# R8C/38T-A Group

## Application of Capacitive touch technology to a metal panel

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## Abstract

The MCU for touch panel, R8C/38T-A Group, incorporates touch sensor control unit hardware (hereinafter called TSCU) which determines whether an electrode is being touched or not by measuring the floating capacitance between the touch electrode and a human body.

This application note explains how to use switches on a metal panel created by applying electrostatic capacitance touch technology.

## Target Device

R8C/38T-A Group

## Contents

## 1. Overview

With an electrostatic capacitance type touch switch, whether the switch is turned on or off can be detected by measuring the electrostatic capacitance between touch electrode and human body (finger). Basically, this switch works even in structure which has a changing distance between a conductive substance and the electrode, if the change in the electrostatic capacitance can be detected. Figure 1-1 shows an example of a button formed with a metal panel. As shown in this figure, pushing the convex-shape metal part close to the electrode works as a switch.

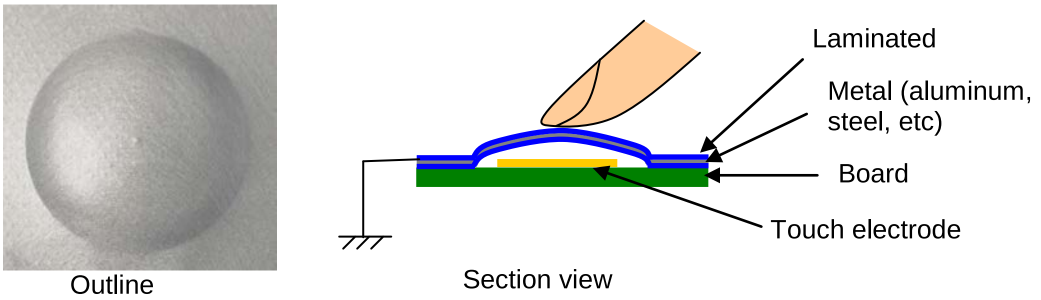



Figure 1-1 Example of Metal Panel Button

Combining a metal panel and electrostatic capacitance method offers potential benefits as follows.

- A front panel may consist of metallic materials such as aluminum, stainless, and etc.
- No need for mechanical contact switches, leading to cost saving.
- The electrostatic capacitance method provides ‘touch’ feeling.
- The metal panel covering the electrode functions as a noise shield, so resistance to RF noise which is a weakness of the electrostatic capacitance method may be increased.

In the following pages, an example of switch with combination of the metal panel and electrostatic capacitance detection method is described.

# 2. Configuration Example of Metal Panel Button

## 2.1 Evaluation Set Configuration

Figure 2-1 illustrates the configuration of evaluation set for metallic panel buttons. Specifically, this evaluation set consists of a metal panel with convex-shape buttons each having different height, a touch MCU R8C/36T-A evaluation board, an emulator debugger E1, and a PC for integrated environment HEW and touch evaluation tool Workbench. On the back side of the panel, touch electrodes are allocated and connected to channels for measurement of the touch MCU. To avoid misjudgment of touch detection from parts other than buttons, the metal panel itself is connected to GND.

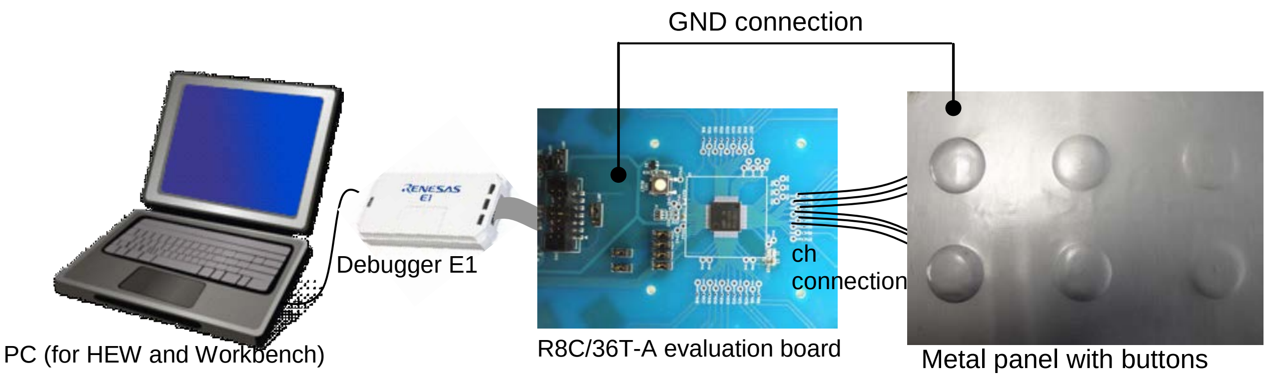



Figure 2-1 Configuration of Evaluation Set for Metallic Panel Buttons

## 2.2 Metal Panel Buttons

Figure 2-2 shows an example of structure of a metal panel button. This button has four layers. From the top, an aluminum board of which both sides are laminated, a double-sided adhesive sheet, a touch electrode, and a glass epoxy board form this button. Pushing the convex-shape aluminum board by a finger brings the metal connected to GND closer to the touch electrode and increases electrostatic capacitance. This increase in electrostatic capacitance is measured by the touch MCU and ON or OFF to the button is detected.

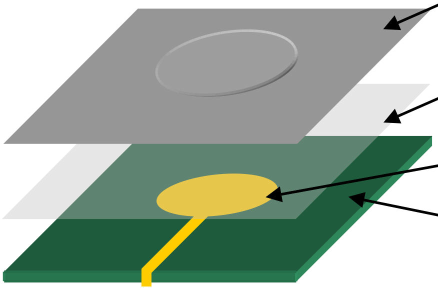



Figure 2-2 Structure of a Metal Panel Button

Note that electrode wiring is set directly below the metal panel in this evaluation set where the touch electrodes are located on a single-side single-layer board. To control parasitic capacitance against the metal panel, it is recommended to use a double layer board where wiring is set on the back side via a through-hole when applying to practical use for products.

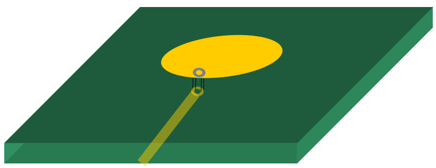
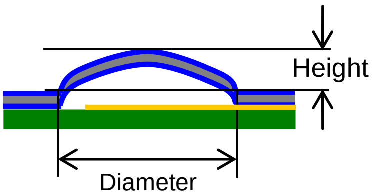
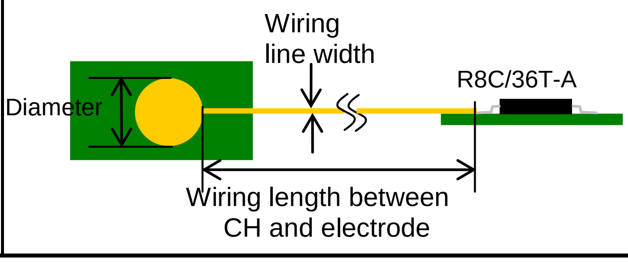


Figure 2-3 Touch Electrode on Double Layer Board

Based on the assumption that the buttons are used for various applications, several sizes of buttons and touch electrodes are provided. Table 2-1 shows each size of buttons used for this evaluation set.

**Table 2-1 Size of Buttons**

<table>
<tr><th rowspan="2"></th><th colspan="2">Convex part of the aluminum board</th><th colspan="3">Touch electrode</th></tr>
<tr><th>Height (mm)</th><th>Diameter (mm)</th><th>Diameter (mm)</th><th>Wiring line width (mm)</th><th>Wiring length between CH and electrode (mm)</th></tr>
<tr><td>Button 1</td><td>0.025</td><td rowspan="6">17</td><td rowspan="3">15</td><td rowspan="6">0.3</td><td rowspan="6">100</td></tr>
<tr><td>Button 2</td><td>0.05</td></tr>
<tr><td>Button 3</td><td>0.1</td></tr>
<tr><td>Button 4</td><td>0.025</td><td rowspan="3">10</td></tr>
<tr><td>Button 5</td><td>0.05</td></tr>
<tr><td>Button 6</td><td>0.1</td></tr>
<tr><td>Legends</td><td colspan="2">
</td><td colspan="3">
</td></tr>
</table>

## 2.3 TSCU Settings and External Circuit Constants for R8C/36T-A

TSCU settings of R8C/36T-A used for this evaluation are as follows. As for meaning of each register, refer to R8C/36T-A hardware manual.

| | | |
|---|---|---|
| DF_TSCUCR0 | 0x0006 | // TSCU Control Register 0 F=1/1(20MHz) |
| DF_TSCUCR1 | 0x0010 | // TSCU Control Register 1 |
| DF_TSCUMR | 0x0000 | // TSCU Mode Register soft trriger |
| DF_TSCUTCR0A | 0x0300 | // TSCU Timing Control Register 0A charge max |
| DF_TSCUTCR0B | 0x0300 | // TSCU Timing Control Register 0B charge max |
| DF_TSCUTCR1 | 0x0307 | // TSCU Timing Control Register 1 Larea 2cyc |
| DF_TSCUTCR2 | 0x8000 | // TSCU Timing Control Register 2 |
| DF_TSCUTCR3 | 0x0000 | // TSCU Timing Control Register 3 |
| DF_TSCUCHC | (0x0080+MAX_CH-1) | // TSCU Channel Control Register 22ch up-down scan |
| DF_TSCUFR | 0x0000 | // TSCU Flag Register |
| DF_TSCUSCS | 0x0020 | // TSCU Secondary Counter Set Register 7count |
| DF_TSCURVR0 | 0x0000 | // TSCU random Register 0 |
| DF_TSCURVR1 | 0x0000 | // TSCU random Register 1 |
| DF_TSCURVR2 | 0x0000 | // TSCU random Register 2 |
| DF_TSCURVR3 | 0x0000 | // TSCU random Register 3 |

External circuit constants of the R8C/36T-A evaluation board are as follows.

Cc: 0.1 μF

Rc: 2.7 KΩ

Cr: 27 pF (with CHxA0 side used)

Rr: 1 KΩ

## 2.4 Measurement Method

Regarding the buttons 1 to 6, touch measurement values (count values) when each of the buttons is not pushed and pushed using a 10 mm ϕ cylindrical metal bar with approximately 600 g weighted are measured on the Workbench status monitor. Figure 2-4 is a picture showing a button pushed with the metal bar. In this evaluation set, the metal panel part is connected to GND. Therefore there is no need to take into consideration influence of electrical resistance or capacitance from a human body and the metal bar as evaluation conditions.

Figure 2-4 A Button Pushed with a Metal Bar

Other conditions of measurement:

- MCU supply voltage 5.00 V
- Temperature (room temperature) 25 °C
- Humidity 30 %
- Workbench4 Ver. 4.60.02

## 2.5 Measurement Result

Table 2-1 shows touch measurement count values when each button is pushed/not pushed. Note that the count values are measured on the status monitor of Workbench and the values measured four times are added to be defined as a measurement result.

Table 2-2 Measurement Result

| | Sizes of buttons | | Measurement result (count values added four times) | | |
|---|---|---|---|---|---|
| | Height of convex part (mm) | Touch electrode diameter (mm) | When not pushed | When pushed | Difference |
| Button 1 | 0.025 | 15 | 1154 | 420 | 734 |
| Button 2 | 0.05 | | 1234 | 570 | 664 |
| Button 3 | 0.1 | | 1290 | 840 | 450 |
| Button 4 | 0.025 | 10 | 1508 | 784 | 724 |
| Button 5 | 0.05 | | 1575 | 964 | 611 |
| Button 6 | 0.1 | | 1580 | 1240 | 340 |

## 2.6 Consideration

**As shown in the result, each button operates properly as a switch because there is enough difference to determine ON or OFF.**
Figure 2-5 shows a relationship between the shape of button and difference in measurement result. As shown in this graph, the higher the convex part, the less difference observed. This is because contact area to the electrode when the button is pushed is smaller.

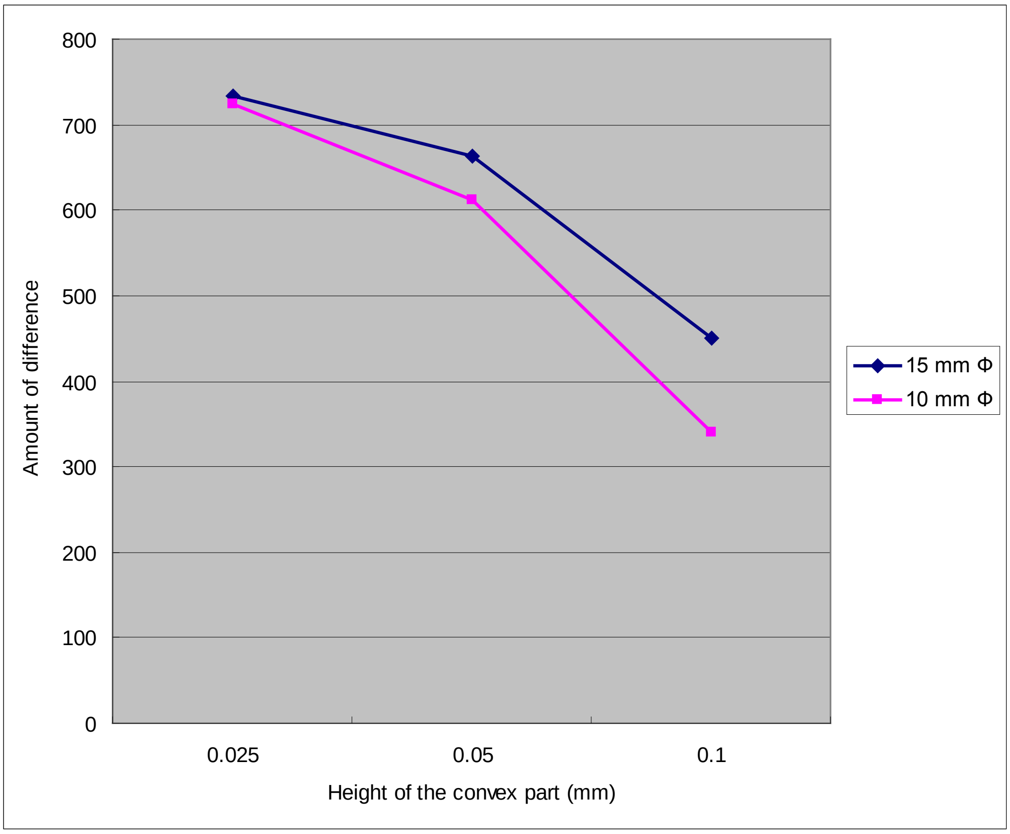



Figure 2-5 Relationship between Button Shape and Difference in Measurement Result

It is a logical conclusion that the smaller electrode has the less difference in measurement result. In addition, the difference based on the size of electrode varies depending on the height of convex part of button. The graph shows the difference observed between two lines (with 10 mm ϕ electrode) and (with 15 mm ϕ electrode) is greater when the convex part is higher.

This is because how much the convex part changes in shape when the button is pushed varies depending on the height of the convex part. Figure 2-6 shows a relationship between height of the convex part and contact area to the touch electrode. When the convex part is high, only the center part of the button changes in shape and the contact area to the electrode is relatively small.

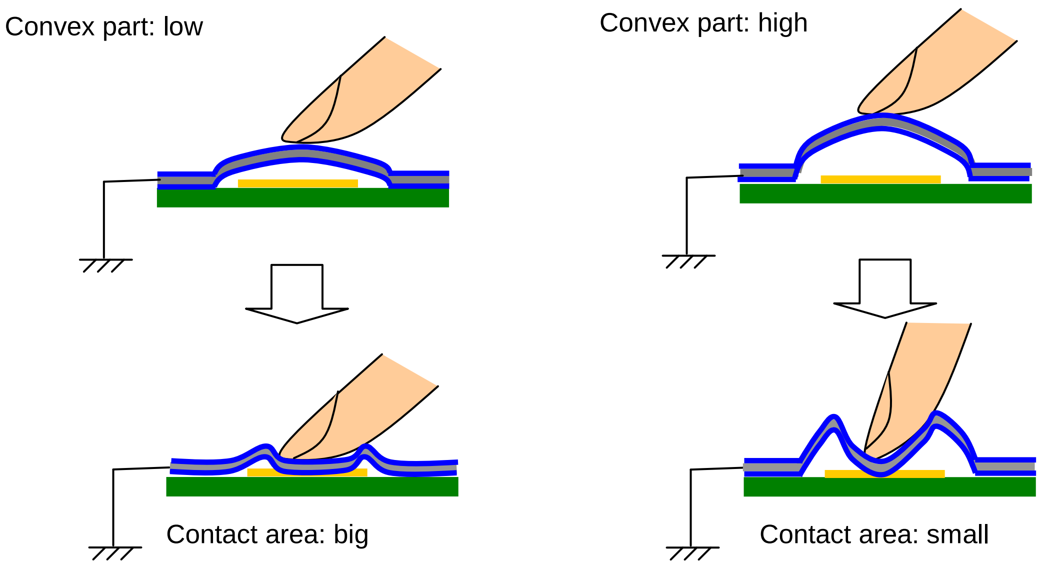



Figure 2-6 Relationship Between Height of the Convex Part and Contact Area

# 3. Appendix. Application to Proximity Sensor

Applications of buttons using the metal panel include a proximity sensor in which the metal panel itself is used as the touch electrode. Specifically, the following application is feasible.

(1) When power is OFF, the product is in low power consumption state and can detect only proximity of a human body with the metal panel used as electrodes.

(2) When the proximity of a human body is detected, the metal panel stops the detection and the convex parts of the metal panel are activated as switches.

(3) The metal panel is connected to GND via MCU pins.

(4) When there is no operation in a certain period of time or a user turns power off, the product enters low power consumption state and the procedure returns to (1).

Distance in order for the metal panel operating as a proximity sensor to detect an approach of a human body is evaluated in the below environment. Figure 3-1 shows the evaluation environment for the proximity sensor. Other conditions such as TSCU settings and external circuit constants are the same as those for evaluating buttons.

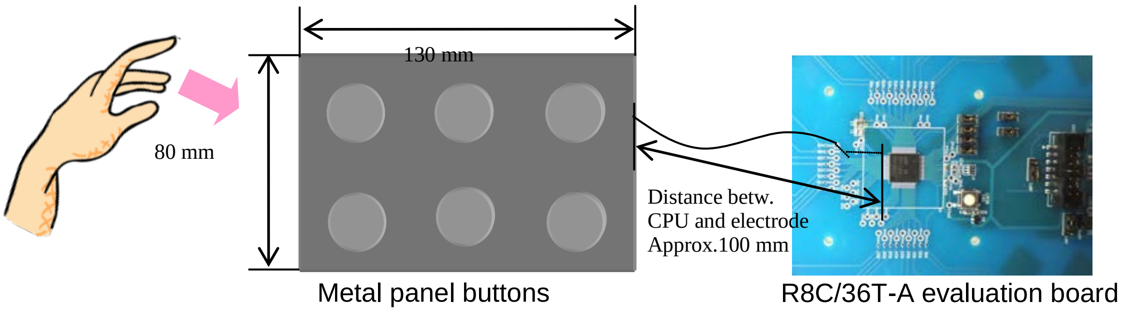



Figure 3-1 Proximity Sensor Evaluation Environment

Figure 3-2 is a graph showing the result of evaluation. As shown in this graph, the panel starts to detect an approach of a hand about 100 mm from it, and the count value decreases in an asymptotic line curve till the distance becomes 0 mm. Although an actual measurement result depends on margin setting against malfunction caused by noise, the evaluation result shows that detecting an approach of a hand within approximately 50 mm is considered possible in this evaluation environment.

| Distance from the panel and hand (mm) | 200 | 175 | 150 | 125 | 100 | 75 | 50 | 25 | 0 |
|---|---|---|---|---|---|---|---|---|---|
| Count value | 640 | 638 | 637 | 633 | 630 | 623 | 600 | 520 | 280 |

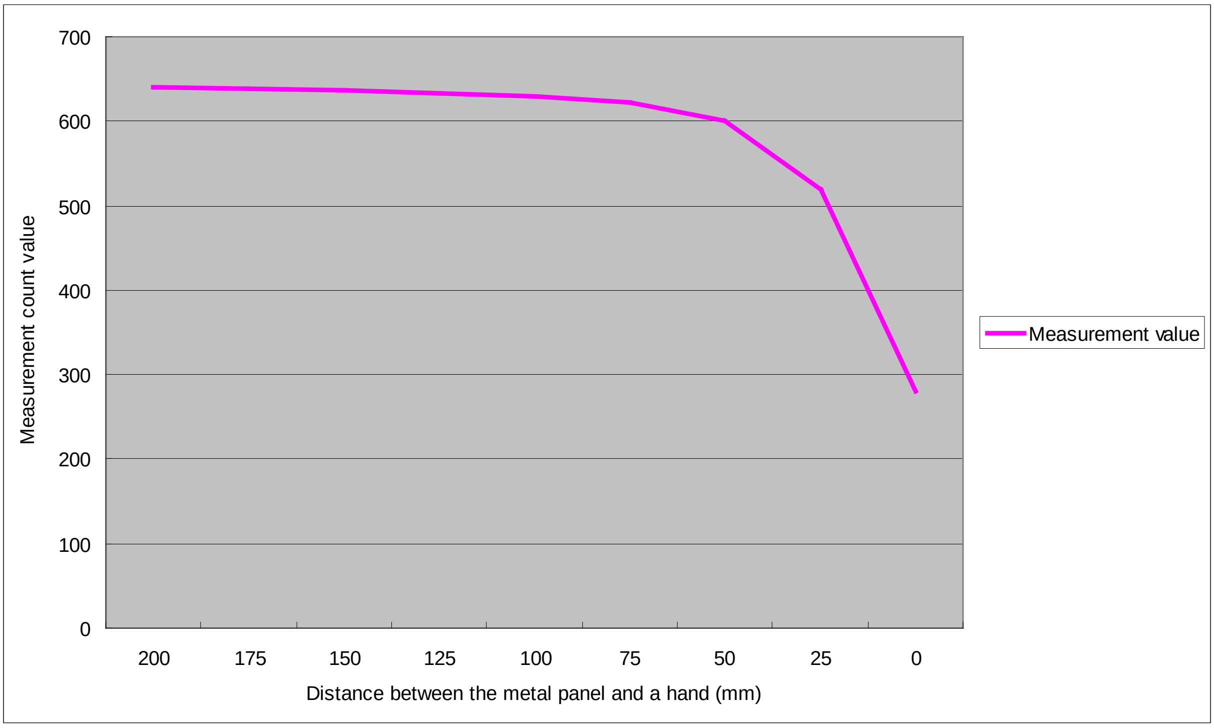



Figure 3-2 Measurement Count Value and Approach of a Hand

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## Revision Record

| Rev. | Date | Description | |
|---|---|---|---|
| | | Page | Summary |
| 1.00 | May 23, 2013 | - | Numbering change(Content is as same as R01AN1214EJ0100) |

## General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this manual, refer to the relevant sections of the manual. If the descriptions under General Precautions in the Handling of MPU/MCU Products and in the body of the manual differ from each other, the description in the body of the manual takes precedence.

1. Handling of Unused Pins
   Handle unused pins in accord 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 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. Unused pins should be handled as described under Handling of Unused Pins in the manual.
2. Processing at Power-on
   The state of the product is undefined at the moment 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 moment 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 moment 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 moment when power is supplied until the power reaches the level at which resetting has been specified.
3. Prohibition of Access to Reserved Addresses
   Access to reserved addresses is prohibited.
   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.
4. Clock Signals
   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has 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. Moreover, 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.
5. Differences between Products
   Before changing from one product to another, i.e. to one with a different type number, confirm that the change will not lead to problems.
   — The characteristics of MPU/MCU in the same group but having different type numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different type numbers, implement a system-evaluation test for each of the products.

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