Implement High-Precision Capacitive Touch Sensor Across a Wide Range of HMI Applications

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Abstract

In recent years, capacitive touch sensors have been introduced in a wide range of applications such as home appliances and industrial equipment, aiming to improve design, water resistance, and dust resistance. However, several issues have arisen depending on the application, such as operation failure due to disturbance noise or water droplets, and prolonged development time due to the lack of technical know-how. To solve these issues, Renesas offers MCUs with the latest generation of capacitive touch sensor IP - CTSU2SL. This white paper introduces the improved noise immunity, water resistance, and low power consumption during intermittent operation of CTSU2SL, as well as the available tools and guidelines for development including examples of application development.

Introduction

The global HMI market is expected to grow at a CAGR of 7.90% by 2029. With the development of HMI technology in recent years, it has become increasingly important to improve UX (User experience) and UI (User Interface) in order to add value to the products. Under these market conditions, there is a growing demand for capacitive touch sensors, which can deploy on a wide-range of materials such as wood or transparent acrylic as operation panels according to the design concept of the enclosure, or as LED-based user guides to provide ease of use. Unlike conventional physical buttons, capacitive touch sensors have no springs or other moving parts, making them less prone to breakdown due to wear and tear and can extend product life. In addition to product longevity, the operation panel is completely flat and has no gaps, making it easy to take measures against dust and water droplets and enhance the ease of cleaning and other maintenance works. This technology has conventionally been used mainly in high-end home appliances that require high functionality and design, but in recent years it is penetrating to low-end home appliances, industrial equipment, and medical and healthcare equipment requiring high-level of cleanliness.

However, various hurdles must be overcome with the introduction of new capacitive touch sensors, , such as preventing false detection of touch events due to disturbance from noise or water droplets, electrode pattern design and sensitivity tuning to achieve comfortable touch operation.

Renesas has a lineup of many MCUs equipped with capacitive touch sensor IP, and has a market track record of more than 10 years, meeting the needs of users who deploy touch sensors in their application. The latest generation of capacitive touch sensor IP - CTSU2SL - has improved noise immunity, water resistance, and low power consumption features compared to the previous generation, enabling superior

operability under various conditions. This white paper introduces the features that have evolved in the CTSU2SL.

Improved Noise Immunity by Multi-Frequency Measurement

Capacitive touch sensors can detect changes in capacitance due to the proximity of a finger or hand, but minute changes may also occur due to disturbance noise in the surrounding environment. Conventional detection methods use single frequency measurement to measure capacitance, so if the disturbance noise frequency is synchronized with the measurement frequency, it cannot be measured accurately, and a touch event may be incorrectly detected. On the other hand, the CTSU2SL multi-frequency measurement method uses three measurement frequencies, so that even if one measurement frequency is affected by disturbance noise, the remaining two measurement frequencies, which are less affected, can accurately detect the event.

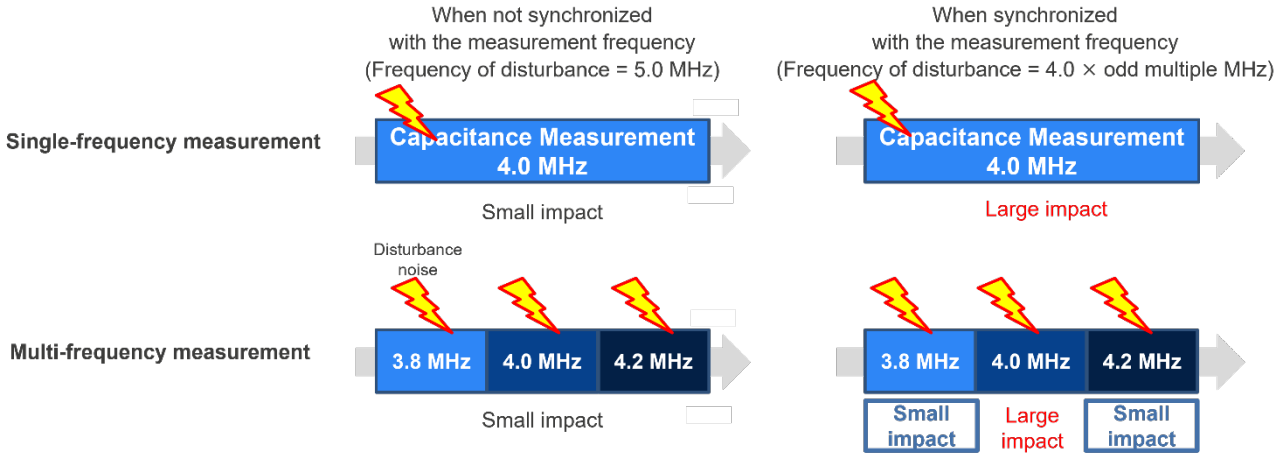

Figure 1: Effects of Disturbance Noise on Single-Frequency Measurement and Multi-Frequency Measurement

Active Shielding for Improved Noise Immunity and Water Resistance

Parasitic capacitance refers to the capacitance of electrodes and wires to which capacitors are not connected on a product board. Large parasitic capacitance may reduce the detection sensitivity of capacitive touch sensors. The active shield of the CTSU2SL is a function that drives the shield guard with a signal of the same potential and phase as the electrode is being measured. This suppresses the increase in parasitic capacitance due to capacitive coupling between the electrode and the shield guard, thereby enhancing noise immunity.

The conventional method causes an increase in capacitance, when water droplets, oil, or other substances bridge the gap between the electrode and the surrounding shield guard during measurement, as it may be misinterpreted as a change in capacitance due to touch operation. However, the active shield can reduce the effect of increased capacitance due to water droplets and other factors with the electrode and the shield

guard during measurement. Therefore, capacitive touch sensors can be safely introduced in environments such as kitchens and restrooms, where water and oil stains tend to adhere.

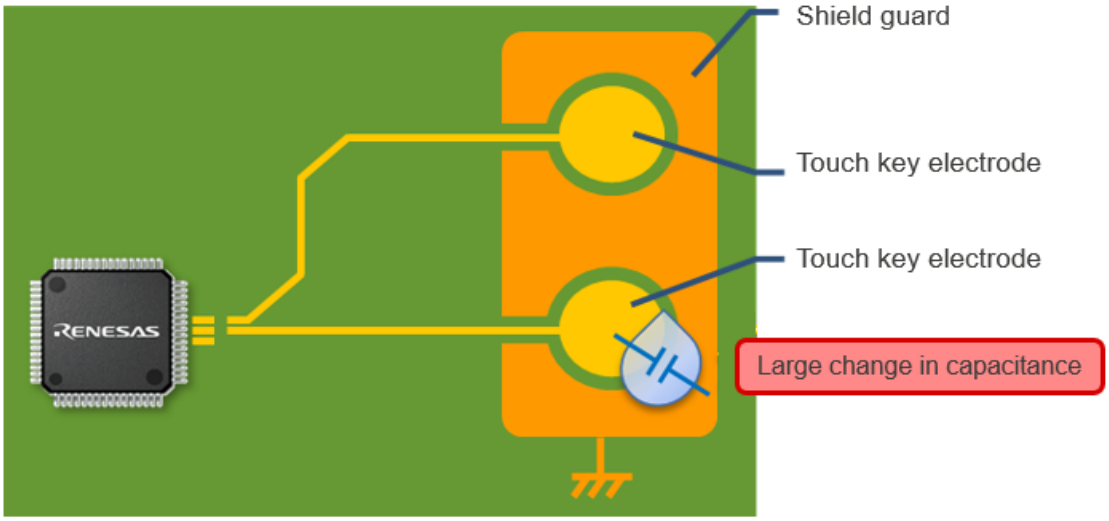

Figure 2: Shield Guard Situation

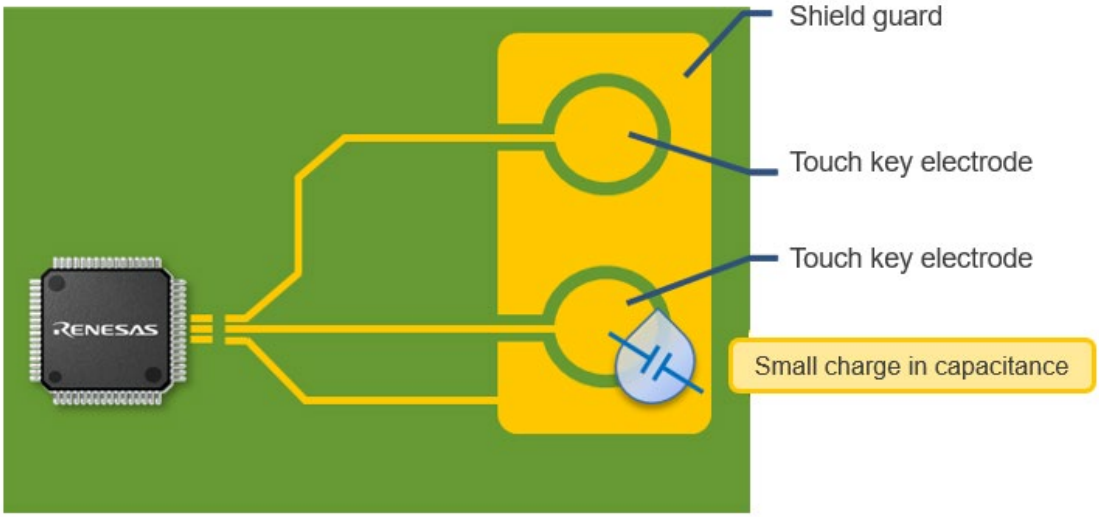

Figure 3: Active Shield Situation

Low Power Consumption with Smart Wake-up Solution

With the increasing number of battery-powered and environmentally friendly products such as smart locks and small home appliances, there is a growing need for low power consumption in HMI technology using capacitive touch sensors. To meet these demands, Renesas offers a smart wake-up solution that uses snooze mode - one of the MCU's low-power modes - and the CTSU2SL automatic judgment function and MEC (Multiple Electrode Connection) function to significantly reduce the standby power of products.

By combining snooze mode, which operates only certain peripheral functions while the CPU has stopped during standby, and the automatic judgment function, which judges the touch of a button in hardware without running the CPU, the product will return to software standby mode without judgment by the CPU when no touch events are detected during snooze mode to maintain low power consumption. Also, the MEC function allows multiple touch buttons to be measured as a single button, reducing measurement time and achieving even lower power consumption.

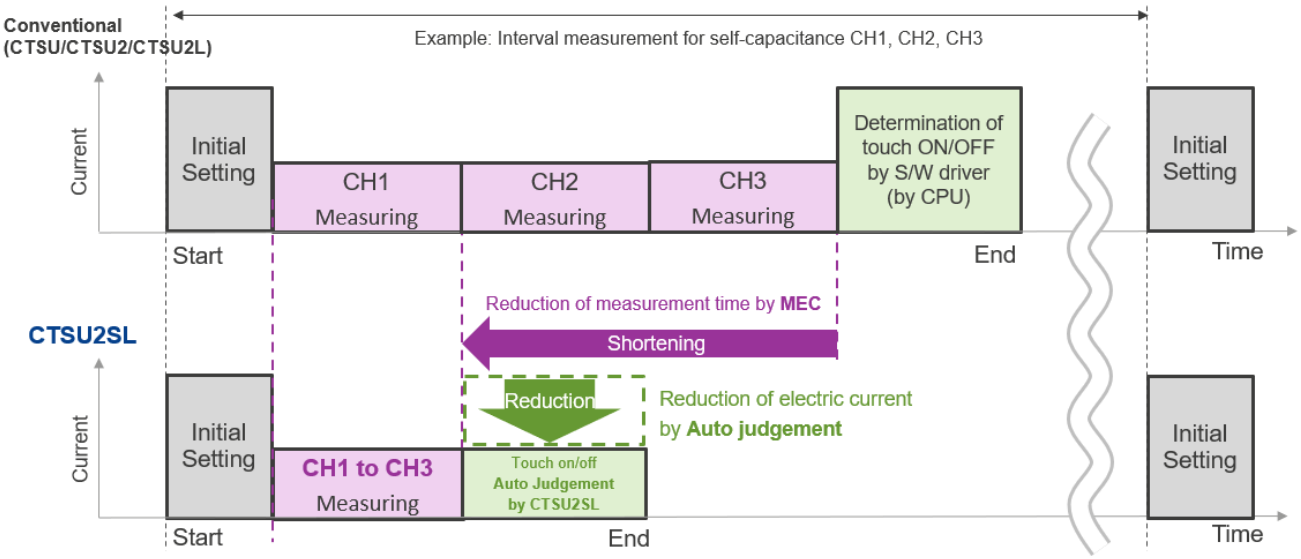

Figure 4: Image of Periodic Measurement at Intermittent Operation

Development Environment Optimized for Capacitive Touch Sensor

- QE for Capacitive Touch

  A time-consuming process of adjusting touch parameters through cut-and-try has been a barrier in the development of capacitive touch sensors. Renesas provides the QE for Capacitive Touch, which is a development support tool for capacitive touch sensors that automatically generates touch detection programs, monitors measured values, and adjusts parameters using a GUI, making it easy to adjust touch sensitivity.

- Capacitive Touch Evaluation System

A board for evaluating capacitive touch sensors, which includes a CPU board with MCU and an expansion board for evaluating buttons, sliders, and wheels, allowing evaluation of all touch ports. Also sample code, such as smart wake-up solution, is provided to allow immediate operation of Renesas' touch key solutions.

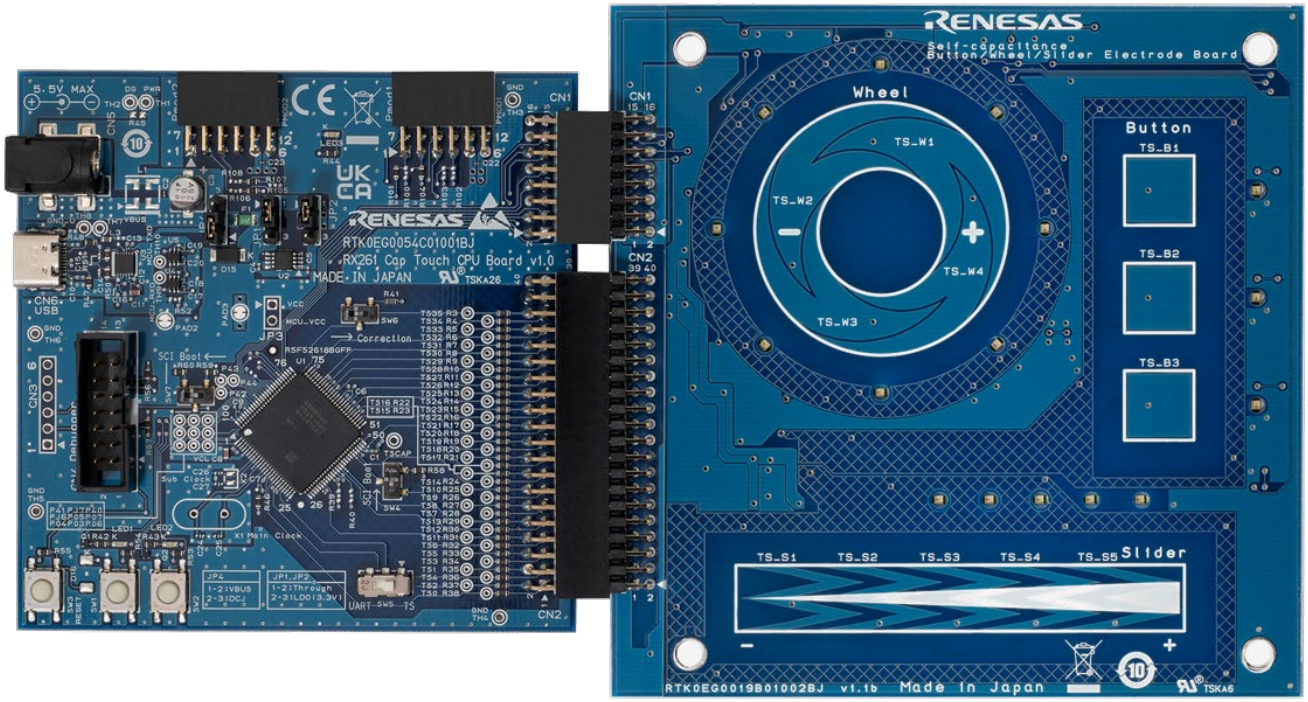

Figure 5: Capacitive Touch Evaluation System for RX261

• CTSU Capacitive Touch Introduction Guide

This introduction guide introduces the detection principle and features of capacitive touch sensors, MCU lineup, hardware, software, development environment and evaluation boards so that even users who are new to capacitive touch sensors can introduce Renesas' touch key solutions.

• CTSU Capacitive Touch Electrode Design Guide

Measurement results of capacitive touch sensors vary depending on various factors such as the shape and size of the touch electrode pad, wiring routing, peripheral patterns, overlay panel thickness, presence of air layer, and the structure inside the product housing. Therefore, the design of electrode sensitivity and noise immunity performance must be fully considered. This guide explains the design of electrode pads and wiring for the use of CTSU and CTSU2x and the various factors associated with them and introduces recommended applications for them.

• Capacitive Touch Noise Immunity Guide

Capacitive touch sensors can be affected by disturbance noise in the surrounding environment because even unwanted electrical signals can cause minute changes in capacitance. Since the magnitude of the effect of this noise varies depending on the hardware design, implementing countermeasures at the design stage will make the sensor more resistant to noise and enable effective product development. This guide describes ways to improve noise immunity for products using the Renesas Capacitive Touch Sensing Unit (CTSU) in accordance with the IEC61000-4 noise immunity standards.

Examples of MCUs with CTSU2SL and Application Development

Renesas MCUs with CTSU2SL enable system control, capacitive touch sensors, security, and other functions on a single chip, reducing BOM costs for users. Among the RX family MCUs with more than 10 years of market experience, both the RX261/RX260 and RX140 are equipped with the CTSU2SL. These MCUs enable capacitive touch sensors to be employed in a variety of applications in addition to general touch applications such as home appliances. For general touch applications, the RX140 can be used to integrate HMI and system control on a single chip, reducing overall system BOM costs. On the other hand, the RX260 can be used when higher processing performance or a larger internal memory capacity than the RX140 is required. The RX261 is recommended to use for applications requiring CAN FD, USB, and security functions.

By adopting proximity buttons that utilize capacitive touch sensors on elevator operation panel, operation can be performed without directly touching the panel, ensuring cleanliness even for equipment used by an unspecified number of people. The RX261 is equipped with CAN FD, while the RX140 is equipped with CAN, so the operation panel and other modules can be connected with reliable communication.

The use of capacitive touch sensors on a smart lock operation panel provides both the water and dust resistance required for outdoor use. Furthermore, by utilizing smart wake-up, which can detect touch events even during standby, power consumption can be reduced, and the built-in battery can extend operating time. In addition, the RX261 can protect user data and securely update firmware via wireless network thanks to the robust security features built into the MCU.

Conclusion

While capacitive touch sensors are increasing in demand, the diversity of applications in which they are deployed demands high noise immunity, water resistance, and low power consumption. Renesas' latest capacitive touch sensor IP - CTSU2SL - meets these needs by offering improved noise immunity through multi-frequency measurement, improved noise and water resistance through active shielding, and low power consumption through smart wake-up. Renesas also offers a variety of evaluation and development solutions to help you implement high-precision capacitive touch sensors and shorten development time.

Related Information

RX261: Microcontrollers with Outstanding Power Efficiency, Advanced Touch Functions, and Robust Security

RX260: Microcontrollers with Outstanding Power Efficiency and Advanced Touch Functions

RX140: Microcontrollers with Third-Generation Touch IP for Even Lower Power Consumption

Capacitive Touch Evaluation System for RX261: A kit embedded with RX261 MCU enabling immediate evaluation and development of touch-key solutions

Capacitive Touch Evaluation System for RX140: A kit embedded with RX140 MCU enabling immediate evaluation and development of touch-key solutions

Capacitive Touch Keys: Specialized page summarizing touch-key solutions

HMI - Market Share Analysis, Industry Trends & Statistics, Growth Forecasts (2024 - 2029) (giiresearch.com)

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