R8C/38T-A Group

Cap Touch Sensitivity Adjustment Flow Chart

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Abstract

The MCUs for touch panel R8C/38T-A Group incorporate hardware which determines whether an electrode is being touched or not by measuring the floating capacitance between the touch electrode and human body. This hardware is called SCU (sensor control unit) and TSCU (touch sensor control unit) in R8C/3xT and R8C/3xT-A respectively.

This document explains how to adjust the cap touch keys sensitivity.

Target Device

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

Contents

1. Constants of External Circuit and Touch Sensitivity

Selecting constants of external circuit is an important point in determining the touch sensitivity and noise tolerance. This chapter explains reasons.

1.1 Importance of Electric Capacitance ΔCx Generated by Touch

Touch sensitivity increases according to the electric capacitance ΔCx generated when the electrode is touched. ΔCx is measured by comparing potential difference at the CHxA port in the cases of 'touch' and 'non-touch'. This difference indicates the touch sensitivity.

The voltage at the CHxA port is calculated by the following formula.

Electric potential at the beginning of measurement
when the electrode is not touched (non-touch)

Formula 1-1

$$\text{Potential at CHxA measurement start} = \frac{Cr}{(Cr + Cx)} Vc$$

Vc: operating voltage (Cc voltage)
Cr: Cr condenser capacitance
Cx: parasitic capacitance
ΔCx: increase in capacitance
when touched

Electric potential at the beginning of measurement
when the electrode is touched (touch)

Formula 1-2

$$\text{Potential at CHxA measurement start} = \frac{Cr}{(Cr + Cx + \Delta Cx)} Vc$$

As stated above, the electric potential at the beginning of measurement at CHxA decreases depending on the electric capacitance ΔCx generated when the electrode is touched. When comparing the voltage in the cases of touch and non-touch, the bigger ΔCx, the greater the potential difference. This difference in voltage indicates the touch sensitivity, and the bigger difference brings advantages in noise tolerance, detecting pressure sensitivity, and etc.

That is, the value of ΔCx determines capabilities as a touch switch. ΔCx can be increased in several ways as follows.

1. Make the electrode for touch bigger (dimensions of a facing finger or approximately twice the size)
2. Reduce the thickness of a panel covering the electrode
3. Use a panel made from materials with greater relative permittivity to cover the electrode

For more details, refer to the application note 'Base of electrostatic capacitance method touch key (REJ05B1347)'.

1.2 Parasitic Capacitance Cx

Another point concerning touch sensitivity is the parasitic capacitance Cx. When the parasitic capacitance Cx >> ΔCx, the difference of electric potential as shown in the above formula (= touch sensitivity) can not be obtained. This decrease in touch sensitivity caused by the parasitic capacitance will be explained below with specific figures assigned in the above formula. (Regarding selection of Cr condenser capacitance, refer to 2.4.)

Example 1) When the parasitic capacitance is small (Vc = 5 V, Cx = 10 pF, Cr = 10 pF, ΔCx = 5 pF)

In the case of non-touch	Potential at CHxA measurement start = 10/ (10 + 10) × 5 = 2.5 V
In the case of touch	Potential at CHxA measurement start = 10/ (10 + 10 + 5) × 5 = 2.0 V

Example 2) When the parasitic capacitance is large (Vc = 5 V, Cx = 30 pF, Cr = 30 pF, ΔCx = 5 pF)

In the case of non-touch	Potential at CHxA measurement start = 30/ (30 + 30) × 5 = 2.5 V
In the case of touch	Potential at CHxA measurement start = 30/ (30 + 30 + 5) × 5 = 2.3 V

As shown in the above examples 1 and 2, when the potentials at CHxA measurement start with the same amount of capacitance ΔCx are compared, the potential difference in the example 1 is greater than that in the example 2. The following measures can be used to reduce the parasitic capacitance when creating a touch board.

1. Set an appropriate size of electrode
2. Leave a space between electrodes
3. Make a wiring length between electrode and MCU short
4. Make a wiring between electrode and MCU thin

For more details, refer to the application note 'Base of electrostatic capacitance method touch key (REJ05B1347)'.

As stated above, hardware design, especially pattern design of the board including electrodes, is very important in building a touch system.

2. Touch Sensitivity Adjustment

This chapter explains procedures to adjust constants of external circuit for touch, a touch/non-touch determination threshold value, and a measuring time on the condition that the board has been properly designed as described in the previous chapter.

2.1 Touch Sensitivity Adjustment Flow Chart

Figure 2-1 and Figure 2-2 show flow charts for touch sensitivity adjustment. For more details of each adjustment, refer to each section.

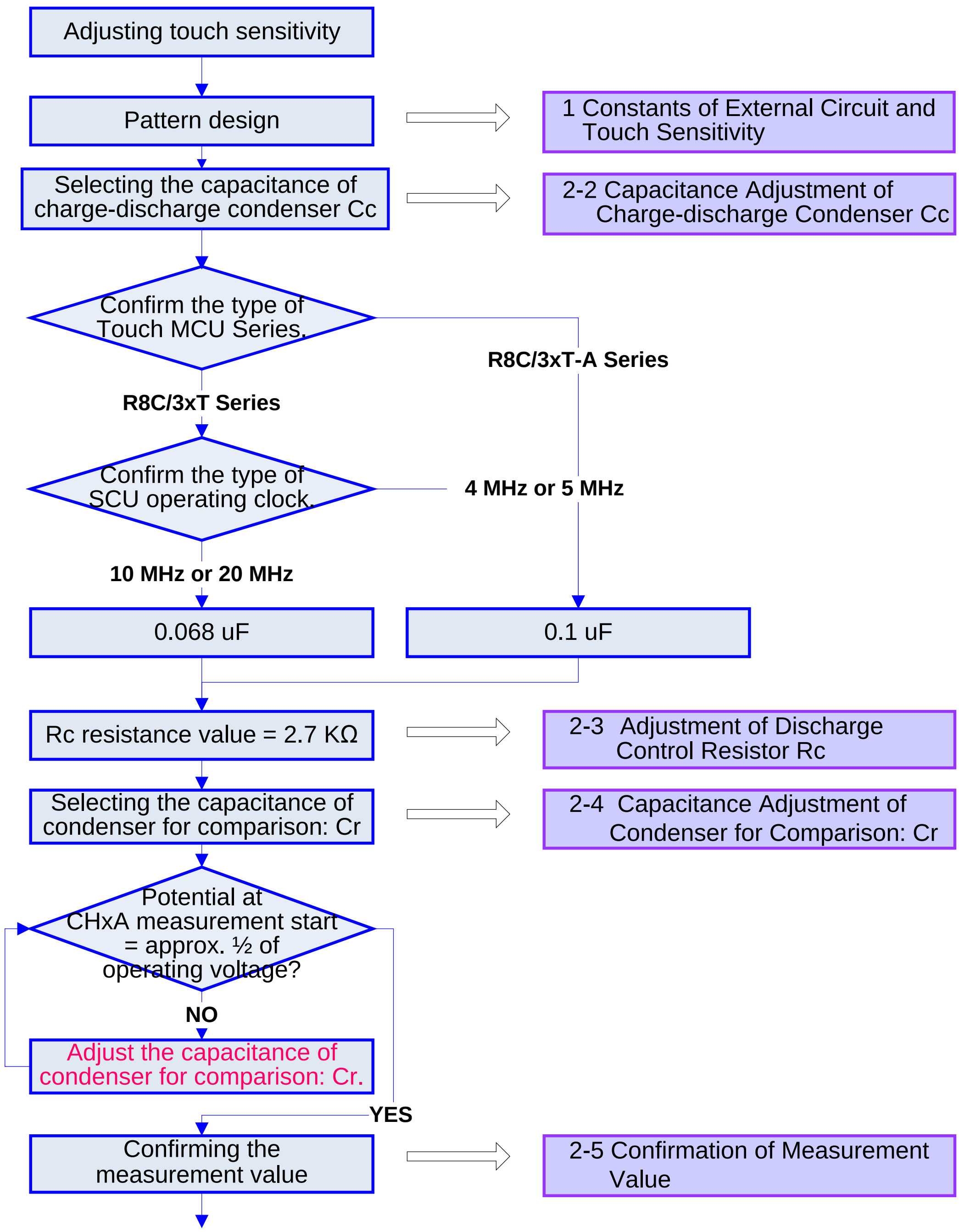


Figure 2-1 Touch Sensitivity Adjustment Flow Chart (I)

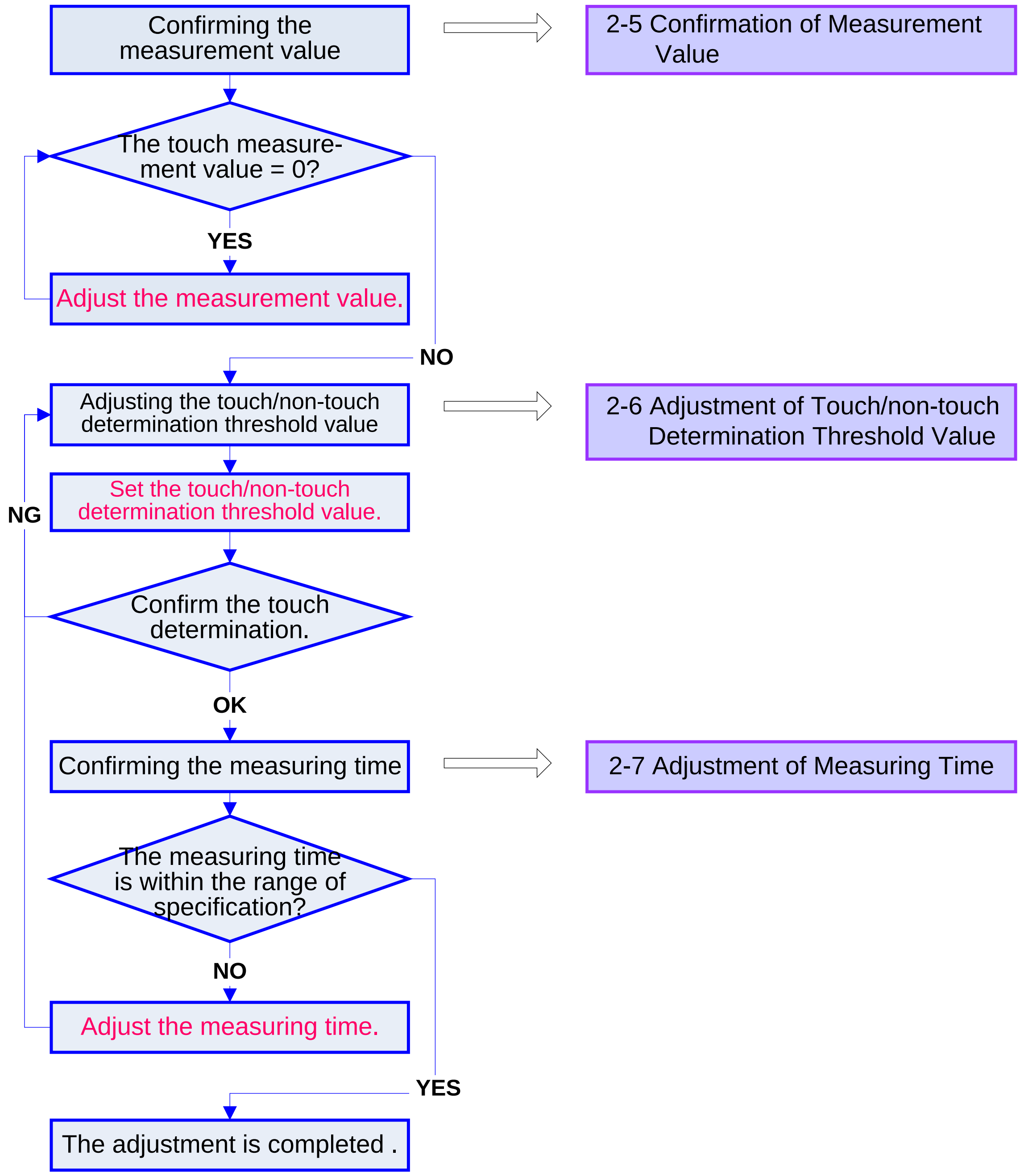


Figure 2-2 Touch Sensitivity Adjustment Flow Chart (II)

2.2 Capacitance Adjustment of Charge-discharge Condenser Cc

Figure 2-3 is a flow chart to adjust the capacitance of charge-discharge condenser Cc. (An excerpt from Figure 2-1)

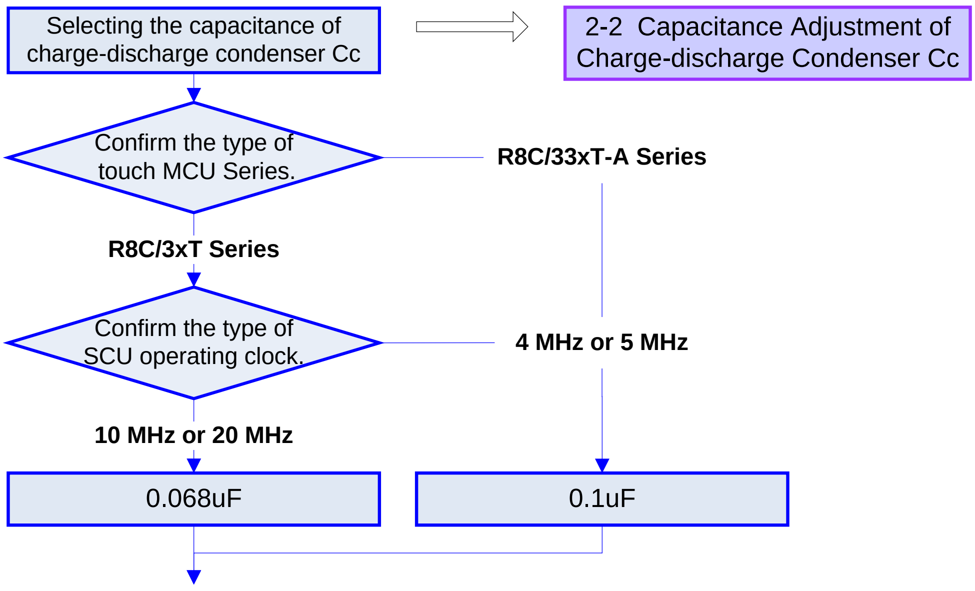


Figure 2-3 Flow Chart to Adjust Capacitance of Cc Condenser

The charge-discharge condenser Cc must have been fully recharged (= Vcc) through the CHxC port before touch measurement is started so as to provide charge to the condenser for comparison Cr and the electrostatic capacitance Cx generated at electrodes. If touch measurement is started while recharging, the start voltage becomes unstable, resulting in variability of count values to be measured. Also, the more charge in Cc, the more count values to be measured. As a result, the measuring time tends to be long. Taking into consideration balance between appropriate count values and measuring time, an appropriate value for Cc is normally approx. 0.1 µF.

As an exception, in the case of using an R8C/3xT Series MCU (R8C/33T, R8C/3JT, and R8C/3NT) and a 10 MHz or more supply clock to SCU, it is recommended to use Cc = 0.068 µF as shown in Figure 2-3. This is because the R8C/3xT Series MCU is assumed to be operated with a 4-MHz or 5-MHz SCU operating clock and charging time to the Cc condenser may not be sufficient in operation with a 10-MHz-or-more clock even when the register for setting charging time is set to the maximum value. (As the R8C/3xT-A Series MCU has a register for setting charging time on the assumption of operation with a 20 MHz clock, there is no problem to use Cc = 0.1 µF.) While touch measurement is not being used, the CHxC port must be set to High output in order for Cc to be fully recharged.

Notes

1. The port drive capability of CHxC port must be set to High in both R8C/3xT Series and R8C/3xT-A Series. When it is set to Low, Cc may not be sufficiently recharged due to current shortage.
2. The voltage charged to Cc depends on the voltage output from the CHxC port. In accordance with the use of general-purpose ports of MCU, the high output voltage falls and the low output voltage rises in all ports. For example, when many LEDs directly drive, execute PWM control, and flash on the ports at the same time, the high output voltage of all MCU ports including the CHxC port repeats falling and rising. Accordingly, the charging voltage to Cc changes and touch measurement becomes unstable. At worst, blinking of LEDs may cause keys to be repeatedly ON and OFF. The amount of port voltage drops caused by drive current is described in MCU hardware manuals. Please refer to them when designing products.

2.3 Adjustment of Discharge Control Resistor Rc

Figure 2-4 is a flow chart to adjust the Rc resistance value. (An excerpt from Figure 2-1)

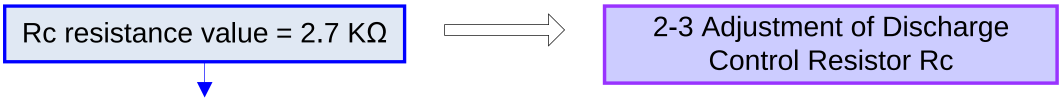


Figure 2-4 Flow Chart to Adjust the Rc Resistance Value

The Rc resistance value is used to control the amount of each discharge from condenser Cc at touch measurement. Also, this value is used to control time for charging from Cc to Cr and Cx. Generally, when the resistance value is raised, the amount of discharge decreases and the apparent count value increases. However, the slope of measurement waveform becomes gentle and noise tolerance is reduced. In addition, Cr and Cx may not be fully-charged due to decrease in the amount of discharge from Cc to Cr and Cx. On the contrary, when the resistance value is reduced, the amount of discharge increases and the apparent count value decreases. However, the slope of measurement waveform becomes steep and noise tolerance is increased. Also, the decrease in the count value may make adjustment difficult. Please use a typical value 2.7 KΩ resistance as the initial value to design the board. After adjusting with this value (2.7 KΩ), fine-tune the RC resistance value when eventually correcting the count value. Normally, the Rc resistance value should be within 2K to 3 KΩ.

2.4 Capacitance Adjustment of Condenser for Comparison: Cr

Figure 2-5 is a flow chart to adjust the capacitance of condenser for comparison, Cr. (An excerpt from Figure 2-1)

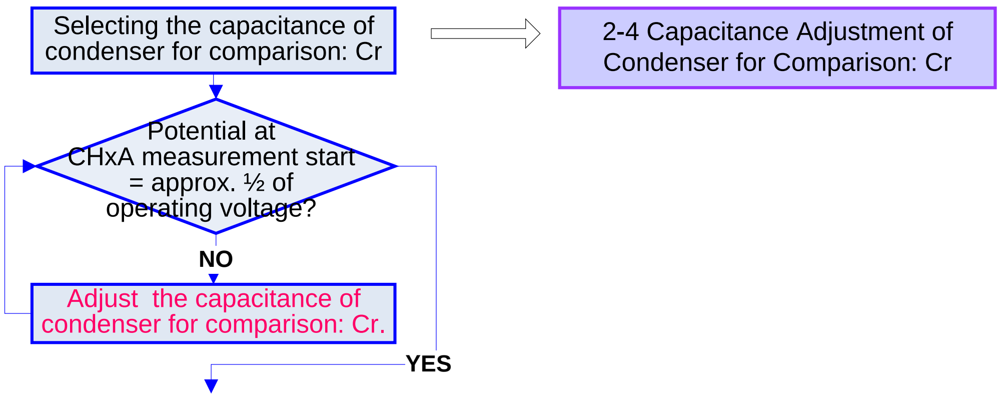


Figure 2-5 Flow Chart to Adjust the Capacitance of Condenser for Comparison: Cr

Cr is an important condenser to regulate the potential at measurement start which determines the touch sensitivity. The charge from Cc is divided at Cr and Cx and measured as voltage at the CHxA point. This difference of voltage (the voltage at the CHxA measurement start) in the cases of non-touch and touch is compared to determine whether the key is ON or OFF. The greater this difference in potential, the more touch sensitivity and noise tolerance due to wider range of setting for a threshold value to be described. (Regarding the touch detection principle which Renesas adopts, refer to the application note 'Base of electrostatic capacitance method touch key (REJ05B1347)'.)

The voltage at measurement start is shown as follows.

In the case of non-touch

$$\text{Potential at CHxA measurement start} = \frac{Cr}{(Cr + Cx)} Vc$$

In the case of touch

$$\text{Potential at CHxA measurement start} = \frac{Cr}{(Cr + Cx + \Delta Cx)} Vc$$

Cr: capacitance of condenser for comparison
Cx: parasitic capacitance
ΔCx: capacitance increased by touch with a finger
Vc: operating voltage

As an example, on the assumption that Cx (parasitic capacitance): 10 pF and ΔCx (capacitance increased by touch with a finger): 2 pF, the following calculation results are obtained according to Cr capacitance. Table2-1 summarizes the results.

When Cr capacitance is 10 pF:

In the case of non-touch Potential at CHxA calculation start = 10/ (10 + 10) × 5 = 2.50 V

In the case of touch Potential at CHxA calculation start = 10/ (10 + 10 + 2) × 5 = 2.27 V

When Cr capacitance is 20 pF:

In the case of non-touch Potential at CHxA calculation start = 20/ (20 + 10) × 5 = 3.33 V

In the case of touch Potential at CHxA calculation start = 20/ (20 + 10 + 2) × 5 = 3.13 V

When Cr capacitance is 5 pF:

In the case of non-touch Potential at CHxA calculation start = 5/ (5 + 10) × 5 = 1.66 V

In the case of touch Potential at CHxA calculation start = 5/ (5 + 10 + 2) × 5 = 1.47 V

Table 2-1 Potential at Measurement Start According to Cr Condenser Capacitance When Cx Capacitance is 10 pF

Cr capacitance	Potential at measurement start when ‘non-touch’	Potential at measurement start when ‘touch’	Potential difference between touch and non-touch
10 pF	2.50 V	2.27 V	0.23 V
15 pF	3.33 V	3.13 V	0.20 V
5 pF	1.66 V	1.47 V	0.19 V

As seen in the above results, when Cx = Cr, the increased ΔCx makes large changes to the potential at measurement start.

Figure 2-6 shows how the potential at CHxA calculation start changes when Cr capacitance is increased and decreased.

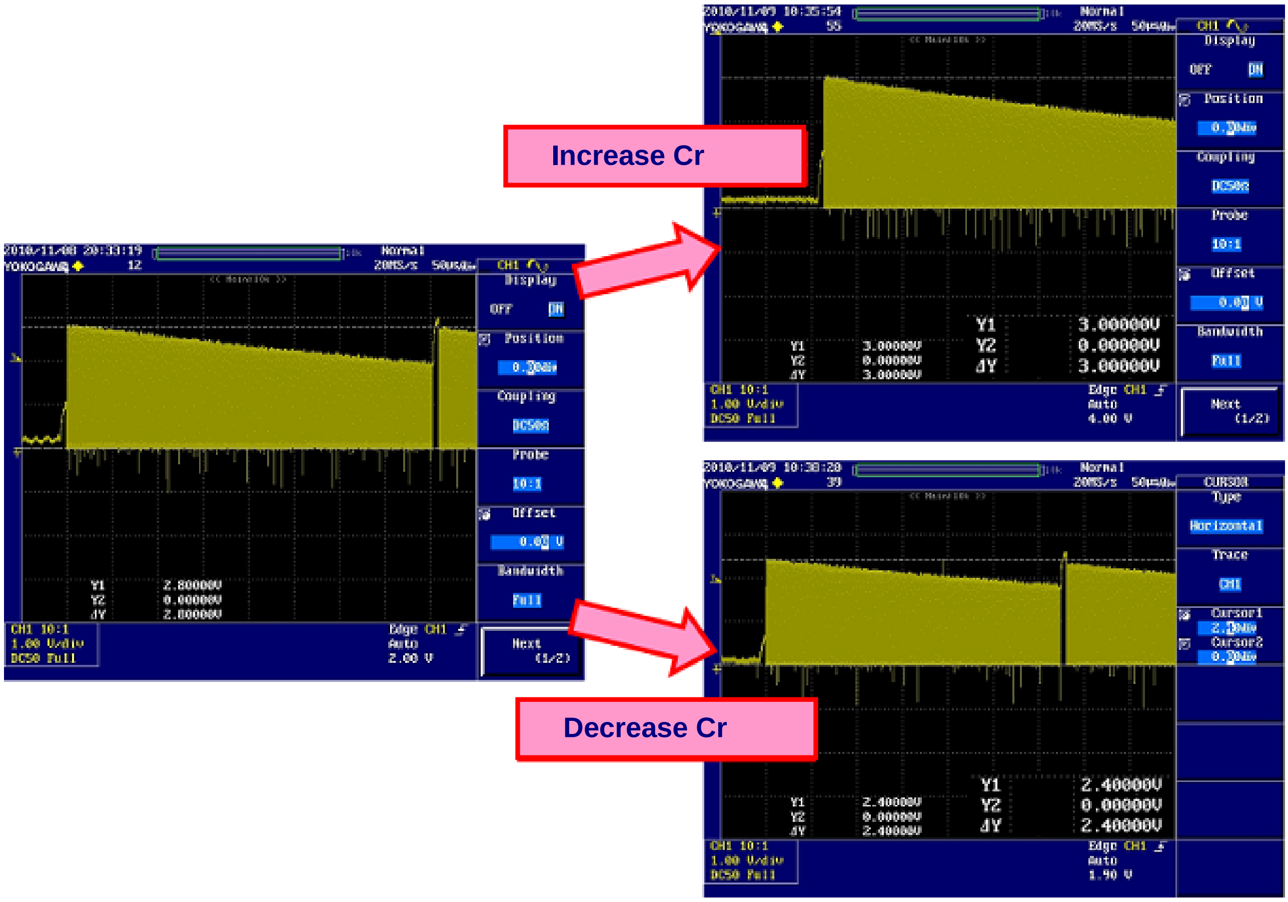


Figure 2-6 Change in Potential at Measurement Start by Adjusting Cr

When actually adjusting the Cr value, it is recommended to use a low capacitance FET probe. After observing the CHxA point by an oscilloscope, adjust Cr so that the voltage at measurement start should become approx. 1/2 of Vcc. Note that ΔCx will increase by the probe capacitance (approx. 0.5 to 2 pF) even when using a low capacitance probe. Also, the parasitic capacitance varies significantly depending on surrounding environment (product chassis, measurement location, and etc.). Therefore Cr must be adjusted in an actual operation environment. Without a low capacitance FET probe, set Cr so that the difference between count values of non-touch and touch operations (the amount of change) should be largest. In such case, adjusting other constants such as Cc, Rc, and register values at the same time makes the effect by Cr unclear. Please make sure to adjust the maximum amount of change as for Cr only.

The R8C/3xT-A Series incorporates two channels of CHxA ports (CHxA0 and CHxA1), and two Cr can be switched for each channel.

For example, in the case of a board pattern shown in Figure 2-7, as the electrode having a long wiring length to the MCU (CH0) and the large-size electrode (CH2) have high parasitic capacitance, those electrodes are measured at CHxA0 with high Cr capacitance. On the contrary, as the electrode having a short wiring length to the MCU (CH1) and the small-size electrode (CH3) have low parasitic capacitance, those electrodes are measured at CHxA1 with low Cr capacitance. As seen in this example, adjust to set the potential at measurement start on each channel to a closest possible value of approx. 1/2 of operating voltage by selecting either of the two Cr according to its parasitic capacitance.

* When it is concluded that either of the two Cr can deal with all electrodes as a result of this adjustment, implement a condenser to one of CHxA0 and CHxA1, and connect the other with its output set to "low" to GND as an unused port. This increases noise tolerance.

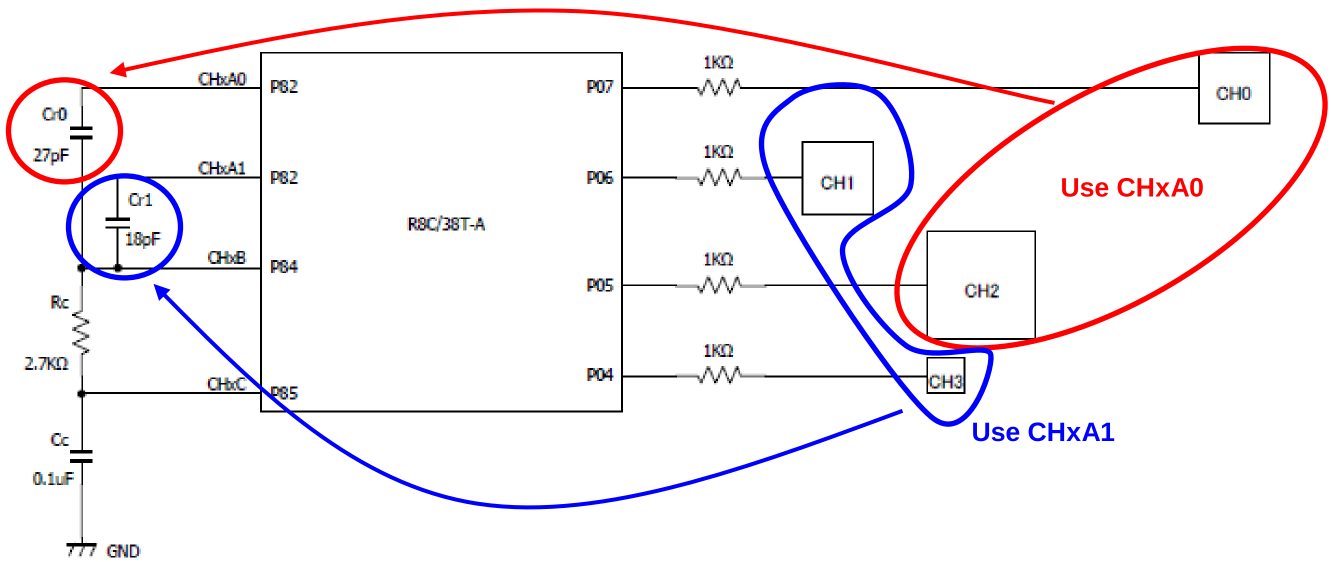


Figure 2-7 Example of the Board Pattern

2.5 Confirmation of Measurement Value

Figure 2-8 is a flow chart to confirm the measurement value. (An excerpt from Figure 2-2)

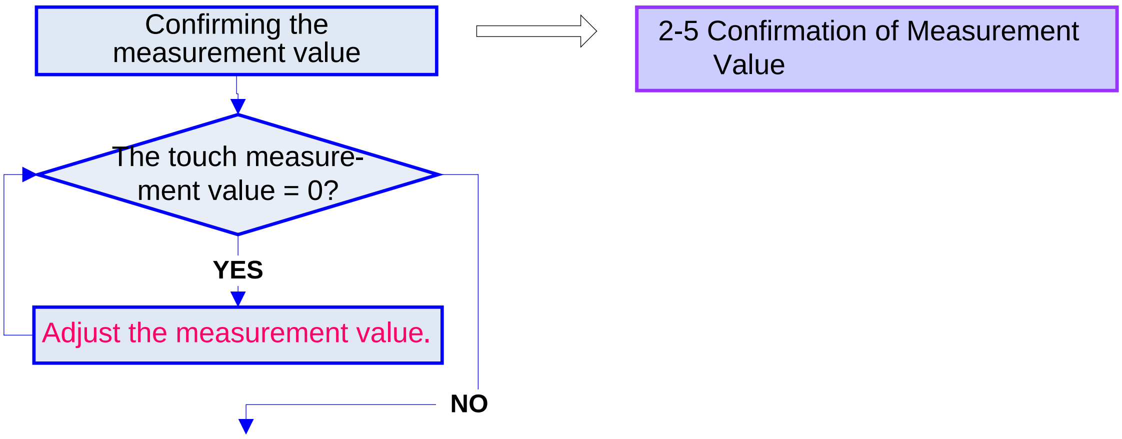


Figure 2-8 Flow Chart to Adjust the Measurement Value

After adjusting constants of the external circuit, check the touch measurement values. The following part explains how to confirm the measurement values using the Status monitor function of the touch sensitivity adjustment tool Workbench.

Check the following point:

- Whether or not the touch measurement values indicate zero as shown in Figure 2-9.

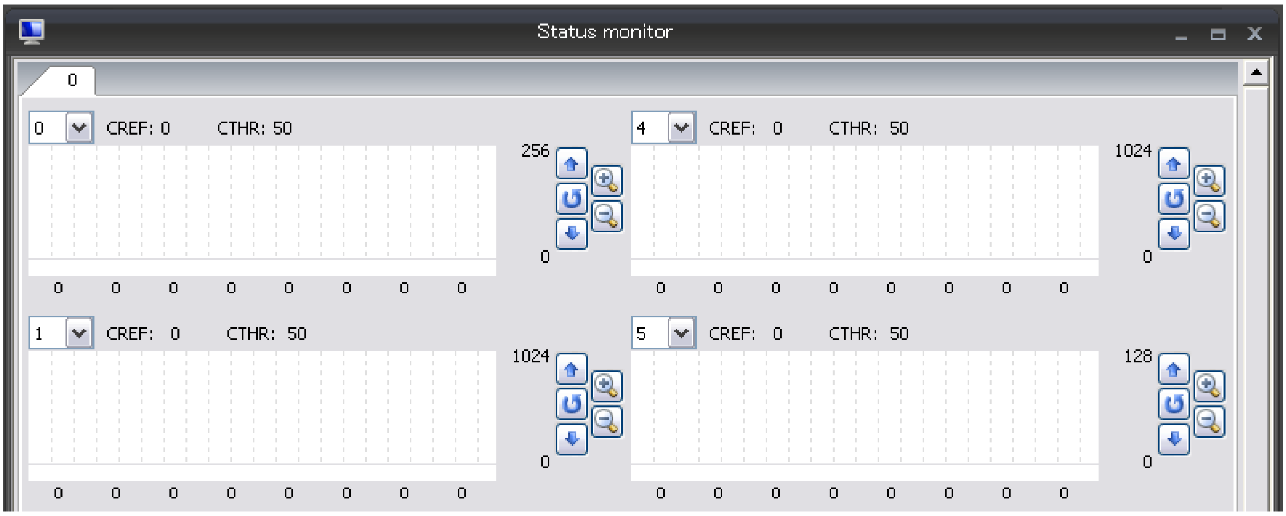


Figure 2-9 Touch Measurement Value: 0

The measurement values indicating zero as shown in Figure 2-9 are attributed to overflow of the measurement counter. In this case, the following countermeasures must be taken.

(1) Reduce the resistance value of Rc condenser

(2) Set the charging period in the SCU timing control register 1 to long

To prevent the measurement values from being zero again, make the above adjustments. When the adjustment result is indicated on Status monitor function of Workbench as shown in Figure 2-10, the adjustment is considered complete.

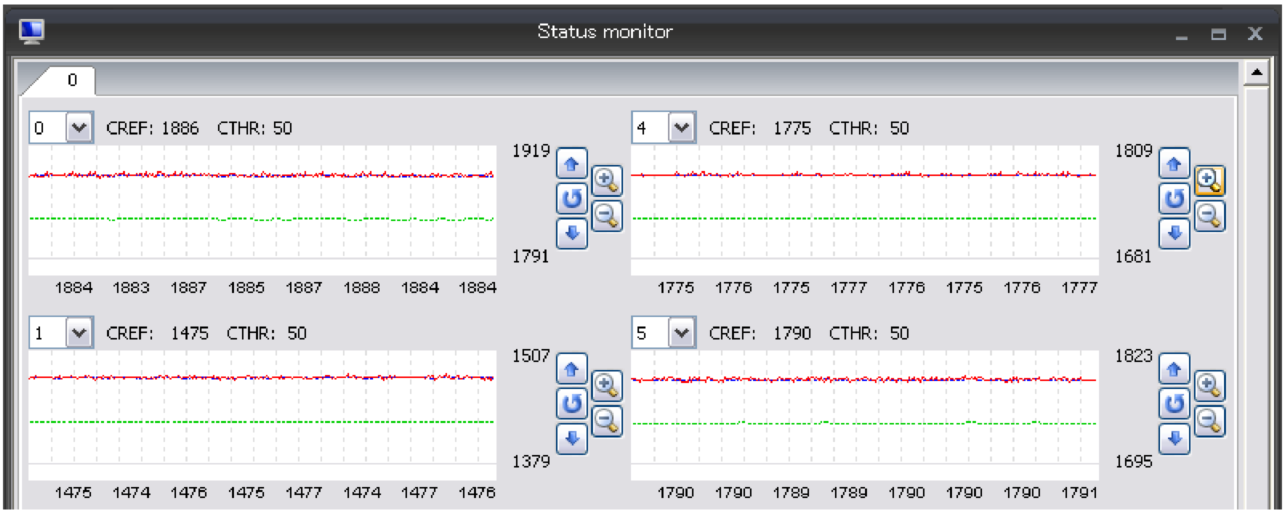


Figure 2-10 Touch Measurement Value

2.6 Adjustment of Touch/non-touch Determination Threshold Value

Figure 2-11 is a flow chart to adjust the touch/non-touch determination threshold value. (An excerpt from Figure 2-2)

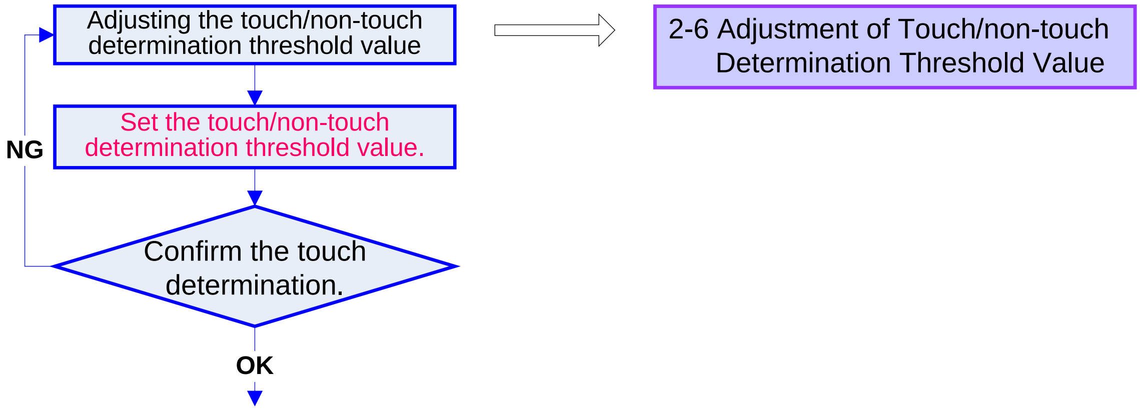


Figure 2-11 Flow Chart to Adjust the Touch/non-touch Determination Threshold Value

The touch/non-touch determination threshold value can be adjusted using the Setup parameters function of Workbench. Procedures are shown below. While Workbench5 is used here as an example, Wokrbech4 can also be used for adjustment.

(1) Start the Setup parameters function of Workbench.

(2) Click the Parameters tab on the Setup parameters and confirm that the ‘Use Drift correction’ checkbox is checked as shown in Figure 2-12.

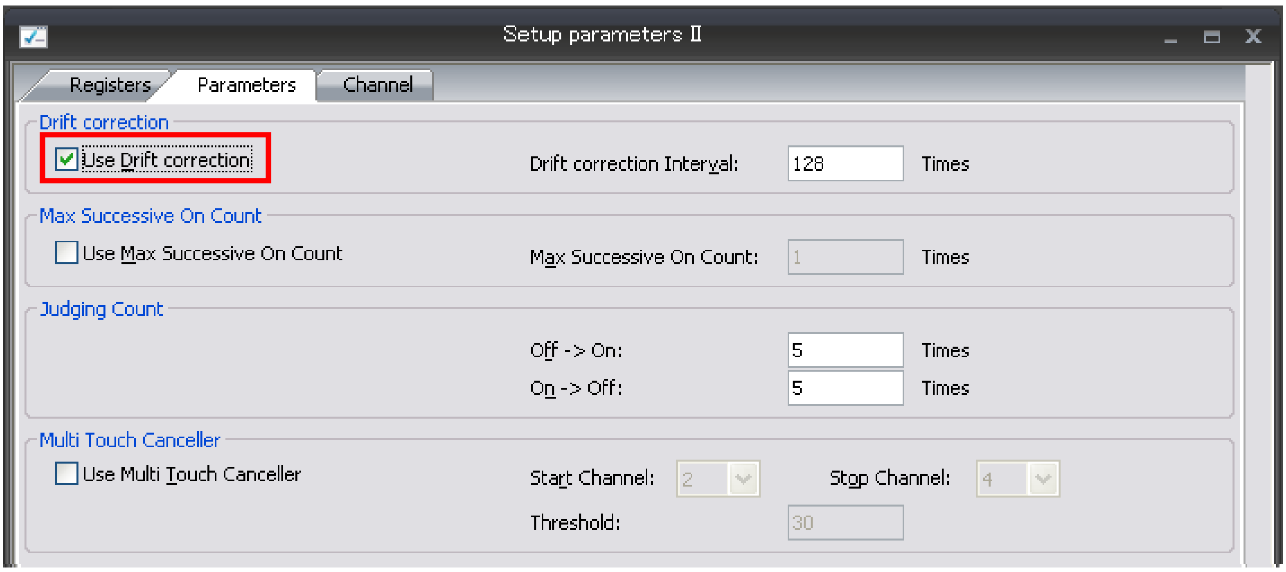


Figure 2-12 Select to Use Drift Correction

(3) Click the Channel tab on the Setup parameters and set Threshold values of all channels to be measured to any number for amount of difference large enough not to determine ‘touch’ (herein defined 1000).

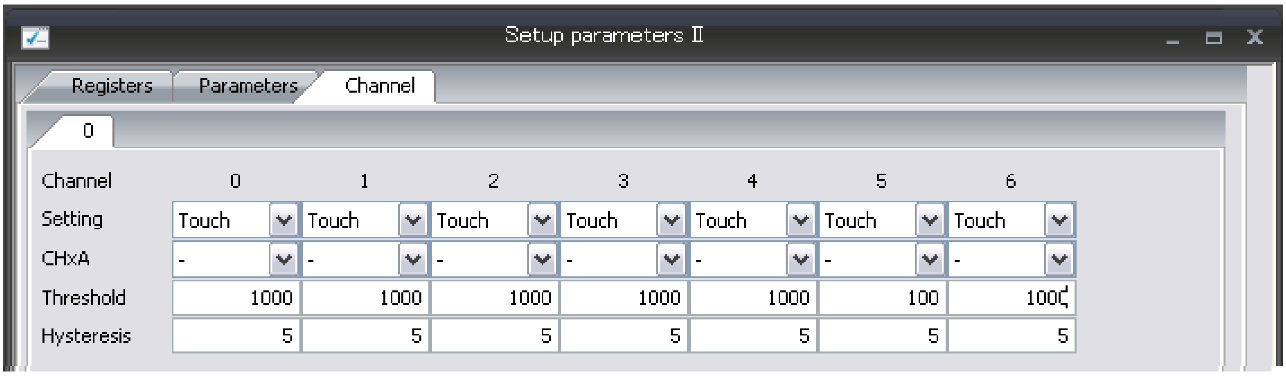


Figure 2-13 Input Threshold Values: 1000

(4) To enable the values input to Threshold, write parameters to data flash of the MCU. In order to write parameters to data flash, select Controls → Write → Write to Device as shown in Figure 2-14, or click the Write parameters to Device icon.

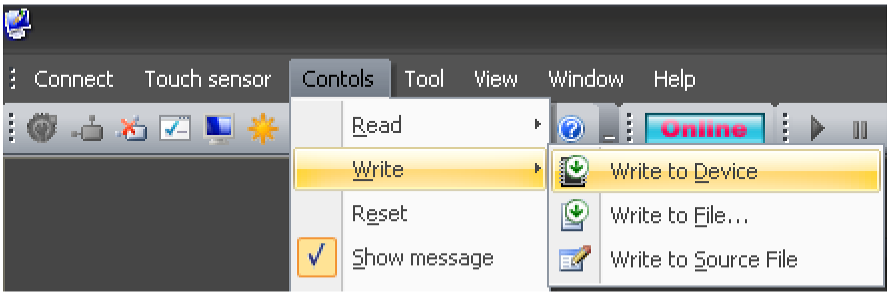


Figure 2-14 Write to Device

(5) When writing is completed, start the Status monitor and click the (Start monitoring) button so that the measurement data are displayed.

(6) Record the CREF value of the key to which the touch/non-touch determination threshold value should be adjusted.

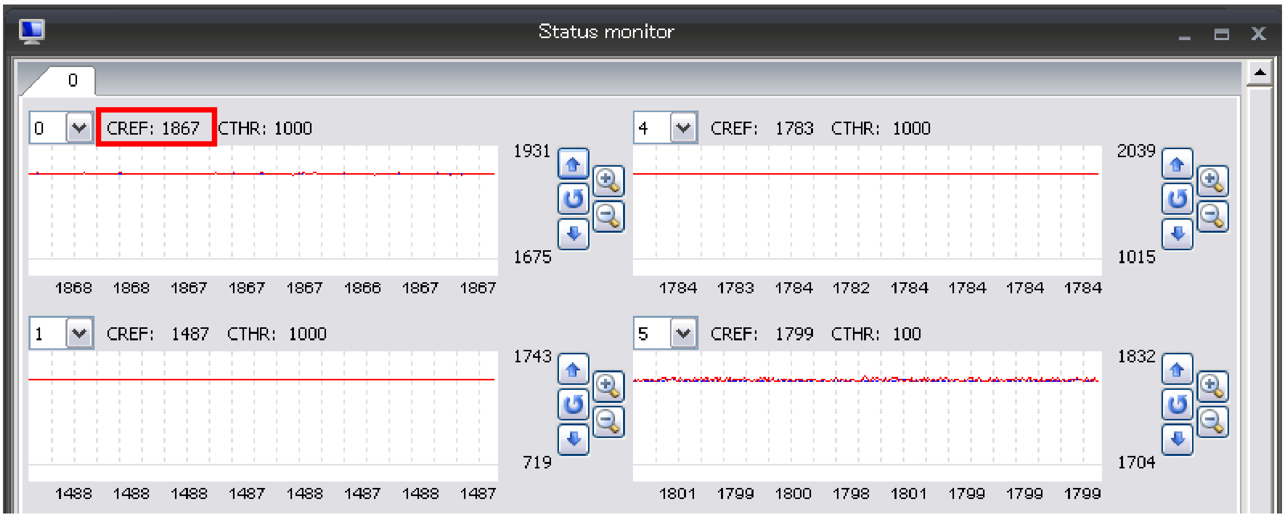


Figure 2-15 CREF When Non-touch

(7) Touch the key to be adjusted and record the CREF value when the measurement data (red line) is stable.

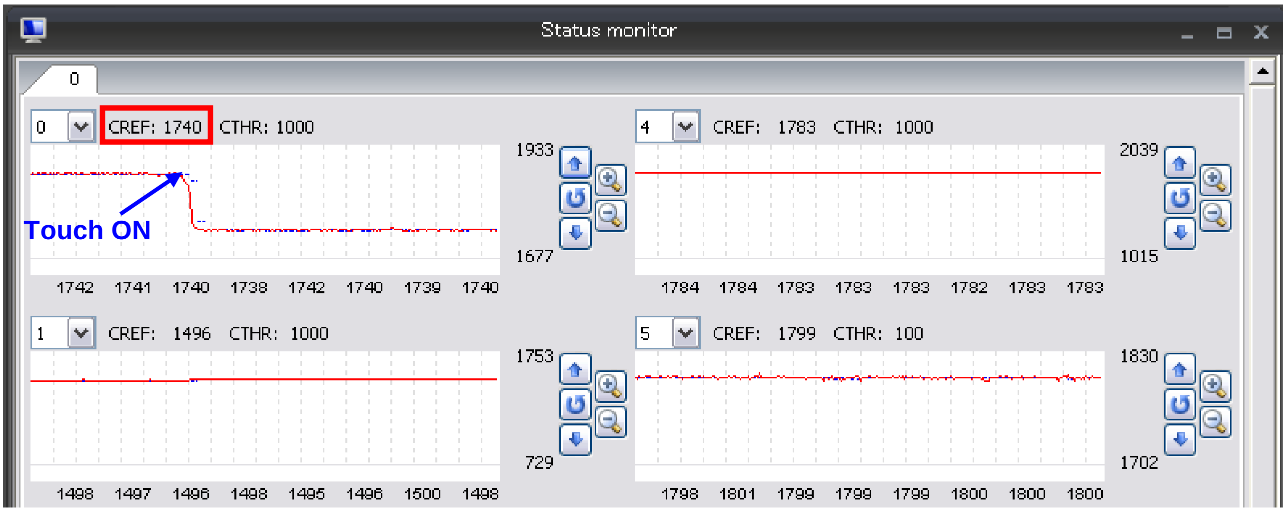


Figure 2-16 CREF When Touch

(8) With the CREF values recorded in steps (6) and (7), calculate the amount of difference generated by touch.

Amount of difference generated by touch = CREF in the case of non-touch - CREF in the case of touch

With actual CREF values in Figure 2-15 and Figure 2-16, the amount of difference can be calculated as follows.

Amount of difference generated by touch = 1867 - 1740 = 127

(9) With the calculated result, set a new touch/non-touch determination threshold value. Renesas' recommended setting value is approx. 70 % of the amount of difference generated by touch.

Touch/non-touch determination threshold value = Amount of difference generated by touch × 0.7 (70 %)

With an actual amount of difference calculated in (8), the threshold value can be calculated as follows.

Touch/non-touch determination threshold value = 127 × 0.7 = 89 (88.9)

*The threshold value must be adjusted appropriately according to specification or noise tolerance of the product. Generally, it should be a large number when the priority is given to noise tolerance and be a small number when the priority is given to touch key response.

(10) Start the Setup parameters and input the calculated threshold value of the corresponding channel.

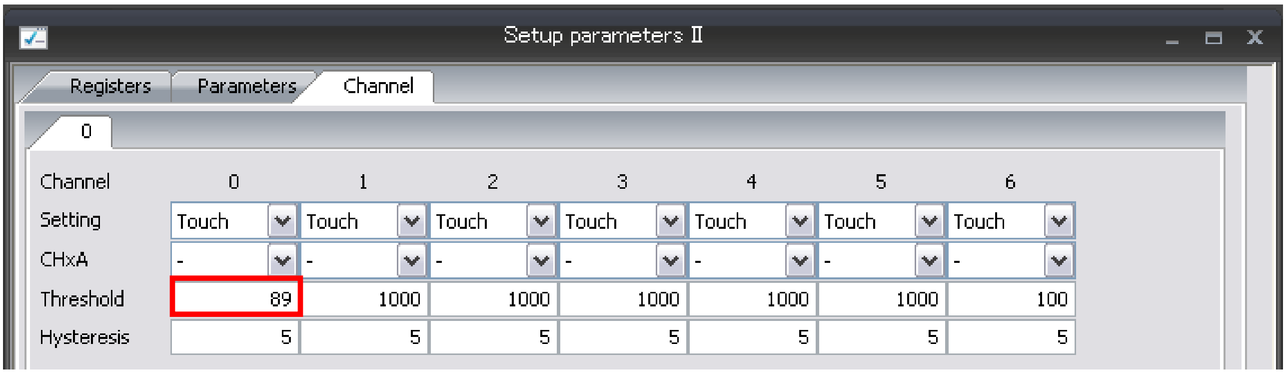


Figure 2-17 Input of the Calculated Threshold Value

(11) Write to data flash in the same way as (4).

(12) When writing is completed, start the Status monitor and click the (Start monitoring) button so that the measurement data are displayed. The input threshold value is enabled and touch/non-touch can be determined as shown in Figure 2-18.

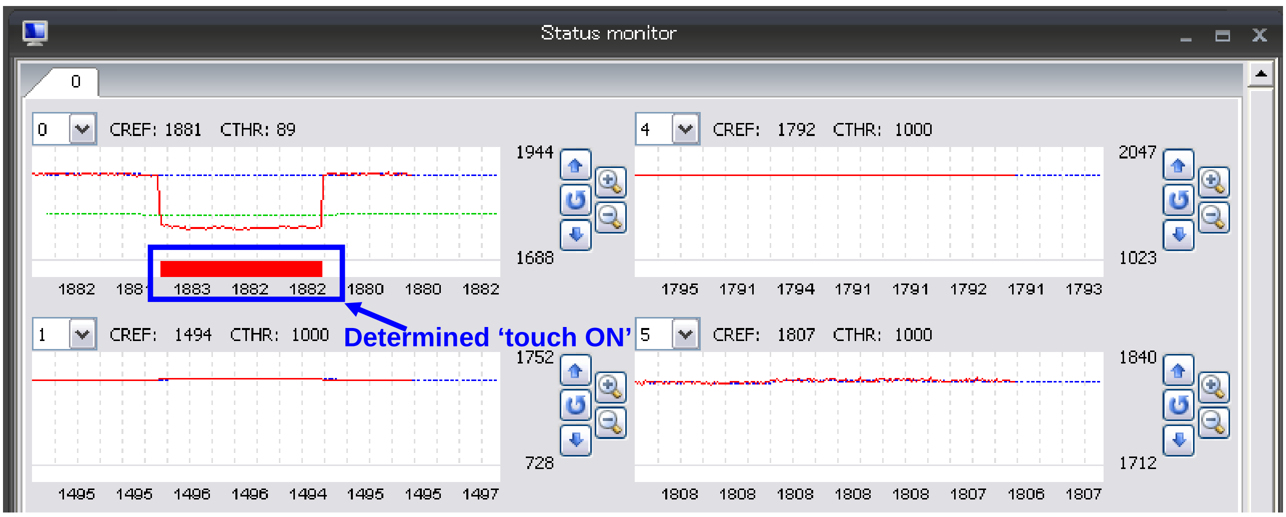


Figure 2-18 Touch OFF/ON Check

The above steps from (1) to (12) are procedures to adjust the touch/non-touch determination threshold value.

2.7 Adjustment of Measuring Time

Figure 2-19 is a flow chart to adjust the measuring time. (Parts in red box: an excerpt from Figure 2-2)

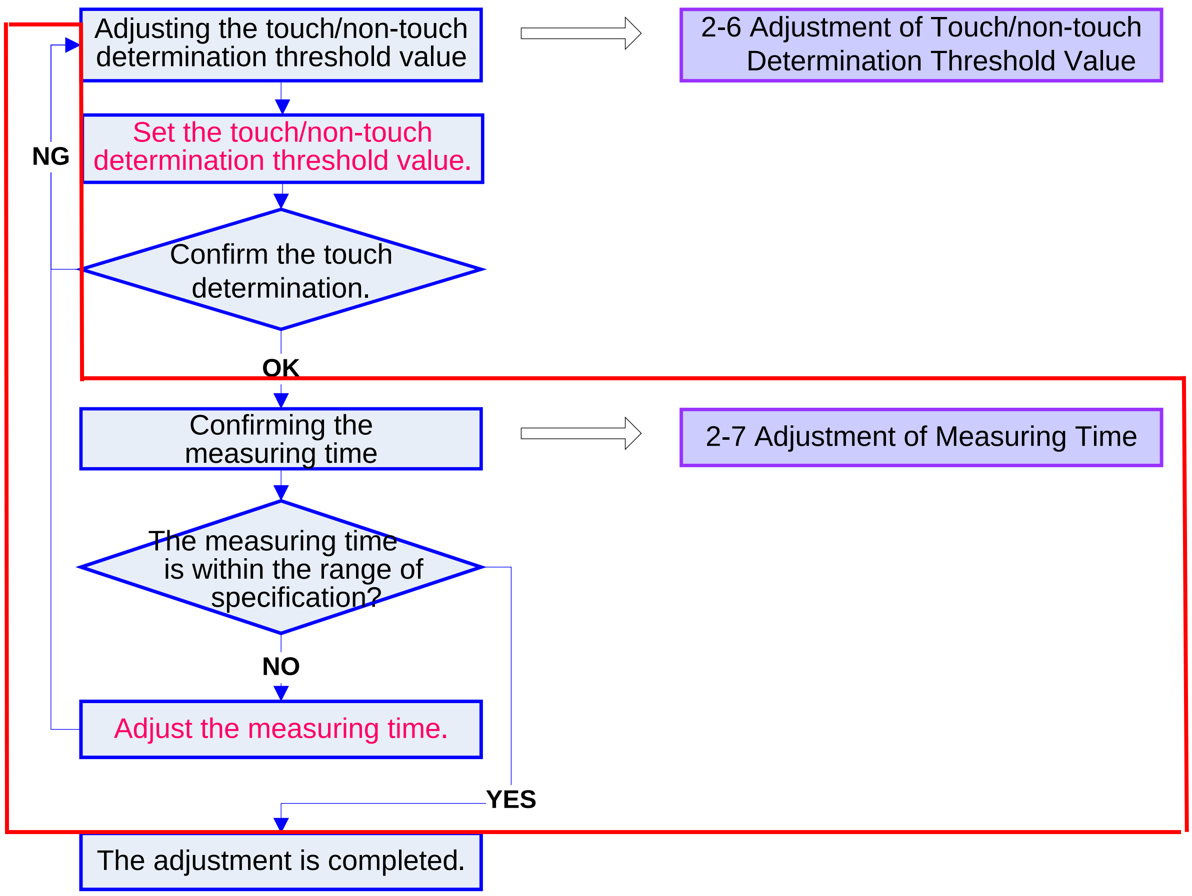


Figure 2-19 Flow Chart to Adjust the Measuring Time

Touch measuring time varies depending on number of channels to be measured, constants of external circuit, and setting values in the SCU timing control register. The measuring time also changes due to a difference in measurement waveforms in the cases of touch and non-touch.

As an example, Figure 2-20 shows a measuring time period with waveforms in the following conditions.

[Operating conditions]

Number of channels to be measured	7 channels
SCU operating clock	20 MHz
Constants of external circuit	Cc: 0.1 uF Rc: 2.7 KΩ Cr: 18 pF
SCU timing control register 0	0x7F (Period 1: 128 cycles)
SCU timing control register 1	0x07 (Period 2: 8 cycles, Period 3: 1 cycle)
SCU timing control register 2	0x08 (Period 4: 1 cycle, Period 5: skip)
SCU timing control register 3	0x05 (Period 6: 6 cycles)

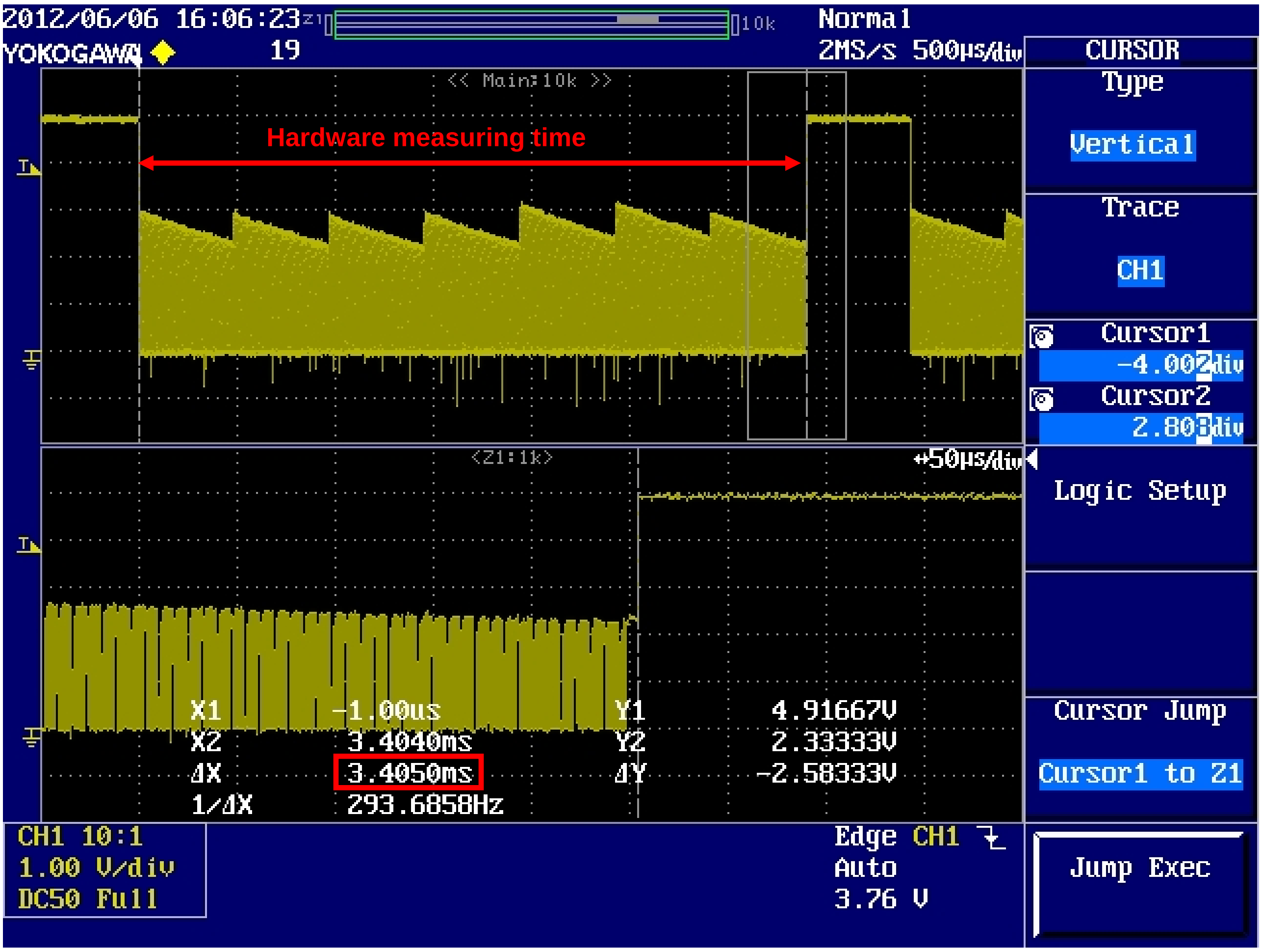


Figure 2-20 Touch Measuring time

Next, Figure 2-21 shows a measurement waveform when the Period 3 (discharging time indicated in red) is extended to shorten the measuring time.

[Operating conditions]

Number of channels to be measured	7 channels
SCU operating clock	20 MHz
Constants of external circuit	Cc: 0.1 uF Rc: 2.7 KΩ Cr: 18 pF
SCU timing control register 0	0x7F (Period 1: 128 cycles)
SCU timing control register 1	0x37 (Period 2: 8 cycles, Period 3: 4 cycles)
SCU timing control register 2	0x08 (Period 4: 1 cycle, Period 5: skip)
SCU timing control register 3	0x05 (Period 6: 6 cycles)

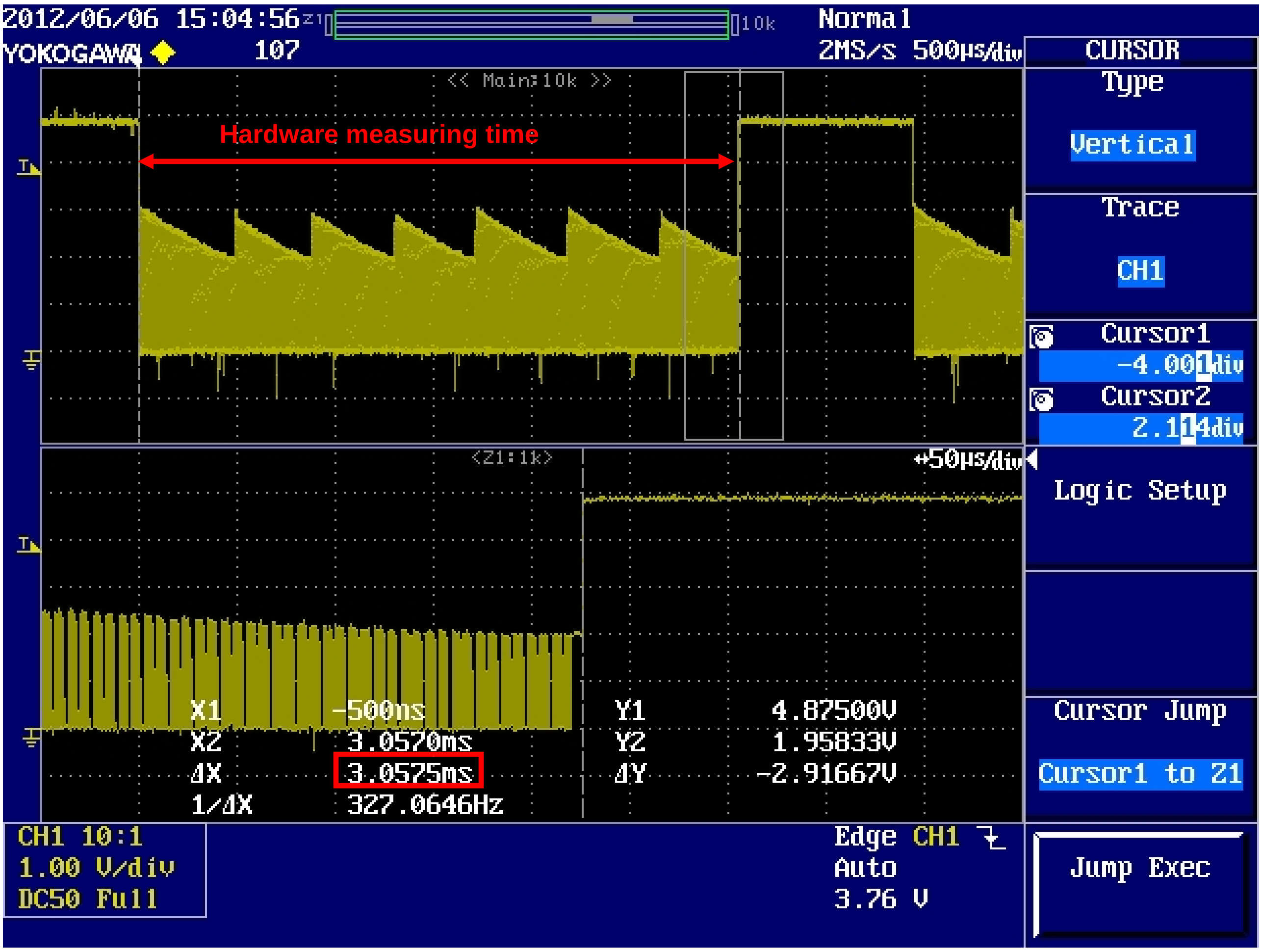


Figure 2-21 Touch Measuring Time When Period 3 Is Changed

Comparing Figure 2-20 with Figure 2-21 shows that the measuring time is reduced by changing Period 3 in the SCU timing control register 1. In this manner, make an adjustment when the total time for measuring all channels differs from the measuring time expected by the system with consideration for key input matching, number of chattering eliminations, and etc.

3. Reference

As reference of adjustment, this chapter describes a result of adjusting an R8C/36T-A evaluation board.

3.1 Operating Environment

Operating environment of R8C/36T-A is as follows.

CPU used	R8C/36T-A (R5F2136CSNFA)
Operating voltage	5 V
CPU clock	20 MHz

3.2 Board Configuration

This evaluation board is compliant with a recommended pattern design in the application note ‘Base of Electrostatic Capacitance Method Touch Key’. The board is configured as follows.

Size of the electrode	12 × 12 mm
Wiring length	Minimum 47 mm (Blue line in Figure 3-1)
	Maximum 98 mm (Red line in Figure 3-1)
Material and thickness of the panel	Acrylic 2 mm
Relative permittivity	3 to 4
Interval between electrodes	5 mm
Interval between an electrode and wiring	2 mm
Diameter of wiring	0.2 mm

Electrode

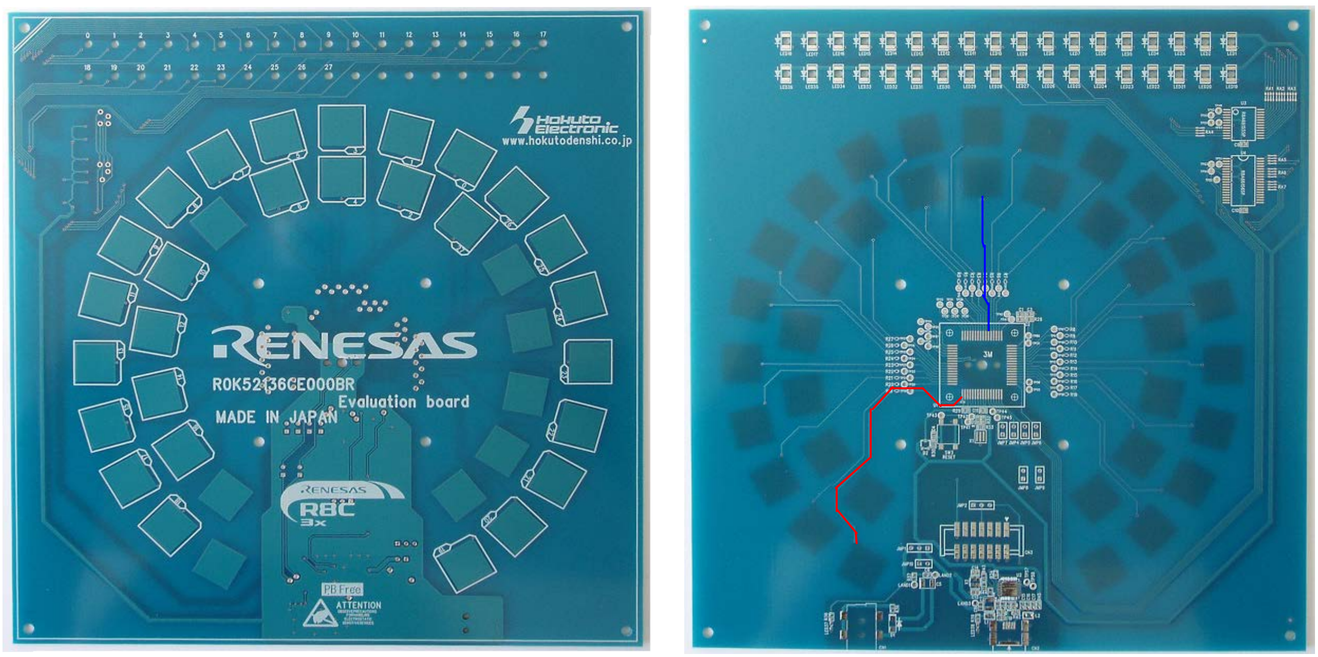


Figure 3-1 R8C/36T-A Evaluation Board

3.3 Constants of External Circuit

As the MCU used is R8C/36T-A and the SCU clock operates at 20 MHz, the capacitance of Cc condenser and the Rc resistance are the below values respectively.

Cc condenser 0.1 uF Rc resistor 2.7 KΩ

The optimum capacitance of Cr condenser can be determined to be 18 pF by comparing Figure 3-2 27 pF measurement waveform with Figure 3-3 18 pF measurement waveform in which potential at measurement start ≈operating voltage/2.

Cr condenser 18 pF

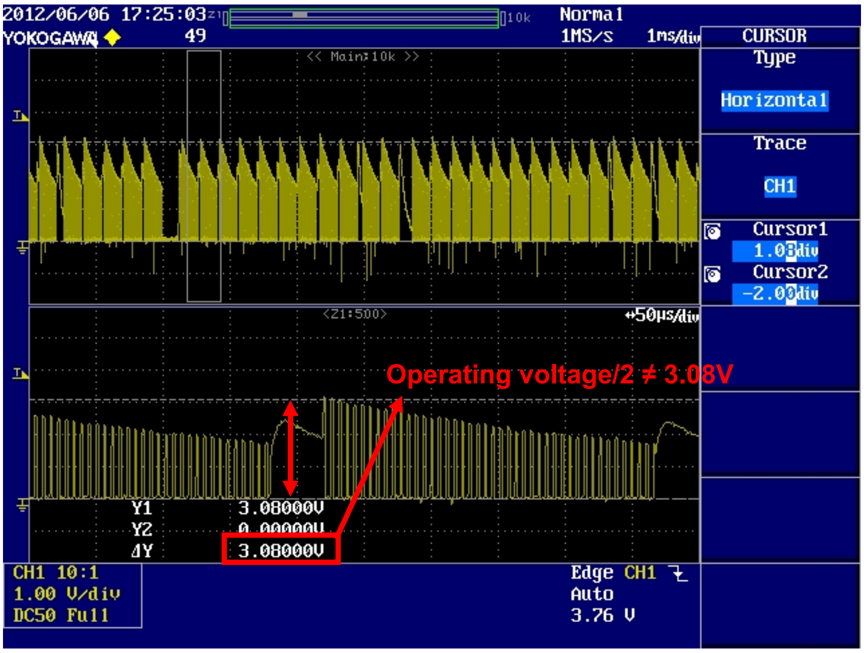


Figure 3-2 Cr Condenser: 27 pF Measurement Waveform

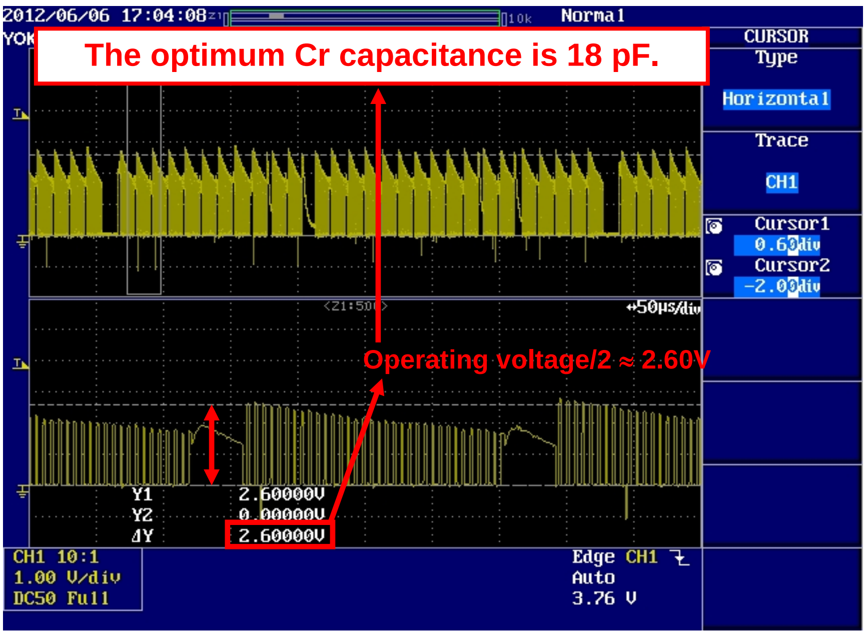


Figure 3-3 Cr Condenser: 18 pF Measurement Waveform

3.4 Calculation of Touch/non-touch Determination Threshold Value

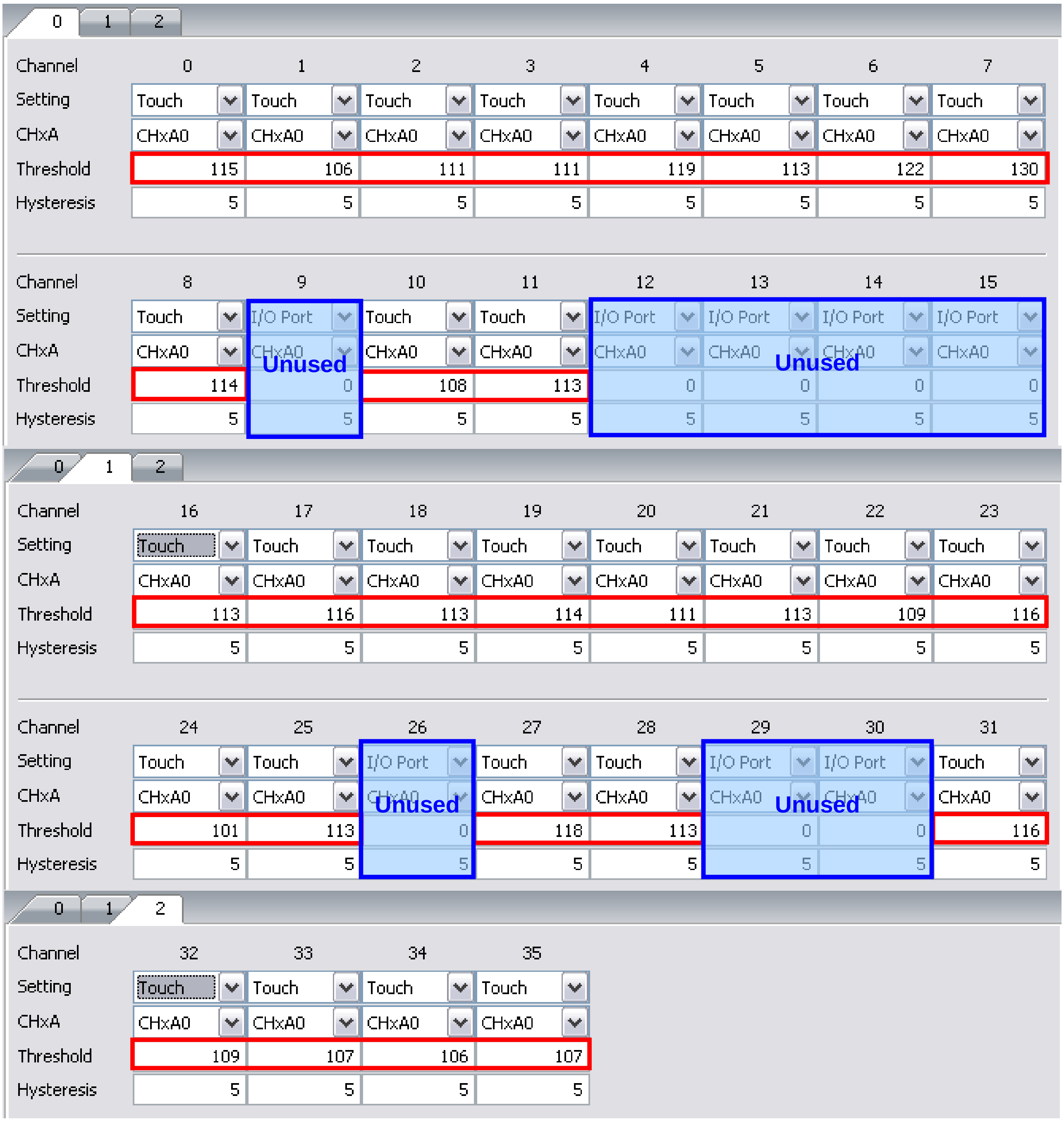
Table 3-1 lists calculation results of touch/non-touch determination threshold value (70% of amount of difference in the cases of touch and non-touch) according to procedures for adjustment.

Table 3-1 Measurement Data

	CREF (non-touch)	CREF (touch)	Difference	Threshold value
CH0	1728	1564	164	115
CH1	1639	1487	152	106
CH2	1786	1627	159	111
CH3	1747	1588	159	111
CH4	1850	1680	170	119
CH5	1747	1586	161	113
CH6	1877	1703	174	122
CH7	2056	1871	185	130
CH8	1784	1621	163	114
CH9	-	-	-	-
CH10	1688	1534	154	108
CH11	1813	1651	162	113
CH12	-	-	-	-
CH13	-	-	-	-
CH14	-	-	-	-
CH15	-	-	-	-
CH16	1761	1600	161	113
CH17	1843	1677	166	116
CH18	1810	1648	162	113
CH19	1849	1686	163	114
CH20	1755	1596	159	111
CH21	1797	1635	162	113
CH22	1696	1540	156	109
CH23	1782	1616	166	116
CH24	1795	1651	144	101
CH25	1823	1662	161	113
CH26	-	-	-	-
CH27	1839	1671	168	118
CH28	1802	1641	161	113
CH29	-	-	-	-
CH30	-	-	-	-
CH31	1838	1672	166	116
CH32	1792	1637	155	109
CH33	1762	1609	153	107
CH34	1773	1621	152	106
CH35	1849	1696	153	107

3.5 Input of Touch/non-touch Determination Threshold Value

The result of writing with the touch/non-touch determination threshold values shown in Table 3-1 input to Workbench is shown in red boxes of Figure 3-4. (Channels in blue boxes are not used.)



0 1 2

Channel	0	1	2	3	4	5	6	7
Setting	Touch	Touch	Touch	Touch	Touch	Touch	Touch	Touch
CHxA	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0
Threshold	115	106	111	111	119	113	122	130
Hysteresis	5	5	5	5	5	5	5	5

Channel	8	9	10	11	12	13	14	15
Setting	Touch	I/O Port	Touch	Touch	I/O Port	I/O Port	I/O Port	I/O Port
CHxA	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0
Threshold	114	0	108	113	0	0	0	0
Hysteresis	5	5	5	5	5	5	5	5

0 1 2

Channel	16	17	18	19	20	21	22	23
Setting	Touch	Touch	Touch	Touch	Touch	Touch	Touch	Touch
CHxA	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0
Threshold	113	116	113	114	111	113	109	116
Hysteresis	5	5	5	5	5	5	5	5

Channel	24	25	26	27	28	29	30	31
Setting	Touch	Touch	I/O Port	Touch	Touch	I/O Port	I/O Port	Touch
CHxA	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0	CHxA0
Threshold	101	113	0	118	113	0	0	116
Hysteresis	5	5	5	5	5	5	5	5

0 1 2

Channel	32	33	34	35
Setting	Touch	Touch	Touch	Touch
CHxA	CHxA0	CHxA0	CHxA0	CHxA0
Threshold	109	107	106	107
Hysteresis	5	5	5	5

Figure 3-4 Result of Inputting Touch/non-touch Determination Threshold Values

3.6 Confirmation of Touch/non-touch Determination Results

Confirm touch detection on Status monitor display of Workbench to check if the threshold value is appropriately set according to the amount of change by touch and if key ON/OFF is correctly determined. Figure 3-5 shows touch/non-touch determination results.

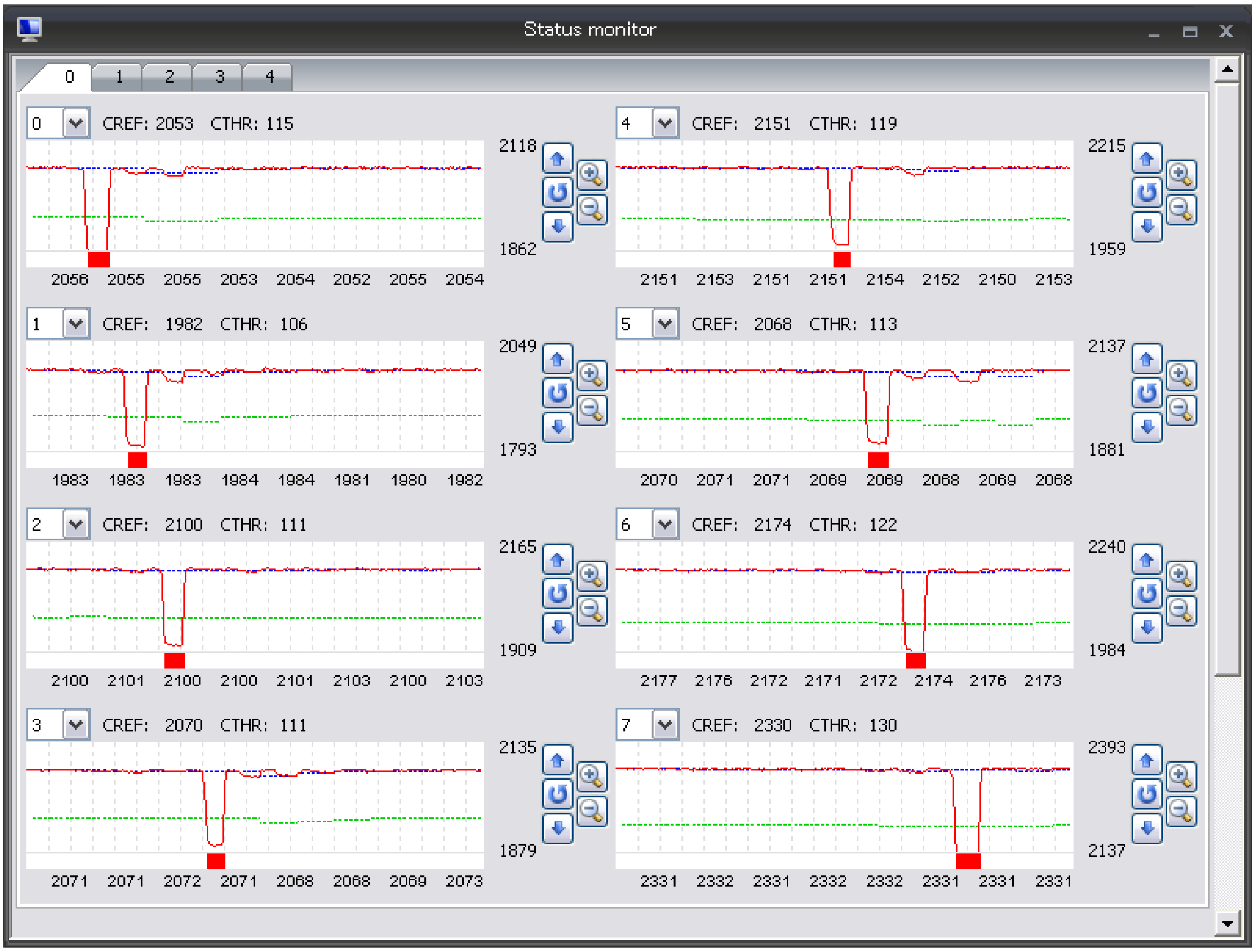


Figure 3-5 Touch/non-touch Determination Results

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Revision Record

Rev.	Date	Description	
		Page	Summary
1.00	May 21, 2013	-	Numbering change (Contents is as same as REJ05B1345-0105)

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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