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## RX130 Group

R12AN0108JJ0100

## Capacitive Water Level Measurement Demo Set

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2020.1.31

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### Introduction

RX130 Group devices include a built-in Capacitive Touch Sensor Unit, or CTSU, that detects changes in capacitance.

This application note describes how to operate the Capacitive Water Level Measurement Demo Set (RTK5RX1300D02001BJ) using the RX130 CTSU.

### Target Devices

RX130 Group

### Related Documents

1. Capacitive Water Level Measurement Demo Set Sample Software (R11AN0440)
2. RX Family Level Monitor User's Manual (R11UZ0027)
3. RX Family CTSU Improved Accuracy Sample Software (R11AN0314)

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## 1. Outline

The RTK5RX1300D02001BJ is a demo set for measuring water levels using the capacitive touch sensor function of the built-in RX130 MCU. This demo set comes with the following features.

- Water level measurement using capacitive touch sensor
- Support for chip set control software (level monitor); demo set can be used without a PC.
- Communication interfaces (USB, Renesas simulator)
- Automatic water level adjustment demonstration with pump
- Confirmation of effect on the electrode with and without shielding
- Simple button-style operation

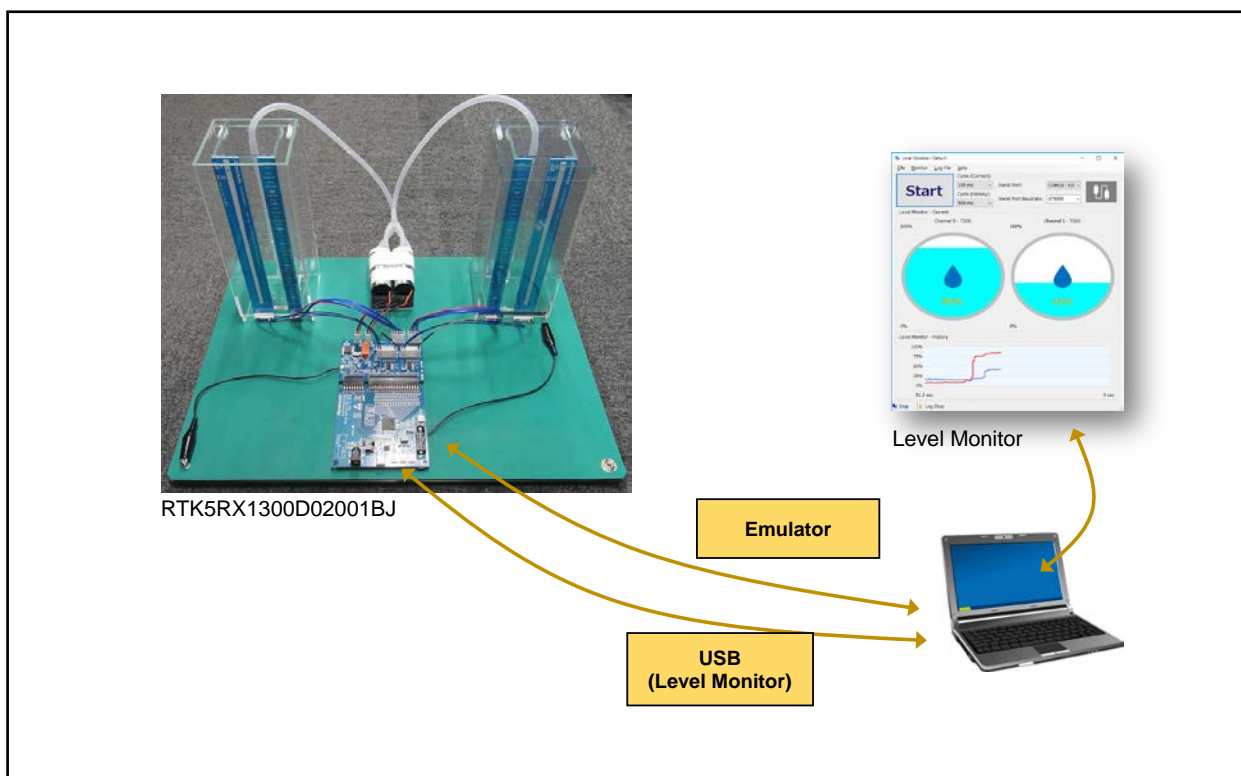


Figure 1-1 Capacitive Water Level Measurement Demo Set

## 2. Demo Set External Appearance

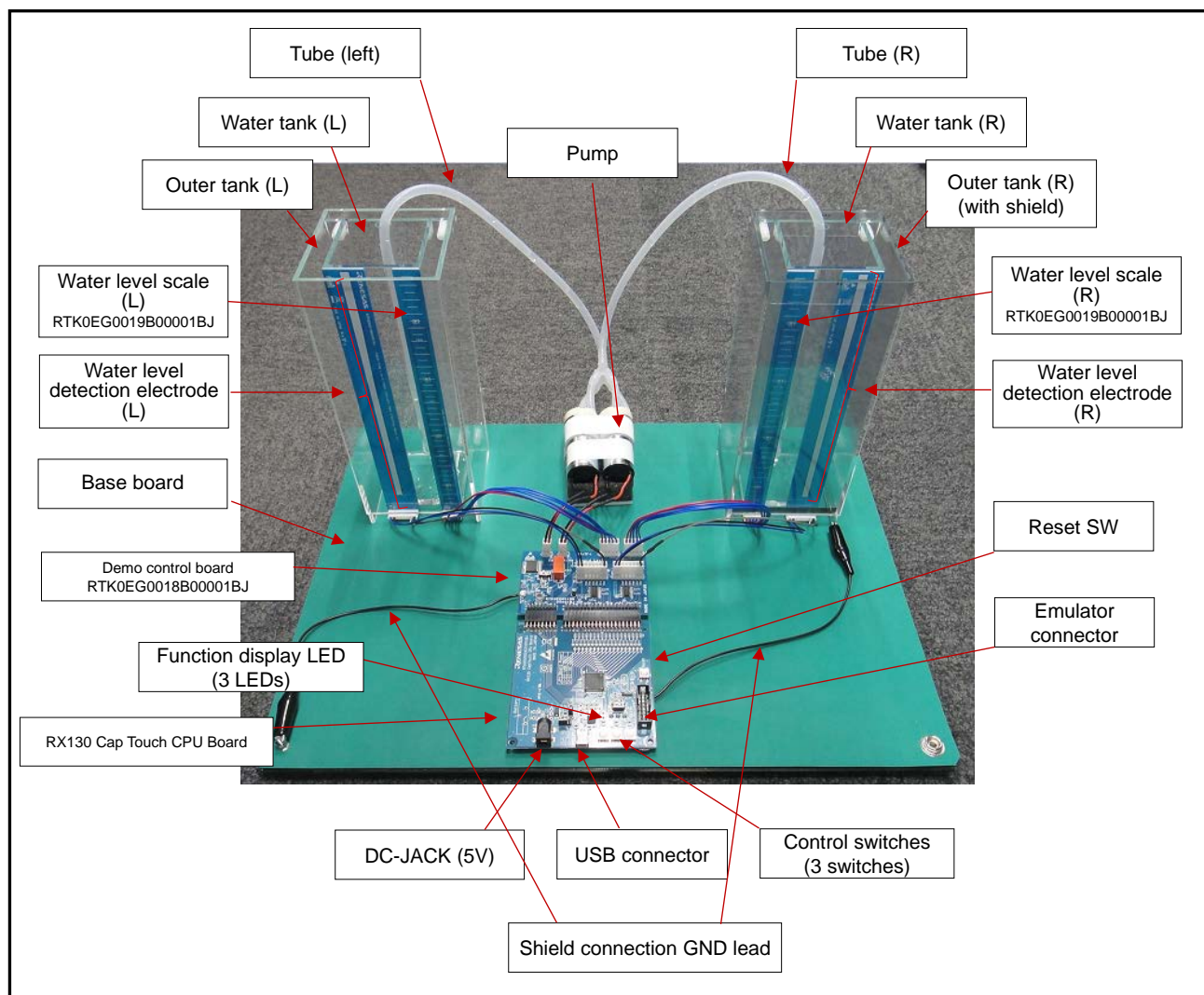


Figure 2-1 Demo Set External Appearance

### 3. Assembly, Demo Preparation, Operating Instructions

#### 3.1 Unpacking and Assembly

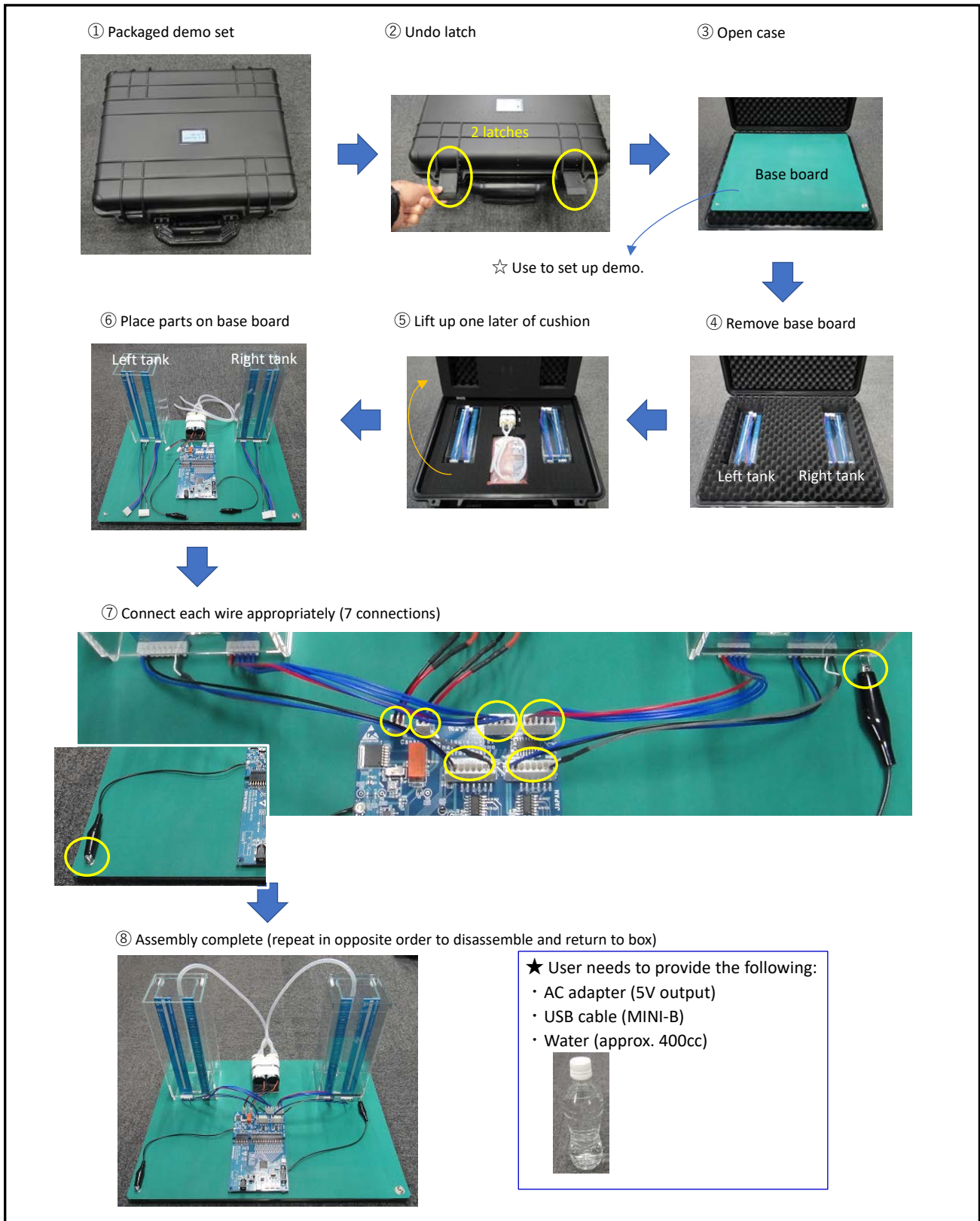
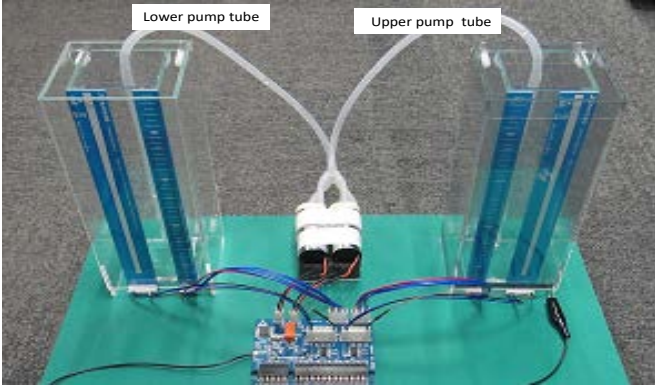


Figure 3-1 Unpacking and Assembly

### 3.2 Demo Preparation (offset adjustment)

Please refer to section 3.4 for instructions on how to control the switches.



Lower pump tube      Upper pump tube

① Offset adjustment preparation

- Conduct preparations when both water tanks are empty.
- Insert lower pump tube into left water tank.
- Insert upper pump tube into right water tank

↓

② Power on

- Select source JP1: 3-2=DC-JACK  
2-1=USB VBUS

③ Implement offset adjustment

- Pressing SW3, SW4, and SW5 simultaneously will automatically adjust offset or both left and right electrodes. During adjustment, LED1, LED2, and LED3 will turn on. When the adjustment is complete, all LEDs will turn off.
- The adjusted offset data is stored in the RX130 data flash memory and is used as the fixed value until the next offset adjustment (and does not change even for power-on or reset.)
- The CTSU current offset function adjusts the measurement counter value to the standard of 15630; the standard value when the tank is empty.
- The parasitic capacitance of the electrode changes depending on installation environment, shield status, harness routing, etc., and changes in temperature change the CTSU current offset. We therefore recommend adjusting the offset when changing the installation environment.

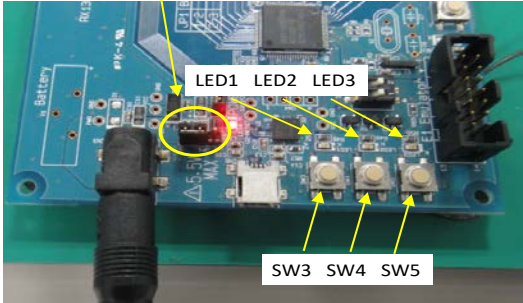


Figure 3-2 Demo Preparation (offset adjustment)

### 3.3 Demo Preparation (setting counter when water tanks are full)

Please refer to section 3.4 for instructions on how to control the switches.

① Fill tank with water (180 - 190mm)

- Fill the left water tank with water from the bottle.
- When all of the water is in the left tank, insert the upper pump tube into the right tank.

② Adjust water to full level.

- Adjust the left tank water level electrode to 175mm. (Use SW4 and SW5 to adjust).

Approx. 175mm

③ Check full water tank counter value with Level monitor

- Turn on level monitor, open Status Monitor window, and click Start button to initiate operations.

④ Set full water position counter value

- Record the average value of the target tank counter (TS17 on the left) in the Status.
- Open the Setup Parameter window, enter value in Upper Threshold, click Write, then Close.

⑤ Carry out steps 2 to 4 for right water tank to complete

Set data is deleted by a reset and the program returns to the initial settings.

Figure 3-3 Demo Preparation (setting counter when water tanks are full)

3.4 How to Operate the Demo Set

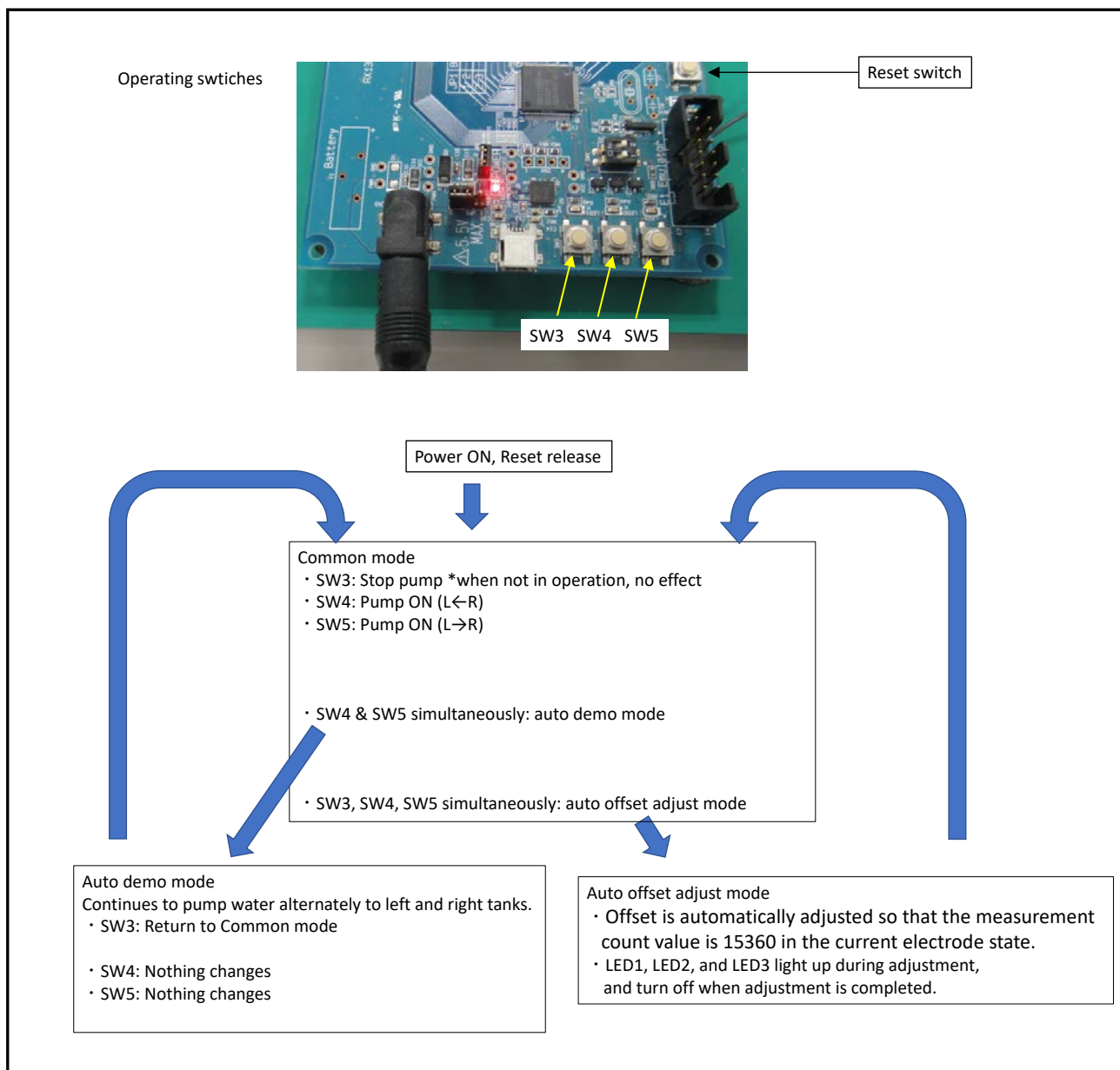


Figure 3-4 Operating Instructions



4. Block Diagram

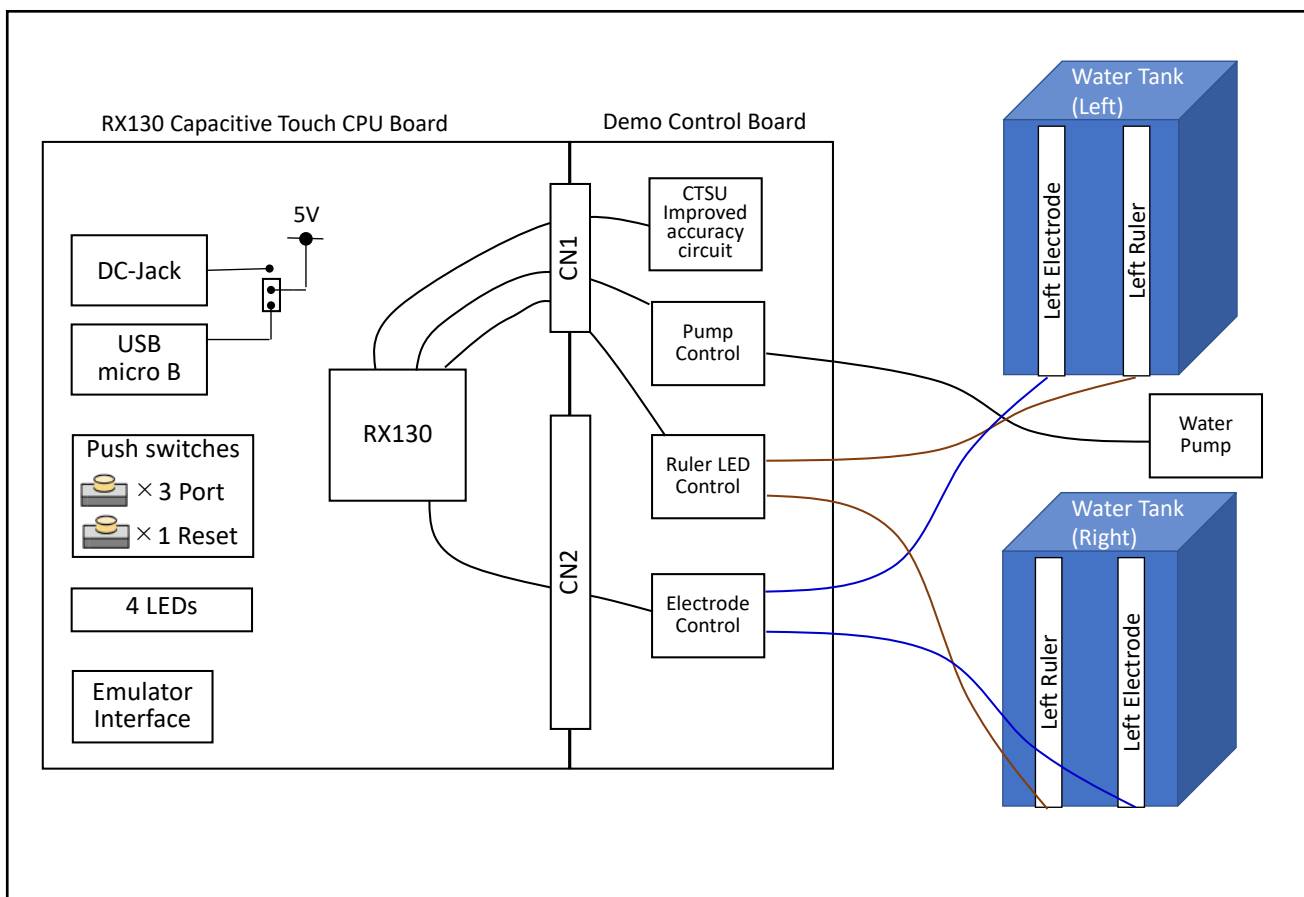


Figure 4-1 Block Diagram

## 5. Operational Explanation

### 5.1 How to Detect Water Level

This demo set uses the RX130 CTSU (Capacitive Touch Sensor Unit) to measure water levels based on the change in capacitance of self-capacitance electrodes attached externally to each acrylic water tank.

The CTSU's self-capacitance method repeatedly charges and discharges electrodes with a constant voltage pulse to measure the change in capacitance according to the current.

By using an electrode with a constant width and a water tank with a constant cross-sectional area, we have designed the relationship between the water level and capacitance to be as linear as possible.

In general, the capacitance of an electrode changes depending on the relative permittivity of the material surrounding the electrode if the electromagnetic field is constant. However, if the object to be measured is conductive, it also functions as an electrode, and behaves differently from the insulating material (see Figure 5-1 (A)). This characteristic must be considered in the development process. Specifically, deposits such as water film or bubbles clinging to the inner wall of the water tank at a point higher than the actual level of the water may be incorrectly measured as the water level. Since normal water contains impurities, we have treated it as a conductor in this app note.

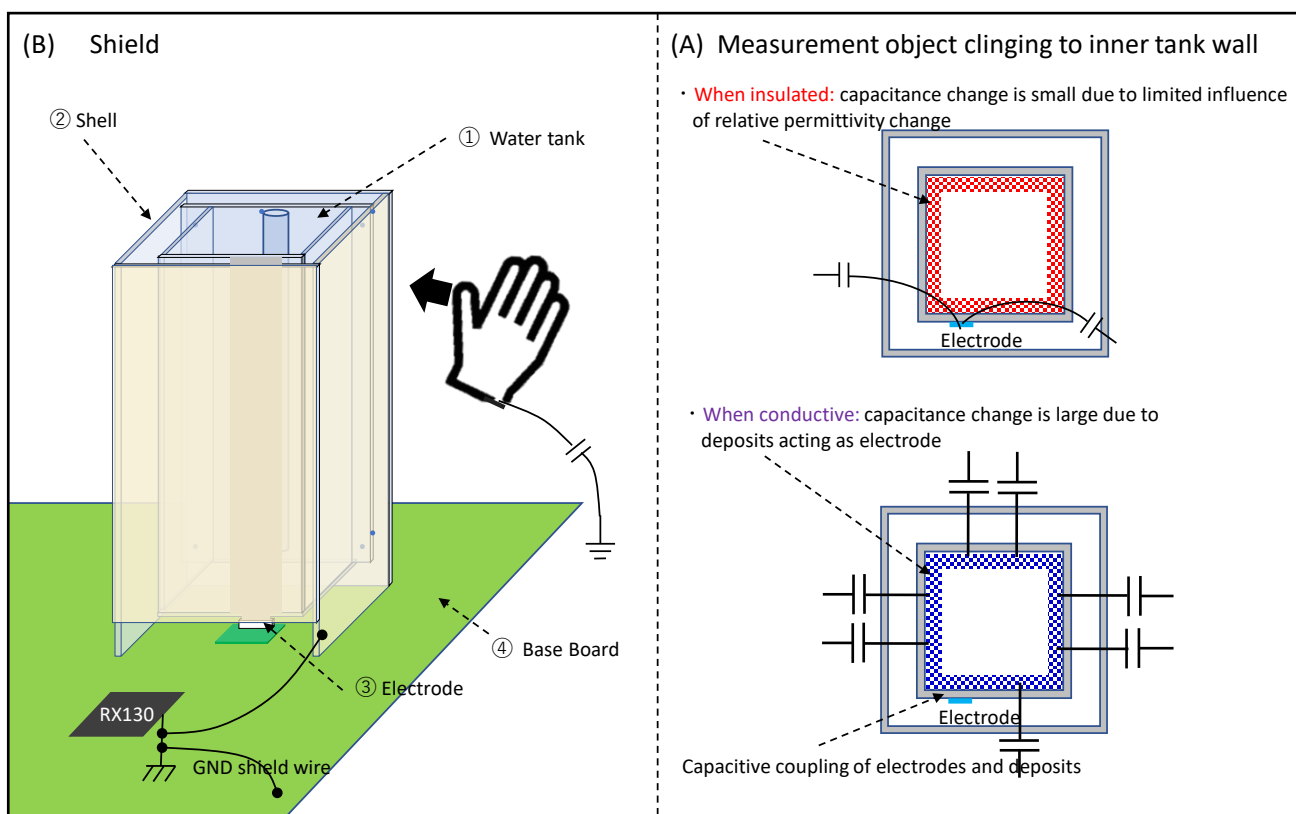


Figure 5-1 Shield and Water Level Measurement Cautions

### 5.2 Shield from Surrounding Environment

To obtain correct measurements with the capacitive touch sensor, it is necessary to cut off influence to the electrodes other than that of the object being measured. The electrodes must be blocked off from any conductive influence other than that of the object to be measured. This demo set is equipped with two components for confirming the shield effect: a conductive sheet for the right-side tank shell and a conductive mat for the base board. These two components can be connected to the MCUs GND to confirm the shield effect (see Figure 5-1 (B)).

As described above, if the GND shield is too close to an electrode it can cause the parasitic capacitance of the electrode to increase too much. Therefore, we have placed the conductive sheet to serve as a GND shield 10mm away from the external shell around the water tank. Also, give careful consideration to the size

and required sensitivity of the electrode when designing the GND shield as the measurement clock frequency is limited when the parasitic capacitance increases.

### 5.3 Electrode Wiring Shield

Electrode wiring (the harness between RX130 and the electrode) is highly susceptible to changes in the surrounding environment. Specifically, changes in the harness routing can cause fluctuations in the distance between the electrode and the conductor (in this case, the tanks), making the parasitic capacitance of the electrode wiring fluctuate as well. When considering the final product, the more measurement accuracy required by the product, the more important it is to control the individual differences in parasitic capacitance. We therefore determined that using a harness is not always a plausible solution.

In this demo set, a coaxial cable is used for shielding in order to suppress the effects of changes in harness routing. Specifically, as shown in Figure 5-2, the electrode signal is shielded by a signal with the same voltage and phase as the electrode signal.

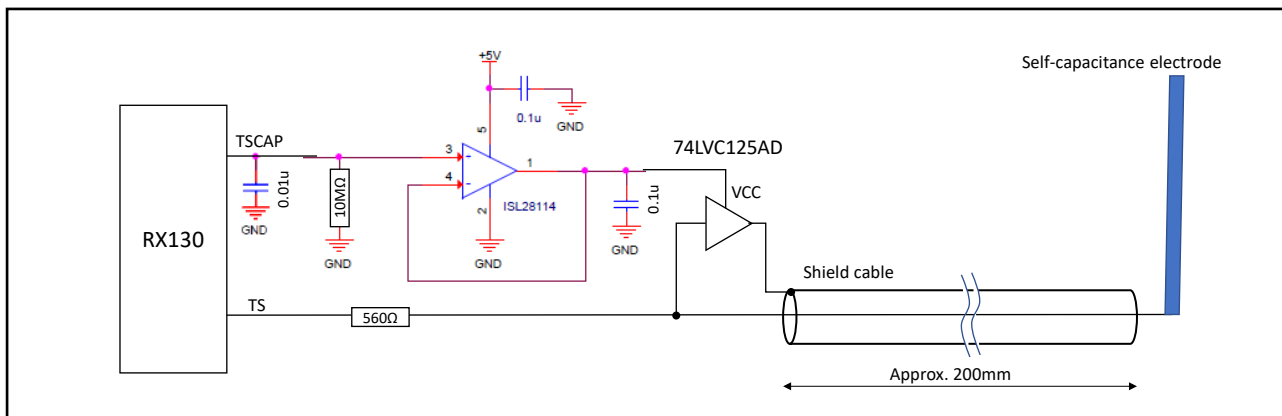


Figure 5-2 Electrode Signal Shield

### 5.4 CTSU Improved Accuracy (3-resistance 7-point correction circuit)

As previously described, the CTSU measures the change in capacitance by modifying electrode charges and discharges into frequency using a current-frequency modulator. The ideal characteristics (current vs. frequency) of current-frequency converters are proportionate, but in reality, errors occur due to individual differences in MCUs and temperature changes.

This demo set uses the circuit shown in Figure 5-3 to suppress the current-frequency converter errors. Correction software is necessary to improve accuracy.

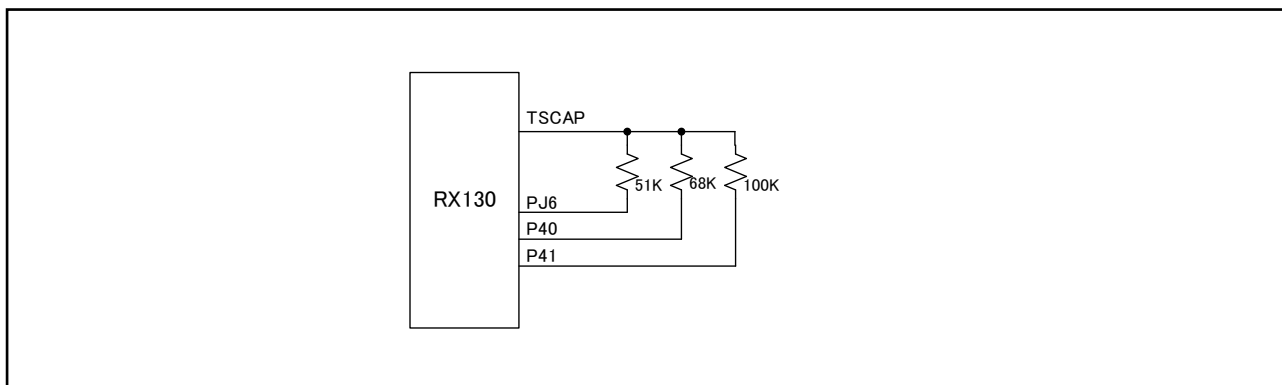


Figure 5-3 CTSU Improved Accuracy Circuit Example (3-resistance 7-point correction circuit)

\*Note: The TSCAP port on this circuit is the same as the TSCAP port shown in Figure 5-2.

## Revision History

Rev.	Date	Description	
		Page	Summary
1.00	Jan. 31, 2020	-	First edition issued

# General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

## 1. Precaution against Electrostatic Discharge (ESD)

A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity.

Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

## 2. Processing at power-on

The state of the product is undefined at the time 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 time 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 time 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 time when power is supplied until the power reaches the level at which resetting is specified.

## 3. Input of signal during power-off state

Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

## 4. Handling of unused pins

Handle unused pins in accordance 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 the 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.

## 5. Clock signals

After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is 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. Additionally, 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.

## 6. Voltage application waveform at input pin

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between  $V_{IL}$  (Max.) and  $V_{IH}$  (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between  $V_{IL}$  (Max.) and  $V_{IH}$  (Min.).

## 7. Prohibition of access to reserved addresses

Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

## 8. Differences between products

Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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## Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,  
Koto-ku, Tokyo 135-0061, Japan  
[www.renesas.com](http://www.renesas.com)

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