
HAND SOLDERING LARGE RADIAL LEADED CERAMIC CAPACITORS

INTRODUCTION

Recommendations offered in this Application Note are intended to provide general guidelines for soldering radial leaded ceramic capacitors. They reflect industry accepted protocols and should, if applied properly, provide the basis for a reliable soldering process. These recommendations may not be applicable to all situations and as such should not be considered a guarantee against failure. Consequently, it becomes the engineer's responsibility to confirm results and make adjustments where necessary to accommodate specific conditions.

OVERVIEW

Multilayer Ceramic Capacitors (MLCC's) are complex composite mechanical structures composed of alternating layers of a dense ceramic substrate and metal electrodes, which are connected by a metal termination that typically contains a glass frit. Each of these materials is characterized by a different Coefficient of Thermal Expansion (CTE), which makes the completed structure highly susceptible to thermal shock.

The degree to which a ceramic capacitor may potentially be effected by thermal shock can be influenced by several factors including the overall mass, size, and geometry of the device itself, the number, thickness and density of its ceramic layers and metal electrodes, the type of termination material utilized and the integrity with which these materials effectively form a single monolithic structure. In addition, there are several external influences that can also impact the degree to which a capacitor may be subjected to thermal stress including, but not limited to, the range of temperatures encountered, the means by which the part is exposed and time of exposure, the type of substrate to which the capacitor is being mounted, and the thermal characteristics and proximity of other components within the assembly.

While thermal shock conditions exist, the possibility of introducing substantial stress within the structure is significantly increased and unless preventative measures are introduced that mitigate these conditions, formation of micro fractures within the capacitor body are highly likely. These micro fractures, depending on their severity, may or may not be detectable thru common testing and inspection practices. This poses significant concern inasmuch as the suspect part may represent a latent failure whereby the product initially presents itself as an acceptable unit and may continue to operate until such time as moisture penetrates the flaw site, and / or it is subjected to further mechanical or thermal stress. In addition, the actual failure may be delayed for an extended period of time and may not be detected until the finished product has been placed in the field.

One area where the initiation of thermal shock can be addressed is in the soldering processes utilized for mounting ceramic capacitors. Ensuring adequate pre-heat and post heat conditions and the selection of the most appropriate soldering process can be critical to the success of the operation. As much as one would prefer a batch or oven soldering process that approach is not always an option. Large radial leaded capacitors for example, generally preclude the use of these methods and this Application Note outlines hand soldering recommendations that should minimize the risk for thermal shock and subsequent micro fracturing of these style capacitors.

HAND SOLDERING RADIAL LEADED CAPACITORS

Hand soldering processes pose a considerable risk to the engineer inasmuch as the process is difficult to control and may result in a much greater possibility that the capacitor will encounter significant temperature gradients and subsequent thermal shock. If the use of a reflow system is not practical and a hand soldering process cannot be avoided, there are a number of precautions that need to be considered to minimize the likelihood of thermal shock.

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The use of a leaded capacitor should always be considered, as the lead offers a certain degree of thermal relief between the fragile ceramic body and the soldering tool. This approach may not be practical for smaller chip sizes but larger packages, especially high voltage designs and those that are 1812 and larger, are much more susceptible to thermal shock so a leaded design should always be used.

As with any soldering process implementation of a preheat stage prior to soldering is strongly recommended and the best approach requires that the entire board assembly be placed in an air circulating oven and be slowly brought up in temperature. Once the desired preheat level is reached, the assembly should be quickly transferred to the soldering station and placed on a heated surface that is maintained at the same temperature as the oven. (See figure 1)

Where practical, choose a low wattage, small tip iron and make the connection on the opposite side of the printed wiring board (PWB) from the capacitor to limit excessive heat transfer. Under no circumstances should the operator allow the soldering iron tip to make direct contact with the lead. Solder should instead be applied directly to the tip of the iron and then touched to the solder pad so that the solder flows around the lead. (See figure 2)

The type and volume of solder utilized and the time the capacitor is exposed to reflow is also extremely important to the success of the operation. Wire solders with a rosin or non activated flux core are preferred and solder volume, solder time and reflow temperature should be limited as much as possible. Information presented in this application note is based on the use of a low temperature solder alloy with a reflow temperature of less than +190°C. Typical solder types would be Sn63 (Sn63 / Pb37) or Sn60 (Sn60 / Pb40).

Hand soldering of components is done in an open air environment and as such the ability to maintain the capacitors at the required preheat temperature for any length of time is usually not feasible. Consequently, where installation of multiple capacitors is required, the PWB assembly will need to be returned to the preheat oven. The typical rule of thumb would be 3 to 5 capacitors, after which the board assembly will again need to be preheated. This process should be repeated until all of the capacitors are soldered.

Chip Capacitor Hand Solder Recommendations	
Process Step	Limit
Preheat Ramp Rate	2.0 - 3.0 °C / sec
Solder Iron Wattage	35 watts max
Solder Time	3 - 5 sec Max
Solder Iron Tip Temperature	290 to 310°C Max
Max Temp Change Preheat to Reflow	55 to 65°C Max
Post Reflow Cooling Cycle	3.0 sec / °C Max

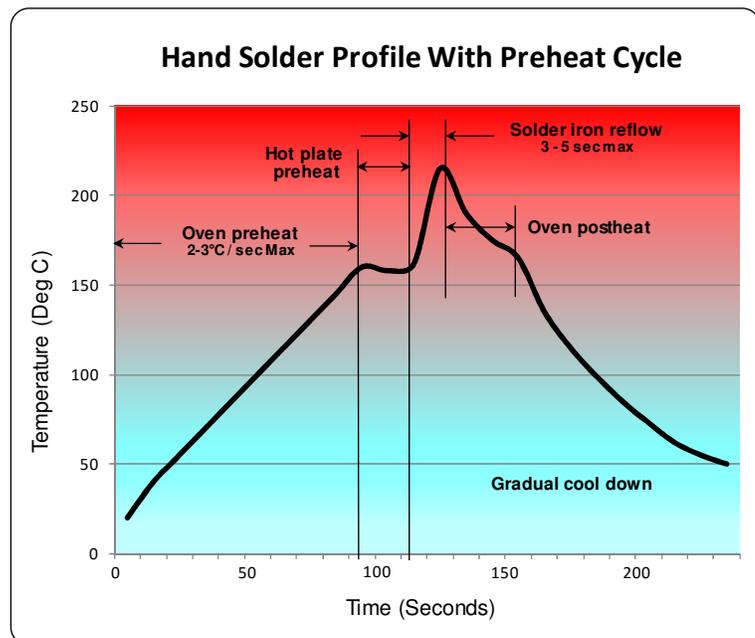


Figure 1 – Soldering Profile / Recommendations

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For larger leaded capacitors, the ability to adequately preheating the PWB assembly becomes extremely difficult and the engineer may need to consider the use of a heat sink as an alternative method of minimizing thermal shock. Spring loaded tweezers or needle nose pliers work well in this situation, when attached to the capacitor lead at a point between the PWB and the capacitor body. (See figure 2)

CAUTION: Some assemblies have a number of component leads, running to a binding post, resulting in a large bundle of wires. In such cases, large power soldering irons may be required to adequately heat the bundles and/or posts, resulting in rapid heat transfer to the components. In these cases, each large capacitor lead needs an individual heat sink to minimize thermal shock cracking.

Once soldering has been completed, assemblies should be allowed to cool naturally to room temperature. If a preheat oven was utilized the PWB should first be returned to the oven to allow the temperature to stabilize and then removed so that the board assembly can cool gradually. Under no circumstances should the PWB assembly be forced cooled or cleaned in a cold degreasing bath.

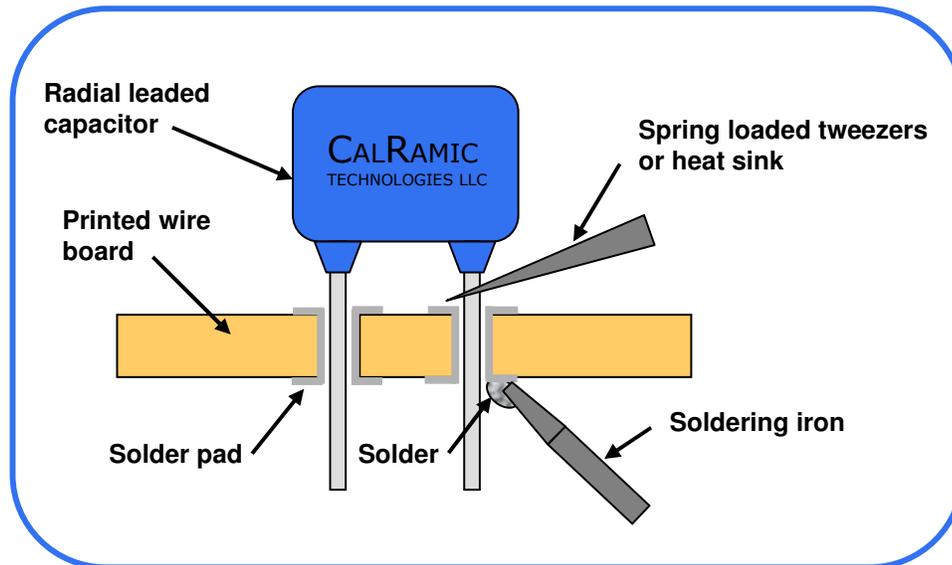


Figure 2 - Heat Sink Attachment for Radial Leaded Capacitors

SUMMARY - KEY POINTS

- ⚡ **Use of preheat or heat sink is strongly encouraged**
 - ⚡ **Use a small tip, low wattage soldering iron**
- ⚡ **Keep solder time, temperature and solder volume to a minimum**
 - ⚡ **Solder from the opposite side of the PWB**
- ⚡ **Do not contact the capacitor lead with the soldering iron**
 - ⚡ **Do not force cool soldered assemblies**
- ⚡ **Allow soldered assembly to reach room temperature before cleaning**

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