RA6M1 Group

Notes on RA6M1 Group High-Temperature Operation

Introduction
Renesas provides RA6M1 Group microcontrollers that operate in high-temperature environments. These products are guaranteed to operate within the stipulated range. However, the reliability of a semiconductor device is influenced greatly by the environment in which it is used. That is, even for products with the same quality level, if one is operated in a more severe environment, its reliability will be reduced. Conversely, if one is used in a less severe environment, its reliability will increase. For example, a device used under extremely severe conditions, such as those used for lifetime testing, may exhibit wear-out failures, even if the environment is within the maximum ratings.

This application note presents notes on operating environments under which RA6M1 Group microcontrollers are used in high-temperature applications.

Target Device
RA6M1 Group

Contents
1. Relationship between Actual Usage Environments for RA6M1 Group Microcontrollers and Reliability ................................................................. 2
   1.1 Approaches to microcontroller reliability ...................................................................... 2
   1.2 Derating ...................................................................................................................... 2
2. Thermal Characteristics Term Definitions ................................................................. 3
3. Thermal Characteristics ............................................................................................ 4
   3.1 RA6M1 Group thermal resistances ........................................................................... 4
4. Derating Examples for Representative High-Temperature Applications ...................... 5
5. Reference Documents ............................................................................................... 7
Revision History .......................................................................................................... 8
1. Relationship between Actual Usage Environments for RA6M1 Group Microcontrollers and Reliability

1.1 Approaches to microcontroller reliability

We strongly recommend that customers follow the items described in this document to assure device reliability when using RA6M1 Group microcontrollers.

Semiconductor device reliability is indicated by the failure rate curve (bathtub curve). This curve is divided into three regions:

- The early failure region, in which failures occur at a relatively early time after device use (operation) is first started.
- The random failure period, during which, after the early failure period, failures occur randomly across the relatively long period during which the device is used.
- The wear-out failure period (end of service life), during which failures increase with the elapsing of the time that is inherent life of the device. (See the Reliability Handbook, Revision 2.50 (R51ZZ0001EJ0250) for further details on the bathtub curve.)

Of these regions, it is the wear-out failure region that is most strongly influenced by the thermal environment in which the semiconductor device is used. The concept of derating is critical to assuring that RA6M1 Group microcontrollers do not reach the wear-out failure region.

1.2 Derating

Derating is defined under JIS Z 8115 as the systematic reduction of load for the sake of improved reliability.

Derating is commonly applied to product groups, such as discreet components and power ICs, where concern is required regarding the junction temperature due to the relationship between the generated power, ambient temperature, and heat sink characteristics. Concern is required even if, in addition to the usage conditions having wide ranges, operation is within those usage conditions (for example, voltage) from the standpoint of the problem of heat generation, and, furthermore, adjustment is required between usage conditions such as ambient temperature, junction temperature, current, and power, which have mutual relationships.

See section 5.2.3, Derating, in the Reliability Handbook, Revision 2.50 (R51ZZ0001EJ0250) for further details on derating.

This application note presents temperature profiles expected for representative high-temperature applications and derating examples that the RA6M1 Group microcontrollers can support.
2. Thermal Characteristics Term Definitions

- Ta (ambient temperature): Ta is the temperature at a place that is not affected by heat sources and is based on measurement methods stipulated by JEDEC (Figure 2-1 and Figure 2-2). See the EIA/JEDEC Standard 51-2 for details. Also see the product and package information that Renesas provides on its website.

![Figure 2-1 Ta measurement position (from the EIA/JEDEC 51-2 Standard)](image)
The mounting board is a 76.2 × 114.3 × 1.6 mm 4-layer board. See the EIA/JEDEC Standard 51-7 for details.

3. Thermal Characteristics

3.1 RA6M1 Group thermal resistances

RA6M1 Group supports $T_{j\max}$ as 125°C. Enclosure environment and printed wiring board (PWB) environment are as described in Table 3.1.

For additional details, refer to the following URL:


Table 3.1 RA6M1 Group thermal resistances

<table>
<thead>
<tr>
<th>Package</th>
<th>Enclosure Environment</th>
<th>PWB Environment</th>
<th>$\theta_{ja}$[°C/W]</th>
</tr>
</thead>
<tbody>
<tr>
<td>100-pin LGA</td>
<td>304.8<em>304.8</em>304.8mm</td>
<td>4 layers</td>
<td>32.9</td>
</tr>
<tr>
<td>PTLG0100JA-A</td>
<td>(JESD51-2 compliant)</td>
<td>(JESD 51-7 compliant)</td>
<td></td>
</tr>
<tr>
<td>100-pin LQFP</td>
<td>304.8<em>304.8</em>304.8mm</td>
<td>4 layers</td>
<td>50.9</td>
</tr>
<tr>
<td>PLQP0100KB-B</td>
<td>(JESD51-2 compliant)</td>
<td>(JESD 51-7 compliant)</td>
<td></td>
</tr>
<tr>
<td>64-pin LQFP</td>
<td>304.8<em>304.8</em>304.8mm</td>
<td>4 layers</td>
<td>52.1</td>
</tr>
<tr>
<td>PLQP0064KB-C</td>
<td>(JESD51-2 compliant)</td>
<td>(JESD 51-7 compliant)</td>
<td></td>
</tr>
<tr>
<td>64-pin QFN</td>
<td>304.8<em>304.8</em>304.8mm</td>
<td>4 layers</td>
<td>22.0</td>
</tr>
<tr>
<td>PWQN0064LA-A</td>
<td>(JESD51-2 compliant)</td>
<td>(JESD 51-7 compliant)</td>
<td></td>
</tr>
</tbody>
</table>
4. Derating Examples for Representative High-Temperature Applications

Table 4.1 lists temperature profiles expected for representative high-temperature applications and recommended temperature profiles for derating. The corresponding packages are the LQFP 100-pin, 64-pin, LGA 100-pin and QFN 64-pin packages, and the package codes are PLQP0100KB-B, PLQP0064KB-C, PTLG0100JA-A and PWQN0064LA-A. Table 4.2 lists the specific corresponding products.

The customer should select the example that is the most similar to the intended application. Contact your Renesas representative if none of these examples are applicable. Derating assumes a 10-year life time.

The recommended temperature profile is calculated based on the total power dissipation and the thermal resistance (Θja) determined from the thermal characteristics definitions assumed for the environment described in section 2 and section 3. For example, if Ta=105°C in No.1, then the total power dissipation for LQFP 64-pin devices will be around 384 mW or lower; users should use these products while maintaining either the thermal resistance assumed in section 3, section 4 or environment with an even lower thermal resistance.
### Table 4.1 Representative High-Temperature Applications

<table>
<thead>
<tr>
<th>No.</th>
<th>Main applications</th>
<th>Assumed temperature profile</th>
<th>Recommended temperature profile for derating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cooking equipment (kitchen stoves, IH heaters)</td>
<td>An operating time of 3 hours/day in a high-temperature environment. Standby or stopped at other times.</td>
<td>-40°C(1) ≤ Tj ≤ 125°C for 3 hours/day. At other times, standby or stopped at -40°C(1) ≤ Tj ≤ 90°C</td>
</tr>
<tr>
<td>2</td>
<td>Appliance motors, power tools</td>
<td>Used for 3 hours/day in a high-temperature environment. Used for 3 hours/day in a non-high-temperature environment. Standby or stopped at other times.</td>
<td>115°C &lt; Tj ≤ 125°C for 3 hours/day. -40°C ≤ Tj ≤ 115°C for 3 hours/day. At other times, standby or stopped at -40°C ≤ Tj ≤ 90°C</td>
</tr>
<tr>
<td>3</td>
<td>EV chargers</td>
<td>Used for 8 hours/day in a high-temperature environment. Standby or stopped at other times.</td>
<td>115°C &lt; Tj ≤ 125°C for 4 hours/day. -40°C ≤ Tj ≤ 115°C for 4 hours/day. At other times, standby or stopped at -40°C ≤ Tj ≤ 85°C</td>
</tr>
<tr>
<td>4</td>
<td>Smart meters, power converters, and equipment that may be installed outdoors (24-hour operation)</td>
<td>Used for 4 hours/day in a high-temperature environment. Used for 4 hours/day in a non-high-temperature environment. Also operating at other times.</td>
<td>115°C &lt; Tj ≤ 125°C for 4 hours/day. -40°C ≤ Tj ≤ 115°C for 4 hours/day. At other times, operating at -40°C ≤ Tj ≤ 100°C</td>
</tr>
<tr>
<td>5</td>
<td>PC and server power supplies (24-hour operation)</td>
<td>Used continuously for 5 years in an environment that includes high-temperature periods.</td>
<td>115°C &lt; Tj ≤ 125°C 15,000 hours. -40°C ≤ Tj ≤ 115°C 30,000 hours</td>
</tr>
<tr>
<td>6</td>
<td>Industrial motors (24-hour operation: example 1)</td>
<td>Used continuously in a high-temperature environment.</td>
<td>102°C &lt; Tj ≤ 112°C 80% -40°C ≤ Tj ≤ 102°C 20% ⋆Used continuously for 10 years</td>
</tr>
<tr>
<td>7</td>
<td>Industrial motors (24-hour operation: example 2)</td>
<td>Used continuously in an environment that includes extreme high-temperature periods.</td>
<td>110°C &lt; Tj ≤ 125°C 5% 105°C &lt; Tj ≤ 110°C 75% -40°C ≤ Tj ≤ 105°C 20% ⋆Used continuously for 10 years</td>
</tr>
<tr>
<td>8</td>
<td>Industrial motors (24-hour operation: example 3)</td>
<td>Used continuously in a high-temperature environment.</td>
<td>Tj ≤ 110°C 100% ⋆Used continuously for 10 years</td>
</tr>
</tbody>
</table>

Note: 1. In case of low-temperature circumstances, operation should be over -40°C(Ta).
Table 4.2 Corresponding products

<table>
<thead>
<tr>
<th>Product part number</th>
<th>Package code</th>
<th>Code flash</th>
<th>Data flash</th>
<th>SRAM</th>
<th>Operating temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>R7FA6M1AD3CLJ</td>
<td>PTLG0100JA-A</td>
<td>512KB</td>
<td>8KB</td>
<td>256KB</td>
<td>-40 to +105°C</td>
</tr>
<tr>
<td>R7FA6M1AD3CFP</td>
<td>PLQP0100KB-B</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R7FA6M1AD3CFM</td>
<td>PLQP0064KB-C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R7FA6M1AD3CMB</td>
<td>PWQN0064LA-A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. Reference Documents
Semiconductor Reliability Handbook Rev. 2.50 (R51ZZ0001EJ0250), January 2017
## Revision History

<table>
<thead>
<tr>
<th>Rev.</th>
<th>Date</th>
<th>Description</th>
<th>Page</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00</td>
<td>Sep.2.21</td>
<td>All</td>
<td>All</td>
<td>First edition issued.</td>
</tr>
</tbody>
</table>
General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)
   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

2. Processing at power-on
   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

3. Input of signal during power-off state
   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

4. Handling of unused pins
   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

5. Clock signals
   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

6. Voltage application waveform at input pin
   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between $V_{IL}$(Max.) and $V_{IH}$(Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between $V_{IL}$(Max.) and $V_{IH}$(Min.).

7. Prohibition of access to reserved addresses
   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

8. Differences between products
   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.
Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.

2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.

3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.

4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.

5. Renesas Electronics products are classified according to the following two quality grades: “Standard” and “High Quality”. The intended applications for each Renesas Electronics product depends on the product’s quality grade, as indicated below.

   *“Standard”*: Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.

   *“High Quality”*: Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user’s manual or other Renesas Electronics document.

6. When using Renesas Electronics products, refer to the latest product information (data sheets, user’s manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.

7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.

8. Please contact a Renesas Products sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.

9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.

10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.

11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.

12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) “Renesas Electronics” as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.

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

(Trademarks)
Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

(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/.