TN1037
Technical note

SLLIMM™- nano mounting instructions and heatsink

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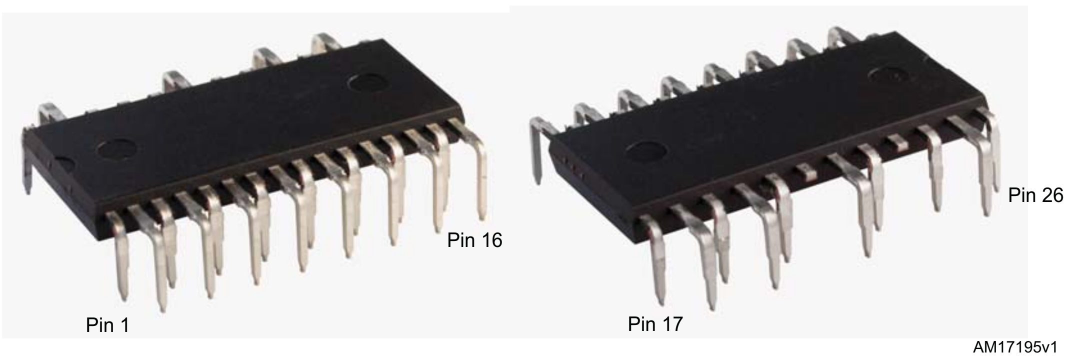
Introduction

SLLIMM™-nano (Small Low-Losses Intelligent Molded Module) is a very compact, high efficiency, dual-in-line intelligent power module with optional extra features for motor drive applications. Thanks to its high electrical performance and very compact size, the fully isolated SLLIMM-nano package (NDIP) is the ideal solution for applications requiring reduced assembly space, without sacrificing thermal performance and reliability.

This technical note provides the main recommendations to properly handle, assemble and rework the SLLIMM-nano devices in addition to some guidelines to improve its thermal management. Some basic mounting instructions are suggested either to limit thermal and mechanical stresses or assure the best thermal conduction and electrical insulation.

Figure 1. SLLIMM-nano images



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1 Heatsink mounting information

Although the SLLIMM-nano is designed to drive electric motors up to 100 W in open air, an external heatsink can be mounted to improve its thermal performance.

This section provides some basic guidelines and the main specifications for ensuring safe heatsink mounting, preventing the application of excessive force to the device and taking into account the following suggestions:

- Avoid applying excessive pressure to the SLLIMM-nano, as it could damage the module and cause saturation of thermal dissipation capability
- Smooth the surface by removing burrs and protrusions of indentations to ensure good contact between the SLLIMM-nano and the heatsink
- Do not touch the heatsink when the application is running to avoid burn injury

1.1 Main specifications

Table 1 provides the main parameters to be used during the heatsink mounting process.

Table 1. Mounting force and heatsink flatness specifications

Item	Condition	Min.	Typ.	Max.	Unit
Device flatness	See *Figure 2*	0		+75	µm
Heatsink flatness	See *Figure 3*	-50		+100	µm
Mounting force (compression)	Force applied to leads standoff (see *Figure 4*)	20	30	40	N
	Force applied to plastic body (see *Figure 5*)	60	70	80	N
Mounting torque (M3 screw)		0.40	0.55	0.70	Nm

Device and heatsink flatness are prescribed as seen in *Figure 2* and *Figure 3*.

Figure 2. Device flatness specification

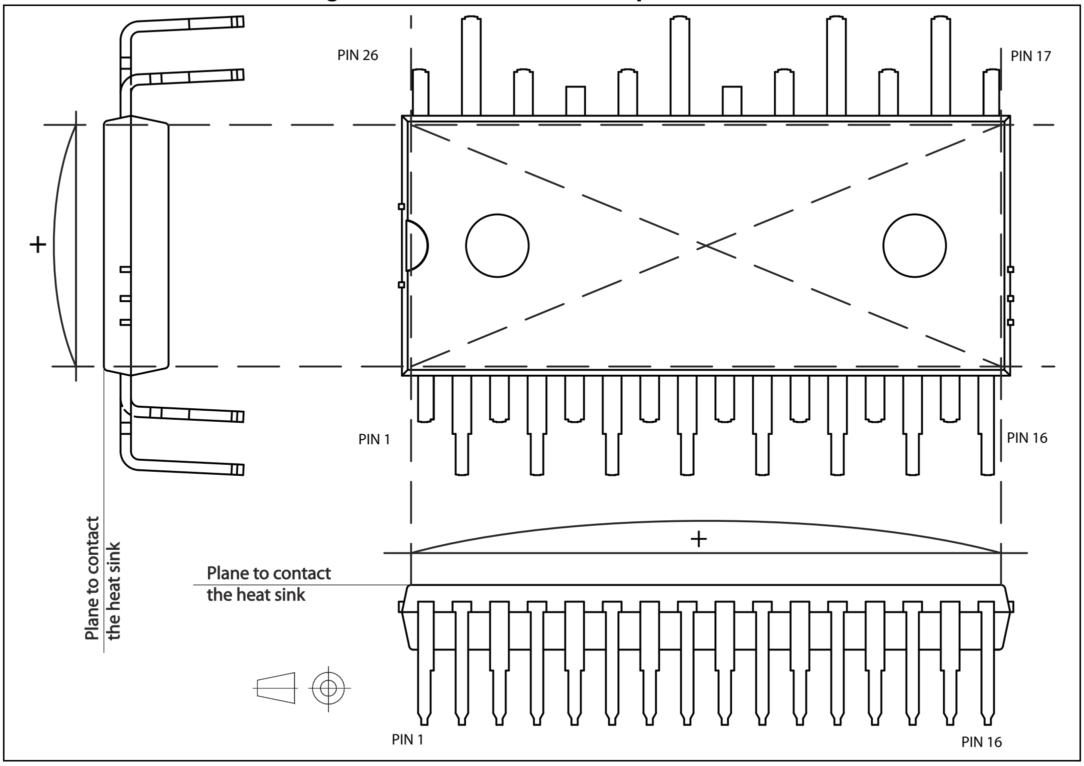


Figure 3. Heatsink flatness specification

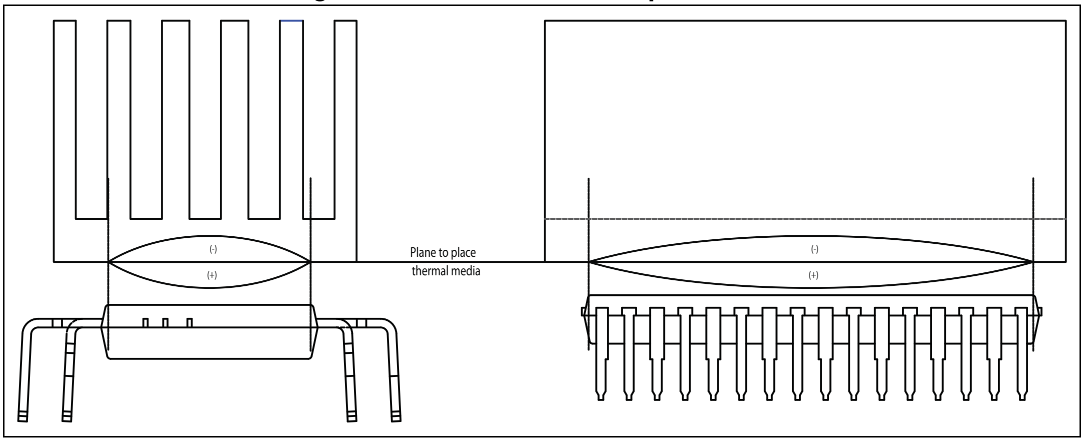


Figure 4. Heatsink force delivery to the leads of SLLIMM-nano

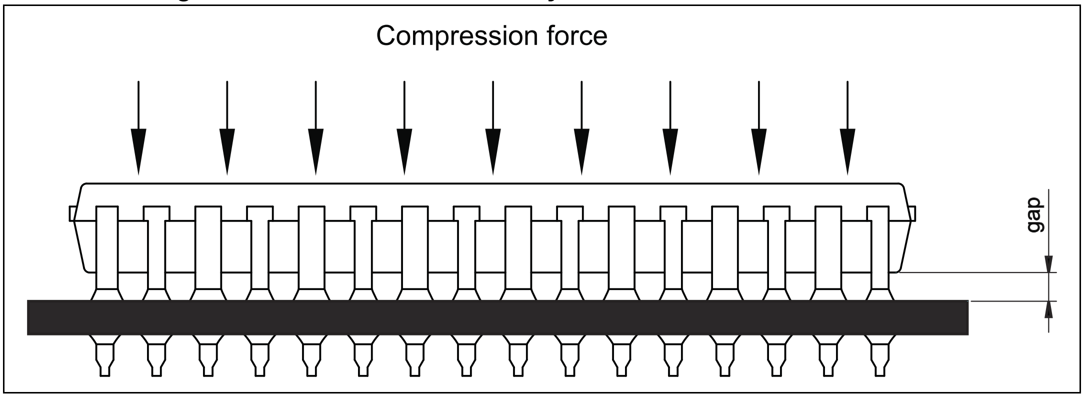
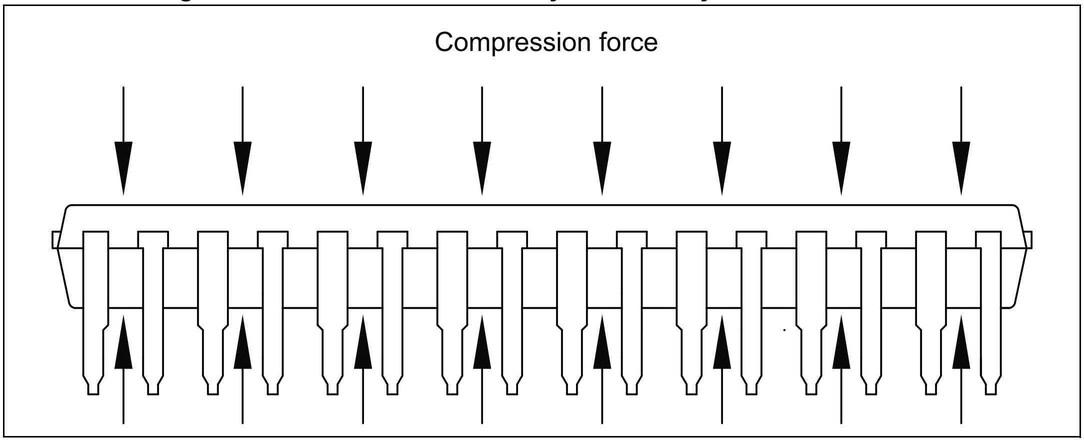


Figure 5. Heatsink force delivery to the body of SLLIMM-nano



1.2 Thermal conductive media

To achieve the most effective heat dissipation, it is necessary to enlarge the contact area as much as possible, which minimizes the contact thermal resistance. Smooth the surface by removing burrs and protrusions. Properly apply a uniform layer of silicon grease, from 100 μm to 200 μm of thickness, between the device and the heatsink to reduce the contact thermal resistance, or use a thermal pad, which is also useful for preventing corrosion of the contact surface. Be sure to apply the coating thinly and evenly, taking care not to leave any voids on the contact surface between the SLLIMM-nano and the heatsink. Ensure the thermal pad or grease has a constant time-quality and long-term endurance within a wide operating temperature range.

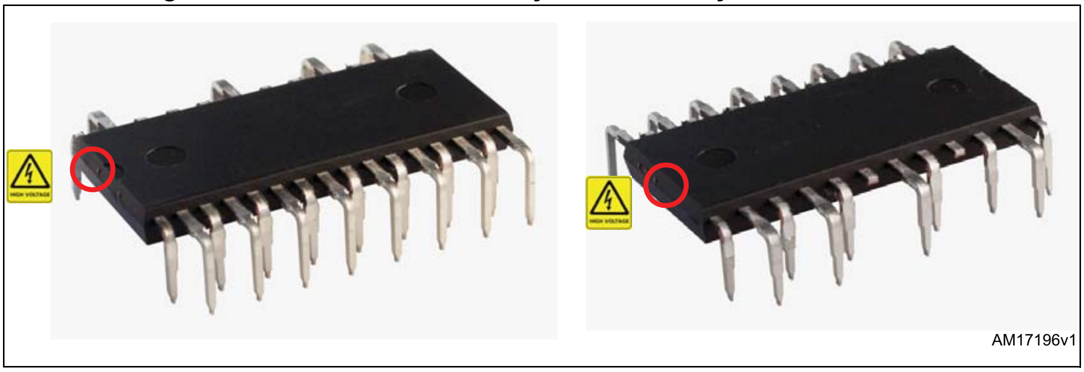
Exceeding the maximum compression force limitation can damage or degrade the device. Ensure that there is no dirt on the contact surface. The thermal pad should be compressed in the range of 10% to 40% of its maximum thickness.

1.3 Safe distances

In order to ensure safe working conditions, spaces between the high voltage SLLIMM-nano contacts and the heatsink must be aligned with creepage and clearance distances for a given application according to the relevant standards, such as IEC 60664 or IEC 60335 and others.

The SLLIMM-nano has some visible trimmed terminations on both lateral sides of the body to improve mechanical stress capability during the process flow, as shown in *Figure 6*. Some of these trimmed terminations are subjected to high voltage. Therefore, special attention must be paid to avoid any direct or indirect contact with these trimmed terminations during the testing phase. Moreover, a safe distance must be maintained between the heatsink and the trimmed terminations. In this case, the thermal pad may play an important role. If the pad is overhanging the package body, further insulation may be gained.

Figure 6. Heatsink force delivery onto the body of SLLIMM-nano



2 Cooling techniques and heatsink mounting proposals

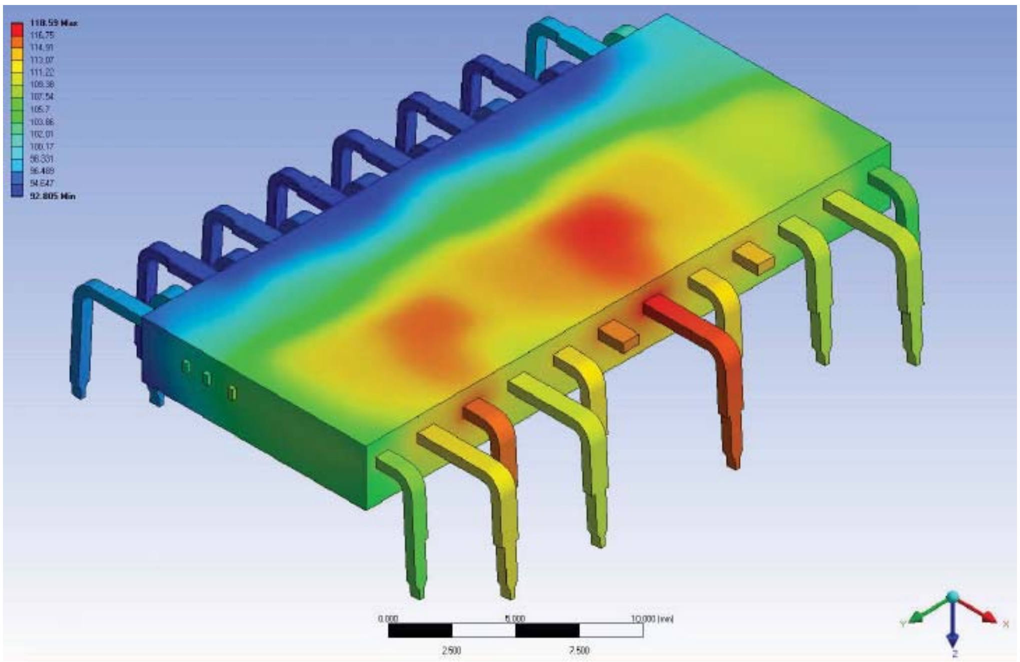
The NDIP is a transfer mold package with no screw holes, therefore some dedicated cooling techniques or heatsink mounting methods must be adopted if a higher power level is targeted.

2.1 Copper plate on the PCB

One of the easiest methods is based on a natural cooling system and a proper design of the PCB layout. In this case, the PCB, along with the pads, acts as a heatsink providing paths for individual packages to effectively transfer heat to the board and the adjacent environment. Therefore, maximizing the area of the metal traces where the power and ground pins of the package are located is a valuable method for reducing the thermal resistance and achieving improved power performance.

The main pins involved in this phenomenon are the positive DC pin (P) and the phase output pins (U, V, W) since they are directly connected to the copper lead frame where the power devices are mounted and IGBTs and diodes are the major source of heat, as shown in the *Figure 7*.

Figure 7. SLLIMM-nano thermography



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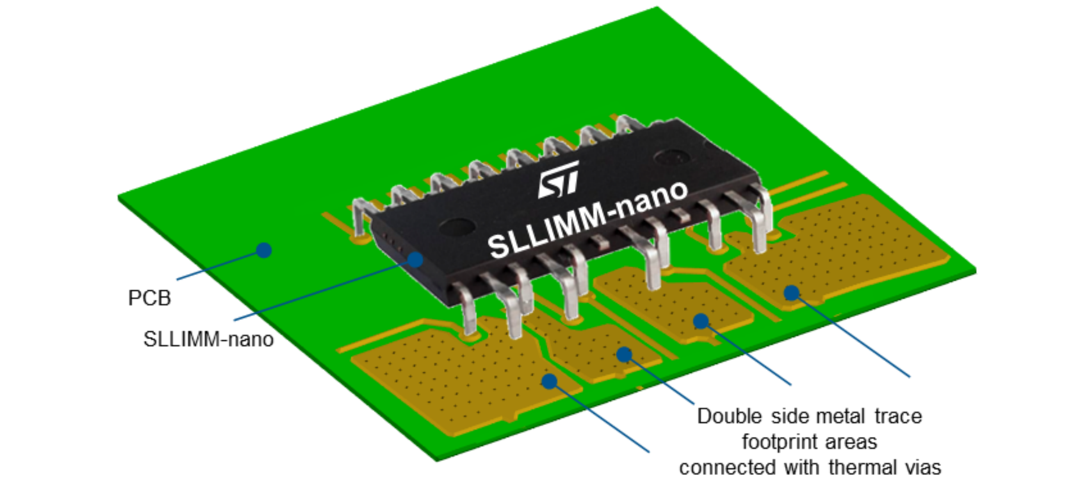
Several factors impact the total thermal performance, such as the area of metal traces, the thickness of the copper plate, their placement on the board and the distance between the SLLIMM-nano and other heat sources. Both sides of the PCB can be used and thermally connected through direct copper connections or thermal vias in order to increase the heat dissipation and reduce the layout complexity.

Figure 8 shows an example of metal traces layout used to dissipate heat on the PCB.

Figure 8. Copper plate on the PCB



Higher thermal performance can be achieved by using a compact external heatsink, in close contact with the SLLIMM-nano.

2.2 Heatsink pasted on the package

The heatsink can be directly pasted on the package of the SLLIMM-nano using a uniform layer of thermal conductive glue or an adhesive foil between the heatsink and the topside of the package, as shown in *Figure 9* and *Figure 10*.

Figure 9. Small heatsink pasted on the package

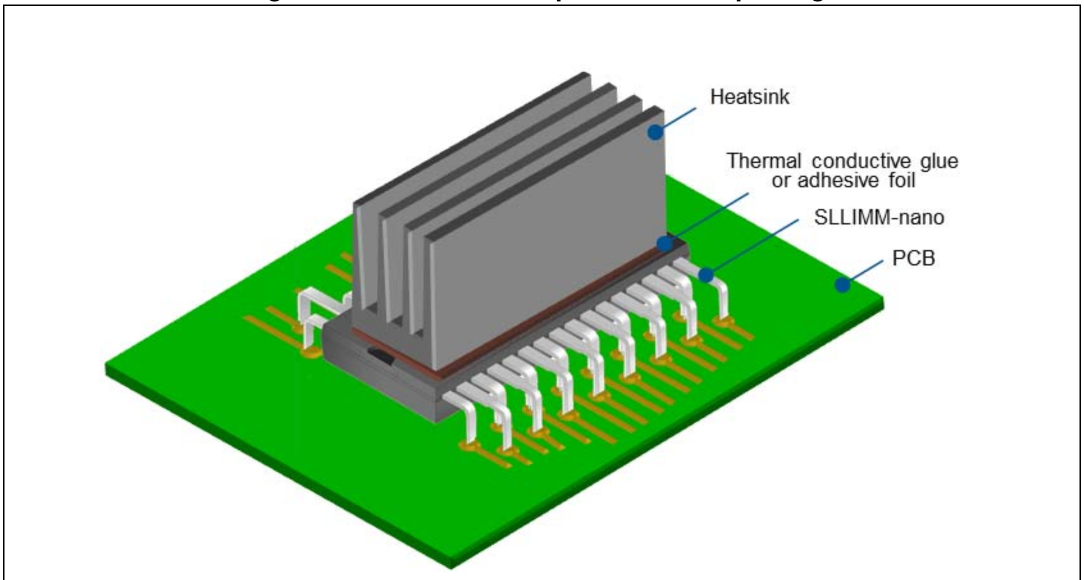
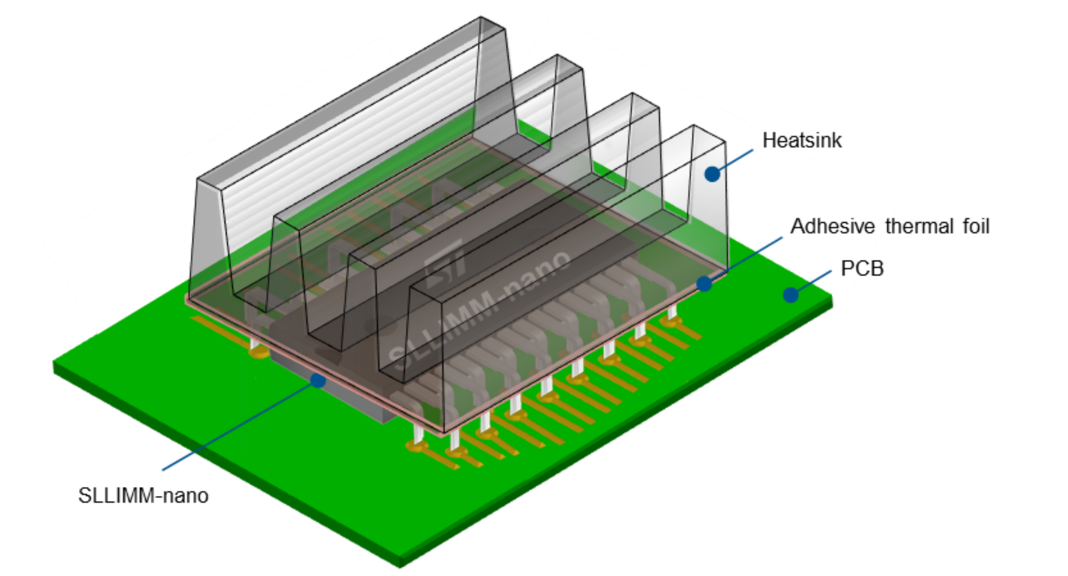


Figure 10. Large heatsink pasted on the package

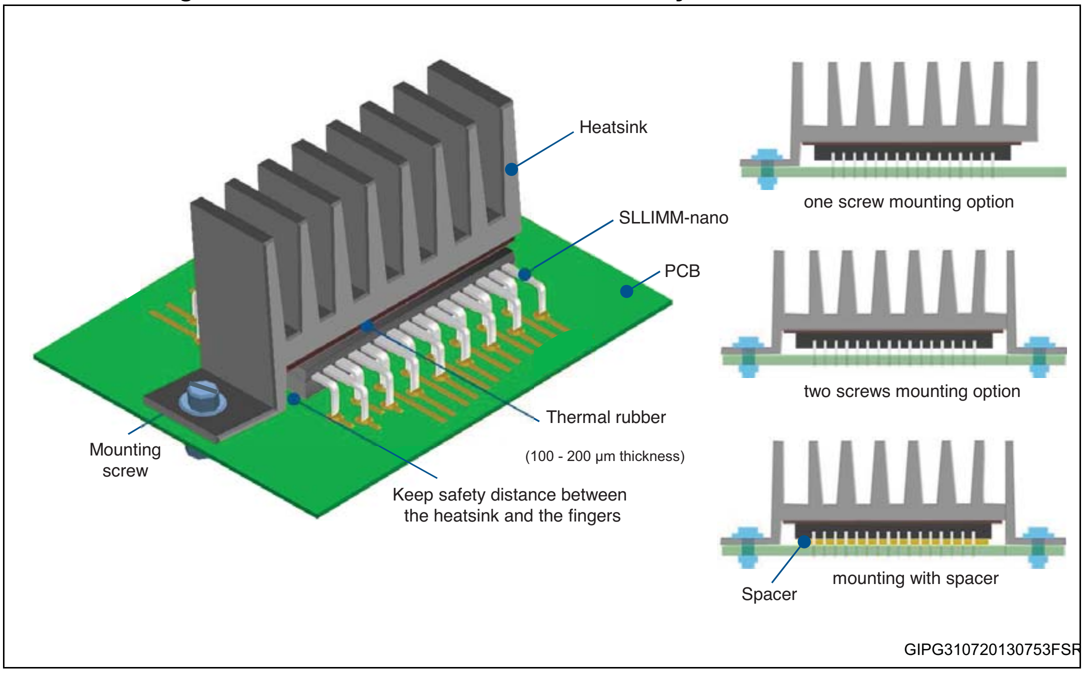


In order to ensure safe working conditions, as previously stated in *Section 1.3: Safe distances*, the adhesive foil or the thermal rubber must be placed to improve electrical isolation and therefore must be properly sized in order to increase the creepage and clearance distances.

2.3 Heatsink bonded on the PCB by mounting screws

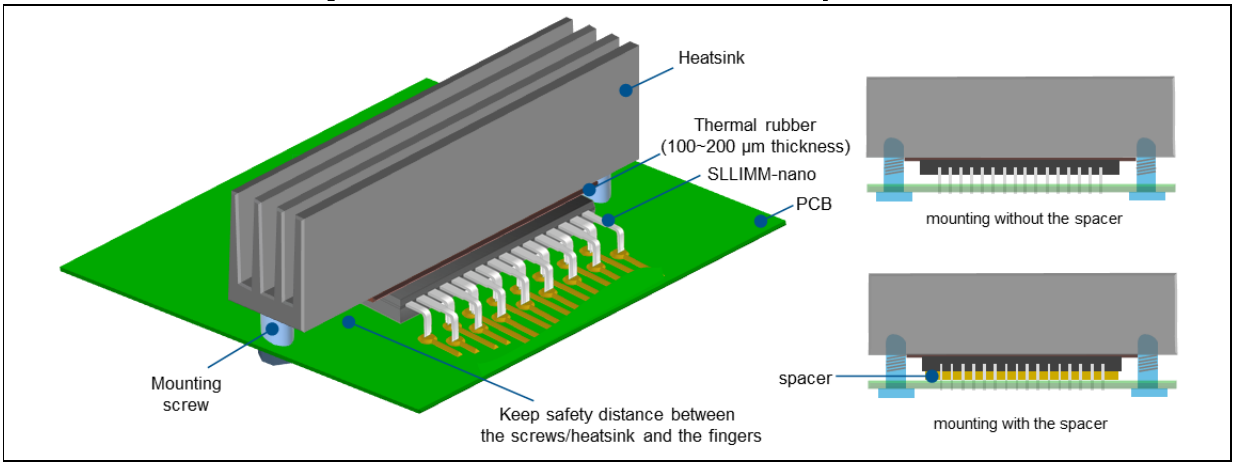
The heatsink can be also bonded on the package and fixed on the PCB using one or two mounting screws (*Figure 11*), ensuring a firmer assembly process. The use of this heatsink with dedicated form factor prevents any possible stress on the leads of SLLIMM-nano and the PCB soldering pads. This technique requires the use of a thermal pad between the heatsink and the topside of the SLLIMM-nano in order to ensure the creepage distance. A safe distance between the shorter side of the device (where some trimmed terminations are placed) and the heatsink must be guaranteed in order to ensure clearance. The two screws option is preferred in order to improve mechanical stability and reliability of the system. Any mismatch in thickness between the SLLIMM-nano and the heatsink can be resolved by using a thin insulated spacer between the device and the PCB.

Figure 11. Heatsink bonded on the PCB by one or two screws



Alternatively, *Figure 12* shows a different-shaped heatsink bonded on the PCB. As an additional requirement of this mounting technique, a minimum distance between the metal screws and the lateral side of the SLLIMM-nano (where some trimmed terminations are placed) must be guaranteed, in order to ensure the clearance distance. The use of plastic screws allows the reduction of such distance. In order to greatly reduce the stress on the leads of the SLLIMM-nano and on the PCB soldering pads, an insulating spacer can be placed between the bottom side of the SLLIMM-nano and the PCB.

Figure 12. Heatsink bonded on the PCB by screws



2.4 Heatsink bonded on the package by plastic screws

Figure 13 and *Figure 14* show a heatsink directly bonded on the SLLIMM-nano package by two plastic screws. This method prevents any possible stress on the leads of the SLLIMM-nano and on the PCB soldering pads, and does not require an insulating spacer. The use of a large head screw improves the heatsink fixing. In addition, a PCB hole the same size as the head screw, placed directly under it, provides lateral binding and improves the stability of the assembly process.

A thermal foil must be placed between the heatsink and the topside of the SLLIMM-nano in order to ensure the creepage distance.

Figure 13. Small heatsink bonded on the package by plastic screws

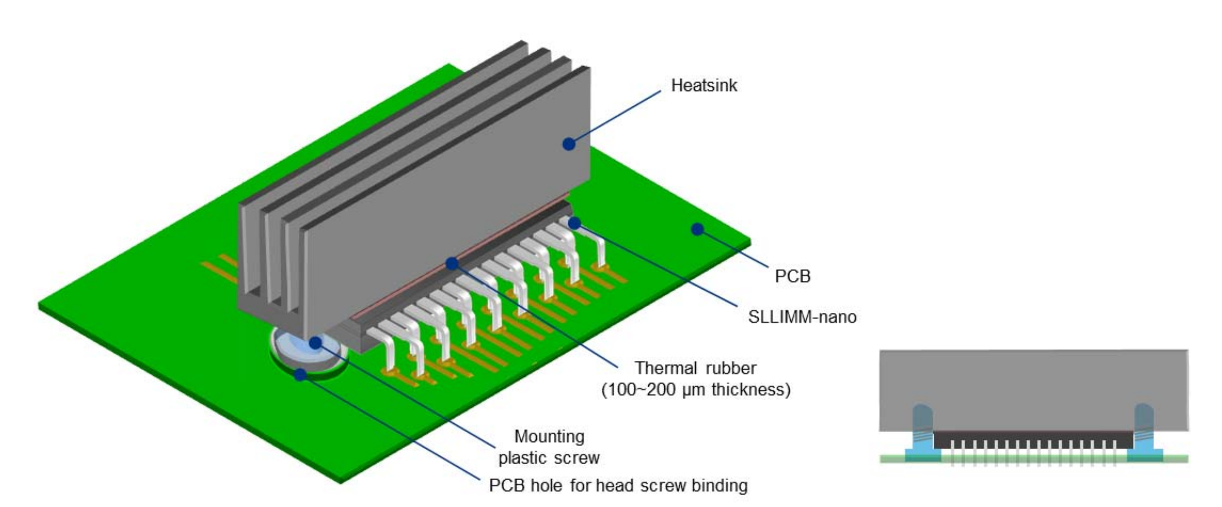
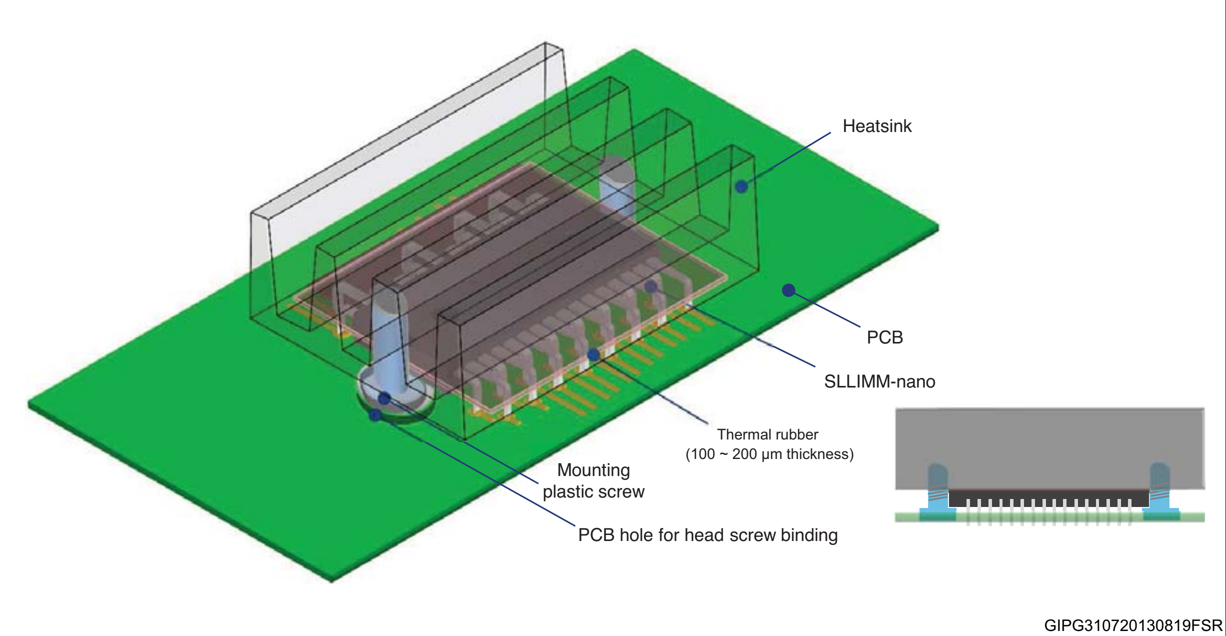


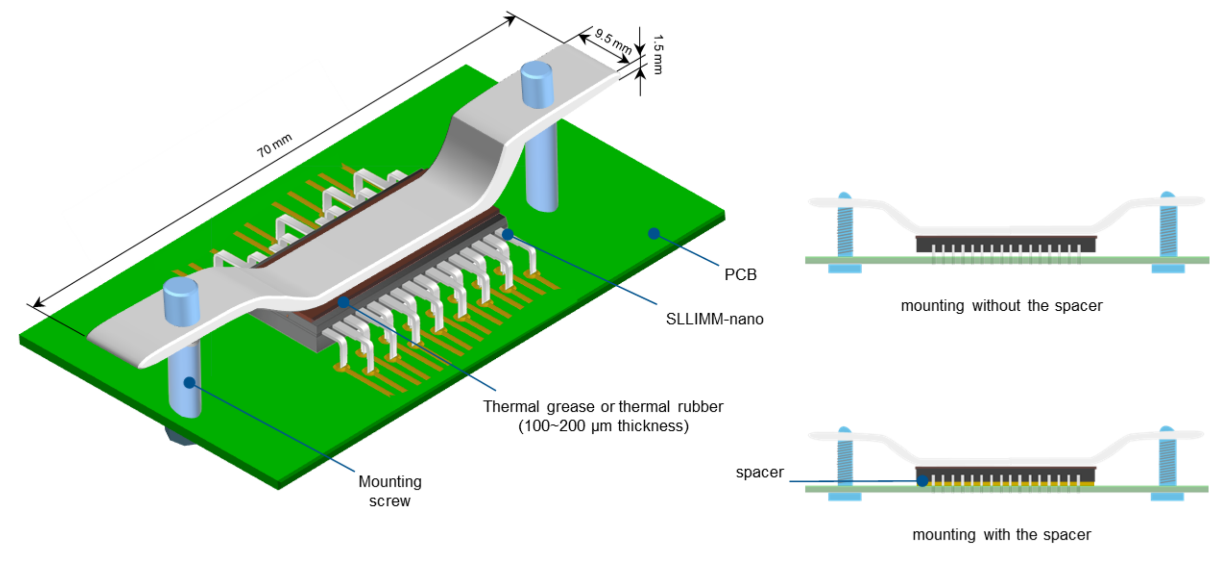
Figure 14. Large heatsink bonded on the package by plastic screws



2.5 Al-plate heatsink bonded on the PCB by mounting screws

A simple aluminum plate heatsink can be bonded on the package of the SLLIMM-nano by two screws housed in the PCB. The dimensions, shown in *Figure 15*, are referred to a thermal impedance of the Al-plate of 18°C/W. The specific shape and the placing of a thermal foil between the heatsink and the topside of the SLLIMM-nano ensure the creepage and clearance distances between the heatsink and the shorter edge of the package. As stated previously for the other mounting techniques, in order to greatly reduce the stress on the leads and on the PCB, an insulating spacer can be placed between the bottom side of the SLLIMM-nano and the PCB.

Figure 15. Al-plate heatsink bonded on the PCB by mounting screws



Finally, a large number of solutions may exist based on application requirements, which could take advantage of metal housing in which the board may eventually be mounted.

3 General handling precautions and storage notices

When using semiconductors, the incidence of thermal and/or mechanical stress to the devices due to improper handling may result in significant deterioration of their electrical characteristics and/or reliability.

3.1 Transportation

Take care when handling the device and packaging material. Ensure that the device is not subjected to mechanical vibration or shock during transport. Do not toss or drop to ensure the device is correctly functioning before mounting on the board. Wet conditions are dangerous. Moisture can also adversely affect the packaging. Place the devices in conductive trays before using them. Hold the package and avoid touching the leads when handling devices. Avoid leaning package boxes or applying uneven stress to them as this could cause the electrode terminals to be deformed or the resin case to be damaged. Throwing or dropping the packaging boxes might cause the devices to be damaged. Wetting the packaging boxes might cause the breakdown of devices when in operation.

3.2 Storage

- Do not apply force or excessive external pressure to the devices while they are in storage.
- Do not store the devices in an area exposed to moisture or direct sunlight.
- Humidity should be kept within the range from 40% to 75%, and the temperature not over 35 °C or below 5 °C.
- Do not store in the presence of harmful gases or in dusty environments.
- Lead solderability is degraded by lead oxidation or corrosion. Use of storage areas where there is minimal temperature fluctuation is highly recommended.
- Use anti-static containers. Unused devices should be stored no longer than one month.

3.3 Environment

- Use a board container or bag that is protected against static discharge when storing device-mounted circuit boards. Do not stack them directly on top of one another and keep them separated to prevent the static charge/discharge which occurs due to friction.
- Be sure cardboard surfaces that come into contact with device packaging are made of materials that will conduct static electricity, and are grounded to the floor surface with a grounding chain.
- Wear finger cots or gloves protected against static electricity if the body comes into direct contact with a device.
- When humidity in the working environment decreases, the human body and other insulators can easily become charged with electrostatic electricity due to friction. Maintain the recommended humidity within 40% to 60% in the work environment. Be aware of the risk of moisture absorption by the products after unpacking from moisture-proof packaging.
- Be sure all equipment and tools in the working area are earth grounded.

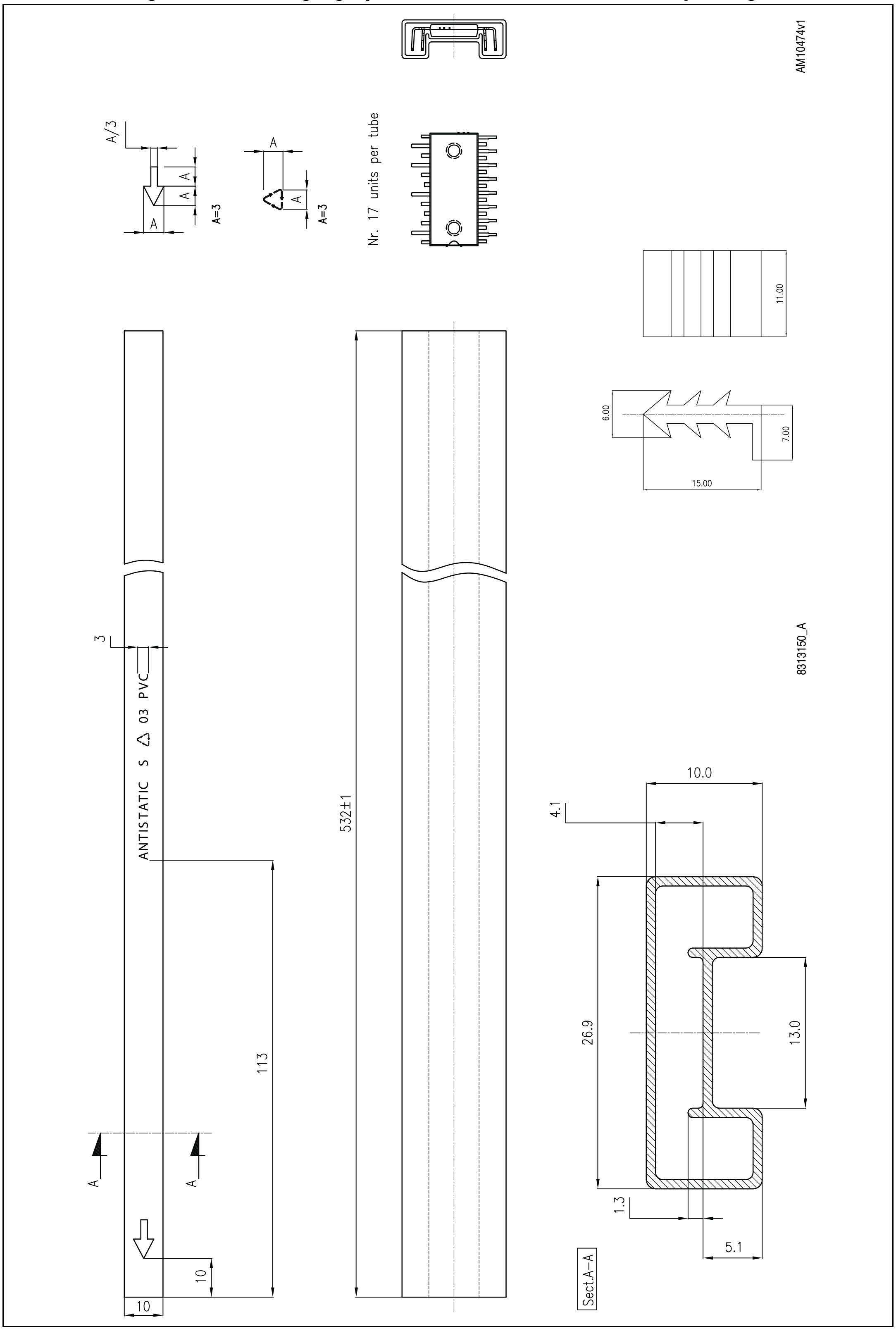
- Take other appropriate measures (e.g. place a conductive mat on the floor of the work area), so that the floor surface is grounded to earth and is protected against electrostatic discharge.
- Cover the workbench surface with a conductive mat, grounded to earth, to disperse static electricity on the surface through resistive components. Workbench surfaces must not be constructed of low-resistance metallic material that allows rapid static discharge when a charged device touches it directly.
- Ensure that work chairs are protected with an anti-static textile cover and are grounded to the floor surface with a grounding chain.
- Install anti-static mats on storage shelf surfaces.
- For transport and temporary storage of devices, use containers that are made of anti-static materials or materials that dissipate static electricity.
- Workers must wear anti-static clothing and conductive shoes (or a leg or heel strap).
- Workers must wear a wrist strap grounded to earth through a resistor of about 1 MΩ.
- If the tweezers used are likely to touch the device terminals, use an anti-static type and avoid metal tweezers. If a charged device touches such a low-resistance tool, a rapid discharge can occur. When using vacuum tweezers, attach a conductive chucking pad at the tip and connect it to a dedicated ground used expressly for anti-static purposes.

3.4 Electrical damage

In order to prevent electrical damage to the device, ensure that electrical measurement equipment is turned off before it makes contact with the device.

3.5 Packaging specifications

Figure 16. Packaging specifications of SLLIMM-nano package



4 Reflow

The SLLIMM-nano is intended to be a through hole device (THD). THDs are typically soldered by wave soldering. However, as the number of THDs on a board continues to decrease in some applications, wave soldering becomes less cost-effective, so the few remaining THDs (mostly connectors and special components) are soldered with selective wave soldering or with pin-in-paste techniques, plus reflow soldering.

4.1 Selective wave soldering of SLLIMM-nano

Wave soldering is a large-scale soldering process by which electronic components are soldered to a PCB to form an electronic assembly. The name is derived from the fact that the process uses a tank to hold a quantity of molten solder; the components are inserted into or placed on the PCB and the loaded PCB is passed across a pumped wave or cascade of solder. The solder wets the exposed metallic areas of the board (those not protected with solder mask), creating a reliable mechanical and electrical connection.

For THDs, only the leads that extend through the drill holes in the PCB contact the hot solder. The body of the package is heated by the hot leads. This has two consequences:

1. The package body is cooler than in the case of reflow soldering
2. The temperature gradient between the leads, the body and inside the package is greater than in the case of reflow soldering.

Therefore, for wave-solderable THDs the heat resistance is tested according to JESD22-B106 and IEC668 2-20 (typically 260 °C, 10 s).

Note: Immersion of the whole package body into the molten solder is not recommended since the SLLIMM-nano is not designed for such a harsh temperature shock.

For evaluation of its ability to withstand full body immersion, please see also JESD22-A111.

There are many types of wave-soldering machines, but their basic components and principles are the same. A standard wave-soldering machine consists of three zones: the fluxing zone, the preheating zone, and the soldering zone. A fourth zone, the cleaning zone, may be used depending on the type of flux applied.

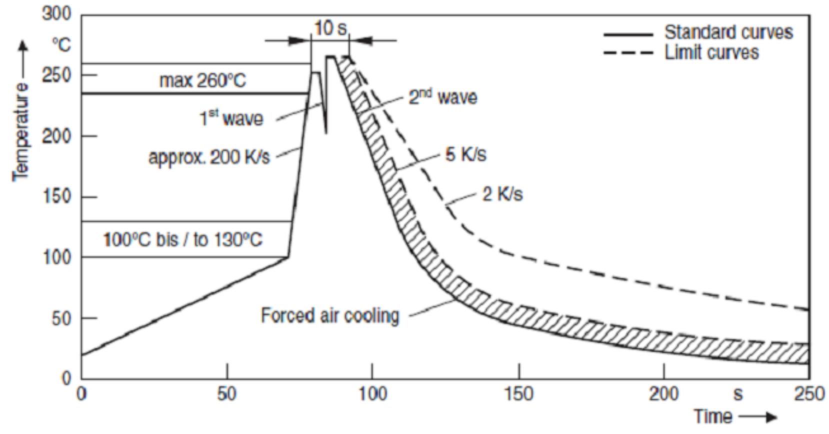
Dual-wave soldering is the most commonly used wave-soldering method (see *Figure 17*). The peak temperatures, ramp rates, and times that are used depend on the materials and the wave-soldering equipment.

The first wave has a turbulent flow and therefore guarantees a wetting of nearly all shapes of leads and board pads, but also creates an increased number of unwanted solder bridges. These solder bridges have to be removed by the second, laminar wave.

When using lead-free solder alloys, a nitrogen atmosphere is recommended.

Selective wave soldering is used when only a few THDs need to be soldered onto the board. Generally this is done after the other components are already soldered by reflow soldering. This requires effective protection of these components undergoing the selective wave soldering. This protection can be achieved either by using special fixtures and deflectors for the PCB and/or a small wave shape achieved by using special wave-guiding tubes or covers.

Figure 17. Typical dual-wave soldering profile



4.2 Other soldering techniques

Besides wave and reflow soldering, other techniques are used in special applications. Examples include selective wave soldering, laser welding and laser soldering, hot bar soldering, and manual soldering with soldering irons and hot air guns.

For this broad group of soldering techniques, which cannot be tested for every component, some general guidelines should be followed:

- The maximum temperature of the package body and leads must not exceed the maximum allowed temperature for reflow or wave soldering.
- The maximum allowed time at high temperatures must not exceed the maximum allowed time for reflow or wave soldering.
- If heat is applied to the leads, the maximum temperatures in the package and of the package body must not exceed the maximum allowed temperatures during reflow or wave soldering.
- For details and special arrangements, please refer to the product datasheet and/or the qualification report.

If long contact and heating times are unavoidable, the resulting temperatures on different leads near the package body should be measured and compared to the temperatures and duration achieved during wave or reflow soldering, which must not be exceeded.

Please ask your local sales, quality, or application engineer to provide you the evaluation report for further information, if needed.

4.3 Pin-in-paste

Another technique used to solder THDs is to print solder paste onto a PCB near or over drill holes through which the leads are then inserted. The reflow of the solder paste is done together with soldering the SMDs, which therefore have to go through the reflow temperature profile. This has two consequences:

1. The temperature is nearly the same for the whole package in contrast to wave soldering.
2. The time for which the peak temperature is applied to the package is much longer compared to wave soldering.

THD are qualified for wave soldering and not for reflow soldering. Therefore, pin-in-paste soldering techniques are not recommended for SLLIMM-nano.

4.4 Heatsink mounting by reflow soldering

In special applications, the heatsink of high-power THDs can be mounted to the board by solder paste printing, pick & place, and reflow soldering. In this case, the packages undergo a reflow profile.

THDs are qualified for wave soldering and not for reflow soldering. Therefore, reflow soldering should not be used for heatsink mounting for the SLLIMM-nano.

5 Rework

If a defective component is observed after board assembly, the device can be removed and replaced by a new one. Repair of single solder joints is generally possible, but requires the proper tools. For example, repairing the solder joint of an exposed die pad cannot be done with a soldering iron.

Whatever rework process is applied, it is important to recognize that heating a board and components above 200 °C may result in damage. As a precaution, every board with its components has to be baked prior to rework. For details, please refer to the international standard J-STD-033.

In any case, mechanical, thermal or thermo-mechanical over-stress must be avoided, and rework done according to JEDEC J-STD-033A, IPC-7711 and IPC-7721.

5.1 Device removal

If a defective component needs to be sent back to the supplier, no further defects must be caused during the removal of this component, because this may hinder the failure analysis by the supplier. The following recommendations should be considered:

- Moisture: depending on the MSL, the package may have to be dried before removal. If the maximum storage time out of the dry pack (see label on packing material) is exceeded after board assembly, the PCB has to be baked according to the recommendations of the PCB manufacturer. Otherwise, too much moisture may have been accumulated and damage may occur (“popcorn” effect).
- Temperature profile: during the de-soldering process it should be assured that the package peak temperature is not higher and temperature ramps are not steeper than for the standard assembly wave process.
- Mechanics: be careful not to apply high mechanical forces for removal. Otherwise failure analysis of the package could be rendered impossible, or the PCB can be damaged. For large packages, pipettes can be used (implemented on most rework systems); for small packages, tweezers may be more practical.

5.2 Site redressing

After removing the defective component, the pads on the PCB have to be cleaned to remove solder residues. This may be done by vacuum de-soldering or wick.

Do not use steel brushes because steel residues can lead to bad solder joints. Before placing a new component, it may be necessary to apply solder paste on PCB pads by printing (special micro-stencil) or dispensing.

5.3 Reassembly and reflow

After preparing the site, the new package can be placed onto the PCB and the leads inserted into the holes. Regarding placement accuracy and placement force, the process should be comparable to the (automatic) pick & place process.

During the soldering process, it should be assured that the package peak temperature is not higher and temperature ramps are not steeper than for the standard assembly process. Soldering wire can be used to re-solder the leads. Use only no-clean solder paste, solder wire, and flux for repair.

5.4 Coating of assembled PCBs

In some applications, coatings are used to prevent damage due to external influences such as:

- Mechanical abrasion
- Vibration
- Shock
- Humidity
- Hand perspiration
- Chemicals and corrosive gases

These influences may cause:

- Electrical leakage due to humidity.
- Corrosion that leads to degradation of conductor paths, solder joints, and any other metalized areas; and/or formation of electrical leakage paths. These can eventually result in electrical shorts (electrical leakage) or open contacts.
- Mechanical damage to conductor paths, solder joints, and components. This damage can lead to electrical failures.

Coatings act as electrically isolating and impervious covers that adhere well to the different PCB materials.

A wide variety of different coatings are available on the market. They differ in:

- Price
- Simple processability (spray, dip, casting, curing, etc.)
- Reparability
- Controllability
- Homogeneity

In any case, please be aware of the chemical, electrical, mechanical and thermo-mechanical interaction between the coating, the PCB and its components. Coatings can affect component reliability.

6 References

1. AN4043 application note
2. SLLIMM-nano datasheets

7 Revision history

Table 2. Document revision history

Date	Revision	Changes
05-Jul-2013	1	Initial release.
12-Jul-2013	2	Updated *Figure 1: SLLIMM-nano images*.
01-Aug-2013	3	Updated *Figure 11: Heatsink bonded on the PCB by one or two screws* and *Figure 14: Large heatsink bonded on the package by plastic screws*.