PCB Design and Assembly Recommendations for Power Tower Module Technology

The Renesas module product family offers a unique high-performance packaging concept, the Power Tower package. This package provides various benefits, including reduced package area and array LGA I/O (lead pitch is 1.1mm) with an integrated dual inductor and two Smart Power Stages (SPS) located on top of the module. Also, the exposed copper ePad technology in the SPSs offers excellent thermal performance. These features make the Power Tower packaged module ideal for many new high-end computing and AI applications where board space, thermal, and electrical performance are essential.

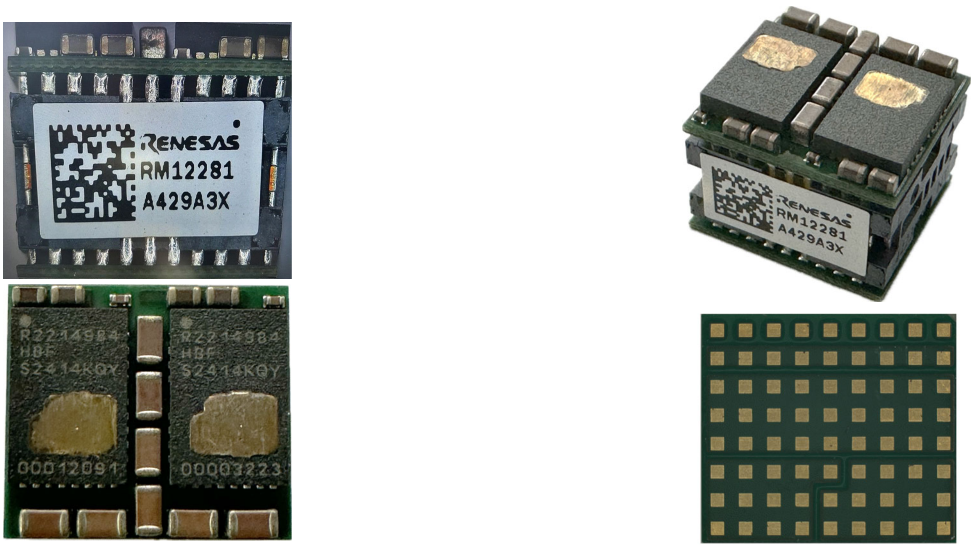
This tech brief provides general guidelines for developing land pattern layouts and solder mounting processes. *Note:* These guidelines are general and should only be considered a starting point in this effort. The user must apply their experiences and development efforts to optimize designs and processes for their manufacturing practices and the needs of varying end-use applications.

Contents

1. Package Construction

1.1 Power Tower Module Packaging Highlights

- Power Tower LGA Laminate technology
  - LGA laminate provides multiple routing layers.
- Power Tower provides superior thermal performance.
  - Power dissipating components are mounted on top of the Power Tower with Top ePads for improved thermal performance.
- Power Tower is flexible.
  - Renesas offers a comprehensive family of Power Tower modules with 8mm thicknesses.
  - The Power Tower connector and laminates can be quickly modified to produce new products.
- Power Tower provides high SMT yields.
  - An NiPdAu lead finish provides excellent solderability.
  - Based on Solder Printing Inspection control in Power Tower assembly, the solder coverage for SPS Thermal Pad and Inductor terminals is 40% minimum. Solder joint reliability is ensured as demonstrated in the reliability stress tests conducted and passed.



8mm Power Tower

Figure 1. Typical Power Tower Module Photos

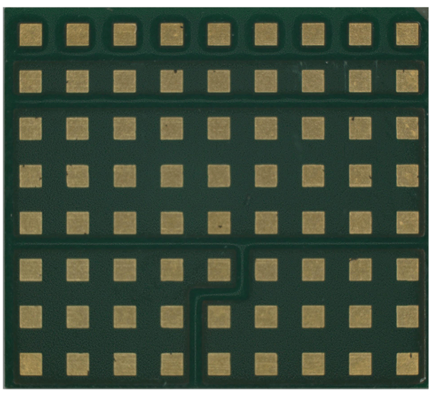


Figure 2. Typical Power Tower Bottom View

Note: The pad finish is NiPdAu for good solderability. The Au finish is 0.6µin thick to prevent gold embrittlement of the solder joint.

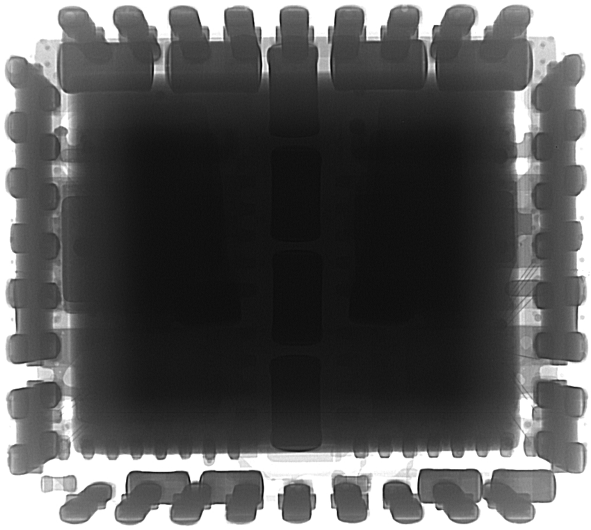


Figure 3. Typical Power Tower Module X-Ray

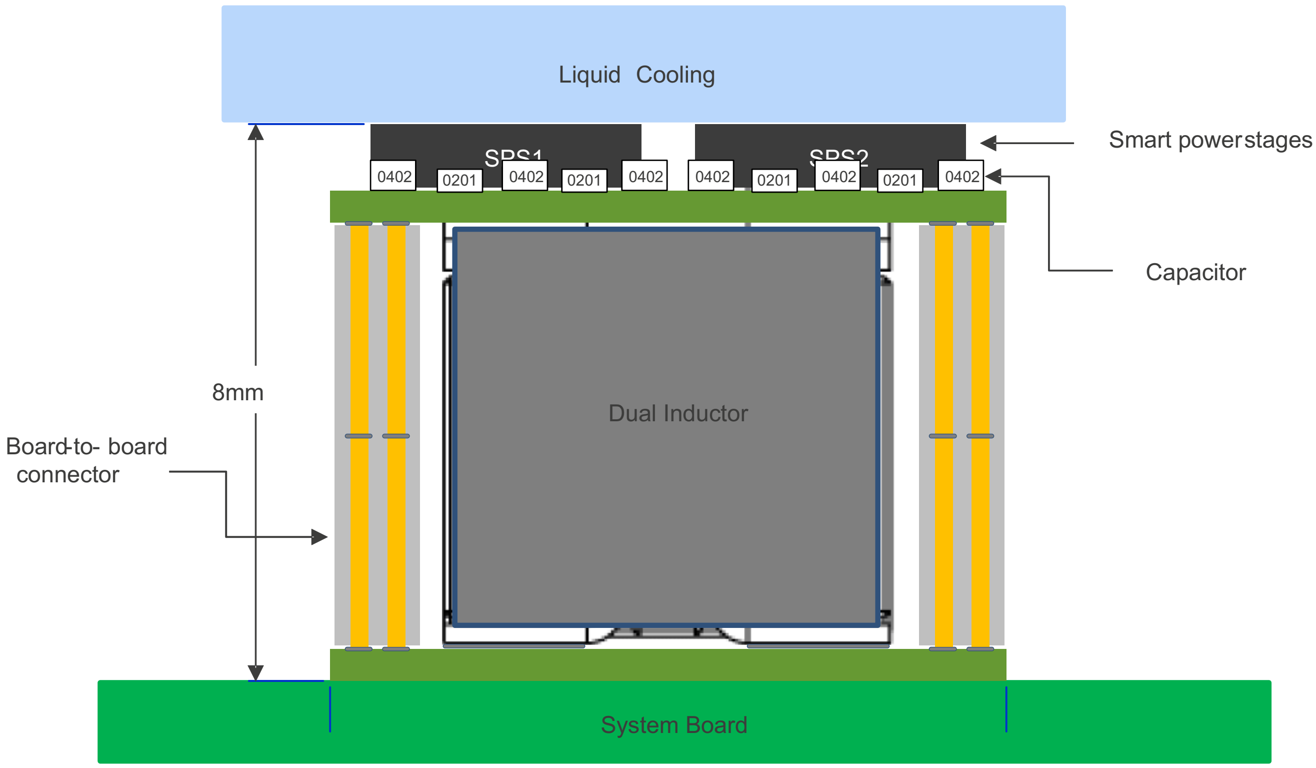


Figure 4. Typical Power Tower Module Cross-Section

2. Moisture Sensitivity

2.1 Moisture Sensitivity Handling, Packing, and Use

2.1.1 Moisture Sensitivity

Power Tower modules are moisture-sensitive devices. All Power Tower modules meet Moisture Sensitivity Level (MSL) 3 per J-STD-020.

Pb-free reflow is qualified per J-STD-020. Peak temperatures vary based on module thickness and volume and are specified on the MSL label.

2.1.2 Packing and Labeling

Renesas packs and labels the Power Tower modules per J-STD-033. Standard packing is in JEDEC trays.

2.1.3 Handling and Use

Customers should handle and use Power Tower modules per J-STD-033. The modules are MSL 3 qualified – do not exceed 168-hour floor life. If floor life is exceeded, bake at +125°C for 8 hours.

3. Reliability

3.1 Standard Power Tower Module Development Flow and Qualification

Discrete component reliability reports are reviewed and approved before the package and/or product builds for qualification (design phase). The Renesas Process Reliability group tests and/or approves process technology wear-out data (such as TDDB, Hot Carrier, HTRB, EM) to ensure the process technology for products such as embedded controllers, power FETs, and power stages meet the Renesas wear-out goals.

The package engineering group executes look-ahead evaluations to ensure the package is robust and meets design goals. When the design phase is complete, the Power Tower module package moves into the Product/Package Reliability qualification phase.

3.2 Typical Reliability Qualification Stress Tests

- MSL Test – Determines Moisture Sensitivity Level per J-STD-020.
- Precondition Stress – Samples for BHAST, UHAST, THB, and TMCL are preconditioned. Stress includes moisture soak per MSL and three-time reflow cycles at the Pb-free peak reflow temperature, per J-STD-020.
- BHAST or THB – Static bias in a moisture-rich environment. Stress targets possible electrolytic-related failure mechanisms. Typical stress runs for 96 hours or 1000 hours, respectively.
- High Temperature Operating Life (HTOL) – Dynamic operation, maximum operating voltage per datasheet. This stress test verifies the long-term reliability of the module. Data is used to calculate the FIT rate and MTTF. Typical stress runs for 1000 hours with module temperature set at +125°C.
- Temperature Cycling (TMCL) – This stress test targets flaws in the thermo-mechanical properties of the module design or BOM. Typical stress includes 500 cycles at -65°C/+150°C or 1000 cycles at -40°C/+125°C.
- High-Temperature Storage Life (HTSL) – This stress test indicates thermally activated failure mechanisms. Typical stress runs for 1000 hours at 150°C.
- Reliability reports are available on the Renesas Quality and Reliability web page.

3.3 Renesas Power Tower Module – Board-Level Reliability

Renesas verifies the BLR of Power Tower modules by doing the following:

- Mounting functional modules or daisy chain modules on PCBs
- Using SAC 305 solder

- Performing temperature cycles of –40°C to +125°C, 12-minute dwell (typical)
- Running 2000 cycles (typical)
- Conducting down point and end point electrical tests to confirm module functionality or no resistance change
- Testing end point cross-section to confirm no solder joint damage

A summary of BLR data is available by request. Detailed reports are also available. Contact Renesas Sales to request a detailed BLR report.

4. PCB Design Guidelines

4.1 Power Tower – PCB Design Guidelines

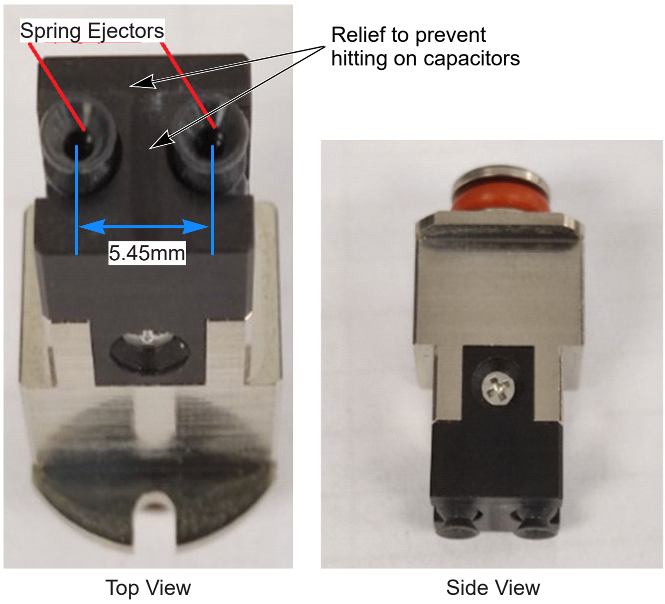
- The Renesas Power Tower package outline drawing in the product datasheet includes a PCB footprint and solder stencil
- PCB lands in the form of SMD pads are preferred to improve gasketing
- PCB lands should match the Power Tower pads one-to-one
- See the Package Outline Drawing (POD) for specific design recommendations
- Solder stencil apertures should be slightly smaller than the solder mask openings, 30µm typical.
- Vias in the pad should be filled and plated over (VIPPO) to prevent solder wicking into the vias.
- Electroless Nickel Immersion Gold (ENIG) PCB finish recommended

5. PCB Assembly Process

5.1 Power Tower – PCB Assembly Process

- Profile with a thermal couple placed under the Power Tower module
- Follow the solder paste supplier's reflow profile, but do not exceed the Power Tower module's qualified peak reflow temp. Pb-free reflow is qualified per J-STD-020:
  - Peak temperature is 245°C for Pb-Free assembly.
  - Time above liquidus (217°C) is 60s-90s maximum
  - See Table 1 and Figure 12.
- Do not exceed the 168-hour out-of-bag limit (MSL 3 qualified)
  - If the time limit is exceeded, bake per MSL label instructions
- Use the following assembly tooling materials for the SMT process:
  - Electroless Nickel Immersion Gold PCB finish (ENIG)
  - Stainless steel, laser cut stencils with Nano-coating
  - 4 mil or 5 mil stencil thickness
  - No clean, low void, Type 3 or 4 solder paste per ANSI/J-STD-005
- Follow the paste supplier recommendation for air or nitrogen purge during reflow.
- Use suggested Power Tower pick and place pickup tool. See Figure 5 through Figure 9.

Tool Design: Cup type with spring ejectors
Pick Position: Mold compound area of QFN
Cup Diameter: 3.1mm (0.122”) or equivalent, Pitch 5.45mm



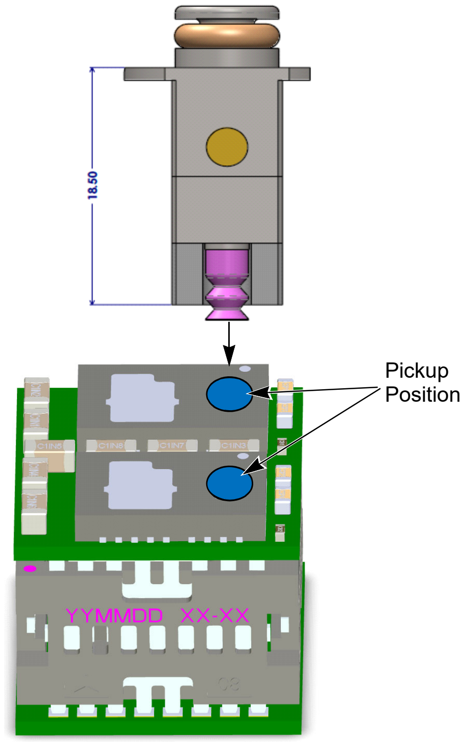


Figure 5. Suggested Power Tower Pickup Tool

Tool Design: Cup type with spring ejectors
Cup Diameter: 3.1mm (0.122”) or equivalent, Pitch 5.45mm

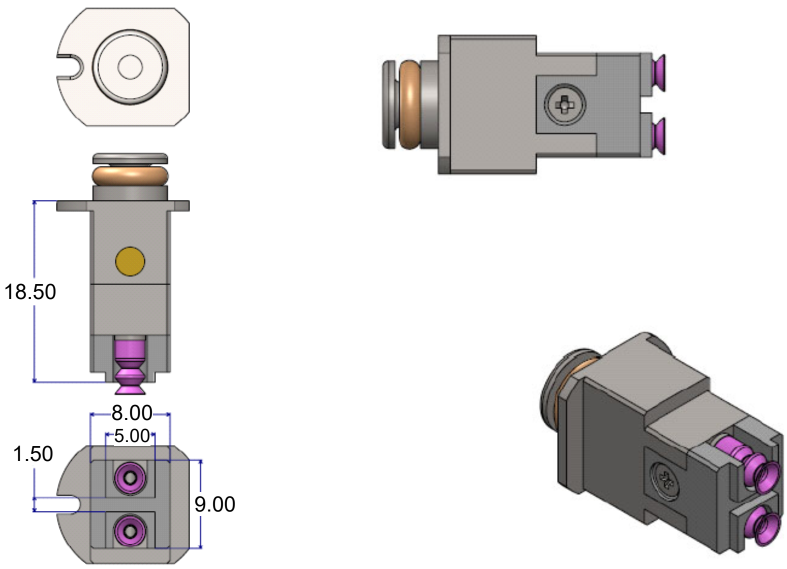


Figure 6. Suggested Power Tower Pickup Tool – Detail 1

Tool Design: Cup type with spring ejectors
Cup Diameter: 3.1mm (0.122") or equivalent, Pitch 5.45mm

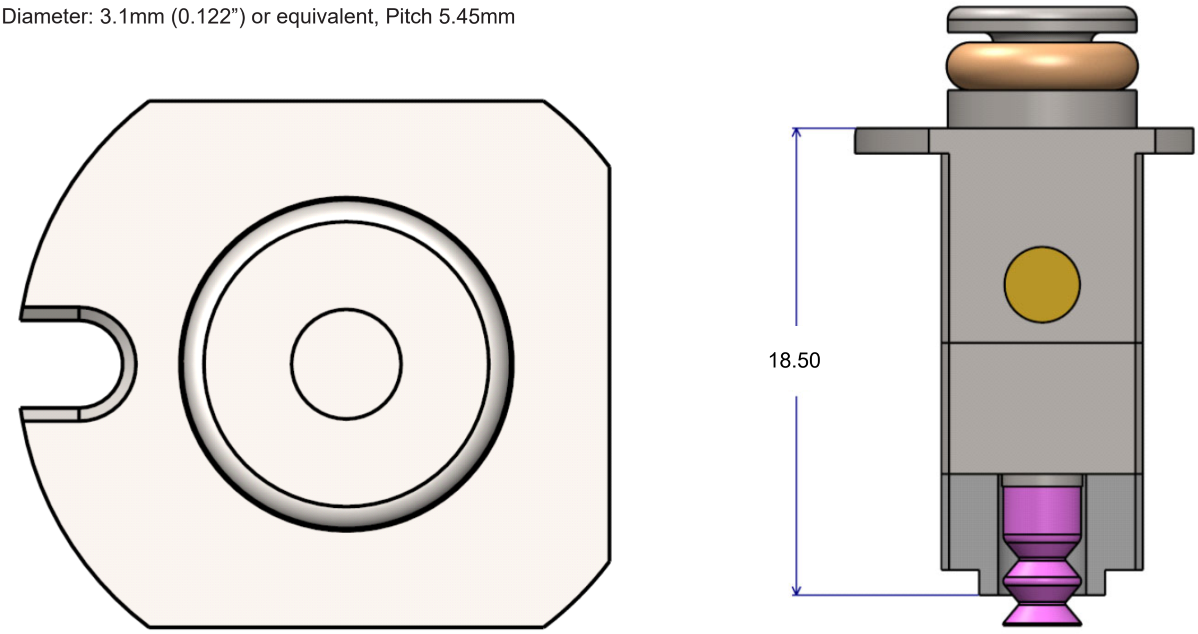


Figure 7. Suggested Power Tower Pickup Tool – Top and Side View

Tool Design: Cup type with spring ejectors
Cup Diameter: 3.1mm (0.122") or equivalent, Pitch 5.45mm

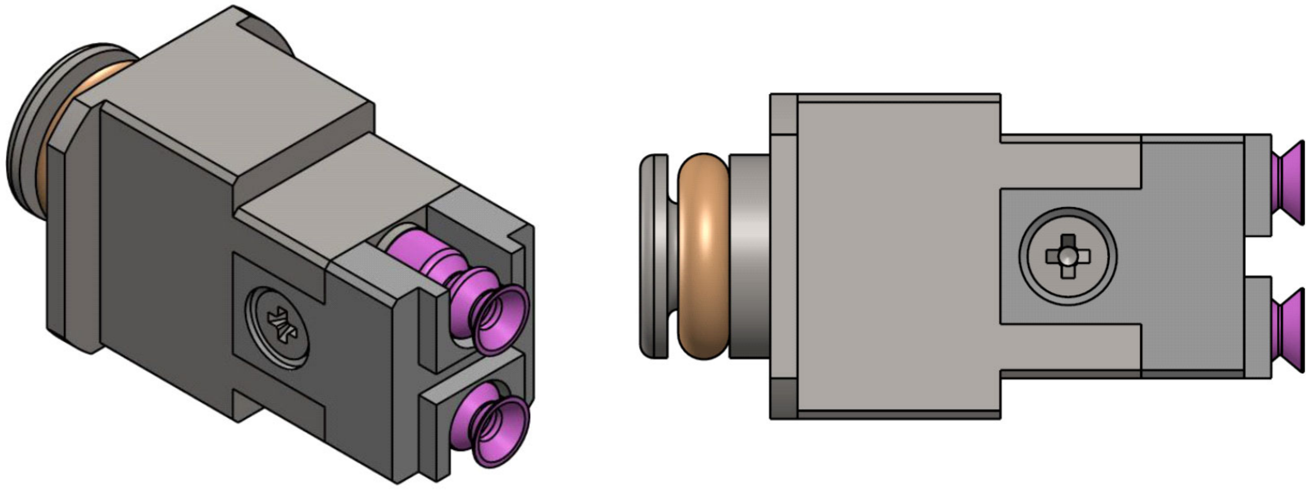


Figure 8. Suggested Power Tower Pickup Tool – 3D and Side View

Tool Design: Cup type with spring ejectors
Cup Diameter: 3.1mm (0.122”) or equivalent, Pitch 5.45mm

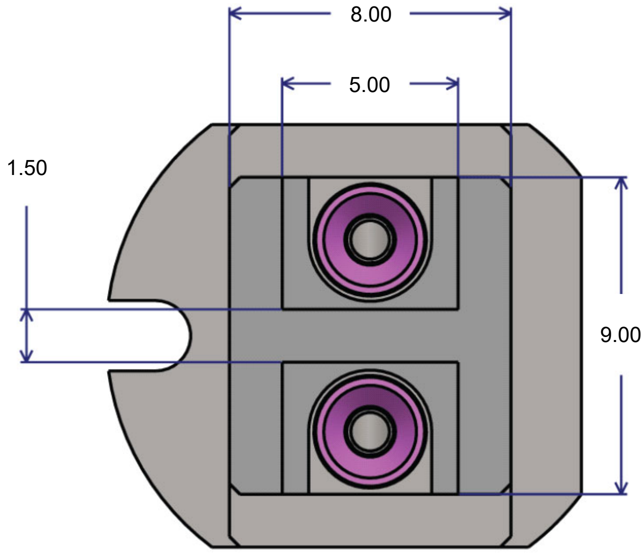


Figure 9. Suggested Power Tower Pickup Tool – Bottom View

- Solder Print Inspection (SPI) is recommended to ensure consistent solder deposit area, height, and volume.

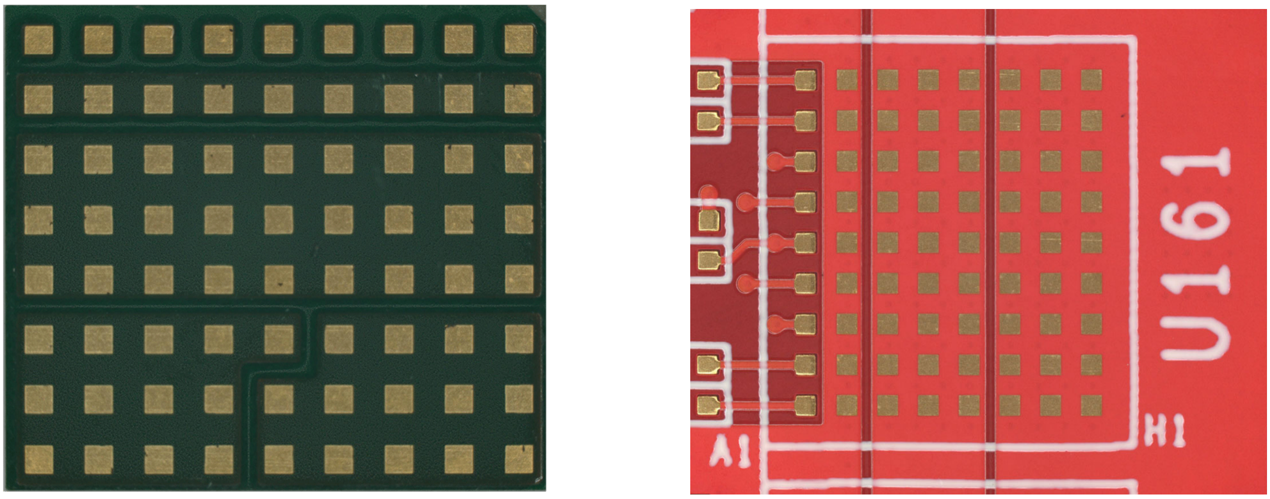


Figure 10. Typical Power Tower Module Photos

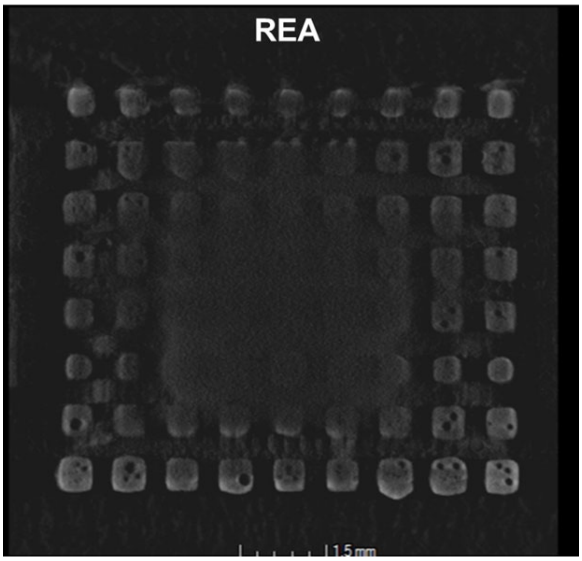


Figure 11. Power Tower Sample X-Ray

Table 1. Reflow Profiles

Profile Feature	Recommended for Pb-Free Assembly
Preheat/Soak	
Temperature Min (T_{SMIN})	150°C
Temperature Max (T_{SMAX})	180°C
Time (t_S) from (T_{SMIN} to T_{SMAX})	75-85seconds
Ramp-up rate (T_L to T_P)	1-3°C/second max.
Liquidous Temperature (T_L)	217°C
Time (t_L) maintained above T_L	35-45 seconds
Peak package body temperature (T_P)	240°C
Time (t_P) within 5°C of the specified classification temperature (T_C); see Figure 12	30 seconds max.
Ramp-down rate (T_P to T_L)	4°C/second max.
Time 25°C to peak temperature	8 minutes max.

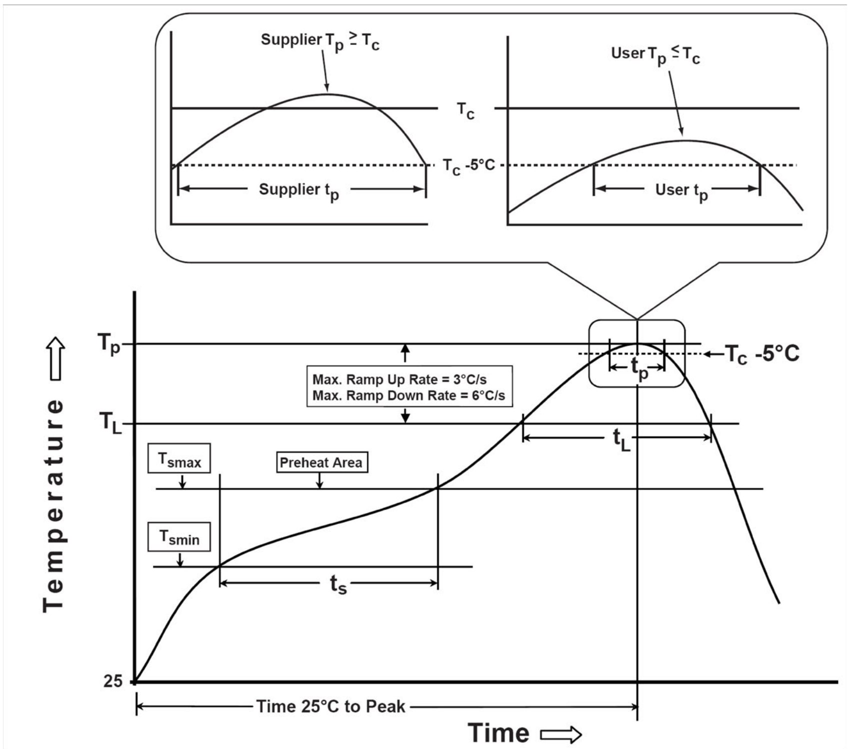


Figure 12. Peak Reflow Profile

5.2 PCBA Solder Joint Voiding Recommendations

- There are no IPC standards for solder joint voids for bottom-terminated components
- Renesas recommends using 25% maximum solder voids.
- Recommended reflow profile is derived from J-STD-020 with parameters optimized for SMT of power tower module at 245°C peak temperature while ensuring robust solder joints with minimal voiding.
- Increase soak time T_{smin} - T_{smax} to 150s to further reduce solder joint voids for high voiding applications.

6. PCBA Rework

For rework of defects underneath the package, the whole package needs to be removed.

Removal and rework of the Power Tower should be done on a rework station with thermal profile control (see Figure 13). The following steps are provided as a guideline – a starting point in developing a successful rework process.

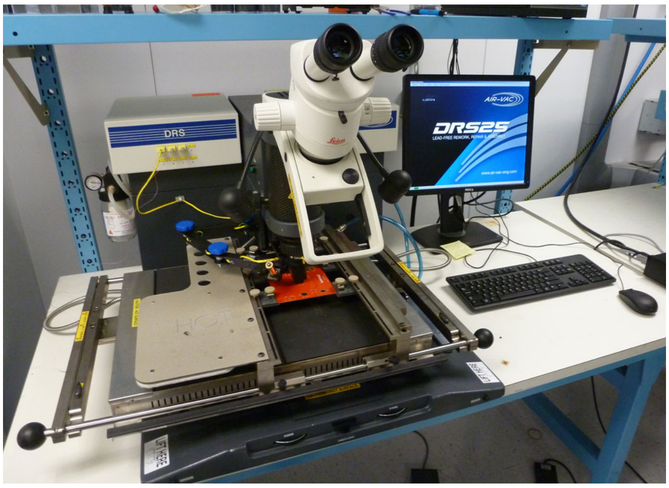


Figure 13. Rework Station with Thermal Profile Control

6.1 Bake

Before rework, bake the PCB assembly at +125°C for at least 8 hours to remove residual moisture.

6.2 Component Removal

Ideally, the reflow profile for part removal should be similar to that of the component attachment. However, the time above liquidus can be reduced as long as the reflow is complete. Typical rework stations heat the board from the bottom side using convective heaters and from the top side with a hot gas nozzle directing heat at the component to be removed (see Figure 14). An appropriate thermal profile must be developed to preheat, soak, and reflow the module on the PCB.

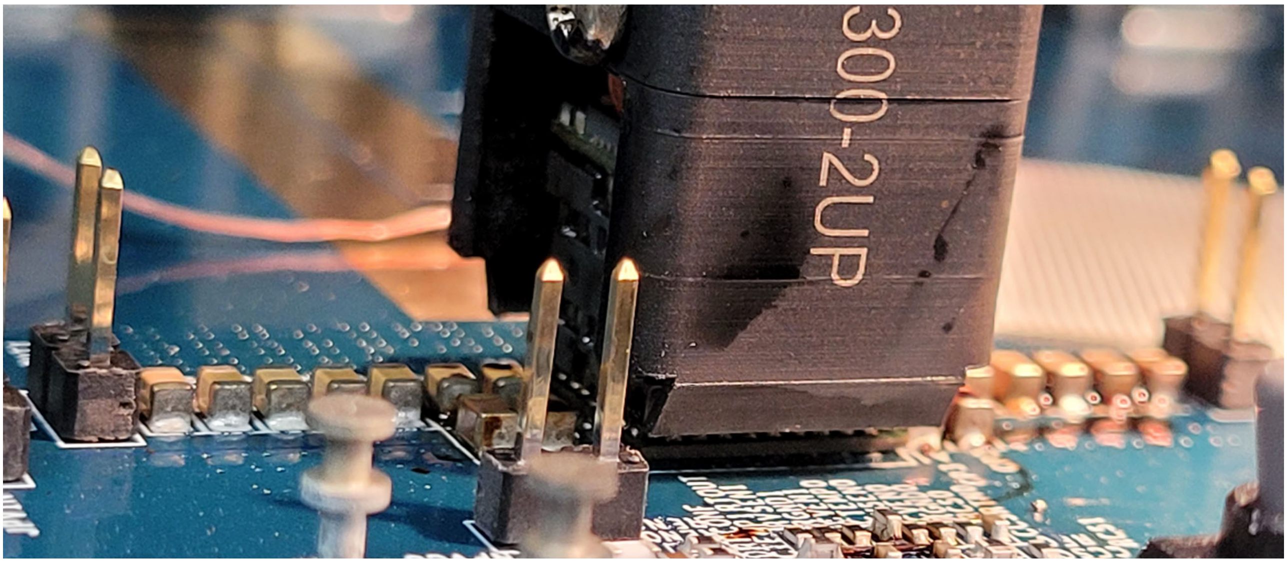


Figure 14. Top and Bottom Preheat

6.3 Component Removal - Reflow

The circuit-board component being removed should reach at least +55°C ±5°C using a temperature ramp of +1°C to +3°C/min before ramping to reflow temperature (see Figure 15).

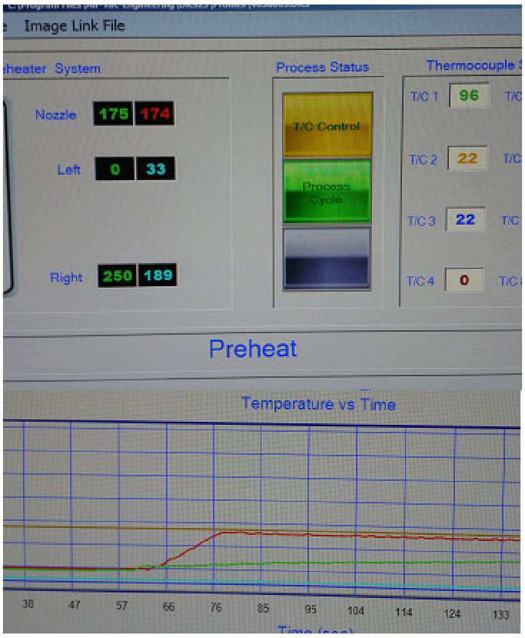
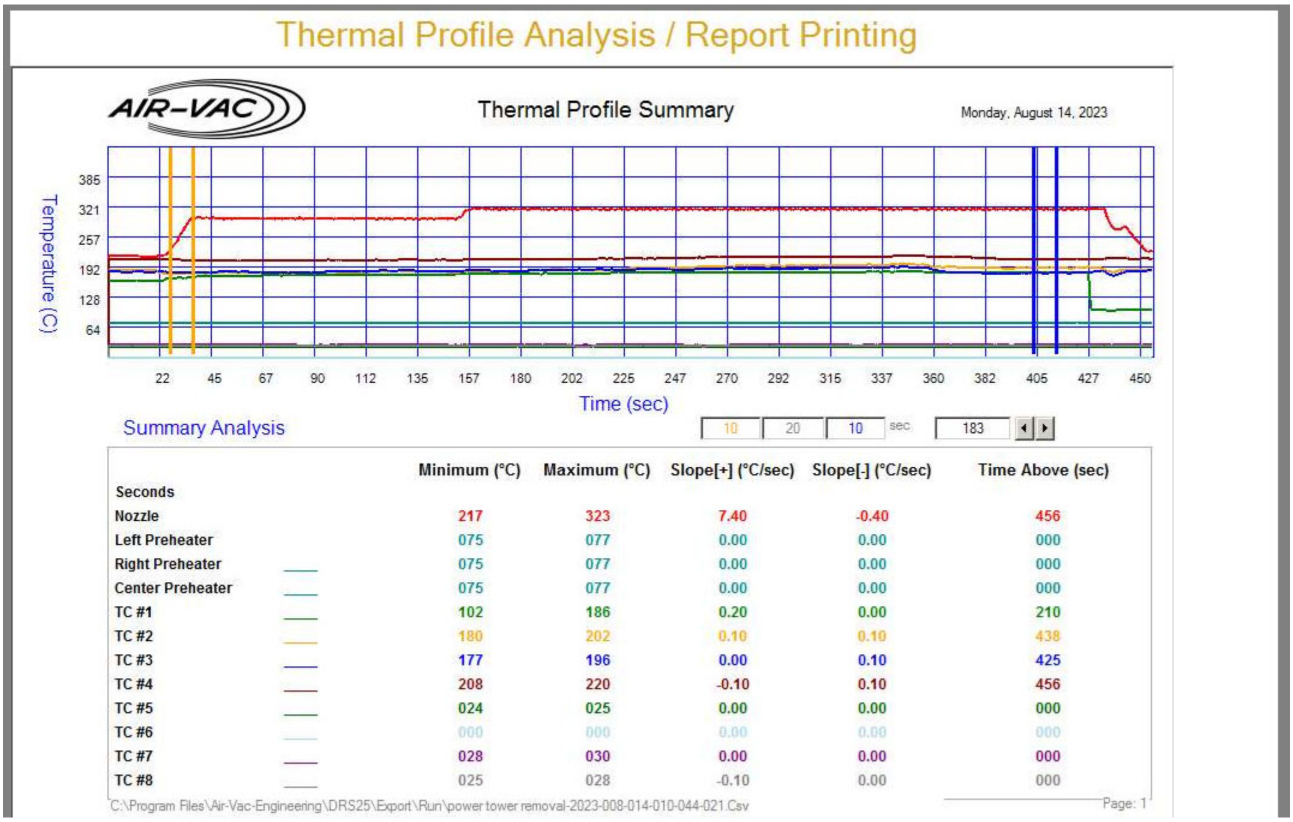


Figure 15. Preheat Control



Seconds	Minimum (°C)	Maximum (°C)	Slope[+] (°C/sec)	Slope[-] (°C/sec)	Time Above (sec)
Nozzle	217	323	7.40	-0.40	456
Left Preheater	075	077	0.00	0.00	000
Right Preheater	075	077	0.00	0.00	000
Center Preheater	075	077	0.00	0.00	000
TC #1	102	186	0.20	0.00	210
TC #2	180	202	0.10	0.10	438
TC #3	177	196	0.00	0.10	425
TC #4	208	220	-0.10	0.10	456
TC #5	024	025	0.00	0.00	000
TC #6	000	000	0.00	0.00	000
TC #7	028	030	0.00	0.00	000
TC #8	025	028	-0.10	0.00	000

Figure 16. Reflow Temperature Control

Peak temperature is dependent on the solder composition. Minimize heating of adjacent components using the lowest peak temperature needed to reflow the solder joints.

When the joints have reflowed, the Power Tower is removed with a vacuum pick-up (see Figure 17).

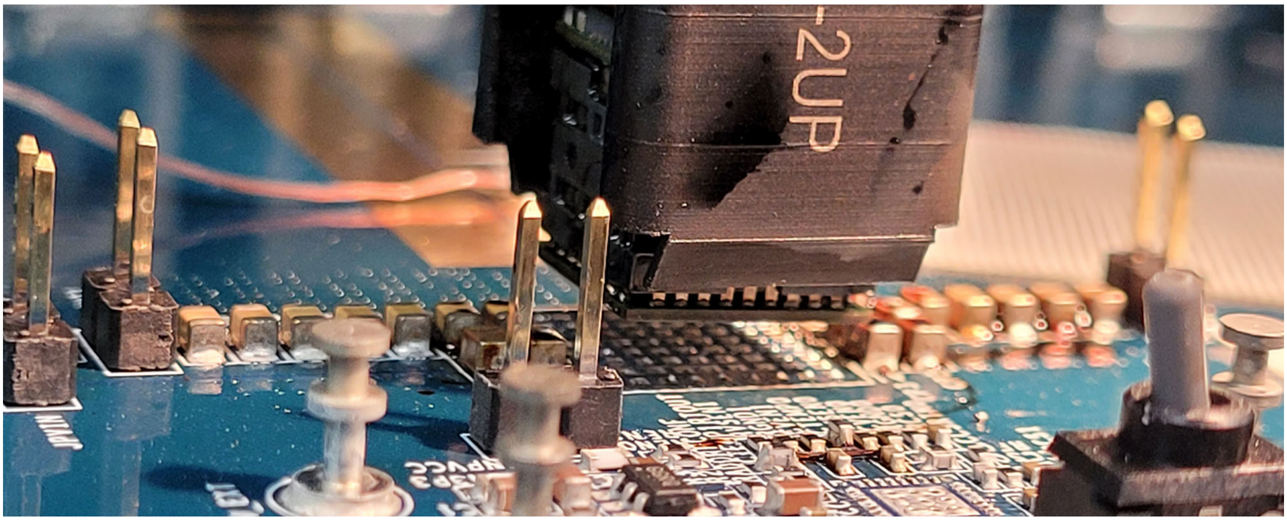


Figure 17. Component Removed with Vacuum Pick-Up

6.4 Site Redress

Clean the site properly, removing residual solder with an appropriate vacuum nozzle. Use the site redress program provided by the rework station (see Figure 18 and Figure 19).

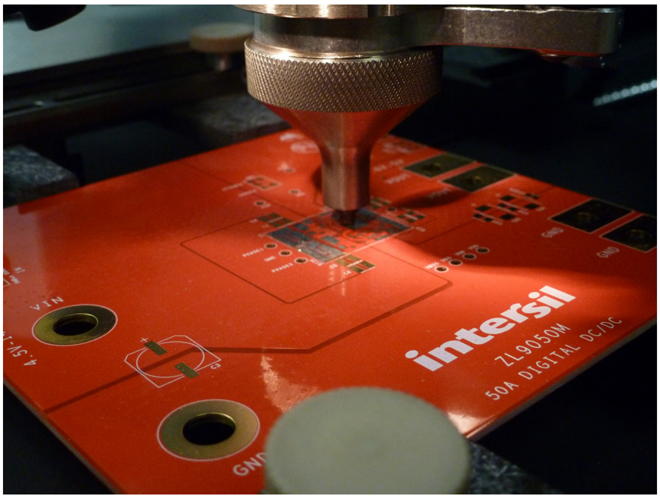


Figure 18. Site Redress

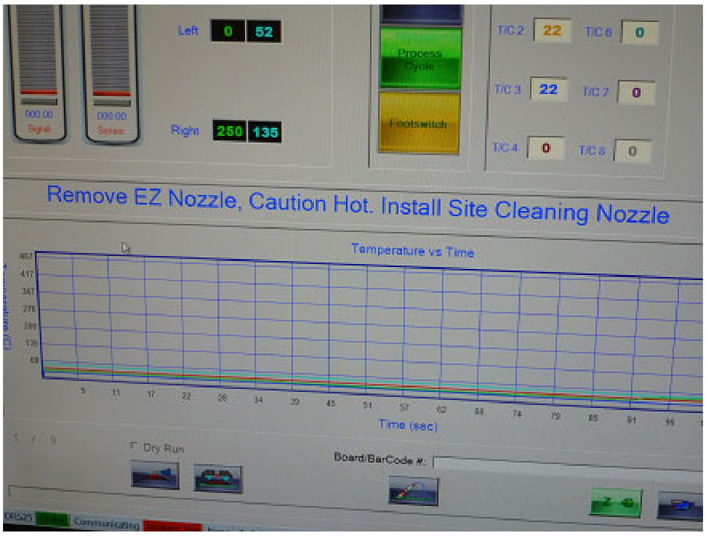


Figure 19. Redress Program

6.5 Solder Paste Printing

Use a miniature stencil specific to the Power Tower component. Using a stereo microscope, align and attach the stencil to the component (see Figure 20). Deposit a small amount of paste on the stencil and use a small squeegee blade to print the paste onto the component (see Figure 21).

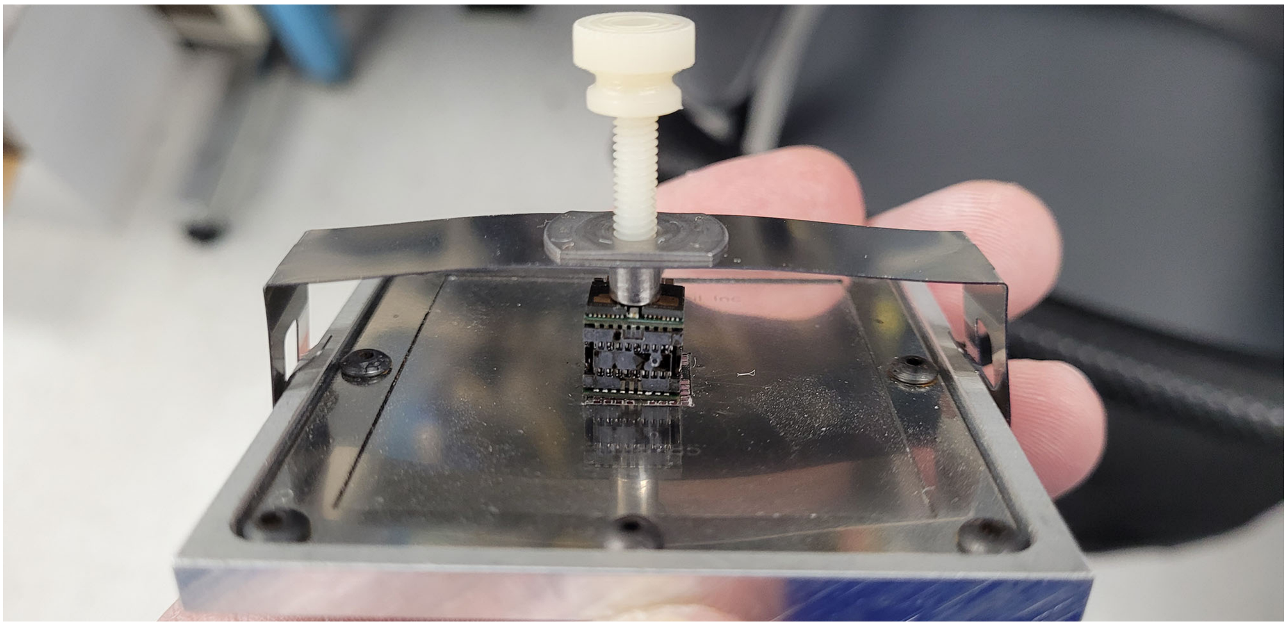


Figure 20. Align Stencil onto Replacement Module

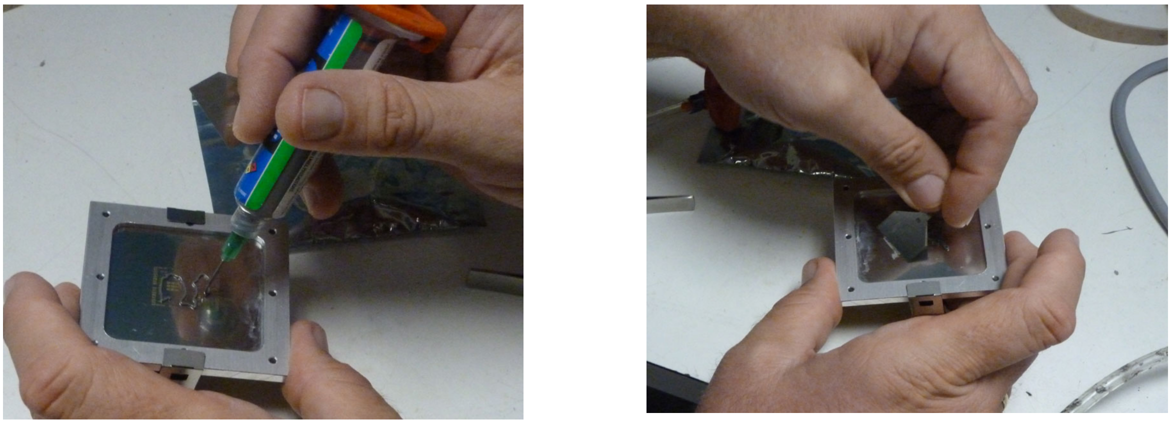


Figure 21. Deposit Paste with a Small Squeegee Blade

6.6 Component Alignment and Placement

Carefully place the Power Tower module in the pick-up position (see Figure 22).

Figure 22. Placement of New Device

Use the rework station's optical system overlay and align the images of the Power Tower terminals with the printed solder and PCB land pattern (see Figure 23).

Figure 23. Overlay Image Alignment

6.7 Component Reflow

Reflow the component using the same reflow profile as originally developed for the PCBA based on the solder paste used (see Power Tower – PCB Assembly Process and Figure 24). The rework is completed (see Figure 25).

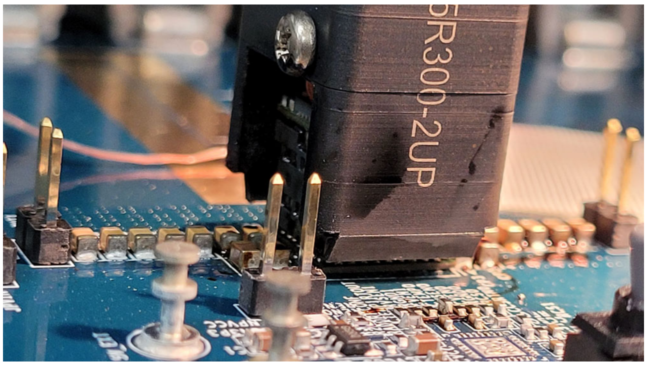


Figure 24. Component Placement

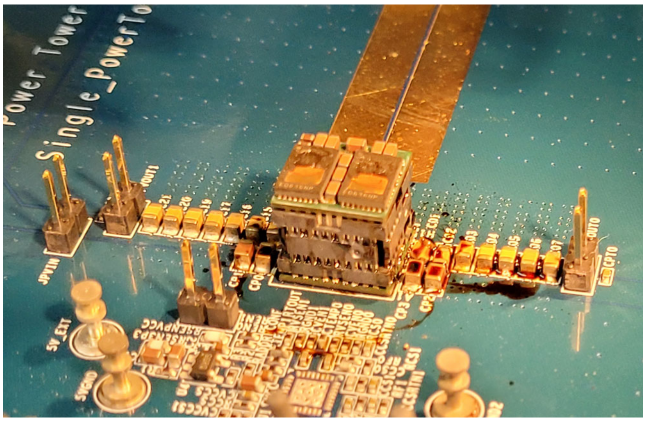


Figure 25. Completed Rework

7. Questions and Answers

- What is Power Tower?
  - Power Tower is a unique, Renesas developed, module packaging technology based on high power densiity and reduced package footprint with LDG I/O, providing superior thermal performance with top-side cold plate cooling.
- Can Power Tower modules be reworked?
  - Yes, a rework station used for BGA rework is recommended. See PCBA Rework.
- Can Power Tower modules be mounted on the bottom side of the PCBA?
  - Power Tower packages with 8mm max thickness can be mounted on bottom side of PCB using reflow SMT attach processes. Power tower cannot be mounted on bottom side of PCB using wave solder process where power tower is submerged into molten solder.
- What is the maximum amount of solder voiding allowed?
  - See discussion in PCBA Solder Joint Voiding Recommendations.

8. Revision History

Revision	Date	Description
1.05	Jun 5, 2025	Corrected document to only show released product.
1.04	May 1, 2025	Updated Power Tower Module Packaging Highlights section.
1.03	Nov 5, 2024	Updated Table 1. Updated the PCBA Solder Joint Voiding Recommendations section.
1.02	Jun 18, 2024	Added figures to the Power Tower - PCB Assembly Process section.
1.01	Jan 31, 2024	Updated the Power Tower - PCB Assembly Process section.
1.00	Sep 15, 2023	Initial release.

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit www.renesas.com/contact-us/.