RA CAPACITIVE TOUCH SOLUTION

RENESAS ELECTRONICS CORPORATION

AGENDA

- Introduction of Renesas Capacitive Touch IP
- RA2L1/RA2E1 Touch Solutions
- Software and tools

INTRODUCTION OF RENESAS CAPACITIVE TOUCH IP

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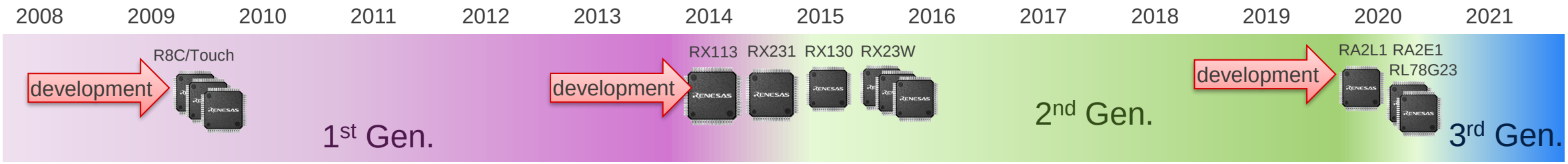
IN THE BEGINNING

We have released MCUs for capacitive touch key solutions.



1st Generation Capacitance Sensor IP installed MCU (From 2008 R8C-33T…)

- Use OMRON licensed measurement methods.
- Supports touch button application only.

2nd Generation Capacitance Sensor IP installed MCU (From 2014 RX113…)

- Renesas original measurement method.
- High noise immunity.
- Mutual capacitance method support

3rd Generation Capacitance Sensor IP installed MCU (From 2019 RA2L1 …)

RENESAS TOUCH LINE-UP

TOUCH DEVICES

RENESAS RX

RENESAS RA

Renesas RA2 Series

Renesas RA4 Series

Renesas RA6 Series

Next devices with new Touch IP coming soon

Renesas RA2 Series

RL78/G2x

RENESAS RX

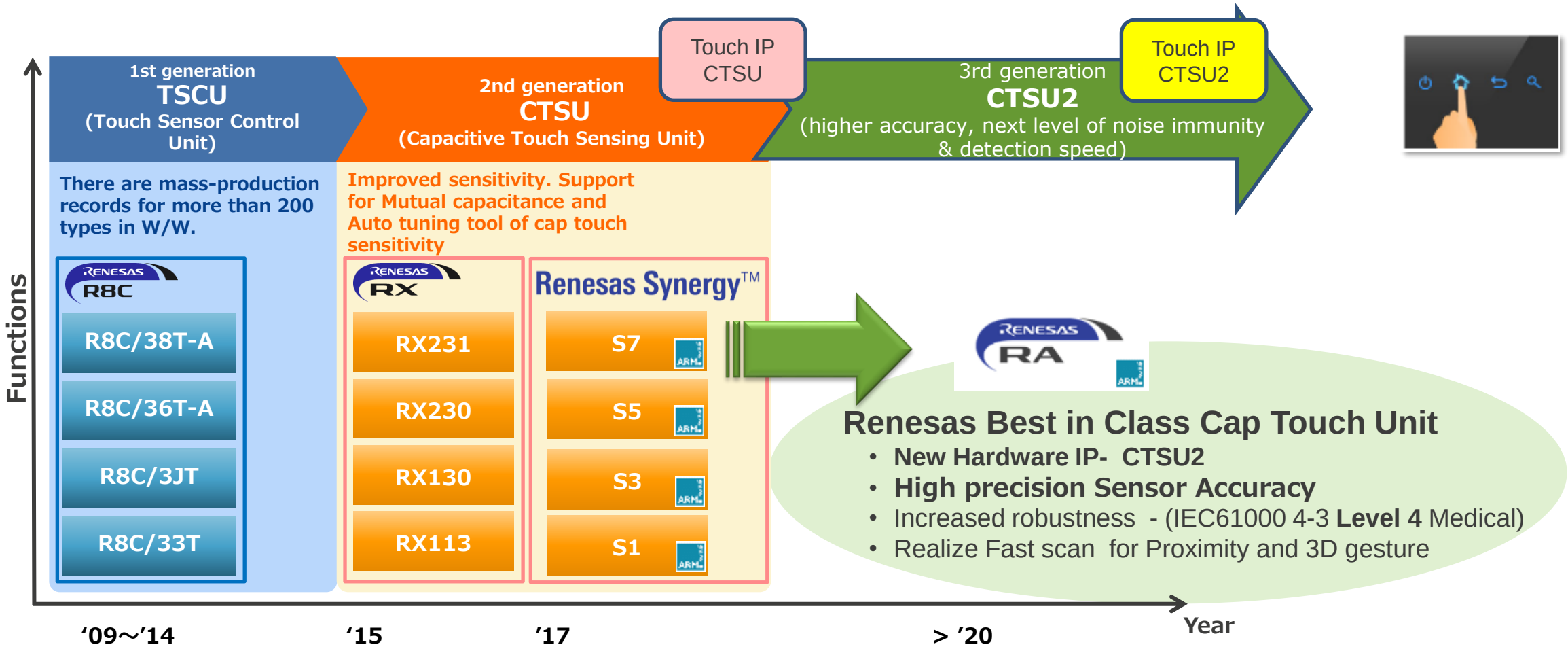
- Self/Mutual technology
- High sensitivity & High Noise Immunity **IEC61000 4-3/4-6 Level 3**
- Tools and Drivers VDE Certification in progress Class B

Cooperation proposals:

- Share our experience concerning the touch solutions
- **Evaluate the new features embedded in RA2 product line**

CAPACITIVE TOUCH SENSOR

IMPROVE TOUCH-KEY SENSOR WHICH HAS A TRACK RECORD ENOUGH



ALREADY ACHIEVED WITH CTSU

Touch IP
CTSU

KEYS FEATURES

- **Supports Switch, Wheel, Slider and Proximity**
- **Autonomous operation to enable ultra-low power touch detection**
- **Support self and mutual-capacitance detection methods**
- **Hardware-assisted sensing/scanning**

High sensitivity

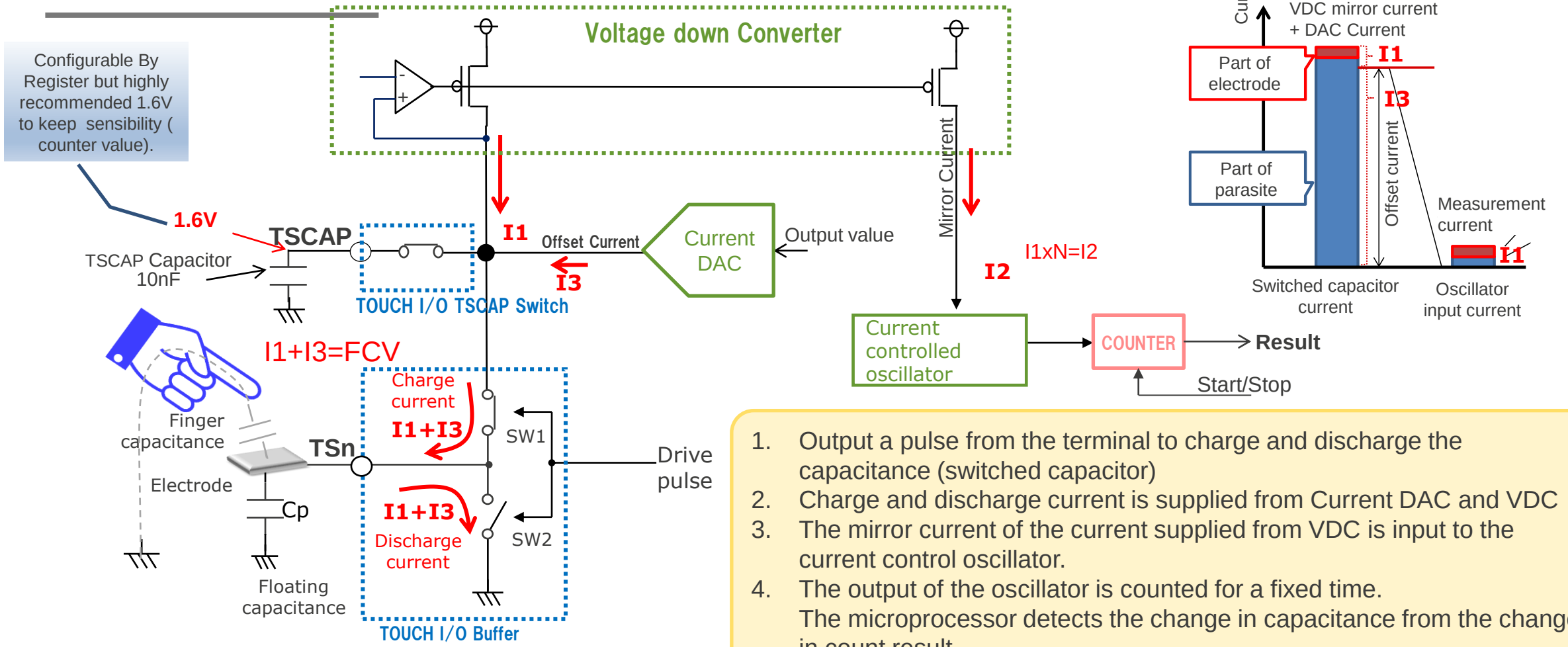
- Sensing of **thick acrylic material, wooden material** and **wear the glove**
- Realizing **300mm-proximity sensing**

High Noise Immunity

- Enhance **water resistance** (Mutual)
- Implementing noise-counter measures in hardware saves significant number of CPU cycles
- **Passed the IEC61000 4-3/4-6 Level 3**

MEASUREMENT PRINCIPLE

Touch IP
CTSU



1. Output a pulse from the terminal to charge and discharge the capacitance (switched capacitor)
2. Charge and discharge current is supplied from Current DAC and VDC
3. The mirror current of the current supplied from VDC is input to the current control oscillator.
4. The output of the oscillator is counted for a fixed time.
   The microprocessor detects the change in capacitance from the change in count result.

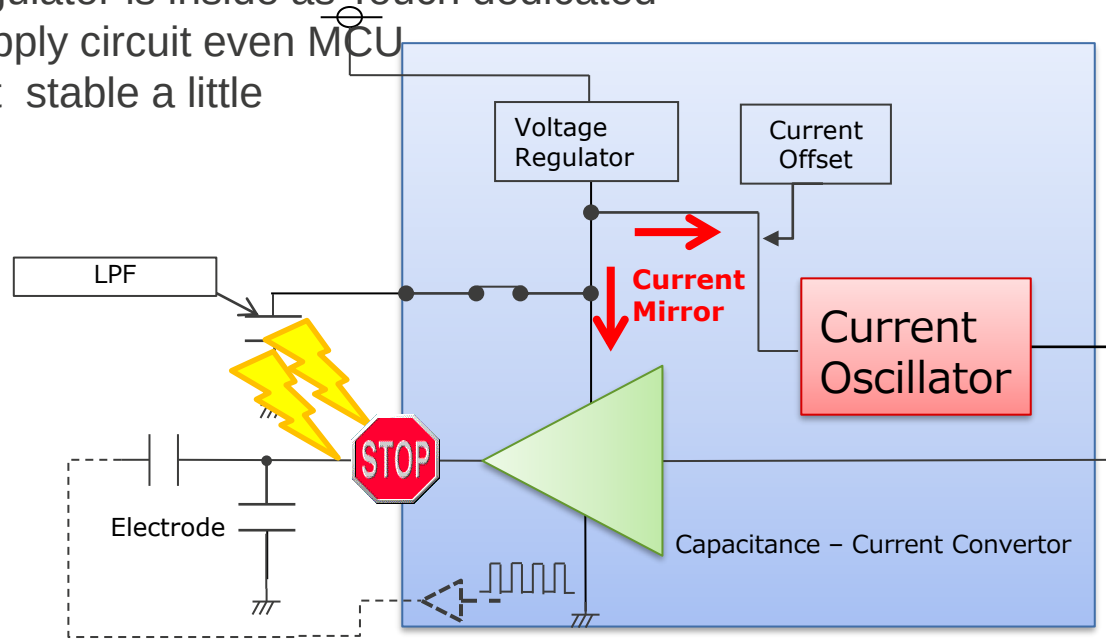
This method integrates. Sensitivity is improved enough to increase the amount of time and number of times.

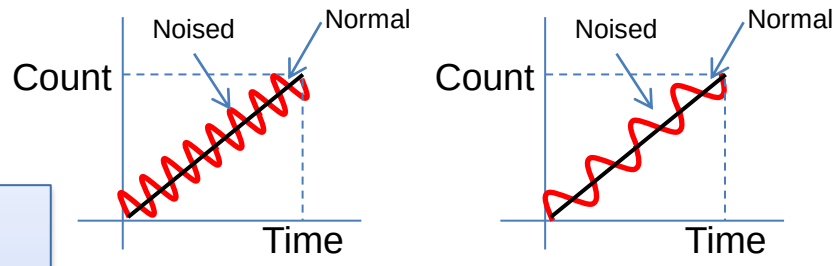
NOISE IMMUNITY PRINCIPE

Touch IP
CTSU

Touch dedicated power supply

> Detection result is stable since there is power regulator is inside as Touch dedicated power supply circuit even MCU Vcc is not stable a little





Noise leveling by integration

> The detection result variation for fixed period can be leveling (period by register setting)

Countermeasure for a synchronous noise

> Refer to next page

Low - impedance input

> Input terminal is connected SCF (Switched Capacitor Filter) and it has low-impedance and it is hard for the noise to come inside since it always connected Power or GND.

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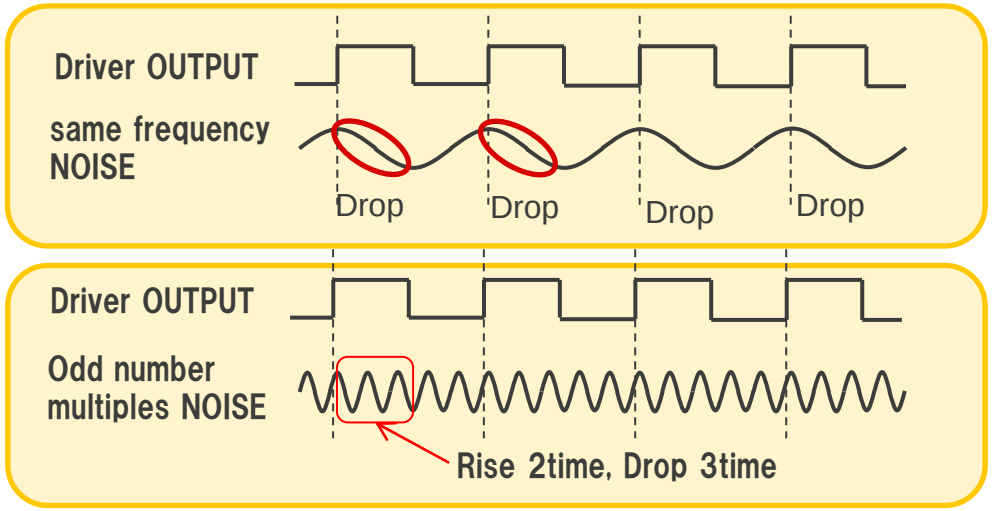
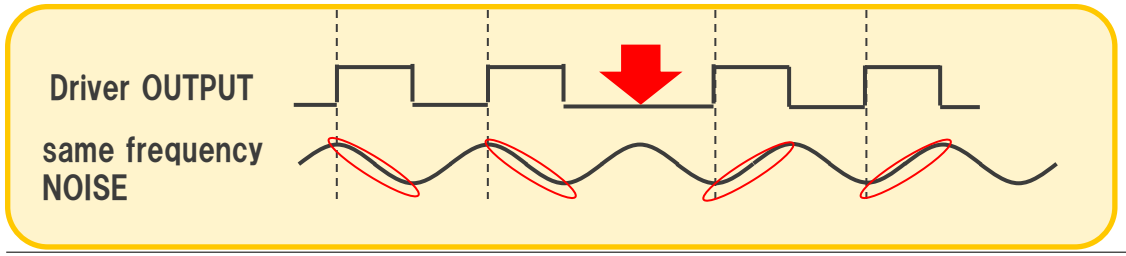
Touch IP
CTSU

NOISE IMMUNITY PRINCIPLE

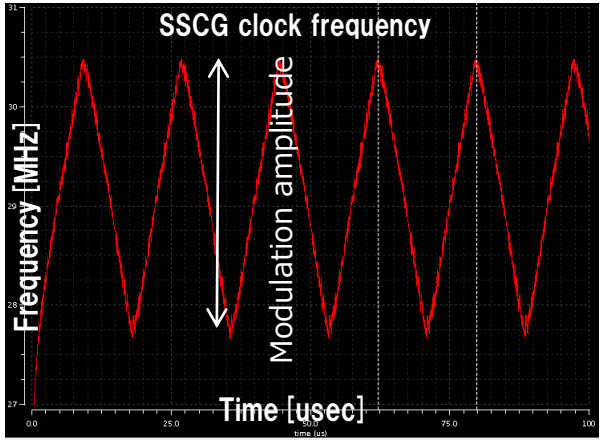
- Switched capacitor clock synchronization noise measures
  Influence occurs for a charge & discharge current the noise that synchronized in a switching period.

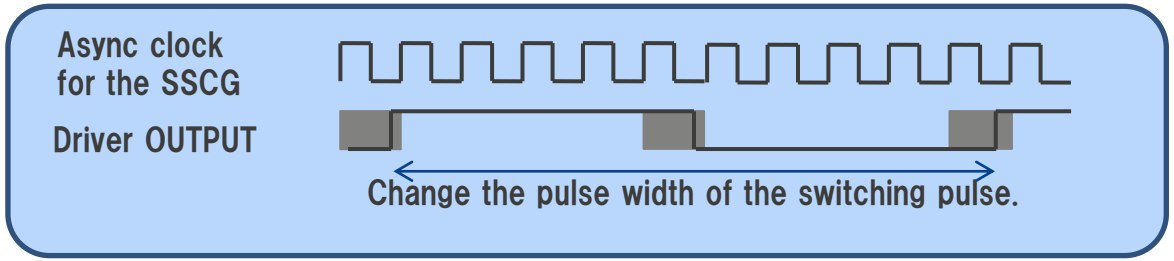


Randomly invert the phase to cancel out the effect.



- High frequency noise measures
  The switching pulse is sampled by the SSCG clock to change the pulse width.





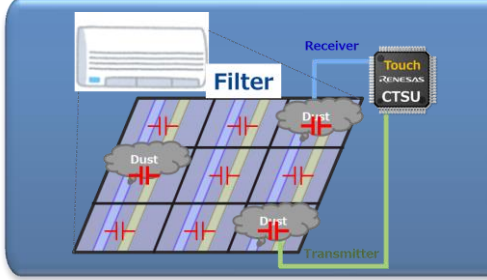
NEW GENERATION CAP TOUCH SENSOR : CTSU2

Touch IP
CTSU2

Upgrade Hardware Noise Immunity

Higher conductive & radiative noise immunity

Support IEC61000 4-x Level 4 (30V/m)



Improve Sensor Accuracy

Support Precision Positioning Sensor , High accuracy 3D gesture Sensor and etc.

Fast scanning & Slow Sampling

Support Screen Scan with Multi fingers Detection & Supper Low Emission

3D gesture with 2 fingers detection

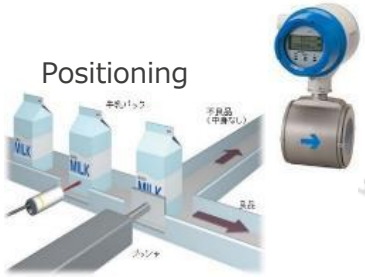
Low emission

Noise sensitive device

High precision

Water flow/Level

Positioning



Toner remain

Strong Water & Ice Resistant

Paper thickness sensor

High speed

Touch screen with multi fingers Without screen IC

3D gesture with 2 fingers detection

BIG IDEAS FOR EVERY SPACE RENESAS

NEW FEATURES

Touch IP
CTSU2

1. **Panel electrode support**
   - Speed up mutual capacitance measurement with newly developed analog IP. Parallel measurement for multiple installations. The new macro is CFC.
2. **High noise immunity**
   - Active shield support.
   - Majority selection by triple frequency measurement.
     IEC61000-4-6 level3 conductive (Support for customer over spec test.)
     IEC61000-4-3 level4 radiative (30v/m)
3. **Accuracy improvement and self-correction function**
   - Correct variations due to manufacturing factors between MCUs.
   - Temperature correction is possible.
   - IP self-test is possible. Contributes to functional safety.(IEC60730)
4. **Function addition**
   - Small current change measurement function.

NOISE IMMUNITY ENHANCEMENT ON CTSU2

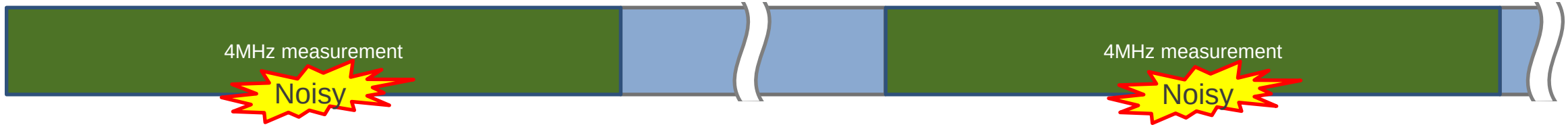
Touch IP
CTSU2

Multi Frequency Scan

To avoid synchronous noise affection

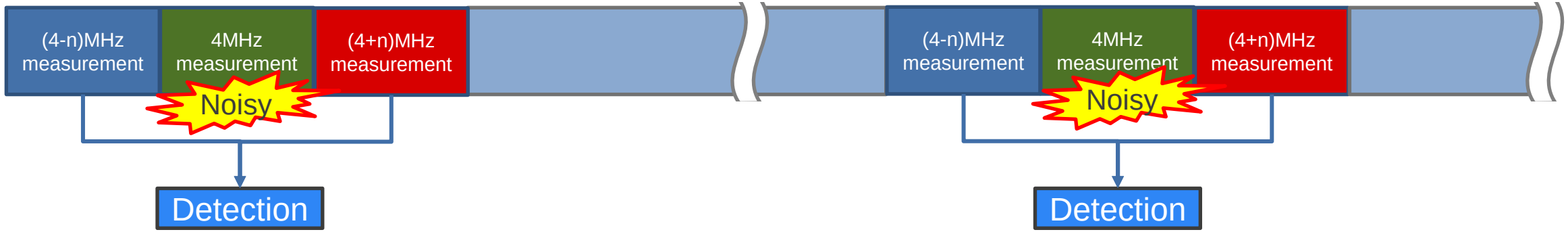
Current method (CTSU)

Fixed 1 kind of drive frequency to measure. So there is some affection from synchronous noise all the time.



NEW method (CTSU2)

3 kinds of different frequencies can interpolate the result which includes noise affection.

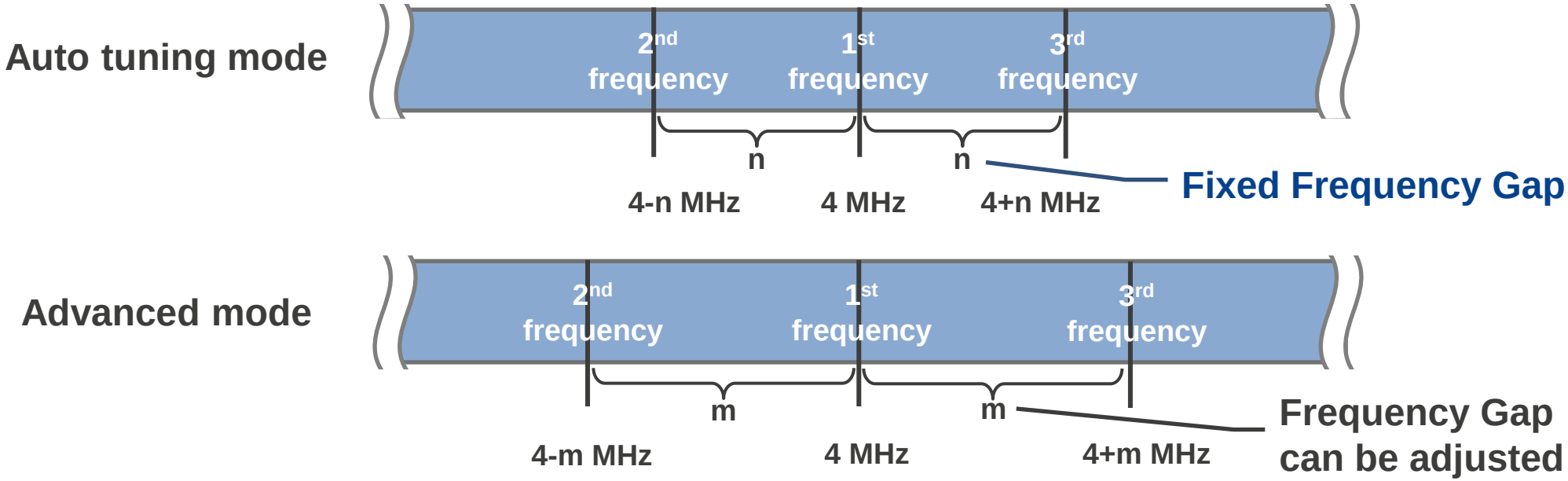


NOISE IMMUNITY ENHANCEMENT ON CTSU2

Touch IP
CTSU2

Multi Frequency Scan
To avoid synchronous noise affection

1st Frequency is same as Sensor Drive Pulse as a base frequency
2nd Frequency and 3rd Frequency can be adjusted by setting Frequency gap setting.



NOISE IMMUNITY ENHANCEMENT ON CTSU2

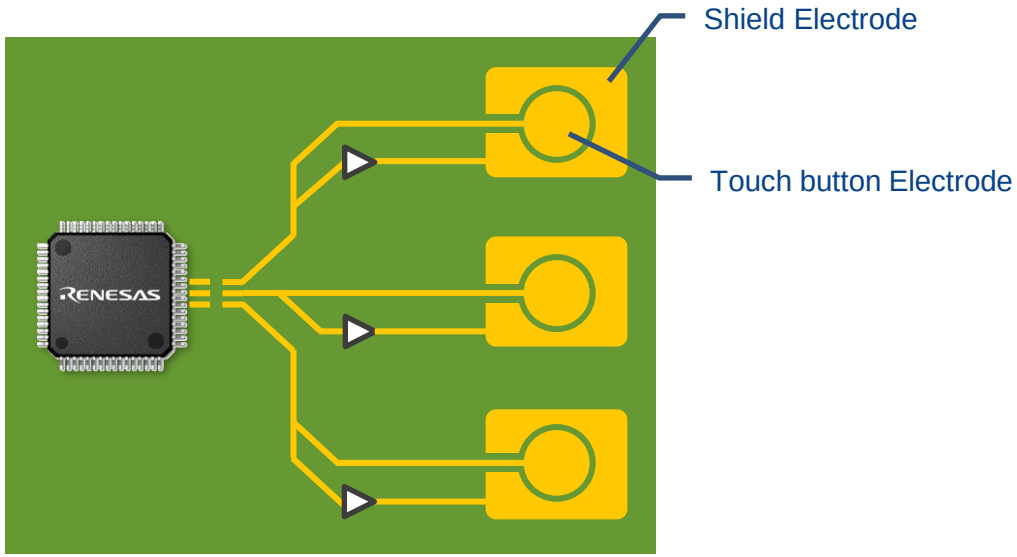
Touch IP
CTSU2

Shield electrode support

CTSU2 supports Shield electrode output in Self capacitance method.

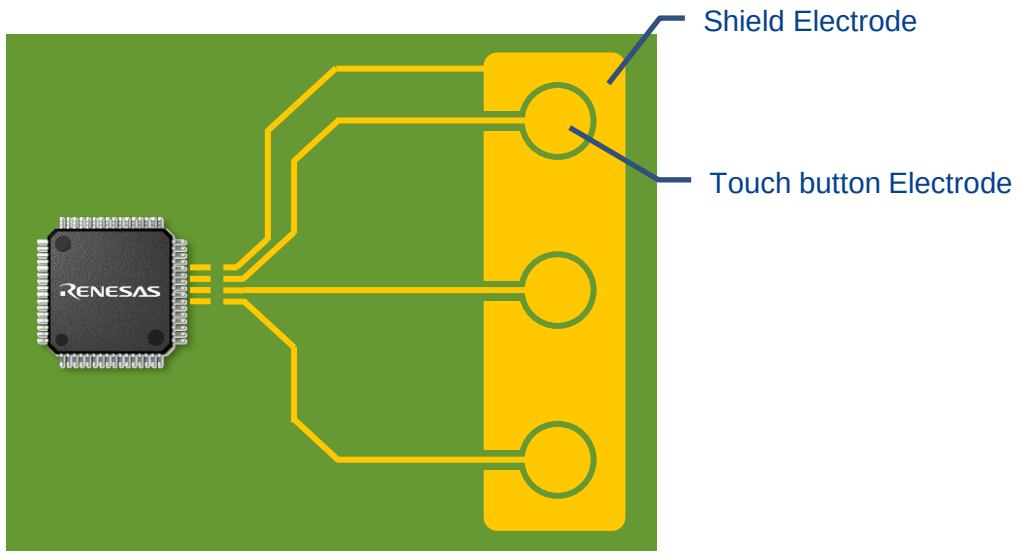
Current method (CTSU)

1 electrode Pad requires 1 shield electrode pattern.
Each shield electrode requires a current driver.



New method (CTSU2)

Several electrode pad can share 1 common shield electrode pattern.
Shield electrode can be driven directly.



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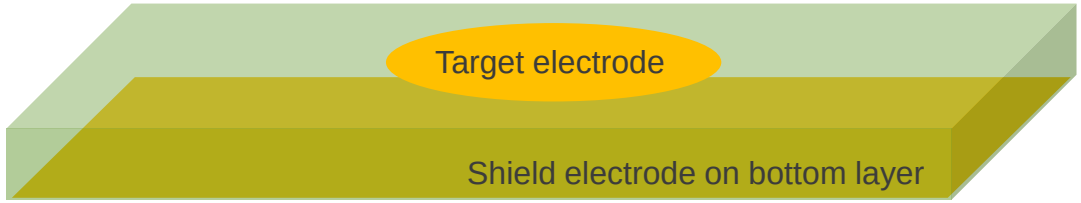
NOISE IMMUNITY ENHANCEMENT ON CTSU2

Touch IP
CTSU2

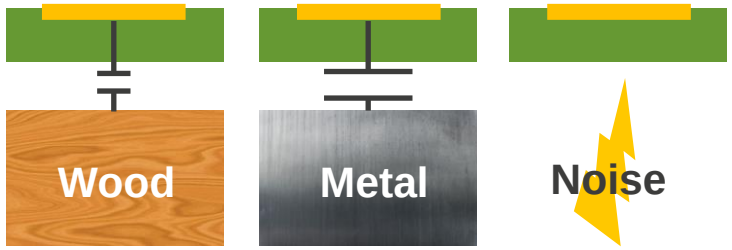
Shield electrode support

Shield electrode on bottom layer reduces a parasitic capacitance and a noise affection from bottom direction.



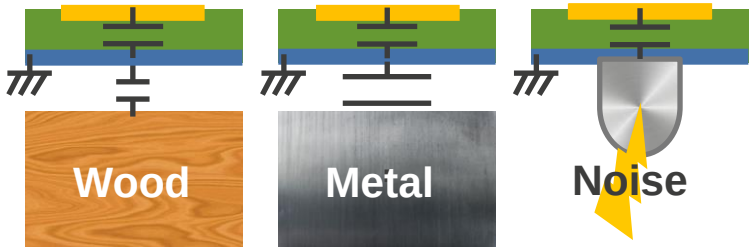
Nothing layouts at the bottom.

Easy to affect from bottom direction.
Parasitic capacitance will change when the condition is changed at the bottom.
Noise will come to electrode directly.



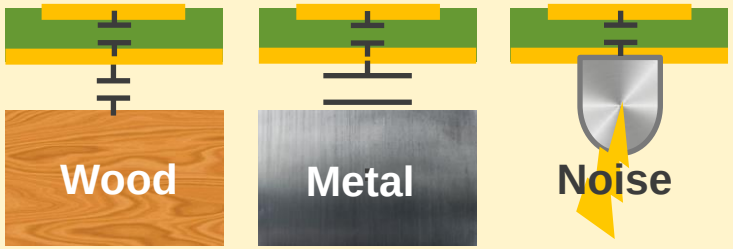
GND pattern at the bottom

Noise from bottom direction can be shielded by GND pattern. However GND pattern is too close to the electrode so parasitic capacitance is got bigger and sensitivity may be reduced.



Shield electrode at the bottom

Noise from bottom direction can be shielded by Shield electrode. And parasitic capacitance can be reduced by Shield electrode.



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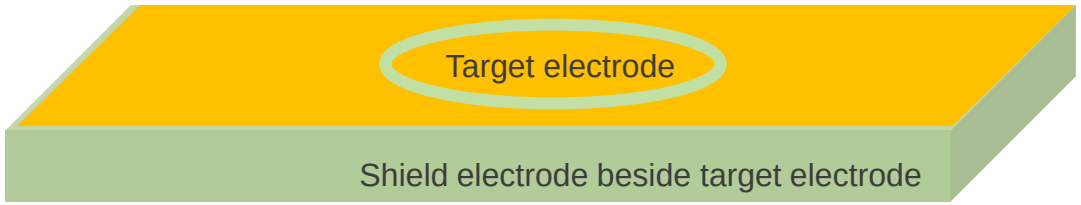
NOISE IMMUNITY ENHANCEMENT ON CTSU2

Touch IP
CTSU2

Shield electrode support

Shield electrode beside of target electrode reduces a noise affection and malfunction by the bridge of water drop.



Nothing layouts beside

There is small additional capacitance in case of the bridge by the small water drop.
However there is no guard pattern so easy to affect from the noise.

GND pattern layouts decide

GND pattern can be reduced noise affection from the side direction. However the water drop bridge may cause malfunction since capacitance with water drop bridge between electrode and GND is bigger.

Shield electrode layouts beside

Shield electrode can be reduced noise affection from the side direction. And additional capacitance by the water drop bride is smaller with Shield electrode and it can be reduced the risk of malfunction.

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SENSOR ACURACY IMPROVEMENT ON CTSU2

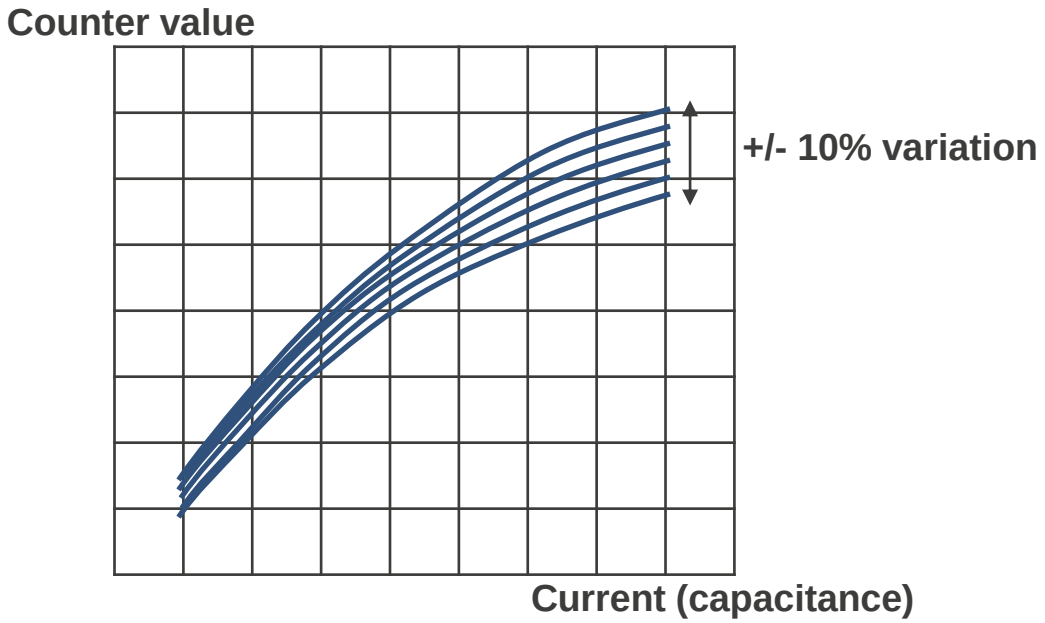
Touch IP
CTSU2

Sensor accuracy is up by improving ICO circuits

Adapt to the application which is required more accuracy such as high precision sensing use.

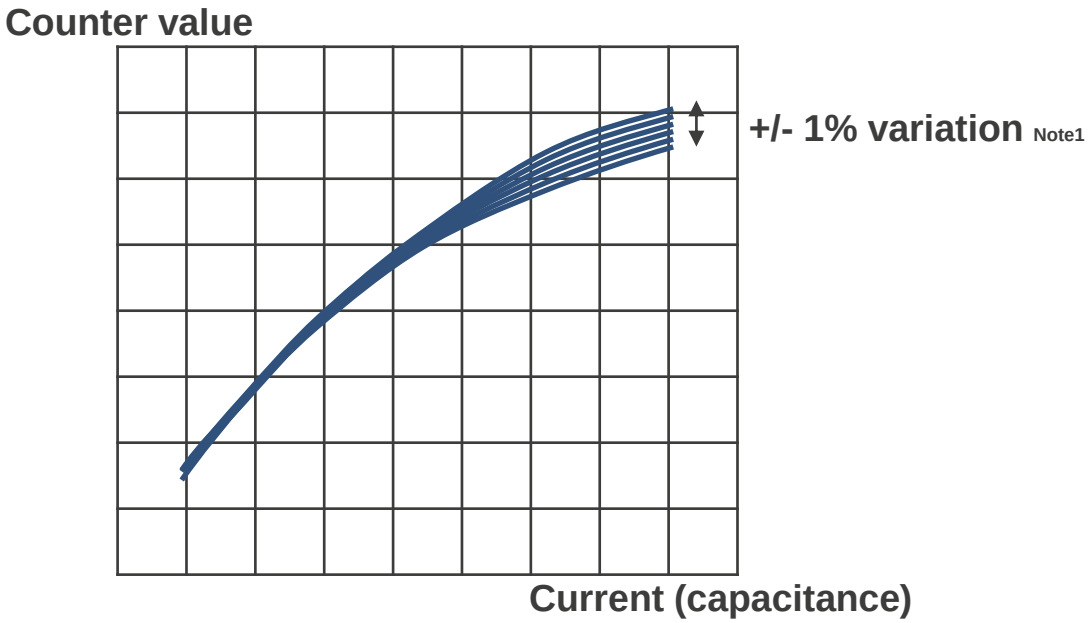
Current circuit (CTSU)

Current-Counter value variation of temperature drift is +/-10%



New circuit (CTSU2)

Current-Counter value variation of temperature drift is +/-1%



Note1: Target specification

SUPPORT HIGH SPEED SCANNING ON CTSU2

Touch IP
CTSU2

High speed scanning by CFC(Capacitance Frequency Conversion) is ready.

Parallel scanning (up to 20ch detection at the same time) can contribute for high speed scanning.

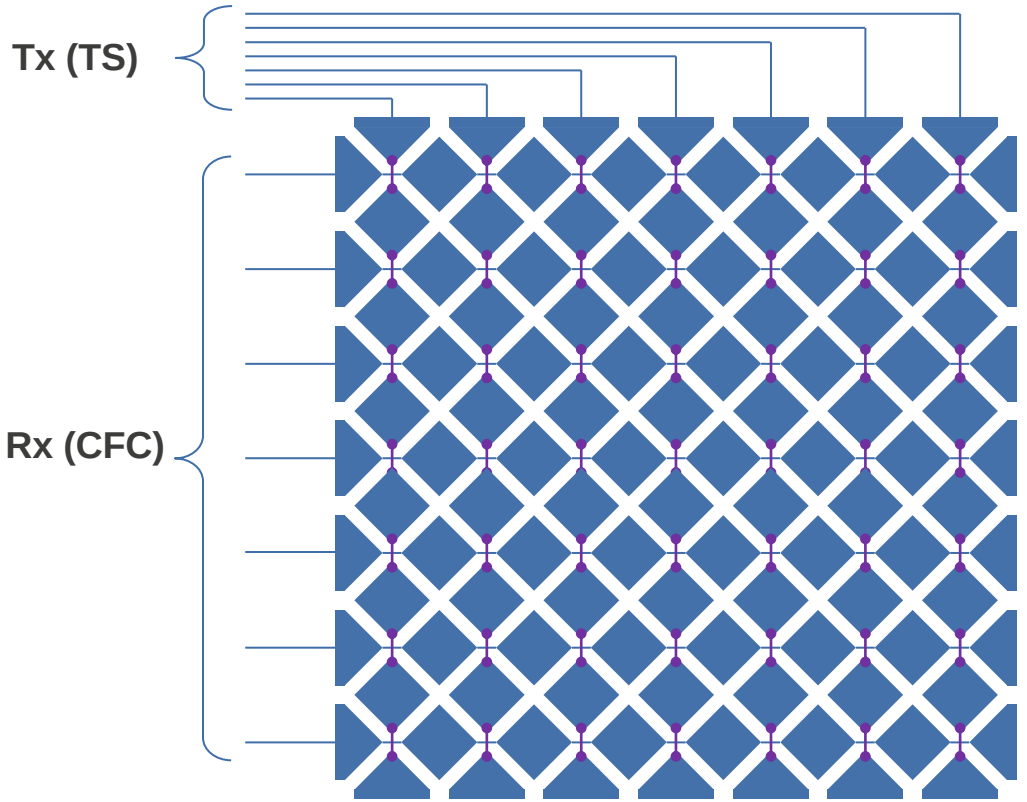
Touch
channel
CTSU

Current method (CTSU)

- Sequential scanning on Mutual matrix
- 7x7 Matrix takes 49 scanning time.

Touch
Channel
CTSU2

- CFC terminal can support parallel scanning (Max 20 ch scanning at the same time)
- 7x7 Matrix takes 7 scanning time



BOM COST REDUCTION

cap touch BOM cost reduction (external components) per cap touch pin

EXTERNAL COMPONENT :

Touch Channel CTSU

- TSCAP
  10nF capacitor
- ICO tolerance/Temperature drift
  68 Ohm resistor
  51 Ohm resistor
  100 Ohm resistor.
- Each cap touch pin:
  560 Ohm resistor

EXTERNAL COMPONENT

Touch Channel CTSU2

- TSCAP :
  10nF capacitor
- Temperature drift correction
  10k ohm resistor
- Each cap touch pin:
  560 Ohm resistor

RA2L1/RA2E1 TOUCH SOLUTIONS

RENESAS RA FAMILY OF ARM® CORTEX®-M CORES

RA2	RA4	RA6
Cortex®-M23 48MHz	Cortex®-M4 & M33 48 ~ 100MHz	Cortex®-M4 & M33 100 ~ 200MHz

Arm Cortex®-M4 / M23 / M33

Integrated Memory
Flash: 32kB ~ 2MB
SRAM: 16kB ~ 640kB
DataFlash, StandbyRAM

Package Line-Up
LQFP, QFN, BGA, LGA, WLCSP
25 to 176 pins

Rich connectivity
USB FS & HS, CAN FD,
Ethernet, LCD controller

IoT ready security
Integrated secure element functionality with Secure Engine MPU, and TrustZone®

Flexible Software Package
HAL driver and stack configuration tools, FreeRTOS and partner ecosystem

Renesas Heritage of 32-Bit MCU Leadership

Scalability
Pin-to-pin & peripheral function, performance 48MHz～200MHz & beyond

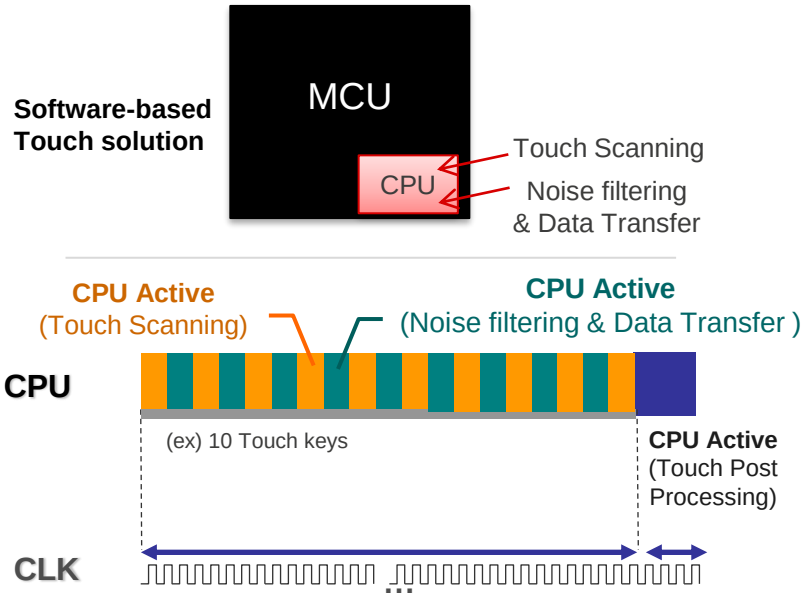
RENESAS RA2 SERIES - GROUP OVERVIEW

Series	Group	Feature
RA2 Series	New RA2L1	48MHz, Cortex M23, 128kB/256kB Flash, 32kB RAM, 48-100pin, CAN, 32ch Cap Touch, Security
	RA2E1	48MHz, Cortex M23, up to 128kB Flash, 16kB RAM, 25-64pin, 30ch Cap Touch, Security
	RA2A1	48MHz, Cortex M23, 256kB Flash, 32kB RAM, 32-64pin, USB, CAN, 24bit Sigma Delta ADC, 16bit ADC, Security

RA – SOLUTION ADVANTAGES

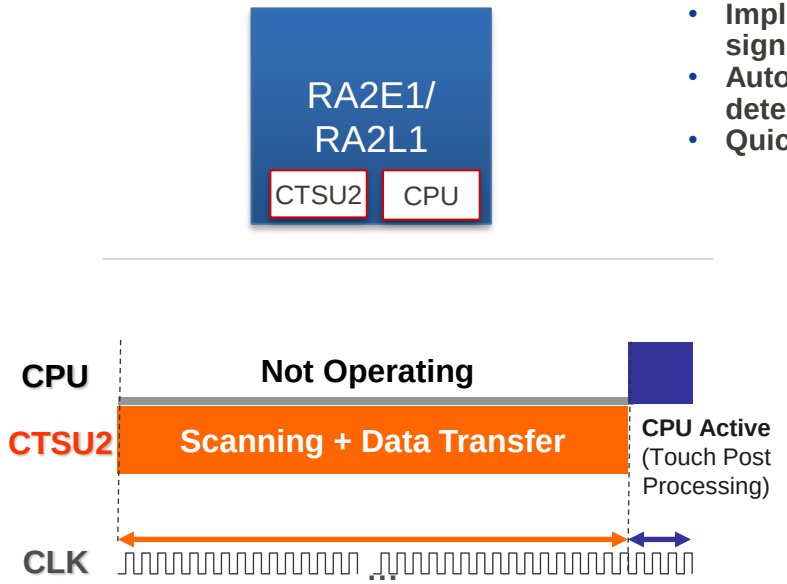
Single chip solutions for system and touch functions

Competitive Solution



- CPU used 100% in software-based Touch solution

Renesas Solution



- CPU in RA2E1/ RA2L1 fully stopped
- Less than 15% CPU usage

Renesas Patented hardware peripheral (CTSU2)

- Hardware-assisted sensing/scanning
- Support self and mutual-capacitance detection methods
- Implementing noise-counter measures in hardware saves significant number of CPU cycles
- Autonomous operation to enable ultra-low power touch detection
- Quick reaction by parallel scanning (@ Mutual mode)

	RA2E1/RA2L1 CTSU2
Technology	Self, Mutual mode
Proximity	100mm+ *
Overlay Thickness (Max.)	10mm (Acrylic) *
Radiated Noise (IEC61000-4-3)	Level 4 (30V/m) Medical *
Conducted Noise (IEC61000-4-6) Class B	Level 3 (10V) *
Inherent Water “Resistance”	Yes (Self/Mutual mode)
Matrix Configuration Support	Yes (Mutual mode)
Auto-tuning	Yes
# of Touch Channels	32 max.

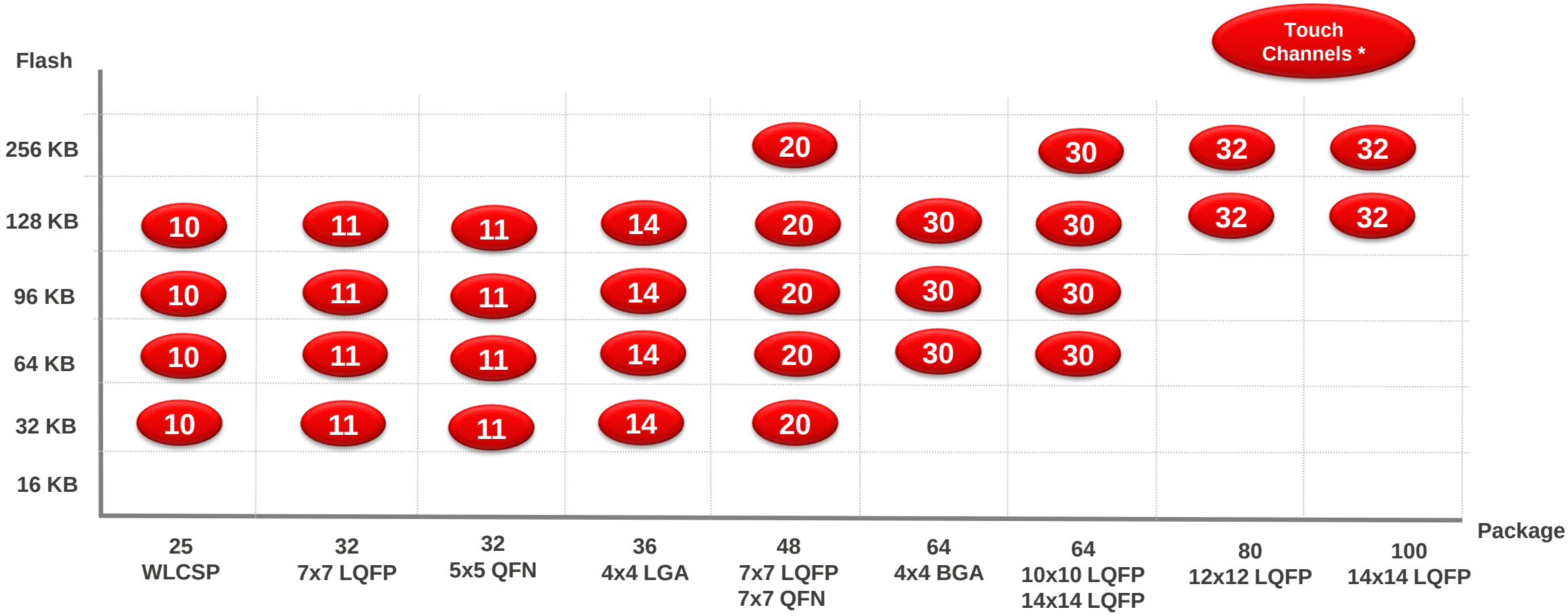
** System dependent*

RA2L1
RA2E1

CTSU COMPARISON

Features	CTSU	CTSU2	Advantage
Scan Time (self/1 electrode)	≈ 600 us	Less than 200 us	Better reactivity
Parallel Electrode Scan	Not supported	Implemented in HW(CFC/ mutual)	Improve Scan Time in Mutual design.
Temperature Drift	10 %	Only 1 %	Better noise immunity Improve accuracy
Multi-freq. scan	Only by software	Done by HW	Better noise immunity Improve scan time
Shield Electrode	Not supported	Implemented in HW	Better noise immunity Reduce Parasitic cap
External Components	Min 3 external components	Min 1 external components	Cost
Available in	RX, RA, Synergy	RA2L1 RA2E1	

RA2L1/RA2E1 CAPACITIVE TOUCH LINE-UP



** 1 Touch channel = 1 key (no matrix configuration)*

RA2L1/RA2E1 USAGE EXAMPLE: APPLIANCE USER INTERFACE

- Major customer in Home Appliance market
- Cap. Touch platform for generic U/I
  - System cost reduction
  - Reliability
  - Ease of cleaning
  - Water proof
  - Navigation

- Customer requests to get the design know-how in-house.
- Less CPU usage for touch detection
- A full reference design is requested

- Competitors:1. MCU with Software touch solution / 2. MCU + Touch sensor IC

- RA2L1/RA2E1 propose as system control MCU with hardware-assisted touch sensing
- Perform and pass all tests as requested
- Achieve below 15% of CPU usage for touch detection
- BoM costs reduce thanks to Single-chip solution

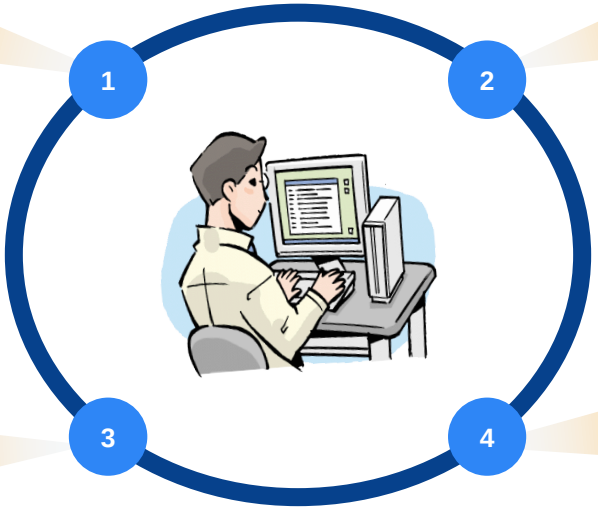
QUICK AND EFFECTIVE TOOL FOR CAP TOUCH

RA2 RENESAS OFFERS CAPACITIVE TOUCH SOLUTION

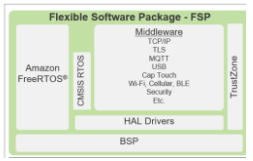
Capacitive touch panel development support environment

HARDWARE
RA2L1/ RA2E1 (CTSU2 support)

Samples => Now



SOFTWARE
MIDDLEWARE & HAL DRIVER



Open source
Low/middle level drivers

Quick and Effective Tool

Auto-tuning Tool to configure parameters and monitor the signals. Automatic code creation

KIT
Evaluation board RSSK RA2L1

EASY TO DEVELOP FIRMWARE SOFTWARE DRIVERS

TOUCH middleware (rm_touch) and CTSU HAL driver (r_ctsu) provides API to control the CTSU peripheral.

These links with QE for Capacitive Touch [RA].

Capacitance measurements at various settings are possible by editing the configuration using our auto-tuning tools.

rm_touch and r_ctsu are included in Firmware Software package =FSP .

Therefore, these are developed according to the FSP architecture.

Based on RX FIT, but with major changes including API.

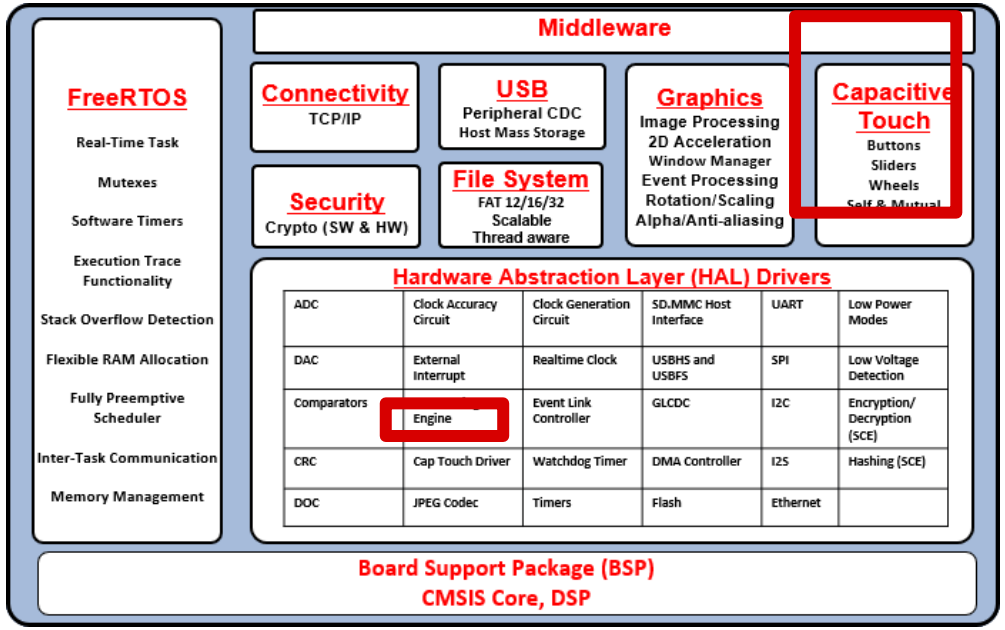
CTSU

RA2A1, RA4M1, RA6M1, RA6M2, RA6M3, RA4W1

RA6M4/M5, RA4M2/M3

CTSU2

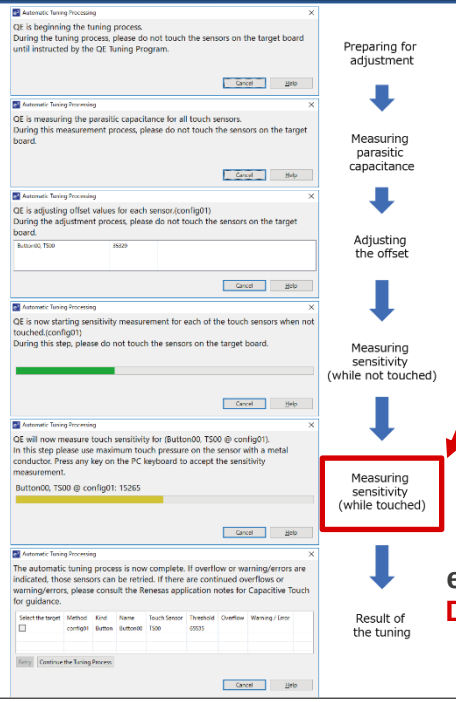
RA2L1, RA2E1



QUICK AND EFFECTIVE TOOL : QE

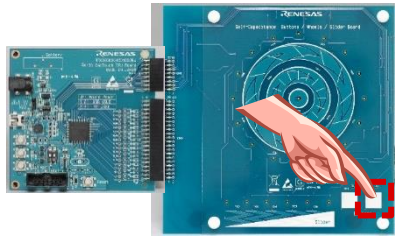
- **Develop touch I/F with easy-to-operate GUI even for beginners**
  Touch sensor tuning and monitoring with easy- to-operate GUI by just following the instructions
- **Automatic tuning touch sensor sensibility**
  Adjust offset/sensibility via tuning just by following the instructions

Tuning window



Preparing for adjustment
↓
Measuring parasitic capacitance
↓
Adjusting the offset
↓
Measuring sensitivity (while not touched)
↓
Measuring sensitivity (while touched)
↓
Result of the tuning

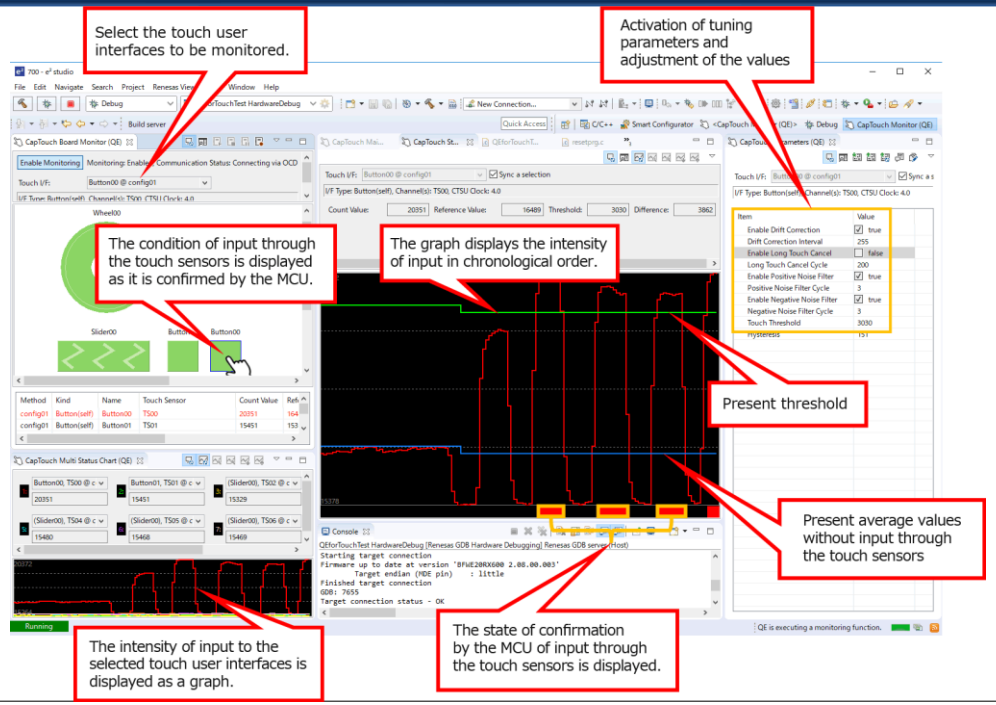
Just touch the electrode ！



Touch

Easy to develop even for beginners！
Just touch the electrode and everything will be automatically tune by the tool.
Drastically reduce development time and efforts！

Monitoring window



SERIAL COMMUNICATION SUPPORT

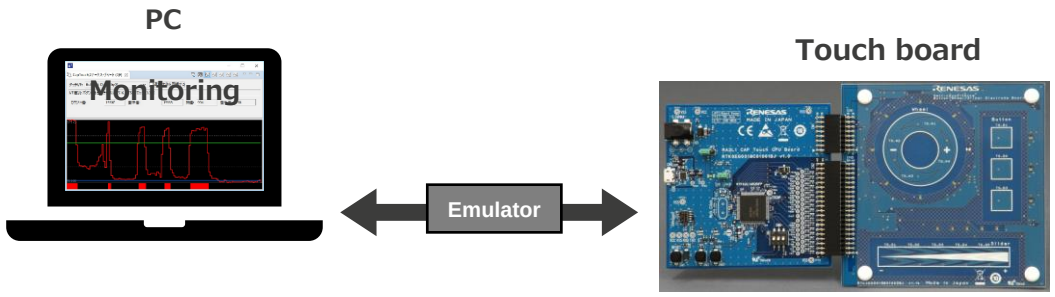
Touch IP
CTSU2

Serial communication support for QE for Capacitive Touch[RA]

Serial communication is useful for monitoring / fine tuning stage after project creation.
User can use not Emulator but USB cable to communicate between QE and touch board.

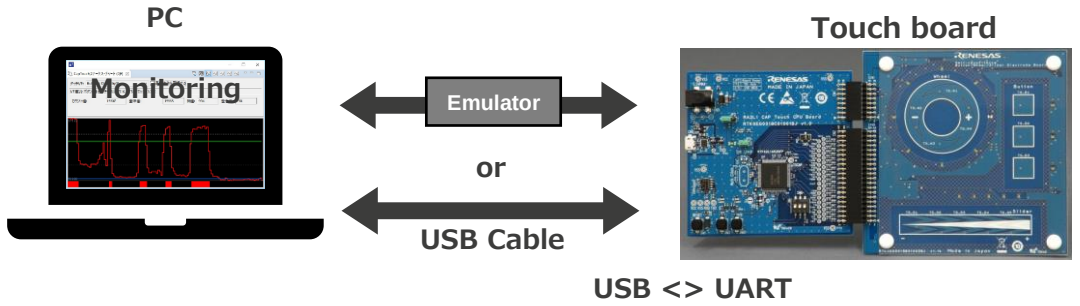
Current QE for Capacitive Touch

User always need to use Emulator connection



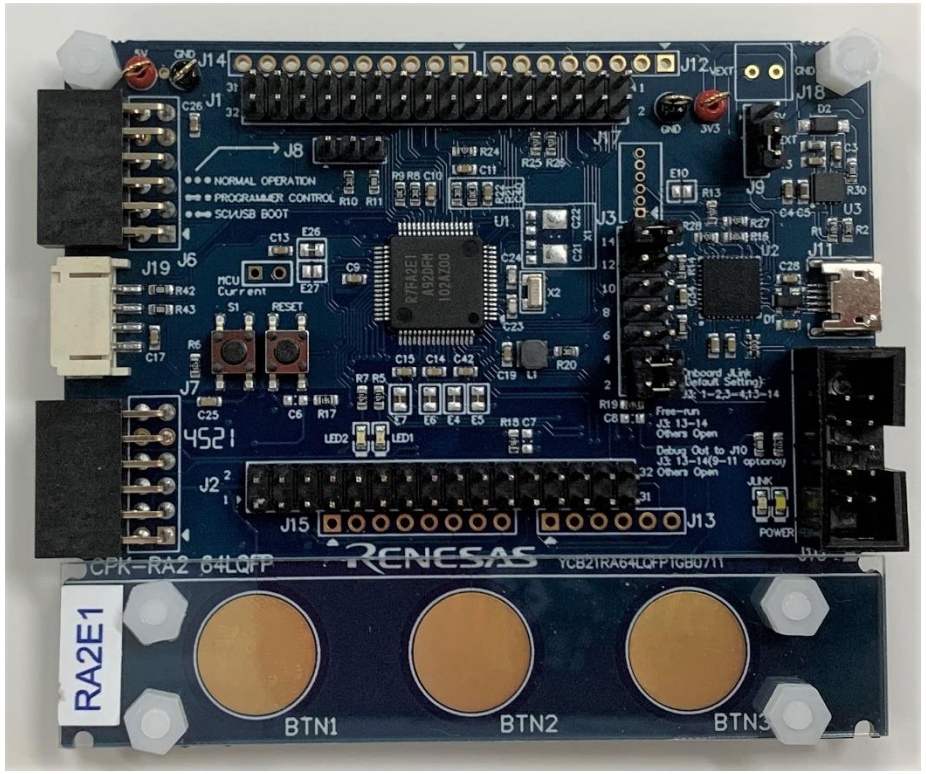
NEW QE for Capacitive Touch (In development)

User can select Emulator I/F or Serial communication for Monitoring



CPK-RA2L1 AND CPK-RA2E1

1. **Start MCU and Cap-touch evaluation immediately**
   - On board J-Link debugger to start development with all supported IDEs, e2studio, Keil/MDK and IAR embedded workshop.
   - 3 touch button available, start captouch development workflow with no additional hardware needed.
2. **Rich Expansion Option**
   - Expansion connector same as EK board.
   - Arduino interface
   - 2 PMOD + 1 Grove IIC
   - Debug-in and Debug out
3. **Support full operation voltage range of RA2**
   - Debug USB power can support 3.3V or 5V operation.
   - With external power supply, can work from 3.0V ~5.5V
   - With level shifter board connected, can support 1.6V~3.0V operation.



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