermometer accuracy limitations.
    - 5% error on thermometer and 5% error at hot air station can lead up to real 262°C temperature on ToF sensor for a hot air blow programming of 250°C
- When a new ToF sensor is to be manually re-soldered on a reworked PCB, coplanarity and airgap (distance from the top of the ToF sensor to the bottom of the coverglass) are to be within tolerance limits of the system assembly.
  - When in phone fully assembled, any major airgap, x-y placement error or coplanarity change can affect distance ranging capability and its accuracy.
  - The ToF sensor has 2 small cavities and should be protected from dust, pollution during manual soldering.
  - A re-calibration on the production line of the new ToF sensor s is required when phone is fully re-assembled.
- If the customer application requires ToF sensor to withstand 3 reflow soldering during manufacturing, in case of rework, ToF sensor device should be de-soldered and replaced by a new ToF sensor for re-soldering on PCB



Safe Re-soldering flow with protection cube

1. Position the ToF sensor on top of a fixture. Pads facing upwards.
2. Align the ToF sensor pads with stencil holes (pads facing upwards).
3. Put some solder paste on the stencil
4. Remove the ToF sensor from the fixture and position it on top of the PCB
5. Placement of protection cube on PCB around the ToF sensor sensors
6. Set the hot air temperature to approximately 215°C and a air blowing level of 30%
7. Place a thermometer probe above the top surface of the ToF sensor module to monitor temperature (+/-5% temperature accuracy).
8. Apply hot air blowing gun at a distance of around **1~2 centimeters** from ToF sensor
9. After a heating time of 1 minute the device will be soldered to the PCB

Stencil + fixture

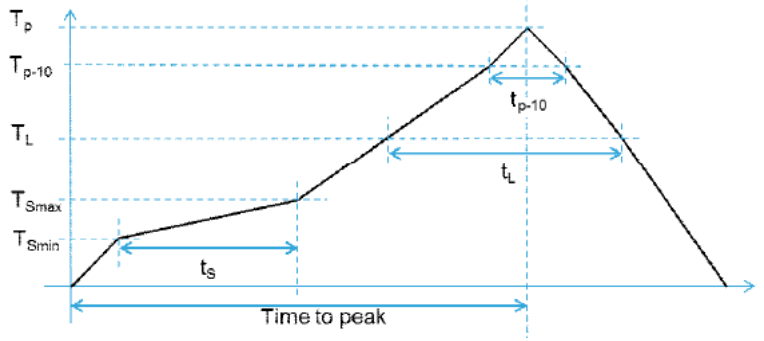


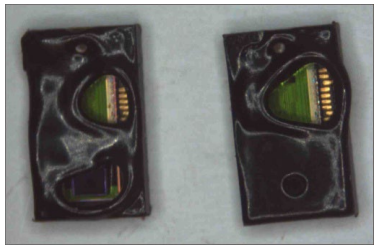
Troubleshooting

Soldering Issues

- ST recommended reflow soldering profile is to be followed and is not a standard profile (like for non-optical ICs)
- ST can guarantee 3x reflow solderings: ToF products are JEDEC Level 3 compliant: All components in the ToF module are designed and qualified **to withstand maximum 3x lead free reflow (up to 260°C). Refer to datasheet**

Parameters	Recommended	Maximum	Units
Minimum temperature (T_S min)	130	150	°C
Maximum temperature (T_S max)	200	200	°C
Time t_s (T_S min to T_S max)	90-110	60-120	s
Temperature (T_L)	217	217	°C
Time (t_L)	55-65	55-65	s
Ramp up	2	3	°C/s
Temperature (T_{p-10})	—	235	°C
Time (t_{p-10})	—	10	s
Ramp up	—	3	°C/s
Peak temperature (T_p)	240	260	°C
Time to peak	300	300	s
Ramp down (peak to T_L)	-4	-6	°C/s





Example of
de-soldering at 350**°C**

- All ST products are MSL level 3 compliant devices

IPC/JEDEC J-STD-033C February 2012

Table 4-1 Reference Conditions for Drying Mounted or Unmounted SMD Packages (User Bake: Floor life begins counting at time = 0 after bake)

Package Body	Level	Bake @ 125 °C +10/-0 °C		Bake @ 90 °C +8/-0 °C ≤5% RH		Bake @ 40 °C +5/-0 °C ≤5% RH	
		Exceeding Floor Life by >72 h	Exceeding Floor Life by ≤72 h	Exceeding Floor Life by >72 h	Exceeding Floor Life by ≤72 h	Exceeding Floor Life by >72 h	Exceeding Floor Life by ≤72 h
Thickness ≤4 mm	2	5 hours	3 hours	17 hours	11 hours	8 days	5 days
	2a	7 hours	5 hours	23 hours	13 hours	9 days	7 days
	3	9 hours	7 hours	33 hours	23 hours	13 days	9 days
	4	11 hours	7 hours	37 hours	25 hours	15 days	9 days
	5	12 hours	7 hours	41 hours	24 hours	17 days	10 days
	5a	16 hours	10 hours	54 hours	24 hours	22 days	10 days

Thank you

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