MaxQFP 封装

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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）
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。
对于高功率应用，MaxQFP_EP（裸露焊盘）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
4.2. 100MaxQFP 封装尺寸图[初步版本]

![100MaxQFP 封装尺寸图](image)
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
MaxQFP 封装的 PCB 设计指南和要求

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
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

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

6.1. 典型的焊后板安装 172 MaxQFP 的 X-Ray 图

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。
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）](image9)

![图 20. 172MaxQFP 发生故障的 J 型引线焊点故障（引线 124）](image10)
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。

![热循环威布尔图](image)

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
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