R8C/38T-A Group

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Wheel operation technique of touch key

Summary

Touch panel microcomputer R8C/33T group builds hardware (SCU: sensor control unit) that perceives the contact of the human body by measuring the stray capacity generated between the touch electrode and the human body into.

In this application note, it explains the technique of the wheel operation that uses SCU.

Target device

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

Contents

1. Arrangement of electrodes

1.1 Outline

We explain the position tracking and the operation of the electrode of the wheel shape.

When the wheel operation and the jog operate with a touch sensor, the number of electrodes, the electrode geometry, and the operation method become important.
Here, it explains the solution that uses four electrodes.

1.2 Electrode geometry and electrode placement of wheel that uses four electrodes

The wheel operation is achieved by processing four electrodes as one sensor.
The device that the capacitance change detected by each interelectrode becomes smooth is necessary to do the wheel operation smoothly.

Figure 1-2- 1 shows an electrode shape example.
This has aimed at the thing that the ratio of the electrode adjoined when the finger is moved changes linear.

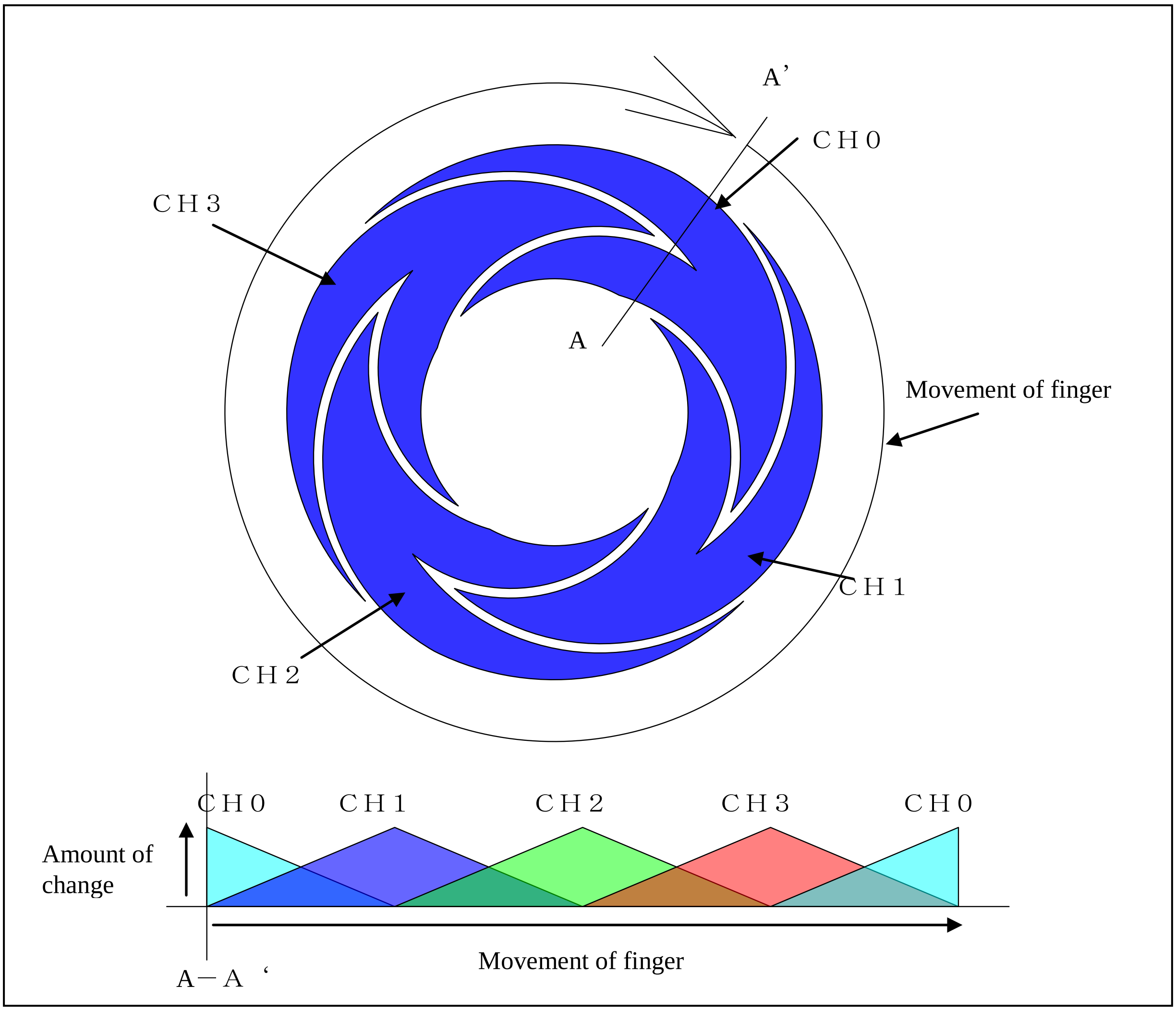

Figure 1-2- 1 Example of composing wheel by four electrodes

1.3 Electrode geometry concepts

To detect the capacitance change by the movement of the finger accurately, the electrode geometry becomes important. It explains as follows by a slider electrode.

① Area ratio relation to adjoining electrode

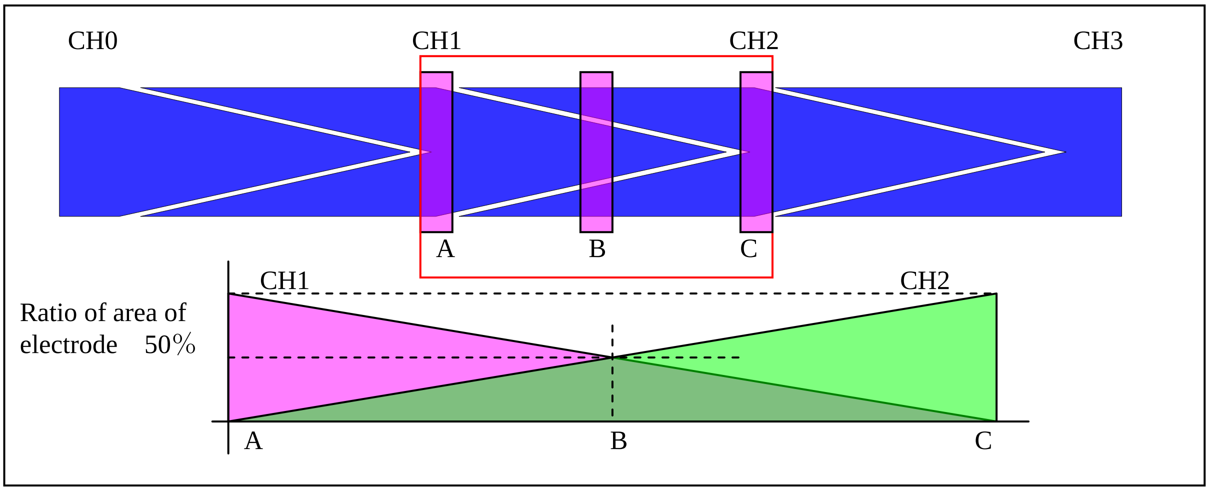

Figure 1-3- 1 Area ratio related chart of electrode

The area ratio of CH1 and CH2 is made the same at the middle position of CH1 and CH2 as shown in Figure 1-3-1.

② About the shape of the adjoining electrode

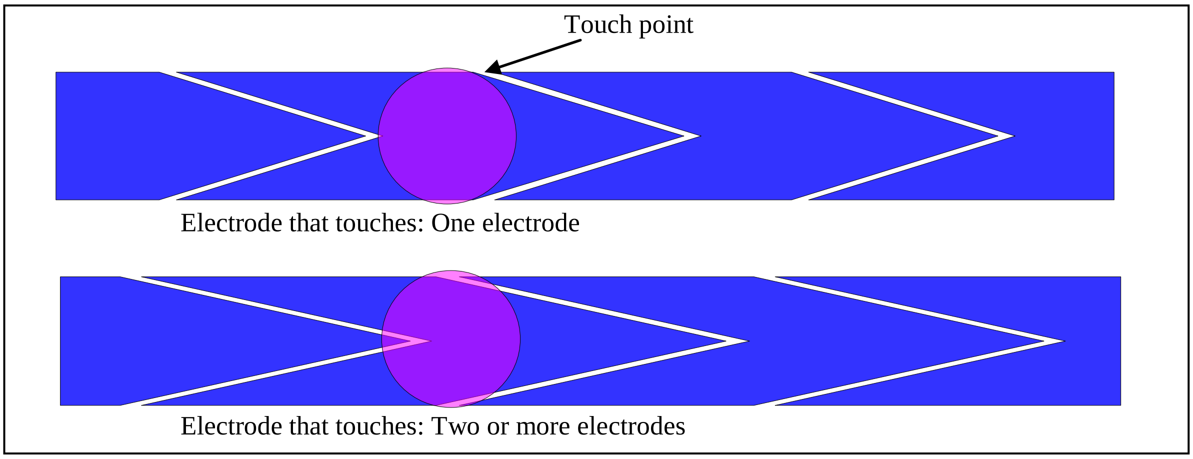

Figure 1-3- 2 Touch area and electrode geometry

By the calculation method of this application notebook,
There had better be much number of electrodes that capacity changes by a touch.
To touch a lot of electrodes when touching, the electrode geometry is decided.
Refer to Figure 1-3-2.

③ Relation between touch area and electrode geometry

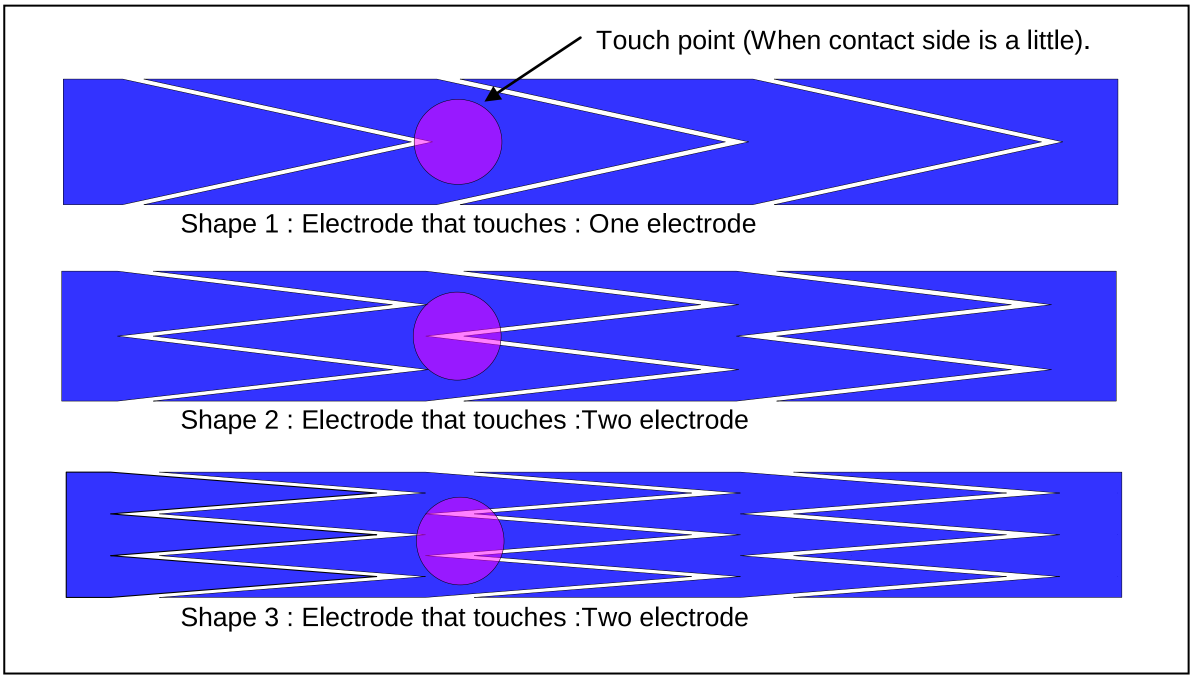

Figure 1-3- 3 Touch area and electrode geometry

When the touch area is a little, it is effective to increase a number of wedge shape.

④ Table related to electrode geometry and gap distance
Table 1-3-1 and Table 1-3-2 show the characteristic change by the electrode geometry and the gap metric.

Table 1-3- 1 Characteristic change by electrode geometry

Characteristic change by electrode geometry (Number of wedge shape)			
Number of wedge shape	Few	←→	Many
Linearity variation	Little inferior	←→	Better
Errors due to touch area	Large		Small
Stray capacitance	Low		Many

Table 1-3- 2 Characteristic change of electrode gap distance

Characteristic change of electrode gap distance			
Distance of gap	Short	←→	Long
Linearity variation	Better	←→	Little inferior
Errors due to touch area	Small		Large
Stray capacitance	Many		Low

Please decide the electrode geometry (number of electrodes CH and width of the electrode) based on the demanded condition (resolution, size, panel, and substrate, etc. as slider/wheel).

2. Calculation method

2.1 Wheel operation using four electrodes

We describe the example of the wheel's composed of four electrodes working.

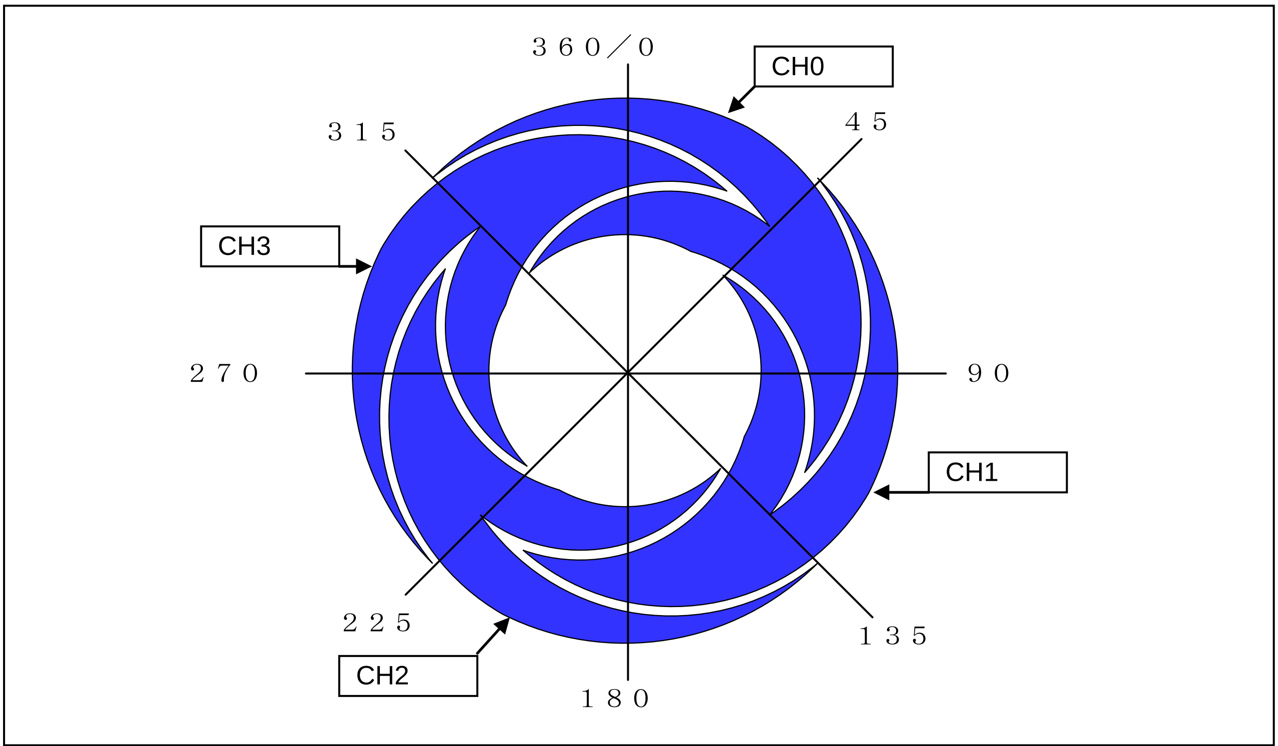

Figure 2-1- 1 Four electrode wheel operation explanation chart

When the wheel is composed of four electrodes, CH0 is arranged to become the position of 45 degrees on the circumference as shown in figure.
Other electrodes are arranged at the position of each 135 degrees, 225 degrees, and 315 degrees, and 360 degrees are composed of four electrodes.

① The amount of the change of CH that the amount of the change is the largest and CH of the adjoining electrode is used for the calculation.
② Angle (AngleX) is calculated by multiplying the angle constant by the amount of the change of each electrode.
③ The AngleX value is offset according to the CH number with the largest amount of the change.

The position touched is output by the following calculating formula as the data of the angle.

$$AngleX = \frac{\triangle ch\max \times 135 + \triangle chdec \times 45 + \triangle chinc \times 225}{\triangle ch\max + \triangle chdec + \triangle chinc}$$

$$Angle = AngleX - 90 + ch\max \times 90$$

Expression 2-1- 1 Four electrode type of calculation of angle of wheel

Note) chmax : CH number of CH that amount of change is the largest
⊿chmax : Amount of change by maximum change CH
⊿chdec : Amount of change by CH that is adjacent to maximum change CH(direction of CCW)
⊿chinc : Amount of change by CH that is adjacent to maximum change CH（direction of CW）

3. Application example

3.1 Example of composing wheel that uses eight electrodes

This that describes the example of composing the wheel by eight electrodes applies the computational method in four electrode wheel.

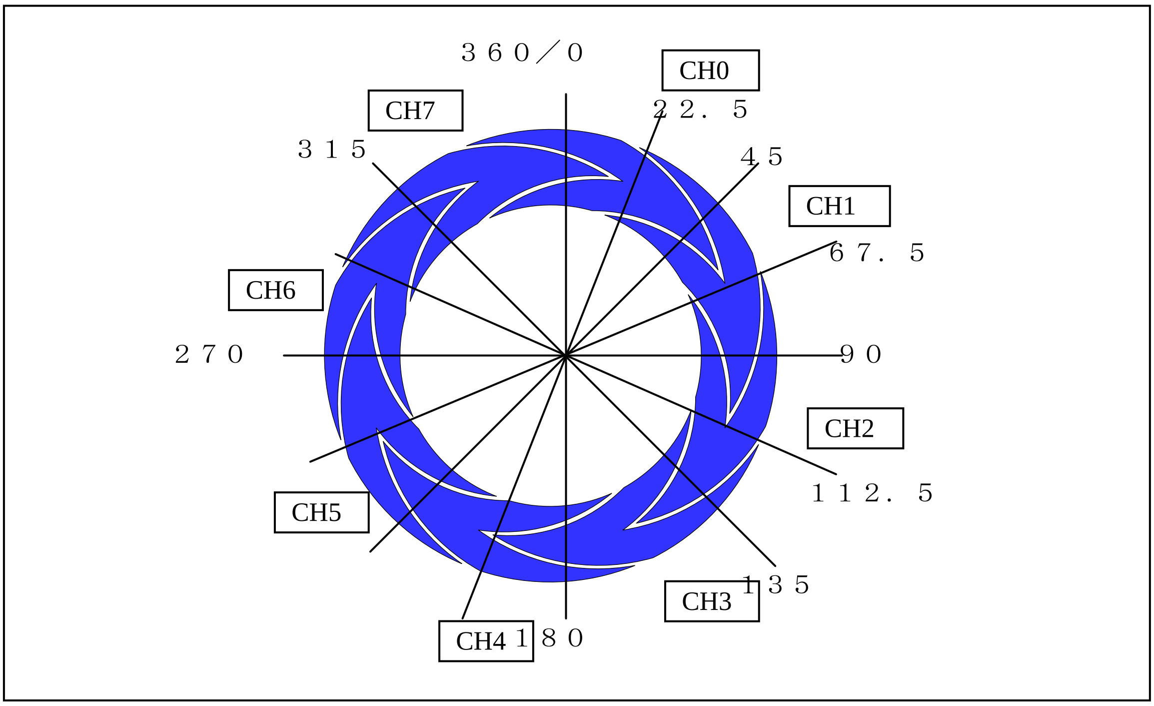

Figure 3-1- 1 Eight electrode wheel operation explanation chart

In the wheel composition that uses eight electrodes, to become the position of 22.5 degrees on the circumference, CH0 is arranged.

① The amount of the change of CH that the amount of the change is the largest and CH of the adjoining electrode is used for the calculation.
② Angle (AngleX) is calculated by multiplying the angle constant by the amount of the change of each electrode.
③ The AngleX value is offset according to the CH number with the largest amount of the change.

The position touched is output by the following calculating formula as the data of the angle.

$$AngleX = \frac{\triangle ch\max \times 67.5 + \triangle chdec \times 22.5 + \triangle chinc \times 112.5}{\triangle ch\max + \triangle chdec + \triangle chinc}$$

$$Angle = AngleX - 45 + ch\max \times 45)$$

Expression 3-1- 1 Eight electrode type of calculation of angle of wheel

Note) chmax : CH number of CH that amount of change is the largest
⊿chmax : Amount of change by maximum change CH
⊿chdec : Amount of change by CH that is adjacent to maximum change CH(direction of CCW)
⊿chinc : Amount of change by CH that is adjacent to maximum change CH（direction of CW）

The angle constant has been simplified in the sample code. (67.5→67 22.5→22 112.5→112)

3.2 Multi positioning in eight electrode wheel

In this calculation method, it is possible to obtain the location information (Angle value) only with three CH. As a result, it is possible in the wheel by eight electrodes to obtain the location information at four positions on practical use.

It exemplifies it as follows.

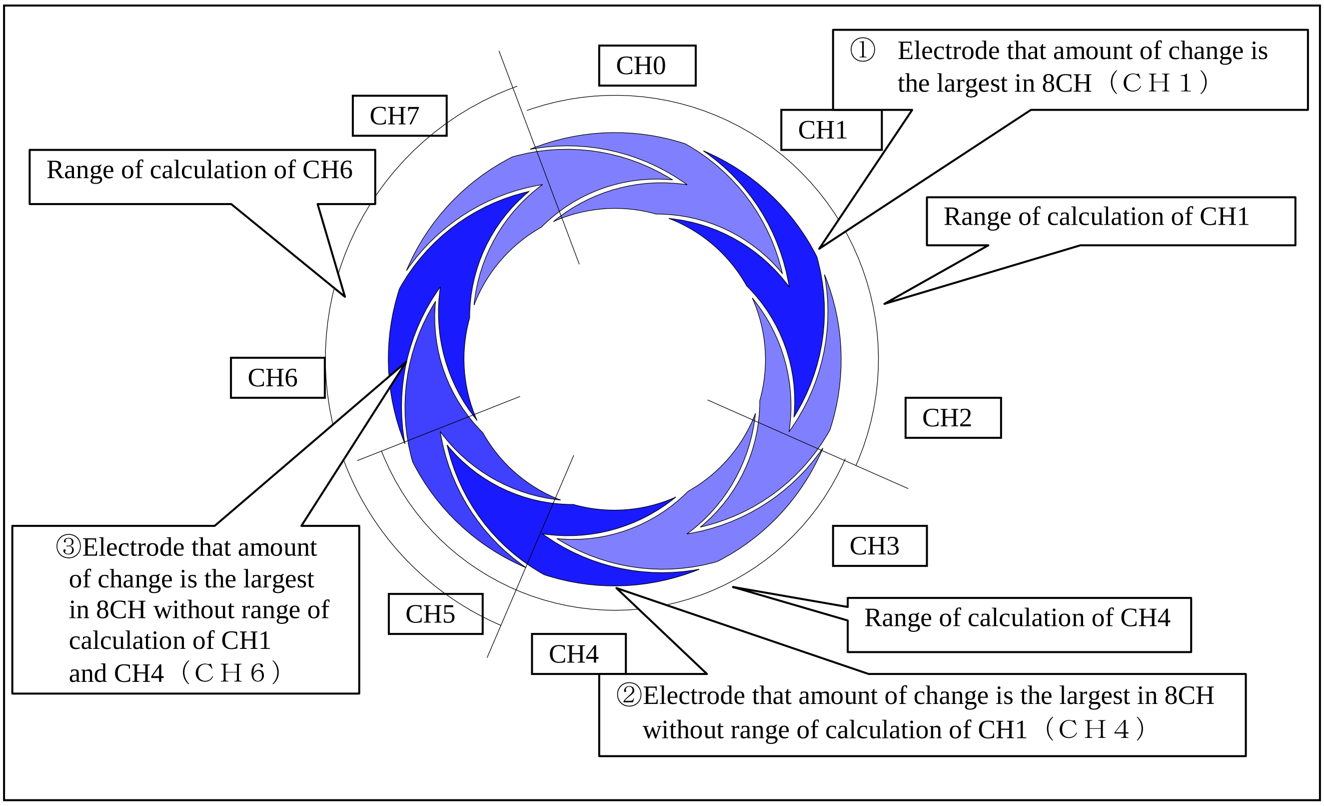

Figure 3-2- 1 Multi positioning operation explanation chart in eight electrode wheel

① The angle is obtained by centering on CH with the maximum value of the change.
(CH1 is amount CH of the maximum change. : CH0,CH1,and CH2 are used for angle calculation.)

② The angle is obtained by centering on CH with the maximum value of the change in CH other than CH used by ①.
(It calculates by centering on CH4. :CH3,CH4,and CH5 are used for angle calculation.)

③ ③ The angle is obtained by centering on CH with the maximum value of the change in CH other than CH used by ① and ②.
(It calculates by centering on CH6. :CH5,CH6,and CH7 are used for angle calculation.)

When CH used for the operation such as the above-mentioned ① and ② doesn't overlap, there is mutually no influence and the location information can be output.

The following applications are thought by using this method.

* The wheel special mode (SHIFT etc.)+ is operated at arbitrary position ON (two point operation).
* The wheel is operated by two points that are right and left or upper and lower (two point operation).
* Information on the angle is allocated as SW information and four SW is recognized simultaneously.
  (When the SW allocation is done in 5 degrees, it is possible to use it as 72 point SW.)

Note) The accuracy of angular information changes depending on the size of the electrode, the pattern shape, and the manner of operation.

4. Drift correction and touch judgment

4.1 Drift correction in wheel operation

About the drift correction in the wheel operation.
The amount of the change of the electrode that doesn't touch in the wheel operation is used to calculate.
Therefore, when an individual drift is controlled like the touch key (note), a correct numerical result is not obtained.

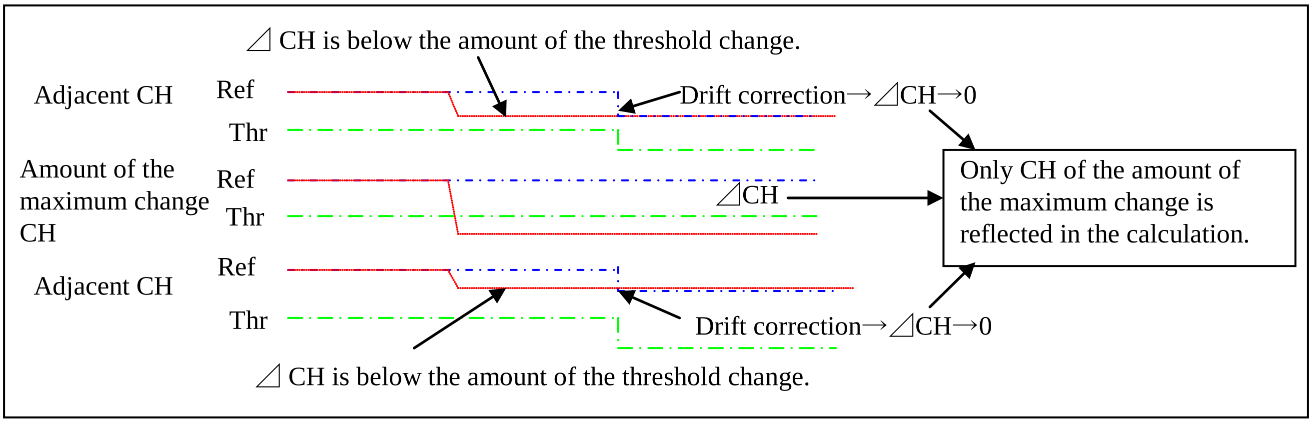

Figure 4-1- 1 Drift correction operation explanation chart

Note) The drift correction is done to CH that does the turning off judgment.

In the wheel operation, it is necessary to correct the drift to all composed CH at the same time.
As the concrete example, the threshold to all the amounts of the change of composition CH is made and the drift is corrected by judging the entire ON/OFF.

$$Asum = \triangle ch0 + \triangle ch1 + \cdots + \triangle ch(N-1)$$ Amount of total change of N channel composition wheel

$$if\ (Asum > ATHR)\{\cdots$$ Judgment of drift correction
ATHR : Wheel threshold

Expression 4-1- 1 Wheel operation total change amount calculation type

In wheel operation CH, the drift correction or the wheel operation processing diverges by judging ATHR and Asum.

4.2 Touch key judgment

When the SW key is allocated and used for angular information.
The turning on judgment is judged from the threshold to the amount of the change used for the angle operation.
To prevent chattering with the adjoined SW key, dead Angle is set.

When you achieve 12CH key by the angle output of four example electrode wheel

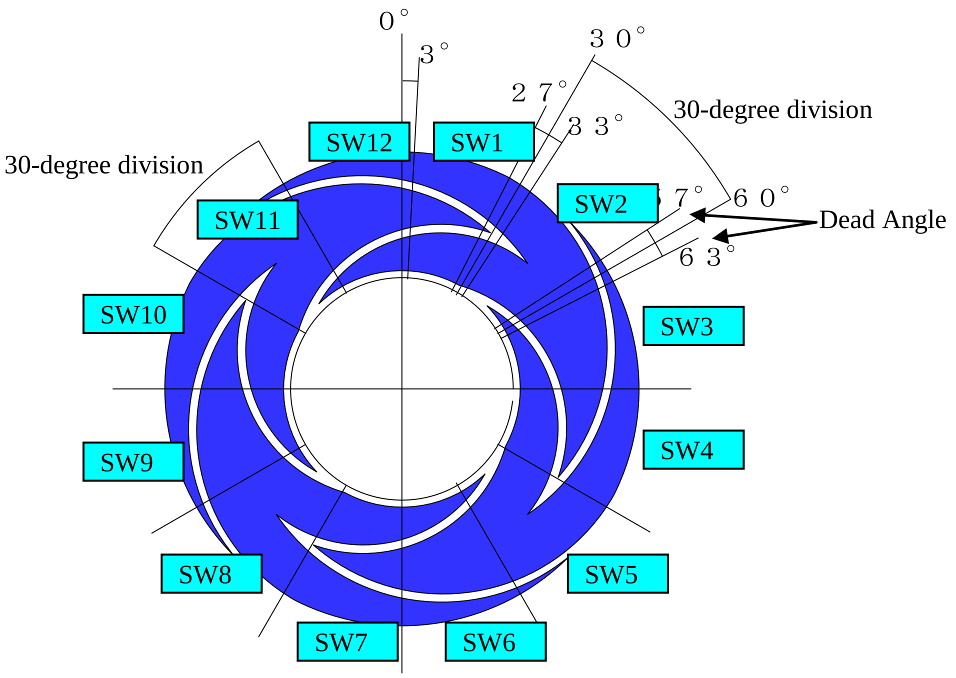

Figure 4-2- 1 Touch key judgment explanation chart

$$SWout = \frac{Angle}{DivAngle}$$

SWout : Output SW number
Angle : Angular information
DivAngle : Division angle

Dead Angle judgment (Dead Angle of 6° is set between each SW)

⊿angle＝Angle-－（SWout×DivAngle）
If（3＜⊿angle＜27 ）・・・

Expression 4-2- 1 Touch judgment operational expression

5. Sample code

```
/*****************************************************************************************/
/*  Function name: swheel1_dec                                                          */
/*  Function: Slider Wheel Process      (Use 4CH  CH0 - CH3)                            */
/*  Input     : Dcount                                                                  */
/*  Output    : Dangle1                                                                 */
/*****************************************************************************************/
extern unsigned short      Dcount[MAX_CH];     /* Measured value variation (work)*/

void   swheel1_dec( void ){
       unsigned long Dangle1;                  /* Angle output */
       unsigned char maxch1[3];                /* Array of Calculate CH number */
       unsigned long D1,D2,D3;
       unsigned char i, j;
/*------------------------- Check variation (ch0-ch3) ---------------------------------*/
       for ( i = 0,j = 0; i < 3; i++) {               /* Check variation (ch0-ch3) */
              if (Dcount[j] < Dcount[i + 1]) {
                     j = i + 1;
              }
       }
/*------------------------------------------------------------------------------------*/
       maxch1[0] = j;             /*Filling an array (CH number of maximum variation)*/
/*------------------------------------------------------------------------------------*/
       if (maxch1[0] == 0) { maxch1[1] = 3;}
       else { maxch1[1] = maxch1[0] - 1;}
       if (maxch1[0] == 3) { maxch1[2] = 0;}
       else { maxch1[2] = maxch1[0] + 1;}
/*------------------------- Angle calculation ---------------------------------------*/
       D1 = Dcount[maxch1[1]] * 45;                                        /* */
       D2 = Dcount[maxch1[0]] * 135;                                       /* */
       D3 = Dcount[maxch1[2]] * 225;                                       /* */
       Dangle1 = D1 + D2 + D3;
       Dangle1 = Dangle1 / (Dcount[maxch1[0]] + Dcount[maxch1[1]] + Dcount[maxch1[2]]);
       Dangle1 = Dangle1 -90 + (maxch1[0] * 90);
}
```

```
/*******************************************************************************/
/*  Function name: swheel2_dec                                                 */
/*  Function: Slider Wheel Process      (Use 8CH  CH4 - CH11)                  */
/*  Input     : Dcount                                                         */
/*  Output    : Dangle[n](0 - 360) Max 4point                                  */
/*******************************************************************************/
extern unsigned short     Dcount[MAX_CH];     /* Measured value variation (work)    */

void   swheel2_dec( void ){
       unsigned long Angle[4];                                  /* Angle output */
       unsigned short D_work_buff[9][2];                        /* work array */
       unsigned char maxch[4][3];                               /* work array */
       unsigned long D1,D2,D3;
       unsigned char i, j,k,n;
/*------------------------- work array initial ----------------------------------------*/
       for ( i = 0 ; i < 9; i++ ) {
              D_work_buff[i][0] = i + 4;
              D_work_buff[i][1] = Dcount[i+4];
              if(i == 8) {
                     D_work_buff[8][0] = 0;
                     D_work_buff[8][1] = 0;
              }
       }
/*------------------------- Angle decode (Max 4 Point out put) ------------------------*/
       for (n = 0; n < 4; n++) {
/*------------------------- Check variation (ch0-ch3) ----------------------------------*/
              for ( i = 0,j = 0; i < 7 ; i++) {
                     if (D_work_buff[j][1] < D_work_buff[i + 1][1]) {
                            j = i + 1;
                     }
              }
/*-----------------------------------------------------------------------------------------*/
              maxch[n][0] = D_work_buff[j][0];
                                    /*Filling an array (CH number of maximum variation)*/
/*-----------------------------------------------------------------------------------------*/
              if (maxch[n][0] == 4) { maxch[n][1] = 11;}
              else { maxch[n][1] = D_work_buff[j - 1][0];}
              if (maxch[n][0] == 11) { maxch[n][2] = 4;}
              else { maxch[n][2] = maxch[n][0] + 1; }
/*-----------------------------------------------------------------------------------------*/
              for ( i = 0; i < 3; i++) {
                     for (j = 0; j < 8; j++) {
                            if(D_work_buff[j][0] == maxch[n][i]) {
                                   for (k = j;k < 8; k++) {
                                          D_work_buff[k][0] = D_work_buff[k+1][0];
                                          D_work_buff[k][1] = D_work_buff[k+1][1];
                                   }
                                   break;
                            }
                     }
              }
/*------------------------- Angle calculation -------------------------------------------*/
              D1 = Dcount[maxch[n][1]] * 22;
              D2 = Dcount[maxch[n][0]] * 67;
              D3 = Dcount[maxch[n][2]] * 112;
              Dangle[n] = D1 + D2 + D3;
              Dangle[n] = Dangle[n] / (Dcount[maxch[n][0]] + Dcount[maxch[n][1]] +
                                                              Dcount[maxch[n][2]]);
              Dangle[n] = Dangle[n] -45 + ((maxch[n][0] - 4) * 45);

       }
}
```

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Revision Record

Rev.	Date	Description	
		Page	Summary
1.00	May 21 2013	—	Numbering change (Contents is as same as REJ05B1403-0100)

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.

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