RAA3064002GFP/RAA3064003GFP

Usage Notes on Correcting Errors in Angles Detected by the Resolver-to-Digital Converter

Summary

This application note presents use cases to explain the timing of correcting errors in measured angles within the flow of developing a product in which the resolver-to-digital converter is used.

Target Devices

RAA3064002GFP (product with guaranteed operation at ambient temperatures up to 85°C)

RAA3064003GFP (product with guaranteed operation at ambient temperatures up to 105°C)

Contents

1. Overview

The resolver-to-digital converter IC (RDC) supports the following three functions to improve accuracy in the detection of angles.

- Gain calibration
- Phase calibration
- Carrier error calibration

The errors in measured angles depend on the RDC and its peripheral circuits and can be corrected following gain and phase calibration. Accordingly, the user is required to implement gain and phase calibration on every control board that incorporates the RDC to achieve the performance stipulated in the datasheet. These two types of calibration can be completed within the control board and do not require rotation of the revolver (and motor).

The errors in the carrier solely depend on the resolver and can be corrected following carrier error calibration. This calibration requires rotation of the revolver at least once to send the RDC signals to the MCU in use (e.g. an RX24T). We thus recommend implementing this calibration before incorporating the motor with a resolver in an end product. Carrier error calibration might not be required. This depends on the level of the errors in the angle signals and on the tolerance of errors by the end product in which the RDC is to be used. The user should determine whether or not the nature of the end product necessitates this calibration.

For the basic operations and usage of each type of calibration, see the separate application note *Using the Driver for Resolver-to-Digital Converter Control (R03AN0013)*.

2. Timing of Calibrating the Errors in Measured Angles

Section 2 describes the timing of correcting the errors in measured angles within the flow of developing a product in which the RDC is to be used. We present three cases according to those in charge of each process within the flow.

2.1 Possible Flow of Development and Responsibility for each Process within the Flow

Figure 1 shows a possible flow of developing a product incorporating a motor module before shipment to the end market. We assume the flow involves the following four processes.

1. Production of a motor incorporating a resolver
2. Development of a control board incorporating the RDC and of a driver to control the motor that incorporates a resolver
3. Assembly of a motor module by combining the motor incorporating a resolver and the control board
4. Assembly of the end product to incorporate the motor module

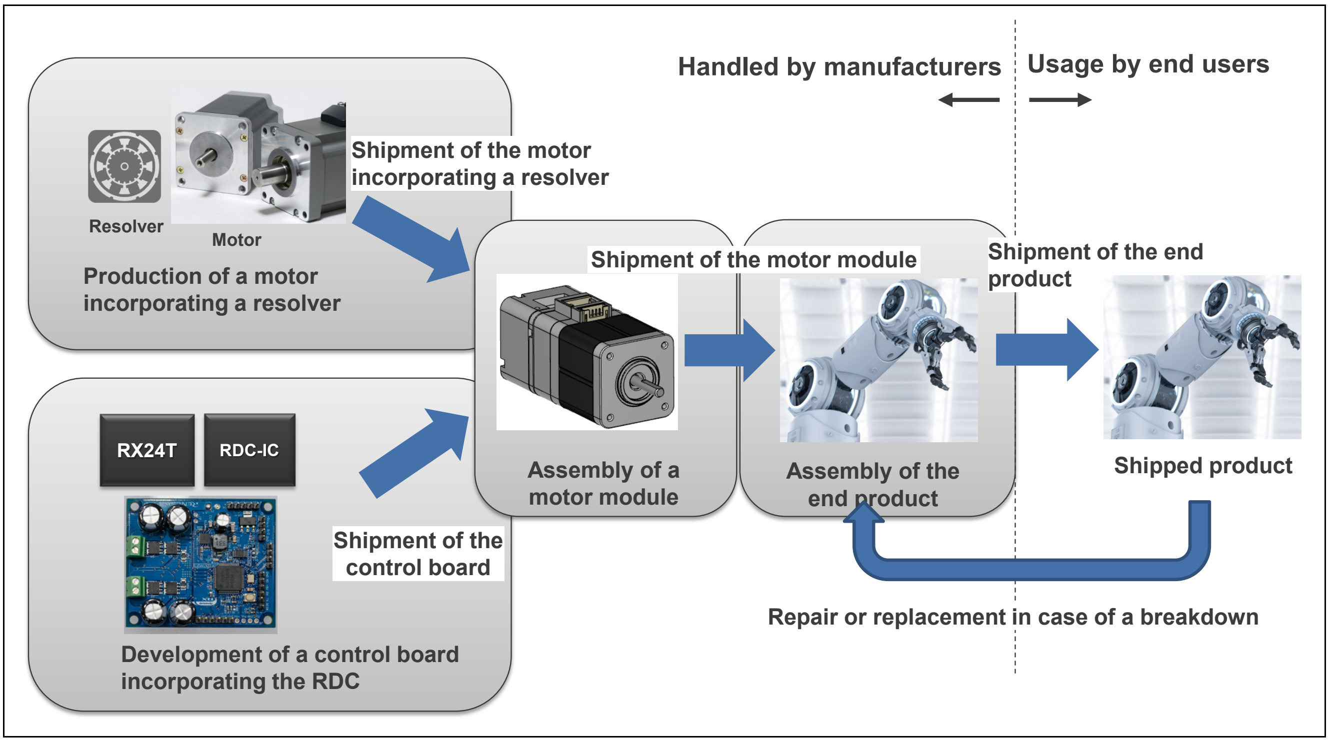

Figure 1. Possible Flow of Developing an End Product

Table 1 shows the three possible combinations of responsibility for each of the processes. We assume either the user of the RDC or a third party can be responsible for development other than that of the control circuit. Sections 2.2 to 2.4 describe the timing of calibrating the errors in measured angles in each of the cases.

Since the production of the motor incorporating a resolver does not involve any of the kinds of error calibration described in this application note, it is not considered in the use cases.

Table 1. Possible Responsibility for each Process

Case	Development of the Control Circuit	Production of the Motor Incorporating a Resolver	Assembly of the Motor Module	Assembly of the End Product
1	User of the RDC	User of the RDC or third party	User of the RDC	User of the RDC
2	User of the RDC	User of the RDC or third party	User of the RDC	Third party
3	User of the RDC	User of the RDC or third party	Third party	Third party

2.2 Case 1: When the User is Responsible for All Processes (Except Possibly Developing the Motor)

Figure 2 shows a flow of development in case 1. The assumption for case 1 is that the user is responsible for all processes except possibly for developing the motor.

2.2.1 Calibration before shipment of the end product

We recommend proceeding with the gain and phase calibration before shipping the control board, and carrier error calibration and correction when assembling the motor module. These calibration processes are also possible when assembling the end product, in that case, however, rotation of the revolver at least once is still required. Accordingly, only decide to proceed with calibration of the motor modules in end products if the end product is one which is capable of at least a single rotation.

2.2.2 Calibration after repair or replacement

(a) In case of repair or replacement of the control board

Gain and phase calibration and correction must be repeated for a repaired or replaced control board.
The same value from carrier error calibration can be used unless the motor incorporating a resolver is replaced. If the user has the value from calibration, re-calibration is not required and he or she can simply use the same value as that before the board was repaired or replaced. If the user does not have the value from calibration, re-calibration to correct the carrier error must proceed for the repaired or replaced board.

(b) In case of repair or replacement of the motor incorporating a resolver

Carrier error calibration and correction must proceed for the motor module after the combination of the resolver and control board in use has been repaired or replaced. Gain and phase calibration are not required if only the motor incorporating a resolver is replaced because this has no effect on these values from calibration.

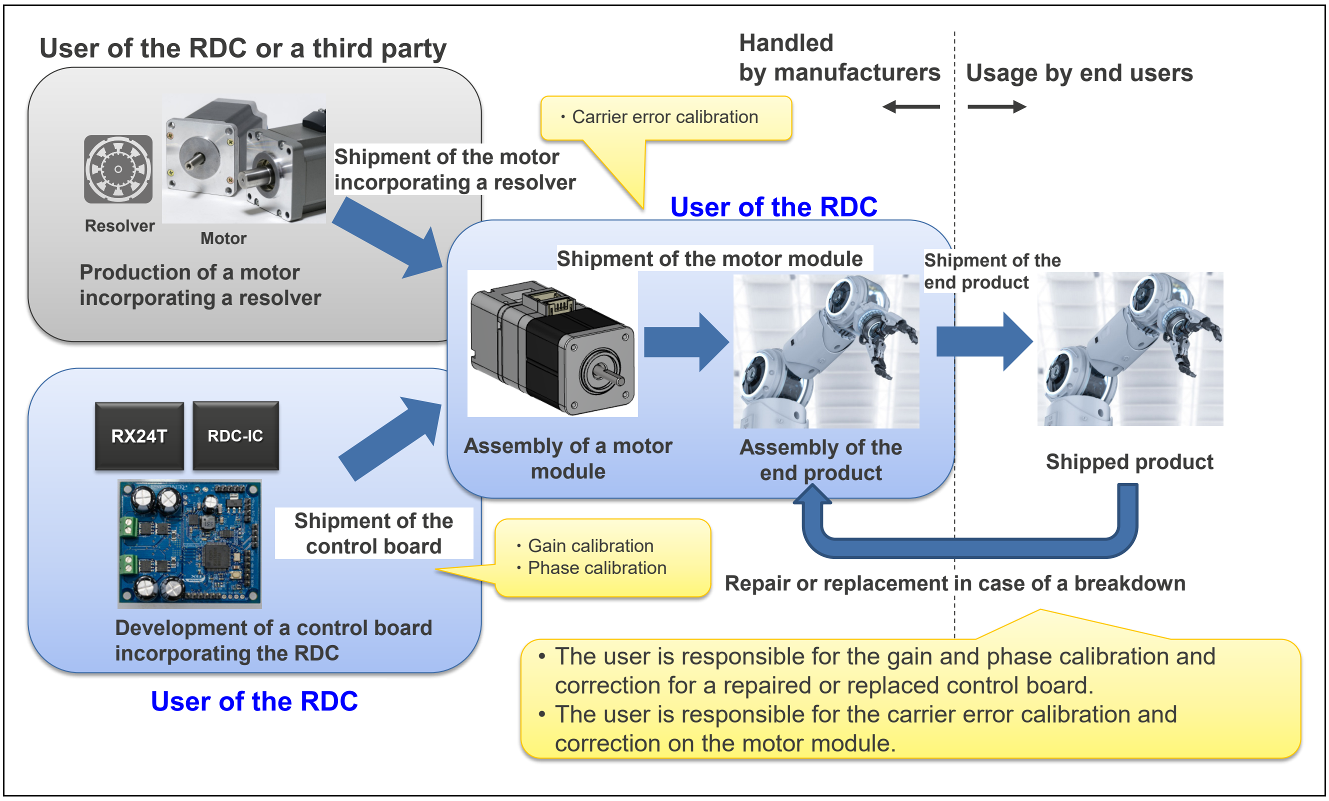

Figure 2. Timing of Calibration to Correct the Errors in Angles in Case 1

2.3 Case 2: When the User is Responsible for Development of the Control Board and Assembly of the Motor Module

Figure 3 shows a flow of development in case 2. The assumptions for case 2 are that the user is responsible for development of the control board and assembly of the motor module, and that a third party is responsible for assembly of the end product.

2.3.1 Calibration before shipment of the end product

We recommend proceeding with the gain and phase calibration before shipping the control board, and carrier error calibration and correction when assembling the motor module so that the user can ship error-corrected motor modules to third parties. If the user wishes to have a third party handle the calibration after shipment of the motor module, he or she should instruct the third party on how to handle the calibration and correction of errors in the measured angles.

2.3.2 Calibration after repair or replacement

(a) In case of repair or replacement of the control board

Gain and phase calibration and correction must be repeated for a repaired or replaced control board.
The same value from carrier error calibration can be used unless the motor incorporating a resolver is replaced. If the user has the value from calibration, re-calibration is not required and he or she can simply use the same value as that before the board was repaired or replaced. If the user does not have the value from calibration, re-calibration to correct the carrier error must proceed for the repaired or replaced board. In such cases, the user should have the third party return the motor module and handle the carrier error calibration and correction, or the user should instruct the third party on how to handle the carrier error calibration and correction.

(b) In case of repair or replacement of the motor incorporating a resolver

Carrier error calibration and correction must proceed for the motor module after the combination of the resolver and control board in use has been repaired or replaced. Gain and phase calibration are not required if only the motor incorporating a resolver is replaced because this has no effect on these values from calibration. The user should have the third party return the motor module and handle the carrier error calibration and correction, or the user should have the third party handle the carrier error calibration and correction. In the latter case, the user should instruct the third party on how to do so.

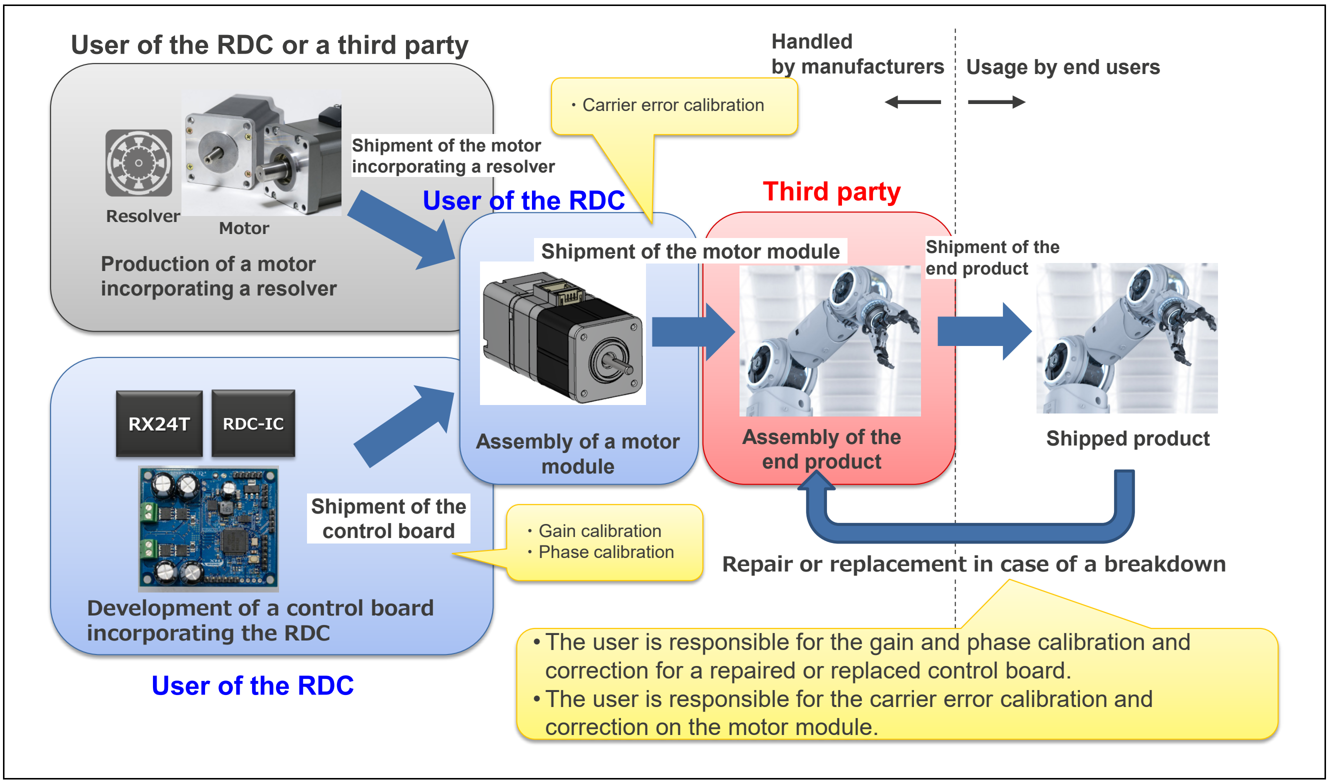

Figure 3. Timing of Calibration to Correct the Errors in Angles in Case 2

2.4 Case 3: When the User is only Responsible for Development of the Control Board

Figure 4 shows a flow of development in case 3. The assumptions for case 3 are that the user is responsible for development of the control board, and that a third party is responsible for assembling the motor module and end product.

2.4.1 Calibration before shipment of the end product

The user must handle gain and phase calibration and correction before shipping the control board.
The carrier error calibration and correction must be handled by the third party responsible for assembling the end product to include the motor module. Accordingly, the user should instruct the third party on how to handle the carrier error calibration and correction.

2.4.2 Calibration after repair or replacement

(a) In case of repair or replacement of the control board

Gain and phase calibration and correction must be repeated for a repaired or replaced control board.
The user must handle the calibration and correction before shipping the repaired or replaced board to third parties. The same value from carrier error calibration can be used unless the motor incorporating a resolver is replaced. If the user has the value from calibration, re-calibration is not required and he or she can simply use the same value as that before the board was repaired or replaced. If the user does not have the value from calibration, he or she should instruct the third party to handle the re-calibration and correction of the carrier error on the repaired or replaced board.

(b) In case of repair or replacement of the motor incorporating a resolver

The third party must handle carrier error calibration and correction on the motor module after the combination of the resolver and control board in use has been repaired or replaced. Gain and phase calibration are not required if only the motor incorporating a resolver is replaced because this has no effect on these values from calibration. The user should instruct the third party to handle the re-calibration and correction for the carrier error and state that gain and phase calibration are not required.

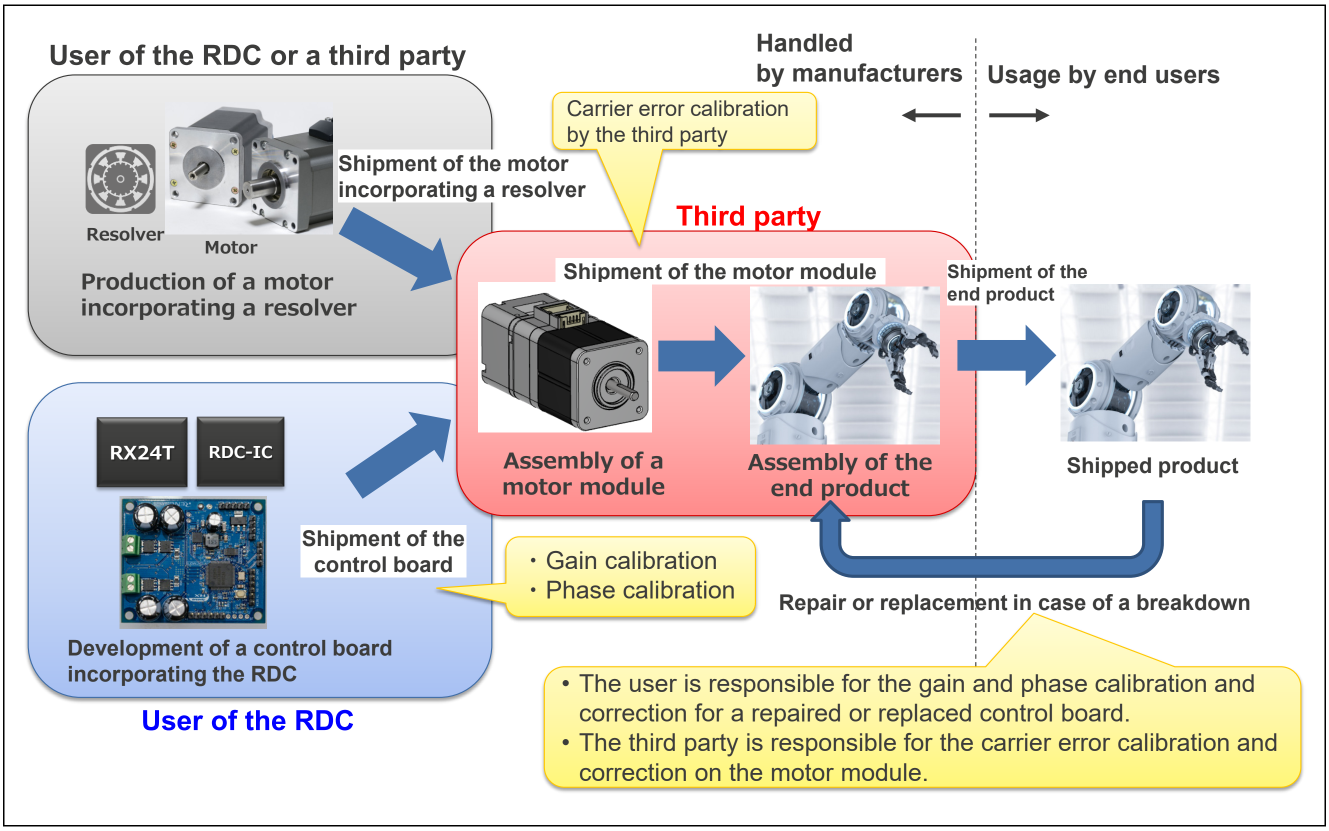

Figure 4. Timing of Calibration to Correct the Errors in Angles in Case 3

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Nov.22.19	—	First edition issued
1.10	Mar.16.20	1	Summary: Body corrected
		2	Section 1 Overview: Body corrected
		3	Figure 1 Possible Flow of Developing an End Product: Corrected
		4	Table 1 Possible Responsibility for each Process: Case 3 Assembly of the End Product corrected
		5	Section 2.2.1 Calibration before shipment of the end product: Body corrected
		5	Figure 2 Timing of Calibration to Correct the Errors in Angles in Case 1: Corrected
		6	Section 2.3.1 Calibration before shipment of the end product: Body corrected
		6	Figure 3 Timing of Calibration to Correct the Errors in Angles in Case 2: Corrected
		7	Figure 4 Timing of Calibration to Correct the Errors in Angles in Case 3: Corrected

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.

Corporate Headquarters

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

Contact information

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