AN11046

Recommendations for PCB assembly of DSN0603-2

Rev. 3 — 30 September 2016 Application note

Document information

Info	Content
Keywords	DSN0603, DSN0603-2, SOD962, 0603 package size, reflow soldering, surface mount, solder paste, stencil aperture, Printed-Circuit Board (PCB), Solder Mask Defined (SMD), footprint, landing pattern, pick and place, Chip-Scale Package (CSP)
Abstract	This application note provides guidelines for board assembly of the ultra-small DSN0603-2 (0.6 × 0.3 mm^2) chip-scale package. The main focus is on recommendations for reflow soldering. For general information about footprint design and reflow soldering, see application note AN10365 (Surface mount reflow soldering description). If not otherwise stated, all measurement units given in this document are metric units. This means that also the package nomenclature (for example the term "0603") refers to metric units.

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Revision history

Rev	Date	Description
1	20120601	Initial version
2	20150923	Completely revised document
3	20160930	Section 1: added comment on tilting and occupied area

1. Introduction

Due to the trend of reduced dimensions and increased density of functionality in smartphones and other mobile devices, there is an increasing request from the industry for extremely small components. Nexperia supports this trend with the new DSN0603-2 (SOD962) package. It is an ultra small surface-mount chip-scale diode package with a size of only 0.6 mm $\times$0.3 mm $\times$0.3 mm (0603 as metric; 0201 in inches).

Due to the very small size of the component, Nexperia investigated the board assembly process intensively in order to offer board mounting recommendations.

This includes PCB mounting pads, stencil apertures, solder paste and board assembly process parameters.

Using the recommended dimensions for pads and stencil as described in this document helps to achieve:

- optimum stand-up height
- minimum tilt
- minimum rotation
- good board assembly process performance

While this application note helps minimizing any unexpected failures, following the advice in this document is not a guarantee for a perfect Surface-Mount Technology (SMT) assembly result. The results may differ depending on the machine capability, ambient conditions, material, etc.

Deviations from this recommendation might result in non-optimal solder results, e.g. increased tilting. Especially, the application of a larger amount of solder paste might lead to increased tilting and a larger occupied area on the PCB than described in the SOD962 package document (http://www.nexperia.com/documents/outline_drawing/SOD962-2.pdf).

2. DSN0603-2 (SOD962): package details

DSN0603-2 (SOD962) is a Discrete Silicon No-leads (DSN) package. It features either electro-plated copper-tin (CuSn) contacts (CuSn pillars) or electroless plated nickel-palladium-gold (NiPdAu) contacts (pads) under the package (bottom terminations) similar to Discrete Flat No-leads (DFN) style packages. The DSN-style package allows 100 % utilization of the package area for active silicon, offering a significant performance advantage per board area compared to products in plastic-molded packages.

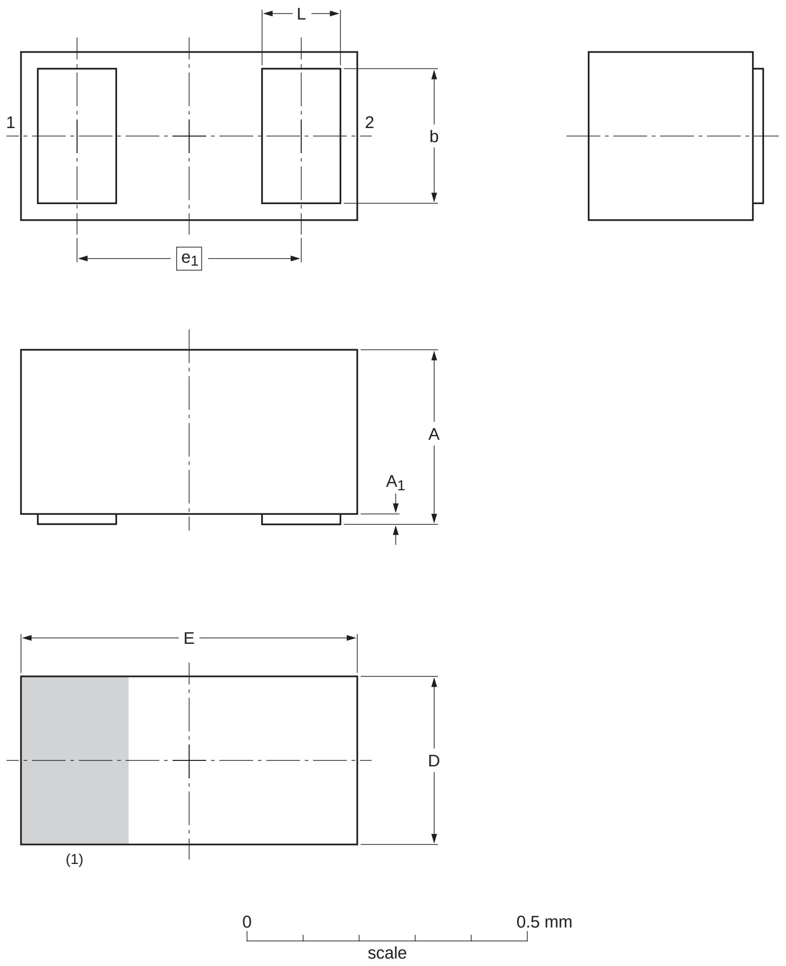
Key Features:

- Ultra small and flat package ($0.6 \times 0.3 \times 0.3$ mm^3)
- 400 μm pad pitch
- Pad size 240×240 μm^2

The visual appearance of DSN0603-2 (SOD962) is shown in Figure 1 whereas Figure 2 shows the package dimensions.

Fig 1. DSN0603-2 (SOD962): visual appearance

Leadless ultra small package; 2 terminals; body 0.6 x 0.3 x 0.3 mm **SOD962-2**



Dimensions (mm are the original dimensions)

Unit		A	A_1	b	D	E	e_1	L
mm	max	0.32	0.03	0.25	0.325	0.625		0.15
	nom						0.4	
	min	0.28		0.23	0.275	0.575		0.13

Note
1. The marking bar indicates the cathode.

sod962-2_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOD962-2						~~13-07-12~~ 13-07-17

Fig 2. DSN0603-2 (SOD962): package dimensions

3. PCB solder pattern

3.1 Solder pad design: general options

There are two types of solder pad / solder resist designs:

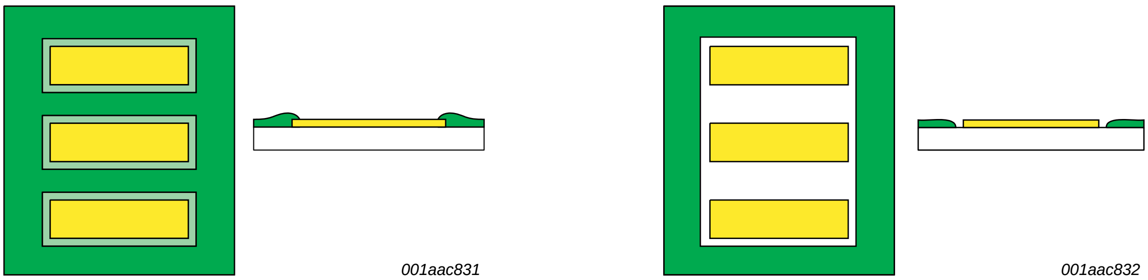
Solder Mask Defined (SMD) and Non-Solder Mask Defined (NSMD).

SMD is a method of designing the solder resist to partially overlap the copper (Cu) landing pattern on the PCB. NSMD designs have a gap between the solder resist and the Cu landing pattern on the PCB. These two types are described in more detail in the next chapter.

3.1.1 SMD solder pad versus NSMD solder pad

If the solder mask extends onto the solder lands, the remaining solderable area is Solder Mask Defined (SMD). The effective solder pad is equal to the copper area that is not covered by the solder mask. This situation is illustrated in Figure 3, left column. In case of an SMD pad, the copper will normally extend 75 μm down to 50 μm underneath the solder mask on all sides. In other words, the copper dimension is 0.1 mm to 0.15 mm larger than the solder mask dimension. These values may vary depending on the class of PCBs used. This allows tolerances in copper etching and solder mask placement during PCB production.

If the solder mask layer starts outside of the solder lands, and does not cover the copper, this is referred to as Non-Solder Mask Defined (NSMD). The effective solder pad is equal to the copper area. In case of an NSMD, the solder mask should be at least 50 μm away from the solder land on all sides. In other words, the solder mask dimension is 100 μm larger than the copper dimension. These values may vary depending on the class of PCBs used. The main requirement is that the solder mask is sufficiently far away from the copper, such that - with the given tolerances in solder mask application - it does not extend onto the copper. An NSMD footprint is shown in Figure 3, right column.



a. SMD solder pad

b. NSMD solder pad

Fig 3. Solder Mask Defined (SMD) versus Non-Solder Mask Defined (NSMD) solder pads

3.2 Solder pad design for DSN0603-2 packages (SOD962)

3.2.1 Recommended reflow solder footprint

Based on the small dimensions of 0603 (0201) devices and the given tolerances for PCB manufacturing, it is recommended to use Non-Solder Mask Defined (NSMD) solder pads.

The DSN0603-2 (SOD962) solder footprint with dimensions and the solder footprint together with the package outline are shown in Figure 4 and Figure 5.

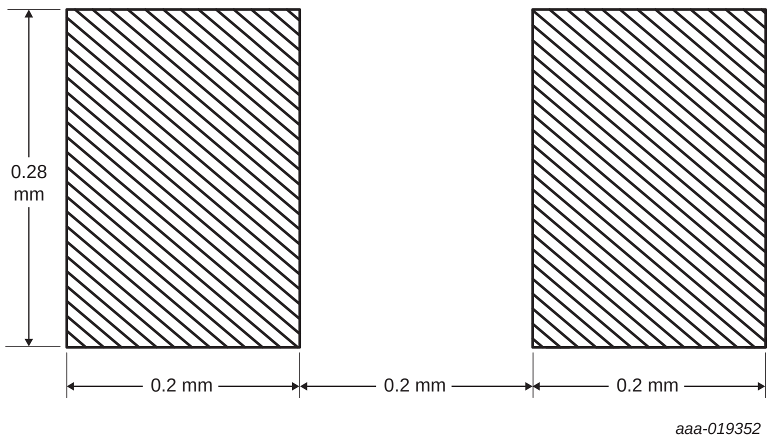


Fig 4. DSN0603-2 (SOD962): recommended reflow solder footprint

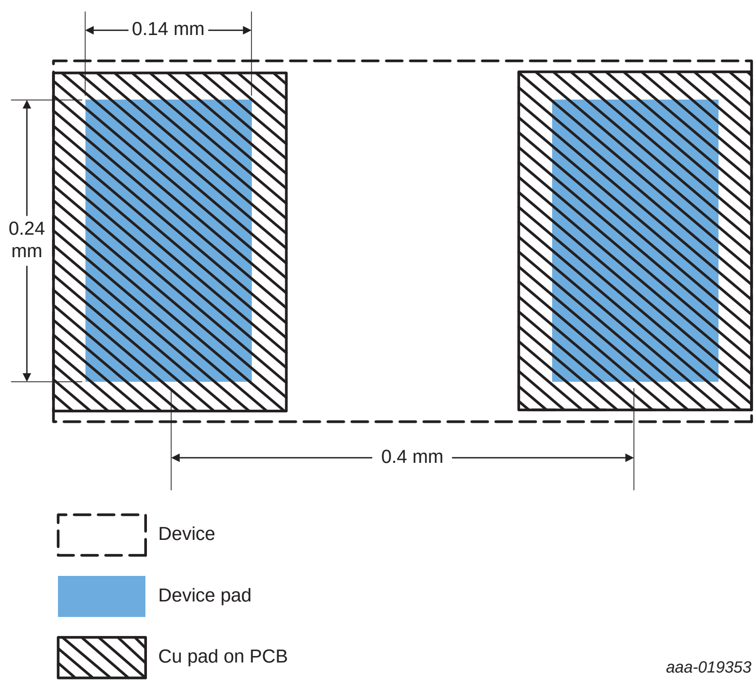


Fig 5. DSN0603-2 (SOD962): recommended reflow solder footprint with package outline

3.2.2 Solder Mask Defined (SMD) footprint on PCB (not recommended)

In case that an SMD solder pad structure is absolutely needed, the recommended solder footprints are given in Figure 6.

As mentioned above, due to the tolerances in the PCB manufacturing, an SMD solder pad structure is not the recommended solution.

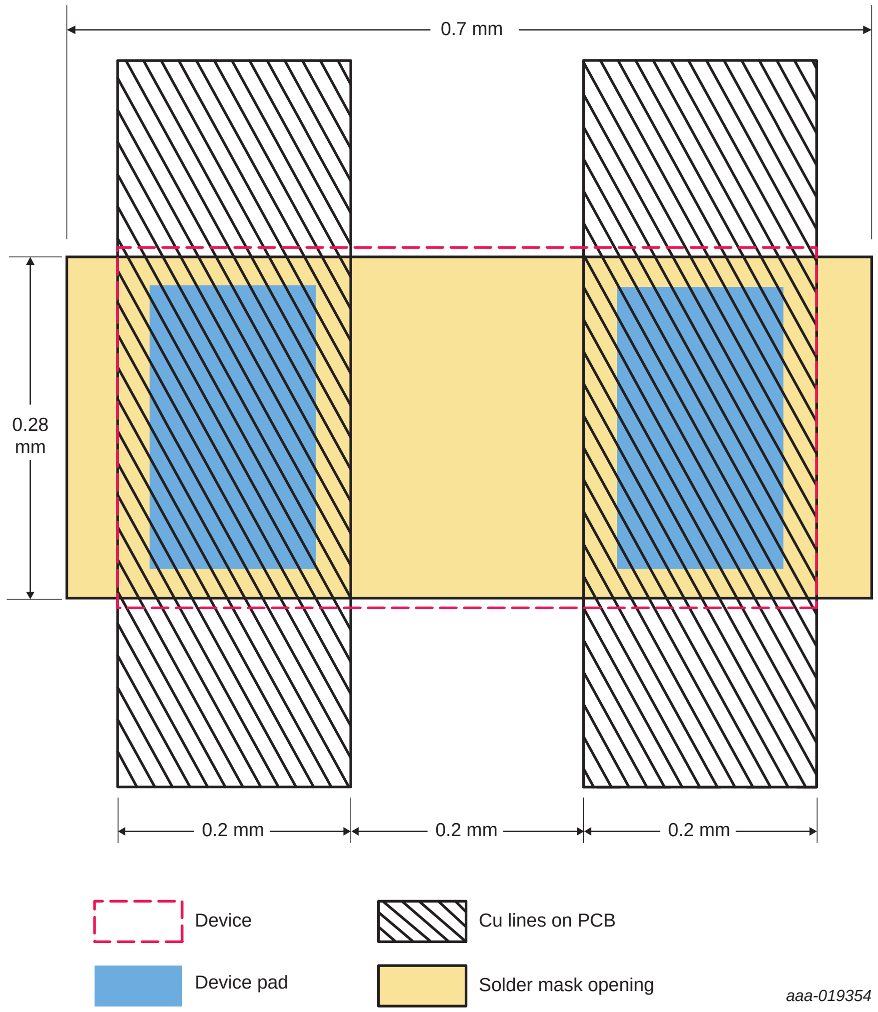


Fig 6. Solder Mask Defined (SMD) footprint on PCB

4. Solder stencil

4.1 Stencil recommendations

Due to small apertures and pad dimensions, use a high-quality stainless-steel stencil manufactured by laser-cut and with electropolish or plasma coating.

The recommended stencil thickness is 100 μm or thinner for the DSN0603-2 package.

For the DSN0603-2 (SOD962) recommended Nexperia footprint (see Section 3.2.1, Figure 4 and Figure 5), the optimum stencil aperture is shown in Figure 7.

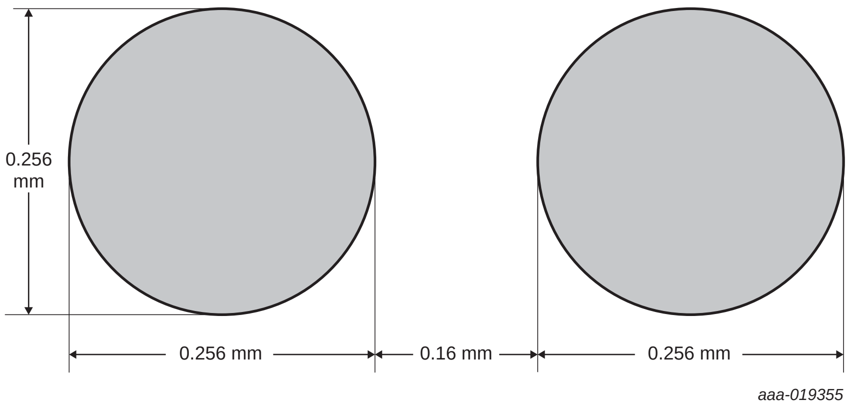


Fig 7. Recommended stencil aperture for DSN0603-2 (SOD962)

Figure 8 shows the stencil opening in combination with the recommended Nexperia footprint and the device pad area. Figure 9 shows the stencil and solder mask opening in case of a Solder Mask Defined (SMD) PCB footprint which is not the recommended footprint solution (see Section 3.2.2).

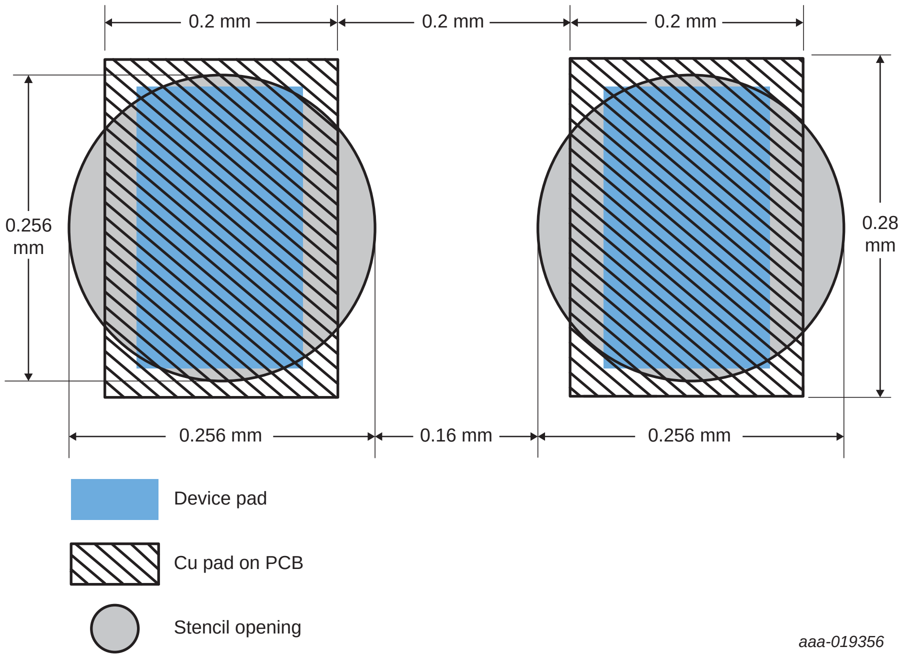
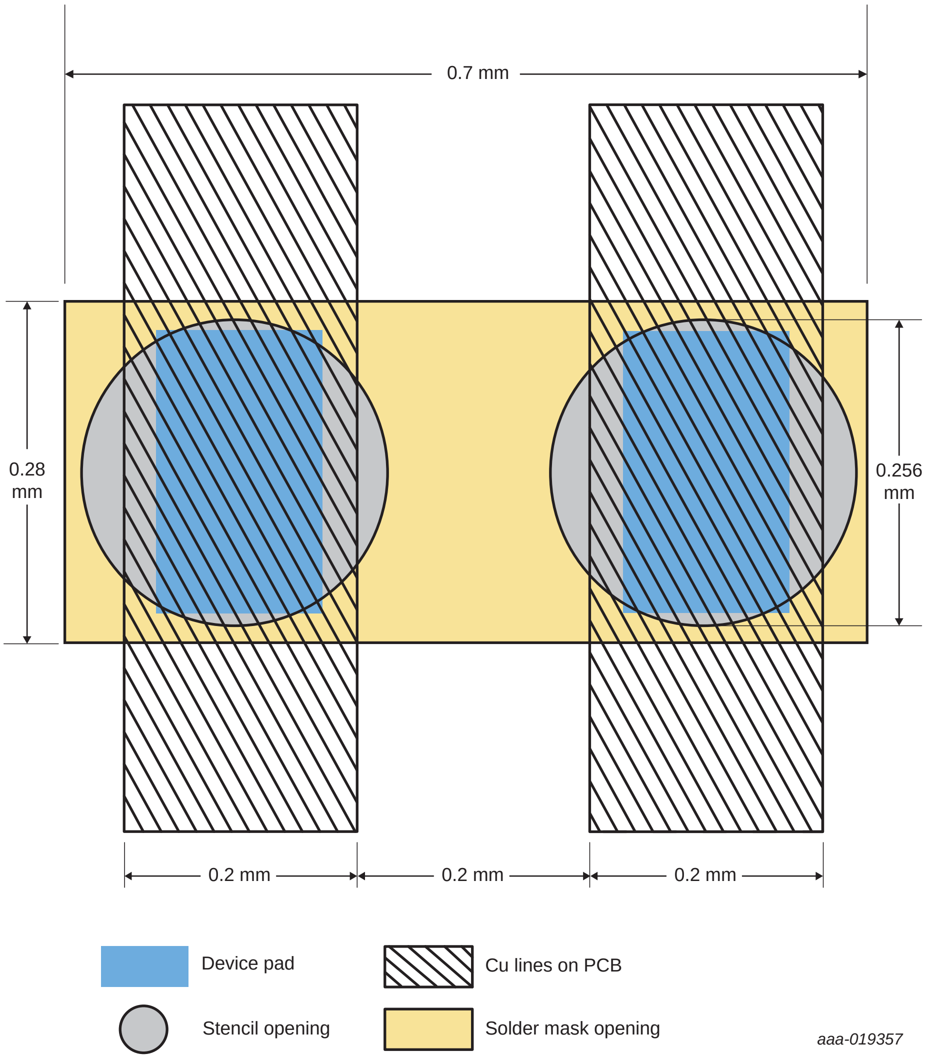


Fig 8. Stencil opening in combination with Cu pads on PCB and the device pads



SMD footprint on PCB is not the recommended solution

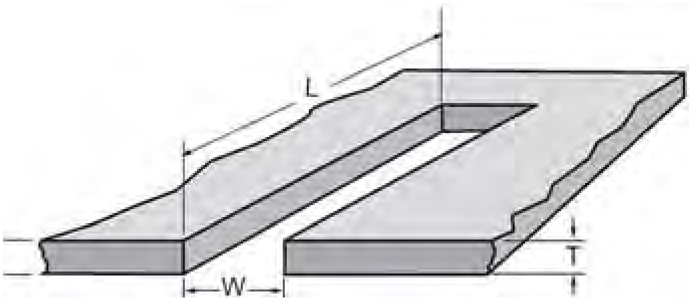
Fig 9. Stencil and solder mask opening in case of an SMD footprint on PCB

4.2 Stencil aperture design

Area and aspect ratio are key design-guidelines for stencil apertures. Due to the small size of DSN0603-2 (SOD962), the requirements on the area ratio are higher than for larger form factors. Nexperia stencil recommendations give an area ratio of 0.64. Smaller values are possible with adequate process control. The lower limit for the area ratio depends on the manufacturing environment and other requirements of the manufacturer.

The aspect ratio should be > 1.5 which is less critical to fulfill. Nexperia stencil recommendations give an aspect ratio of 2.56.

For explanation of area and aspect ratio, refer to Figure 10.



Cross -sectional view of a stencil

aaa-019083

$$\text{Area ratio} = \frac{\text{area of aperture opening}}{\text{area of aperture walls}} = \frac{L \times W}{2 \times (L + W) \times T}$$

$$\text{Aspect ratio} = \frac{\text{width of the aperture}}{\text{thickness of the stencil foil}} = \frac{W}{T} > 1,5$$

Fig 10. Explanation of area and aspect ratio

Table 1. Area and aspect ratio for stencil apertures as recommended

Stencil thickness T = 100 μm

Nexperia recommended footprint	Aperture size	Area ratio target > 0.62	Aspect ratio target > 1.5
DSN0603-2 (SOD962)	256 $\mu m^2 \times \Pi/4$	0.64	2.56

Table 1 shows the values for aspect and area ratio of the optimum stencil apertures with a stencil thickness of 100 μm. It results in acceptable area ratios for the Nexperia footprint recommendations.

5. Solder paste

Besides stencil aperture and thickness, the used solder paste has a significant impact on the printing performance. As shown in Table 2, solder pastes are available in different solder powder grain sizes.

Table 2. Solder paste types

Type	Powder grain size in μm			
	Less than 0.5 % larger than	10 % max. between	80 % max between	10 % max. less than
1	160	150-160	75-150	75
2	80	75-80	45-75	45
3	60	45-60	25-45	25
4	50	38-50	20-38	20
5	40	25-40	15-25	15
6	25	15-25	5-15	5
7	15	11-15	2-11	2

Use a solder paste type 4 and higher (smaller grain size) in combination with a stencil aperture thickness of 100 μm for the DSN0603-2 (SOD962) package. As solder paste is sensitive to age, temperature, and humidity, follow the handling recommendations of the paste manufacturer.

6. Soldering process

For soldering of DSN0603-2 package, following standard reflow processes and typical temperature profiles are suitable:

- Convection reflow under nitrogen atmosphere is preferred to improve the solder wetting.
- Convection reflow under air atmosphere also works, but solder joint surfaces are rough, flux residues often become darker and the soldering behavior may deteriorate.
- Vapor phase soldering is also possible.

A reflow solder profile for tin-silver-copper alloys, so-called SAC alloys (SnAg3.8Cu0.7) based on the IPC/JEDEC joint industry standard J-STD-020D is recommended. Refer to Figure 11 and Table 3.

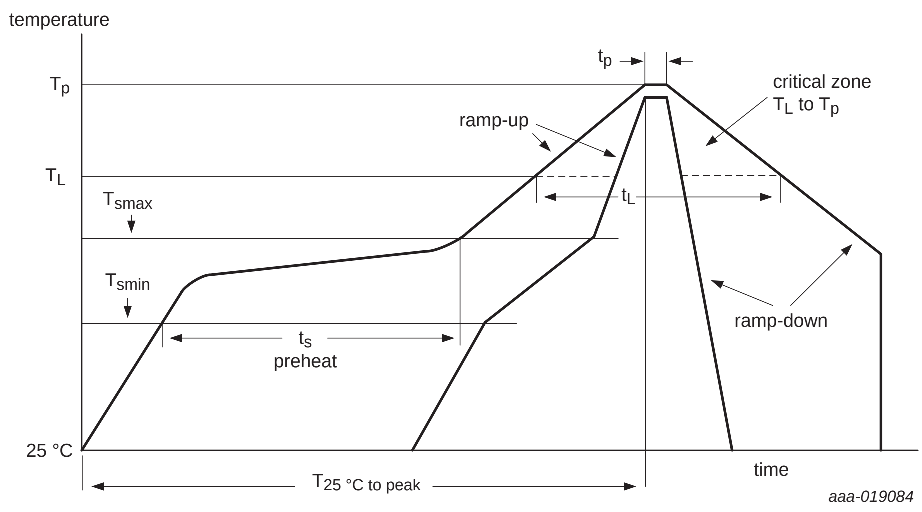


Fig 11. Reflow solder profile based on IPC/JEDEC J-STD-020D

Table 3. Pb-free profile feature and specification based on IPC/JEDEC J-STD-020D

Profile feature	Values for Pb-free assembly
Average ramp-up rate (T_{smax} to T_p)	3 °C/s maximum
Preheat	
Minimum temperature (T_{smin})	150 °C
Maximum temperature (T_{smax})	200 °C
Time (t_s) from T_{smin} to T_{smax}	60 s to 180 s
Liquidus temperature (T_L)	217 °C
Time (t_L) maintained above T_L	60 s to 150 s
Peak/classification temperature (T_p)	260 °C
Time within 5 °C of actual peak temperature (t_p)	10 s to 30 s
Ramp-down rate	6 °C/s maximum
Time 25 °C to peak temperature ($t_{25°C\ to\ peak}$)	8 minutes maximum

7. Handling recommendations

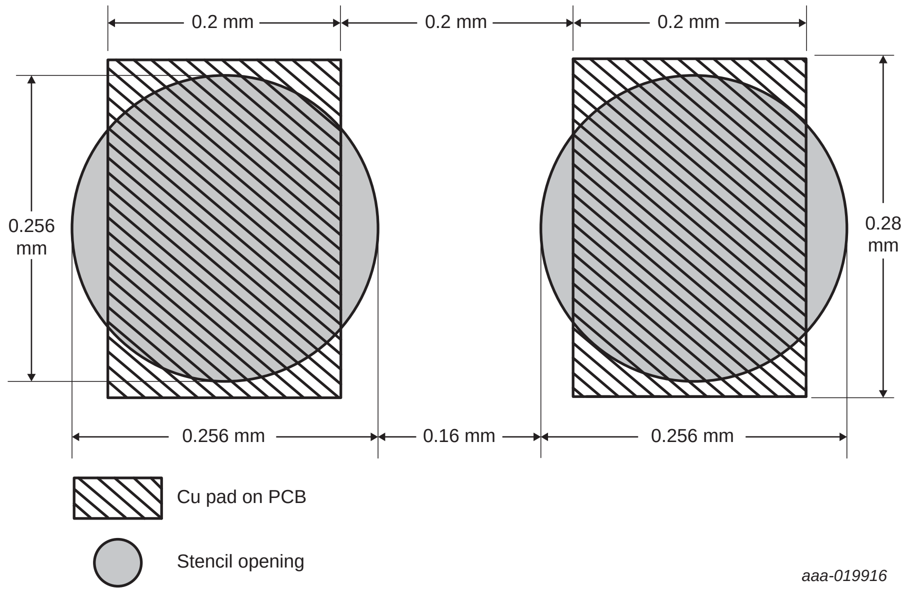
Besides the PCB and stencil design requirements, the ultra small size of the DSN0603 and as consequence the low weight of the component requires that some attention be paid to the pick and place (P&P) process. Electrostatic charge may cause problems during the pick and place (tape out) process. Nexperia has implemented preventive measures such as using a conductive plastic carrier tape (embossed tape).

For rework, use equipment suitable for the ultra small package size and for handling bare silicon devices. Manual handling with tweezers (e.g. for repair) is not recommended.

8. Summary

8.1 Recommended solder footprint and stencil aperture

The recommended solder footprint including stencil aperture is shown in Figure 12 for DSN0603-2 (SOD962).



Recommended stencil thickness: 100 μm or thinner

Fig 12. DSN0603-2 (SOD962): solder footprint and stencil aperture

8.2 Further recommendations

8.2.1 Stencil layout and solder paste

- Stencil thickness of 100 μm or thinner in combination with type 4 solder paste (refer to Table 2) is recommended.
- A stencil aperture dimension as shown in Figure 7 and Figure 12 is recommended for DSN0603-2 (SOD962).
- To get best printing (and soldering) results, control the cleaning cycle of the stencil.

8.2.2 Solder pad design

- Non-Solder Mask Defined (NSMD) pads with a gap between Cu pad and solder resist of 50 μm are recommended.
- Conductor (Cu trace) between solder pads on PCB is not recommended.
- Do not connect solder pads by μ-via.
- Connection by Cu traces (lines) is preferred.

8.2.3 Soldering process

- Convection reflow under nitrogen atmosphere is preferred.
- Convection reflow under air atmosphere also works, but:
  - Using an unfavorable layout, products lean toward undefined tilting and rotation and solder joints tend to more voiding.
  - Solder joint surfaces are rough, flux residues often become darker and the soldering behavior may deteriorate.
- Vapor phase soldering is also possible.

8.2.4 Handling recommendations

- Manual handling with tweezers (e.g. for repair) is not recommended.
- Keep control of thawing time of solder paste bundle to avoid too much humidity in paste.
- To prevent drying of flux in solder paste, maintain the relative humidity of shop floor at solder paste print until reflow to 40 % to 60 %.
- Relative humidity of shop floor at pick and place > 30 %.

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