文档编号：AN13621
第 0 版，2022 年 4 月

MaxQFP 封装

作者：恩智浦半导体

1. 简介

本应用笔记为恩智浦的 MaxQFP 封装的处理和电路板上安装提供指导。建议使用本应用笔记中包括的信息进行 MaxQFP 封装的 PCB 脚印设计、电路板上安装和焊接。

2. 范围

本文档件包含关于在恩智浦组装的 MaxQFP 封装以及恩智浦的组装和测试供应商的通用信息。有关恩智浦产品的更多细节，请访问 www.nxp.com 或联系相应的产品应用团队。对于每个产品的要求，需要开发工作来优化电路板组装过程和应用设计。此外，行业标准（如 IPC 和 JEDEC），以及电路板组装环境中的普遍做法也是很好的参考。

3. 封装背景

到目前为止，已经开发了两种外观尺寸的 MaxQFP：

- 172 个引脚（16x16 mm 外观尺寸）
- 172 个引脚 + EP（16x16 mm 外观尺寸）
- 100 个引脚（10x10 mm 外观尺寸）

目录

这些能够取代 5 个符合 JEDE 的 QFP，其引脚数为：64、80、100、144 和 176，如下图所示。

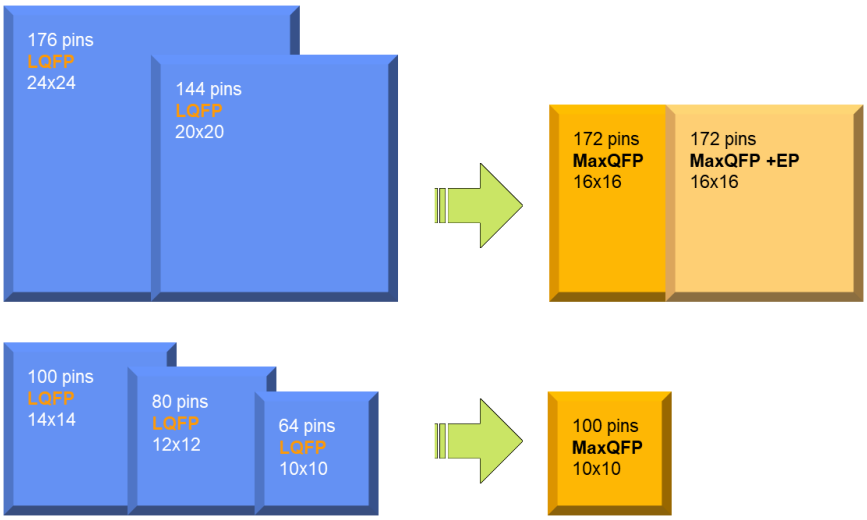


图 1. MAXQFP 和 LQFP 之间的目视比较，显示外观尺寸缩小程度高达 56%

MaxQFP（如下图所示）是一种新的高密度方块扁平封装（QFP）。它将鸥翼型和 J 型引线结合在一个类似于 QFP/LQFP 封装的经过模塑的封装体中。

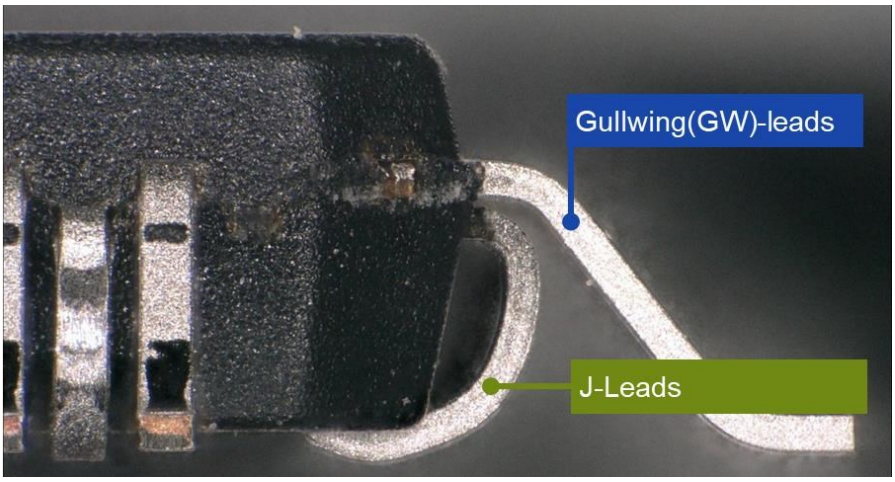


图 2. MaxQFP 封装 - 侧视图

外环引线是鸥翼型（GW）引线，内环引线是 J 型引线。

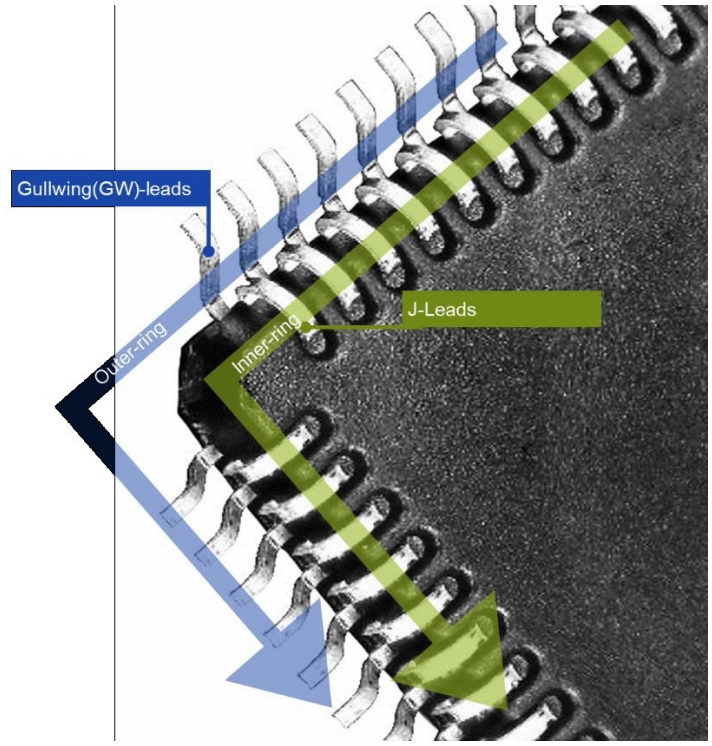


图 3. MaxQFP 封装的底角视图

- J 型引线位于内侧，在两条鸥翼型（GW）引线之间。
- 同一类型的相邻引线（如 J 型引线）之间的外部引线间距为 0.65 mm。
- 不同类型的相邻引线（即 J 型引线和鸥翼型引线之间）的间距是 0.325 mm。

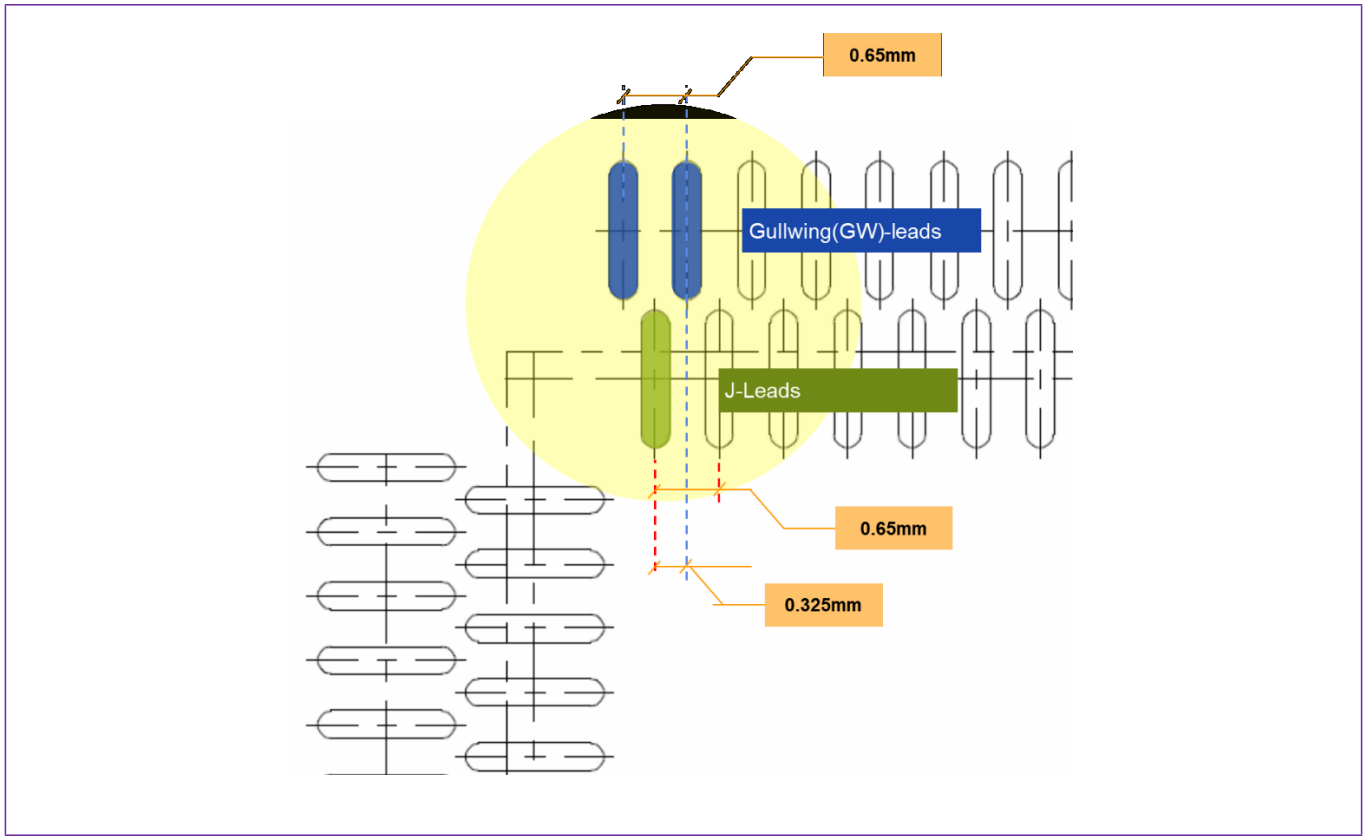


图 4. MaxQFP 封装底部视图

对于高功率应用，MaxQFP_EP（裸露焊盘）也已经被开发出来，如图 5 所示。它与 QFP_EP 类似，其中模具标志的一部分暴露在外，使其能够被焊接到印刷电路板（PCB）上，从而在 PCB、封装体和模具之间形成极好的、短的热连接。这种热性能明显优于没有裸露焊盘的类似引线式封装。MaxQFP 和 MaxQFP_EP 封装的热性能（如热阻）将在后面详细说明。

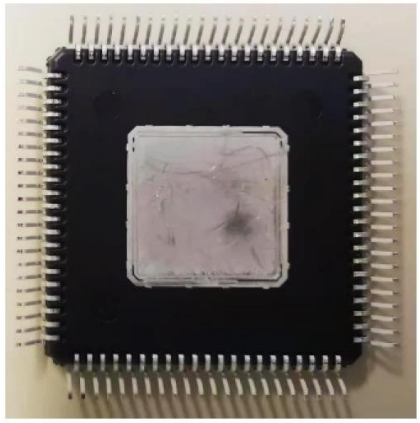


图 5. MaXQFP_EP 带有外露的焊盘以改善热性能

其好处如下：

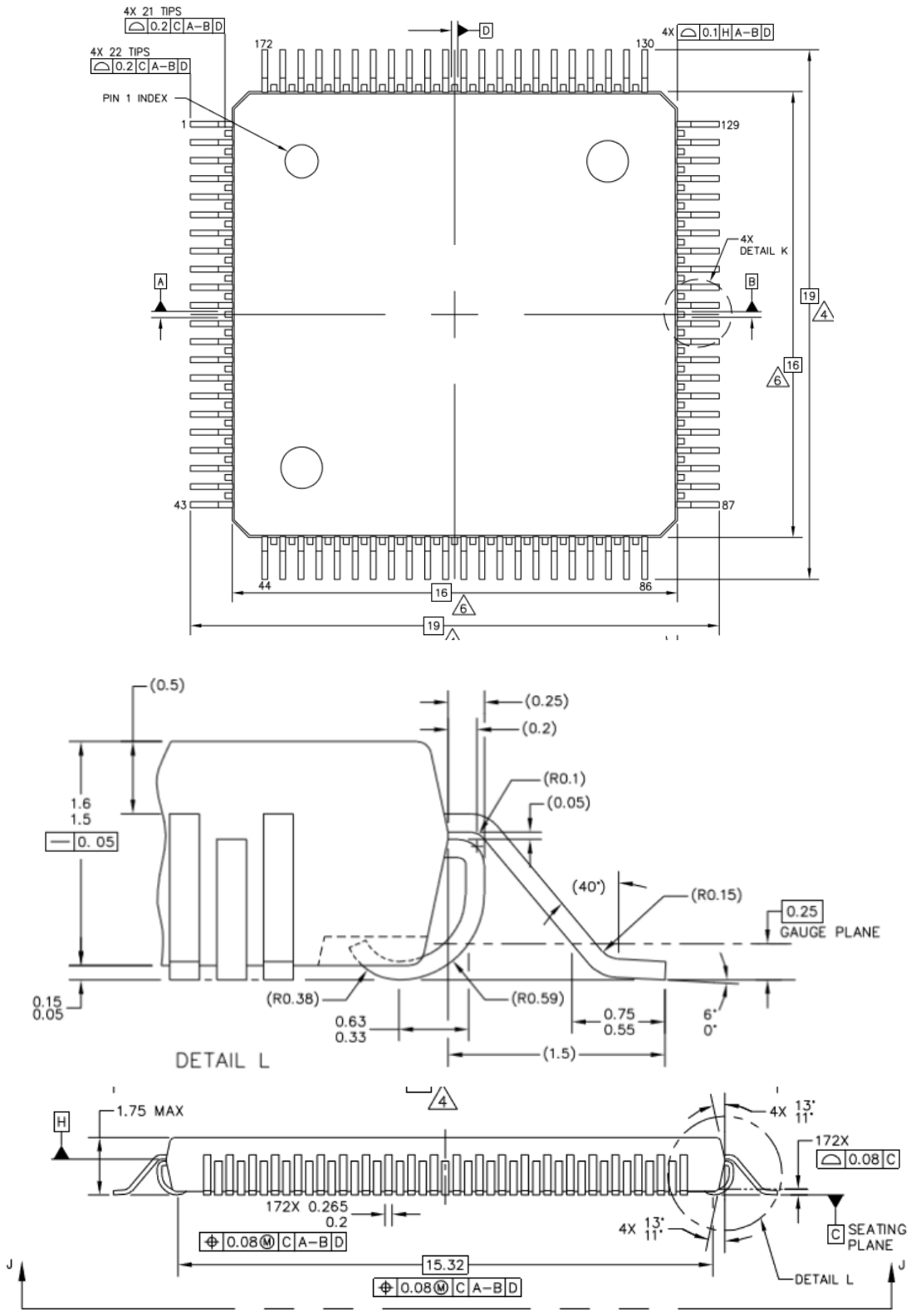
- 经过验证的 AEC 1 级可靠性
- 在较小的区域内以较低的成本实现更多的 IO
- 占用电路板面积减少可达 56%（与 LQFP 的相同引线数相比）
- 恩智浦的独特技术

产品化

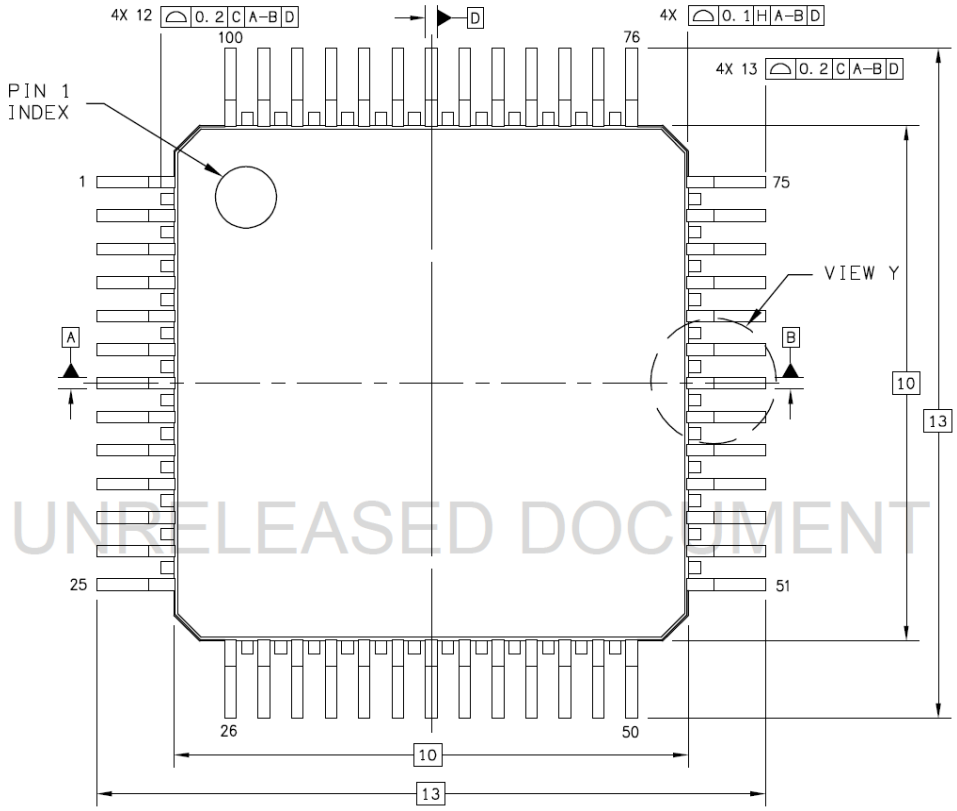
- 下一代有引线产品的外观尺寸车身安全平台

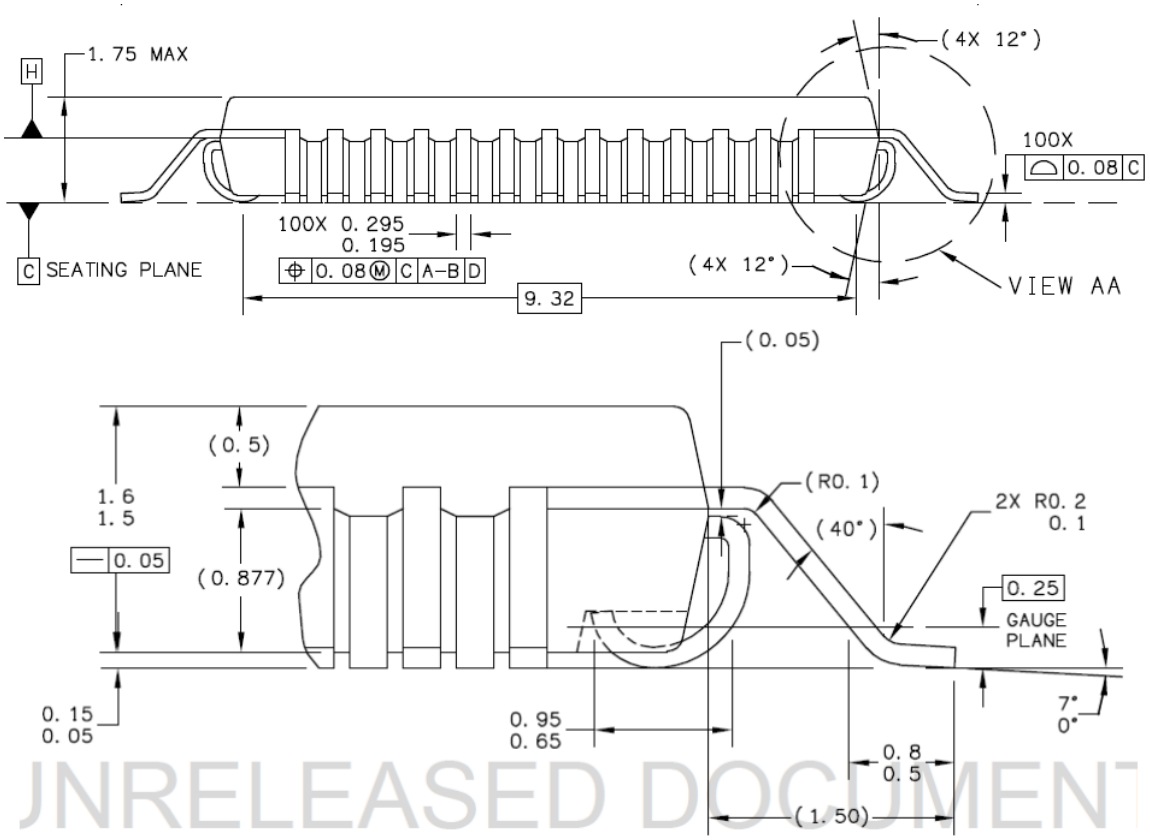
4. MaxQFP 封装尺寸图

4.1. 172MaxQFP 封装尺寸图


4X 21 TIPS
0.2 C A–B D
4X 22 TIPS
0.2 C A–B D
PIN 1 INDEX
172
130
1
129
43
87
44
86
D
4X 0.1 H A–B D
4X
DETAIL K
A
B
19
4
16
6
(0.5)
(0.25)
(0.2)
(R0.1)
(0.05)
1.6
1.5
0.05
(40°)
(R0.15)
0.25
GAUGE PLANE
0.15
0.05
(R0.38)
(R0.59)
0.63
0.33
0.75
0.55
6°
0°
(1.5)
DETAIL L
H
1.75 MAX
4X 13°
11°
172X
0.08 C
172X 0.265
0.2
0.08 M C A–B D
C SEATING
PLANE
15.32
J

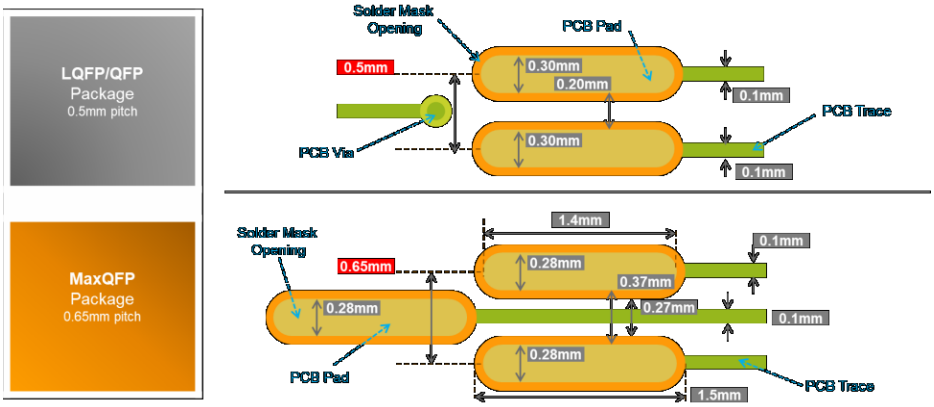
4.2. 100MaxQFP 封装尺寸图[初步版本]





5. MaxQFP 封装的 PCB 设计指南和要求

正确的 PCB 脚印和模板设计对表面贴装组装的数量和随后安装的封装部件的电气和机械性能至关重要。设计始于获得正确的封装图纸。



- 推荐 1.4 x 0.28 mm 焊盘用于鸥翼型和 J 型引线

- 焊盘周边有 0.05 mm 的阻焊膜间隙

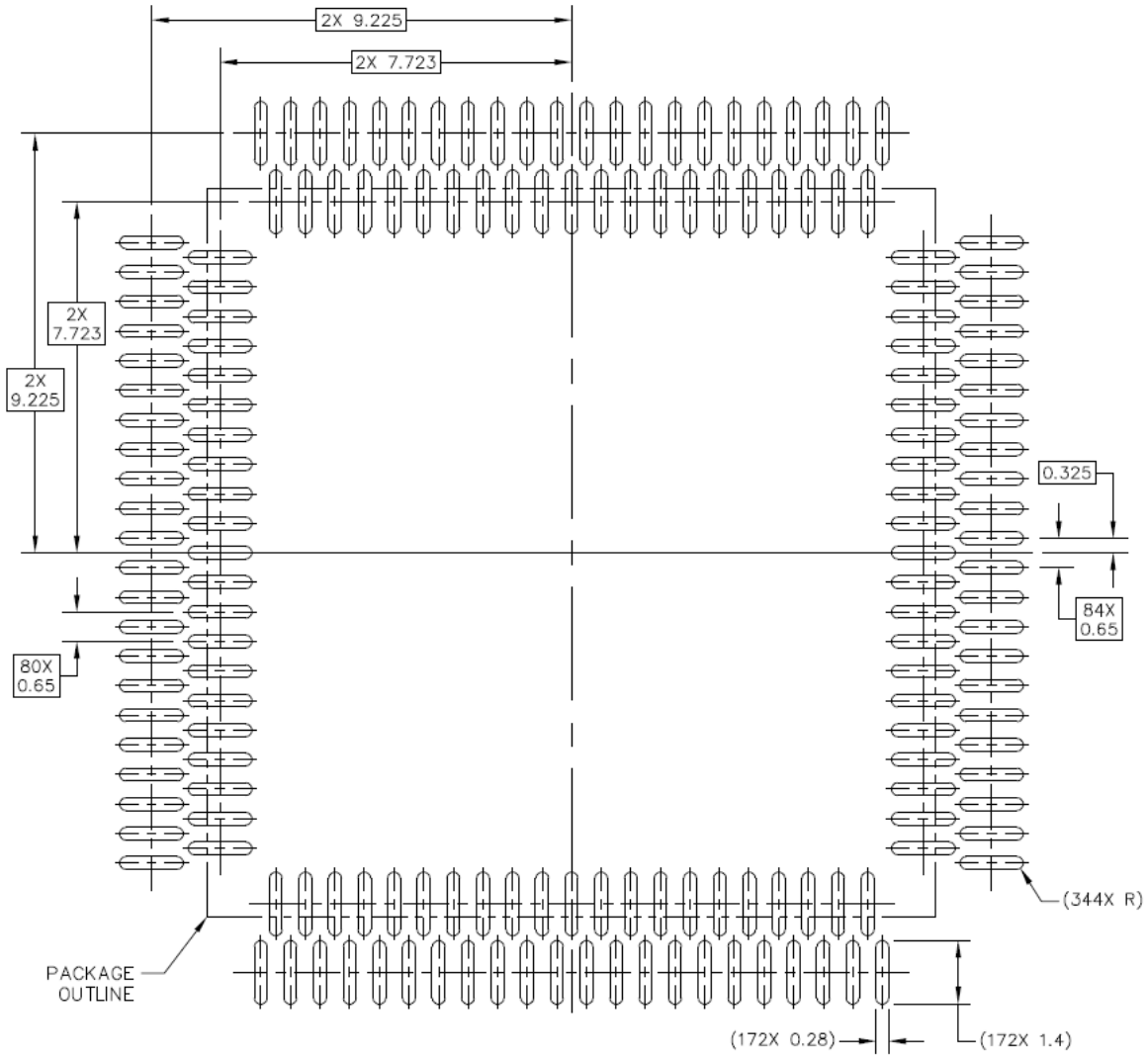


图 6. PCB 上的铜焊盘

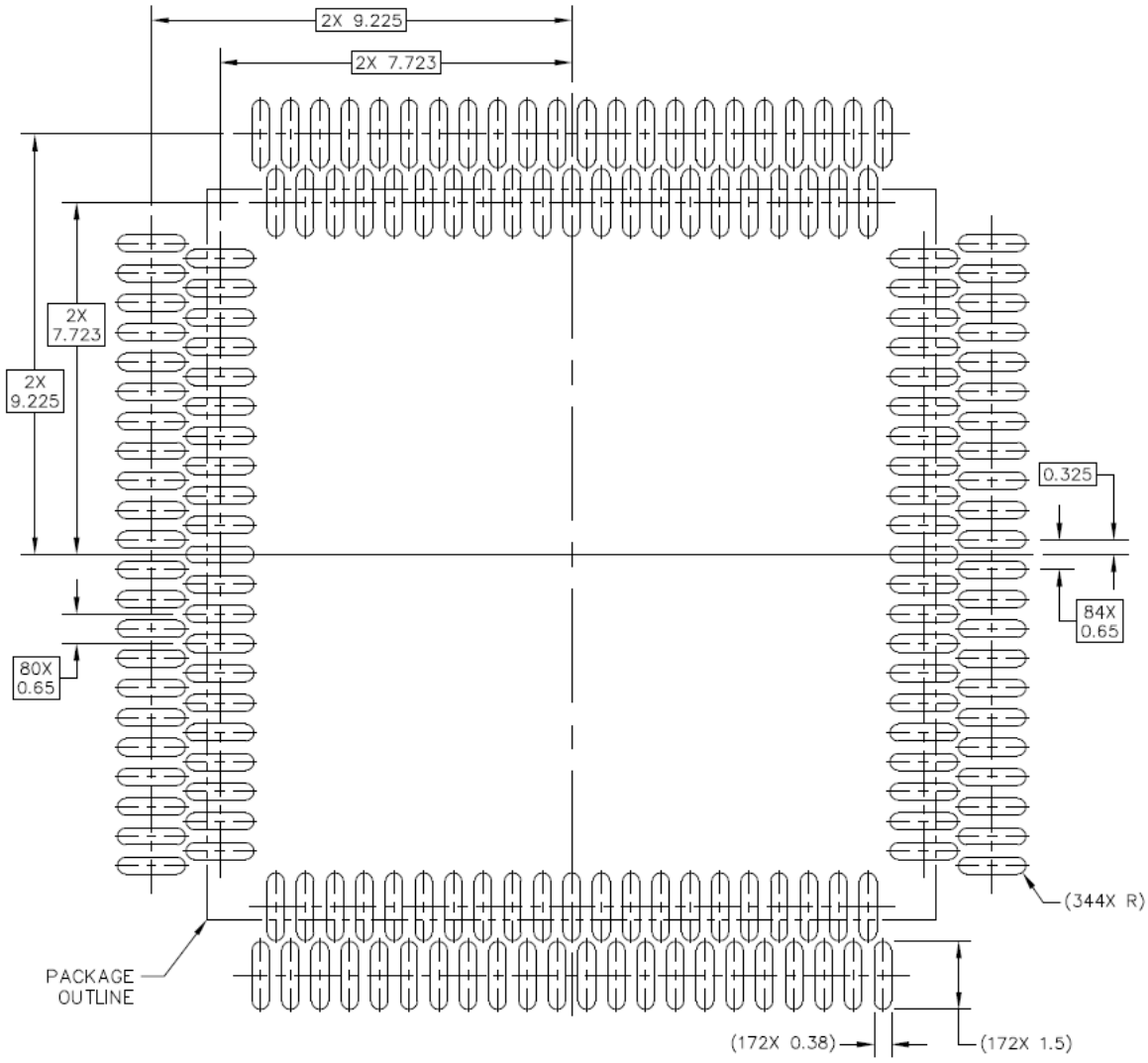

2X 9.225
2X 7.723
2X
7.723
2X
9.225
0.325
84X
0.65
80X
0.65
(344X R)
PACKAGE
OUTLINE
(172X 0.38)
(172X 1.5)

图 7. PCB 上的阻焊膜

5.1. 172 MaxQFP 封装推荐的 PCB 脚印设计

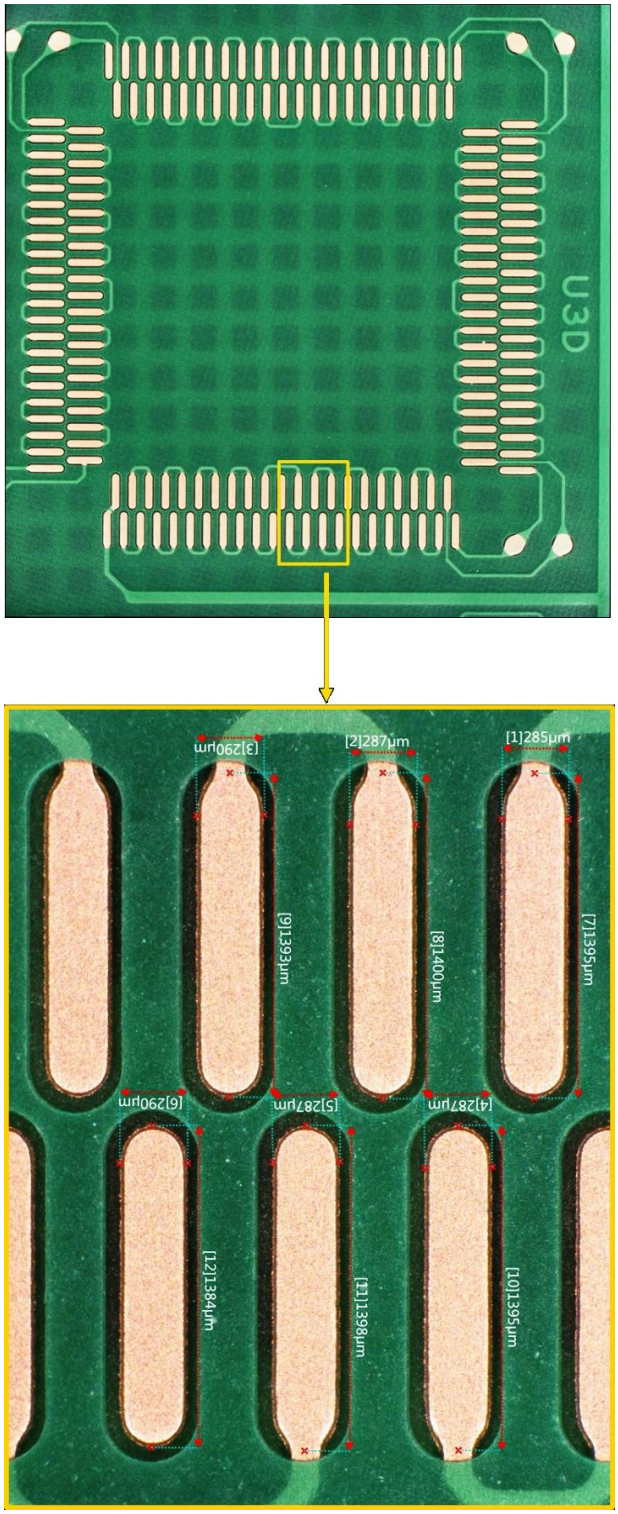


图 8. 推荐的 172 MaxQFP PCB 脚印示例

5.2. 172MaxQFP - 焊膏印刷

- 建议使用 0.125 mm 厚的模板
- 也可以使用其他厚度，如 0.150 mm

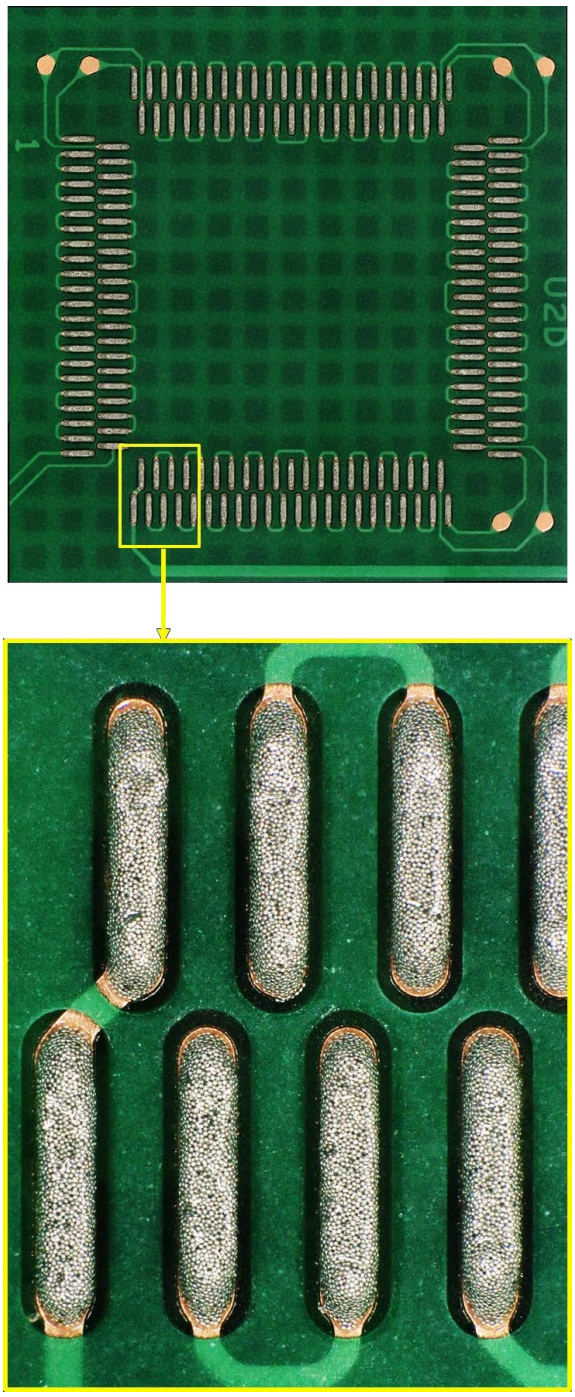


图 9. 示例：推荐使用焊膏印刷的 172 MaxQFP PCB 脚印

5.3. 172 MaxQFP 的光学映像回流焊到 PCB 上

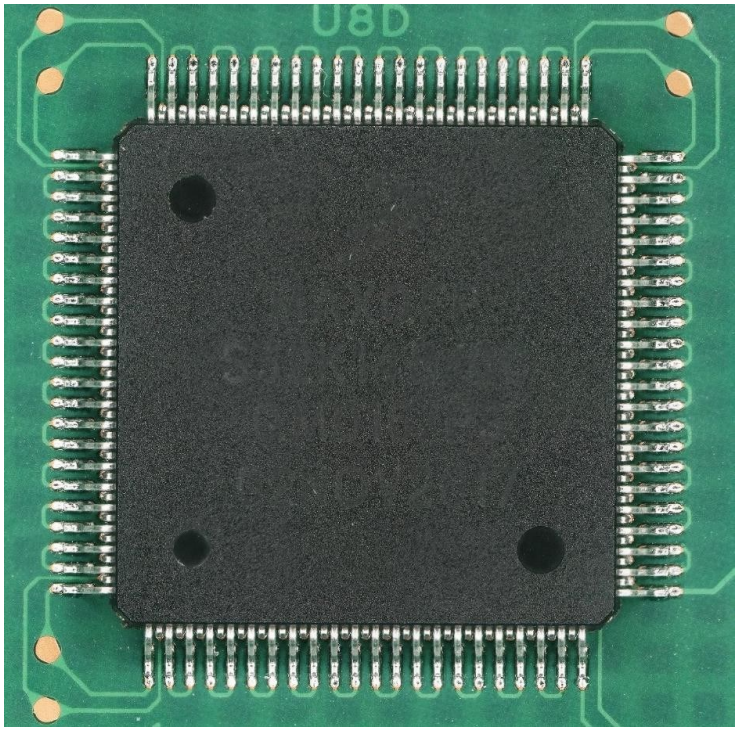


图 10. PCB 上的封装顶视图

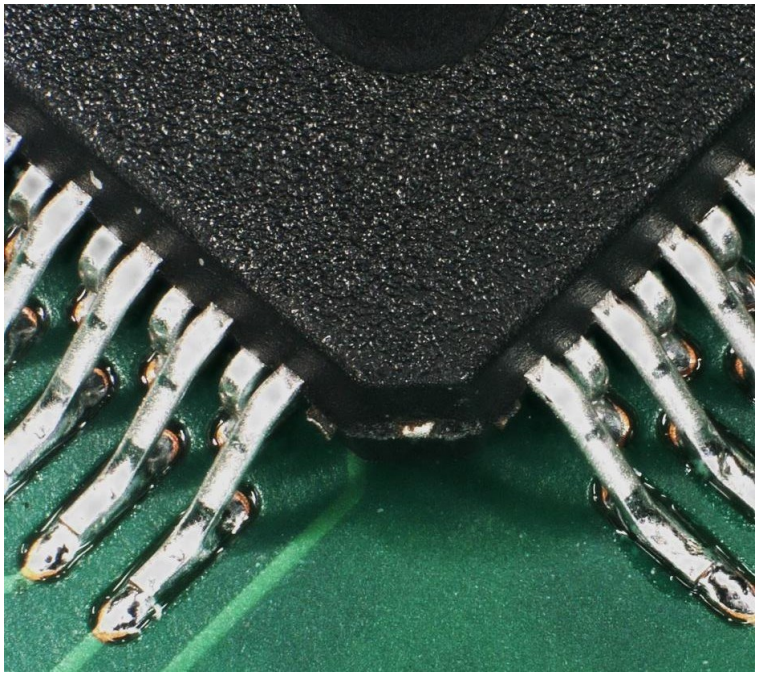


图 11. PCB 的封装角视图

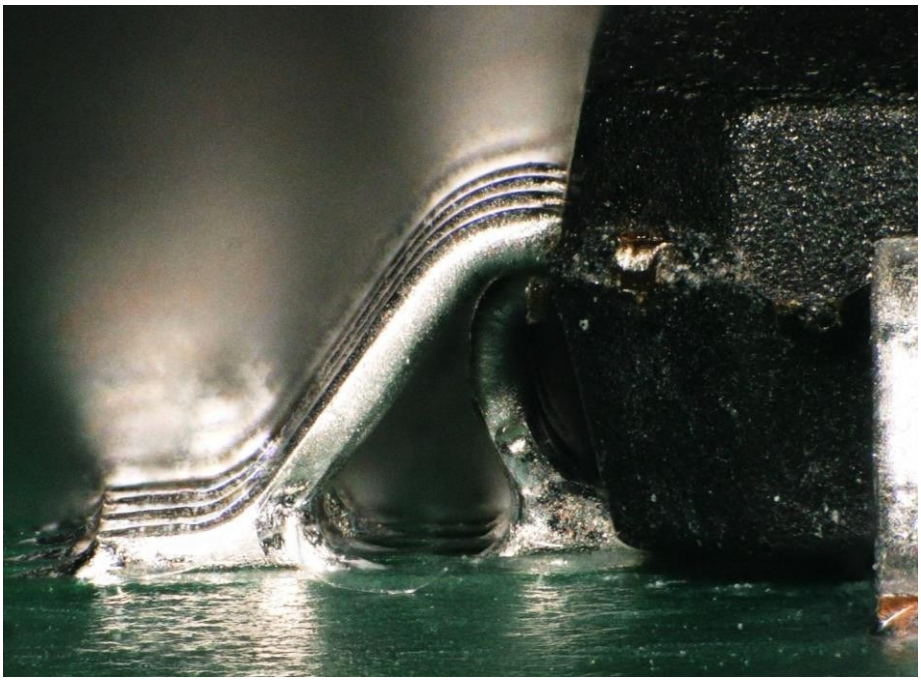


图 12. 172 MaxQFP 通过回流焊焊接到 PCB 上

5.4. MaxQFP 自动光学检测（AOI）的兼容性

由于这是行业中的一个新的封装，因此围绕它有许多疑问。人们会对“自动对象检查”是如何进行的产生怀疑和担忧。围绕是否需要 X 射线检查，也可能会有疑问。这些问题已被证明是无关紧要的。一些 AOI 供应商已经证明：侧面摄像头系统能够检测 MaxQFP。

传统的顶视摄像头 AOI 系统在检测 MaxQFP 封装时会遇到一些困难。这是由于 PCB 安装后的 J 型引线的焊点位于封装体的下面。这些焊点无法用传统的 AOI 系统来检测，因为它只提供顶视图。因此，对于 MaxQFP（或 PLCC）的焊点检测，需要配备带有侧面摄像头的系统。

AOI 系统的侧面摄像头可以很容易地捕捉到 J 型引线焊点的光线反射。有许多 AOI 供应商已经确认，他们带有侧面摄像头的 AOI 系统可以检测到 MaxQFP 焊点。

例如，一个带有 8 个同心的且有角度的摄像头 AOI 系统模块能够获得无遮挡的视野。

- J 型引线的检查是用角度检查来完成的。AOI 系统核实焊接的存在和流动、桥接和可能的污染。
- 鸥翼型引线的检查也是用角度检查法进行的。AOI 系统核实与 J 型引线相同的焊接缺陷，同时也检查引线是否被抬升、移位或断裂。

AOI 系统可以利用用于 LQFP 的基于几何的算法。这些算法需要进行一些调整和调优来检测 MaxQFP。可以与 AOI 供应商讨论这些调整，以确保正确识别故障。调整和调优可能会产生额外的费用，这取决于 AOI 供应商。

特别要强调以下几点：

- MaxQFP 封装不会产生新的焊点故障模式
- 如果 QFP 的鸥翼型（GW）引线不需要检查主要的焊点，那么就不需要检查 MaxQFP 了。同理，这也适用于 PLCC J 型引线
- 强烈建议使用带有侧面摄像头的 AOI 系统，因为它可以更容易地观察到 PLCC J 型引线。

6. 172 MaxQFP 板级焊点可靠性

- 恩智浦对 MaxQFP 进行了大量的 SMT 组装和板级可靠性热循环测试
- 使用了专门设计的测试板（如下图）
- 请看右边的 PCB 和 SMT 细节
- SMT 组装使用 0.125 mm 厚度模板，实现了 100%的焊接良率

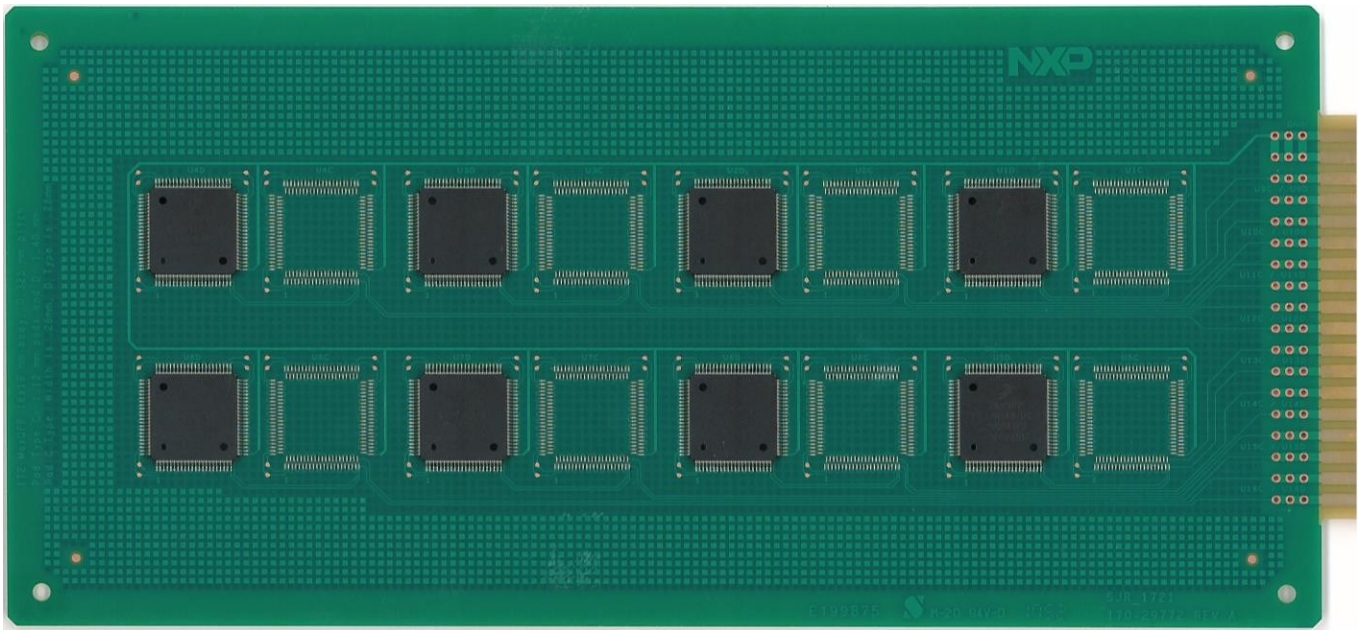


图 13. 用于板级可靠性测试的 172 MaxQFP PCB

表 1. MaxQFP 板级可靠性测试 PCB 和 SMT 细节

条目项	属性值	值
电路板	长 x 宽（mm）	114.3 x 251.36
	厚度（mm）	1.57
电路板材料	绝缘材料	高 Tg FR4
	铜箔层	6 层
焊盘	焊盘尺寸（mm x mm）	鸥翼型和 J 型引线为 1.40 x 0.28。 焊接掩模间隙为 0.05。
	表面处理	OSP（有机可焊性防护剂）
模板	厚度（mm）	0.125
	孔径尺寸	与铜焊盘比例为 1:1
	材料	带有纳米涂层的细纹 不锈钢
焊膏	成分	SAC305
	型号	不清洁，ROL0，IV 型粉末
回流焊	类型	在空气中的对流回流焊，峰值为 240C

6.1. 典型的焊后板安装 172 MaxQFP 的 X-Ray 图

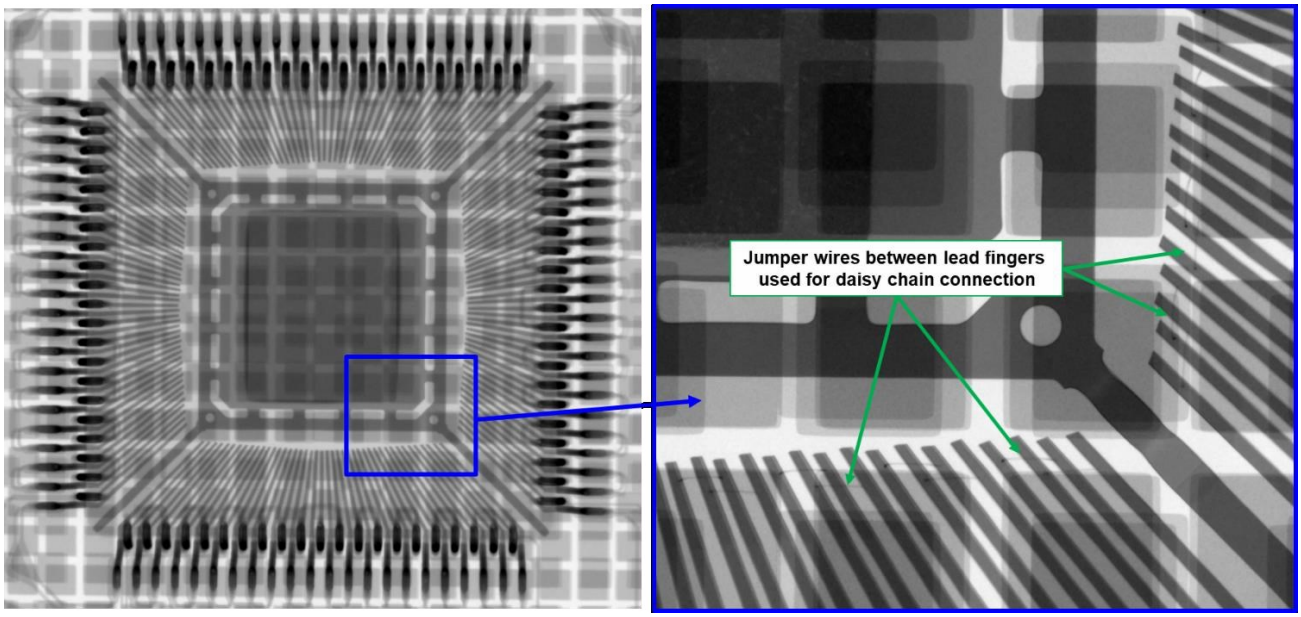


图 14. 顶视图（穿过封装）

6.2. 172 MaxQFP 板级可靠性热循环细节

- 热循环测试细节：
  - -40 至 125°C 的单室循环
  - 最小坡度和停留时间，一小时循环
  - 连续的原位电阻监测，当电阻≥1000Ω 时就会发生故障
  - 样本量大小为 32 个零件

- 结果：
  - 在 9191 次循环时，首次故障发生
  - 威布尔特性寿命为 13049 个循环
  - 通常零件上的循环一直到>63%故障，但由于优异的可靠性，测试在 12018 次循环、30%故障时终止。

图 15. 单室热循环

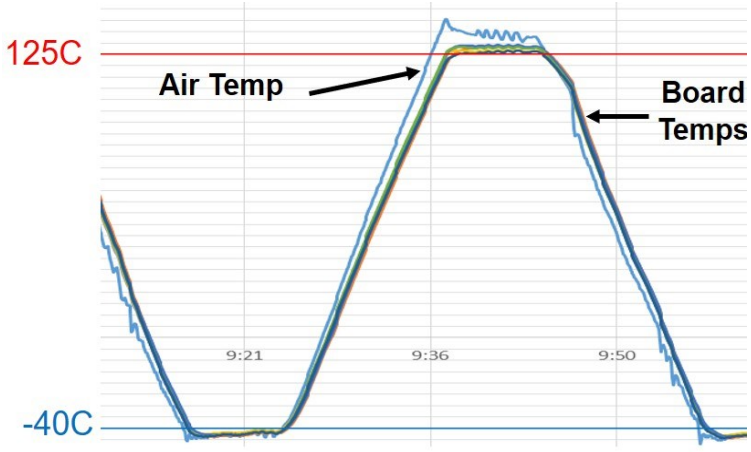


图 16. 热循环曲线图

6.3. 172 MaxQFP 的时间零点截面分析

6.3.1. 172 MaxQFP 热循环前的截面分析

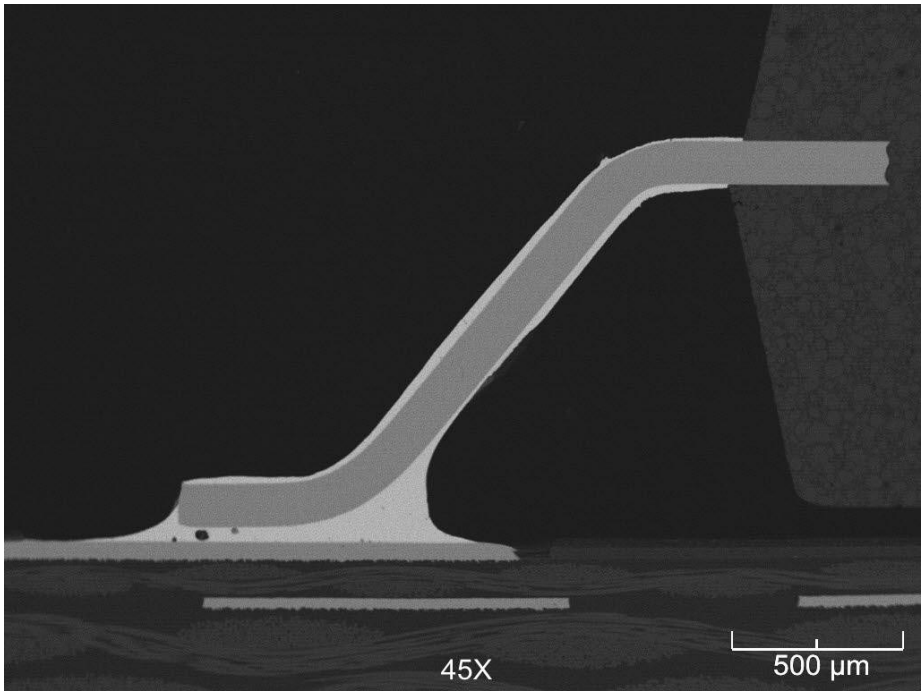


图 17. 172 MaxQFP 鸥翼型引线焊点（45X）

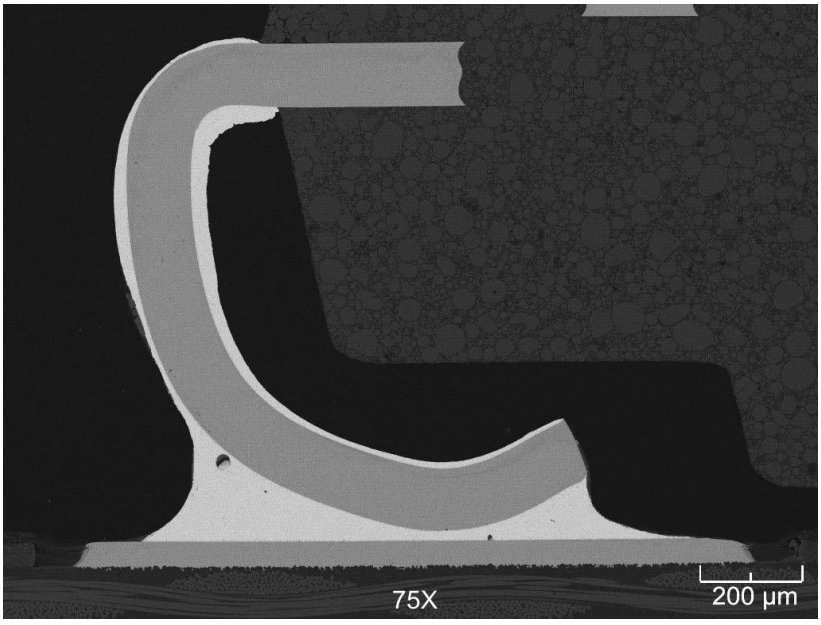


图 18. 172MaxQFP 的 J 型引线焊点（75X）

6.3.2. 172 MaxQFP 热循环后的截面分析

- 零件在 11212 次循环（J 型引线）和 10157 次循环（鸥翼型引线）时，发生故障。
- 在 12018 次循环时得出的截面。
- 故障发生在大块焊料中。

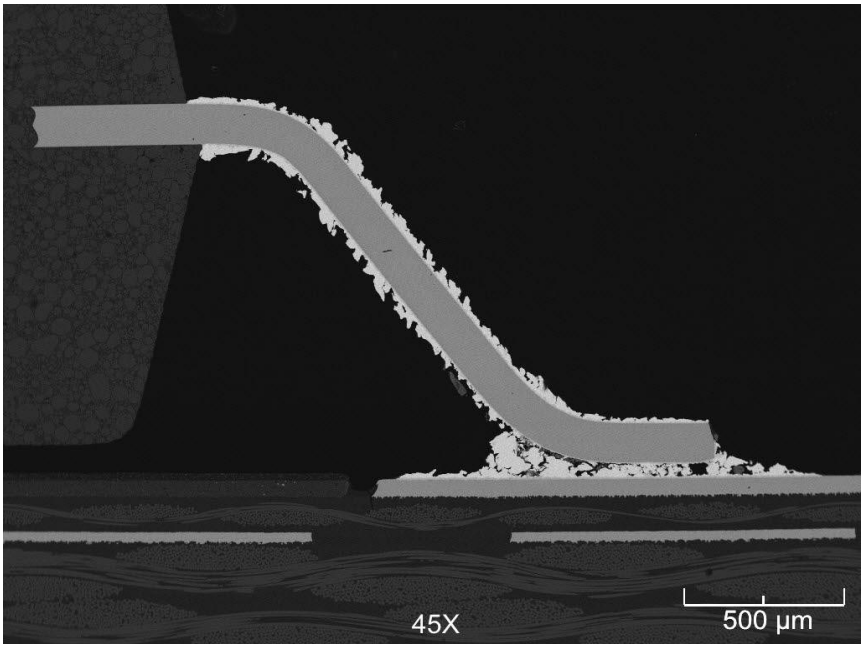


图 19. 172MaxQFP 发生故障的鸥翼型引线焊点（引线 9）

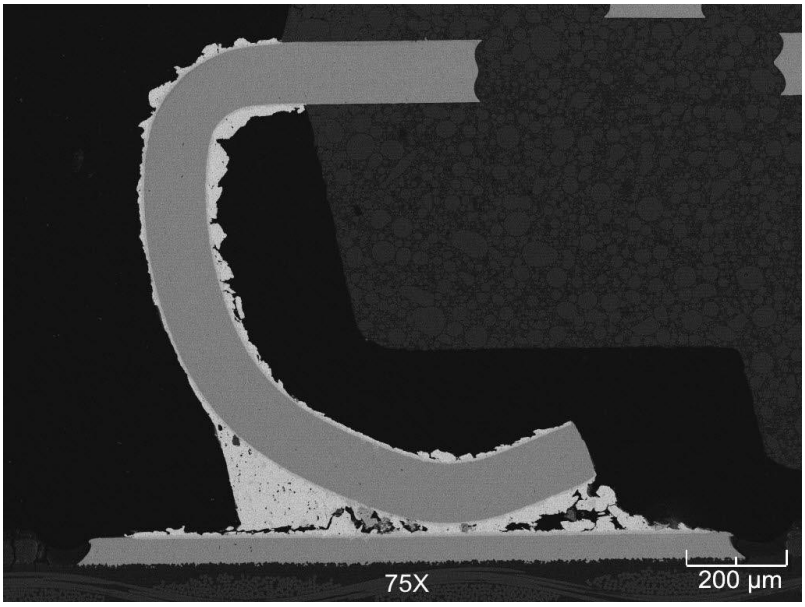


图 20. 172MaxQFP 发生故障的 J 型引线焊点故障（引线 124）

6.4. 172 MaxQFP 板级热循环威布尔图

- 172 MaxQFP 超过了所有已知的 AEC 1 级 BLR 要求，直到 9791 次板级循环，产生第一次故障。
- 请注意，这种类型的测试通常会持续到>63%故障，但由于出色的 BLR 结果，测试在 12018 次循环、30%故障时就终止了。

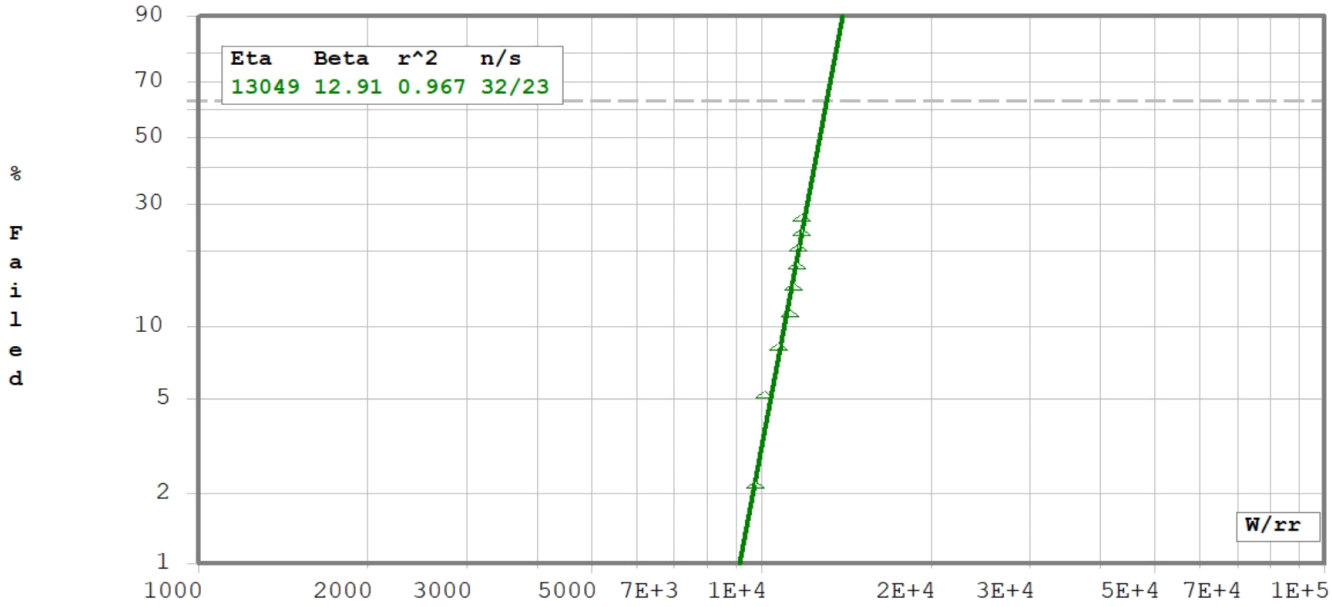


图 21. 热循环威布尔图

7. 总结

- MaxQFP 是一种成本效益高、小尺寸和高可靠性的封装，超过了 AEC 1 级要求。
- 它展示了出色的 SMT 良率和板级热循环可靠性。
- 封装已经过广泛的测试、建模和特性分析。
- 使用有角度的摄像头显示 J 型引线的“自动光学检测”（AOI）。
- 已经计划在恩智浦的各种产品中使用。

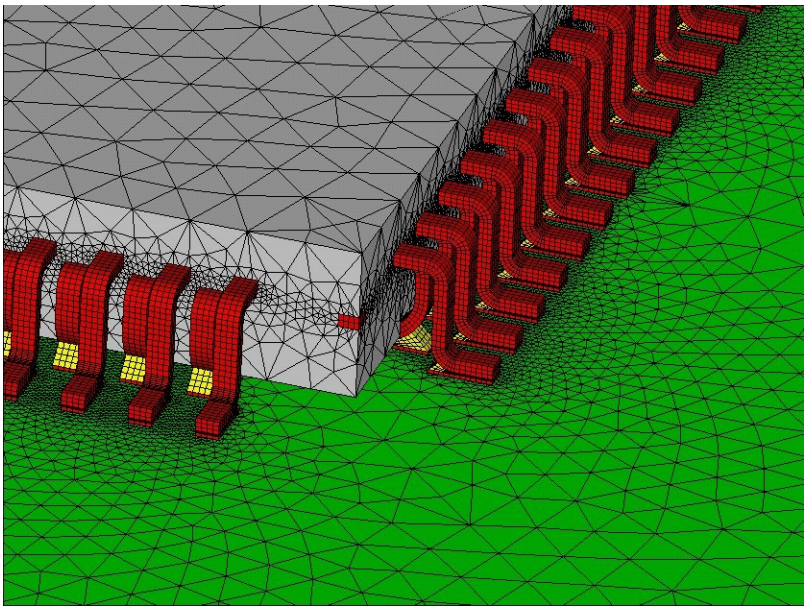


图 22. PCB 上的 MaxQFP 的有限元模型

8. 参考资料

- MaxQFP 172 – 恩智浦的新封装平台
- 172MAXQFP – 机械尺寸图
- 100MAXQFP – 机械尺寸图

Legal information

Definitions

Draft — A draft status on a document indicates that the content is still under internal review and subject to formal approval, which may result in modifications or additions. NXP Semiconductors does not give any representations or warranties as to the accuracy or completeness of information included in a draft version of a document and shall have no liability for the consequences of use of such information.

Disclaimers

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, NXP Semiconductors does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. NXP Semiconductors takes no responsibility for the content in this document if provided by an information source outside of NXP Semiconductors.

In no event shall NXP Semiconductors be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, NXP Semiconductors' aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms and conditions of commercial sale of NXP Semiconductors.

Right to make changes — NXP Semiconductors reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. NXP Semiconductors makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using NXP Semiconductors products, and NXP Semiconductors accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the NXP Semiconductors product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

NXP Semiconductors does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using NXP Semiconductors products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). NXP does not accept any liability in this respect.

Terms and conditions of commercial sale — NXP Semiconductors products are sold subject to the general terms and conditions of commercial sale, as published at http://www.nxp.com/profile/terms, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. NXP Semiconductors hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of NXP Semiconductors products by customer.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

Evaluation products — This product is provided on an “as is” and “with all faults” basis for evaluation purposes only. NXP Semiconductors, its affiliates and their suppliers expressly disclaim all warranties, whether express, implied or statutory, including but not limited to the implied warranties of non-infringement, merchantability and fitness for a particular purpose. The entire risk as to the quality, or arising out of the use or performance, of this product remains with customer.

In no event shall NXP Semiconductors, its affiliates or their suppliers be liable to customer for any special, indirect, consequential, punitive or incidental damages (including without limitation damages for loss of business, business interruption, loss of use, loss of data or information, and the like) arising out the use of or inability to use the product, whether or not based on tort (including negligence), strict liability, breach of contract, breach of warranty or any other theory, even if advised of the possibility of such damages.

Notwithstanding any damages that customer might incur for any reason whatsoever (including without limitation, all damages referenced above and all direct or general damages), the entire liability of NXP Semiconductors, its affiliates and their suppliers and customer’s exclusive remedy for all of the foregoing shall be limited to actual damages incurred by customer based on reasonable reliance up to the greater of the amount actually paid by customer for the product or five dollars (US$5.00). The foregoing limitations, exclusions and disclaimers shall apply to the maximum extent permitted by applicable law, even if any remedy fails of its essential purpose.

Translations — A non-English (translated) version of a document is for reference only. The English version shall prevail in case of any discrepancy between the translated and English versions.

Security — Customer understands that all NXP products may be subject to unidentified vulnerabilities or may support established security standards or specifications with known limitations. Customer is responsible for the design and operation of its applications and products throughout their lifecycles to reduce the effect of these vulnerabilities on customer’s applications and products. Customer’s responsibility also extends to other open and/or proprietary technologies supported by NXP products for use in customer’s applications. NXP accepts no liability for any vulnerability. Customer should regularly check security updates from NXP and follow up appropriately.

Customer shall select products with security features that best meet rules, regulations, and standards of the intended application and make the ultimate design decisions regarding its products and is solely responsible for compliance with all legal, regulatory, and security related requirements concerning its products, regardless of any information or support that may be provided by NXP.

NXP has a Product Security Incident Response Team (PSIRT) (reachable at PSIRT@nxp.com) that manages the investigation, reporting, and solution release to security vulnerabilities of NXP products.

Suitability for use in automotive and/or industrial applications — This NXP product has been qualified for use in automotive and/or industrial applications. It has been developed in accordance with ISO 26262 respectively IEC 61508, and has been ASIL- respectively SIL-classified accordingly. If this product is used by customer in the development of, or for incorporation into, products or services (a) used in safety critical applications or (b) in which failure could lead to death, personal injury, or severe physical or environmental damage (such products and services hereinafter referred to as “Critical Applications”), then customer makes the ultimate design decisions regarding its products and is solely responsible for compliance with all legal, regulatory, safety, and security related requirements concerning its products, regardless of any information or support that may be provided by NXP. As such, customer assumes all risk related to use of any products in Critical Applications and NXP and its suppliers shall not be liable for any such use by customer. Accordingly, customer will indemnify and hold NXP harmless from any claims, liabilities, damages and associated costs and expenses (including attorneys’ fees) that NXP may incur related to customer’s incorporation of any product in a Critical Application.

Trademarks

Notice: All referenced brands, product names, service names, and trademarks are the property of their respective owners.

NXP — wordmark and logo are trademarks of NXP B.V.

AMBA, Arm, Arm7, Arm7TDMI, Arm9, Arm11, Artisan, big.LITTLE, Cordio, CoreLink, CoreSight, Cortex, DesignStart, DynamIQ, Jazelle, Keil, Mali, Mbed, Mbed Enabled, NEON, POP, RealView, SecurCore, Socrates, Thumb, TrustZone, ULINK, ULINK2, ULINK-ME, ULINK-PLUS, ULINKpro, µVision, Versatile — are trademarks or registered trademarks of Arm Limited (or its subsidiaries) in the US and/or elsewhere. The related technology may be protected by any or all of patents, copyrights, designs and trade secrets. All rights reserved.

Airfast — is a trademark of NXP B.V.

Altivec — is a trademark of NXP B.V.

Arteris — Portions of this document contain content provided by Arteris, Inc. or its subsidiaries (collectively, “Arteris”). Arteris is the sole owner of such content.

CodeWarrior — is a trademark of NXP B.V.

ColdFire — is a trademark of NXP B.V.

ColdFire+ — is a trademark of NXP B.V.

CoolFlux — is a trademark of NXP B.V.

CoolFlux DSP — is a trademark of NXP B.V.

EdgeLock — is a trademark of NXP B.V.

EdgeScale — is a trademark of NXP B.V.

eIQ — is a trademark of NXP B.V.

Embrace — is a trademark of NXP B.V.

Freescale — is a trademark of NXP B.V.

GreenChip — is a trademark of NXP B.V.

ICODE and I-CODE — are trademarks of NXP B.V.

Immersiv3D — is a trademark of NXP B.V.

I2C-bus — logo is a trademark of NXP B.V.

JCOP — is a trademark of NXP B.V.

Kinetis — is a trademark of NXP B.V.

Layerscape — is a trademark of NXP B.V.

MagniV — is a trademark of NXP B.V.

Mantis — is a trademark of NXP B.V.

MIFARE — is a trademark of NXP B.V.

MIFARE Classic — is a trademark of NXP B.V.

MIFARE FleX — is a trademark of NXP B.V.

MIFARE4Mobile — is a trademark of NXP B.V.

MIFARE Plus — is a trademark of NXP B.V.

MIFARE Ultralight — is a trademark of NXP B.V.

MiGLO — is a trademark of NXP B.V.

MOBILEGT — is a trademark of NXP B.V.

NTAG — is a trademark of NXP B.V.

NXP SECURE CONNECTIONS FOR A SMARTER WORLD — is a trademark of NXP B.V.

Oracle and Java — are registered trademarks of Oracle and/or its affiliates.

Processor Expert — is a trademark of NXP B.V.

QorIQ — is a trademark of NXP B.V.

QorIQ Qonverge — is a trademark of NXP B.V.

RoadLink — wordmark and logo are trademarks of NXP B.V.

SafeAssure — is a trademark of NXP B.V.

SafeAssure — logo is a trademark of NXP B.V.

SmartLX — is a trademark of NXP B.V.

SmartMX — is a trademark of NXP B.V.

StarCore — is a trademark of NXP B.V.

Symphony — is a trademark of NXP B.V.

Tower — is a trademark of NXP B.V.

UCODE — is a trademark of NXP B.V.

VortiQa — is a trademark of NXP B.V.

Vybrid — is a trademark of NXP B.V.

For more information, please visit: http://www.nxp.com

For sales office addresses, please send an email to: salesaddresses@nxp.com

Date of release: 04/2022

Document identifier: AN13621