High accuracy in Ultra-Low-Pressure Sensors: Managing offset shifts after solder reflow

Application Note

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Abstract

Ultra-low-pressure sensors provide exceptionally high sensitivity for applications such as airflow, HVAC, and industrial control. Due to this sensitivity, mechanical stresses introduced during surface-mount reflow soldering can result in measurable offset shifts. This application note explains the physical mechanisms responsible for this behavior and summarizes post-reflow test results for the LP2-1440 Series and provides assembly and post-reflow calibration recommendations to ensure stable system-level performance. The guidelines presented for the LP2-1440 are broadly applicable to Merit Sensor Systems' low- and ultra-low-pressure sensor products intended for surface-mount reflow assembly.

Introduction

Surface-mount reflow soldering exposes sensors and PCBs to elevated temperatures and significant thermal gradients. For ultra-low-pressure MEMS sensors, these conditions can induce residual mechanical stresses that influence the zero-pressure output after assembly. While these effects are generally small, they can represent a meaningful percentage of full scale for sensors operating at very low-pressure ranges.

LP2-1440 Series Overview

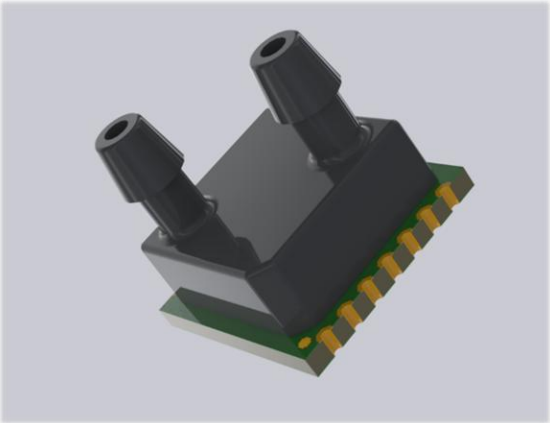

Figure 1 - LP2 Series

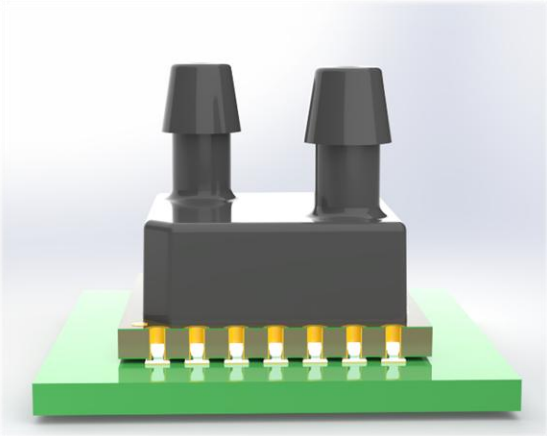

Figure 2 - Reflowed LP2 Series

The LP2-1440 Series is a surface-mount differential pressure sensor family based on piezoresistive MEMS technology. Pressure applied across the sensing diaphragm produces mechanical strain that is converted into an electrical output. Because the sensing mechanism directly responds to mechanical stress, the device is inherently sensitive to package and PCB-induced stresses introduced during assembly steps and solder reflow.

Post-Reflow Offset Shift Definition

Post-reflow offset shift is defined as the change in sensor output measured at zero pressure before reflowing compared to after reflowing and cooldown. This phenomenon is distinct from output change due to temperature change during operation, long-term aging drift, or pressure hysteresis.

Physical Mechanisms

Post-reflow offset shift is primarily caused by thermal expansion (TCE) mismatch between the silicon die, package materials, solder joints, and PCB. Residual mechanical stress may be transferred from the application circuit board, and sensor package, to the MEMS diaphragm, and this mechanical stress can partially relax (come back to equilibrium), over time, following reflow.

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Post-Reflow Calibration

Final Post Calibration Offset Correction should be performed **after all reflow steps and after allowing sufficient time for mechanical stress relaxation**. This ensures assembly-induced offset shifts are properly compensated at the system level.

For more information about Post Calibration Offset Correction please check Merit Sensor` s *App Note 108:*

https://meritsensor.com/assets/documents/pdf/an108-%20post-calibration-offset-correction-on-pressure-sensors.pdf

Post-Reflow Assembly Recommendations

Merit Sensor Systems conducted post-reflow offset stability testing on **LP2-1440** variants using standard lead-free reflow conditions. All measurements were performed at room temperature with both pressure ports at atmospheric pressure.

See reflowing recommendations at section “Design and Assembling Recommendations” below.

LP2-1440: 150Pa (0.6 inch of H_2O):

A measurable offset shift is observed a few hours after reflowing, followed by slow increase over the next few days. The lower pressure ranges make this variant more sensitive to assembly-induced stress relative to full scale.

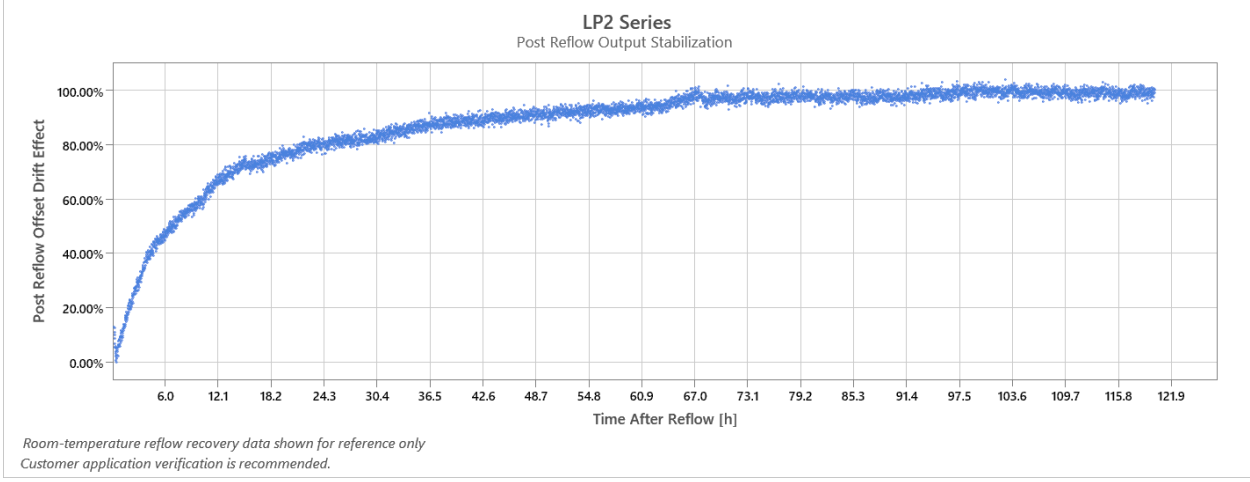

Figure 3 – Post-Reflow Drift Effect X Time After Reflowing Ultra the LP2-150Pa (0.6 inch of H_2O)

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Suggested waiting times between reflow and offset correction:

- 12hrs after reflowing will show around 70% of reflow-drift effects
- 24hrs after reflowing will show around 80% of reflow-drift effects
- 72hrs after reflowing will show around 100% of reflow-drift effects

Note on Pressure Range Dependency - Pressure ranges up to 2500Pa (10 inches of H_2O)

The post-reflow testing presented in this application note was performed using the LP2-1440 150 Pa (0.6 inch of H_2O) pressure variant. Due to the lower full-scale range, this device is inherently more sensitive to assembly-induced mechanical stress when evaluated as a percentage of full scale. LP2-1440 devices with higher full-scale pressure ranges are expected to exhibit reduced relative post-reflow offset shift and faster stabilization behavior under similar assembly conditions.

LP2-1440: 2500 Pa range (10 inches of H_2O):

Offset shifts on higher pressure ranges are smaller relative to full scale and stabilize more quickly.

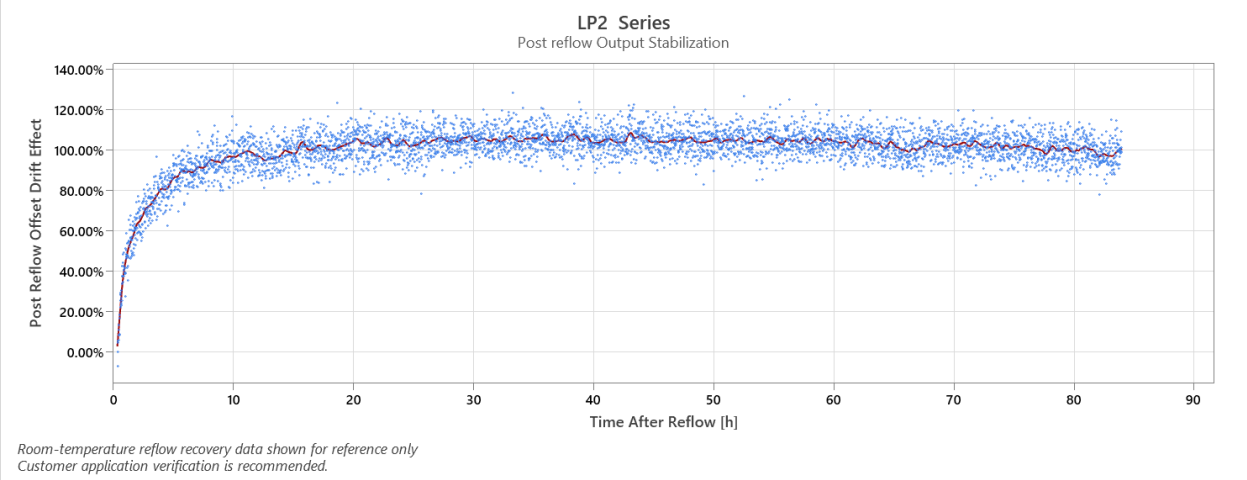

Figure 4 – Post-Reflow Drift Effect X Time After Reflowing the LP2-2500Pa (10 inches of H_2O)

Suggested waiting times between reflow and offset correction:

- 5hrs after reflowing will show around 80% of reflow-drift effects

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- 10hrs after reflowing will show around 100% of reflow-drift effects

Note on Pressure Range Dependency - Pressure ranges > 2500Pa (10 inches of H_2O)

The post-reflow testing presented in this application note was performed using the LP2-1440 2500 Pa (10 inches of H_2O) pressure variant. Due to the lower full-scale range, this device is inherently more sensitive to assembly-induced mechanical stress when evaluated as a percentage of full scale. LP2-1440 devices with higher full-scale pressure ranges are expected to exhibit reduced relative post-reflow offset shift and faster stabilization behavior under similar assembly conditions.

Design and Assembly Recommendations

To minimize post-reflow offset effects, avoid asymmetric copper layouts beneath the sensor, limit mechanical constraint around the footprint, and follow standard lead-free reflow profiles without excessive peak temperature or dwell time.

Reflowing recommendations:

Please check Merit Sensor`s App *Note 101* for reflowing guidance:

https://meritsensor.com/assets/documents/pdf/an101-reflow-soldering.pdf

Summary

Post-reflow offset shift is a normal and manageable characteristic of ultra-low-pressure MEMS sensors. With appropriate PCB design, assembly control, and post-reflow calibration, LP2-1440 sensors deliver stable and repeatable performance in surface-mount applications.

References

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