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(TB334) Guidelines for Soldering Surface Mount Components to PC Boards

1. Introduction

Special care must be taken when soldering surface mount components to a printed circuit (PC) board. There are 4 commonly used techniques for soldering surface mount components (SMCs) to a PC board. They are:

- Infrared (IR)
- Forced Convection (FC)
- Vapor Phase Reflow (VP)
- Wave Soldering (WS)

Infrared, Forced Convection and Vapor Phase reflow are the preferred soldering methods. Wave soldering typically involves increased heating rates, higher temperatures and increased flux exposure.

The primary phases of the reflow process are: flux activation, melting the solder particles in the solder paste, wetting the surfaces to be joined, and solidifying the solder into a strong metallurgical bond.

Optimum fusing of the component leads with the solder paste on the board is achieved when the leads attain the melting temperature of the plated solder alloy. The maximum heating and cooling rates (ramp rate) should be controlled to avoid thermal shock of the SMCs.

2. IR Reflow

The IR reflow technique involves transferring thermal energy supplied via infrared lamps to the circuit board, solder, and component. This heating approach in its basic form is essentially a line-of-sight surface-heating technique. Therefore, the amount of thermal energy absorbed varies with board size, component size, component orientation, and materials used. The surface temperature of the board is not uniform throughout the soldering process and board edges tend to run 10^oC to 20^oC higher than the temperature at the center of the board. Component overheating is possible if care is not taken to ensure the temperature remains relatively even across the board.

3. Forced Convection

The Forced Convection reflow technique involves transferring thermal energy supplied via heated air forced or blown on the circuit assembly from above and/or below. This method has some advantages over IR reflow processing. Board heating is more uniform compared with an IR process. Component overheating and thermal shock are also less likely, as components tend to change temperature at a rate closer to that of the PCB. Assembly size, component size, component orientation, and component material have less effect on the soldering process with forced convection as compared to the IR Reflow process.

4. Vapor Phase Reflow

The vapor phase reflow technique uses vapor from a boiling inert fluorocarbon liquid. The heat of condensation provides a thermal constraint dependent on the fluorocarbon liquid selected. A typical fluorocarbon liquid used in the industry has a boiling point of 215^{o}C. The PC board temperature exposure should be very uniform using this method. The temperature gradient across the surface of the board should be minimal. The component location design rules for even heating are not as sensitive as the rules for the IR reflow soldering process.

5. Solder Profile Development

Heating Rate - To avoid thermal shock to sensitive components the maximum heating rate should be controlled. It is desirable to hold the heating rate to less than 5^{o}C/s.

Preheat Zone - Boards should be preheated prior to the reflow step. Over-baking the solder paste and exceeding the glass transition temperature of the epoxy in FR-4 boards should be avoided. The temperature of the component and the PC board should be in the range of 105^{o}C to 145^{o}C depending upon the reflow method used.

Time above Solder Melting Point - It is recommended that the solder at the joint be kept above its melting point to allow for sufficient time for the solder to flow, wet the lands, and the leads. Total time above 180^{o}C. could range from 10 sec. to 150 sec. depending upon the type of equipment used, board size, component size, etc. Extended duration above the solder melting point may damage the board and sensitive components. This value should be minimized, but should also be chosen to allow for good solder joint formation. Most solder manufacturers will provide a recommended reflow profile based on solder composition and flux chemistry.

Peak Reflow Temperature - The peak temperature of the solder joint during reflow should be high enough for adequate flux action and solder flow to obtain good wetting. The maximum peak temperatures are 215^{o}C / 220^{o}C for Infrared and Forced Convection reflow and 215^{o}C / 219^{o}C for Vapor Phase reflow depending on package dimensions (Refer to J-STD-020A). Exposure time to peak temperatures should be minimized.

Cooling Rate - The cooling rate of the solder joint after reflow is important. Faster cooling rates, result in smaller grain size of the solder, and higher fatigue resistance. However, care should be taken to avoid an excessive temperature gradient resulting in potential component damage due to mechanical stress.

6. Summary of Soldering Precautions

The soldering process can create a thermal stress on any semiconductor component. The melting temperature of solder is higher than the maximum rated operating temperature of the device. The amount of time the device is at peak reflow temperature should be minimized to assure device reliability. Therefore, the following precautions should always be observed in order to minimize the thermal stress to which the devices are subjected.

1. Always preheat the device.

2. Keep the delta temperature between the preheating phase and soldering phase less than

100^oC.

3. Failure to preheat the device can result in excessive thermal stress which can damage the device.

4. The maximum temperature gradient should be less than 5^oC per second when transitioning from the preheating phase to soldering phase.

5. The maximum soldering temperature and time for wave soldering must not exceed 260^oC for 5s on the leads and case of the device.

6. The peak temperature in the soldering process should be at least 30^oC higher than the melting point of the solder chosen.

7. Forced cooling after the soldering phase will increase the temperature gradient and may result in latent failures due to mechanical stresses.

8. Mechanical stress or shock should be avoided during cooling.

PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

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