

Application Note AN-3011

Surface Mounting Technology Assembly Guidelines for Fairchild's Microcouplers™ (Ball Grid Array)

Optocoupler technology, consisting of a light source and a photosensitive detector surrounded by a transparent light pipe housed in an epoxy plastic package, has been around for the last thirty to forty years. Traditional optocouplers offer insulation safety and electrical signal isolation between input and output. However, today's DC/DC converters demand optocouplers that are highly efficient, capable of handling higher temperatures, and available in much smaller packaging than ever before.

To that end, Fairchild's FODB100 family of surface-mount, Pb-free microcouplers™ are among the first in the industry to significantly reduce the package footprint while improving thermal performance. Additionally, these innovative optocouplers use an AlGaAs (Aluminum Gallium Arsenide) diode which provides higher efficiency and better stability over a range of temperatures than a standard GaAs (Gallium Arsenide) diode.

Since these products utilize Fairchild's advanced BGA packaging, they call for an updated approach to SMT (Surface Mounting Technology) assembly. In this application note, we will detail the steps and guidelines for assembling these devices as well as providing an overview of the advantages of the microcoupler's BGA assembly platform.

SMT Assembly Overview

In order to realize the advantages of the microcoupler's small, innovative packaging, it is first necessary to understand the SMT assembly process.

The key steps of successful SMT assembly include:

1. Screen printing solder paste on the printed circuit board (PCB)
2. Placing components on the PCB
3. Solder reflow
4. Flux removal (recommended to used non cleaning flux)

Tips and recommendations on how to effectively complete these steps are provided in the following sections.

Printing Circuit Board Design

As shown in Figure 1, two basic types of land patterns are used for surface mount packages:

- NSMD or non-solder mask defined pads. These pads have a larger mask opening than the metal pads.
- SMD or solder mask defined pads. These pads have a smaller solder mask opening than the metal pads.

Although both types of pads can be used in this application, NSMD-type pads are highly recommended for most applications. They have the advantage of tighter copper dimensions, compared to solder mask dimensions, and the uniform coverage is better at the solder melting temperature. An additional advantage is the lower stress concentration on the microcoupler solder joint and the accompanying increased solder joint reliability. However, this advantage can only be realized when NSMD pads are employed on both the PCB and the microcoupler.

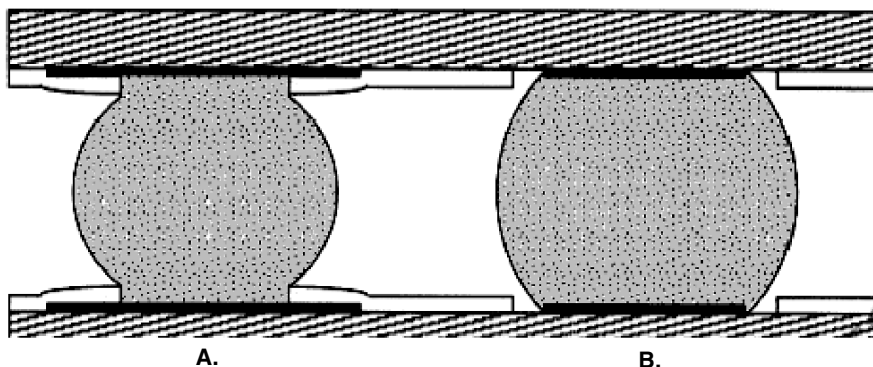


Figure 1. A comparison of the microcoupler's solder joints. "A" shows a solder-mask defined pad, and "B" shows a non-solder mask defined pad.

Compared to the NSMD pads, the SMD pads have a greater copper area and their solder-mask overlap has better adhesion strength to the fiber/glass laminate. This extra bending and accelerated thermal cycling testing causes a weak link where the pad is adhered to the PCB and could be the main failure location, as opposed to the typical solder fracture.

Table 1. Recommended NSMD Pad and Mask Opening Sizes

Pad Layout	Solderable Pad Size	Solder Mask Opening Size
NSMD	$0.65 \pm 0.05\text{mm}$	$0.80 \pm 0.05\text{mm}$

In addition to the recommendations shown in Table 1, it is highly recommended that the solderable pads be 1oz copper in thickness and have an electroplated nickel-immersion gold finish.

Table 2 shows the reliability data for the microcoupler mounted to the NSMD pad during thermal cycle tests.

Figure 2 shows the recommend landing pad for the microcoupler (FODB10X).

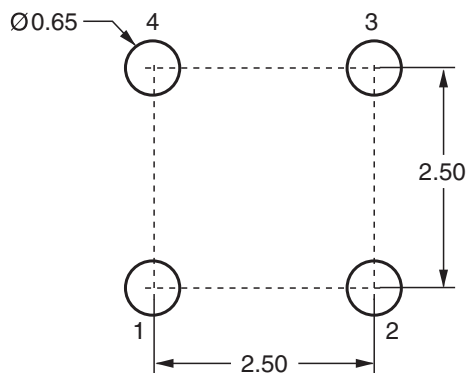


Figure 2. Microcoupler (FODB10X) Footprint for PCB Layout

The traces that connect the solderable pads should be 0.15 to 0.2 mm wide to avoid excessive wetting that might reduce the standoff. The good thermal isolation of the traces results in an excellent solder joint. One recommendation is to have the via connection very close to the trace that connects the pad. The via reduces the heat flow from the pads and maintains the heat on the pads resulting in a good solder joint formation.

Copper trace fan-outs for the NSMD PCBs should have the fan trace symmetrical across the X and Y axes. An asymmetric fan-out configuration may result in rotation of the part, due to the surface tension of solder. The copper track should be symmetrical, as outlined in Figure 3.

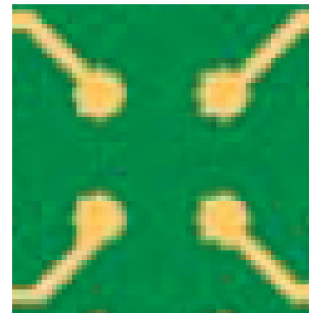


Figure 3. Symmetrical Copper Track in PCB Layout

Solder Paste Screen Printing on PCB

Solder paste, paste flux or liquid flux can be applied to the PCB prior to the assembly. Spraying, dispensing or foaming are all acceptable methods. This step is important to not only reduce the oxidation on the pad, but also the solder ball on the microcoupler. Mild oxidation may occur on the solder ball during storage, burn-in and dry baking in a non-inert environment. The most common reason to apply flux is to maintain the compatibility of the current process.

Table 2. Reliability Data

Device Name	FODB100				
RELIABILITY TEST	Duration	Sample Size	Qualification Lot #1	Qualification Lot #2	Qualification Lot #2
Component Level					
TMCL w/Level 1 Precon @ -40°C to +125°C, 15 min dwell	Precondition	45	0/45	0/45	0/45
	100 cycles	45	0/45	0/45	0/45
	200 cycles	45	0/45	0/45	0/45
Board Level					
TMCL @ -10°C to +100°C, 15 min dwell	100 cycles	45	0/45	0/45	0/45
	500 cycles	45	0/45	0/45	0/45
	1,000 cycles	45	0/45	0/45	0/45

The solder ball is comprised of the near eutectic solder and since its entire volume is molten during reflow, it is not necessary to add solder volume to the joint with solder paste. The 0.85mm-diameter ball provides enough volume to give a standoff height of 0.7mm to 0.75mm across the device, depending on the device to board pad configuration. The solder has a sufficient collapse height to ensure that no opens will occur due to board warpage at elevated temperatures. The recommended stencil thickness is 6mils and the aperture openings for the NSMD pads are $0.80 \pm 0.5\text{mm}$.

Solder Alloys and Lead-Free Requirements

Since the industry is shifting to meet the new lead-free requirements, Fairchild's microcoupler products were specifically designed to meet these requirements as well. Table 3 below shows all of the solder ball alloys. The current standard alloy used for the solder paste is a 63:37 Sn:Pb eutectic solder material with a liquidus temperature of 183°C. The recommended solder paste material is 95.5Sn 3.9Ag 0.7Cu with a liquidus temperature of 218°C.

Table 3. Solder Alloys

Composition	Solidus (°C)	Liquidus (°C)
62Sn36Pb2Ag (Sn62)	179	Eutectic
63Sn37Pb (Sn63)	183	Eutectic
86.9Sn10In3.1Ag	204	205
91.8Sn3.4Ag4.8Bi	211	213
96.2Sn2.5Ag0.8Cu0.5Sb	215	217
95.5Sn3.8Ag0.7Cu	217–218	Eutectic
95.5Sn3.9Ag0.6Cu	217–218	Eutectic
High Melting-Point Alloys		
95Pb5Sn	308	312
90Pb10Sn	274	302

Component Placement

The ball grid array in Fairchild's microcouplers employs relatively large pitches compared to other devices. For this reason, pick and place is much simpler and the requirements for machine accuracy are much lower. Additionally, due to the tight ball size to the device edge tolerances (better than ± 2 mils) relative to the pitch, visual inspection can be performed off the body outline. This is the method currently used for much smaller devices in the industry using high speed pick and place machines. New "look-up" equipment with upward-looking vision specifically designed for the ball grid array is widely available. This bottom-side inspection equipment centers off the ball array itself and can check for missing, misaligned, or defective balls, and in some cases, can calculate device co-planarity real time. Sometimes, only balls on the outer or perimeter row are recognized and used for placement.

Due to the fact that the microcoupler is self centering in the reflow process, a device can be placed up to 50% off pad and still be capable of successfully realigning itself. No underfill material is required to maintain the solder joint reliability. The 2.5mm pad pitch and 0.85mm ball size increases the solder joint reliability of this package. The self-centering feature, which is a result of the surface tension of the molten solder, can be easily observed by placing devices deliberately off pad and reflowing.

Solder Paste Reflow

The microcoupler is reflowed using a standard SMT reflow process. A nitrogen purge is highly recommended to promote quick and higher wetting force of the solder. Due to wide variations in PCB sizes, a temperature profile of the board is required with thermo-couples mounted at various locations on the board to determine the temperature gradient on the PCB.

The microcoupler's recommended temperature profile for a 95.5Sn 3.8Ag 0.7Cu solder reflow is shown in Figure 4.

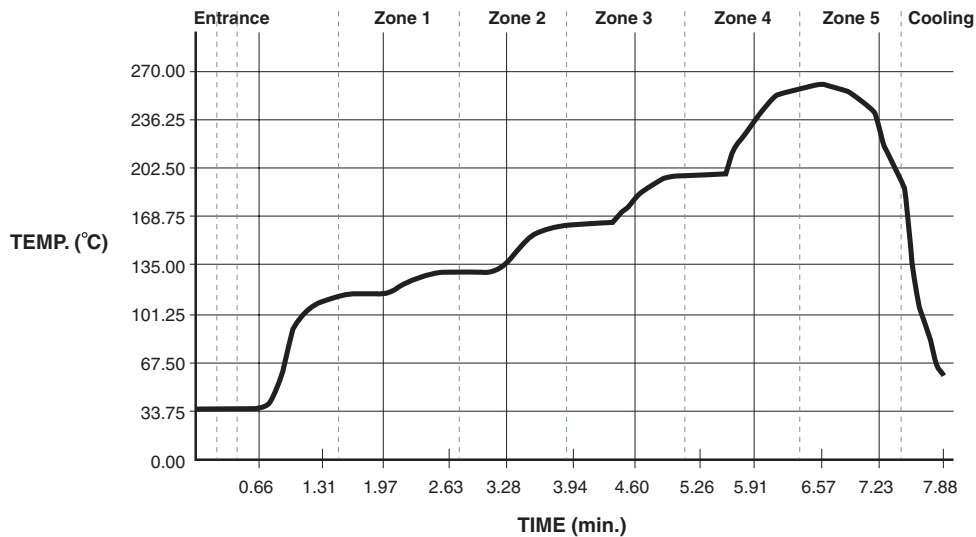


Figure 4. Recommended Infrared Reflow Soldering Profile

Reflow Profile for Pb Free

	Convection Reflow
Average ramp-up rate (183°C to peak)	3°C/sec max
Preheat temperature 125(±25)°C to 200°C	60–180°C
Temperature maintained above 220°C	60–150 sec
Time within 5°C of actual peak temperature	20–40 sec
Peak temperature range	260 ± 5°C
Ramp down rate	6°C/sec max
Time 25°C to peak temperature	8 min max

Summary

Fairchild's microcoupler products are simple to handle in the assembly area and use the same assembly process as the BGA platform. Since all of the solder balls are at the edge of the microcoupler package and are therefore visible with readily-available, bottom-side inspection equipment, costly and time-consuming x-ray inspection could be dropped from the inspection process altogether. In addition, the microcouplers meet the new lead-free requirements.

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