AN11689

Recommendations for PCB assembly of DSN1006

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Document information

Info	Content
Keywords	DSN1006, DSN1006-2, DSN1006U-2, SOD993, SOD995, 0402 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 DSN1006 (1.0 × 0.6 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).

Revision history

Rev	Date	Description
1	20150729	Initial version

Contact information

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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. NXP supports this trend with the new DSN1006-2 (SOD993, symmetrical contacts) and DSN1006U-2 (SOD995, asymmetrical contacts) packages. They are ultra small surface-mount chip-scale diode packages with a size of only 1.0 mm × 0.6 mm × 0.27 mm (0402).

Due to the very small size of the component, NXP 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 will help 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.

2. DSN1006 (SOD993, SOD995): package details

DSN1006-2 (SOD993) and DSN1006U-2 (SOD995) are Discrete Silicon No-leads (DSN) packages. They feature tin (Sn) plated metal contacts 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:

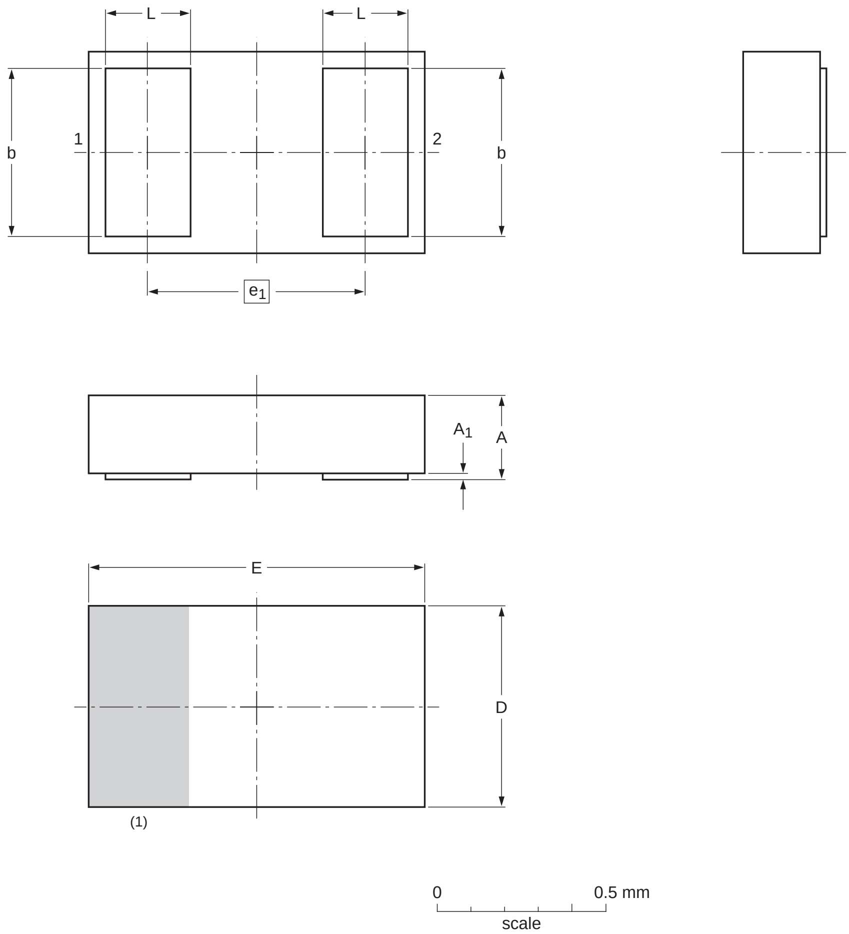
- Ultra small and flat package (1.0 × 0.6 × 0.27 mm^3)
- Sn-plated contacts for soldering on PCB
- Symmetrical contact pads for DSN1006-2 (SOD993)
- Asymmetrical contact pads for DSN1006U-2 (SOD995)

The visual appearance of DSN1006-2 (SOD993) is shown in Figure 1 whereas Figure 2 shows the package dimensions.

The visual appearance of DSN1006U-2 (SOD995) is shown in Figure 3 whereas Figure 4 shows the package dimensions.

Fig 1. DSN1006-2 (SOD993): visual appearance

DSN1006-2, leadless ultra small package; 2 terminals; body 1.0 x 0.6 x 0.27 mm **SOD993**



Dimensions (mm are the original dimensions)

Unit		A	A_1	b	D	E	e_1	L
mm	max	0.30	0.03	0.51	0.65	1.05		0.26
	nom						0.65	
	min	0.24		0.49	0.55	0.95		0.24

Note

1. The marking bar indicates the cathode.

sod993_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOD993						~~14-10-24~~ 14-10-24

Fig 2. DSN1006-2 (SOD993): package dimensions

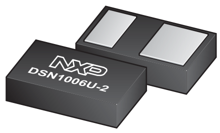
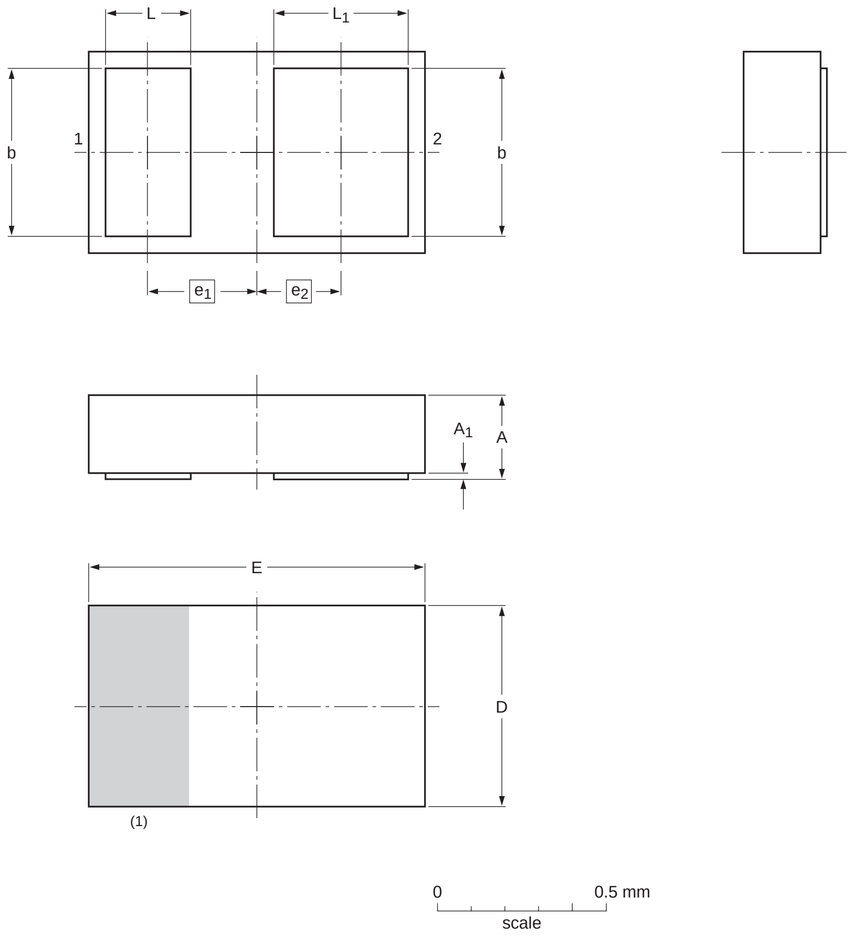


Fig 3. DSN1006U-2 (SOD995): visual appearance

DSN1006U-2, leadless ultra small package; 2 terminals; body 1.0 x 0.6 x 0.27 mm **SOD995**



Dimensions (mm are the original dimensions)

Unit		A	A_1	b	D	E	e_1	e_2	L	L_1
mm	max	0.30	0.03	0.51	0.65	1.05			0.26	0.41
	nom						0.325	0.25		
	min	0.24		0.49	0.55	0.95			0.24	0.39

Note

1. The marking bar indicates the cathode.

sod995_po

Outline version	References				European projection	Issue date
	IEC	JEDEC	JEITA			
SOD995						~~14-12-09~~ 15-05-29

Fig 4. DSN1006U-2 (SOD995): package dimensions

3. PCB solder pattern

3.1 Solder pad design: general options

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

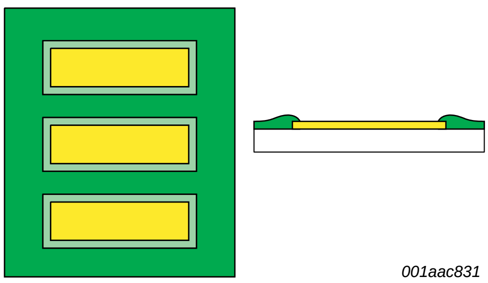
Solder Mask Defined (SMD) and Non-Solder Mask Defined (NSMD).

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.

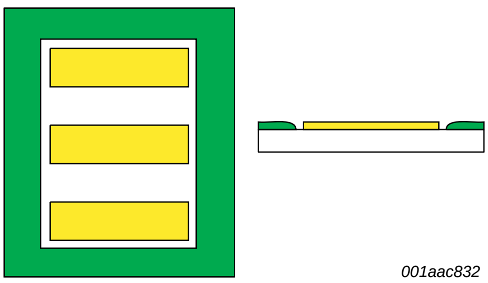
3.1.1 SMD solder pad versus NSMD solder pad

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 5, 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 5, right column.



a. SMD solder pad



b. NSMD solder pad

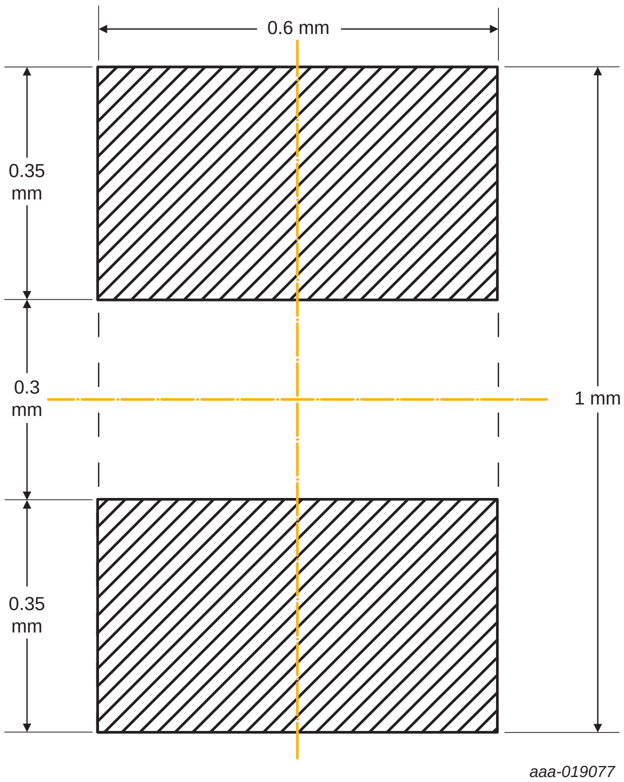
Fig 5. Solder Mask Defined (SMD) versus Non-Solder Mask Defined (NSMD) solder pads

3.2 Solder pad design for DSN1006 packages (SOD993, SOD995)

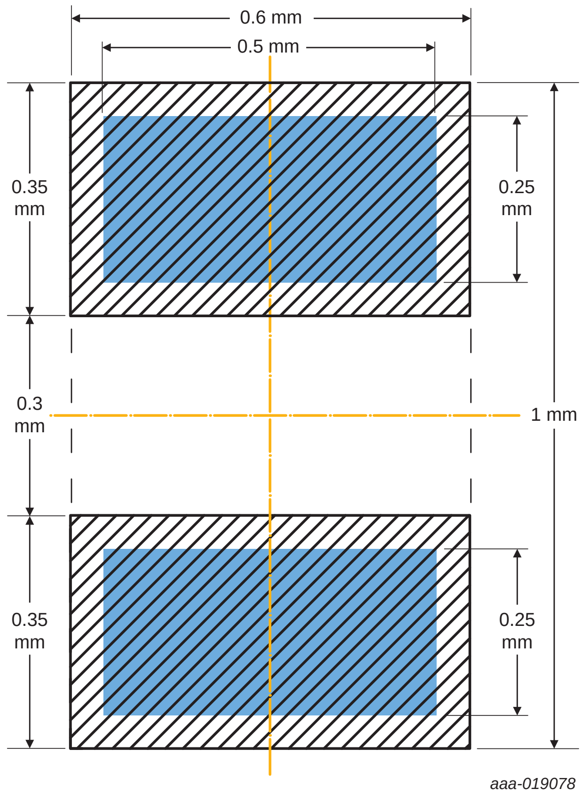
3.2.1 Recommended reflow solder footprints

Based on the small dimensions of 1006 (0402) devices and the given tolerances for PCB manufacturing, it is recommended to use Non-Solder Mask Defined (NSMD) solder pads.

The DSN1006-2 (SOD993) solder footprint with dimensions and the solder footprint together with the package outline are shown in Figure 6.



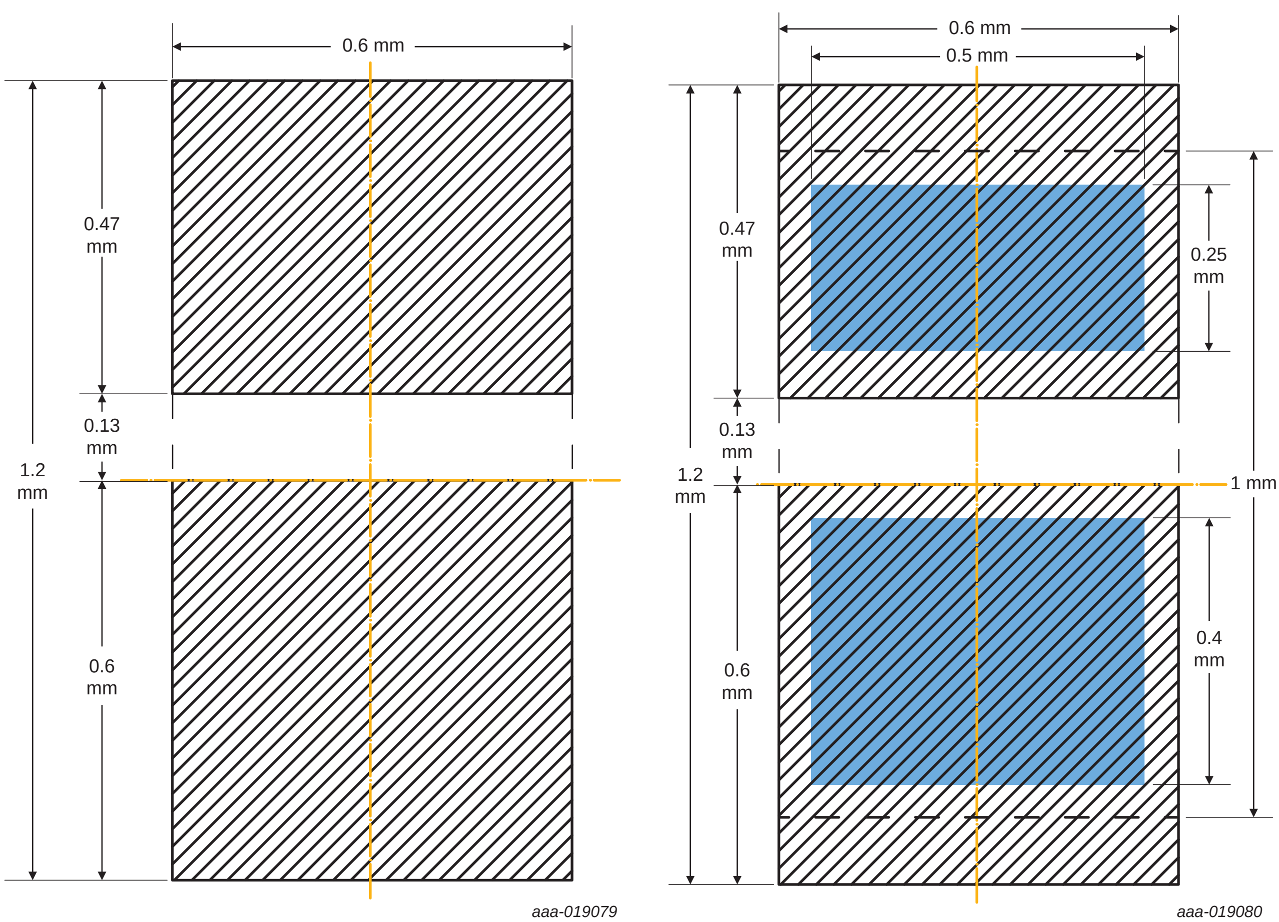
a. Reflow solder footprint



b. Reflow solder footprint and package outline

Fig 6. Recommended solder footprint for DSN1006-2 (SOD993)

The DSN1006U-2 (SOD995) solder footprint with dimensions and the solder footprint together with the package outline are shown in Figure 7.



a. Reflow solder footprint

b. Reflow solder footprint and package outline

Fig 7. Recommended solder footprint for DSN1006U-2 (SOD995)

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 for the DSN1006 packages.

For the DSN1006-2 (SOD993) recommended NXP footprint (see Section 3.2.1, Figure 6), the optimum stencil aperture is shown in Figure 8.

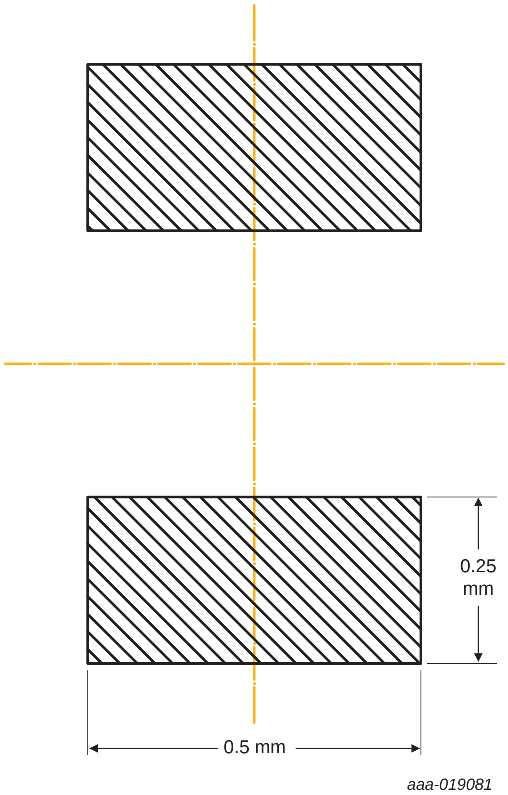


Fig 8. Recommended stencil aperture for DSN1006-2 (SOD993)

For the DSN1006U-2 (SOD995) recommended NXP footprint (see Section 3.2.1, Figure 7, the optimum stencil aperture is shown in Figure 9.

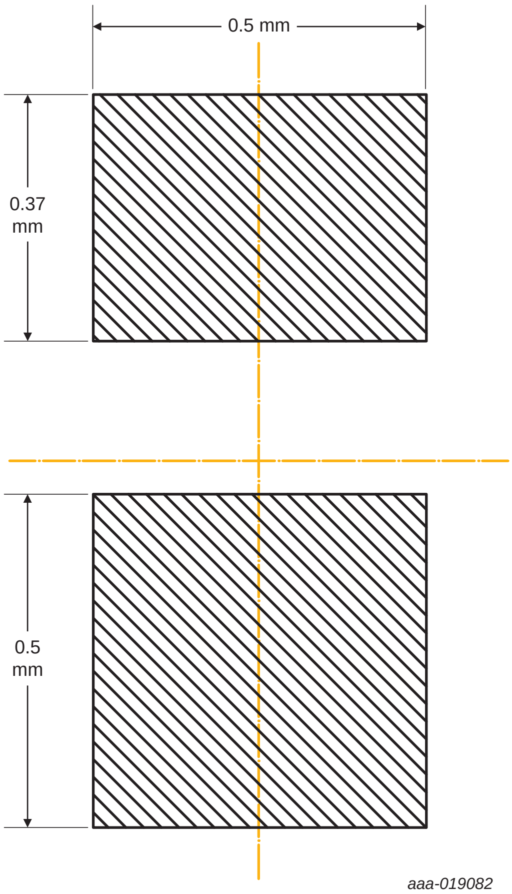
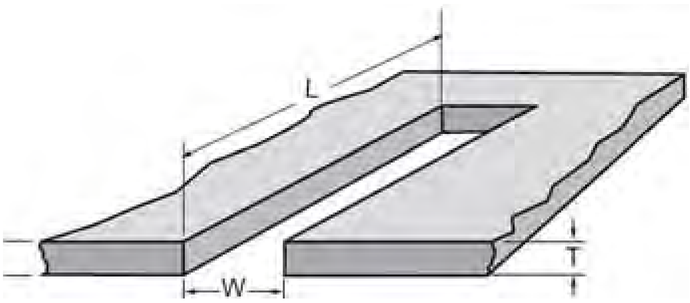


Fig 9. Recommended stencil aperture for DSN1006U-2 (SOD995)

4.2 Stencil aperture design

Area and aspect ratio are key design-guidelines for stencil apertures. The area ratio for a standard approach is > 0.66. Smaller values are possible with adequate process control. Of course, it depends on the manufacturing environment and other requirements of the manufacturer.

The aspect ratio should be > 1.5 which is less critical to fulfil. 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

NXP recommended footprint	Aperture size	Area ratio target > 0.62	Aspect ratio target > 1.5
DSN1006-2 (SOD993)	250 × 200 μm^2	0.83	2.50
DSN1006U-2 (SOD995)	370 / 500 × 500 μm^2	minimum 1.06	minimum 3.70

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 NXP 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 DSN1006 (SOD993, SOD995) packages. As solder paste is sensitive to age, temperature, and humidity, follow the handling recommendations of the paste manufacturer.

6. Soldering process

For soldering of DSN1006 packages, 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.

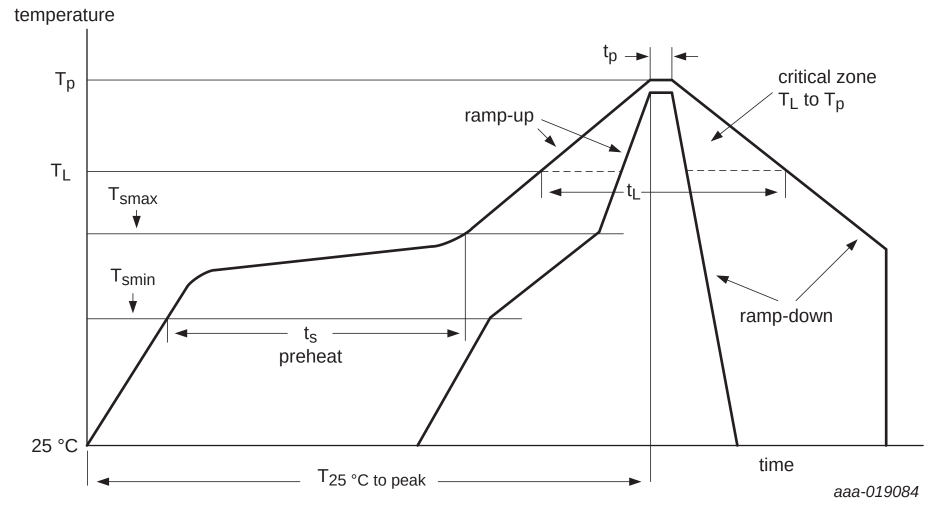


Fig 11. Reflow solder profile based on IPC/JEDEC J-STD-020D

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

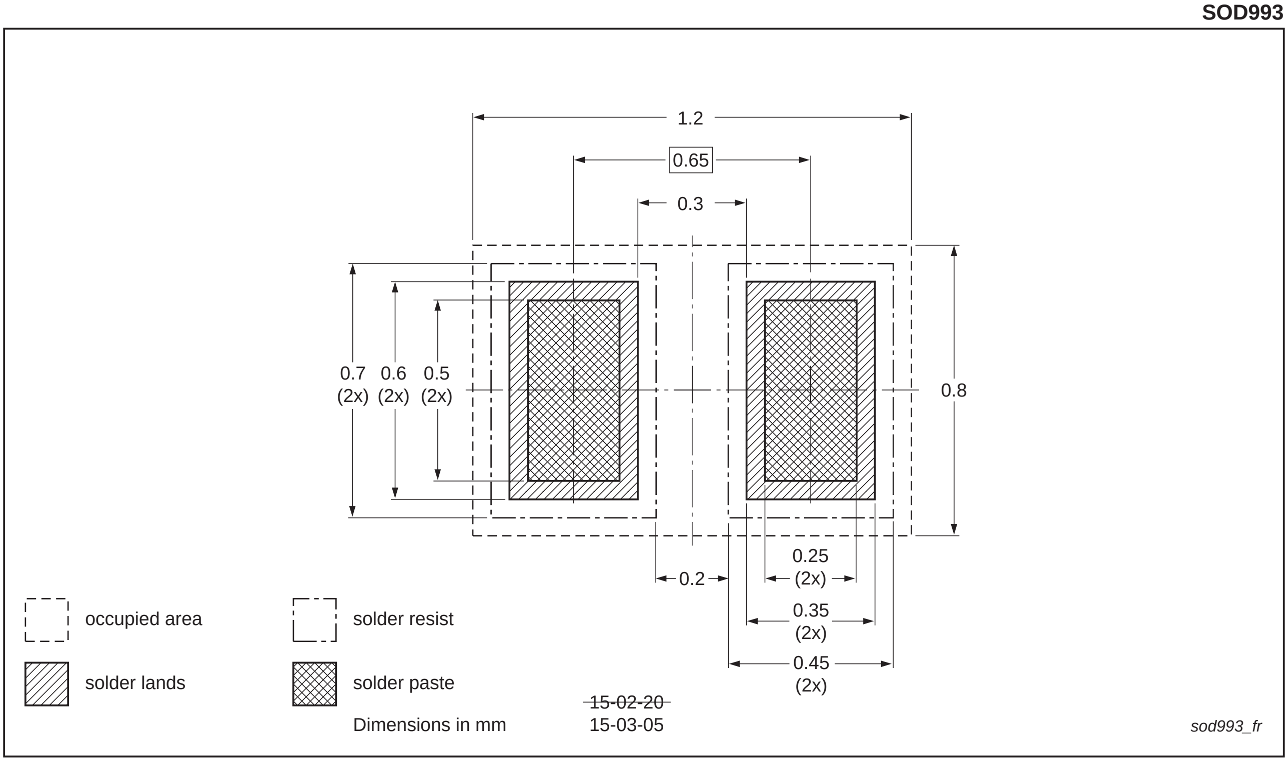
Besides the PCB and stencil design requirements, the ultra small size of the DSN1006 and as consequence the low weight of the component requires that some attention be paid to the pick and place (P&P) process. Electrostatic charge may cause problems during the pick and place (tape out) process. NXP has 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

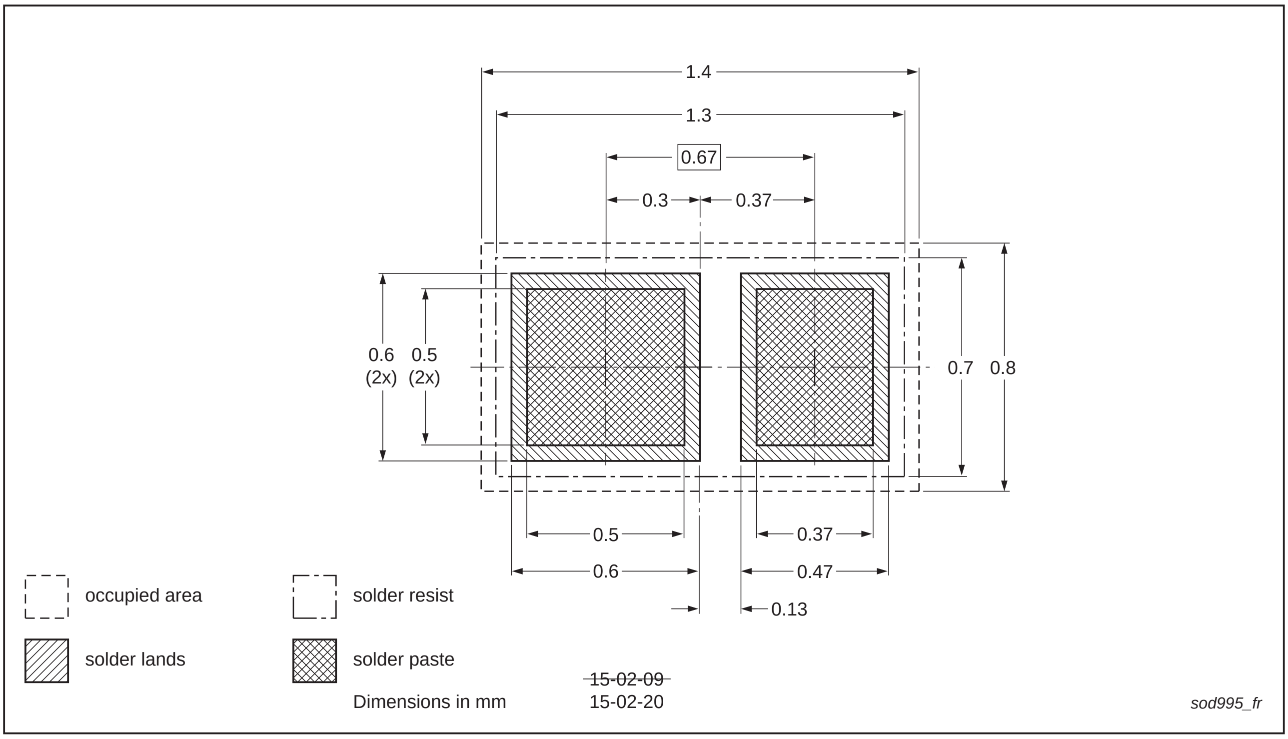
8.1 Recommended solder footprint and stencil aperture

The recommended solder footprint including stencil aperture are shown in Figure 12 for DSN1006-2 (SOD993) and in Figure 13 for DSN1006U-2 (SOD995).



Recommended stencil thickness: 100 µm

Fig 12. DSN1006-2 (SOD993): solder footprint and stencil aperture



Recommended stencil thickness: 100 µm

Fig 13. DSN1006U-2 (SOD995): solder footprint and stencil aperture

8.2 Further recommendations

8.2.1 Stencil layout and solder paste

- Stencil thickness of 100 µm in combination with type 4 solder paste (refer to Table 2) is recommended.
- A stencil aperture dimension as shown in Figure 8 and Figure 12 is recommended for DSN1006-2 (SOD993).
- A stencil aperture dimension as shown in Figure 9 and Figure 13 is recommended for DSN1006U-2 (SOD995).
- 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 towards undefined tilting and rotation and solder joints tend to increase 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 %.

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