RA8D1 Group

Notes on RA8D1 Group High-Temperature Operation

Introduction

Renesas provides RA8D1 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 RA8D1 Group microcontrollers are used in high-temperature applications.

Target Device

RA8D1 Group

Contents

1. Relationship between Actual Usage Environments for RA8D1 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 RA8D1 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 RA8D1 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 RA8D1 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.

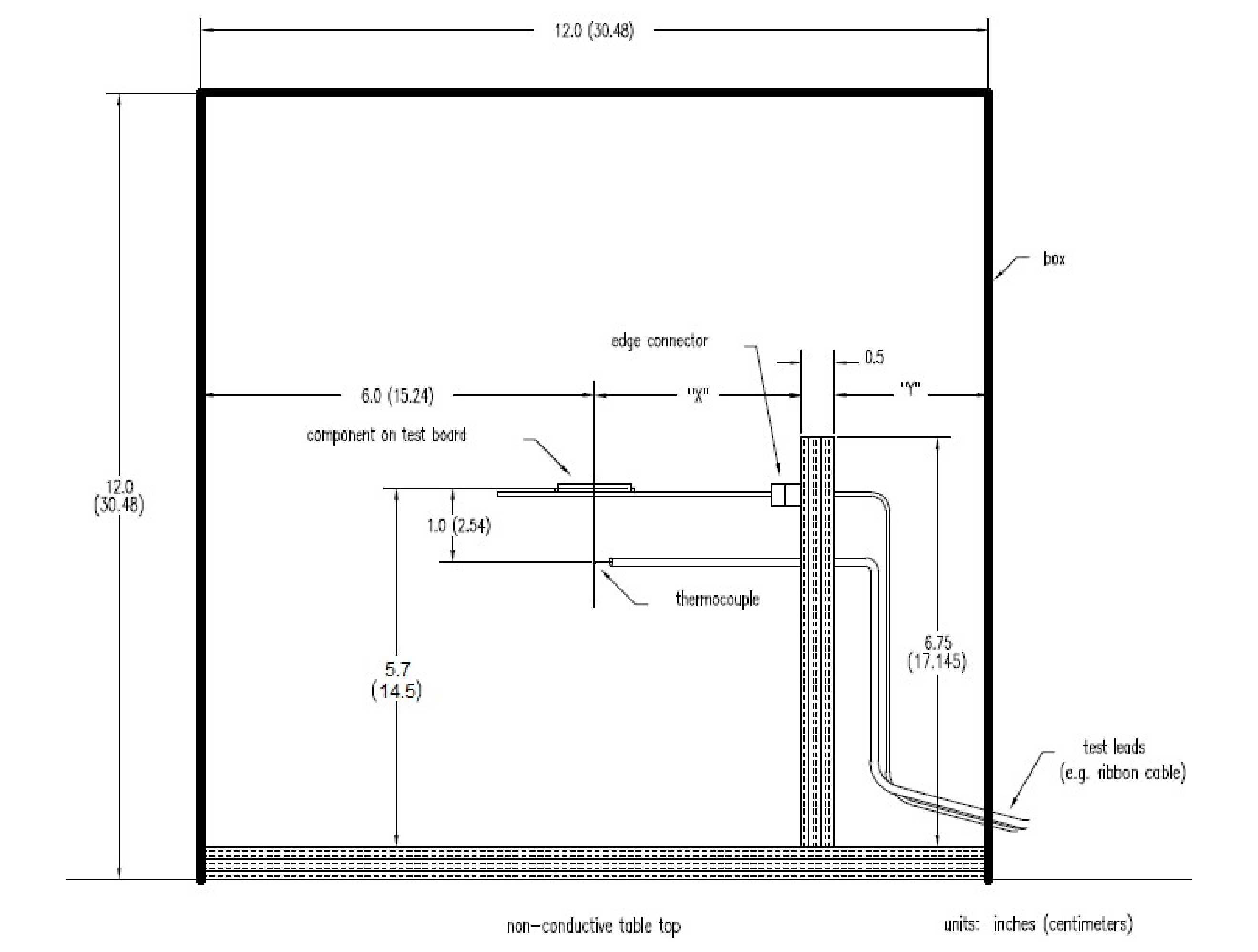

Figure 2-1 Ta measurement position (from the EIA/JEDEC 51-2 Standard)

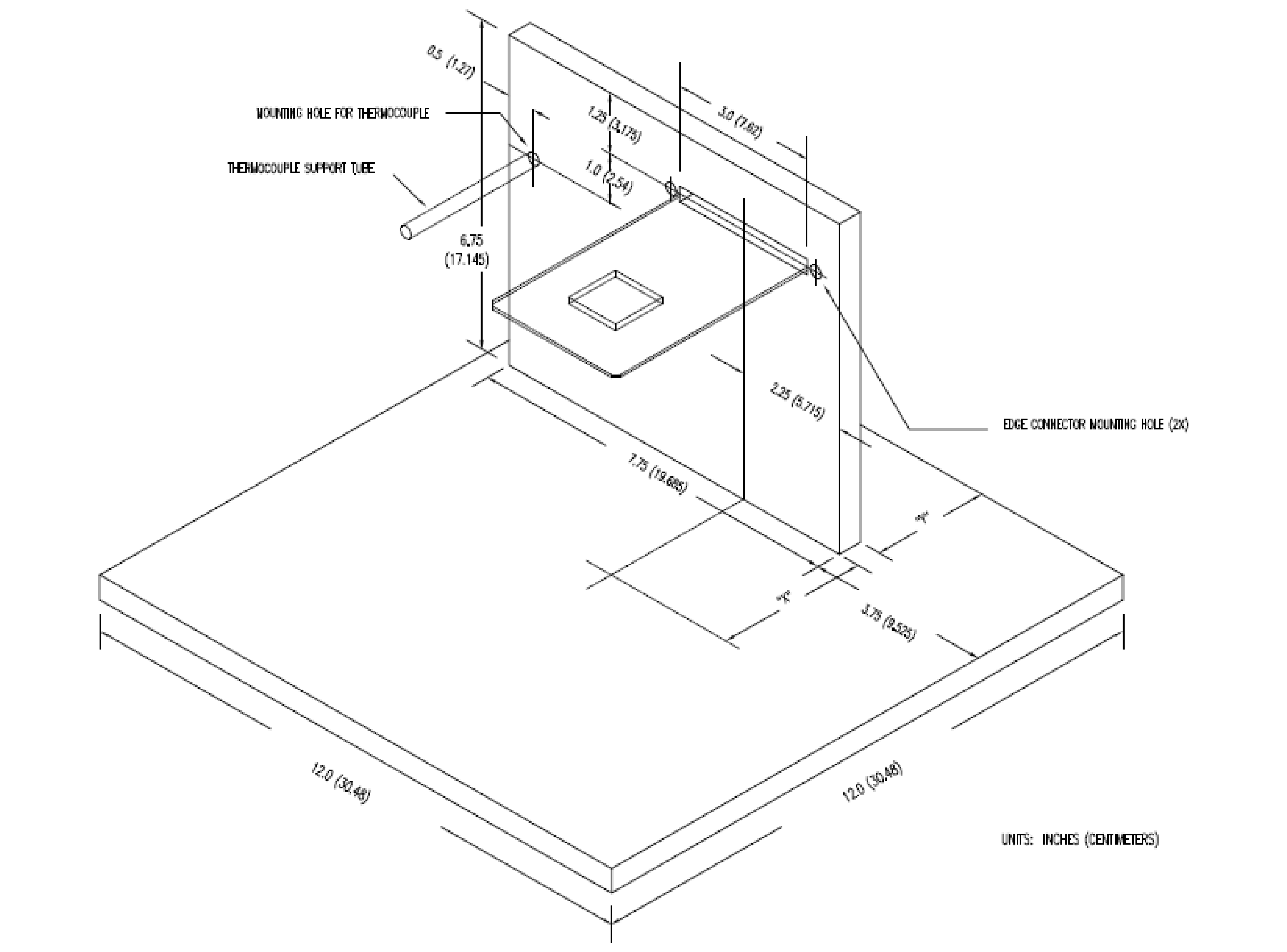

Figure 2-2 Ta measurement position - bird's eye view (no chassis)
(from the EIA/JEDEC 51-2 Standard)

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 RA8D1 Group thermal resistances

RA8D1 Group supports Tjmax as 125℃. Enclosure environment and printed wiring board (PWB) environment are as described in Table 3.1.

For additional details, refer to the following URL:

https://www.renesas.com/us/en/support/technical-resources/packaging/characteristic/heat-dissipation.html

Table 3.1 RA8D1 Group thermal resistances

Package	Enclosure Environment	PWB Environment	θ ja[℃/W]
224-pin BGA PLBG0224GD-A	304.8*304.8*304.8mm (JESD51-2 compliant)	4 layers (JESD 51-9 compliant)	21.5
176-pin LQFP PLQP0176KJ-A	304.8*304.8*304.8mm (JESD51-2 compliant)	4 layers (JESD 51-7 compliant)	32.0

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 224 BGA and LQFP 176-pin packages, and the package codes are PLBG0224GD-A and PLQP0176KJ-A respectively. 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 Tj. Tj can be calculated by the total power dissipation, Ta and the thermal resistance (Θja) determined from the thermal characteristics definitions assumed for the environment described in section 2 and section 3. Example of Tj calculation is described in User's Manual Electrical Characteristics Chapter.

Table 4.1 Representative High-Temperature Applications

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

Note: The ambient temperature (Ta) should be -40°C or higher.

Table 4.2 Corresponding products

Product part number	Package code	Code flash	Data flash	SRAM
R7FA8D1AHECBD	PLBG0224GD-A	2MB	12KB	1MB
R7FA8D1BHECBD				
R7FA8D1AHECFC	PLQP0176KJ-A			
R7FA8D1BHECFC				
R7FA8D1AFECBD	PLBG0224GD-A	1MB		
R7FA8D1BFECBD				
R7FA8D1AFECFC	PLQP0176KJ-A			
R7FA8D1BFECFC				

5. Reference Documents

Semiconductor Reliability Handbook Rev. 2.50 (R51ZZ0001EJ0250), January 2017

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Nov.22.23	All	First edition issued

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.

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