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Soldering / Mounting Chip Capacitors, Radial Leaded Capacitors and EMI Filters

Introduction

This application note is intended to give guidance to engineers and board designers on mounting and soldering Syfer products.

We are increasingly asked to supply definitive soldering information such as solder profiles for specific applications and board designs. Whilst we will always offer what advice and assistance we can, we are not able to offer such precise information as it necessitates a thorough knowledge of the entire board design, other components, materials and equipment being used.

The information we can supply is to indicate general limits and recommendations for successful use of our products.

Pad Design for SM Chips and Filters

Final pad layout is the responsibility of the board designer and must take into account such factors as placement accuracy. For this reason any pad dimensions supplied are recommendations and may be changed by the board designer to suit individual applications.

Syfer conventional 2-terminal chip capacitors can generally be mounted using pad designs in accordance with IPC-7351, Generic Requirements for Surface Mount Design and Land Pattern Standards.

This standard gives recommended land pattern (pad) dimension calculations, but there are some other factors that can also be considered.

1. It has been shown that a pad design narrower than the width of the chip capacitor can increase the mechanical strength of the capacitor joint, leading to an reduction in the incidence of mechanical cracking of the capacitor due to board distortion. This is achieved at the expense of a side fillet to the solder joint. Syfer do not consider this a problem, but the use of this design is left to the discretion of the board manufacturer.
2. The position of the chip on the board should be considered to reduce the chances of mechanical cracking occurring as a result of board bending. Generally, the chip should be mounted parallel to any potential bend line. 3-Terminal and larger components are more susceptible to mechanical cracking. Refer to Syfer application note AN0005 for more information on mechanical cracking and AN0001 for details of Syfer Flexicap polymer termination.
3. Where high voltages are involved, particularly with smaller size components, it can be advantageous to machine a slot in the board between the pads allowing access to the underside of the component. This ensures adequate removal of debris (eg flux / solder balls) from under the component after soldering and cleaning, and allows complete coverage with conformal coating to prevent electrical flashover.

3-Terminal components (EMI filter chips, SM filters etc) are not specifically covered by IPC-7351, but recommended pad dimensions are included in the Syfer catalogue / website for these components.

Reflow Soldering Chip Capacitors and SM Filters

Syfer recommend a reflow profile of the same general shape as shown below for soldering SM capacitors. This is as generally defined in IPC / JEDEC J-STD-020D.

<u>Recommended Reflow Soldering Profile</u>

When discussing a reflow profile, we can only give a general recommendation as to the shape of the profile. We cannot give a definitive profile of the actual peak temperatures, as this is dependant on a number of factors which can only be decided by the assembler – the type of solder used, the size, specification and arrangement of other components on the board and the overall thermal mass of the board.

All Syfer Sn/Ni plated termination chip capacitors are compatible with both conventional and lead free soldering, with peak temperatures of 260ºC to 270ºC acceptable. Any solder types with liquidus temperatures suitably low can be used.

SM Filters type SBSP can be treated as conventional chip capacitors as above, but types SBSG and SBSM have a soldered construction and must not be allowed to exceed 220ºC – above this temperature damage will occur.

Generally, we recommend that the ramp is maintained such that the components see a temperature rise of 1.5ºC to 4ºC per second. This is to maintain temperature uniformity through the MLCC and prevent the formation of thermal gradients within the ceramic. In practise, thermal gradients larger than this can still be acceptable, and smaller chip sizes are less susceptible to problems.

In house, Syfer tend to ramp direct to reflow, without a specific dwell or temperature soak. A temperature soak is perfectly acceptable if board complexity or other components demand it or the assemblers own preference is to do so.

The time for which the solder is molten should be maintained at a minimum, so as to prevent solder leaching, although this is less of a problem with Sn/Ni plated terminations. Extended times above 230ºC can cause problems with oxidisation of Sn plating. Use of inert atmosphere can help if this problem is encountered. PdAg terminations can be particularly susceptible to leaching with lead free, tin rich solders and trials are recommended for this combination.

To allow multiple reflow operations, Syfer Sn/Ni plated termination chip capacitors can withstand up to 3 reflow operations at temperatures up to 260ºC.

Cooling to ambient temperature should be allowed to occur naturally, particularly if larger chip sizes are being soldered. Natural cooling allows a gradual relaxation of thermal mismatch stresses in the solder joints, very important for large chips. Draughts should be avoided. Forced air cooling can induce thermal breakage, and cleaning with cold fluids immediately after a soldering process may result in cracked MLC capacitors.

Generally, Syfer recommend convection reflow (also referred to as hot air reflow) as the best method of soldering chip capacitors.

IR reflow is acceptable, but care must be taken when recording and setting soldering profiles as the heating effect is related to the heat absorption rate and thermal conductivity of the materials used – for example the solder paste, ceramic body, metal plating and board material will all absorb heat at slightly different rates. In extreme cases this can induce large temperature deltas in the capacitors. Finally, IR reflow can be susceptible to shadowing (some components blocking direct heat transfer to others) and board layout must be considered accordingly.

Vapour phase reflow soldering can be used, but the nature of this method of applying heat is such that very high temperature ramp rates can be observed. Particularly with larger capacitors, this has been shown to induce micro cracks due to induced temperature deltas. Pre-heat of the components must be carefully controlled.

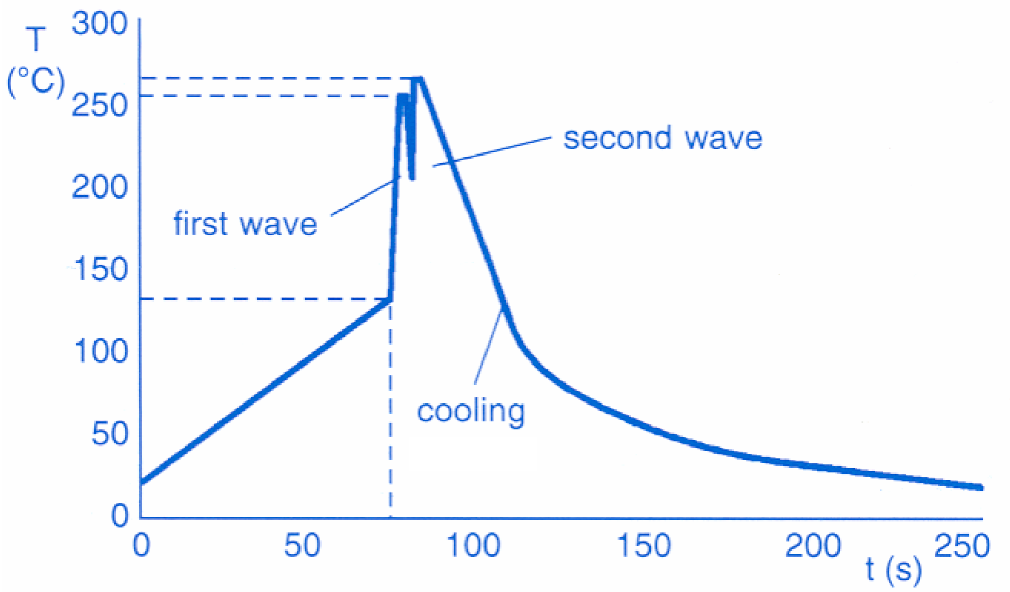
Radial leaded capacitors can be soldered using pin intrusive reflow techniques, but only if the maximum temperature is restricted to 220ºC as these components are soldered construction as SM filters.

Wave Soldering Chip and Radial Leaded Capacitors

Wave soldering is generally acceptable, but the thermal stresses in the wave can lead to potential problems with larger or thicker chips. Particular care should be taken when soldering SM chips larger than size 1210 and with a thickness greater than 1.0mm for this reason. Any chip capacitor should be verified as compatible with a particular wave solder profile.

NOTE – all temperatures refer to wave side of the board. Radial capacitors can be wave soldered into through holes, but the encapsulated capacitor body must always be on the top of the board and must never be immersed in the wave.

If wave soldering is to be carried out, we recommend a profile of the general shape as below (single wave of the same general shape is also acceptable).



Maximum permissible wave temperature is 270ºC for SM chips and 260ºC for Radial Leaded capacitors – see also note above regarding radial leaded capacitors.

The total immersion time in the solder should be kept to a minimum. It is strongly recommended that Sn/Ni plated terminations are specified for wave soldering applications. PdAg termination is particularly susceptible to leaching when subjected to lead free wave soldering and care should be taken if it is used for this application.

Total immersion exposure time for Sn/Ni terminations is 30s at a wave temperature of 260ºC. Note that for multiple soldering operations, including the rework, the soldering time is cumulative.

The pre-heat ramp should be such that the components see a temperature rise of 1.5ºC to 4ºC per second as for reflow soldering. This is to maintain temperature uniformity through the MLCC and prevent the formation of thermal gradients within the ceramic.

The preheat temperature should be within 120ºC maximum (100ºC preferred) of the maximum solder temperature to minimise thermal shock.

Design and jigging should be sufficient to prevent board warping during the soldering process. Board warping can introduce stresses that result in problems such as mechanical cracking which may only be apparent at a later stage.

Cooling to ambient temperature should be allowed to occur naturally if possible, particularly if larger chip sizes are being soldered. Natural cooling allows a gradual relaxation of thermal mismatch stresses in the solder joints, very important for large chips. Draughts should be avoided. Forced air cooling can induce thermal breakage, and cleaning with cold fluids immediately after a soldering process may result in cracked MLC capacitors.

Rework of Chip Capacitors

If it is necessary to remove and replace a chip capacitor (rework), then particular care must be taken to prevent thermal gradients being generated within the ceramic body. Thermal gradients can result in micro cracks being generated, which can result in subsequent failure.

Syfer recommend hot air/ gas as the preferred method for applying heat for rework. Apply even heat surrounding the component to minimise internal thermal gradients.

Syfer do not recommend the use of soldering irons or other techniques that apply direct heat to the chip or surrounding area, as these can cause severe thermal mismatch gradients within the components resulting in micro cracks being generated. If soldering irons must be used it is important not to allow the iron tip to come into direct contact with the chip capacitor, but is applied to the pad adjacent to the capacitor and the heat allowed to soak gradually into the chip.

Minimise the rework heat duration, and allow components to cool naturally after soldering. Do not force cool as this can induce cracking. Ensure components are at room temperature before any cleaning process.

Hand Soldering Radial Leaded Capacitors

Radial capacitors can be hand soldered into boards using soldering irons, provided care is taken not to touch the body of the capacitor with the iron tip. Soldering should be carried out from the opposite side of the board to the radial to minimise the risk of damage to the capacitor body.

Generally, the tip temperature of the iron should not exceed 300°C and the dwell time should be 3-5 seconds maximum to minimise the risk of cracking the capacitor due to thermal shock. Where possible, a heat sink should be used between the solder joint and the body, especially if longer dwell times are required.

Use of Silver Loaded Epoxy Adhesives

Chip capacitors can be mounted to circuit boards using silver loaded adhesive provided the termination material of the capacitor is selected to be compatible with the silver loaded adhesive. This is normally PdAg. Standard tin finishes are often not recommended for use with silver loaded epoxies as there can be electrical and mechanical issues with the joint integrity due to material mismatch.

Mounting and Soldering to Panel Mount filters

The ceramic capacitor, which is the heart of the filter, can be damaged by thermal and mechanical shock, as well as by over-voltage. Care should be taken to minimise the risk of stress when mounting the filter to a panel and when soldering wire to the filter terminations.

It is important to mount the filter to the bulkhead or panel using the recommended mounting torque, otherwise damage may be caused to the capacitor due to distortion of the case. When a threaded hole is to be utilised, the maximum mounting torque should be 50% of the specified figure which relates to unthreaded holes. For details of torque figures for each filter range, please see below.

Mounting into bulkhead

Thread	Torque (max)	
	With nut	Into tapped hole
M2.5 & 4-40UNC	-	0.15Nm (1.3 lbf in)
M3	0.25Nm (2.2 lbf in)	0.15Nm (1.3 lbf in)
6-32 UNC	0.3Nm (2.7 lbf in)	0.15Nm (1.3 lbf in)
M3.5	0.35Nm (3.1 lbf in)	0.18Nm (1.6 lbf in)
M4 & 8-32 UNC	0.5Nm (4.4 lbf in)	0.25Nm (2.2 lbf in)
M5, 12-32 UNEF & 2BA	0.6Nm (5.3 lbf in)	0.3Nm (2.7 lbf in)
M6 & ¼-28 UNF	0.9Nm (8.0 lbf in)	-
M8	1.0Nm (8.9 lbf in)	0.5Nm (4.4 lbf in)
M10	3Nm (26.6 lbf in)	-
M12	4Nm (35.4 lbf in)	-
M16	7Nm (61.7 lbf in)	-
M20	10Nm (88.5 lbf in)	-
M24, M25	14Nm (123.9 lbf in)	-

Terminal Connections

Thread	Torque (max)
M3	0.5Nm (4.4 lbf in)
M4	1.2Nm (10.6 lbf in)
M6	2.5Nm (22.1 lbf in)
M8	5.0Nm (44.3 lbf in)

When tightening terminal connections, always use 2 spanners to prevent twisting of terminal.

For threads not listed, please contact the factory for recommended tightening torque.

Hexagonal devices should be assembled using a suitable socket. Round bodied filters may be fitted to the panel in one of two ways (and should not be fitted using pliers or other similar tools which may damage them):

- Round bodies with slotted tops are designed to be screwed directly into a panel using a simple purpose-designed tool.
- Round bodies without slotted tops are intended to be inserted into slotted holes and retained with a nut.

To ensure the proper operation of the filters, the filter body should be adequately grounded to the panel to allow an effective path for the interference. The use of locking adhesives is not recommended, but if used should be applied after the filter has been fitted.

Users should be aware that the majority of filters have an undercut between the thread and the

mounting flange of the body, equal to 1.5 x the pitch of the thread. Mounting into a panel thinner than this undercut length may result in problems with thread mating and filter position. It is recommended that a panel thicker than this undercut length be used wherever possible.

Filters with a thread run-out will have an un-threaded portion between the head and the start of the thread. This may need to be allowed for in hole design.

Maximum plate thickness is specified for each filter in order that the nut can be fully engaged even when using a washer.

When Soldering to axial wire leads, the tip temperature of the iron should not exceed 300°C and the dwell time should be 3-5 seconds maximum to minimise the risk of cracking the capacitor due to thermal shock.

Where possible, a heat sink should be used between the solder joint and the body, especially if longer dwell times are required.

Bending or cropping of the filter terminations should not be carried out within 4mm (0.157”) of the epoxy encapsulation and the wire should be supported when cropping wherever possible.