Multifuse® Polymer PTC Soldering Recommendations

Introduction

The most important consideration in reliability is achieving a good solder bond between a surface mount device (SMD) and substrate since the solder provides the thermal path from the chip. A good bond is less subject to thermal fatiguing and will result in improved device reliability. The most economical method of soldering is a process in which all components are soldered simultaneously.

Soldering of Polymer PTCs

Multifuse® Polymer PTCs are made from conductive filled polymer. In normal operation, the conductive particles in the polymer form a continuous path, which allows current to flow through the device without interruption. Typical base resistance of the device is hundreds of milliohms. When there is an overload condition, the polymer heats up internally from I^2R heating. When the polymer heats up to approximately 100-125 °C, its molecular structure changes from semi-crystalline to amorphous. This causes a macroscopic expansion, which breaks the conductive paths. When the conductive paths are broken there is a large increase in resistance - typically several orders of magnitude. At this point, the device is in the "tripped state".

Upon cooling, the polymer reforms to its semicrystallized state and the conductive pathways are reestablished. However, when the polymer recrystallizes it does not return immediately to the same base resistance. It does not compact as tightly as when it was pre-tripped, and therefore the post trip resistance is typically 50 % higher then the initial resistance. Note the post trip resistance increase is not a cumulative effect; additional tripping will not cause increases in resistance in excess of the first trip. Further resistance recovery is possible if the device is conditioned by actively current cycling the device or passively heating the device below 85 °C. *Figure 1* shows the change in resistance under temperature cycling or environmental cycling. This process is similar to an environmental burn in process, which is done by many circuit board manufacturers. Over a short number of cycles, the resistance typically decreases from 1.8 to 1.5 times the initial resistance.

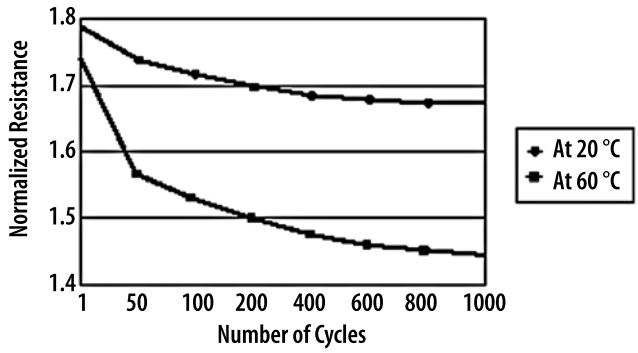


Figure 1: Resistance recovery after passive conditioning

Reflow Soldering

The preferred technique for mounting surface mount components on substrates is the method of reflow soldering. In a reflow process, the solder paste is printed on the component sites of the printed circuit board. Then the components are placed on the board on top of the solder paste. Often, a separate adhesive is used to hold the device in place until soldering takes place. The board and attached components are then heated to activate the flux, elevate the temperature of the base metals, and melt (or reflow) the solder.

Recommended substrates: Alumina or FR4 PCB material.

It is best to prepare the substrate by either dipping the substrate in a solder bath or by screen printing solder paste.

After the substrate is prepared, devices are picked and placed in position with vacuum pencils. The device may be placed without special alignment procedures due to its self-aligning properties during the solder reflow process and will be held in place by surface tension.

For reliable connections, the following should be adhered to:

1. *The maximum temperature of the leads or tab during the soldering cycle should not exceed 260 °C.*
2. *The flux must affect neither components nor connectors.*
3. *The residue of the flux must be easily removed.*

Having first been fluxed, all components are positioned on the substrate. The slight adhesive force of the flux is sufficient to keep the components in place.

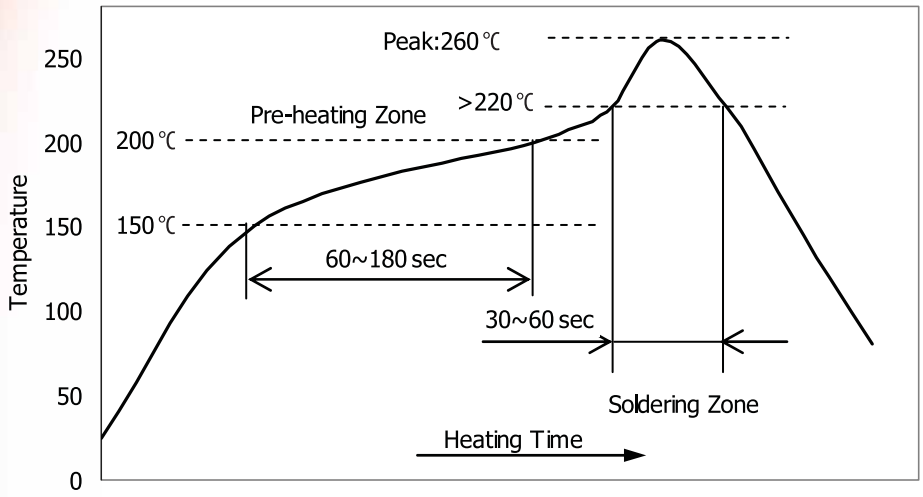
Solder pastes contain a flux and therefore have good inherent adhesive properties, which eases positioning of the components. Allow flux to dry at room temperature or in a 70 °C oven. Flux should be dry to the touch.

With the components in position, the substrate is heated to a point where the solder begins to turn to an amorphous state. This can be done on a heating plate, on a conveyor belt running through an infrared tunnel, or by using vapor phase soldering.

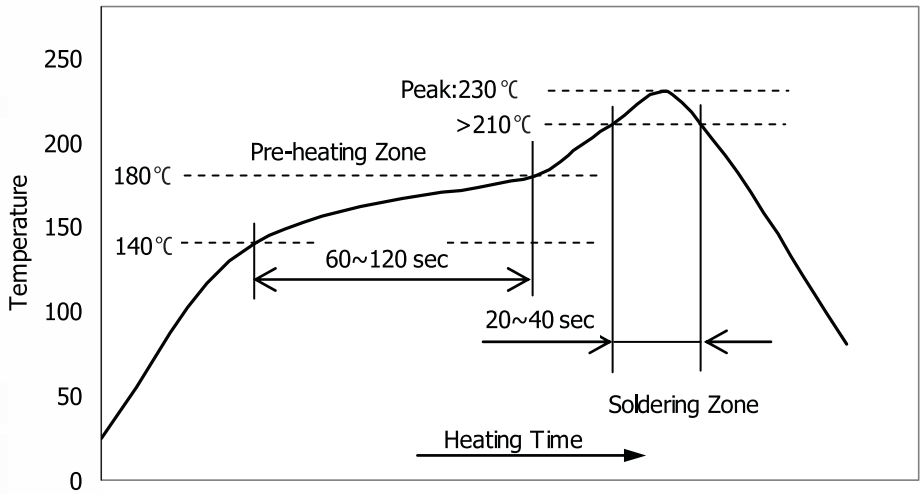
No matter which method of heating is used, the maximum allowed temperature must not exceed 260 °C during the soldering process. For further temperature behavior during the soldering process, see *Figure 2*, recommended reflow profile.

SOLDERING RECOMMENDATIONS

Pb-Free Solder Reflow Profile



Sn-Pb Solder Reflow Profile



Profile Feature	Sn-Pb Solder	Pb-Free Solder
Pre-heat Zone	140 ℃~180 ℃ 60-120 seconds	150 ℃~200 ℃ 60-180 seconds
Soldering Zone	>210 ℃ 20-60 seconds	>220 ℃ 30-60 seconds
Peak Temperature	230 ℃ max. 10 seconds	260 ℃ max. 10 seconds

Figure 2: Recommended reflow profile

SOLDERING RECOMMENDATIONS

The surface tension of the liquid solder tends to draw the leads of the device towards the center of the soldering area and has a correcting effect on slight misalignments. However, if the layout leaves something to be desired, the same effect can result in undesirable shifts; particularly if the soldering areas on the substrate and the components are not concentrically arranged. This problem can be solved using a standard contact pattern, which leaves sufficient scope for the self-positioning effect.

After the solder has set and cooled, the connections are visually inspected. Finally, the remnants of the flux must be removed carefully.

Use vapor degrease with an azeotrope solvent or equivalent to remove flux. Allow to dry.

After drying procedure is complete, the assembly is ready for testing and/or further processing.

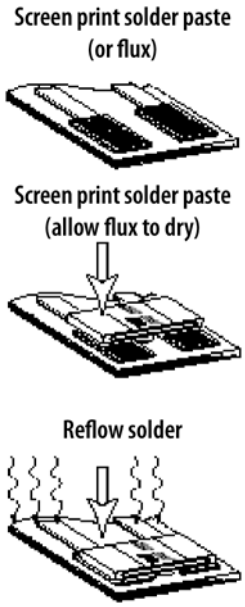


Figure 3: Reflow Soldering PTCs

After up to 3 consecutive reflows Multifuse® Polymer PTCs are still fully functional although post trip resistance may drift beyond the $R1_{max}$ specification.

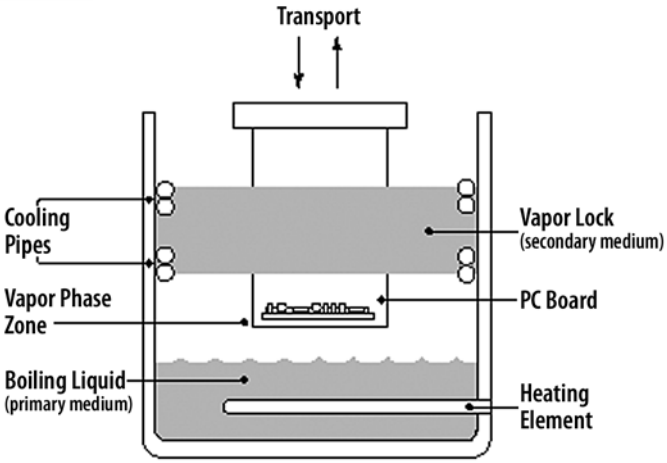


Figure 4: Principle of vapor phase soldering

Vapor Phase Soldering

In the vapor phase soldering process, the entire PC board is uniformly heated within a vapor phase zone at a temperature of approximately 200 °C. The saturated vapor phase zone is obtained by heating an inert (inactive) fluid to the boiling point. The vapor phase is locked in place by a secondary vapor (See *Figure 3*). Vapor phase soldering provides uniform heating and prevents overheating.

SOLDERING RECOMMENDATIONS

Wave Soldering[1]

One of the benefits of surface mount technology is that devices can be mounted to both top and bottom sides of the printed circuit board. During wave soldering, components on the underneath side are actually immersed into the hot molten solder. The plastic-metal interface can be affected if left for more than 5 seconds. Most wave soldering operations occur at temperatures between 240 °C to 260 °C. Epoxies used for semiconductor encapsulation have glass transition temperatures between 140 °C to 170 °C. An integrated circuit exposed to these temperatures can risk long term functionality and reliability. However, with topside mounting (as used for DIPs) there are some factors that reduce the risk.

1) Only the tips of the leads are exposed to the solder temperature.
2) The printed circuit board acts as a heat sink and also shields the components from the temperature of solder. Actual measurements on DIPs show that they are exposed to a temperature between 120 °C to 150 °C in a 5-second pass through the solder wave. This accounts for the fact that packages mounted in the conventional manner (topside only) are very reliable.

Wave soldering requires the use of fluxes to assist solderability of the components to the circuit board. In some instances, the boards and components are processed through acid cleaning prior to passing through the wave. If epoxy-metal separation has occurred, the flux and acid residues (which may be present due to inadequate cleaning) will be forced into the separation mainly by capillary action as they move away from the solder heat source. Once the package is cooled, these contaminants are now trapped inside the package and are able to diffuse with available moisture over time. It should be stressed that electrical tests performed immediately after soldering generally will give no indication of this potential problem. As time passes, however, the end result will be corrosion of the chip metallization and premature failure of the device in the field. Procedures for wave soldering PCBs with

(a) surface mount devices only, and (b) leaded components are shown in *Figures 5* and *6*. Not every Multifuse® Polymer PTC can be wave soldered. The following table outlines the models that can and cannot be wave soldered.

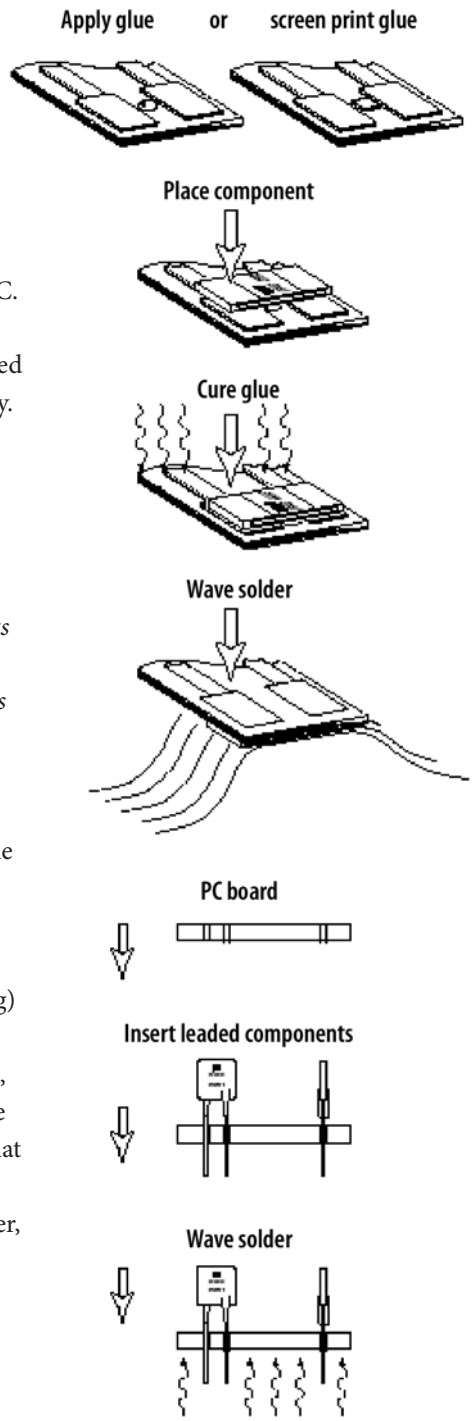


Figure 6: Wave soldering Radial PTCs

[1]*Do not wave solder the body of the PPTC.*

SOLDERING RECOMMENDATIONS

Multifuse® Product families that can be reflow soldered and/or wave soldered:

Product Family	Reflow Solder	Wave Solder
MF-R	Yes*	Yes
MF-RX	Yes*	Yes
MF-RX/72	Yes*	Yes
MF-R/90	Yes*	Yes
MF-RX/250	Yes*	Yes
MF-R/600	Yes*	Yes
MF-RG	Yes*	Yes
MF-RHT	***Yes***	***Yes***
MF-MSMD	Yes	Yes
MF-MSMF	Yes	No
MF-USMD	Yes	Yes
MF-NSMF	Yes	No
MF-SM	Yes	No
MF-SM/250	Yes	No
MF-SMDF	***Yes***	***No***
MF-USMF	***Yes***	***No***
MF-SMHT	Yes	No
Strap models	Yes**	No

** Can be reflow soldered if methods such as intrusive reflow are used.*
*** Can be reflow soldered but not commonly used. Spot welding is a more common method.*

Hand Soldering

It is possible to solder the surface mount Multifuse® Polymer PTCs with a miniature hand-held soldering iron, but this method has particular drawbacks and should, therefore, be restricted to laboratory use and/or incidental repairs on production circuits. It is difficult to control the amount of heat generated and transferred to the PTC.

The following outlines the recommended hand soldering procedure:

1. *Properly orient the part and place it on the PCB pads. Use a tweezers to hold the part from the sides and do not press down on the top surface of the PTC.*
2. *When soldering, the actual placement of the solder iron tip should be at the joint in the center of the pad on the PCB and the PTC terminal.*
3. *Maintain a clean tip at all times.*
4. *Sometimes it is necessary to apply a small amount of flux to the terminals.*
5. *Use a very slight amount of solder on both PCB pads using a syringe. Too much solder will cause the part to sit at an angle. Solder paste is recommended instead of solder wire for MF-SMDF, MF-MSMF & MF-NSMF product families.*
6. *Keep the temperature as low as possible in the region below 350 °C.*
7. *Hold the tip on the joint to heat the joint while holding the solder in the joint as well (for as short a time as possible).*
8. *Do not place the solder directly on the tip, but rather into the joint of the two surfaces being joined.*
9. *Hold the tip in place and once the solder wicking begins feed solder until the joint is full.*

Hand Soldering Parameters for Multifuse® Components	Max Solder Iron Tip Temperature	Max Contact Time with Component Lead
Sn-Pb Soldering	350 °C	3~4 sec
Pb-Free Soldering	350 °C	3~4 sec

For surface mount devices rework should be confined to removal of the installed product and replacement with a fresh device.

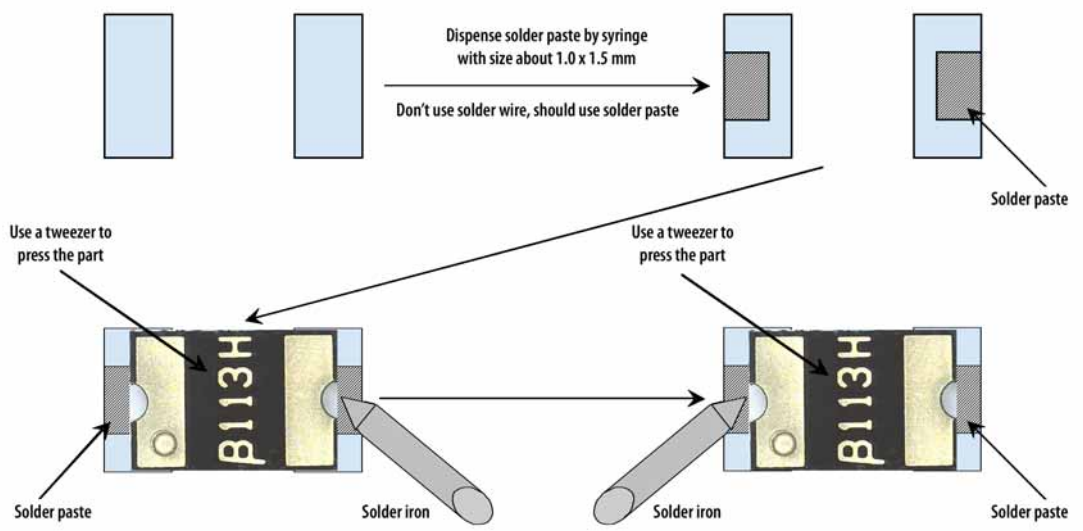


Figure 7: Guide for hand soldering SMD PTCs

Pre-Heating

Pre-heating is recommended for good soldering and avoiding damage to the devices, other components and the substrate. Maximum pre-heating temperature is 160 °C while the maximum preheating duration may be 10 seconds. However, atmospheric pre-heating is permissible for several minutes provided temperature does not exceed 125 °C.

There are three different ways to preheat the printed circuit board: electric heaters, convection heating process and infrared heating process. Cost, space and personal preference are some of the parameters used when deciding which method works best in your situation.

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SOLDERING RECOMMENDATIONS

Gluing Recommendations

Prior to wave soldering, surface mount devices (SMDs) must be fixed to the PCB or substrate by means of an appropriate adhesive. The adhesive (in most cases, a multicomponent adhesive) has to fulfill the following demands:

- *Uniform viscosity to ensure easy coating.*
- *No chemical reactions upon hardening, in order not to deteriorate the component and PC board.*
- *Straightforward exchange of components in case of repair.*

Cleaning Recommendations

PC board or substrate cleaning in solvents is permitted at approximately 70 °C to 80 °C.

The soldered parts should be cleaned with azeotrope solvent followed by a solvent such as methyl, or isopropyl alcohol.

Cleaning of the parts is best accomplished using an ultrasonic cleaner, which has approximately 20 watts of output per one liter of solvent. The solvent should be replaced on a regular basis.

Dip Soldering

This is very similar to wave soldering, but is a hand operation. The same considerations as above should be followed, particularly the time-temperature cycle, which may become operator dependent. Due to the wide process variations that may occur, this method is not recommended.

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