R8C/38T-A group

R01AN1538EJ0100
Rev.1.00
May 21, 2013

MW broadcasting noise immunity improvement by SCU adjustment

Summary

The Touch panel microcomputer R8C/33T group contains a hardware peripheral (SCU: sensor control unit) that monitors the "touch" of the human body by measuring the stray capacitance generated between the touch electrode and the human.

In this application note, we show the example of improving immunity of the noise (especially Middle Wave broadcasting) conducted from the human body to the electrode when touching.

Target device

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

Contents

1. Frequency response

1.1 Outline

In capacitance Touch sensing, it is measured the count value by the threshold voltage of CHxA terminal. And the count value is sensitive to the noise from the power supply, human body, etc. In this application note, we show the method of the Middle Wave broadcasting noise (from the human body) immunity.

As shown “Figure 1-1”, when the human touches the electrode in the strong electric field (ex. near by MW broadcasting tower), the human receives radio wave like a antenna, and the potential difference is generated between the electrode and Earth. It is effect to the touch sensing.

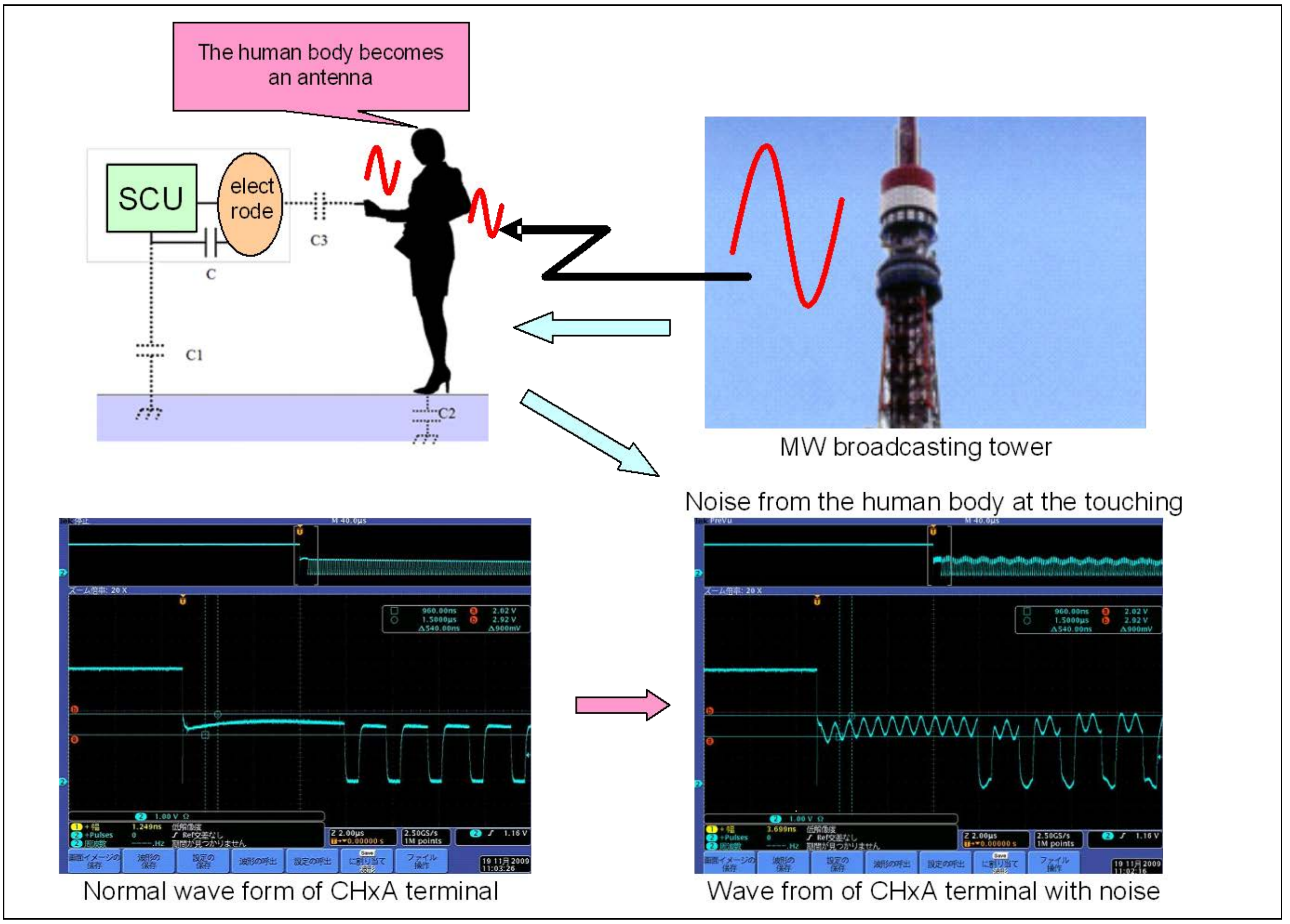

Figure 1-1 Noise incorporation from the human body

1.2 The main factor affecting to measurement

There are two factors affecting to the threshold of the touch measurement by R8C/33T.

(1) The noise wave over lied to the measurement waveform.

(2) The interfere wave generated by the measurement cycle and the noise cycle.

1.2.1 Superimposed periodicity noise to measurement waveform

R8C/33T series detects the touch ON/OFF by judgment the threshold at a constant cycle. (It is shown “Figure 1-2”) Therefore, when the noise wave over-lied to the measurement waveform, there is a possibility of failing the judgment.

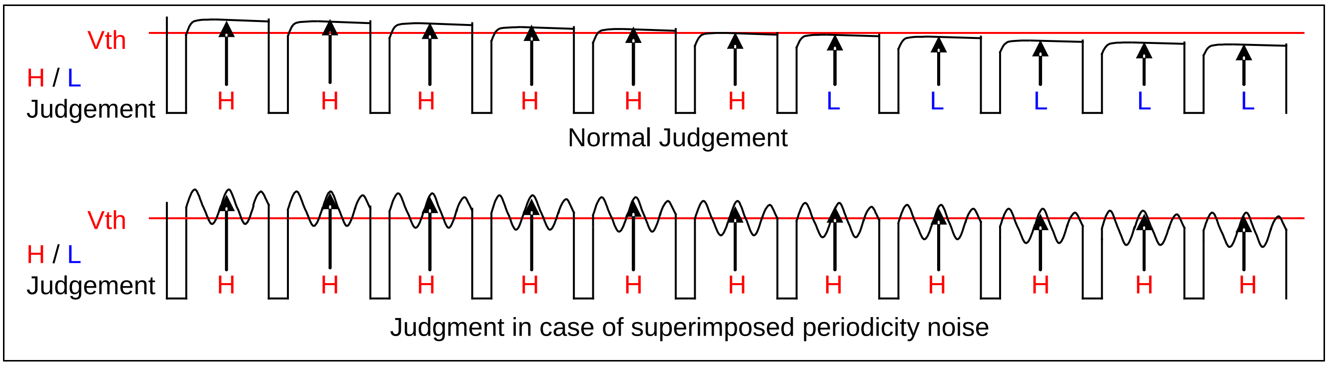

Figure 1-2 A case of superimposed periodicity noise

1.2.2 “Interfere wave” generated by the measurement cycle and the noise cycle

The electric capacity has been detected by repeating "The electrical discharge "Low" measurement "Hi-z"" in the measurement terminal. It is a one of the cyclic wave. In general, when different waves at the cycle comes in succession, the “Interfere wave” is generated, and it disturbs the measurement of the electric capacity.

“Figure 1-3 ” shows “Interfere wave” generated by the measurement cyclic wave and the noise cyclic wave.

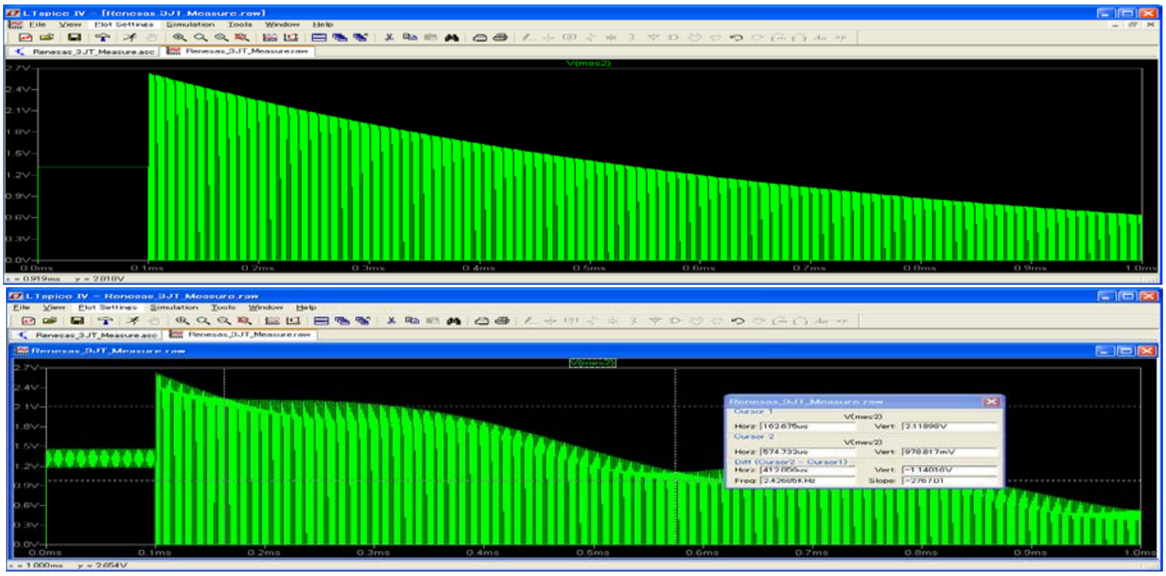

Figure 1-3 "Interfere wave” (Simulation model)

1.3 Frequency response change by SCU setting

1.3.1 Example of frequency response's changing by SCU register setting

“Figure 1-4” and “Figure 1-5” shows the frequency response change by SCU settings.

The chart of Mean value changing (1) and the chart of fluctuation band of measurement value(2) are defined as follows;

(1) The ratio of the measurement mean value when non-noise is impressed while touched 100 times and the measurement mean value when the noise is impressed while touched 100 times.

(2) The ratio of the standard deviation the measurement value change when non-noise is impressed while touched 100 times and the standard deviation the measurement mean value change when the noise is impressed while touched 100 times.

Impressed Noise; It is sine wave impressed to the touch panel through the dummy finger on the panel. The frequency is MW band (531 KHz - 1602 KHz) and sweeps 9 KHz step.

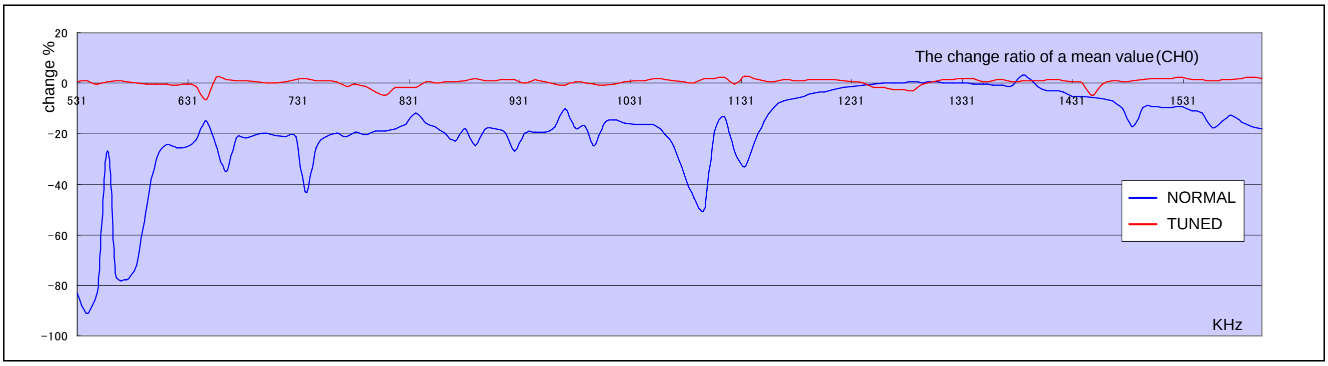

Figure 1-4 The chart of Mean value changing

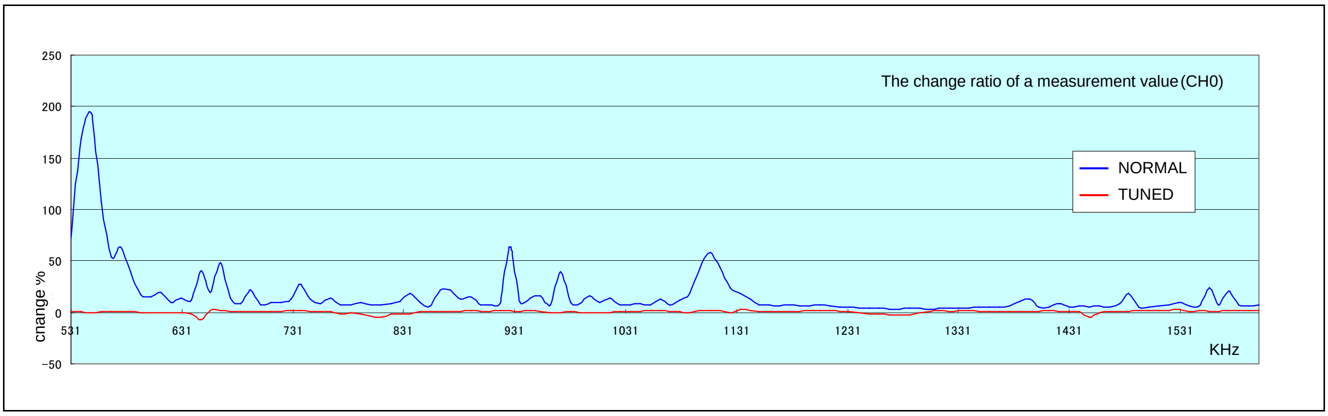

Figure 1-5 The chart of fluctuation band of measurement value

Setting condition

NORMAL setting: The measurement waveform length: 1.8 μSEC, Secondary counter: 7 times.

TUNED setting: The measurement waveform length: 6.2 μSEC, Secondary counter: 3 times,

Majority measurement ON: 15 times.

1.3.2 Frequency response data acquisition method and condition (reference)

“Figure 1-6 ” shows a environment for the acquisition of frequency response data, and “Figure 1-7” shows outline of the environment.

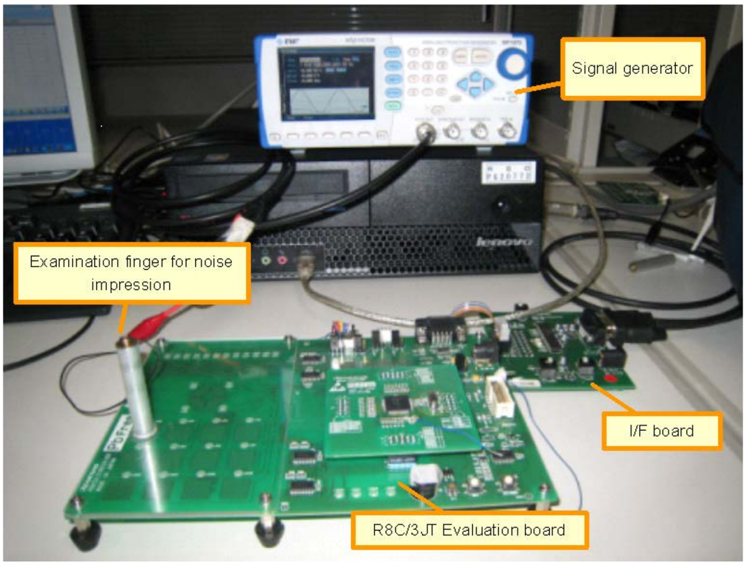

Figure 1-6 Picture of frequency response data acquisition environment

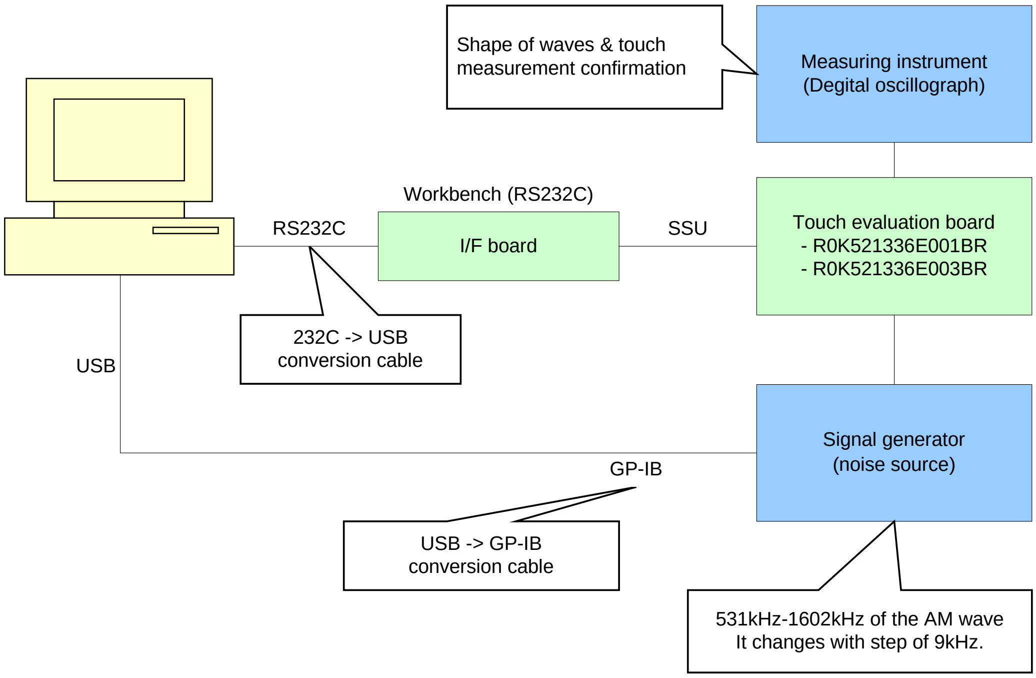

Figure 1-7 Outline of frequency response data acquisition environment

2. SCU registers

2.1 SCU Status Periods

"Figure 2-1" shows SCU Status Periods. Refer "R8C/33T Group Hardware Manual" for detail.

After Period 4 is defined as 'Pre measurement' and after Period 5 is defined as 'Main measurement'.

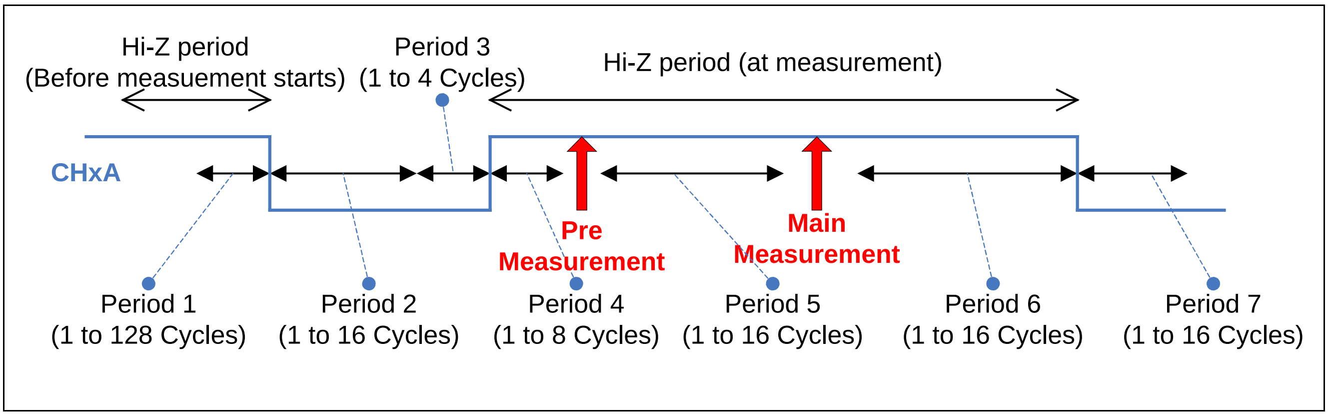

Figure 2-1 SCU Status Periods

2.2 SCU Control register 0 (SCUCR0)

Address 02C0h								
bit	b7	b6	b5	b4	b3	b2	b1	b0
Symbol	SCUIE	BCSHORT	SCCLK1	CSSLK0	DLTCKE	SCINIT	SCUE	SCSTRT
Initial value	0	0	0	0	0	0	0	0

Figure 2-2 The outline of SCU Control register 0

Table 2-1 The details of SCU Control register 0

Bit	Symbol	Bit name	Function	R/W
b0	SCSTRT	Measurement start bit	0: Measurement stops 1: Measurement starts	R/W
b1	SCUE	SCU operation enable bit	0: Operation disabled 1: Operation enabled	R/W
b2	SCINIT	SCU control block initialize bit	Writing 1 to this bit initializes the SCU control block and registers.	R/W
b3	DLYCKE	Delay clock enable bit	0: Operation disabled 1: Operation enabled	R/W
b4	SCCLK0	Count source select bit	00: f1 01: f2 10: f4 11: Do not set.	R/W
b5	SCCLK1			
b6	BCSHORT	CHxB - CHxC short select bit	0: No shorted (The shorting switch is always turned OFF.) 1: Shortened (The shorting switch is turned ON in Status 7 and 14, and turned OFF in status 4, 11, and 18. The switch is turned ON in Status 6 and 15, and turned OFF in Status 11)	R/W
b7	SCUIE	SCU interrupt enable bit	0:SCU interrupt disabled 1:SCU interrupt enabled	R/W

DLYCKE bit (Delay clock enable bit)

The unit of about 5 nsec makes the delayed thing possible the timing of the Main measurement. Refer to "4.4 Delay measurement" for details.

2.3 SCU Mode register (SCUMR)

Address 02C1h								
bit	b7	b6	b5	b4	b3	b2	b1	b0
Symbol	SCCAP1	SCCAP0	CONST	MJNUM2	MJNUM1	MJNUM0	RANDOM	PREMSR
Initial value	0	0	0	0	0	0	0	0

Figure 2-3 The outline of SCU Mode register

Table 2-2 The details of SCU Mode register

Bit	Symbol	Bit name	Function	R/W
b0	PREMSR	Pre measurement enable bit	0: Pre measurement disabled 1: Pre measurement enabled	R/W
b1	RANDOM	Random measurement enable bit	0: Random measurement disabled 1: Random measurement enabled	R/W
b2	MJNUM0	Majority measurement sampling times select bit	000: Majority measurement disabled 001: 3 times 010: 5 times 011: 7 times 100: 9 times 101: 11 times 110: 13 times 111: 15 times	R/W
b3	MJNUM1			R/W
b4	MJNUM2			R/W
b5	CONST	Measurement period constants select bit	0: No constant 1: Constant	R/W
b6	SCCAP0	Touch sensor measurement start trigger select bit	00: Software trigger (the SCSRT bit in the SCUCR0 register) 01: Do not set 10: Measurement start trigger from Timer RC 11: External trigger (SCUTRG)	R/W
b7	SCCAP1			R/W

PREMSR bit (Pre measurement enable bit)

Pre Measurement after Status Period 4 is enabled.

If the Pre measurement "H" recognition frequency was added to the Main measurement "H" recognition frequency, the number of measurement result counts becomes it.

Refer to "4.1 Pre measurement " for details.

RANDOM bit (Random measurement enable bit)

Random measurement is carried out in Main measurement after Status Period 5.

Refer to "4.2 Random measurement" for details.

MJNUM0-2 bit (Majority measurement sampling times select bit)

The Majority measurement is carried out in Main measurement after Status Period 5.

Moreover, it provides for the frequency of Majority measurement sampling.

Refer to "4.3 Majority measurement " for details.

CONST bit (Measurement period constants select bit)

Regardless of random setting/decision by majority frequency when you set random and the decision by majority sampling

Fixing the measurement section becomes possible.

The measurement section becomes changeable by random value/decision by majority frequency when not selecting it.

3. Frequency response improvement technique

3.1 The Case of the noise wave over-lied to the measurement wave

R8C/33T Group has three methods of noise reduction as follows;

(1) Random measurement

(2) Majority measurement

(3) Delay measurement

These measurements improves the weakness for the outside factor (periodical noise such as a broadcasting waves) by losing the periodicity of the electric potential judgment.

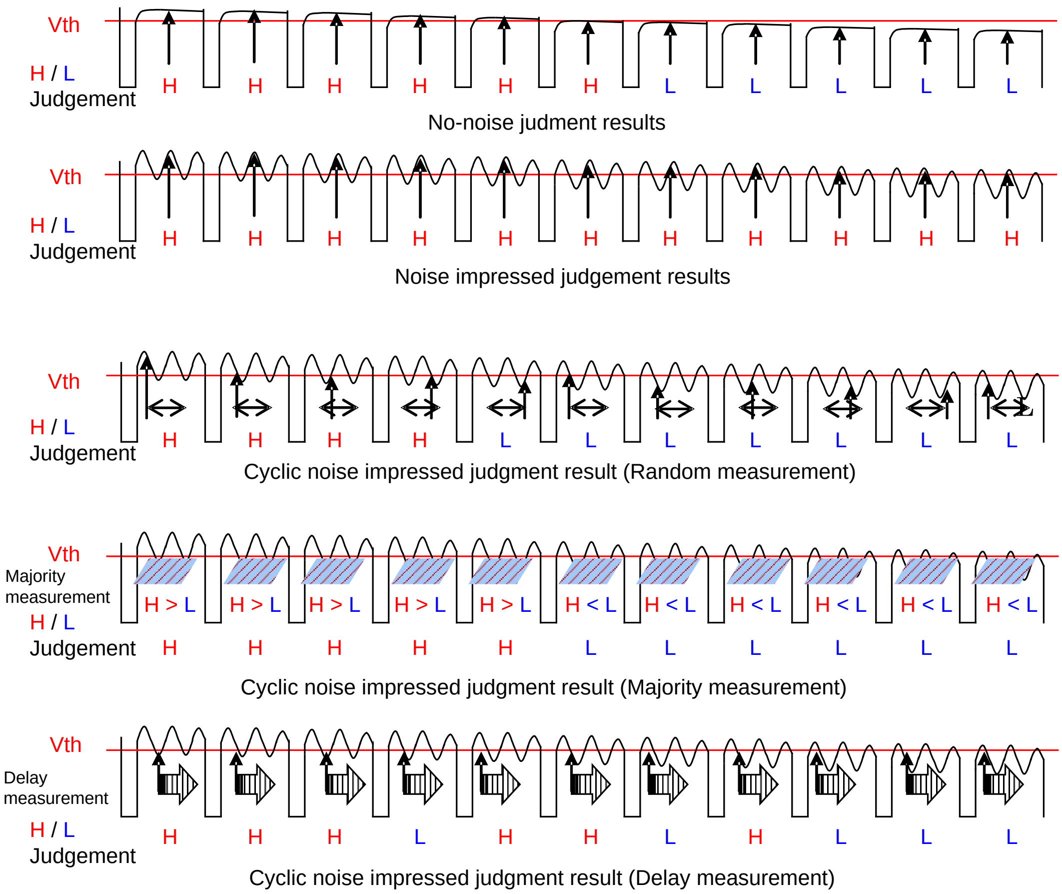

Figure 3-1 Noise reduction images

3.2 Case of "Interfere wave" generated by the measurement and the noise cycle

"Figure 3-1" shows the interfere noise reduction by using Secondly counter.

R8C/33T Group is able to reduce the noise by tuning the measurement waveform length and adjusting the SCU register of Secondly counter. These setting is worked for low frequency (10 KHz or less) noise cancellation, and it means setting "Lower frequency of Low-frequency noise cancellation".

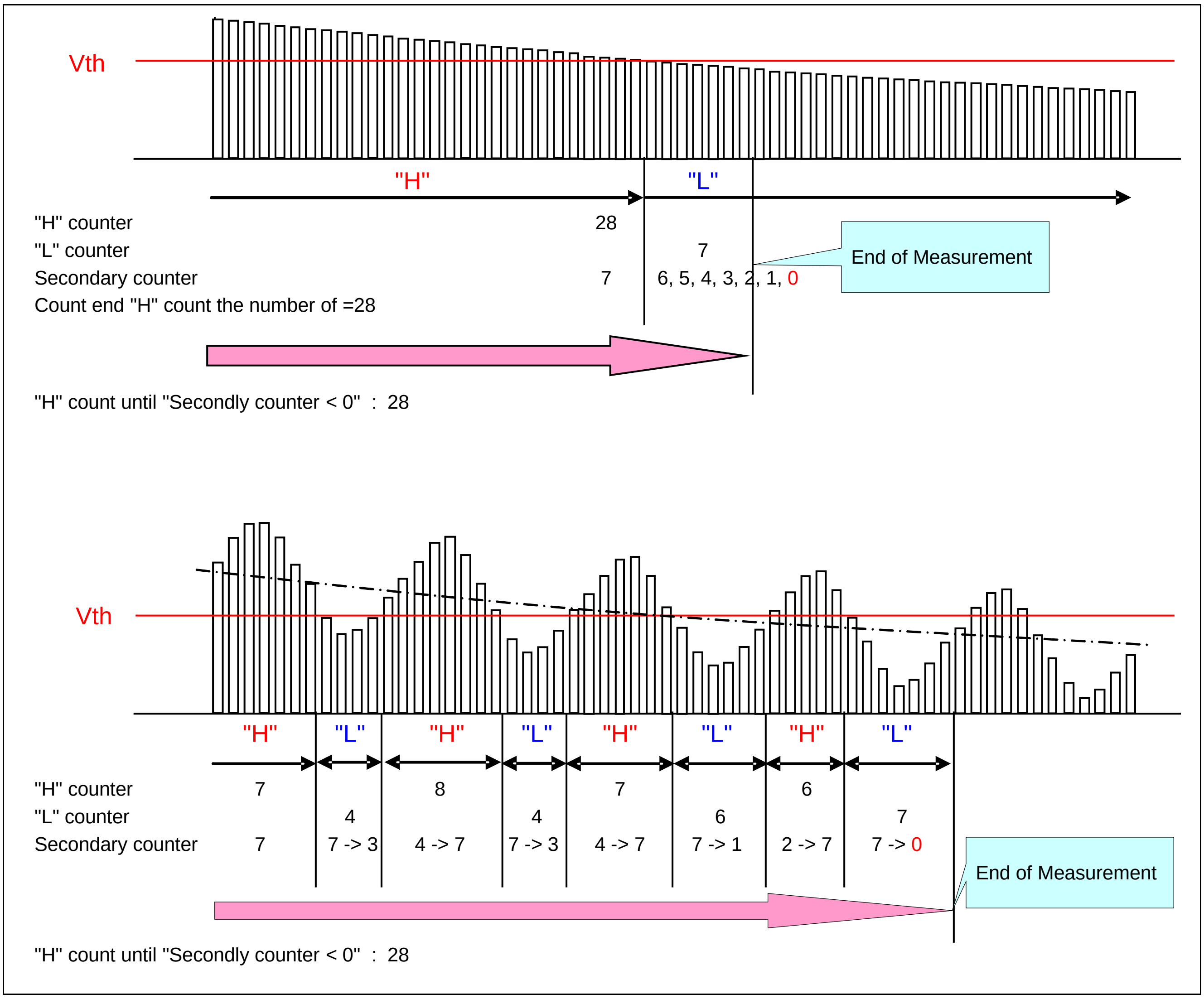

Figure 3-2 Image of noise reduction by using Secondary counter

Refer to the "4.5 Secondary counter" for details.

4. SCU Register setting

4.1 Pre measurement

4.1.1 The details about Pre measurement

Pre measurement executes a measurement after Status Period 4 (cf. "Figure 2-1") separately from the Main measurement.

The measurement value (of Primary/Secondary counter) is made from Pre and Main measurement result.

Table 4-1 and Table 4-2 shows values of Primary/Secondary counter using Pre and Main measurement.

Table 4-1 Count operation (Pre measurement is enabled) [measurement step-1]

Judgement of Pre measurement	Judgment of Main Measurement	Primary counter
H	H	+1 +1 = +2
H	L	+1 +0 = +1
L	H	+0 +1 = +1
L	L	+0 +1 = +0

Table 4-2 Count operation (Pre measurement is enabled) [measurement step-2]

Judgement of Pre measurement	Judgment of Main Measurement	Primary counter	Secondary counter
H	H	+1 +1 = +2	+1(*1)
H	L	+1 +0 = +1	-1
L	H	+0 +1 = +1	+1(*1)
L	L	+0 +1 = +0	-1

*1 The secondary counter setting register value is an upper bound. Only the MAIN result is reflected in the secondary counter

Regardless of the Main measurement type(Random measurement, Majority measurement, Delay measurement), Pre measurement can be used.

Note) Pre measurement is not able to use without Main measurement.

4.1.2 Register settings for Pre measurement

Address 02C1h								
bit	b7	b6	b5	b4	b3	b2	b1	b0
Symbol	-	-	-	-	-	-	-	PREMSR
Initial value	-	-	-	-	-	-	-	0

Figure 4-1 SCU Mode register (Extracts about Pre measurement settings)

Table 4-3 SCU Mode register (Extracts about Pre measurement settings)

Bit	Symbol	Bit name	Function	R/W
b0	PREMSR	Pre measurement enable bit	0: Pre measurement disabled. 1: Pre measurement enabled.	R/W
b1	-	-	-	-
b2	-	-	-	-
b3	-			-
b4	-			-
b5	-	-	-	-
b6	-	-	-	-
b7	-			-

Set “1” to PREMSR bit in case of using Pre measurement.

4.2 Random measurement

4.2.1 The details about Random measurement

Random measurement controls to change the measurement timing showing with “Figure 2-1”.

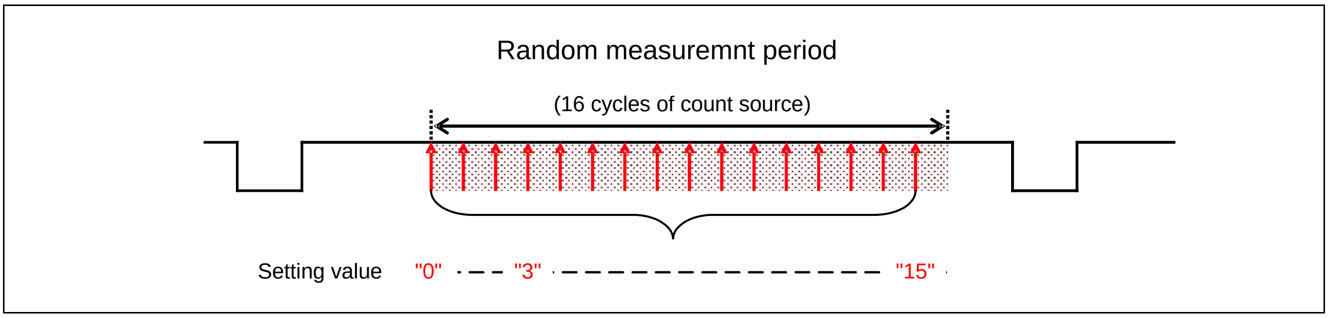

Figure 4-2 Random measurement period

<Specification>

1. Random measurement uses Random value storage register (SCRVR0 - SCRVR7). (4bit x 16 = 64bit = 8byte)
2. Measurement timing is 16 kinds. The value of SCRVR0 - SCRVR7 decides the measurement timing and the measurement order.

The timing of Random measurement is decided according to the value in Random value storage register (SCRVR0 - SCRVR7) after Status Period 5 showing “Figure 2-1”.

The range of the timing: “the setting values in SCRVR0 - 7” × “the cycle of count source”

SCRVR0 - 7 is referred in order from 0 to 15 at a measurement.

When the channel to measure is changed, SCRVR0 - 7 is referred to from (0).

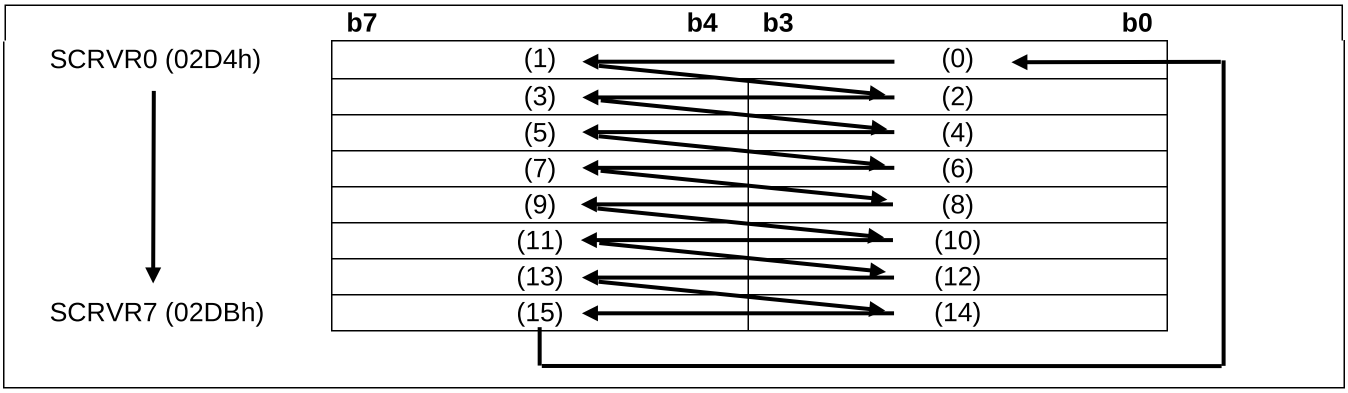

Figure 4-3 The order of reference to Random value storage register

4.2.2 Register settings for Random measurement

The register related to Random measurement is as follows.

Address 02C1h

bit	b7	b6	b5	b4	b3	b2	b1	b0
Symbol	-	-	CONST	-	-	-	RANDOM	-
Initial value	0	0	0	0	0	0	0	0

Figure 4-4 SCU Mode register (Extracts about Random measurement settings)

Table 4-4 SCU Mode register (Extracts about Random measurement settings)

Bit	Symbol	Bit name	Function	R/W
b0	-	-	-	-
b1	RANDOM	Random measurement enable bit	0: Random measurement disabled 1: Random measurement enabled	R/W
b2	-	-	-	-
b3	-			
b4	-			
b5	CONST	Measurement period constants select bit	0: No constant 1: Constant	R/W
b6		-	-	-
b7				-

Set “1” to RANDOM bit in case of using Random measurement.

Set “1” to CONST bit, when the measurement period is made constant regardless of the measurement timing at the Random measurement. (The setting of CONST bit is valid when Random measurement or Majority measurement is enabled)

The change of the measurement periods by the difference of CONST bit settings is as follows.

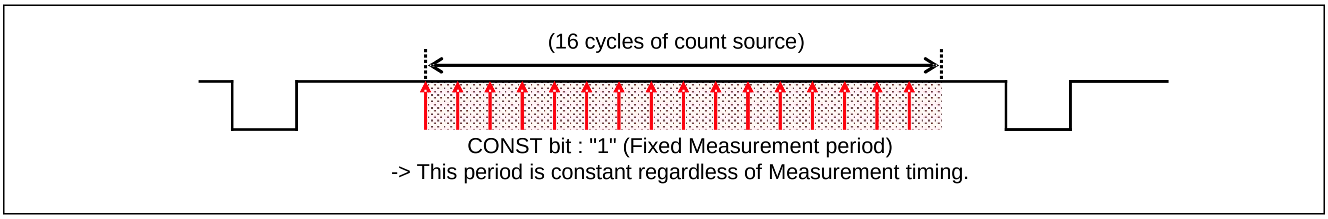

Figure 4-5 Fixed Measurement period

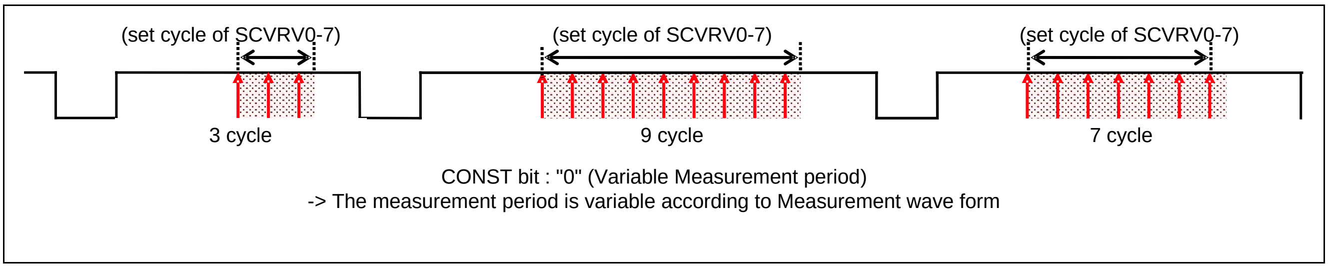

Figure 4-6 Variable Measurement period

4.2.3 Random value storage register settings

Table 4-5 Random value storage register

Address	Symbol	b7	b6	b5	b4	b3	b2	b1	b0	Value after reset
02D4h	SCRVR0	Reference (1)				Reference (0)				00h
02D5h	SCRVR1	Reference (3)				Reference (2)				00h
02D6h	SCRVR2	Reference (5)				Reference (4)				00h
02D7h	SCRVR3	Reference (7)				Reference (6)				00h
02D8h	SCRVR4	Reference (9)				Reference (8)				00h
02D9h	SCRVR5	Reference (11)				Reference (10)				00h
02DAh	SCRVR6	Reference (13)				Reference (12)				00h
02DBh	SCRVR7	Reference (15)				Reference (14)				00h

Set the measurement timing to reference (0) - (15) in the range of “0x00” - “0x0F”.
It is not necessary to be unique value, if the value is within the above range.

A example of setting of Random value storage register settings and measurement timing related to the setting are as follows.

Table 4-6 Example of SCRVR0 - 7 settings

02D4h	SCRVR0	A	3
02D5h	SCRVR1	5	C
02D6h	SCRVR2	1	8
02D7h	SCRVR3	4	9
02D8h	SCRVR4	E	2
02D9h	SCRVR5	6	B
02DAh	SCRVR6	F	0
02DBh	SCRVR7	7	D

Table 4-7 Measurement timing changing

Reference order	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	0	1	2	3	4	--	--	--
Measurement timing	3	A	C	5	8	1	9	4	2	E	B	6	0	F	D	7	3	A	C	5	8	--	--	--

Note:

The settings of Random value storage register(SCRVR0 - 7) is held until the setting is changed. Therefore, Measurement will be carried out repeatedly according to the 16 kinds of measurement timings.
16 kinds of measurement timings may not be effective in the specific noise frequency band.
In that case, consider countermeasures, for example, to decide the value of the Random value storage register settings using a random number.

4.3 Majority measurement

4.3.1 The details about Majority measurement

Majority measurement measures the number of times that is set during the measurement period, and judges “H”/”L” from measurement results using decision by majority.

Refer to “Figure 2-1” about the measurement periods.

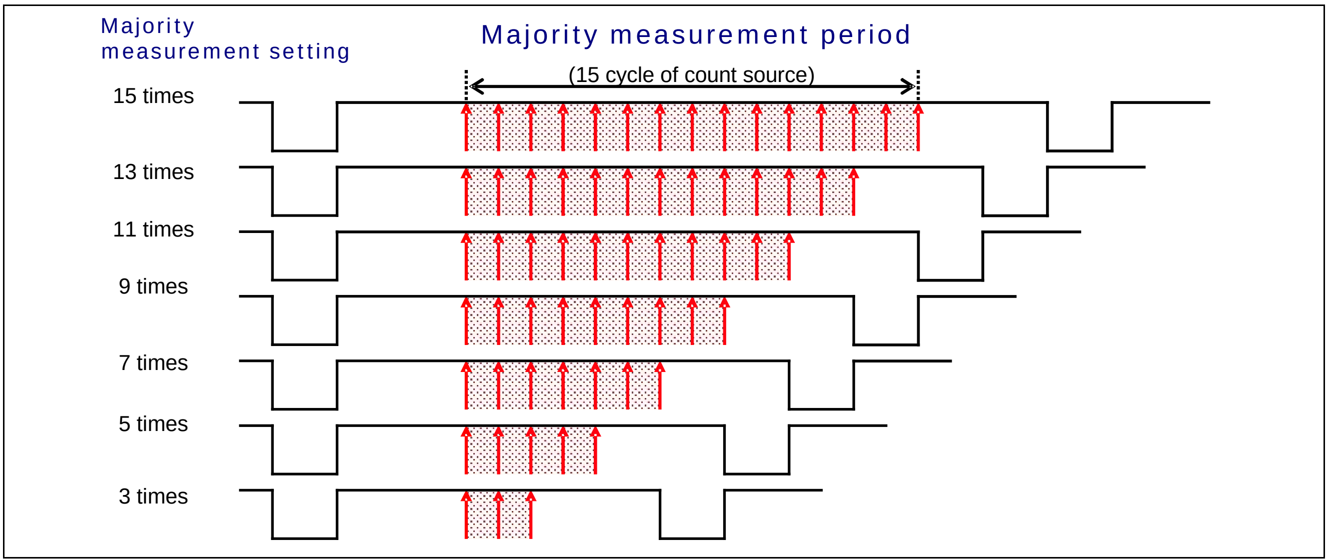

Figure 4-7 Majority measurement image

The Majority measurement judges “H”/”L” for the specified number of times in a measurement waveform and judges ‘H’ or ‘L’ using decision by majority. In addition, an interval of Majority measurement is decided according to the cycle of count source.

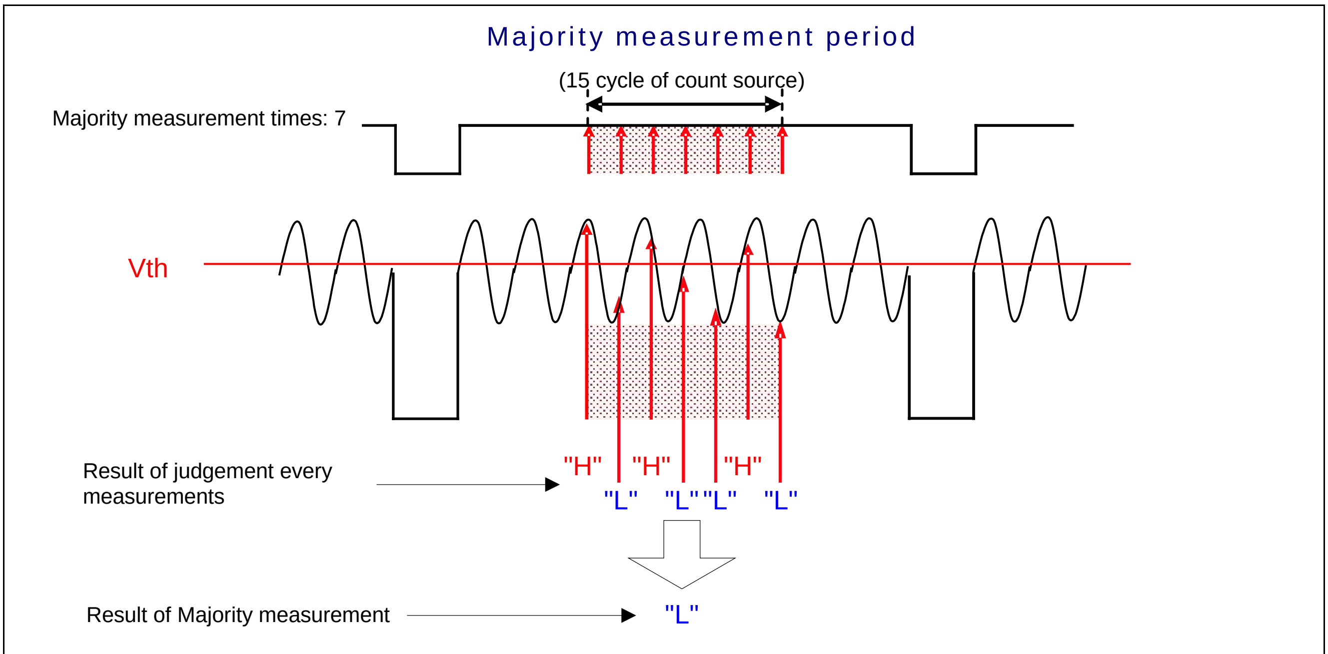

Figure 4-8 Judgement of Majority measurement

4.3.2 Register settings for Majority measurement

The register related to Majority measurement is as follows.

Address 02C1h								
bit	b7	b6	b5	b4	b3	b2	b1	b0
Symbol	-	-	CONST	MJNUM2	MJNUM1	MJNUM0	-	-
Initial value	0	0	0	0	0	0	0	0

Figure 4-9 SCU Mode register (Extracts about Majority measurement settings)

Table 4-8 SCU Mode register (Extracts about Majority measurement settings)

Bit	Symbol	Bit name	Function	R/W
b0	-	-	-	-
b1	-	-	-	-
b2	MJNUM0	Majority measurement sampling times select bit	000: Majority measurement disabled 001: 3 times 010 5 times 011: 7 times 100: 9 times 101: 11 times 110: 13 times 111: 15 times	R/W
b3	MJNUM1			R/W
b4	MJNUM2			R/W
b5	CONST	Measurement period constants select bit	0: No constant 1: Constant	R/W
b6	-	-	-	-
b7	-			-

Set a value from “1” to “7” to MJNUM0 - MJNUM2 bit in case of using Majority measurement. Setting “0” to MJNUM0 - MJNUM2 invalidates Majority measurement.

Set “1” to CONST bit, when the measurement period is made constant regardless of the number of Majority measurements. (The setting of CONST bit is valid when Random measurement or Majority measurement is enabled.)

The change of the measurement period by the difference of CONST bit settings is as follows.

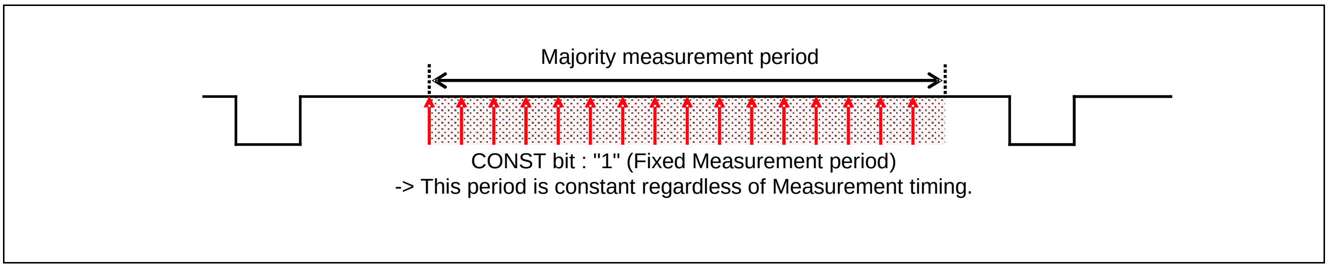

Figure 4-10 Fixed Majority measurement period

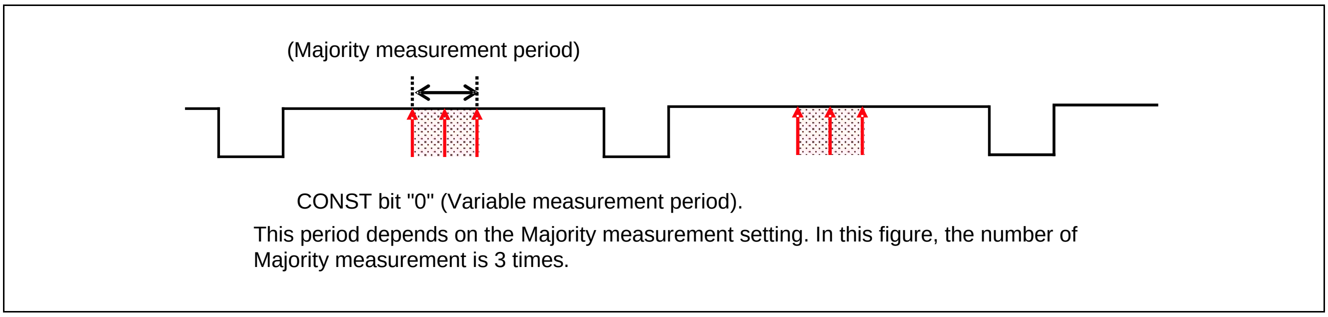

Figure 4-11 Variable Majority measurement period

4.4 Delay measurement

4.4.1 The details about Delay measurement

The Delay measurement can delay timing of measurement (Main measurement, Random measurement, Majority measurement) by a unit for 5 nsec uniformly. The quantity of delay is set in SCRVR0 - 7.

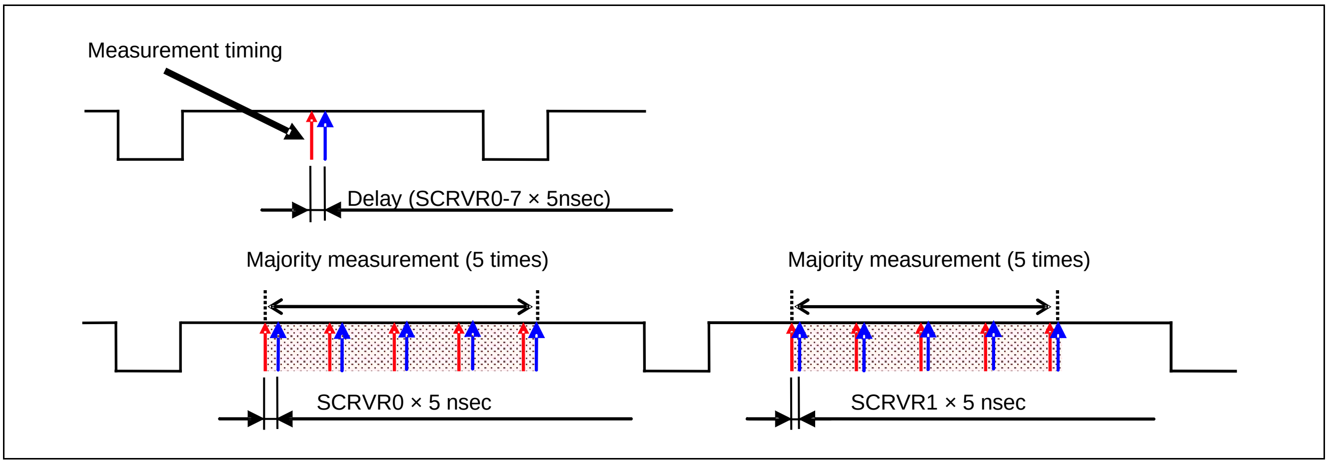

Figure 4-12 Delay measurement

< Specification >

1. Delay measurement uses Random value storage register SCRVR0-7 as a storage for Delay coefficient. (4bit × 16 = 64bit = 8byte). Delay coefficient uses 0-2 bits and 4-6 bits in SCRVR0 - 7.
2. The Delay time at the measurements is decided according to SCRVR0 - 7.

When Delay measurement is effective, the Delay is decided according to 0-2 bit or 4-6 bit of the Delay coefficient storage register (SCRVR0 - 7) after Status Period 5 showing in “Figure 2-1”.

Delay: “setting value in SCRVR0 - 7” × “5 nsec”

Delay coefficient storage register is referred in order from (0) to (15) every measurement showing in the following figure. After reference (15), the reference is started from reference (0). When the channel to measure is changed, SCRVR0 - 7 is referred from (0).

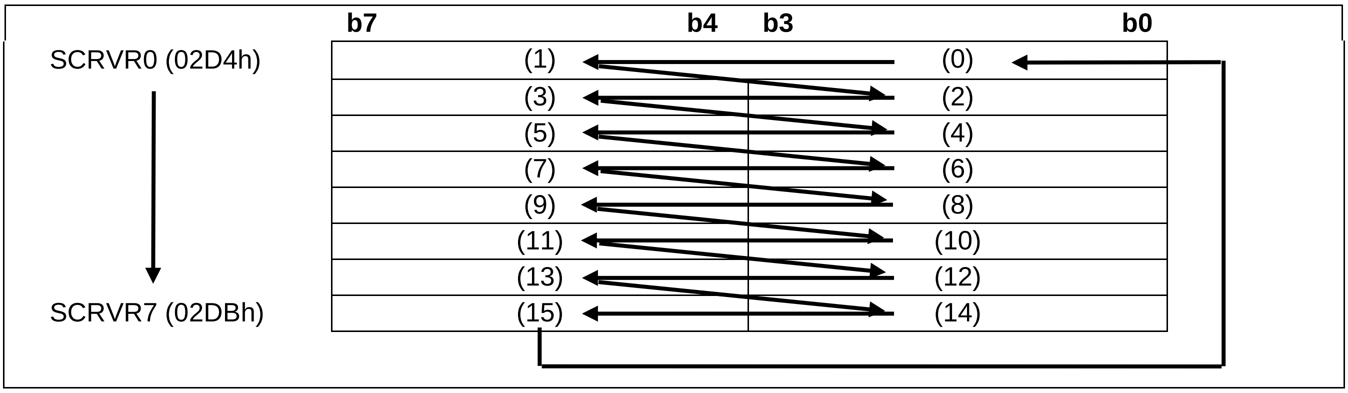

Figure 4-13 Delay coefficient storage register (using together with Random value storage register)

4.4.2 Register settings for Delay measurement

The register related to Delay measurement is as follows.

Address 02C0h

bit	b7	b6	b5	b4	b3	b2	b1	b0
Symbol	-	-	-	-	DLYCKE	-	-	-
Initial value	0	0	0	0	0	0	0	0

Figure 4-14 SCU Control register (Extracts about Delay measurement settings)

Table 4-9 SCU Control register (Extracts about Delay measurement settings)

Bit	Symbol	Bit name	Function	R/W
b0	-	-	-	-
b1	-	-	-	-
b2	-	-	-	-
b3	DLYCKE	Delay clock enable bit	0: Delay measurement disabled 1: Delay measurement enabled	R/W
b4	-	-	-	-
b5	-	-	-	-
b6	-	-	-	-
b7	-	-	-	-

Set “1” to DLYCKE bit in case of using Delay measurement

4.4.3 Delay coefficient storage register settings

Table 4-10 Delay coefficient storage register (used with Random value storage register)

Address	Symbol	b7	b6	b5	b4	b3	b2	b1	b0	Value after reset
02D4h	SCRVR0	-	Reference (1)			-	Reference (0)			00h
02D5h	SCRVR1	-	Reference (3)			-	Reference (2)			00h
02D6h	SCRVR2	-	Reference (5)			-	Reference (4)			00h
02D7h	SCRVR3	-	Reference (7)			-	Reference (6)			00h
02D8h	SCRVR4	-	Reference (9)			-	Reference (8)			00h
02D9h	SCRVR5	-	Reference (11)			-	Reference (10)			00h
02DAh	SCRVR6	-	Reference (13)			-	Reference (12)			00h
02DBh	SCRVR7	-	Reference (15)			-	Reference (14)			00h

Set the Delay value to reference (0) - (15) in range of “0x00” - “0x07”. In addition, bit 3 and bit 7 are always ignored.
It is necessary to be unique value, if the value is within the above range.

An example of the setting of the Delay coefficient storage register and the quantity of delay are as follows.

Table 4-11 Example of SCRVR0-7 for Delay coefficient (using with Random value)

Address	Symbol	Register setting value		Random value		Delay value	
		4 - 7 bits	0 - 3 bits	Valid value	Valid value	Valid value	Valid value
02D4h	SCRVR0	A	3	A	3	2	3
02D5h	SCRVR1	5	C	5	C	5	4
02D6h	SCRVR2	1	8	1	8	1	0
02D7h	SCRVR3	4	9	4	9	4	1
02D8h	SCRVR4	E	2	E	2	6	2
02D9h	SCRVR5	6	B	6	B	6	3
02DAh	SCRVR6	F	0	F	0	7	0
02DBh	SCRVR7	7	D	7	D	7	5

Table 4-12 Measurement timing change by setting

Reference order	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	0	1	2	3	4	--	--	--
Delay coefficient	3	2	4	5	0	1	1	4	2	6	9	6	0	7	5	7	3	2	4	5	0	--	--	--

Note:

Delay coefficient storage register is used together with Random value storage register. Therefore lower 3 bit of Random value becomes the Delay when random measurement and Delay measurement are used at the same time.
Set SCU clock in 10 MHz or less, in case of using Delay measurement.

4.5 Secondary counter

4.5.1 The details for Secondary counter

This chapter explains Low-frequency noise cancellation by the use of Secondary counter.

Refer to [R8C/33T Hardware manual] about the measurement using Primary counter and Secondary counter. The examples that "Interfere wave" has an influence on the measurement are shown in “Figure 4-15” and “Figure 4-16”.

R8C/33T carries out measurement by a judgment of the threshold in the measurement timing. The end of measurement is judged by the subtraction of Secondary counter.

In the normal judgment of threshold, after “L” detection, R8C/33T measures a number of times set in Secondary counter and finishes a measurement. However, under the influences of “Interfere wave”, R8C/33T carries out a addition of Secondary counter when "H" is detected in a judgment of the threshold before the subtraction of the Secondary counter becomes “0”. The early end of the measurement by the judgment of periodic "L" due to a fall of the electric potential by the “Interfere wave” is prevented in this way, and the influence of the periodicity noise is reduced.

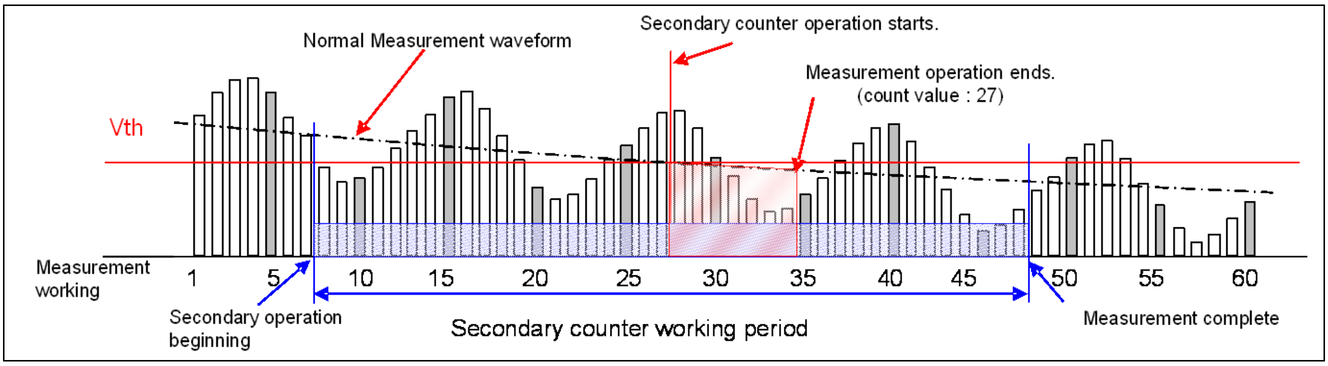

Figure 4-15 Example: Secondary counter setting = 7 times

Secondary counter is disable

Measurement	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Primary counter	1	2	3	4	5	6	7	7	Measurement value 7									
Threshold judging	H	H	H	H	H	H	H	L	“L" The measurement is ended by detection.									

Secondary counter is enable (Secondary counter setting: 7 times)

Measurement	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Primary counter	1	2	3	4	5	6	7	7	7	7	7	8	9	10	11	12	13	14
Secondary counter	7	7	7	7	H	7	7	6	5	4	3	4	5	6	7	7	7	7

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
15	15	15	15	15	16	17	18	19	20	21	22	22	22	22	22	22	22
7	6	5	4	3	4	5	6	7	7	7	7	6	5	4	3	2	1

37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
23	24	25	26	27	27	27	27	27	27	27	Measurement value 27						
2	3	4	5	6	5	4	3	2	1	0	Secondary CNT = 0->measurement end						

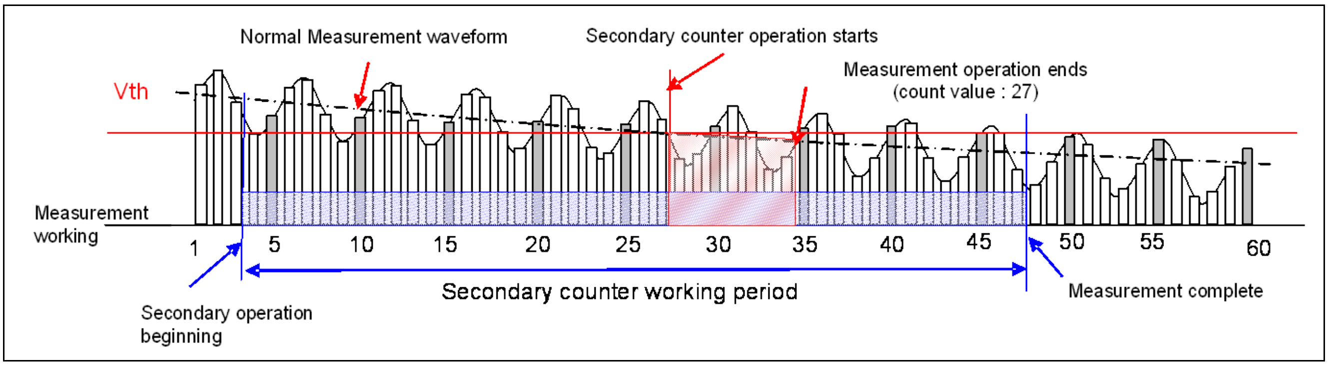

Figure 4-16 Example: Secondary counter setting = 2 times

Secondary counter is disable

Measurement	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Primary counter	1	2	3	3	Measurement value 3													
Threshold judging	H	H	H	L	"L" The measurement is ended by detection.													

Secondary counter is enable (Secondary counter: 7 times)

Measurement	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Primary counter	1	2	3	3	4	5	6	7	7	8	9	10	11	11	12	13	14	14
Secondary counter	7	7	7	6	7	7	7	7	6	7	7	7	7	6	7	7	7	6

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
14	15	16	17	17	17	18	19	20	20	20	22	23	24	24	24	25	26
5	6	7	7	6	5	6	7	7	6	5	6	7	7	6	5	6	7

37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
26	26	26	27	28	28	28	28	28	28	28	Measurement value 27						
6	5	4	5	6	5	4	3	2	1	0	Secondary CNT = 0->measurement end						

4.5.2 Secondary counter setting and Lower frequency of Low-frequency noise cancellation

Low-frequency noise cancellation with Secondary counter makes use of a periodicity of "Interfere wave".

This chapter takes the measurement in the neighborhood of the threshold for an example and explains relations between Secondary counter setting and Lower frequency of Low-frequency noise cancellation.

The principle of Low-frequency noise cancellation with Secondary counter is as follows.

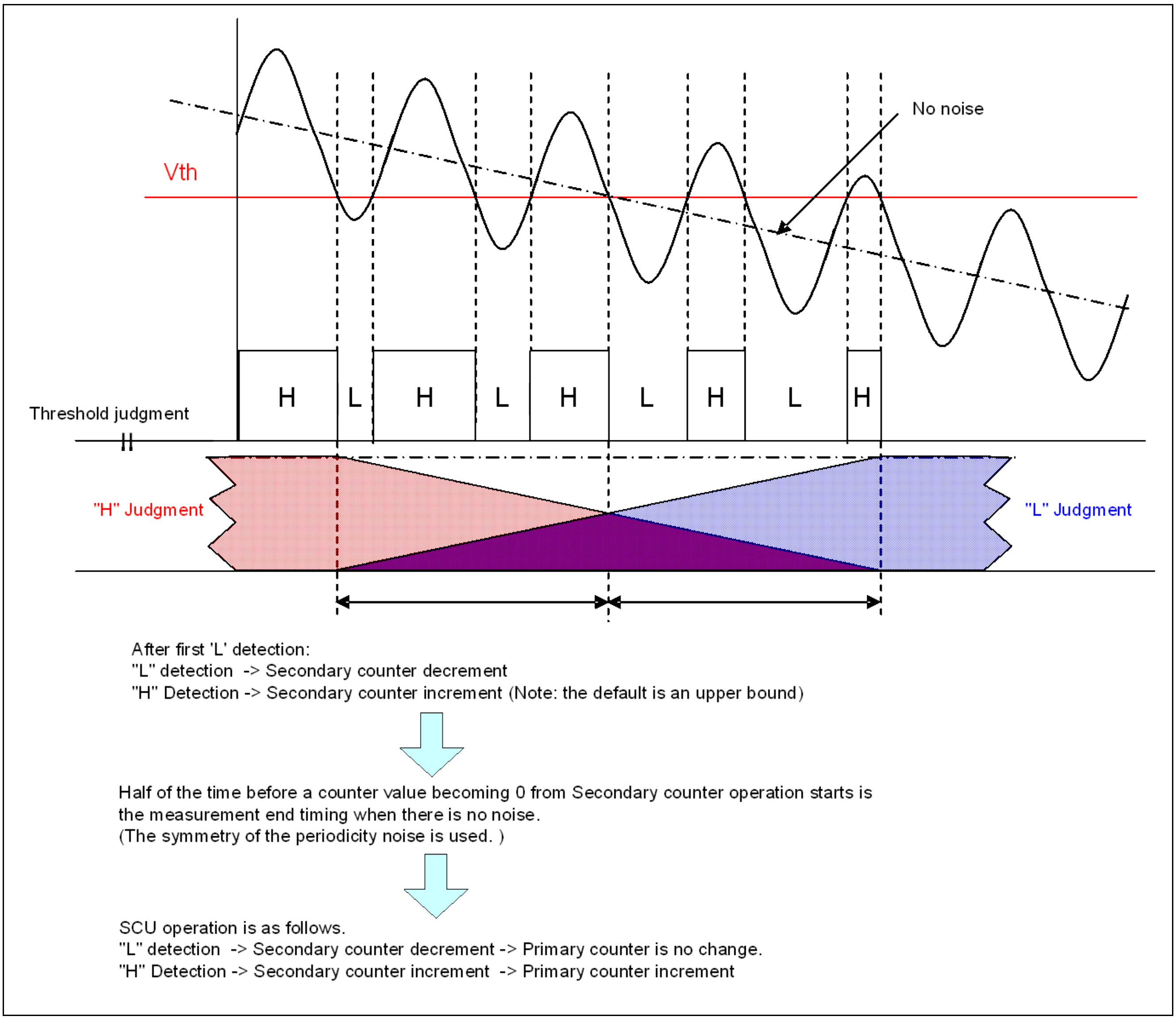

Figure 4-17 Noise cancellation using Secondary counter

The explanation about Lower frequency of Low-frequency noise cancellation is as follows.

As previously described, the Low-frequency noise cancellation with Secondary counter makes use of the symmetricalness of noise cycle. The timing of measurement end depends on the setting of Secondary counter. The relation between Secondary counter and the noise cycle is as follows.

To operate the noise cancellation with Secondary counter effectively, a product of “Counter operating time” by “Secondary counter initial value” is necessary more than half of the noise cycle.

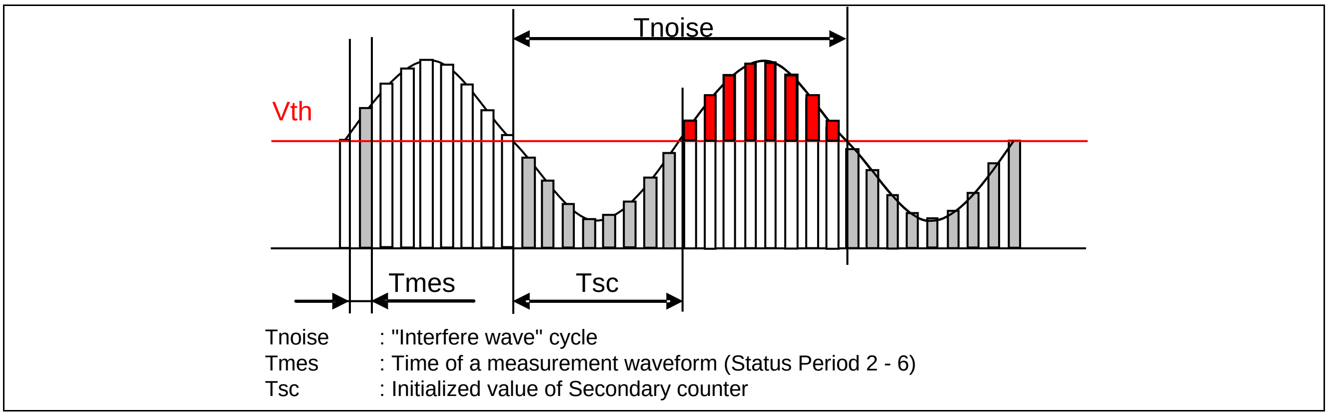

Figure 4-18 Relations between Secondary counter and Noise cycle

The differences of the measurement value by the setting of Secondary counter are as follows.

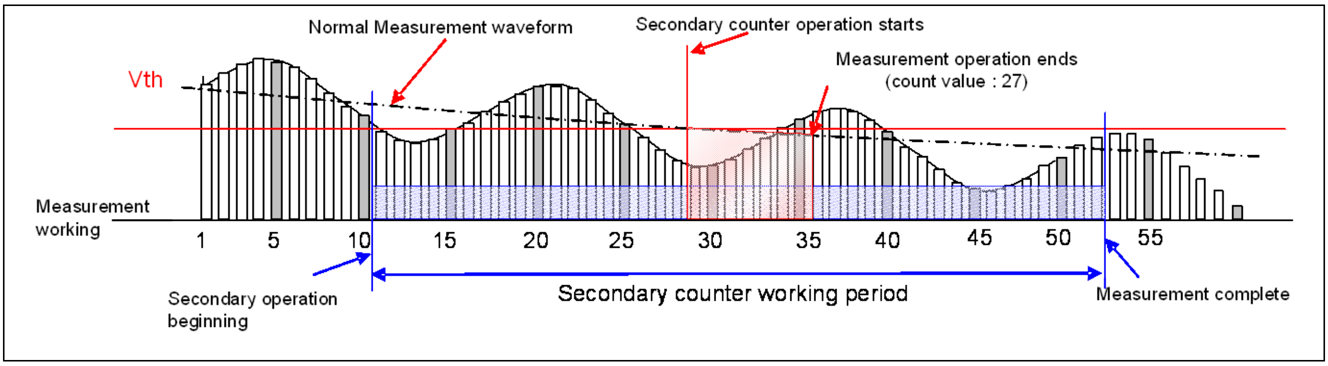

Figure 4-19 Measurement end timing: Secondary counter setting = 7 times

Secondary counter setting: 7 times (SCSCSR = 07h)

Measurement	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Primary counter	1	2	3	4	5	6	7	8	9	10	10	10	10	10	11	12	13	14
Secondary counter	7	7	7	7	7	7	7	7	7	7	6	5	4	3	4	5	6	7

	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	15	16	17	18	19	20	21	21	21	21	21	21	21	21	Measurement value :21			
	7	7	7	7	7	7	7	6	5	4	3	2	1	0	Measurement end			

	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54

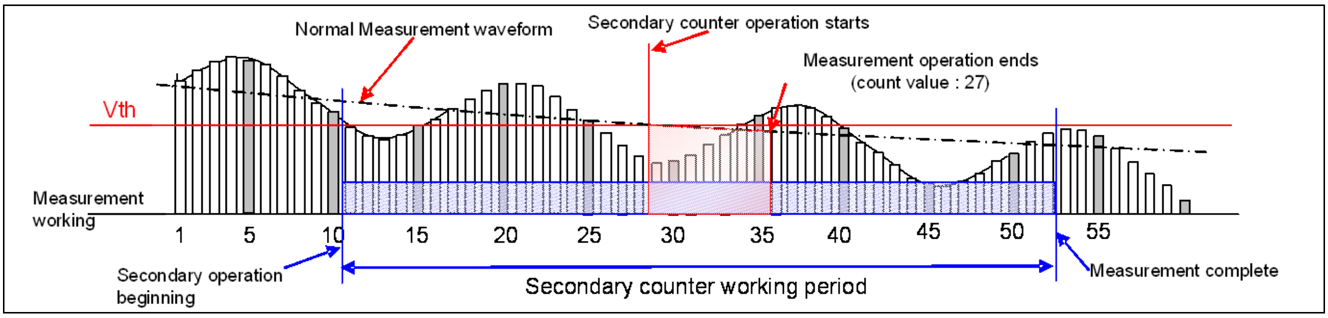

Figure 4-20 Measurement end timing: Secondary counter setting = 15 times

Secondary counter setting: 15 times (SCSCSR = 0Fh)

Measurement	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Primary counter	1	2	3	4	5	6	7	8	9	10	10	10	10	10	11	12	13	14
Secondary counter	15	15	15	15	15	15	15	15	15	15	14	13	12	11	12	13	14	15

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
15	16	17	18	19	20	21	21	21	21	21	21	21	21	21	22	23	24
15	15	15	15	15	15	15	14	13	12	11	10	9	8	7	8	9	10

37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
25	26	27	27	27	27	27	27	27	27	27	27	27	27	27	27	Measurement value 27	
11	12	13	12	11	10	9	8	7	6	5	4	3	2	1	0	Measurement end	

When Secondary counter is 15(cf. Figure 4-20), the measurement value is about the same with a measurement value when there is no "Interfere wave". However, noise cancellation is not function enough because Secondary counter setting is short for a “Interfere wave” when Secondary counter is 7 (cf. Figure 4-19).

This expresses the time that is set in "Tmes * Tsc" is "Tnoise" in “Figure 4-18”.

In this way, the setting of “Tmes” and “Tsc” becomes the lower limit of Low-frequency noise cancellation.

4.5.3 "Interfere wave" caused of the measurement cycle and the noise cycle

Hereinafter, "Interfere wave" and "Interfere wave frequency" is called "Alias" and "Alias frequency".

"Alias" and the "Alias frequency" caused by a measurement and a noise can be calculated by "Formula 4-1".

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

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

Formula 4-1 Alias frequency calculation

In addition, R8C/33T group can set Lower frequency of Low-frequency noise cancellation by adjustment of the measurement waveform length and adjustment of Secondary counter setting register (SCSCSR) shown in "4.5.2 Secondary counter setting and Lower frequency of Low-frequency noise cancellation".

The formula to calculate "Lower frequency of Low-frequency noise cancellation" is as follows.

$$Fcut = Fm \times Sc \times 1 / 2$$

Fcut	:	Lower frequency of Low-frequency noise cancellation
Fm	:	Measurement cycle (1 / "Setting time of Status periods 2 - 6")
Sc	:	Secondary counter setting

Note) Fm x Sc : Lower half cycle of Cancellation

Formula 4-2 Low frequency calculation

Using "Alias frequency" and "Lower frequency of Low-frequency noise cancellation", approximate frequency response is calculated.

As a guidelines for the effects of Low-frequency noise cancellation on any noise band, FN ratio (Alias / Cancellation ratio) becomes data to make a decision.

$$FN\ ratio = Fe / Fcut$$

FNratio	:	Alias / Cancellation ratio
Fe	:	Alias frequency
Fcut	:	Lower frequency of Low-frequency noise cancellation

Formula 4-3 Alias/Cancellation ratio calculation

4.5.4 Example of frequency response calculating by “Alias”

Examples of the calculation and the measures of rough frequency response using the formulas about "Alias" are as follows.

(1) Calculation of Fm(Measurement frequency) and Fcut(Cancellation lower frequency) according to the measurement waveform length and Secondary counter setting

Measurement waveform length	Measurement frequency	Secondary counter setting	Lower frequency
μSEC	Fm(KHz)	Times	Fcut(KHz)
1.8	555.556	7	39.683

(2) With Fn(Noise frequency), Fm(Measurement frequency), n(Degree), Fcut(Lower frequency), relation between “Alias frequency” for the noise frequency and the “Alias/Cancellation ratio” is summarized in the following table.

Table 4-13 Low frequency noise response (1)

Fn(KHz)			-	549	558	576	-	-	1098	1107	1116	-
n	1	Fe	-	6.56	2.44	11.44	-	-	542.44	551.44	560.44	-
		FN ratio	-	0.17	0.06	0.29	-	-	13.67	13.90	14.12	-
	2	Fe	-	562.11	553.11	544.11	-	-	13.11	4.11	4.89	-
		FN ratio	-	14.17	13.94	13.71	-	-	0.33	0.10	0.12	-
	3	Fe	-	1117.67	1108.67	1099.67	-	-	568.67	559.67	550.67	-
		FN ratio	-	28.17	27.94	27.71	-	-	14.33	14.10	13.88	-
	4	Fe	-	1673.22	1664.22	1655.22	-	-	1124.22	1115.22	1106.22	-
		FN ratio	-	42.17	41.94	41.71	-	-	28.33	28.10	27.88	-
	5	Fe	-	2228.78	2219.78	2210.78	-	-	1679.78	1670.78	1661.78	-
		FN ratio	-	56.17	55.94	55.71	-	-	42.33	42.10	41.88	-
	6	Fe	-	2784.33	2775.33	2766.33	-	-	2235.33	2226.33	2217.33	-
		FN ratio	-	70.17	69.94	69.71	-	-	56.33	56.10	55.88	-
	7	Fe	-	3339.89	3330.89	3321.89	-	-	2790.89	2781.89	2772.89	-
		FN ratio	-	84.17	83.94	83.71	-	-	70.33	70.10	69.88	-

Fn around 558 KHz or 1107 KHz satisfies "Alias/Cancellation ratio < 1".

This suggests the possibility that a measurement value becomes unstable from influence of the alias by the noise mixture around 558 KHz or 1107 KHz in case of the measurement waveform length and Secondary counter setting mentioned above.

The response of the R8C/3JT evaluation board by the setting of the (1) are as follows.

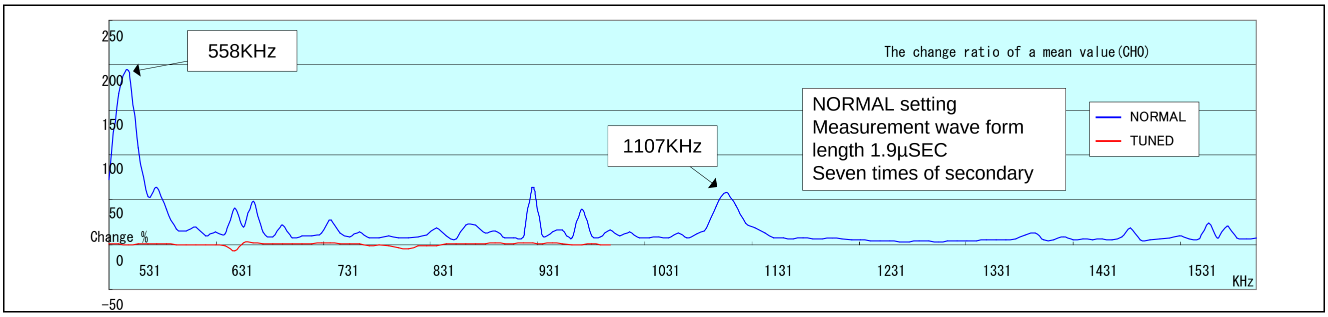

Figure 4-21 Frequency response (1)

(3) The calculation of frequency response when the measurement waveform length and Secondary counter is changed.

Measurement waveform length	Measurement frequency	Secondary counter setting	Lower frequency
μSEC	Fm(KHz)	Times	Fcut(KHz)
6.2	161.29	31	2.601

(4) With Fn(Noise frequency), Fm(Measurement frequency), n(Degree), Fcut(Lower frequency), relation between "Alias frequency" for the noise frequency and the "Alias/Cancellation ratio" is summarized in the following table.

Table 4-14 Low frequency noise response (2)

Fn(KHz)			-	549	558	576	-	-	1098	1107	1116	-
n	1	Fe	-	387.71	396.71	405.71	-	-	936.71	945.71	954.71	-
		FNratio	-	149.04	152.50	155.95	-	-	360.07	363.53	366.99	-
	2	Fe	-	226.42	235.42	244.42	-	-	775.42	784.42	793.42	-
		FNratio	-	87.04	90.50	93.95	-	-	298.07	301.53	304.99	-
	3	Fe	-	65.13	74.13	83.13	-	-	614.13	623.13	632.13	-
		FNratio	-	25.04	28.50	31.95	-	-	236.07	239.53	242.99	-
	4	Fe	-	96.16	87.16	78.16	-	-	452.84	461.84	470.84	-
		FNratio	-	36.96	33.50	30.05	-	-	174.07	177.53	180.99	-
	5	Fe	-	257.45	248.45	239.45	-	-	291.55	300.55	309.55	-
		FNratio	-	98.96	95.50	92.05	-	-	112.07	115.53	118.99	-
	6	Fe	-	418.74	409.74	400.74	-	-	130.26	139.26	148.26	-
		FNratio	-	160.96	157.50	154.05	-	-	50.07	53.53	56.99	-
	7	Fe	-	580.03	571.03	562.03	-	-	31.03	22.03	13.03	-
		FNratio	-	222.96	219.50	216.05	-	-	11.93	8.47	5.01	-

This tables expresses that Low frequency noise response around 588 KHz or 1107 KHz where Fn satisfies "Alias/Cancellation ratio < 1" at the setting before the change is improved.

The response of the R8C/3JT evaluation board by the setting of the (3) are as follows.

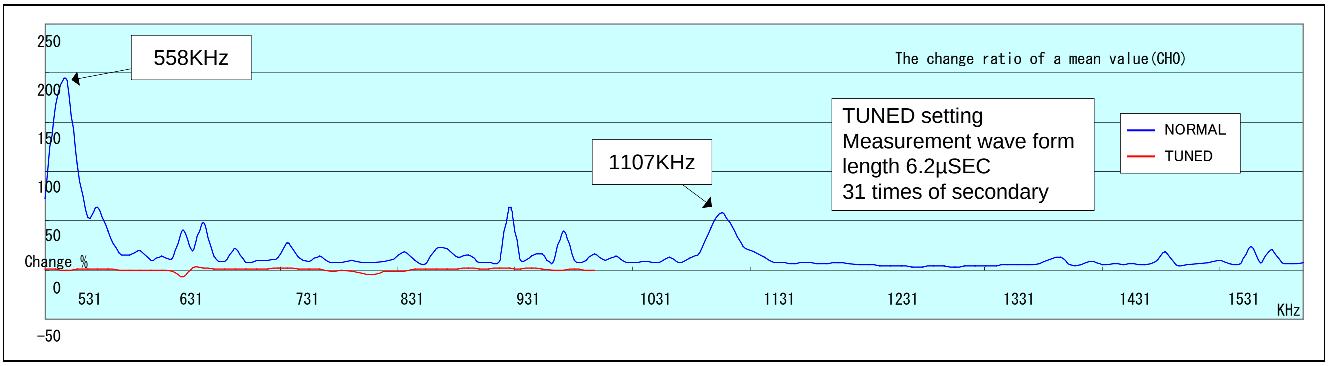

Figure 4-22 Frequency response (2)

5. Combination of measurement methods

Combination of measurement methods is as follows.

Table 5-1 Combination of measurement method

	Multiple measurement				Remarks
	Pre measurement	**Delay measurement**	**Random measurement**	**Majority measurement**	
Pre measurement		○	○	○	
Delay measurement	○		○	○	Register sharing with Random measurement
Random measurement	○	○		○ (Note-1)	Register sharing with Delay measurement
Majority measurement	○	○	○ (Note-1)		Be careful about the measurement wave length

Note-1
When Random measurement is used with Majority Measurement at the same time, Majority measurement is started after the end of Random measurement. Therefore be careful about the measurement wave length increasing.

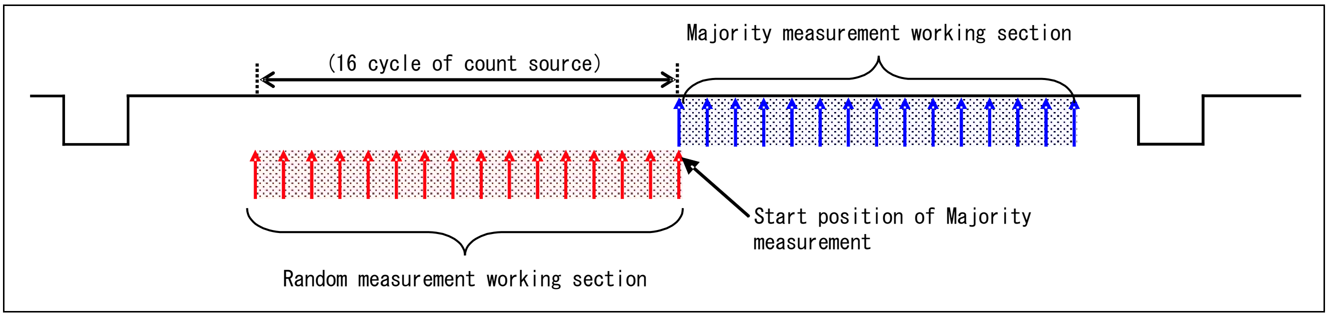

Figure 5-1 Multiple measurement - Random & Majority

Website and Support

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

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

Revision Record

Rev.	Date	Description	
		Page	Summary
1.00	May.21.2013		Numbering change (Contents is as same as REJ05B1388-0100)

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.

SALES OFFICES Renesas Electronics Corporation http://www.renesas.com

Refer to "http://www.renesas.com/" for the latest and detailed information.

Renesas Electronics America Inc.
2880 Scott Boulevard Santa Clara, CA 95050-2554, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
1101 Nicholson Road, Newmarket, Ontario L3Y 9C3, Canada
Tel: +1-905-898-5441, Fax: +1-905-898-3220

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-651-700, Fax: +44-1628-651-804

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-65030, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
7th Floor, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100083, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 204, 205, AZIA Center, No.1233 Lujiazui Ring Rd., Pudong District, Shanghai 200120, China
Tel: +86-21-5877-1818, Fax: +86-21-6887-7858 / -7898

Renesas Electronics Hong Kong Limited
Unit 1601-1613, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2886-9318, Fax: +852 2886-9022/9044

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 906, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics Korea Co., Ltd.
11F., Samik Lavied' or Bldg., 720-2 Yeoksam-Dong, Kangnam-Ku, Seoul 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141