ANALOG DEVICES

AN-652
APPLICATION NOTE

One Technology Way • P.O. Box 9106 • Norwood, MA 02062-9106 • Tel: 781/329-4700 • Fax: 781/326-8703 • www.analog.com

Considerations for Soldering Accelerometers in LCC-8 Packages onto Printed Circuit Boards

By Hubert Geitner

INTRODUCTION

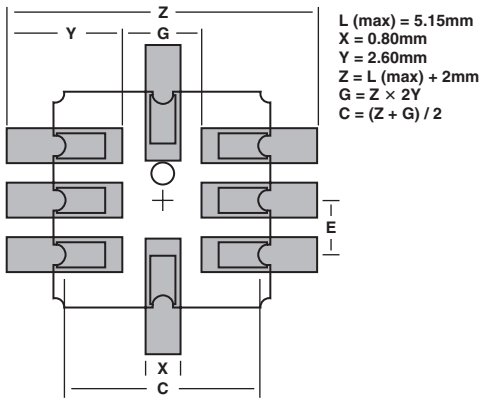
The ADXL78/ADXL278/ADXL193 are low cost, complete single-axis or dual-axis accelerometers that can measure both static acceleration like tilt or gravity and dynamic acceleration like shock and vibration. They are available in an ultrasmall ceramic leadless chip carrier package (LCC-8). The ceramic package is hermetically sealed with a metal lid and can be soldered onto a printed circuit board (PCB). This application note discusses what to consider when soldering an LCC-8 package to a PCB.

PCB DESIGN AND LAYOUT

Land pattern and pad sizes should be tested and qualified in the manufacturing process. IPC, The Association Connecting Electronics Industries, created the Surface Mount Design and Land Pattern Standard (IPC-SM-782). A recommended pad design is shown in Figure 1.

Symmetry and balance are important considerations for the PCB layout and design. Traces should be connected to the pads in a symmetric fashion. Asymmetric pads or several connections to one pad would lead to solder migration. Balanced trace entry to the pad minimizes component rotation. Vias and through holes should not be part of the pad.

Additionally, solder mask thickness has to be monitored if the component is not placed into a solder mask window.



	X	Y	Z	G	C	E
LCC-8 PAD (mm)	0.80	2.60	7.15	1.95	4.55	1.27
LCC-8 PAD (mils)	31.5	102	281	76.8	179	50.0

Figure 1. LCC-8 IPC Land Pattern (IPC-SM-782)

SOLDERING

The LCC-8 is a leadless SMD package and is soldered predominantly using reflow techniques. To avoid deterioration of the hermetic solder seal, the LCC-8 should not be wave soldered.

During soldering, there are several potential error sources to consider. To minimize measurement errors, accelerometers need to point exactly to a known direction. Using the recommended land patterns (Figure 1) will give a very close alignment of the package to the given in-plane direction from the layout of the land pattern.

Experiments conducted by Analog Devices showed that all 160 units of a population correctly self-aligned to the pads after reflow even if the placement of the component was fairly coarse (but within the limits of the castellation). The surface tension of the liquid solder pulls the component into the pad-given position. No visual rotational misalignment was evident and measurements showed very good alignment performance of the LCC package (Figures 2 to 5).

RELIABILITY

An LCC-8 package has a ceramic base, so its coefficient of thermal expansion (CTE) is different from that of FR4, a commonly used PCB material. Leadless packages do not have leads to take the stress of the CTE mismatch, so the solder has to handle this stress. The larger the LCC package, the higher the stress. An LCC-8 package, however, is very small (5 mm × 5 mm). The effects of CTE mismatch are much smaller than with larger LCC packages and are more similar to other small ceramic components, such as passive chip arrays.

Internal and external research (temperature cycling tests with various temperatures, dwell times, and solder heights) showed that the reliability depends on the solder thickness. A thickness of 4 mils is more reliable than a thickness of 1 mil, but even the 1 mil solder height showed very good performance. For improved reliability in extreme applications, solder heights greater than 1 mil are recommended. Uniform solder distribution contributes to higher reliability.

Table I shows the number of failure-free cycles at different solder heights and temperature cycles. A total of 128 sensors were used for temperature cycling tests.

Table I. Failure-Free Cycles

		Number of Cycles			
Thermal Cycle (°C)	**Dwell Time (Minutes)**	**1 mil Solder Height**	**2 mil Solder Height**	**3 mil Solder Height**	**4 mil Solder Height**
+25/+35	60/60	624400	647900	668600	687700
–40/+105	60/60	833	1114	1399	1698
–40/+125	10/10	430.5	651	884	1131
–40/+85	60/60	1731	2109	2486	2875
–40/+105	20/20	950	1246	1546	1858
–40/+105	30/30	914	1206	1502	1810
0/+100	30/30	952	1335	1743	2179

Another reliability consideration is gold embrittlement. The LCC-8 castellation (contact area) has tungsten as a base material, nickel as the middle layer, and gold as the top layer.

A mass of more than 2.5% gold inside the solder will significantly change the Young's modulus (C.J. Thwaites, 1973). Tests with a standard PbSn paste soldering profile (Figure 2) showed that the mass contribution of gold in the solder is 0.47% (Figure 6) at the given geometries. The solder volume is based on an 8 mil stencil with 5% aperture reduction. This amount of gold does not raise a concern for the reliability of the solder joint of an LCC-8 package. Results from testing confirmed that there is no significant difference between gold-plated and pre-tinned units.

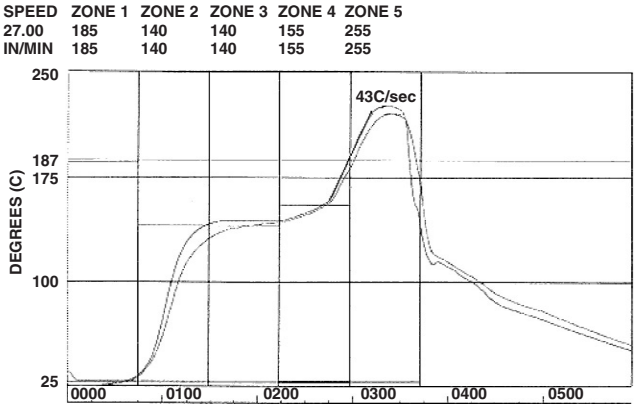


Figure 2. Tests with Standard PbSn Paste Soldering; The LCC Package Supports Standard Reflow Profiles

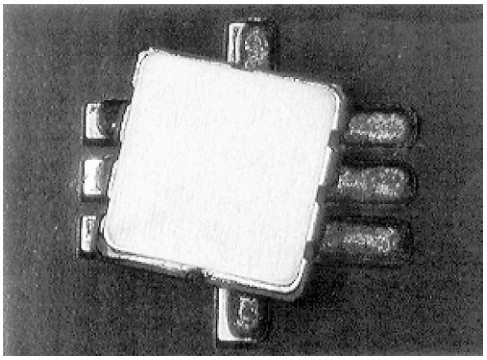


Figure 3. Package-to-Board Alignment (before Reflow)

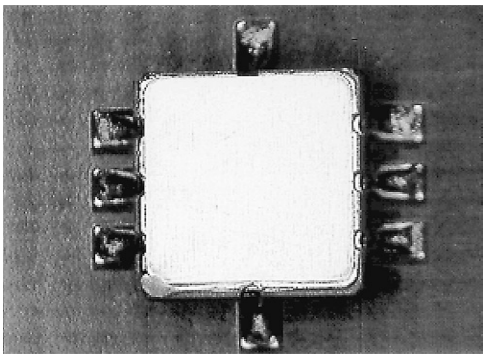


Figure 4. Package-to-Board Alignment (after Reflow)

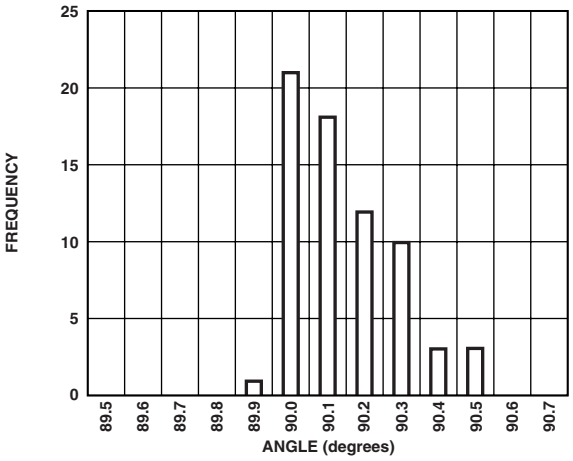


Figure 5. LCC Angle Alignment after Solder; The LCC Package Aligns Very Well to the Pads of the Layout after Reflow Soldering

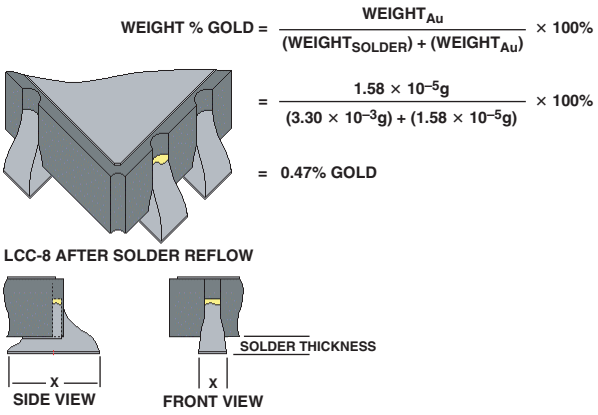


Figure 6. LCC-8 Percent Gold by Weight Calculation

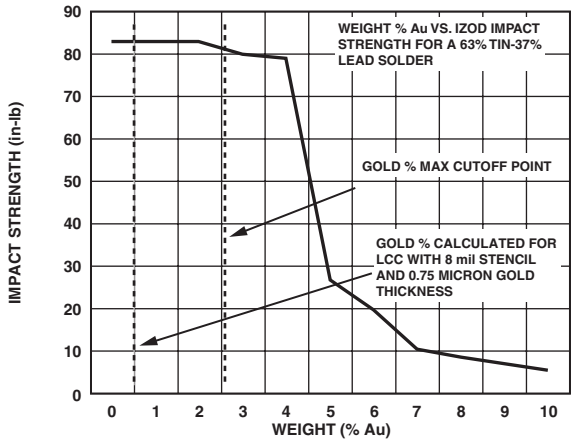


Figure 7. Gold Embrittlement of Solder Joint (Source: "Some Aspects of Soldering Gold Surfaces," C.J. Thwaites, Tin Research Institute, 1973)

CONCLUSION

The assembly of the ceramic LCC-8 leadless chip carrier package onto the FR4 printed circuit board has excellent self-alignment capabilities. With the recommended land pattern and solder height, the CTE mismatch of the small package on the PCB has proven to be noncritical. Gold-plated castellation did not lead to a level of gold embrittlement that would change the Young's modulus and, therefore, the reliability of the solder joints is very high.

ACKNOWLEDGEMENT

This application note is based on research and development results of a multidisciplined group around Allyson Hartzell and Brad Workman of Analog Devices Micromachined Products Division.

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