Soldering Surface Mount Components

Concerns regarding the use of water-soluble flux

Water soluble fluxes can leave weak organic acid (WOA) residues that must be thoroughly removed from all pc board components. All fine wire components, like many inductors, should be considered potentially susceptible.

Thorough rinsing and drying is required to remove water-soluble flux residue from all pc board areas, especially irregular component surfaces where contaminants can easily collect. If not removed completely, water-soluble flux residue can cause immediate or latent corrosion.

Coilcraft strongly recommends consulting both the solder and water-soluble flux manufacturer for complete application information.

For further reference:

Kester, Inc. (www.kester.com)

Kester, Inc. Knowledge Data Base Article (http://www.kester.com/en-us/technical/kb_detail.aspx?KnowledgeID=25)

Indium Corporation of America (www.indium.com)

Alpha Metals (www.alphametals.com)

Introduction

Soldering is the process of using a metal alloy with a low melting temperature (solder) to fuse the electrical contacts of a component to the pads of a circuit board. Proper soldering maximizes the strength and conductivity of the connection. Poor soldering can result in weak connections, higher resistance that causes heat buildup at the connection, and possible failure of the component.

The type of components and the pads to which they will be attached dictate the appropriate soldering method. The correct amount and duration of heat to be applied is a function of the heat transfer characteristics of the component, the circuit board, the solder pads, the solder (and flux), and the environment in which the soldering takes place. For this reason, effective soldering requires reasonably controlled conditions. Some experimentation is usually required to determine the optimal conditions for each application.

Types of Solder

Solder comes in the form of paste, wire (also called string solder), bar, and in preformed shapes. There are many alloy combinations of solder, but the most common combination for electronics has been 63Sn/37Pb (63% Tin, 37% Lead) solder, which has a melting point of 183°C (361°F).

Environmental regulation agencies are urging the use of low-lead or no-lead solders. A common no-lead solder composition is 96.5% Tin / 3.5% Silver. Tin / Silver solder has a higher melting temperature (221°C/430°F), which could cause process difficulties when used as a replacement for lead-based solder. The entire circuit must be designed to withstand the higher temperatures used for the low-lead or no-lead solders. Another environment-friendly option, “no-clean” solders are used in applications where post-reflow cleaning using CFC-based cleaners is to be avoided.

Flux

Soldering flux is applied to the connection area to remove oxidation from the metal surfaces to be soldered, and to aid in solder flow. If metal oxidation is not removed, solder does not adhere well to the solder pad. Flux can be applied separately, just before applying the solder, or simultaneously when using solder paste or rosin-core solder.

Solder paste typically contains flux, and rosin-core solder has a center core of flux. As these types of solder melt, flux is released, eliminating the need for a separate flux application.

General Soldering Guidelines

All soldering applications require the following considerations:

- **Preparation** – Clean connections are essential to soldering. Clean connections maximize the ability of the solder to adhere uniformly to the joint surfaces (wetting).
- **Soldering Method** – The component type and size, and your specific application determine the soldering method.
- **Materials Selection** - The component contacts, circuit board pads, solder, and flux materials must all be compatible with the soldering method.
- **Maximum Temperature** – The soldering materials and method determine the temperature profile. All components must be able to withstand the maximum exposure temperature of the soldering operation for the specified time duration.

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Soldering Methods

The appropriate soldering method depends on the specific application, production volume and time requirements, and the types of components to be soldered. Automatic methods include wave, infrared (IR) reflow, air convection reflow, radiant heating reflow, and vapor phase soldering. Manual methods include using a soldering iron with wire-type solder, or reflow using wire solder or paste and a hot air pencil or gun.

When using only surface mount technology (SMT) components, a reflow process is best. For thru-hole components, and where thru-hole and SMT components are combined on the same board, a wave soldering process is typically used. In some cases, combinations of wave soldering and reflow soldering are used.

Thermal Profiles

With any soldering method, the optimal preheating, heating, and cooling cycle chosen for a particular method results in complete wetting of all solder joints and minimized thermal stresses. Too little heat does not allow the solder to melt and flow properly. Too much heat can cause oxidation to take place before the solder solidifies, resulting in a "cold" solder connection. Too much heat can also cause damage to the component or circuit board. Cold solder connections are weaker and have higher resistance than a normal connection. Heating or cooling too quickly can cause thermal shock leading to cracked materials. The recommended cooling method is always gradual cooling to room temperature in order to avoid thermal shock.

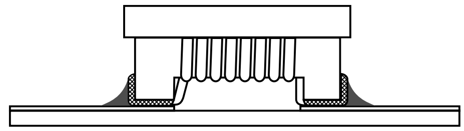
Reflow Profile

As with all soldering methods, the optimal reflow profile for a circuit board assembly is dependent on the solder material, solder amount, flux, temperature limit of each soldered component, heat transfer characteristics of the circuit board and component materials, and the layout of all components. For example, a component with a heat-sink element attached may require a longer heating cycle than other components on the same circuit board. The temperature vs. time limitation of the least robust component of the circuit board assembly ultimately dictates the optimal temperature profile.

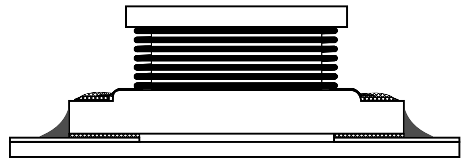
Contact the solder, circuit board and component manufacturers to determine the temperature limits for your particular application. See **Temperature Limits** for our chip and power inductor maximum temperature specifications.

Solder Amount

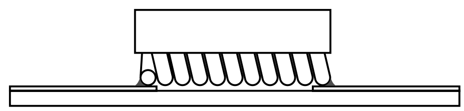
An optimal solder fillet is determined by part size, termination style, and pad geometry. Experimentation is recommended to establish the amount of solder to be applied to the connection. The solder fillet radius should be approximately the height of the inductor terminal. Optimal solder fillets for a chip inductor, power inductor, and "Spring" inductor are shown in Figure 1.



Chip Inductor



Power Inductor



Spring Inductor

Figure 1. Optimal Solder Fillets

Part Positioning

Tombstoning (also called drawbridging) is when one end of a component tips up during soldering. It results from uneven forces on the ends of the part. To avoid tombstoning or other movement of SMT components during soldering, ensure that the solder quantity, positioning, and heating is even at all solder joints.

The magnetic fields of unshielded inductors couple when placed in close proximity to each other. The closer the spacing, the stronger the magnetic coupling. To minimize inductor coupling, avoid narrow spacing between solder lands of adjacent inductors.

Adhesives

If an adhesive is used to pre-attach the component, make sure that it is kept as far as possible from the solder joint area. If too much adhesive is used, it can creep into the solder joint, causing soldering problems.

Reworking Soldered Joints

When manually reworking soldered joints, hot air reflow is recommended as a more controlled method than using a soldering iron. If a soldering iron must be used, follow the manual soldering technique described later.

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Chip Inductor Soldering

Use the following table as a guideline for selecting a soldering method based on the size of a surface-mount component.

The preference of a soldering method is based on temperature control and even heat distribution. Reflow is always the preferred automatic method for even and controlled soldering. Wave soldering is discouraged as it requires the part to be secured to the board in a separate operation before soldering. When soldering manually, a hot air pencil provides a reasonably controlled and evenly distributed amount of heat to a solder connection without making direct contact. Soldering smaller size chip inductors with a soldering iron is discouraged due to lack of temperature control, although it may be possible under carefully controlled conditions.

	Soldering Method			
	Automatic		Manual	
Size	Reflow	Wave	Hot Air Pencil	Soldering Iron
0201	P	A	P	A
0302	P	A	P	A
0402	P	A	P	A
0603	P	A	P	O
0805	P	A	P	O
1008	P	A	P	O
1206	P	A	P	O
1812	P	A	P	O

Key: P = Preferred; O = Optional; A = Avoid

Temperature Limits

Our chip inductors meet the requirements of the “Resistance to Soldering Heat” qualification standard, described in our Chip Inductor Qualification Standards. The Resistance to Soldering Heat test method and specification are as follows:

Test Method/Condition

Inductors shall be reflowed onto a PC board using 96.5 Sn/3.5 Ag or 63 Sn/37 Pb solder paste. Solder process shall be at a maximum temperature of 260°C.

For 63 Sn/37 Pb solder paste: >183°C for 120 seconds.

For 96.5 Sn/3.5 Ag solder paste: >217°C for 90 seconds.

Specification

There must be no case deformation or change in dimensions. Inductance shall not change more than the stated tolerance.

Power Inductor Soldering

The same logic for choosing a chip inductor soldering method can be applied to power inductor soldering. Reflow is the preferred method for SMT components. Other methods are possible, but typically do not offer process controls comparable to reflow methods.

Temperature Limits

Our power inductors meet the requirements of the “Resistance to Soldering Heat” qualification standard, described in our Power Inductor Qualification Standards. The Resistance to Soldering Heat test method and specification are as follows:

Test Method/Condition

Inductors shall be reflowed onto a PC board using 96.5 Sn/3.5 Ag or 63 Sn/37 Pb solder paste. Solder process shall be at a maximum temperature of 260°C.

For 63 Sn/37 Pb solder paste: >183°C for 120 seconds.

For 96.5 Sn/3.5 Ag solder paste: >217°C for 90 seconds.

Specification

Inductance shall not change more than the stated tolerance.

Manual (Hand) Soldering Technique

While the amount of solder, and the amount and duration of heat to be applied are application-specific, the following general hand-soldering guidelines will lead to consistent and reliable solder connections. A hot air pencil is preferred for even heat application and control, however, the following technique applies to hand-soldering of surface-mount or thru-hole electronic components using rosin-core solder and a soldering iron.

Preparation

Before beginning the soldering process, identify the solder composition and flux type (if you’re not using rosin core solder). The solder type dictates the appropriate temperature of the soldering iron tip. Use small diameter wire solder for soldering small SMT components.

Before heating the soldering iron, select an appropriate size tip. Use a smaller tip for fine work and a larger tip for larger connections. Clean the tip of any contamination or oxidation. Try not to scratch the tip surface, as scratches cause the tip to lose heat too quickly. Place a sponge, soaked in cold water, nearby for frequent tip cleaning between soldering operations.

Clean the electronic component’s contacts/leads and the circuit board pads of any contamination or residue.

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Soldering Iron Temperature

The optimum temperature setting is the lowest one that allows the solder to melt completely and flow into the solder connection.

A temperature-controlled soldering iron is recommended, especially for fine wire applications. For standard 63Sn/37Pb rosin core solder, set the solder tip temperature to a maximum of 280°C (536°F). If you are using no-clean 63Sn/37Pb solder, set the tip to ~260°C (500°F).

If a different type of solder is to be used, check the solder manufacturer's recommendations for the specific solder type. The solder manufacturer may only provide the melting temperature range, so you may have to experiment to determine the appropriate soldering iron tip temperature.

Place the Component

Center the electronic component on the circuit board mounting pads. For thru-hole components, feed the leads through the holes and bend the end of the lead over to hold it in place.

Tin Soldering Iron Tip

Apply a small amount of solder to the heated soldering iron tip. This aids in conducting heat to the solder connection and prevents the tip from overheating. A clean, tinned soldering iron tip appears shiny. An overheated or burnt tip appears brown or black. Water soluble flux tends to wick up and away from the soldering iron tip, causing it to overheat. No-clean solders contain less flux, and may require more frequent tinning of the tip.

Pre-tinning the component leads/contacts and the circuit board pads can also improve the solderability of the connection.

Heat the Connection

If you are using a separate flux, apply a small amount to the connection area.

Apply the soldering iron tip to the opposite side of the connection to where the solder is applied. Hold the tip of the soldering iron for a few seconds against the connection so that it touches the component lead/contact and the circuit board pad. For larger connections, more heating time may be required.

Apply the Solder

Touch the end of the solder wire to the heated connection on the side opposite of the soldering iron tip. Allow the solder to flow into the connection. If the heating is sufficient, the solder spreads out into the connection and wicks up onto the component lead/contact. Once this happens, stop adding solder, and then remove the soldering iron.

Do not move the component or board until the solder connection cools for a few seconds. Moving the component or board before it cools can result in a "cold" solder connection.

When soldering is complete, clip off excess lead lengths close to the connection. Use an ohmmeter to check for a short or open connection.

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