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AN-9078

Surface Mount Guidelines for Motion SPM® 7 Series

Introduction

This application note provides assembly guidelines for the PQFN package of the Motion SPM® 7 series. This document focuses on the design of stencil, which plays a crucial role in producing reliable solder joints. The setting conditions comply with general recommendations. The reference design and related application notes are listed in the Related Resources section.

Package Description

Power Quad Flat No-lead (PQFN) is a surface-mount plastic package with lead pads located on the bottom surface of the package. Figure 1 shows the external appearance of package for the Motion SPM® 7 series.

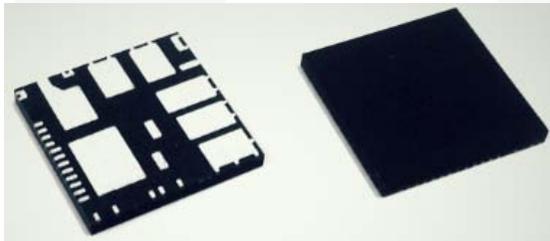


Figure 1. External Appearance of PQFN Package for Motions SPM® 7 Series

The SPM 7 series has six fast-recovery MOSFETs (FRFET®) and a three-phase HVIC. Figure 2 shows the structure of the Motion SPM® 7 series.

The bottom side of the copper lead frame is plated with tin (Sn) to ensure enhanced adhesion of solder.

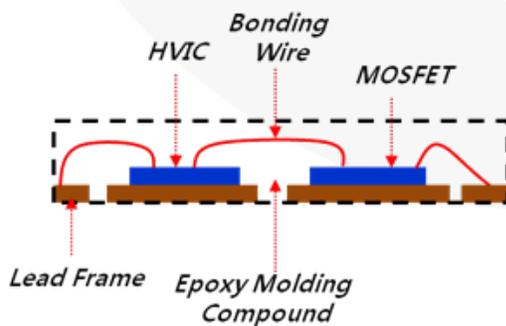


Figure 2. Structure of Motion SPM® 7 Series

Soldering Condition

Solder Paste

The SPM® 7 series performs well with lead-free solder. An evaluation test was performed with solder paste, HeeSung LFM-48W NH(M), which is lead-free and halogen-free. Table 1 shows information for this solder paste.

Table 1. Information for Solder Paste

| Part Number | Powder Size [μm] | Composition [%] | Flux [%] |
|---------------|------------------|----------------------------------|----------|
| LFM-48W NH(M) | 20-38 | Sn / Ag / Cu 96.5 / 3.0 / 0.5 | 11.0 |

The SPM 7 series performs similarly well with solder paste Senju M705-GRN360-K2-V.

Solder paste is applied to lands using stencil to print. The printing process of solder paste is very important to prevent defects in PCB assembly.

Reflow Soldering Profile

Heating is necessary to melt solder paste on adjacent lands without overheating and damaging electrical components. Heating can be accomplished by passing the assembly through a reflow oven, under an infrared lamp, or by soldering individual joints with a hot-air pencil. Reflow soldering is the most common method of attaching surface-mount components to a circuit board by heating. Figure 3 shows the recommended reflow-profile provided by the maker of solder paste, HeeSung LFM-48W NH(M).

Table 3. Type of Pattern

| Pattern | Stencil | PCB |
|--------------------------|---------|-----|
| Comb | | |
| Square without Via Holes | | |
| Square with Via Holes | | |
| Honeycomb | | |

| Pattern | X-Ray | |
|-----------|-------|--|
| Honeycomb | | |

Note:

1. Thickness of stencil is 100 μm.

Thickness and Opening Width of Stencil

To determine the appropriate pattern of the stencil, several thickness and opening width were evaluated as shown in Figure 11 and Table 5. With the results of the void level, 150 μm thickness and 200 μm opening width are preferred; as shown in Table 10 in comparison with Table 7, Table 6, and Table 5. Generally, 50 μm and 100 μm thickness are not recommended for PQFN package because solder amount may not be sufficient to ensure reliable solder joints.



Figure 11. Thickness of Stencil

Table 5. Opening width of Stencil

| Opening Width | Stencil | |
|---------------|---------|--|
| 200 μm | | |
| 300 μm | | |

Table 4. Result for Different Patterns

| Pattern | X-Ray | |
|--------------------------|-------|--|
| Comb | | |
| Square without Via Holes | | |
| Square with Via Holes | | |

Table 6. Result for 100 μm Thickness, 300 μm Opening Width

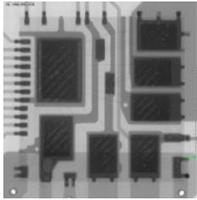
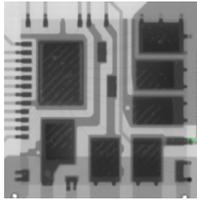
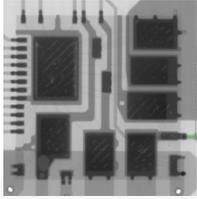
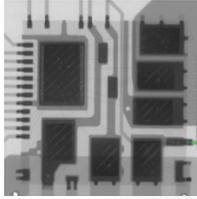
| Condition | X-Ray | |
|---|---|---|
| 50 μm Thickness 300 μm Opening Width |  Void Level \approx 20% |  Void Level \approx 22% |
| |  Void Level \approx 21% |  Void Level \approx 20% |

Table 9. Result for 150 μm Thickness, 300 μm Opening Width

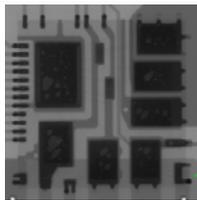
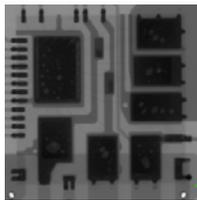
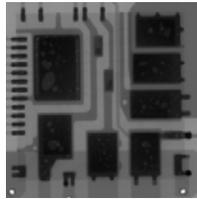
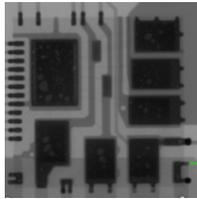
| Condition | X-Ray | |
|--|---|---|
| 150 μm Thickness 300 μm Opening Width |  Void Level \approx 25% |  Void Level \approx 24% |
| |  Void Level \approx 25% |  Void Level \approx 22% |

Table 7. Result for 100 μm Thickness, 300 μm Opening Width

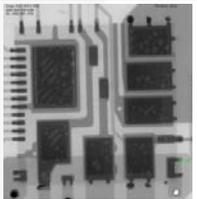
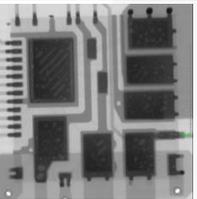
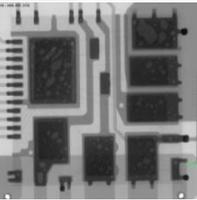
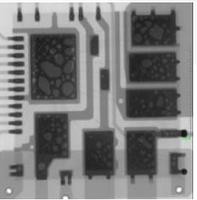
| Condition | X-Ray | |
|--|---|---|
| 100 μm Thickness 300 μm Opening Width |  Void Level \approx 23% |  Void Level \approx 25% |
| |  Void Level \approx 30% |  Void Level \approx 38% |

Table 8. Result for 100 μm Thickness, 200 μm Opening Width

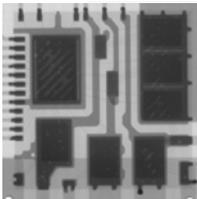
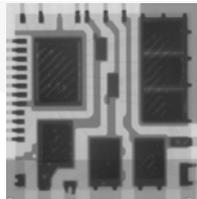
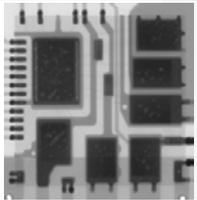
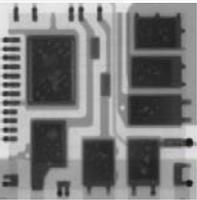
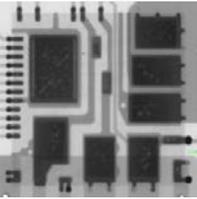
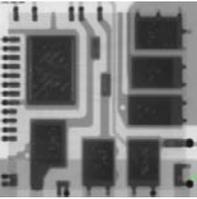
| Condition | X-Ray | |
|---|---|---|
| 100 μm Thickness, 200 μm Opening Width |  Void Level \approx 19% |  Void Level \approx 20% |

Table 10 shows the best performance, with proper 30 μm push depth, which represents reaming thickness of solder paste after pushing the device and prior to reflow.

Table 10. Result for 150 μm Thickness, 200 μm Opening Width

| Condition | X-Ray (Best Case) | |
|--|---|---|
| 150 μm Thickness 200 μm Opening Width |  Void Level \approx 18% |  Void Level \approx 20% |
| |  Void Level \approx 18% |  Void Level \approx 17% |

To determine effectiveness of masking for the island, partial masking was evaluated, as shown in Table 11.

Table 11. Island of Stencil

| Type | Stencil |
|------------------|---------|
| Island Soldering | |
| Island Masking | |

As shown in Table 12, overflowed solder was found intermittently. Therefore, island masking is recommended.

Table 12. Results for Island Masking

| Type | Stencil |
|------------------|---------|
| Island Soldering | |
| Island Masking | |

Reflow Direction

Figure 12 shows the direction of reflows performed in this evaluation.

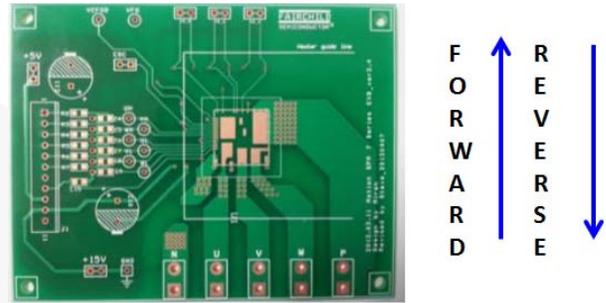


Figure 12. Reflow Direction

Figure 13 and Figure 14 show the similar void levels in each reflow direction. Judging from the X-ray comparison, there is no significant difference.

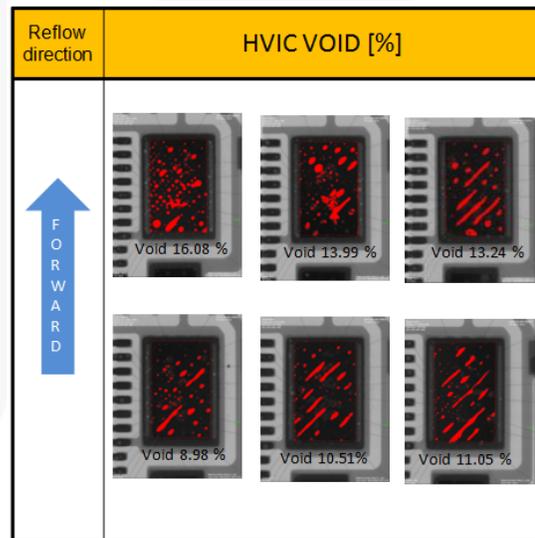


Figure 13. HVIC Solder Void for Forward Direction

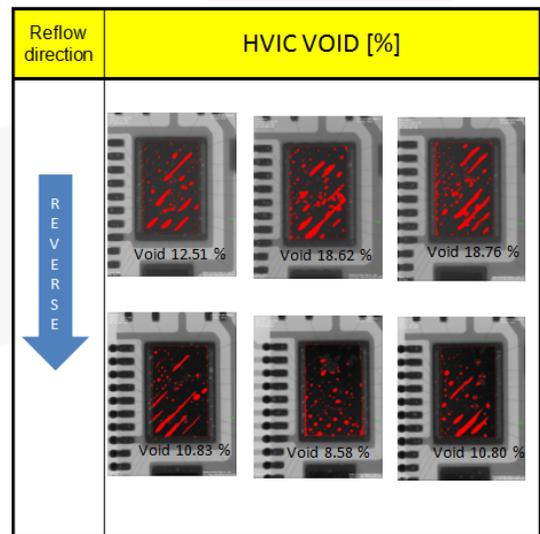


Figure 14. HVIC Solder Void for Reverse Direction

Summary and Conclusions

The evaluation was conducted to find optimized soldering conditions for the SPM7 series in PQFN packages.

Different stencil designs were studied to reduce solder voids that can lead to defects in solder joints. Judging from the evaluation results, the recommended design of the stencil is comb pattern, 200 μm width mask openings, 150 μm stencil thickness, and island masking.

Figure 15 shows the guidelines for selecting recommended conditions related to stencil design.

Large solder voids on solder joints can lead to failures and reliability problems. Figure 16 shows the difference between the worst and the best mounting on PCB (100 μm thickness of stencil and honeycomb pattern was the worst case). To ensure expected performance in the field, board level tests were performed after soldering with the recommended conditions. The conditions and results are listed in Table 13.

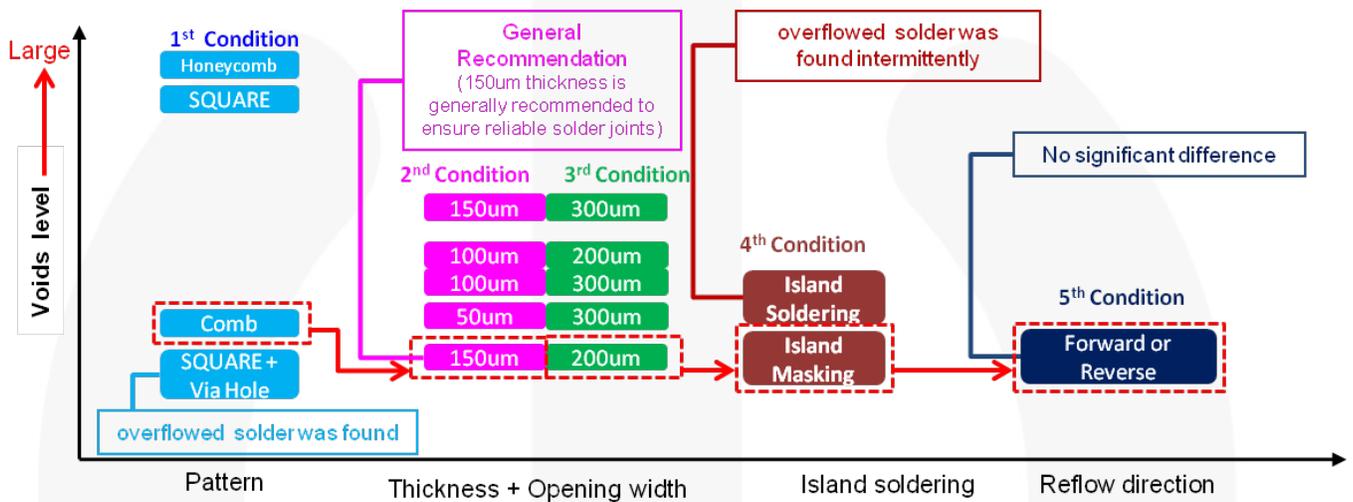


Figure 15. Chart for Selection of Recommended Conditions

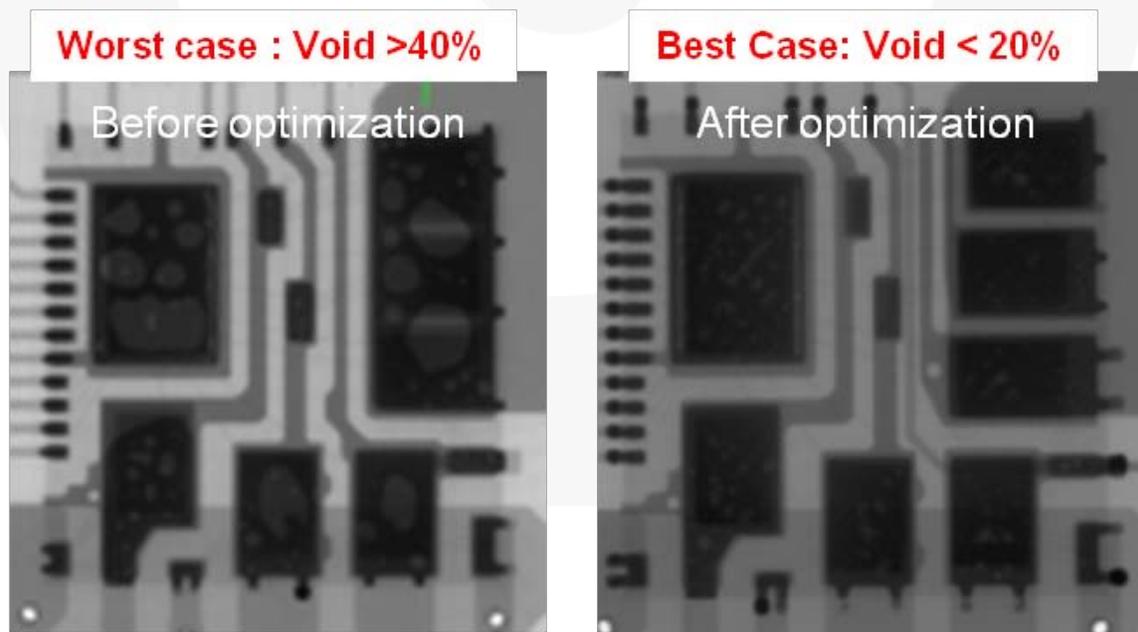


Figure 16. X-Ray Comparison of Worst Case and Best Case

Table 13. **Result of Board-Level Test (Temperature Cycling)**

| Test Conditions | PCB Type | Reference Standard | Result |
|---|-------------|--------------------|--------|
| <ul style="list-style-type: none"> ▪ Temperature Cycling ▪ -40°C / +80°C temperature extremes ▪ 10 Minute Dwell Time ▪ ≤0 Minute Dwell Rate ▪ 400 Temperature Cycles | CEM3 (1.0t) | IPC-9017 | Passed |
| | FR4 (1.0t) | | |
| | FR4 (1.2t) | | |
| | FR4 (1.6t) | | |

Note:

- Soldering condition is based on the recommended condition in Figure 15.

Related Resources

[AN-9077 — Surface Mount Guidelines for Motion SPM® 7 Series](#)

[RD-356 — Fairchild Motion SPM® 7 Series Reference Design](#)

[FSB70325 — Motion SPM® 7 Series](#)

[FSB70625 — Motion SPM® 7 Series](#)

[FSB70250 — Motion SPM® 7 Series](#)

[FSB70450 — Motion SPM® 7 Series](#)

[FSB70550 — Motion SPM® 7 Series](#)

[SPM® Module Design Guide](#)

[Motion Control Design Tool](#)

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