RX231/230/23T Group

Notes on High-Temperature Operation of RX231/230/23T Group Microcontrollers

Introduction

Renesas provides RX Family microcontrollers that operate within guaranteed operating ranges of −40 to 85°C and −40 to 105°C. These products are guaranteed to operate within the stipulated range. Note, however, that the quality and reliability of semiconductor devices is influenced greatly by the environment in which they are 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. Inversely, if one is used in a less severe environment, its reliability will increase. For example, if a device is used under extremely severe conditions such as those used for lifetime testing, this can result in wear-out failures, even if the environment is within the maximum ratings.

This application note presents notes on operating environments under which RX231/230/23T Group microcontrollers are used in high-temperature (85 to 105°C) applications.

Contents

1. Relationship Between Actual Usage Environments for RX Family 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 RX Family 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, and then the wear-out failure period (end of service life), during which failures increase associated with the elapsing of the time that is inherent life of the device. See the Reliability Handbook, Revision 1.00 (R51ZZ0001EJ0100) 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 RX Family 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.

The quality and reliability of semiconductor devices are greatly influenced by the environment of use. That is, products with the same quality may be less reliable in harsh environments, and more reliable when the usage environment is less harsh. Even when used within the maximum ratings, if a device is used under extremely stringent conditions equivalent to lifetime tests, wear-out-like failures may result. Hence the concept of derating is extremely important.

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 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.

For details on derating, refer to 5.2.3, Derating, in Semiconductor Reliability Handbook, rev. 2.50 (R51ZZ0001EJ0250).

This application note presents temperature profiles expected for representative high-temperature (85 to 105°C) applications and derating examples that the RX231/230/23T 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 Renesas provides on its web site.

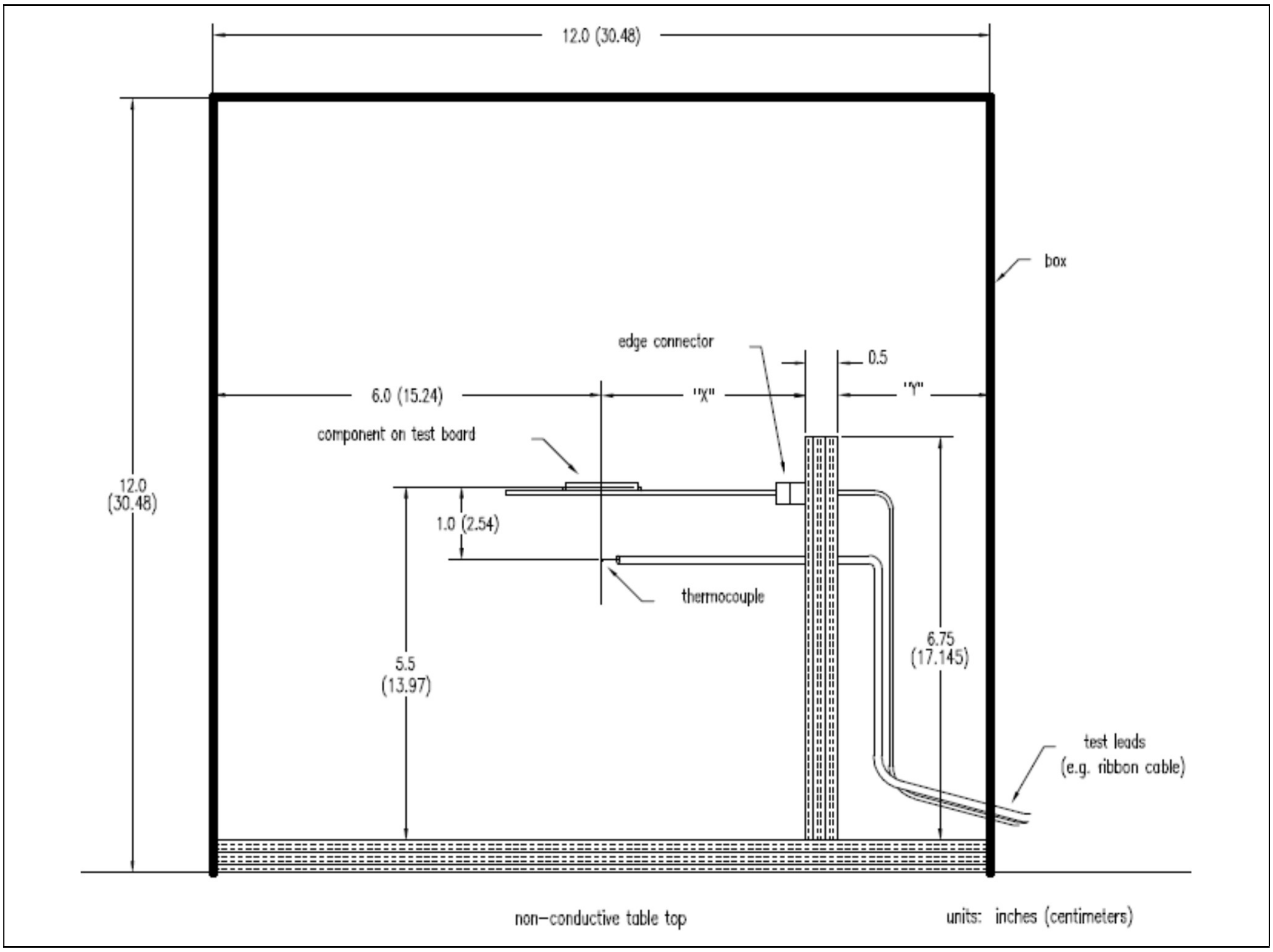

Figure 2.1 Ta Measurement Position (From the EIA/JEDEC 51-2 Standard)

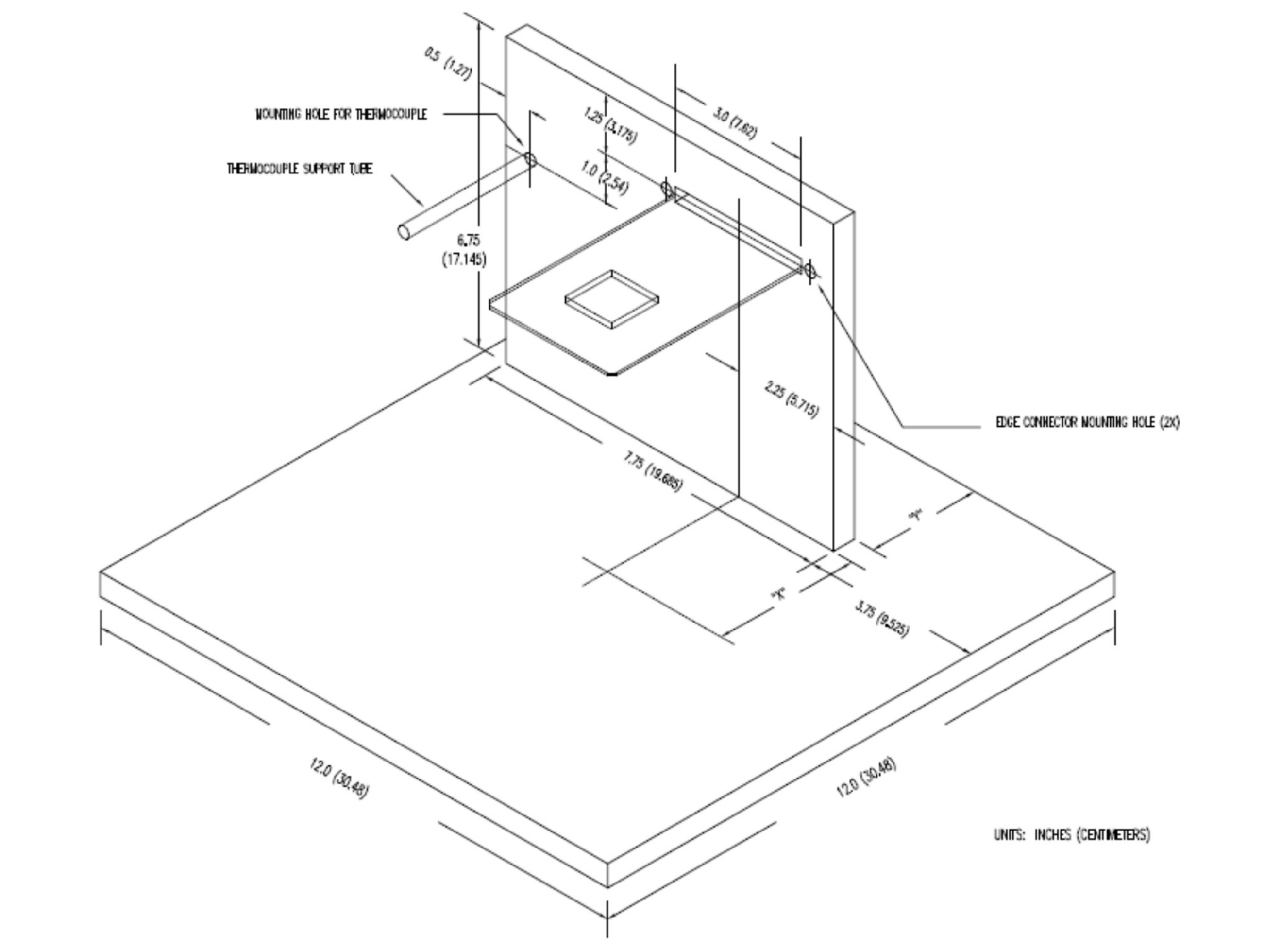

Figure 2.2 Ta Measurement Position — Bird's Eye View (No Chassis)
(From the EIA/JEDEC 51-2 Standard)

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. Derating Examples for Representative High-Temperature Applications

Table 3.1 lists temperature profiles expected for representative high-temperature applications and recommended temperature profiles for derating.

The corresponding packages are the LQFP 48, 52, 64, and 100-pin packages and the QFN 48 and 64 packages. The package codes are PWQN0048KB-A, PWQN0064KC-A, PLQP0048KB-B, PLQP0048KB-A, PLQP0052JA-A, PLQP0064KB-C, PLQP0064KB-A, PLQP0100KB-C, and PLQP0100KB-A. Table 3.2 lists the specific corresponding products.

The customer should select the example that is the most similar to their application. Contact your Renesas representative if none of these examples are applicable. Except for No.5, derating assumes 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 3. The total power consumption for RX231/230 is 130mW or lower. For RX23T, it's 140mW or lower with LQFP 52 and 64-pin and 120mW or lower with LQFP 48-pin. Use these products while maintaining either the thermal resistance assumed in section 3 or an environment with an even lower thermal resistance.

Table 3.1 Representative High-Temperature (85 to 105°C) 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.	–40°C ≤ Ta ≤ 105°C for 3 hours/day. At other times, standby or stopped at –40°C ≤ Ta ≤ 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.	95°C < Ta ≤ 105°C for 3 hours/day. –40°C ≤ Ta ≤ 95°C for 3 hours/day. At other times, standby or stopped at –40°C ≤ Ta ≤ 90°C
3	EV chargers	Used for 8 hours/day in a high-temperature environment. Standby or stopped at other times.	95°C < Ta ≤ 105°C for 4 hours/day. –40°C ≤ Ta ≤ 95°C for 4 hours/day. At other times, standby or stopped at –40°C ≤ Ta ≤ 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.	95°C < Ta ≤ 105°C for 4 hours/day. –40°C ≤ Ta ≤ 95°C for 4 hours/day. At other times, operating at –40°C ≤ Ta ≤ 80°C
5	PC and server power supplies (24-hour operation)	Used continuously for 5 years in an environment that includes high-temperature periods.	95°C < Ta ≤ 105°C 15,000 hours –40°C ≤ Ta ≤ 95°C 30,000 hours
6	Industrial motors (24-hour operation: example 1)	Used continuously in a high-temperature environment.	82°C < Ta ≤ 92°C 80% –40°C ≤ Ta ≤ 82°C 20%
7	Industrial motors (24-hour operation: example 2)	Used continuously in an environment that includes extreme high-temperature periods.	90°C < Ta ≤ 105°C 5% 85°C < Ta ≤ 90°C 75% –40°C ≤ Ta ≤ 85°C 20%
8	Industrial motors (24-hour operation: example 3)	In continuous use in high-temperature environment	Ta ≤ 90°C, 100%

Table 3.2 Corresponding Products

Product	Package	Product	Package
R5F52318AGFP	PLQP0100KB-B	R5F52315AGFP	PLQP0100KB-B
R5F52318BGFP		R5F52315CGFP	
R5F52318AGND	PWQN0064KC-A	R5F52315AGND	PWQN0064KC-A
R5F52318BGND		R5F52315CGND	
R5F52318AGFM	PLQP0064KB-C	R5F52315AGFM	PLQP0064KB-C
R5F52318BGFM		R5F52315CGFM	
R5F52318AGNE	PWQN0048KB-A	R5F52315AGNE	PWQN0048KB-A
R5F52318BGNE		R5F52315CGNE	
R5F52318AGFL	PLQP0048KB-B	R5F52315AGFL	PLQP0048KB-B
R5F52318BGFL		R5F52315CGFL	
R5F52317AGFP	PLQP0100KB-B		
R5F52317BGFP			
R5F52317AGND	PWQN0064KC-A	R5F52306AGFP	PLQP0100KB-B
R5F52317BGND		R5F52306AGND	PWQN0064KC-A
R5F52317AGFM	PLQP0064KB-C	R5F52306AGFM	PLQP0064KB-C
R5F52317BGFM		R5F52306AGNE	PWQN0048KB-A
R5F52317AGNE	PWQN0048KB-A	R5F52306AGFL	PLQP0048KB-B
R5F52317BGNE		R5F52305AGFP	PLQP0100KB-B
R5F52317AGFL	PLQP0048KB-B	R5F52305AGND	PWQN0064KC-A
R5F52317BGFL		R5F52305AGFM	PLQP0064KB-C
R5F52316AGFP	PLQP0100KB-B	R5F52305AGNE	PWQN0048KB-A
R5F52316CGFP		R5F52305AGFL	PLQP0048KB-B
R5F52316AGND	PWQN0064KC-A		
R5F52316CGND			
R5F52316AGFM	PLQP0064KB-C	R5F523T5AGFL	PLQP0048KB-A
R5F52316CGFM		R5F523T5AGFD	PLQP0052JA-A
R5F52316AGNE	PWQN0048KB-A	R5F523T5AGFM	PLQP0064KB-A
R5F52316CGNE		R5F523T3AGFL	PLQP0048KB-A
R5F52316AGFL	PLQP0048KB-B	R5F523T3AGFD	PLQP0052JA-A
R5F52316CGFL		R5F523T3AGFM	PLQP0064KB-A

4. Reference Documents

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

Website and Support

Renesas Electronics Website
http://www.renesas.com/

Inquiries
http://www.renesas.com/contact/

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Oct 31, 2015	—	First edition issued
1.10	Aug 03, 2016	5	The total power consumption for RX23T changed.
1.30	Oct.19,2020	5	Added example 8 of high-temperature profile.
		2,7	Updated the Reference Reliability Handbook to Rev.2.50

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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