Recommended Attachment Techniques for ATC Multilayer Chip Capacitors

Bulletin No. 201

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1.0. SCOPE. This document describes the attachment techniques recommended by ATC for ceramic chip capacitors. This document is non-exhaustive. Customers with specific attachment requirements, or attachment scenarios that are not covered by this document, should contact ATC.

2.0. HANDLING. Handling of both the capacitor and substrate should be minimized. Assembly operators should wear gloves or finger cots. Whenever precise orientation of the capacitor is required prior to heating, use plastic tweezers.

3.0. AUTOMATED CHIP PLACEMENT. The industry has adopted two distinct approaches to automated chip placement and the use of pick-and-place equipment: Non-contact Alignment and Mechanical Pickup and Centering.

The most common approach is Non-Contact Alignment. This approach uses vision assist to correct 'placement angles' after pickup.

The second approach is Mechanical Pickup and Centering. In this method, the user is advised to apply centering jaw pressure of no greater than 300 grams to the sides of the chips. Excessive 'centering pressure' may crack the chip. The user is also advised not to exceed 300 grams of 'placement pressure' (Z-axis pressure) with any of the automated systems for the same reason.

4.0. CHIP MOUNTING PAD DIMENSIONS. The metallized pad or land area on the end user's substrate must be properly designed. Improper dimensioning or spacing of the land areas may result in poor solder fillets or tombstoning. Good land design will depend on the end user's application.

Recommended mounting pad dimensions for ATC components are referenced in ATC Technical Bulletin ATC No. 001-820. Other useful information on assembly practice may be found in IPC-A-610, and in the documentation listed in Section 13.0.

5.0. FLUX. Flux removes tarnish films, maintains surface cleanliness, and facilitates solder spread during attachment operations. Non-activated rosin fluxes decrease the surface tension of solder, facilitating the spreading activity of the solder during attachment operations. Activated fluxes clean surfaces by reducing oxides, in addition to decreasing the surface tension of the solder. The flux must be compatible with the soldering temperature and soldering times required in the customer's application.

Soldering attachment methods employed should permit the flux to attain its activation temperature (100-200 °C) just prior to achieving the working temperature of the alloy. The end user should avoid prolonged exposure of rosin fluxes to temperatures above the char point of the rosin (285 °C) since char will be difficult to clean from the parts. For flux cleaning, refer to Section 11.0.

6.0. SOLDER. Numerous solder compositions are available to suit specific application requirements. For silver bearing substrate conductor patterns or silver bearing component metallizations, Sn62 is recommended. For non-noble components or conductors, Sn63 (or equivalent) is recommended. For chip attachment to gold conductors, In50 is suggested. Use In50 to avoid gold scavenging and/or embrittlement. For applications that require a no-lead solder, Sn95.5 is commonly used. Typical alloy composition and melting ranges are shown in Table 1.

The end user may be required to perform sequential attachment operations. In this case, ATC recommends a step soldering approach. A full range of alloys is available. Refer to IPC/EIA-J-STD-006A or to specific vendor literature for more information.

6.1. Solder Pastes. Solder pastes or creams are frequently used. RMA-based materials are suggested. RMA-based materials ensure adequate application characteristics even when the solder alloy components have become oxidized.

A solder paste will afford many advantages when used with various reflow attachment technologies, such as Vapor Phase, Infrared Radiation, or Hot Air Convection methods. The solder paste should be screen-printed onto the substrate, applying solder to selected land areas. The chips should then be placed on top of the solder paste by means of automatic pick-and-place (refer to Section 3.0) or by manual placement.

7.0. CHIP AND SUBSTRATE PREPARATION. ATC recommends that substrates be pre-tinned by some means prior to reflow attachment. Alternatively, organic coatings can be useful for preventing the passivation of circuit traces. The user should clean the substrate in accordance with the methods described in Section 11.0.

TABLE 1: RECOMMENDED SOFT SOLDERS

ALLOY	COMPOSITION	SOLIDUS	LIQUIDUS	COMMENT
In52	52 In, 48 Sn	118 °C	118 °C	Eutectic
Sn62	62.5 Sn, 36.1 Pb, 1.4 Ag	179 °C	179 °C	Eutectic
Sn63	63 Sn, 37 Pb	183 °C	183 °C	Eutectic
In50	50 In, 50 Pb	180 °C	209 °C	–
No-lead	95.5 Sn, 3.8 Ag, 0.7 Cu	217 °C	217 °C	Eutectic
Hi-Temp	5 Sn, 93.5 Pb, 1.5 Ag	296 °C	301 °C	–
Sn5	5 Sn, 95 Pb	308 °C	312 °C	–

8.0. REFLOW ATTACHMENT. ATC recommends three methods of reflow attachment: Convection Reflow, Vapor Phase Reflow and Infrared Reflow. All are best accomplished in conveyorized ovens.

The most critical assembly issue for ceramic chip capacitors is the heating and cooling rate. See Figure 1. In the preheat portion of the process, ideal profiles for any of these methods will exhibit a ramp-up rate that is equal to 2 °C/second. The user is advised to never exceed a maximum rise rate of 4 °C/second.

Pay careful attention to the ramp down rate. After exiting from a soldering operation, the board or substrate should be allowed to cool at its own natural rate, without heat sinking. Never withdraw parts from the oven at temperatures above 100 °C. Cool products to well below 60 °C before attempting any cleaning operations.

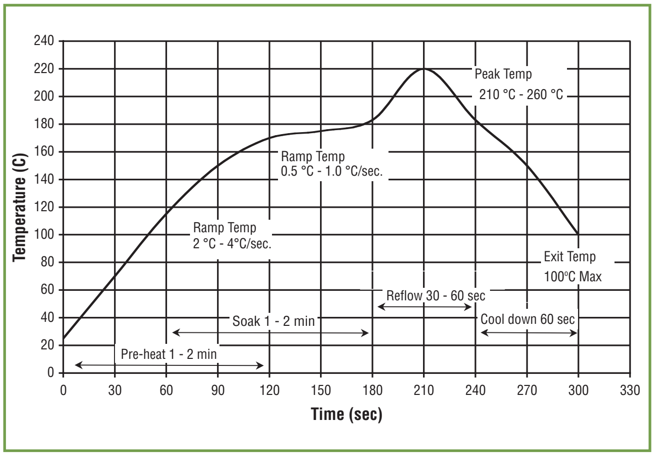

Figure 1. Typical Infrared or Convection Reflow Profile

TABLE 2: RECOMMENDED PARAMETERS FOR VARIOUS REFLOW SOLDERING PROCESSES

Reflow Method	Solder Type	Preheat Section		Soak Section		Reflow Section		Cooling Section	
		Max (°C/sec.)	Duration (sec.)	Max (°C/sec.)	Duration (sec.)	Peak (°C)	Duration (sec.)	Max (°C/sec.)	Duration (sec.)
Convection	Sn 63	2	60-120	4	60-120	210-245	30-60	4	60-120
	No-lead	2	60-120	4	60-120	250-260	30-60	4	60-120
	Hi-Temp	2	60-120	4	60-120	330-340	30-60	4	60-120
Vapor Phase	Sn 63	2	60-120	N/A	N/A	215	Varies	4	60-120
	No-lead	2	60-120	N/A	N/A	230	Varies	4	60-120
	Hi-Temp	Not possible with vapor phase method							
Infrared	Sn 63	2	60-120	4	60-120	210-245	30-60	4	60-120
	No-lead	2	60-120	4	60-120	250-260	30-60	4	60-120
	Hi-Temp	2	60-120	4	60-120	330-340	60-90	4	60-120

8.1. Convection Reflow. Perhaps the most basic reflow process, this technique uses a conveyor to transport boards through an oven with several controlled heating zones. In this case, energy is supplied to resistance heating elements and heat transfer is accomplished by convection. Peak temperature and soak time may be important for components with organic or polymeric constituents but, from a ceramic component standpoint, heating and cooling rates are the most critical variables in the process. Good soldering practice will limit reflow time to a maximum of 60 seconds above the solidus point of the alloy. Refer to Table 2.

8.2. Vapor Phase Reflow. Heating is accomplished by the condensation of perflorinated solvent vapors. Heating rates of all exposed surfaces is very uniform and repeatable from assembly to assembly. Both in-line conveyor and batch systems are in use. The immersion time required for reflow varies from about ten seconds to one minute. It is possible to achieve very rapid heating with this process, especially in the batch version. Care must be taken to accommodate the maximum permitted heating rates for ceramic components.

8.3. Infrared Reflow. Infrared radiation is a popular method for solder reflow. The infrared energy is provided by lamps or specially muffled panel-type heat sources. Both the top and bottom of the board can be heated, sometimes with different temperature profiles. Heating tends to be a function of the emissivity of the materials and their inherent thermal conductivity. Solder pastes absorb infrared radiation and heat quicker than the chip metallization. Because infrared is line-of-sight, large or tall components may cause "shadowing" of some board areas. This requires special attention be paid to pad dimensions, component size, and component placement. Refer to Table 2.

9.0. WAVE SOLDERING. Wave soldering contrasts with reflow soldering in two aspects:

1. The chips must be attached to the assembly before soldering by means of a gluing operation.
2. The attachment process will add the solder used in joining and forming the fillet.

Wave soldering is accomplished by passing the assembly through a standing wave or dual waves of molten solder. Because of the high potential for thermal shock in this process, ATC does not recommend wave soldering for the attachment of its products. Larger sizes are at greater risk for internal dielectric fracture, resulting in insulation resistance failures. In particular, parts larger than EIA-1210 size or larger than ATC B Case may be especially prone to thermal shock in wave soldering processes.

It is also generally accepted that X7R and BX dielectrics are more sensitive than C0G ceramics. Therefore, special care should be taken to avoid the use of wave soldering for the attachment of ATC 200 and 900 Series products. When there is no other process choice, follow the guidelines in Figure 2. For additional information, please contact ATC.

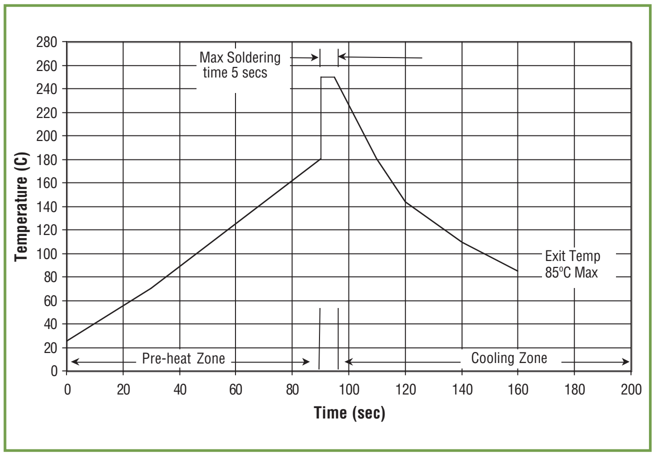

Figure 2. Typical Wave Solder Profile

9.1. Wave Soldering Recommendations. ATC recommends the following:

1. Adjust belt speed per the manufacturer's recommendations in order to insure a dwell time in the solder wave of 2 to 3 seconds.
2. Adjust the solder pot temperature to a range of +240 °C to +250 °C.
3. The flux station (foam or wave) preheat temperature should range from +80 °C to +105 °C
4. The preheat temperature must not exceed a level of 100 °C below the solder wave temperature and the preheat rate of 1.5 to 2.5 °C/sec.
5. The underside PC board temperature at the last preheat zone should be approximately 150 °C.
6. Check that the difference between the solder temperature and the board is 100 °C or less at the point in time when the PC board leaves the last preheat zone.
7. Permit the board to air-cool at ambient conditions. Do not force-cool the board.
8. It is not recommended to wave solder chips with case sizes greater than 1210 due to the risk of thermal shock. This can result in the formation of micro cracks that may cause insulation resistance failures.

10.0. HAND SOLDERING. Hand soldering with a soldering iron is a manual process. Unlike solder reflow where all variables are under tight machine control, this process is subject to the variability of individual operators and training programs. Each solder connection can see different temperatures, different stresses and varying amounts of solder.

The most important aspect of hand soldering is operator skill. The operator must fully understand the operation being performed. Care should be taken not only in soldering, but in handling. Never touch electronic components with bare hands. Never allow the tip of the soldering iron to come in contact with a ceramic component, even at its terminal.

The following hand soldering technique is recommended for proper installation of a chip capacitor across two lands of a substrate.

1. As outlined in Section 7.0, properly prepare the chip and substrate for a solder assembly.
2. The soldering iron should be of a size appropriate to the component and should have a temperature-controlled tip not exceeding 545 °F or 285 °C.
3. Care must be exercised to avoid damaging the component. Pick up the capacitor with a pair of tweezers or with a vacuum pickup.
4. Place flux at the joint area of each terminal. Refer to Section 5.0.
5. Place the capacitor across the two land areas on the substrate. For best results and to preclude the possibility of thermal shock, ATC recommends that the board or substrate be pre-heated to and held at a temperature 50-100 °C below the working temperature of the solder.
6. If lands are of different size, solder the smaller land area first. Hold the chip in place with tweezers or vacuum pickup. See Figure 3.

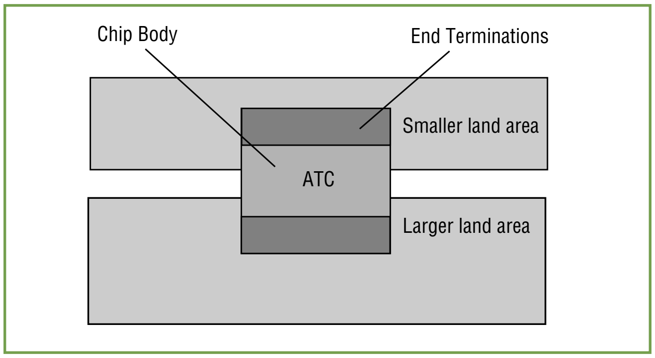

Figure 3. Solder the smaller land area first

7. Make sure that the capacitor is flat on the substrate and place the soldering iron on the land near the chip termination/land interface. When the solder starts to flow, move the tip of the iron slowly towards the chip. Quickly remove the tip once a fillet has formed. See Figure 4.

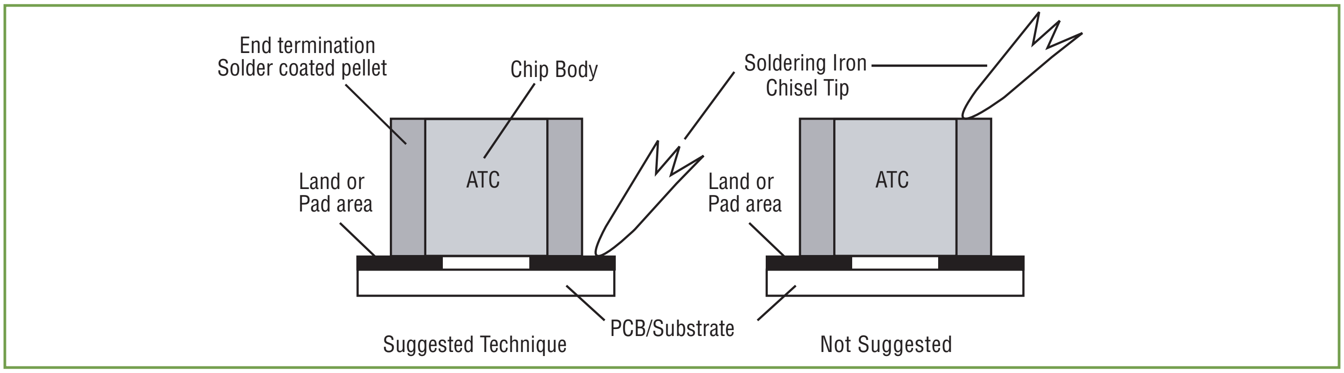

Figure 4. Recommended soldering techniques

8. Fillets should have sufficient solder to join the land at least 25% of component height and exhibit a concave profile. Excess solder can cause mechanical stress on components, thereby diminishing reliability.
9. The fillet should show even flow of solder and should be free of solder peaks and voids.
10. After examining the chip capacitor to make sure it is still flat on the board, repeat steps 7 through 9 for the opposite land connection.
11. The assembly is now complete. Flux residues should be removed with a solvent cleaner as described in Section 11.0 or by equivalent methods.

11.0. POST ATTACHMENT CLEANING. Solvent or aqueous cleaning can remove most contaminants generated after soldering operations. Cleaning is most often performed in ultrasonic tanks, vapor degreasers or ultrasonic vapor degreasers. Typical cleaning cycles may employ more than one step in order to effectively remove contaminants. Care must be taken to insure that residues are removed from beneath the component in order to insure long-term reliability.

12.0. CONDUCTIVE EPOXY BONDING. Epoxy connection is a technically demanding technique. It requires the user to be familiar with the material requirements and reliability considerations of the conductor system chosen. ATC typically recommends either its gold over nickel barrier termination (termination style "CA") or its Ag/Pd alloy termination for compatibility with these applications.

13.0. REFERENCES. For further information on component assembly, refer to the following documents:

1. IPC-A-610: Acceptability of Electronic Assemblies, available from IPC, 2215 Sandus Road, Northbrook, IL 60062.
2. IPC/EIA-J-STD-006A: Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications, available from EIA, 2500 Wilson Blvd, Arlington, VA 22201
3. IPC/EIA-J-STD-004: Requirements for Soldering Fluxes, available from EIA, 2500 Wilson Blvd, Arlington, VA 22201
4. ATC-001-820: Suggested Mounting Pad Dimensions for ATC Multilayer Chip Capacitors, ATC Applications Engineering Department, 17 Stepar Place, Huntington Station, NY 11746

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