R8C/38T-A Group

Summary of Noise Countermeasures

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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 countermeasures against each noise regarding touch detection.

Target Device

R8C/33T, R8C/3JT, R8C/3NT, R8C/36T-A and R8C/38T-A Group

Contents

1. Noises Affecting Touch Detection

Generally, capacitive touch (hereinafter called 'touch') detection is easily influenced by exogenous noises because of the structure of electrodes for capacitive detection. When touch detection is affected by a noise, the touch keys may not work properly as follows.

- A key is turned ON without key operation.
- A key operation can not be accepted.
- A key does not react appropriately in accordance with key operation.
  (A key operates unstably. e.g. ON/OFF operations are repeated.)
- A key is turned ON when a finger approaches, reacting too sensitively

In this chapter, types of noises which affect touch detection are described. In addition, changes in temperature and aged deterioration of parts are also introduced as a part of disturbance.

1.1 Types of Noises

Figure 1-1 shows examples of noises which affect the touch detection. Most of electric appliances for home use such as fluorescent light, liquid crystal TV, IH cooking heater, PC, etc. contain an inverter power supply which generates tens to hundreds Hz inverter noises. Also, a radio broadcasting tower, cell tower, or two-way radio emits electric waves in thousands kHz to several GHz band. These radiation noises influences touch detection by breaking into the MCU from touch electrodes or power supply/GND lines. Besides, touch detection may be affected by noises from a power-supply circuit of a device with touch keys or a control system of LED or inverter motor. Furthermore, changes in temperature or aged deterioration of parts such as touch circuit condenser can also be regarded as a part of disturbance of touch detection.

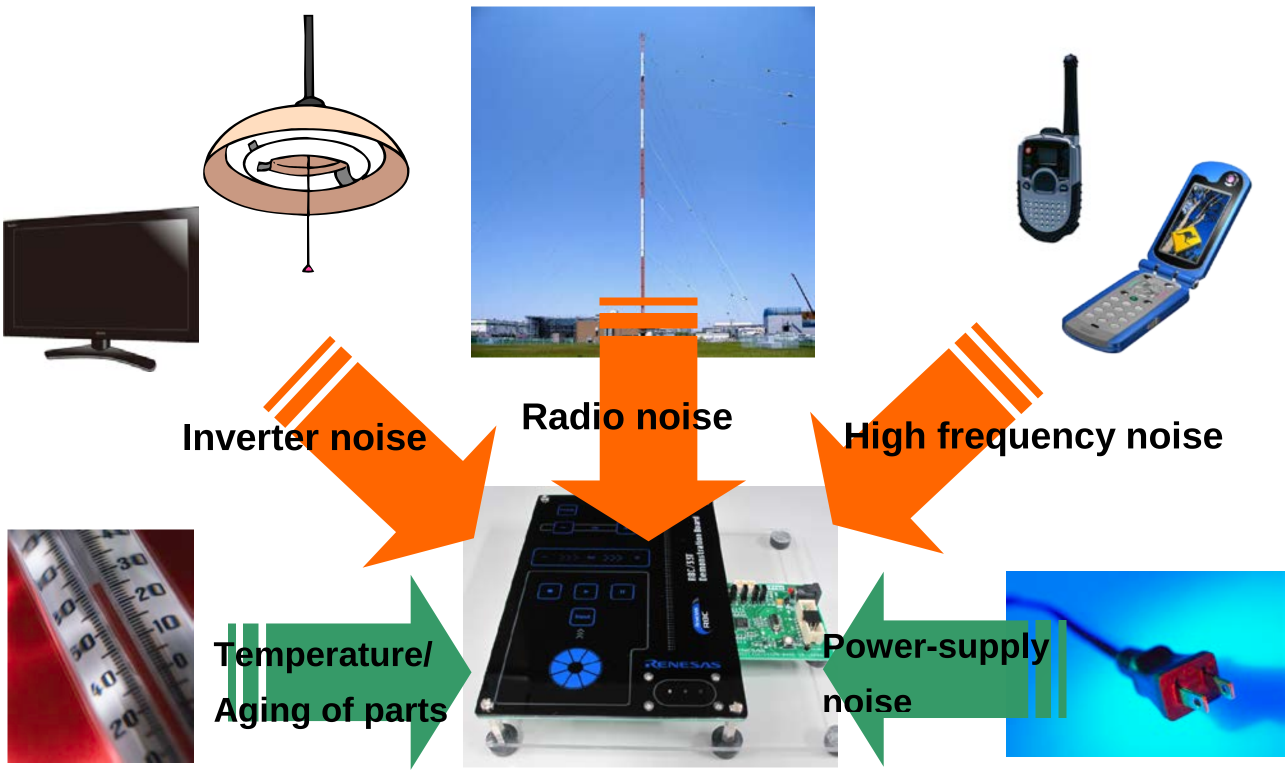


Figure 1-1 Noises Affecting Touch Operation

1.2 Features of Respective Noises

How much a noise affects touch detection differs depending on its amplitude, modulation degree, and frequency. In this chapter, typical noise sources and influence are described for each frequency band.

1.2.1 Low Frequency (to several hundred kHz)

Typical noise sources in low frequency band are hum from an AC power supply (50Hz or 60Hz), inverter devices (around 5 kHz to 200 kHz), and etc. Specifically inverter devices including a fluorescent light, AC adapter, IH cooking heater are commonly used at home and often cause problems. In addition, when a product itself uses PWM control for LEDs or motors, a noise may be applied through capacitive coupling of wiring or power supply/GND lines. **Figure 1-2** illustrates waveforms measured from normal touch operation and touch operation with an inverter noise from a fluorescent light (approx. 50 kHz) superimposed. It shows that the waveform measured from touch operation is fluctuant in accordance with noise cycles.

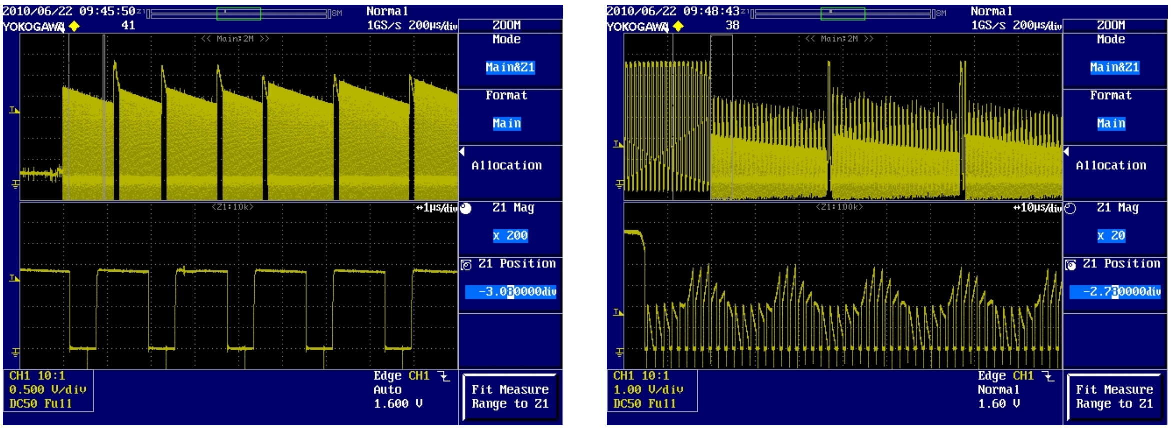


Figure 1-2 Waveforms of Normal Touch (left) and Touch with a Noise from Fluorescent Light (right)

1.2.2 Middle Frequency (to several MHz)

As for middle frequency band, a representative example is a middle wave broadcasting tower. As the middle wave radio uses amplitude modulation (AM wave), the noise intensity varies in accordance with superimposed sound. Also, the AM wave can be transmitted through a human body. This makes it difficult to take countermeasures against the noise because the capacitance change of the human body is measured as well when a person operates a key. Additionally, an alias may be generated because the wave is close to touch measurement frequency. Therefore a special measure must be taken. However, since this case can be possible only around the broadcasting tower, need for the special measure would be restricted to a specific area in approximately 1 Km radius of the tower. **Figure 1-3** shows a case in which the AM wave is applied to a touch circuit via a human body. In this case, some unexpected operations may occur, for example, keys produce no response when touched, keys react hyper-sensitively, or ON/OFF operations are repeated.

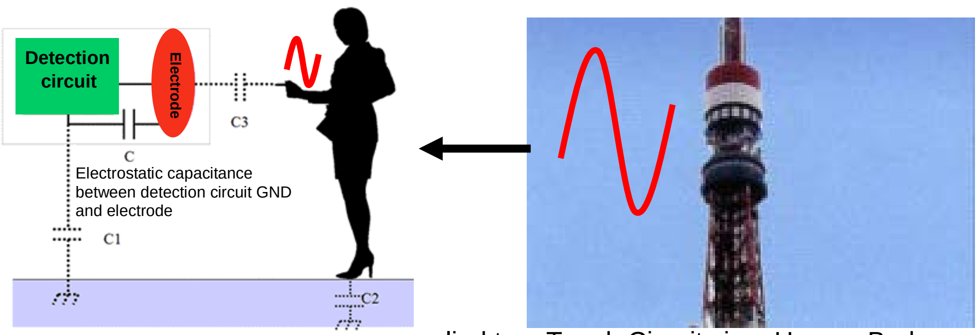


Figure 1-3 AM Wave Applied to a Touch Circuit via a Human Body

1.2.3 High Frequency (several MHz or higher)

Representative examples in high frequency band are an FM radio (around 20 MHz to 500 MHz), mobile phone (around 800 MHz to 2 GHz), and TV broadcasting tower (around 30 MHz to 300 MHz). In the high frequency band, distance highly effects to the gain attenuation. Therefore there is no case of the same influence as the middle wave broadcasting tower affecting touch operation in approximately 1 Km radius of the tower. However, measures for mobile phones are necessary because they are always emitting electric waves and sometimes placed on a product with touch keys. Also, measures in other cases, for example a measure for a car with illegally-turned up radio gain passing around the neighborhood, may be required. **Figure 1-4** shows an example in which a mobile phone is placed on a touch key panel. In this case, in addition to countermeasures against the noise caused by the electric wave, measures in a case where the mobile phone itself works as capacitance to turn a key ON must be taken.

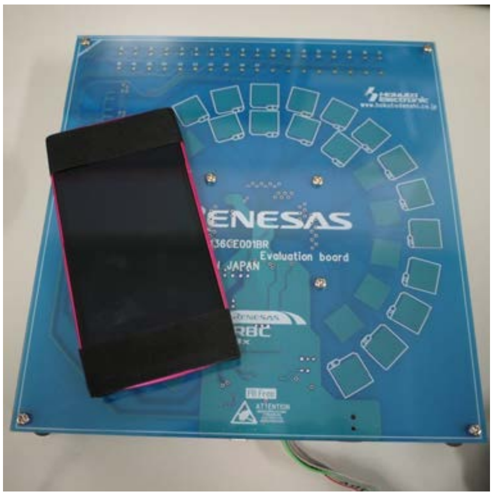


Figure 1-4 A Mobile Phone Placed on a Touch Key Panel

1.2.4 Changes in Temperature and Aged Deterioration of Parts (several Hz or lower)

Although changes in temperature and aged deterioration of parts would not directly disturb touch electrodes, values of the condenser and resistor used for the touch circuit change gradually and touch sensitivity also changes accordingly. Since changes with respect to time are small, measures can be simple. However, selecting parts such as condensers and resistors requires attention because parts having a low tolerance for temperature or aging may affect touch detection beyond the extent of adjustment by software.

2. Noise Countermeasures

Renesas Touch Panel MCUs incorporate various countermeasure functions against noises by hardware. In addition, the high-speed 16-bit CPU realizes a stronger noise immunity using noise filtering by software. This chapter introduces each function and adjustment method, and then describes board and chassis designs with high tolerance to noises. **Figure 2-1** shows frequency bandwidth of noise sources and bandwidth of effective countermeasures corresponding to each noise. Noises exist widely from extremely low frequency to GHz band. Basic noise countermeasures (secondary counter setting, touch measurement timing adjustment, touch measurement waveform adjustment, drift correction, and etc.) have already been provided to touch APIs for each touch MCU. However, additional countermeasures may be required depending on a product used and operating environment.

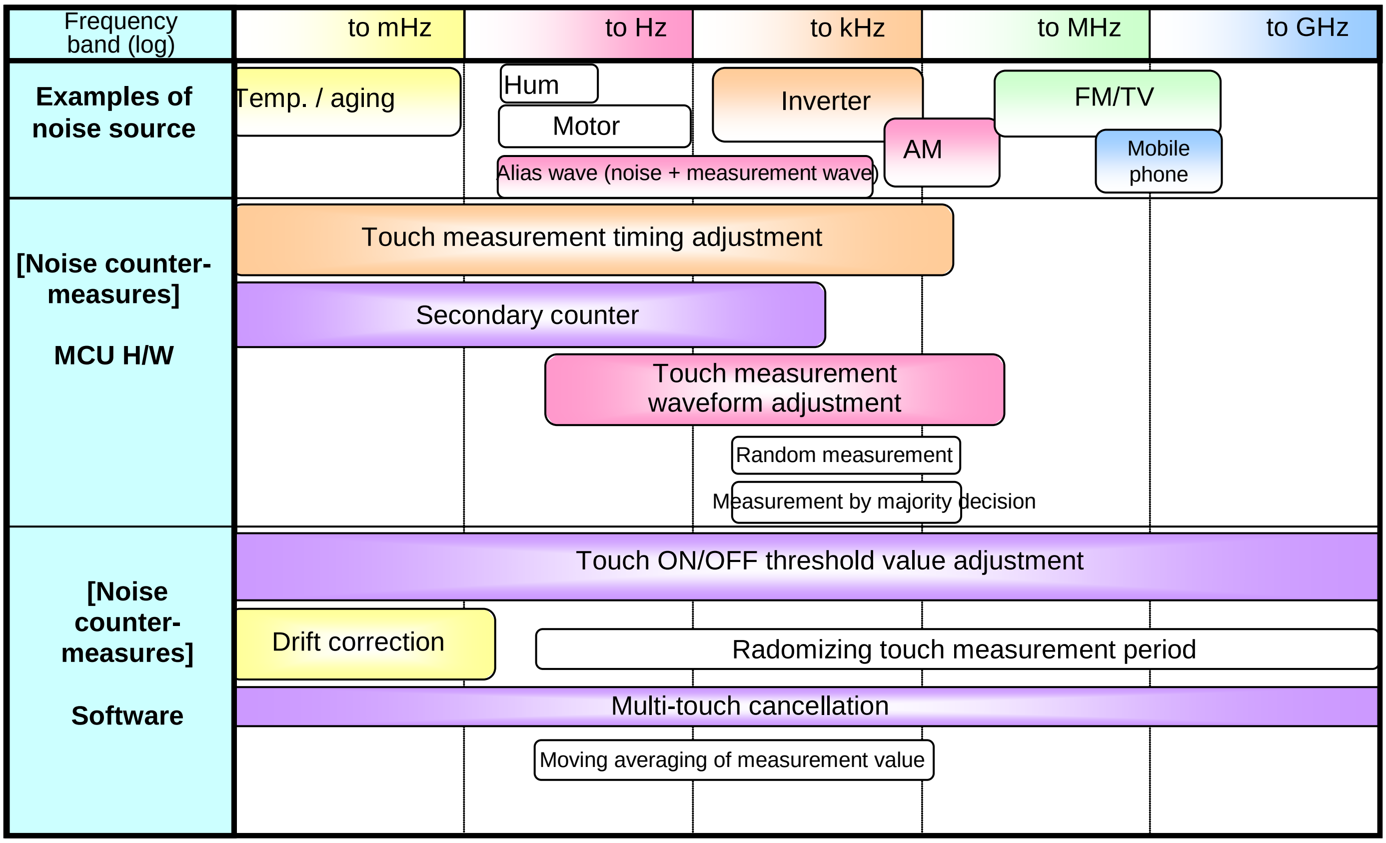


Figure 2-1 Frequency Bandwidth of Noise Sources and Effective Countermeasure Bandwidth

2.1 Hardware Design

2.1.1 Circuit and Board Design

This part explains notes on developing and designing a touch board with respect to noise. As for general board design, refer to the application note “Base of electrostatic capacitance method touch key”.

(a) Electrodes for Touch

Recommended shapes of electrodes to detect touch by a finger are●and■in approximately 10 × 10 to 15 × 15 mm size. A shape of ▲or E-shape is not recommended since an electrode in those shapes works as an antenna receiving noises. Lighting with LED lights from the back of the electrode is also effective when its form is in a donut-shape or mesh configuration. However, in those forms, the sensitivity of the electrode can be weakened due to decreased area or a noise can be generated by the PWM control of the LED. Touch sensitivity must be as high as possible because it works as an eventual countermeasure against noises. Refer to 2.3.1 Adjustment of Threshold Value for more details.

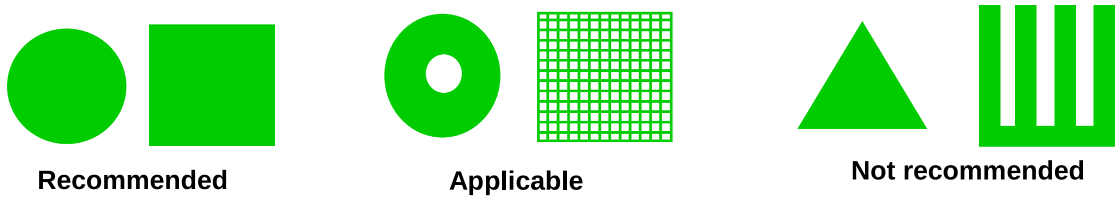


Figure 2-2 Shapes of Touch Electrodes

(b) Electrode Wiring

Wire connection between touch electrodes and CPU ports should be as short as possible (within 180 mm). Also, the connection should be designed at some point distant from wiring for PWM output, and serial communication, etc. to prevent noise contamination due to capacitance coupling (see **Figure 2-3**.). When crossing the touch electrode wiring and signal wiring by necessity, cross those lines at a right angle on two sides (the front and the back) of the board (see **Figure 2-4**.). Regarding wiring of touch electrodes and signal lines, refer to the application note “Development case of LED dimmer by PWM with touch detecting”.

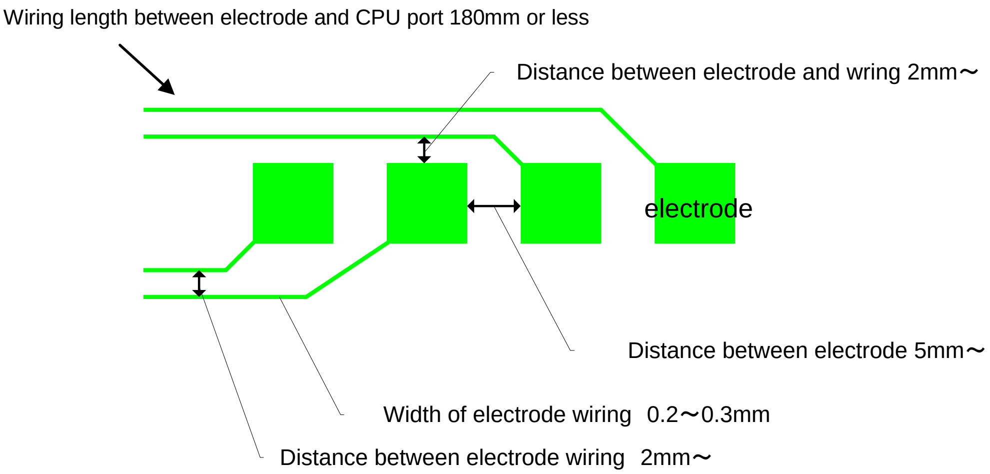


Figure 2-3 Recommended Electrode Wiring

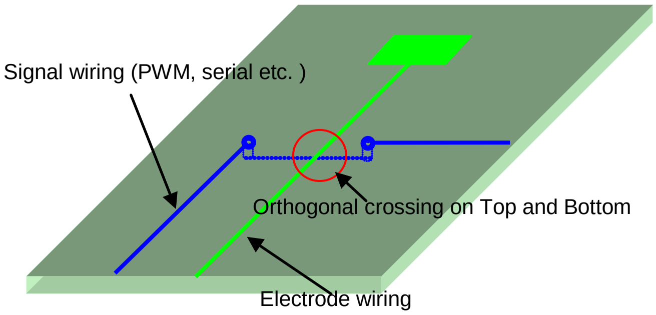


Figure 2-4 Example of Crossing Electrode Wiring and Signal Wiring

(c) **Design around the Ports CHxA, CHxB, and CHxC**

When a noise contaminates to the CHxA, CHxB, or CHxC port, measurement on all touch channels is affected. Therefore, each port, condensers (Cr and Cc), and the resistor (Rc) must be connected as close as possible. On the backside of the board, a GND pattern covering MCU, the ports, Cr, Cc, and Rc must be placed. **Figure 2-5** shows an example of layout of Cr, Rc, Cc and the GND pattern on the backside.

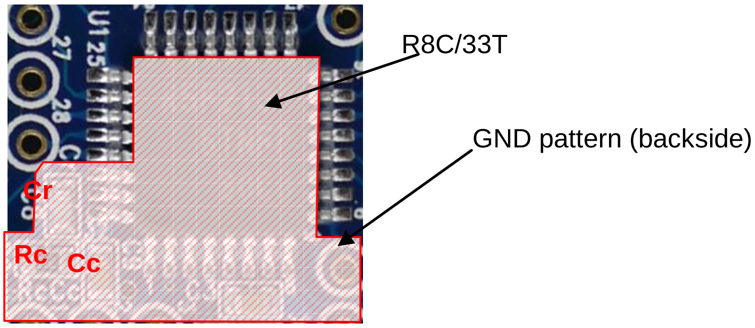


Figure 2-5 Layout of Cr, Rc, Cc and GND Pattern (on back)

(d) **Electrodes and GND Shield of the Electrode Wiring**

To get the sufficient touch sensitivity, parasitic capacitance of electrodes and electrode wiring must be minimized. Therefore, it is not recommended to place metal frames or the GND pattern around electrodes and electrode wiring. However, the electrodes and electrode wiring should be protected by the GND pattern when an electromagnetic field shield is required because of a strong RF noise from the product inside and surrounding environment. In this case, a mesh GND pattern is recommended in order to decrease the parasitic capacitance as much as possible. Samples of the board pattern are shown in **Figure 2-6**. A normal (not mesh type) GND is used around MCU, Cr, Rc, and Cc, and a mesh GND pattern is used for electrodes and electrode wiring.

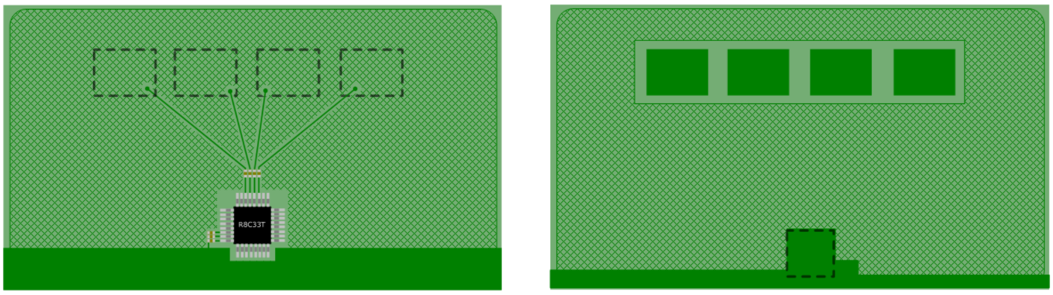


Figure 2-6 Samples of Electromagnetic Shield by GND Patterns

(e) **Power Supply Design**

Safe power supply with sufficient capacity must be ensured for the MCU. In the case of touch measurement, the CHxC port is instantaneously charged with the maximum drive current (40 mA when the drive capability is large). In addition to this current, the amount of current flowing in other ports should be taken into account. Power supply using a three-pin regulator is preferable. Attention needs to be paid to noises superimposed on the power supply line as well.

2.1.2 Chassis Design

To the extent it does not become the parasitic capacitance for electrodes and electrode wiring, the surrounding of the touch board should be protected by an electromagnetic field shield using metal. Also, the touch detection ports require attention to electrostatic discharge failure because they come into high-impedance state. Normally, as the electrodes have been protected by a non-conducting material, electrostatic discharge failure would not be generated from the surface. However, static electricity may cut in through a gap in the chassis or a hole and reach to the touch detection ports. Therefore, the chassis should be designed not to have such a gap or hole. Allocating the GND pattern around the board is also effective in discharging static electricity (see **Figure 2-7**.). Note that a noise caused by static electricity is instantaneous, so touch detection processing on averaging the measured values, etc. is not directly affected.

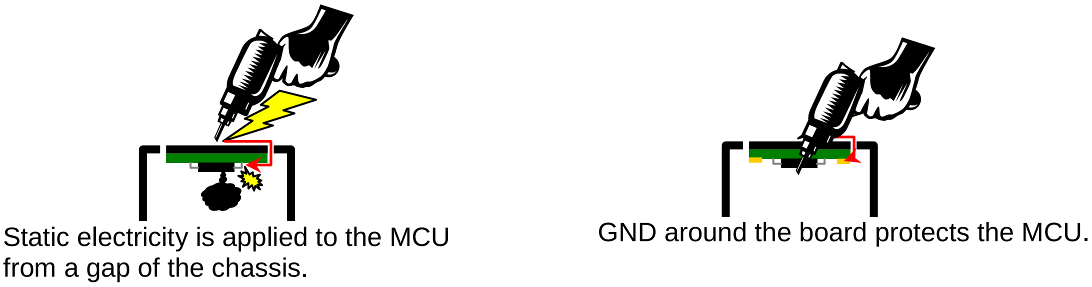


Figure 2-7 Influence of Static Electricity

2.2 Settings of Touch Detection Circuit

The touch panel MCU contains functions to eliminate or reduce noises when detecting touch. Those functions are explained in this part. As for countermeasures against noises such as inverter, AM wave, and etc., respective application notes have been provided. Please refer to them.

2.2.1 Touch Measurement Timing Adjustment

In the touch detection method adopted by Renesas, while comparing the divided voltage between Cx (electrostatic capacitance) and Cr (a condenser to be compared), the MCU determines touch or non-touch by measuring the number of repetition which Cc (a condenser for charging/discharging) constantly repeats charging and discharging. For more details, refer to “Base of electrostatic capacitance method touch key”.

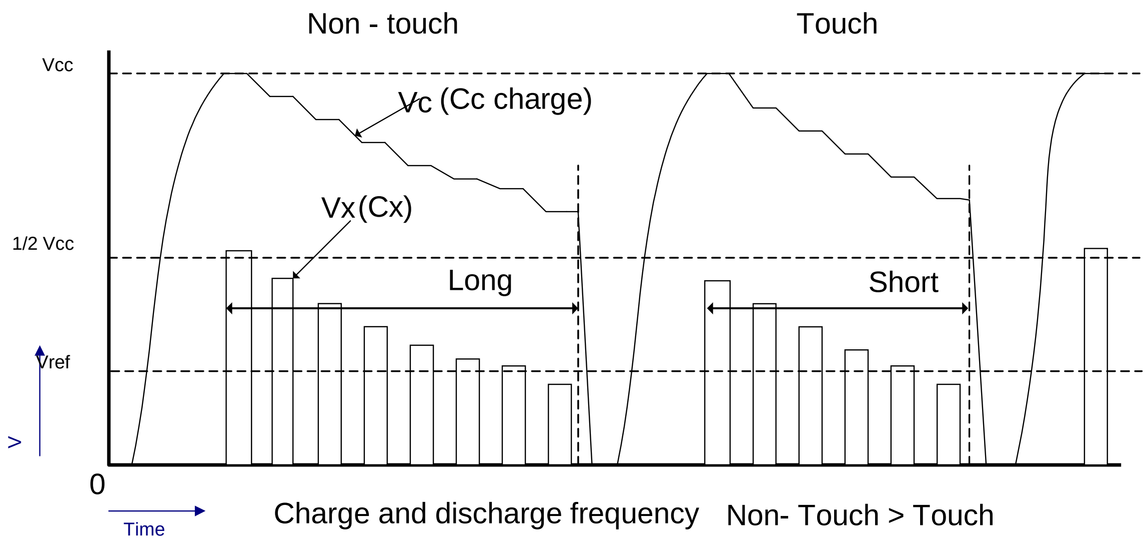


Figure 2-8 Waveform Outline of Touch Detection Operation

As shown in **Figure 2-8**, charge in Cr and Cx are completely discharged. (Both edges of Cr and Cx are connected to the GND.) After each discharge, Cr and Cx are charged by Cc, and their voltage levels are compared with Vref. After that, charge in Cr and Cx are discharged again. In a case where charge in Cr and Cx are affected by an RF noise, all are discharged together at the same time and Cr and Cx are charged again.

There is a bit of time lapse after the most vulnerable electrode to noises, Cr, receives a noise before it generates electricity. **Figure 2-9** shows a relationship between noise influence to touch measurement waveform and touch measurement timing. When the CHxA point is at the GND level (Cx and Cr are discharging), a noise is not superimposed. When the CHxA point reaches to Hi-Z (Cx and Cr are being charged by Cc), touch electrodes and wiring start to receive noises, functioning as antennas. If the timing to measure the level of the CHxA point (Vx) is delayed, influence by noises becomes large. On the other hand however, setting the measurement timing to a proper point realizes measurement with very little influence from noises.

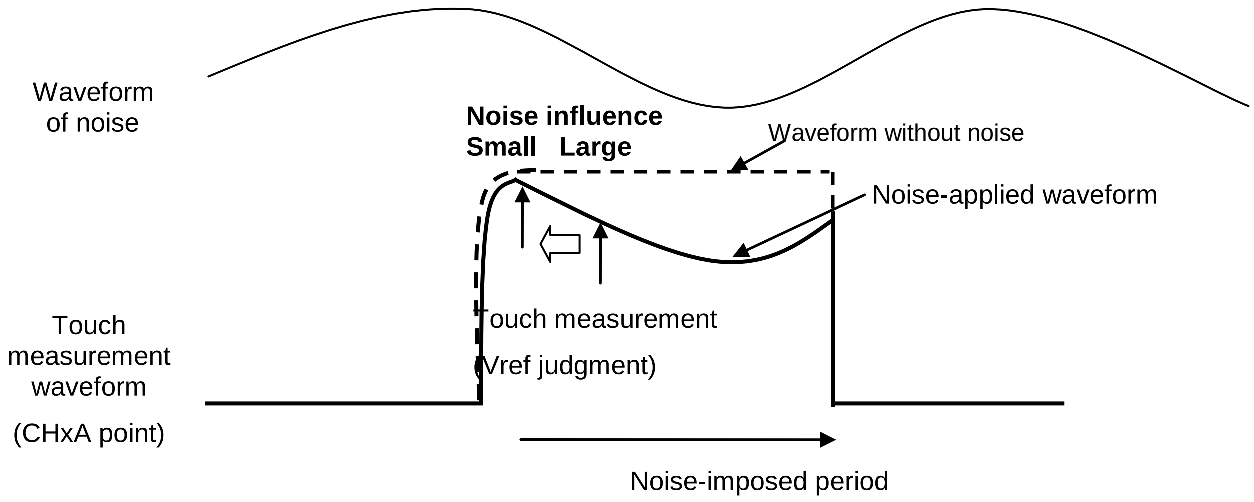


Figure 2-9 Relationship between Noise Influence to Touch Measurement Waveform and Touch Measurement Timing

In addition to using these behaviors, touch measurement without influence from RF noises is enabled by comparing the voltage level after start of charging to Cr and Cx before electricity generation by the RF noises.

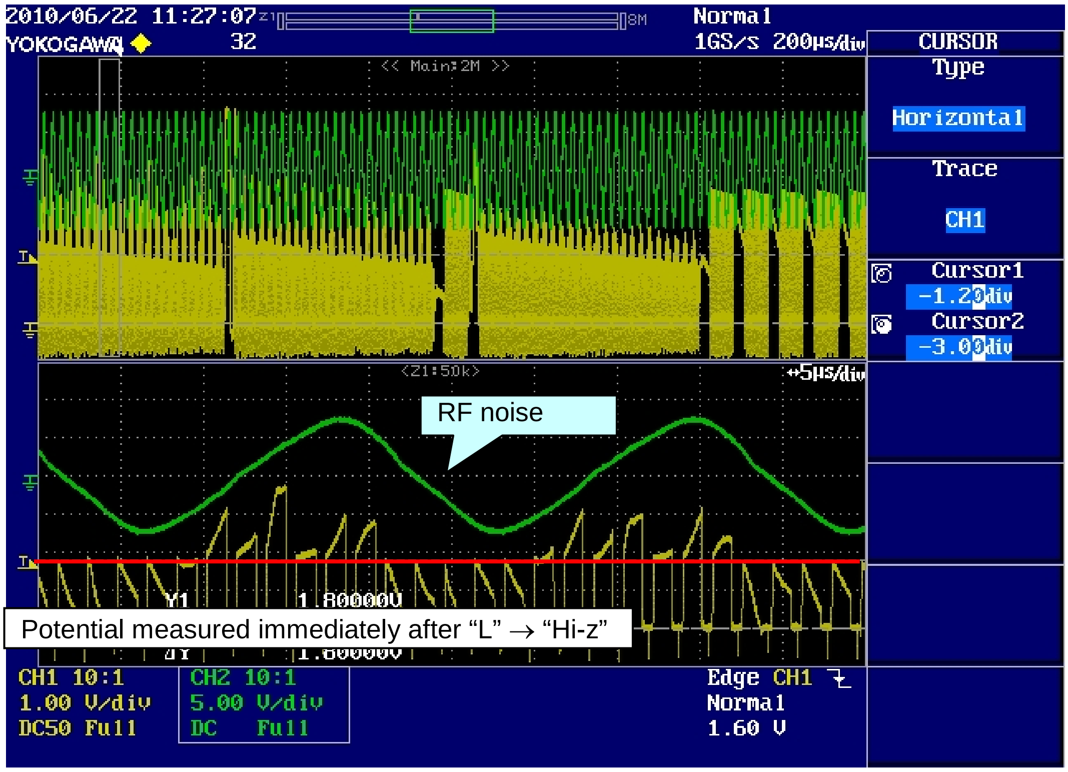


Figure 2-10 RF Noise Superimposed on Touch Measurement Waveform

Figure 2-10 shows an RF noise superimposed on touch measurement waveform. The RF noise waveform affects the measurement waveform, which largely exceeds/falls below the level judgment value (normally 0.35 Vcc). However, immediately after start of charging Cr and Cx, charge is almost at a stable level since the influence from the RF noise to electricity generation is little. Adjusting the level judgment timing to approx. 100 nSEC after the charge start by using TSCU period setting enables measurement almost without influence from the noise. Also, this measurement method can reduce the influence caused by approximately 1 MHz or less. For more details of the adjustment method, refer to the application note "The implement of the inverter noise immunity by SCU setting".

2.2.2 Secondary Counter

The secondary counter has a function to stabilize the touch measurement values by reducing jitter, functioning as a low-pass filter when a noise with relatively low frequency is superimposed on the touch measurement waveform. The secondary counter works as the sub counter of the main counter. The secondary counter starts operation when the touch measurement end condition is satisfied (Vx falls below Vref). With reference to a count value set beforehand, the secondary counter decrements when the Vx voltage below Vref is detected, and it increments when the Vx voltage over Vref is detected. When the count value becomes 0, the measurement is finished.

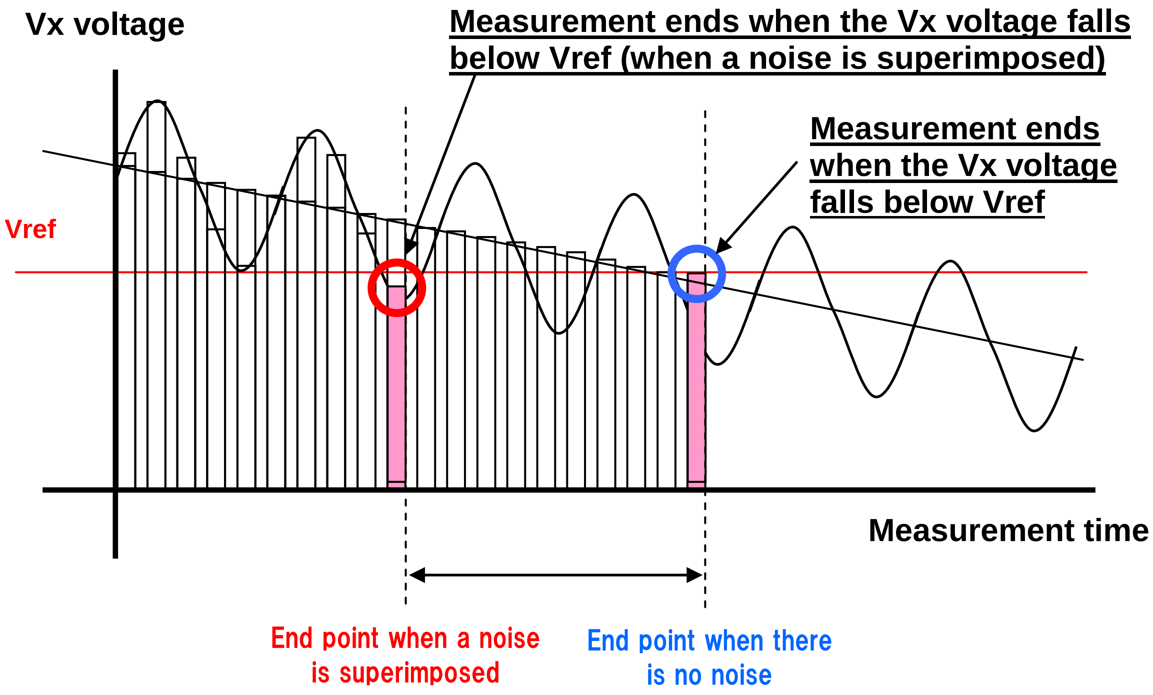


Figure 2-11 Measurement Waveform on Which a Periodic Noise Is Superimposed

Figure 2-11 shows a measurement waveform on which a periodic noise is superimposed. When a noise is superimposed, the Vx voltage falls below Vref in the process of measurement. Therefore, the measurement ends earlier as a result of the noise than would have been without it, resulting in failure in precise measurement.

Figure 2-12 and **Figure 2-13** are operation examples of the secondary counter. The secondary counter ends the measurement as described above. The primary counter increments only when the measured voltage is over Vref and ends count when the secondary counter ends operation. Regardless of whether a noise is superimposed or not, the primary counter value (measurement value) is the same value. This means the secondary counter is effective in noise elimination. The frequency band of noise which can be reduced using the secondary counter depends on an initial value and measurement cycle. When the initial value is 32 and the measurement cycle is 1.1 μSEC:

The upper limit of valid frequency = Initial value × Measurement cycle × 1/2

= 32 × 1.1 μSEC × 1/2 = Approx. 28 kHz

For more details of the secondary counter operation, refer to the application note “MW broadcasting noise immunity improvement by SCU”.

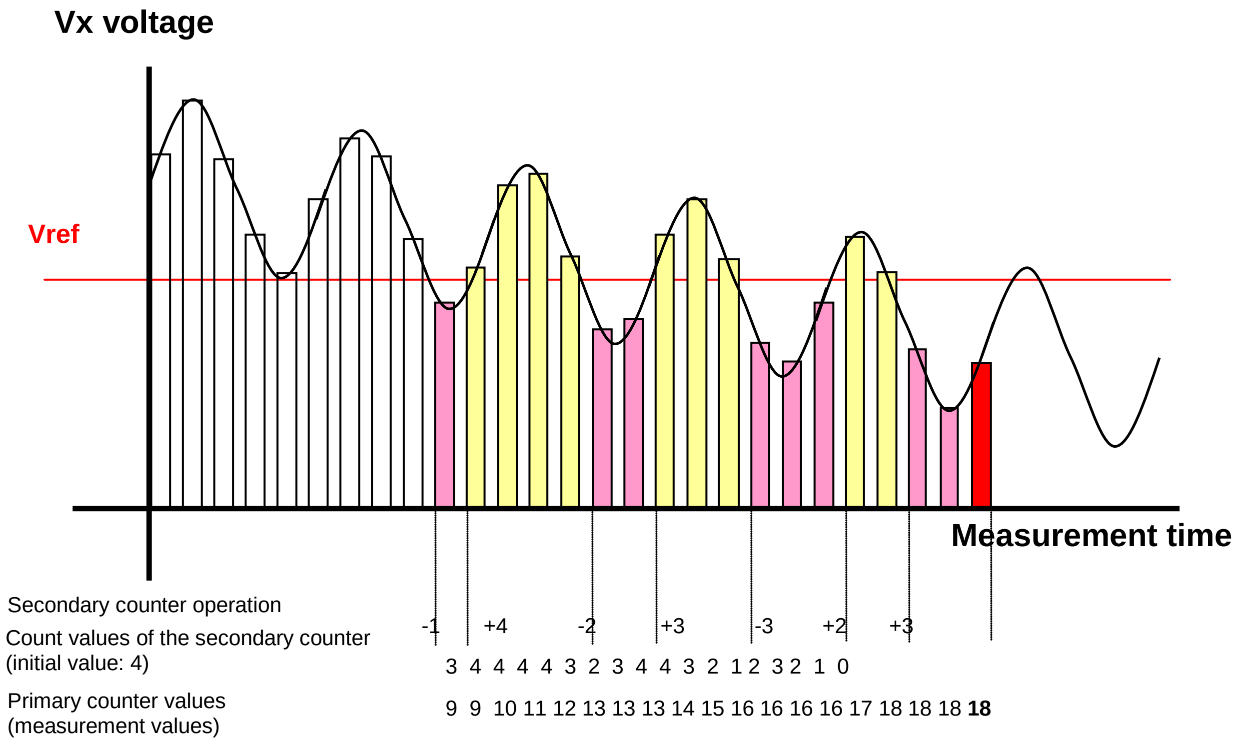


Figure 2-12 Operation Example of the Secondary Counter When a Noise Is Superimposed

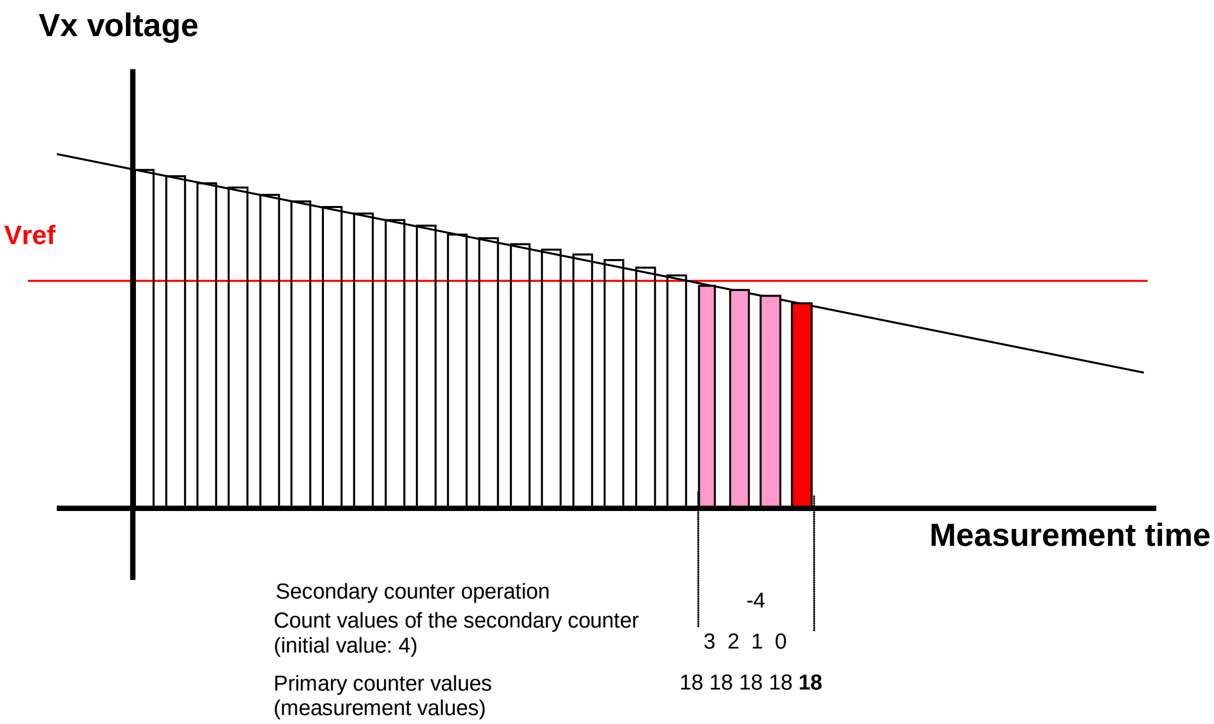


Figure 2-13 Operation Example of the Secondary Counter without Noise

2.2.3 Touch Measurement Waveform Length Adjustment

In touch measurement, charging and discharging Cr and Cx are repeated at a regular interval, so the measurement waveform has periodicity. Therefore, in a case where a noise intrudes via a human body causing the Cx values to change periodically, an alias wave (synthetic wave) may be generated depending on the noise frequency. As a result, the whole measurement waveform may heave up. **Figure 2-14** shows results from simulating the touch measurement waveforms.

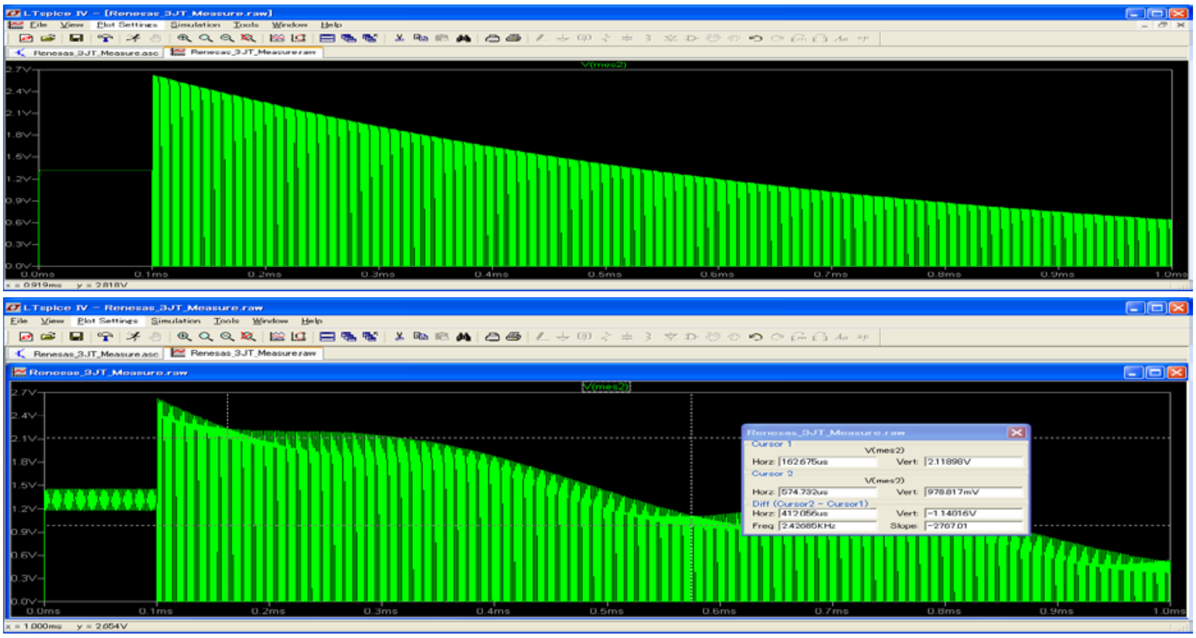


Figure 2-14 Touch Measurement Waveform Simulation

(Upper: without noise, lower: noise superimposed)

The measurement waveform heaves up only when the capacitance on the human body operating a touch key: Cx is fluctuating due to the noise. When a noise is imposed as an electromagnetic wave, the noise can be eliminated using the touch measurement timing adjustment described above.

The heave of the measurement waveform caused by the generated alias affects touch measurement. Reducing the influence requires to curb the generation of the alias wave. When the noise frequency is located near the measurement cycle, however, it is impossible to completely eliminate the noise. Therefore, the alias frequency to be generated is suppressed within the valid frequency of the secondary counter described above so as to curb the noise by adjusting the measurement frequency. Formula 1 shows a formula that will give the alias frequency from noise frequency and measurement frequency. Based on this formula and calculation of the valid frequency of the secondary counter, the measurement cycle should be adjusted as a countermeasure against the problematic noise frequency.

$$Fe = | Fn - (Fm \times n) |$$

Fe: Alias frequency
Fn: Noise frequency
Fm: Measurement frequency
n: Degree (Harmonics)

Formula 1 Alias Frequency Calculation

For more details, refer to the application note “MW broadcasting noise immunity improvement by SCU”.

2.2.4 Other TSCU Settings

(a) **Random Measurement**

Random measurement is used to reduce the noise influence by pseudo-randomizing the measurement timing of a periodic noise in order to spread the noise elements. The disadvantage is that sensitivity becomes unstable due to spread measurement values. For more details, refer to the hardware manual and the application note “MW broadcasting noise immunity improvement by SCU”.

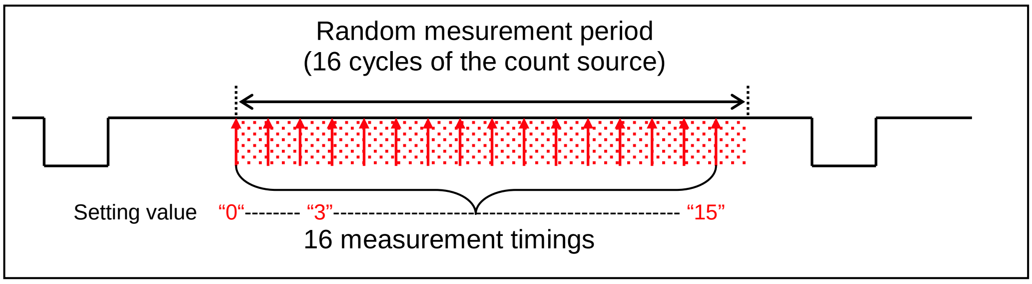


Figure 2-15 Random Measurement Timing

(b) **Measurement by Majority Decision**

Measurement by majority decision is used to find a result of touch measurement by determining it by the majority of the results from measurement timings set up to 15 times at one measurement. This method can reduce the influence from sporadic noises generated irregularly at one measurement. For more details, refer to the hardware manual and the application note “MW broadcasting noise immunity improvement by SCU”.

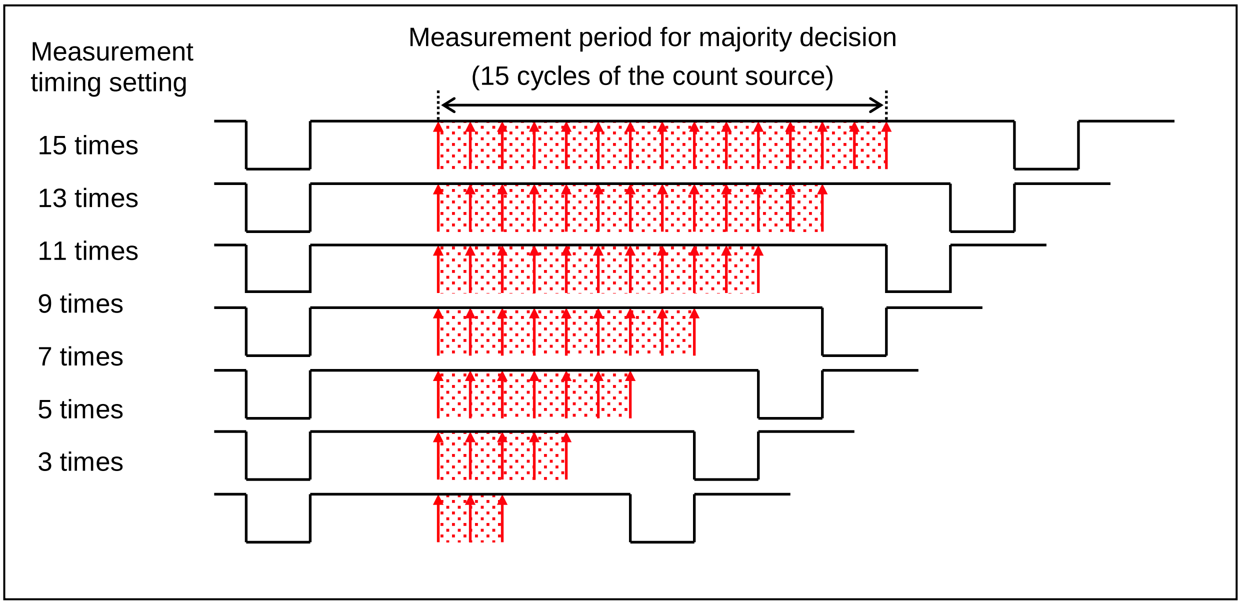


Figure 2-16 Timings for Measurement by Majority Decision

2.3 Countermeasures by Software

In addition to noise countermeasures by hardware, Renesas Touch MCU provides noise cancellation functions by software. This part explains such functions.

2.3.1 **Adjustment of Threshold Value**

The threshold value is the most basic and important adjustment point in touch measurement. The average value in a case of non-touch (reference value) and the measurement value in a case of touch are compared with the threshold value for touch judgment. When the difference between the two values is larger than the threshold value, the operation is determined as ‘touch’. Therefore, adjusting the threshold value means determining not only touch sensitivity but also margin to a noise. Figure 2-17 shows a relationship between the measurement value and the threshold value. Even when the count value changes due to a noise, the operation is not judged as touch unless the count value is below the threshold value.

As shown in Figure 2-1, the noise countermeasures by MCU hardware are focused on noises from inverter devices, etc. corresponding to frequency bandwidth up to several MHz. High-frequency noises emitted from a mobile phone or FM transceiver require adjusting the threshold value in addition to countermeasures by board design and chassis design.

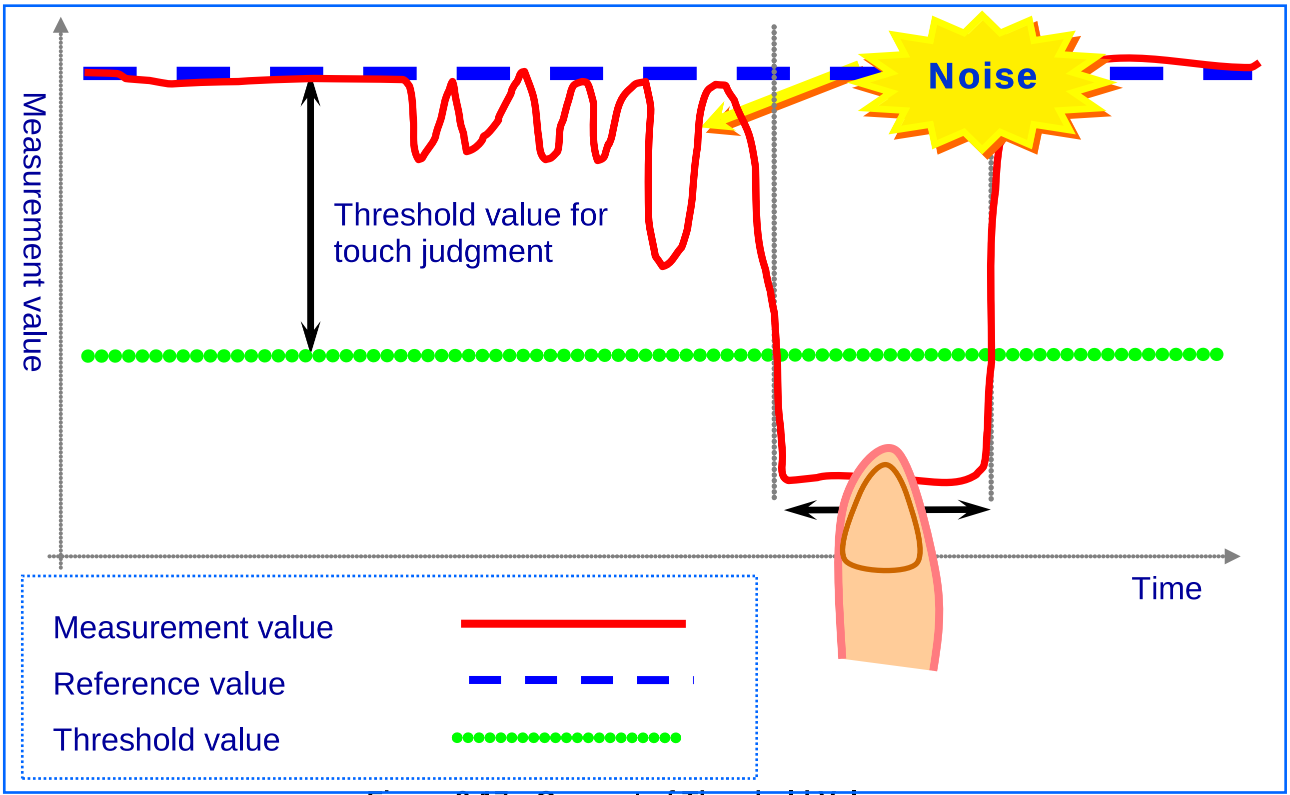


Figure 2-17 Concept of Threshold Value

Experience shows that the recommended threshold value is approximately 70 % of the difference. Note that, however, the threshold value should be adjusted appropriately according to specification of the product or noise surrounding. For more details, refer to the application note “Touch adjustment flow chart”.

2.3.2 Drift Correction

Whether a key is touched or not is determined by comparing the difference of measurement values at touch/ non-touch with the threshold value. A value obtained from averaging the measurement values at a certain period is used as a reference value, which is updated at regular intervals. This averaging method is called drift correction. Adjusting the number of times and period enables to minimize variability of touch measurement depending on changes in temperature or power supply voltage. The assumed frequency characteristic is 1 Hz or less. Faster updating interval may disable touch ON detection because drift correction responds sensitively when a key is touched. Figure 2-18 shows an example of drift correction. In this example, an average of 32 touch measurement values is used as the reference value for the next 32 touch measurements. For more details of drift correction, refer to the application note "S/W driver for Touch Sensor"

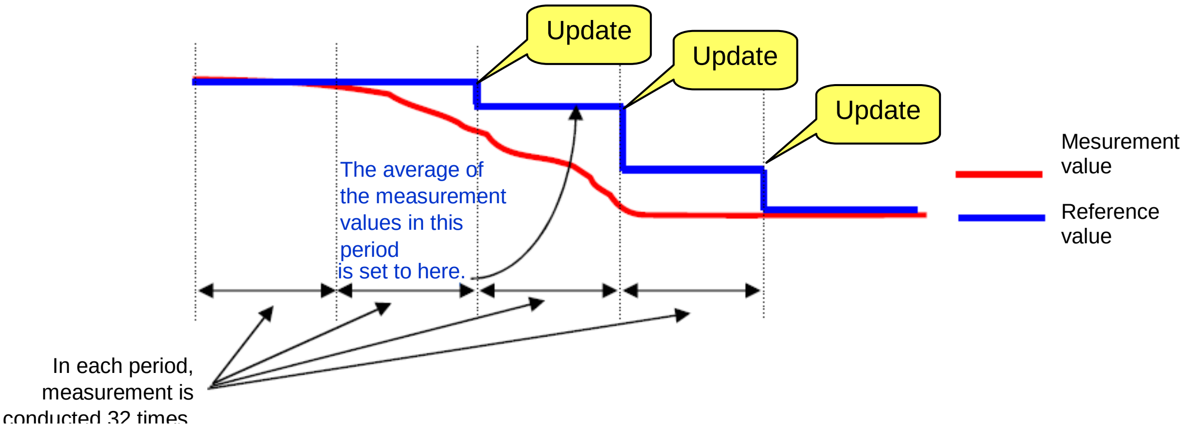


Figure 2-18 Drift Correction

2.3.3 Multi-touch Cancellation

Multi-touch cancellation is used to turn all keys off when the sum of amount of changes in a group, which is formed from grouped touch measurement channels, exceeds a certain value. In addition to cancellation in a case where multiple keys in one group are pushed, multi-touch cancellation functions to prevent the keys from operating incorrectly when a certain amount of noise is imposed on multiple channels. Specifically, when an electric wave is generated with a high-frequency noise source such as mobile phone or FM transceiver put on the surface of touch panel, the noise is uniformly imposed to all touch electrodes. Each noise countermeasure may not be enough to handle such case. With this multi-touch cancellation, malfunction of keys is prevented in such case. However, pushing simultaneously multiple keys is disabled on specification, so this multi-touch cancellation must be set to be executed after keys requiring multi-touch are categorized into such a group. For more details, refer to "S/W driver for Touch Sensor".

2.3.4 Measurement Cycle Adjustment

When operating in scan mode, TSCU conducts measurement on the touch channel set to be measured. After the last channel is measured, an interrupt is generated, and then TSCU enters waiting state to wait until receiving a start order. When TSCU is started next by a periodic timer, etc., the start timing at CH0 is normalized by MCU clock accuracy. If a noise with cycles synchronized with this timer is superimposed, measurement on CH0 and the noise are synchronized. As a result, a malfunction by the noise may occur only on the CH0. (This synchronization does not occur on other CHs.)

Figure 2-19 shows an example of synchronization of measurement cycles and the noise. In this example, there always are troughs of the noise waveform around the end of CH0 measurement. Therefore, the measurement ends earlier and the measurement value becomes small. As a result, only CH0 may be detected as touch ON. Although CH1, CH2, or later CH are also affected, CH with the larger CH number receives the less influence because the timing fluctuates.

To solve this problem, the TSCU start cycle is randomized not to be a regular cycle. As another solution, keeping a continuous measurement state by starting TSCU in the measurement end interrupt handling for randomization is also effective.

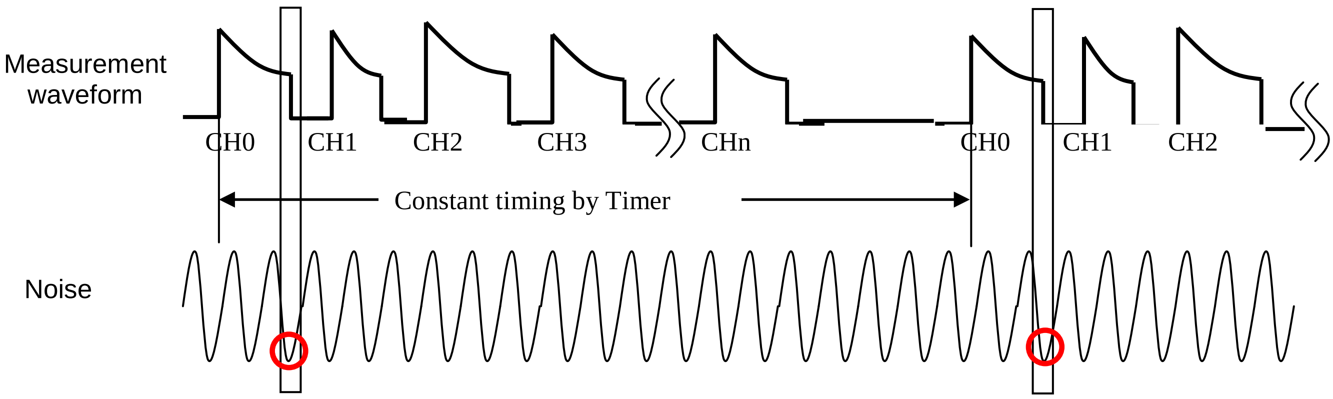


Figure 2-19 Synchronization of Measurement Cycles and Noise

2.3.5 Other Software Processing

(a) **Successive ON Cancellation**

Successive ON cancellation is a function to execute drift correction by turning the touch state off once when touch ON state continues for a certain number of times. It was originally developed to prevent a key from being continuously touched without intention. This functions to avoid the successive key ON state caused by noises.

(b) **Moving addition**

The measurement values detected by TSCU are always added for n times (as for the provided API, 4 times) in software processing so as to be used for touch ON/OFF judgment. This allows preventing misjudgment due to differences in measurement values caused by a spike noise. Increasing the number of additions raises noise tolerance; on the other hand however, it makes key response slowly.

(c) **First Key Recognition**

Noise in the system can cause increased sensitivity to a touch event. In many cases there will not be false touch events but once a valid touch is attempted multiple sensors will exceed the threshold. Multiple key reject can be used to prevent the multiple responses but this result in a loss of functionality. When this increased sensitivity is doing to noise it is found that the intended touch key reaches the threshold first, then adjacent keys react later as the noise influences the overall fields. Application level code is used to recognize a single touch and continue to “debounce” and decode only that channel until it is released. This works in conjunction with the Multiple Key Reject feature to provide a strong countermeasure to false actuations and still allow normal operation of the application

(d) **Application level “Debounce”**

Even with all the hardware and driver level countermeasures there still can be spurious touch “events” which result in a valid touch value returned from the driver level. The application or functional implementation layer should implement a “debounce” or noise rejection count function. Though the touch switches do not bounce this function is similar to a standard debounce function used for mechanical switches. It requires that the switch signal remains valid for a period of time before it is passed to the next higher level of processing. In touch detection it is typically very easy to implement by requiring any touch event to be consistent over a given number of scans. For example, if a single scan takes 10 milliseconds then the functional implementation layer could check for ten consecutive scans with the same key touched before it is registered as valid. The total response time is still 100 milliseconds which is typically acceptable.

3. Evaluation

To objectively evaluate noise tolerance of electrostatic capacitance method touch keys, a part of the noise immunity test IEC61000-4 Series is generally used. However, test items in IEC are not always equal to actual noise sources, which should be evaluated as well. In this chapter, test methods in IEC610000, those for noise source products which caused a problem, and respective test results on Renesas demo boards are introduced.

3.1 IEC61000 4-X Immunity Test

In IEC 61000-4 Series, several noise immunity tests have been defined. Among those tests, items related to noises on touch keys are the following two: 4-3 Radiation Electromagnetic Field Immunity Test and 4-6 RF Conducted Disturbance Immunity Test. While definition of ‘malfunction’ differs depending on each product, malfunction regarding touch keys is defined that any one of the touch keys is turned Off to ON during the test.

3.1.1 IEC61000 4-3 Radiation Electromagnetic Field Immunity Test

Radiation electromagnetic field immunity test is a test to evaluate disturbance to product operation by radio waves from transceiver, broadcasting station, and etc. Specifically to check malfunction, AM modulated vertical and horizontal waves are irradiated to the test target while each of the frequency is being swept from 80 MHz to 1 GHz. According to electric intensity used for the test, levels are defined.
3V/m: consumer equipment level (level 2), 10V/m: industrial equipment level (level 3)
For more details of the test contents, refer to IEC test specifications.

3.1.2 IEC61000 4-6 RF Conducted Disturbance Immunity Test

RF conducted disturbance immunity test is a test to confirm whether waves emitted from transceivers, broadcasting station, etc. disturb operations of the product by being conducted through its power supply line or signal lines. To check malfunction, AM modulated noise signals are applied to or superimposed on the power supply line using an induction coil while each of the frequency is being swept from 150 kHz to 80 MHz. According to the voltage level used for the test, levels are defined.
3V: consumer equipment level (level 2), 10V: industrial equipment level (level 3)
For more details of the test contents, refer to IEC test specifications.

3.1.3 Evaluation Result on Renesas Demo Boards

Table 3-1 shows the evaluation result of each RENESAS demo-board using R8C/36T-A and R8C/3JT.

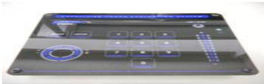
		R8C/36T-A WW kit 		R8C/3JT TV type board 
		Direct keys	Wheel & Slider	Direct Key only
EN61000-4-3	3V/m (consumer level)	80MHz-1000MHz Vertical/Horizontal Pass	80MHz-1000MHz Vertical/Horizontal Pass	80MHz-1000MHz Vertical/Horizontal Pass
	10V/m (industrial level)	80MHz-1000MHz Vertical/Horizontal Pass	Trying	80MHz-1000MHz Vertical/Horizontal Pass
EN61000-4-6	3Vrms (consumer level)	150KHz-230MHz Pass	150KHz-230MHz Pass	150KHz-80MHz Pass
	10Vrms (industrial level)	150KHz-230MHz Pass	Trying	150KHz-80MHz Pass

Table 3-1 Test Result on Renesas Demo Board

As the noise countermeasure depends on a panel shape, product design, noise environment and etc, we have to concern using and combining each noise countermeasure with checking their effects. The noise countermeasures each boards mount are shown bellow.

R8C/36T-A WW kit

- Electrodes and GND Shield of the Electrode Wiring
- Secondary Counter
- Adjustment of Threshold Value
- Drift Correction
- Moving addition
- First Key Recognition
- Multi-touch cancellation (implemented at application layer)
- Application level “Debounce”

R8C/3JT TV type board

- Touch Measurement Timing Adjustment
- Secondary counter
- Touch measurement waveform length adjustment
- Threshold value adjustment
- Drift correction
- Multi-touch cancellation
- Adjustment of measurement cycles
- Successive ON cancellation
- Moving addition

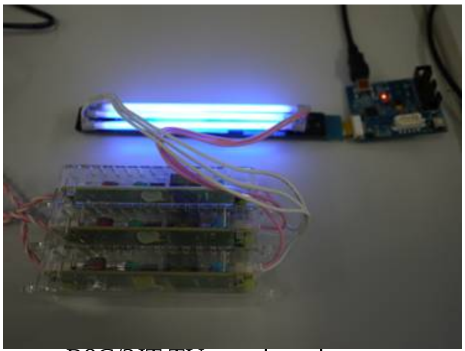
3.2 Noise Test from Each Product

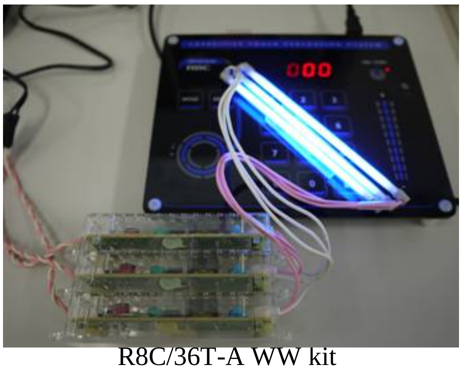
In addition to the immunity tests described above, Renesas conducts tests for noises emitted from actual products and components. Each test result is shown below.

3.2.1 Inverter Fluorescent Light

We tested the inverter fluorescent light noises as the inverter noise source. Figure 3-1 is shown the test environment. We tested the key malfunction and key operation with the noise environment that the touch board with the cold fluorescent tubes separated approximately 40mm by the acrylic chip. The cold fluorescent tube specifications are below.

- 3 tubes (110mm x 4mm size)
- Power supply 12V DC
- Inverter frequency about 50KHz (Little frequency drift by the load)





R8C/3JT TV type board R8C/36T-A WW kit

Figure 3-1 Noise test using the cold fluorescent tube light

As results, **<u>both of boards has no malfunction and no matter with operating by a finger touch.</u>**

3.2.2 FM Transceiver

We tested FM transceiver transmitting noise as as RF noise source. Figure 3-2 is shown the test environment. We tested the key malfunction and key operation with the noise environment that the touch board with the FM transceiver separated approximately 100mm from the board. FM transmitter specifications are below.

- 430MHz band FM transmitter (Tested 435.00MHz)
  - Output power 10W
  - Transmitting 3sec, Receiving 3sec, 10times repeats
  -

R8C/3JT TV type board R8C/36T-A WW kit

Figure 3-2 Noise test using FM transmitter

As results, **<u>both of boards has no malfunction and no matter with operating by a finger touch.</u>**

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Revision Record

Rev.	Date	Description	
		Page	Summary
1.00	May 22. 2013	—	Numbering change (Content is as same as R01AN1220EJ0100)

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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