# Solder Reflow Guide for Surface Mount Devices

June 2009 Technical Note TN1076

## Introduction

This technical note provides general guidelines for a solder reflow and rework process for Lattice surface mount products. The data used in this document is based on IPC/JEDEC standards. Each board has its own profile which depends upon the reflow equipment used and the board design. The PCB must be individually characterized to find the reliable profile. This document covers both the SnPb Eutectic process and the Pb-Free process.

## Reflow

- Use caution when profiling to insure the maximum temperature difference between components is less than 10°C (7°C within an individual component).
- Forced convection reflow with nitrogen is preferred (with maximum oxygen content of 50-75 PPM).

## Inspection

- Pre-reflow: Use visual inspection to verify solder paste dispense location and quantity.
- Pick and Place: Use machine vision as necessary to ensure proper component placement.
- Post reflow: Use electrical testing to verify solder joint formation (100% post-reflow visual inspection is not recommended).

## Cleaning Recommendations

- After solder reflow, printed circuit boards should be thoroughly cleaned and dried using standard cleaning equipment.
- Final rinse should be warm DI water (50° to 75°C) with resistivity of 0.2 Meg Ohms/cm or greater.
- After cleaning, boards should be baked for a minimum of 1 hour at 125°C to evaporate residual moisture.

## Rework Recommendations

Removal and replacement of SMT packages on printed circuit boards is fairly straightforward. However, reattachment or touch-up of SMT packages that have already been soldered to the board is not practical in most cases.

A few important criteria should be considered when choosing a rework system:

- Minimize the change in temperature across the solder joint array to promote good solder joint formation, minimize intermetallic growth, improve solderability and minimize component warpage.
- Minimize die temperature to prevent die delamination and wire bond failure.
- Minimize board temperature adjacent to the rework site to reduce intermetallic growth, prevent secondary reflow, and prevent possible component delamination.
- For boards with no internal ground plane, apply localized heat to the SMT package. When the solder is molten, remove package using appropriate vacuum tool.
- While the board is still hot, remove excess solder from the site using a vacuum desoldering system or a soldering iron and solder wicking material. Use care to avoid damaging the solder pads or the surrounding solder mask.
- For PCBs with internal ground plane(s), preheat the entire board to at least 80°C before removing the SMT packages.

- Use alcohol to remove residual flux, then wash the entire board using the standard board cleaning process before attempting to replace SMT components.

## BGA Reballing

BGA reballing is not recommended. Reballed BGA packages will void the original Lattice specifications.

## Pb-Free/RoHS-Compliant Products

All Lattice Pb-Free products are also fully RoHS compliant. Lattice offers a broad range of Pb-Free/RoHS-compliant products in a variety of package configurations. These packages include the Thin Quad Flat Pack (TQFP), Quad Flat Pack (QFN), Fine Pitch BGA (fpBGA), Fine Pitch Super BGA (fpSBGA) and Chip-Scale BGA (csBGA).

## Peak Reflow Temperature ($T_P$) by Package Size

Table 1 illustrates the peak reflow temperatures by package size. Refer to the Package Diagrams document and use maximum package dimensions to determine package thickness and volume.

***Table 1. Peak Reflow Temperature ($T_P$)***

| Classification | Package Thickness | Volume < 350 $mm^3$ | Volume = 350 - 2000 $mm^3$ | Volume > 2000 $mm^3$ |
|---|---|---|---|---|
| SnPb Eutectic Package | < 2.5 mm | 240 + 0/-5°C | 225 + 0/-5°C | |
| | ≥ 2.5 mm | 225 + 0/-5°C | | |
| Pb-Free Package | < 1.6 mm | 260 + 0/-5°C | | |
| | 1.6 mm to < 2.5 mm | 260 + 0/-5°C | 250 + 0/-5°C | 245 + 0/-5°C |
| | ≥ 2.5 mm | 250 + 0/-5°C | 245 + 0/-5°C | |

Note: Package volume excludes external terminals (balls, bumps, lands, leads) and non-integral heat sinks.

Tables 2 and 3 show the peak reflow temperature for Lattice devices by package type and size.

***Table 2. Peak Reflow Temperature ($T_P$) by Package Type and Size, SnPb Packages***

| Package Type | Number of Leads/Balls | Moisture Sensitivity Level | Peak Reflow Temp (+0/-5°C) |
|---|---|---|---|
| caBGA | 49 | 3 | 240 |
| | 100 | 3 | 240 |
| | 256 | 3 | 240 |
| csBGA | 56 | 3 | 240 |
| | 64 | 3 | 240 |
| | 100 | 3 | 240 |
| | 132 | 3 | 240 |
| | 144 | 3 | 240 |
| ucBGA | 64 | 3 | 240 |
| | 132 | 3 | 240 |
| fcBGA | 1020 | 4 | 225 |
| | 1152 | 4 | 225 |
| | 1704 | 4 | 225 |

***Table 2. Peak Reflow Temperature ($T_P$) by Package Type and Size, SnPb Packages (Continued)***

| Package Type | Number of Leads/Balls | Moisture Sensitivity Level | Peak Reflow Temp (+0/-5°C) |
|---|---|---|---|
| fpBGA | 100 | 3 | 240 |
| | 144 | 3 | 240 |
| | 208 | 3 | 225 |
| | 256 | 3 | 225 |
| | 388 | 3 | 225 |
| | 416 | 3 | 225 |
| | 484 | 3 | 225 |
| | 516 | 3 | 225 |
| | 672 | 3 | 225 |
| | 676 | 3 | 225 |
| | 680 | 3 | 225 |
| | 900 | 3 | 225 |
| | 1152 | 3 | 225 |
| | 1156 | 3 | 225 |
| fpSBGA | 680 | 3 | 225 |
| | 1036 | 4 | 225 |
| ftBGA | 256 | 3 | 225 |
| | 324 | 3 | 225 |
| TQFP (thickness: 1.4mm) | 48 | 3 | 240 |
| | 64 | 3 | 240 |
| | 100 | 3 | 240 |
| | 128 | 3 | 240 |
| | 144 | 3 | 225 |
| | 176 | 3 | 225 |
| TQFP (thickness: 1.0mm) | 44 | 3 | 240 |
| | 48 | 3 | 240 |
| BGA | 272 | 3 | 225 |
| | 388 | 3 | 225 |
| | 492 | 3 | 225 |
| PLCC | 20 | 1 | 225 |
| | 28 | 1 | 225 |
| | 44 | 3 | 225 |
| | 68 | 3 | 225 |
| | 84 | 3 | 225 |
| PQFP | 100 | 3 | 225 |
| | 120 | 3 | 225 |
| | 128 | 3 | 225 |
| | 144 | 3 | 225 |
| | 160 | 3 | 225 |
| | 208 | 3 | 225 |
| | 240 | 3 | 225 |
| | 304 | 3 | 225 |
| PQFP with Heat Sink | 160 | 3 | 225 |
| | 208 | 3 | 225 |

*Table 2. Peak Reflow Temperature ($T_P$) by Package Type and Size, SnPb Packages (Continued)*

| Package Type | Number of Leads/Balls | Moisture Sensitivity Level | Peak Reflow Temp (+0/-5°C) |
|---|---|---|---|
| QFN | 24 | 1 | 240 |
| | 32 | 1 | 240 |
| | 48 | 3 | 240 |
| | 64 | 3 | 240 |
| SBGA | 256 | 3 | 225 |
| | 320 | 3 | 225 |
| | 352 | 3 | 225 |
| | 432 | 3 | 225 |
| | 600 | 3 | 225 |
| SSOP | 28 | 1 | 225 |

*Table 3. Peak Reflow Temperature ($T_P$) by Package Type and Size, Pb-Free Packages*

| Package Type | Number of Leads/Balls | Moisture Sensitivity Level | Peak Reflow Temp (+0/-5°C) |
|---|---|---|---|
| caBGA | 49 | 3 | 260 |
| | 100 | 3 | 260 |
| | 256 | 3 | 260 |
| csBGA | 56 | 3 | 260 |
| | 64 | 3 | 260 |
| | 100 | 3 | 260 |
| | 132 | 3 | 260 |
| | 144 | 3 | 260 |
| ucBGA | 64 | 3 | 260 |
| | 132 | 3 | 260 |
| fcBGA | 1020 | 4 | 245 |
| | 1152 | 4 | 245 |
| | 1704 | 4 | 245 |
| fpBGA | 100 | 3 | 260 |
| | 144 | 3 | 250 |
| | 208 | 3 | 250 |
| | 256 | 3 | 250 |
| | 388 | 3 | 250 |
| | 484 | 3 | 250 |
| | 516 | 3 | 250 |
| | 672 | 3 | 250 |
| | 680 | 3 | 250 |
| | 900 | 3 | 250 |
| | 1152 | 3 | 250 |
| | 1156 | 3 | 250 |
| ftBGA | 256 | 3 | 260 |
| | 324 | 3 | 260 |

***Table 3. Peak Reflow Temperature ($T_P$) by Package Type and Size, Pb-Free Packages (Continued)***

| Package Type | Number of Leads/Balls | Moisture Sensitivity Level | Peak Reflow Temp (+0/-5°C) |
|---|---|---|---|
| TQFP (thickness: 1.4mm) | 44 | 3 | 260 |
| | 48 | 3 | 260 |
| | 64 | 3 | 260 |
| | 100 | 3 | 260 |
| | 128 | 3 | 260 |
| | 144 | 3 | 260 |
| | 176 | 3 | 260 |
| TQFP (thickness: 1.0mm) | 44 | 3 | 260 |
| | 48 | 3 | 260 |
| BGA | 272 | 3 | 250 |
| | 388 | 3 | 250 |
| PLCC | 20 | 1 | 250 |
| | 28 | 1 | 245 |
| | 44 | 3 | 245 |
| | 84 | 4 | 245 |
| PQFP | 100 | 3 | 245 |
| | 120 | 3 | 245 |
| | 128 | 3 | 245 |
| | 144 | 3 | 245 |
| | 160 | 3 | 245 |
| | 208 | 3 | 245 |
| QFN | 24 | 1 | 260 |
| | 32 | 1 | 260 |
| | 48 | 3 | 260 |
| | 64 | 3 | 260 |
| SBGA | 256 | 4 | 250 |
| | 320 | 4 | 250 |
| | 352 | 4 | 250 |
| | 432 | 4 | 245 |
| | 680 | 4 | 245 |

## Reflow Profile for SMT Packages

The typical reflow process includes four phases.

1. **Preheat** – Brings the assembly from 25°C to $T_S$. During this phase the solvent evaporates from the solder paste. Preheat temperature ramp rate should be less than 2°C/second to avoid solder ball spattering and bridging.

   - Solder Ball Spattering – The most common solder balling defect is spattering which is caused by explosive evaporation of solvents. It can be eliminated by a slower temperature rise in the preheat phase.
   - Bridging – Often seen on fine pitch components and usually caused by inaccurate or splashy screen printing. But it can also be a result of solder paste slumping caused by rapid temperature rise in the preheat phase.

2. **Flux Activation** – The temperature rises slowly and reaches a point at which the flux completely wets the surfaces to be soldered.

3. **Reflow** – In this phase, the temperature rises to a level sufficient to reflow the solder. The flux wicks surface oxides and contaminants away from the melted solder, resulting in a clean solder joint.

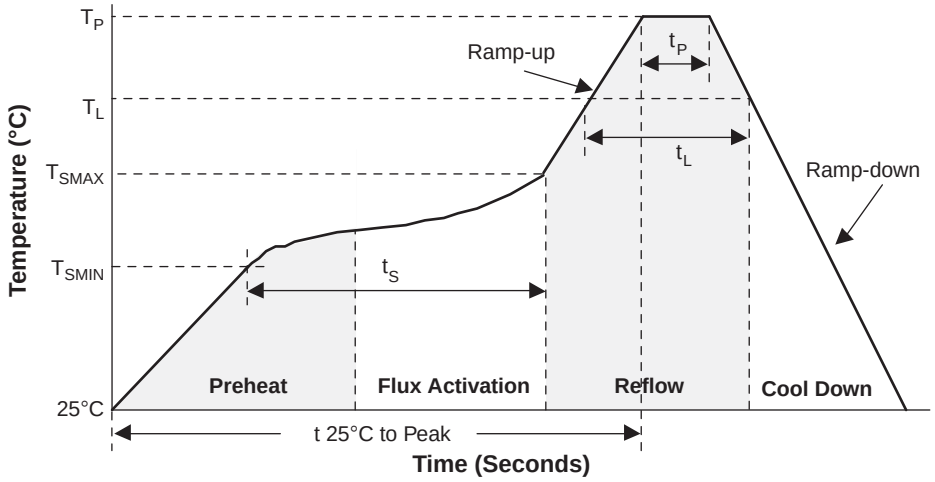
4. **Cool Down** – Ramp down rate should be as fast as possible in order to control grain size, but should not exceed 6°C/second.

Table 4 and Figure 1 describe the reflow profile.

***Table 4. Reflow Profiles***

| Parameter | Description | Sn-Pb Eutectic Package | Pb-Free Package |
|---|---|---|---|
| Ramp-Up | Average Ramp-Up Rate ($T_{SMAX}$ to $T_P$) | 3°C/second max. | 3°C/second max. |
| $T_{SMIN}$ | Preheat Peak Min. Temperature | 100°C | 150°C |
| $T_{SMAX}$ | Preheat Peak Max. Temperature | 150°C | 200°C |
| $t_S$ | Time between $T_{SMIN}$ and $T_{SMAX}$ | 60-120 seconds | 60-180 seconds |
| $T_L$ | Solder Melting Point | 183°C | 217°C |
| $t_L$ | Time Maintained above $T_L$ | 60-150 seconds | 60-150 seconds |
| $t_P$ | Time within 5°C of Peak Temperature | 10-30 seconds | 20-40 seconds |
| Ramp-Down | Ramp-Down Rate | 6°C/second max. | 6°C/second max. |
| t 25°C to $T_P$ | Time from 25°C to Peak Temperature | 6 minutes max. | 8 minutes max. |

***Figure 1. Thermal Reflow Profile***




## Technical Support Assistance

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## Revision History

| Date | Version | Change Summary |
|---|---|---|
| — | — | Previous Lattice releases. |
| April 2008 | 02.2 | Updated Peak Reflow Temperature ($T_P$) by Package Type and Size table. |
| June 2009 | 02.3 | Updated QFN information in Peak Reflow Temperature ($T_P$) by Package Type and Size, SnPb Packages table. |
| | | Updated QFN information in Peak Reflow Temperature ($T_P$) by Package Type and Size, Pb-Free Packages table. |