

Accelerate Development Time with Renesas Capacitive Touch Sensor Unit (CTSU)

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Introduction

The capacitive touch market is rapidly growing with many market sectors integrating multi-sensory features to deliver a better design and more convenient user experience. The capacitive touch-key technology enables innovative switches in terms of designability and operability with a light touch. It also replaces not only buttons but also wheels, and sliders. Compared to the mechanical button, capacitive touch-key is more robust, as there is no need of physical parts and wear-out failure, dust and splash-proof designs, maintainability. Its flat design structure improves maintainability. In addition to maintenance, capacitive touch can reduce system cost by replacing mechanical parts to PCB patterning.

However, it takes a lot of development time and cost to implement advanced usability, such as high sensitivity, noise immunity and waterproof.

Renesas capacitive-touch solution is highly sensitive, has a high noise immunity, low power consumption, and simplifies development. Read on to learn more about the various functions that can help you to accelerate your development time.

Value of Renesas Capacitive Touch



Figure.1 Renesas Capacitive Touch Solution Value Proposition.

Measurement Principles of Renesas Capacitive Touch

Touch detection method (CTSU) enables high sensitivity and high noise resistance for advanced features like gesture control and multi touch in consumer electronics and smart devices.

CTSU developed by Renesas converts capacitance into current and quantifies capacitance measurement using a switched capacitor circuit. The measured value is corrected, and the noise component is reduced by filtering. Finally, the judgment is made by comparing with the threshold value. Through this methodology, the capacitive touch sensor can recognize more materials and gestures to be used in various applications.

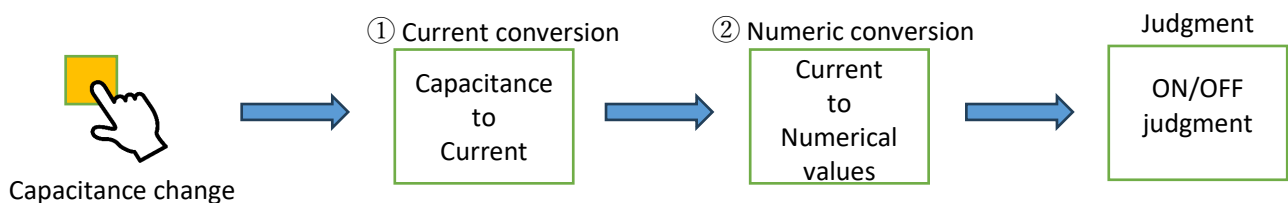


Figure 2: Flow from Capacitance Measurement to Touch Judgment

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Below diagram will show you in detail how Renesas could conduct the following two critical points, delivering a more sensitive touch technology for your application needs.

① High sensitivity capacitance-current conversion

Convert capacitance to current with high sensitivity by optimization of sensor drive pulse frequency.

② High sensitivity oscillator

Achieved high-resolution measurement by high-sensitivity oscillator.

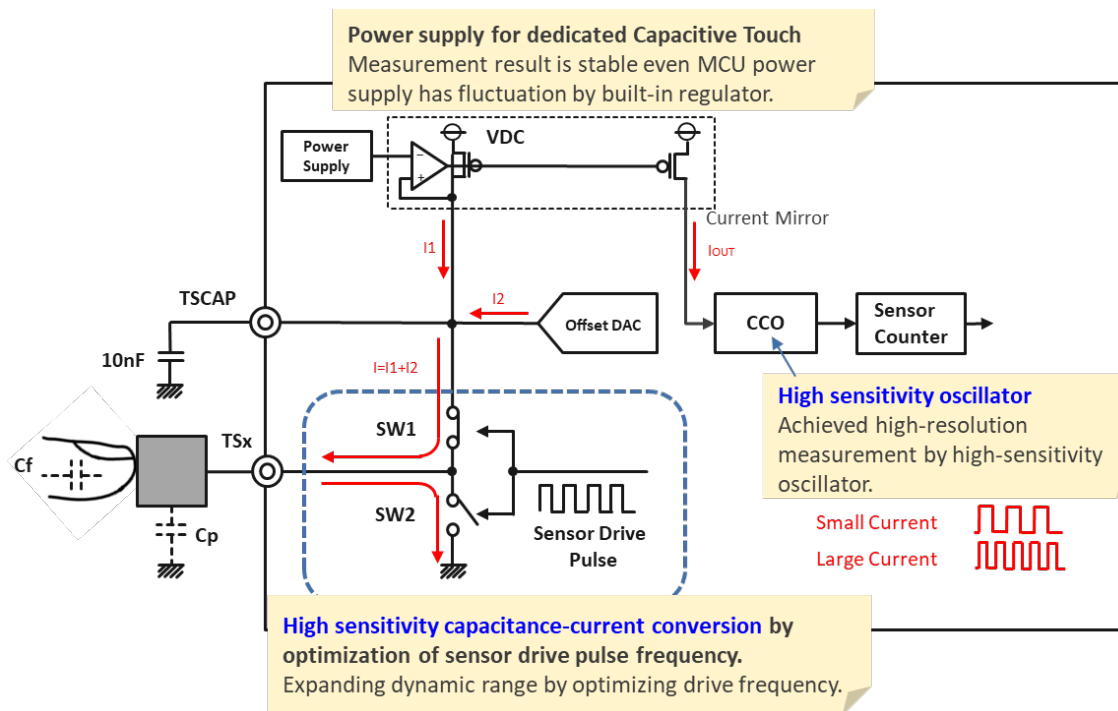


Figure 3: Measurement Circuit of Capacitive Touch Sensor Unit (CTSU)

Canceling parasitic capacitance by Offset current DAC
Digitalizing electric current volume focusing on touching capacitance change by cutting off parasitic capacitance.

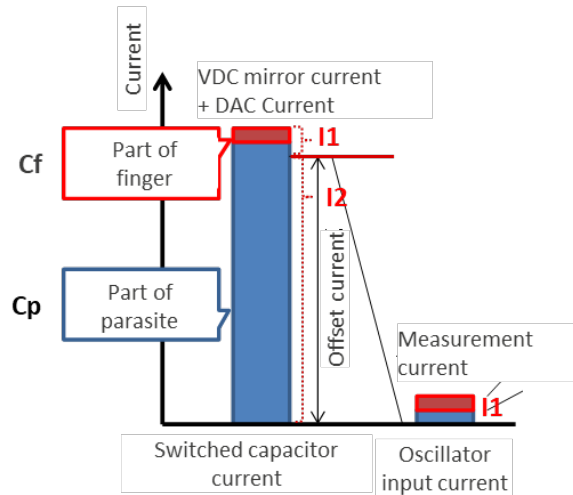


Figure 4: Offset Tuning Process of Self-Capacitance Method

Capacitive Touch Sensor Type

Compared with CTSU1, the latest CTSU2 has the following added functions and enhanced features to enable high-speed multi-touch experience, higher precision, and be able to use near a wet environment.

Enhanced Noise Immunity

- Synchronous noise avoidance function by multiple sensors drives pulse frequency measurement

Improved Water Resistance

- Improvement of water resistance by the self-capacitance method using an active shield electrode

Enhanced Scan Speed

- Addition of " Capacitance-Frequency Conversion " (CFC) that supports parallel simultaneous scanning

Reduction of Software Processing Load

- Addition of automatic judgment function
- Addition of automatic correction function

Different microcontrollers are embedded with different capacitive touch sensor types, allowing users to select the ideal functions for their development. The following table summarized the functions for different capacitive touch sensor types.

Accelerate Development Time with Renesas Capacitive Touch Sensor Unit (CTSUs)

Function	CTSUs/ CTSUsa	CTSUsb	CTSUs2	CTSUs2L	CTSUs2La	CTSUs2SL	CTSUs2SLa
Self-capacitance method	✓	✓	✓	✓	✓	✓	✓
Mutual-capacitance method	✓	✓	✓	✓	✓	✓	✓
Random pulse frequency measurement	✓	✓	△	△	△	△	△
Multi-frequency measurement			✓	✓	✓	✓	✓
Active shield			✓	✓	✓	✓	✓
Automatic judgment				✓*1 *2	✓*1 *2	✓ *2	✓*3
Automatic correction				✓*1	✓*1	✓	✓
Automatic multi-frequency correction							✓
Multiple Electrode Connection (MEC)		✓			✓	✓	✓
Capacitance-Frequency Conversion (CFC)			✓				

Table 1: Comparison of the Capacitive Touch Sensor Functions

✓ : Supported

△ : This function is not supported by the driver because it supports multi-frequency measurement.

*1 : Achieved when used with SNOOZE-mode programmable controller (SMS).

*2 : Automatic judgment is measured by JMM.

*3 : Automatic judgment is measured by VMM or JMM.

Random Pulse Frequency Measurement

This method reduces the noise effect when measuring capacitance, by desynchronizing the noise and the sensor drive pulse. Capacitance is measured by outputting a sensor drive pulse. When noise is mixed in this sensor drive pulse, the measurement result fluctuates. For this reason, CTSUs1 reduces the effect of noise by outputting random pulses that are not synchronized with noise by spread spectrum or phase shifting. This function enables anti-noise in your end product and reduces your development time.

Multi-Frequency Measurement

Multi-clock measurement is a measuring method by using multiple different frequencies for the sensor drive pulse to reduce the noise effect when measuring capacitance

Capacitance is measured by outputting a sensor drive pulse. When noise is mixed in this sensor drive pulse, the measurement result fluctuates. For this reason, CTSUs2 is equipped with a multi-frequency measurement function that enables measurement with several clocks with differing frequencies. There are two measurement methods for multi-frequency measurement touch judgment – Value Majority Mode and Judgement Majority Mode.

Value Majority Mode (VMM)

Value Majority Mode (VMM) is a method to determine the value by adding two measurement values that are close to each other from the measurement results of three frequencies.

Judgement Majority Mode (JMM)

Judgement Majority Mode is a method in which each of the three frequency measurements is judged by a majority vote.

Active Shield

Active shield is a method of noise suppression while reducing the effect of capacitive coupling between the electrode and the shield pattern. As an operation, the shield pattern is driven by a signal of the same potential and phase as the electrode being measured.

This function drives the shield guard with the same potential and phase as the electrode being measured. Using the active shield will reduce capacitance coupling between the electrode and shield guard as well reduce noise interference. This function also makes your product water-proof with the self-capacitance method.

Automatic Judgment

Automatic judgment function to judge the touch of a button by hardware without activating CPU. Therefore, low power consumption operation can be realized.

Automatic Correction

Automatic correction function to correct sensor CCO (ICO) with hardware. It does not consume the main processor processing time because the hardware handles the correction calculation without using the software's correction calculation processing.

Multiple Electrode Connection (MEC)

Multiple Electrode Connection (MEC) is a function of connecting self-capacitance type electrodes inside CTSU to measure them as a single electrode. If you use MEC, you can use any key to return from standby mode.

Capacitance-Frequency Conversion (CFC)

By using CFC pin as the receiving pin and switching to the mutual-capacitance parallel measurement mode, it is possible to simultaneously measure several pins.

How to Start Renesas Capacitive Touch System Development

Accelerate Your Capacitive Touch System Development

Developing a capacitive touch system can take up a lot of time. To help developers to reduce the development time and accelerate time to market, Renesas provides the [Capacitive Touch Introduction Guide](#) that summarized the cap-touch development flow and important technical information, including development environment and evaluation kits, to efficiently build a cap-touch system.

Efficiently Design Capacitive Touch Electrode

After MCU selection and trial evaluation with Capacitive Touch Evaluation System, users will start to design electrode patterns for your system. There are design constraints for sensitivity and anti-noise, which can be overcome if users understand the design rules to implement high -sensitive Cap-Touch system. Renesas offers the [Capacitive Touch Electrode Design Guide](#) sharing design information of electrode pads, wiring as well as on how to deal with related issues and potential problems. This guide also includes actual design samples based on self-capacitance method and mutual-capacitance method, enabling users to efficiently design electrode patterns.

Noise is also an important factor in a cap-touch system, as too much noise may delay the response of touch capabilities. The [Capacitive Touch Noise Immunity Guide](#) introduced the different types of noise, and noise reduction functions of Renesas cap-touch IP. Learn how to design anti-noise board with Software filter and evaluation results listed in this app-note.

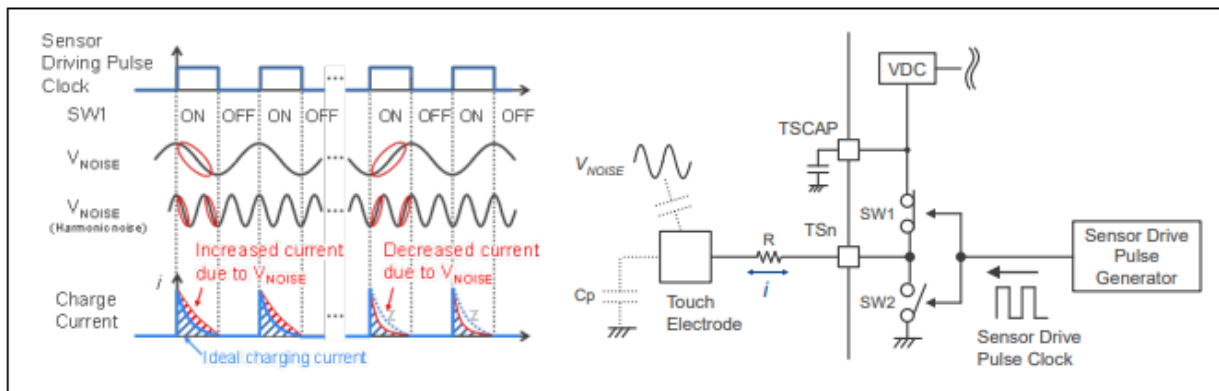


Figure 5. Example of Charge Current Error Due to Periodic Noise

How to create Capacitive Touch Software

A Cap-Touch software development is needed during prototyping PCB. Refer to Renesas' [Overview of Capacitive Touch Software](#) to efficiently develop software. All the information from software structure to hardware parameters are explained in detail in the following figure.

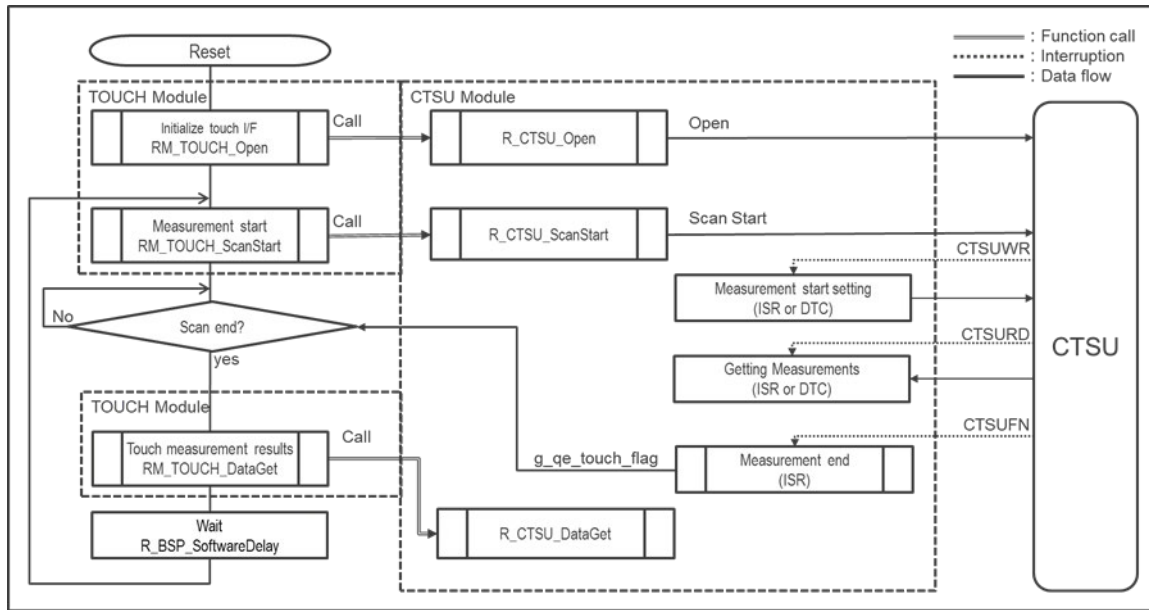


Figure 6. Basic Behavior Model of Renesas Capacitive Touch

Renesas continues to provide useful application notes to help users to accelerate the touch system development. Explore the wide range of [Capacitive Touch Evaluation Systems](#) embedded with different MCUs that would help you to jumpstart the touch evaluation and development. For more information, visit <http://www.renesas.com/key-technologies/human-machine-interface-hmi/capacitive-touch>

Conclusion

The various embedded functions of the Capacitive Touch are integrated into our broad MCU portfolio to reduce noise, increase sensitivity for various materials with enhanced waterproof capabilities. This white paper will help you to select the MCU with the suitable technology for your next Touch development. Jumpstart your development with Renesas' capacitive touch kits that provide you with the platform to easily start prototyping.

References

- [Capacitive Sensor Microcontrollers CTSU Capacitive Touch Introduction Guide](#)
- [Capacitive Touch HMI Solutions](#): Learn about the technology, the recommended MCUs with touch function and the reference solutions based on various touch applications.
- [Capacitive Touch Evaluation System](#): Start capacitive touch development at ease.

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(Rev.1.0 Mar 2020)

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Doc Number: R30WP0015EU0100