# RX231 Group

## CTSU Application Example: 3D Gesture Demo Set (Hardware)

R01AN4219EJ0100
Rev.1.00
Jan 16, 2018

## Introduction

The RX231 Group is equipped with hardware (Capacitive Touch Sensor Unit; CTSU) that senses contact of the human body by measuring the capacitance generated between the touch electrode and the human body (hand, etc.).

This application note explains the hardware specifications of the 3D Gesture Demo Set (RTK5RX2310D00000BR) which is a sample application of the CTSU mutual capacitance method.

## Target Devices

RX231 Group

## Related Documents

1. RX Family CTSU API Reference Guide (R30AN0215EJ)
2. RX Family CTSU Mutual-capacitance Touch Measurement (R30AN0217EJ)
3. RX113 Group CTSU Basis of Cap Touch Detection (R30AN0218EJ)
4. CTSU 3D Position Calculation Sample Software (R01AN4101EJ)

## Contents

# 1. Overview

The RTK5RX2310D00000BR is a demonstration kit that detects 3D gesture motion by CTSU of RX231. This demo kit has the following features.

- Simple parts configuration: gesture detection only requires an MCU, electrodes on a substrate pattern, a resistor and a capacitor.
- Quick and easy setup and operation: basically the demo board is already enclosed in a case and uses just three switches.
- Detection distance from about 200 mm (board size: 160 mm x 160 mm)
- Easy-to-use demo (runs with PC demo application)
- Includes all tools and necessary interfaces (USB, BLE, E1 emulator)

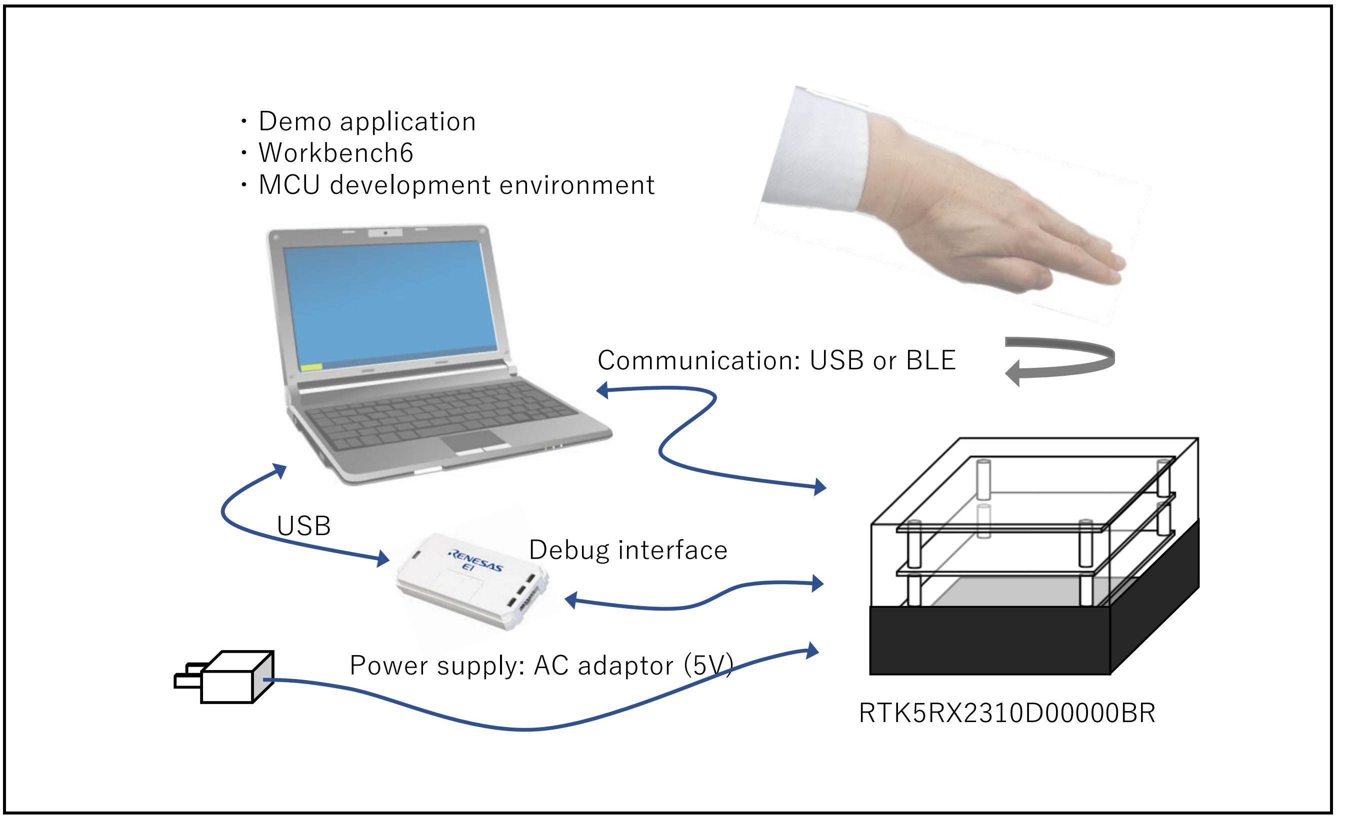



**Figure 1-1 3D Gesture Demo System**

## 2. External Appearance

Figure 2-1 to Figure 2-4 show the external appearance and part names related to the 3D Gesture Demo Set.

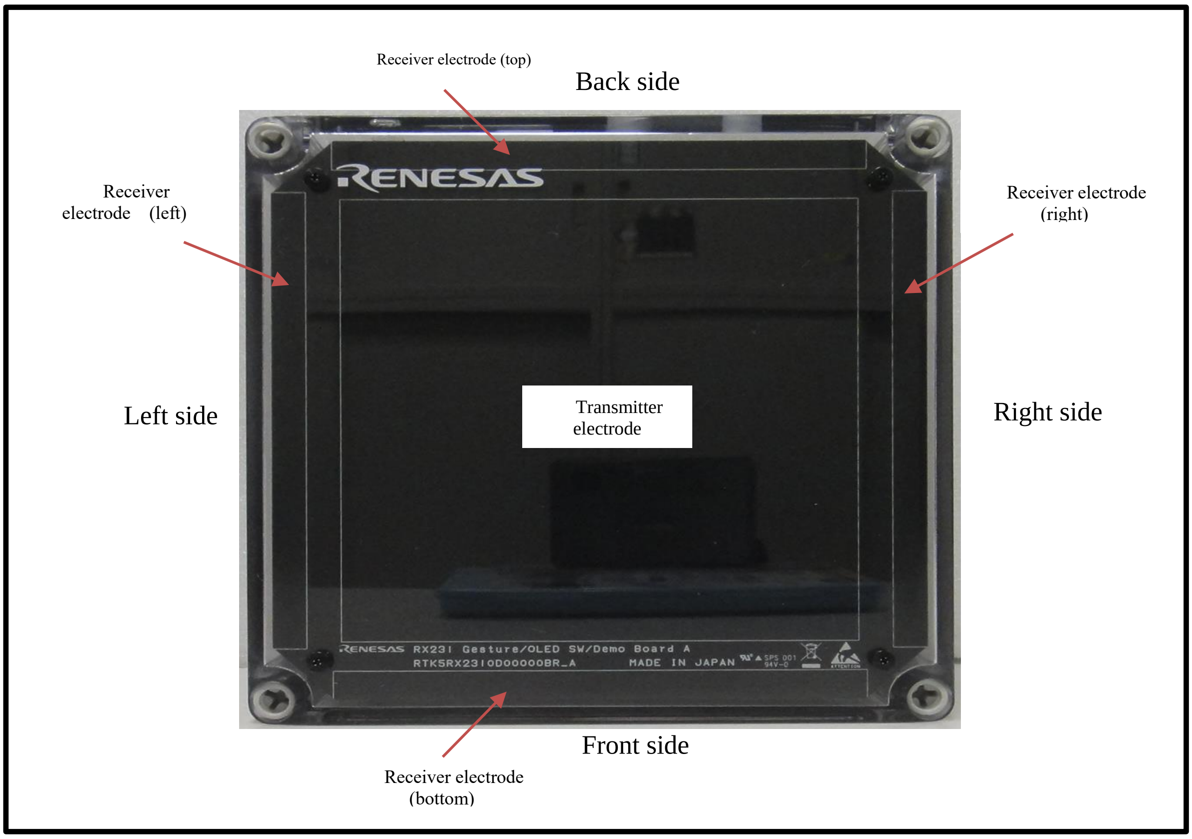



**Figure 2-1 External Appearance (top view)**

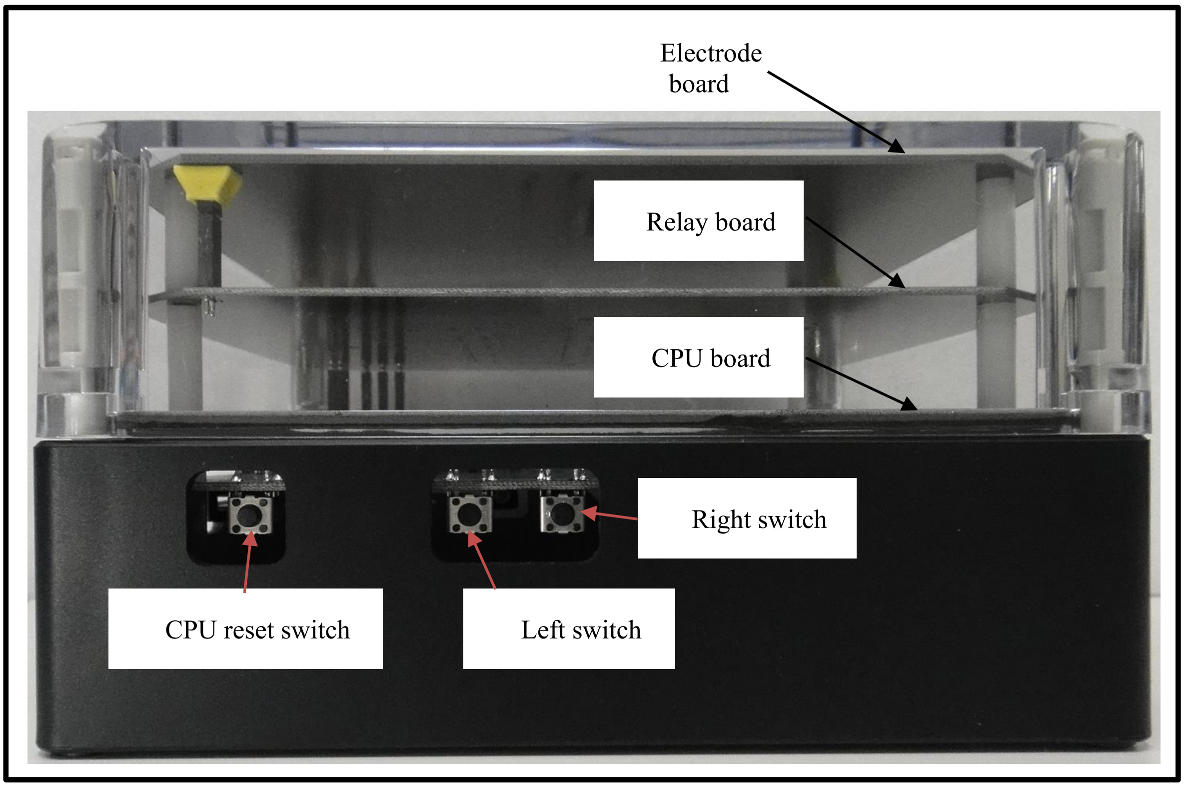



**Figure 2-2 External Appearance (front view)**

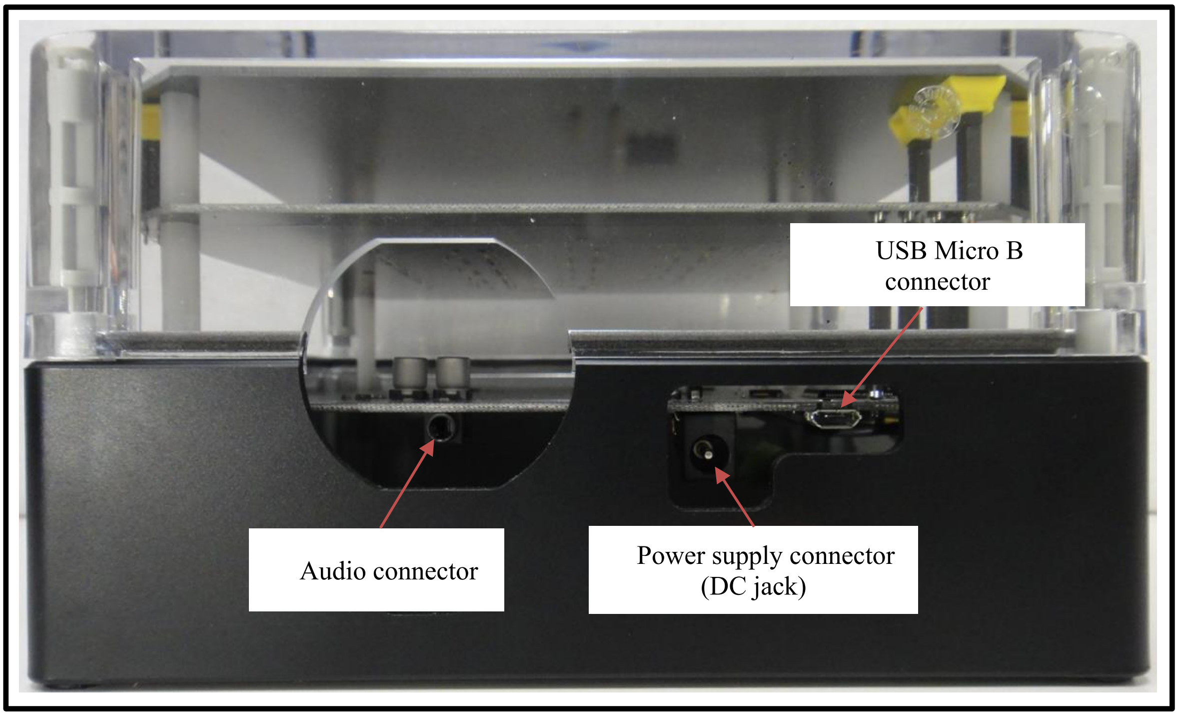



**Figure 2-3 External Appearance (back view)**

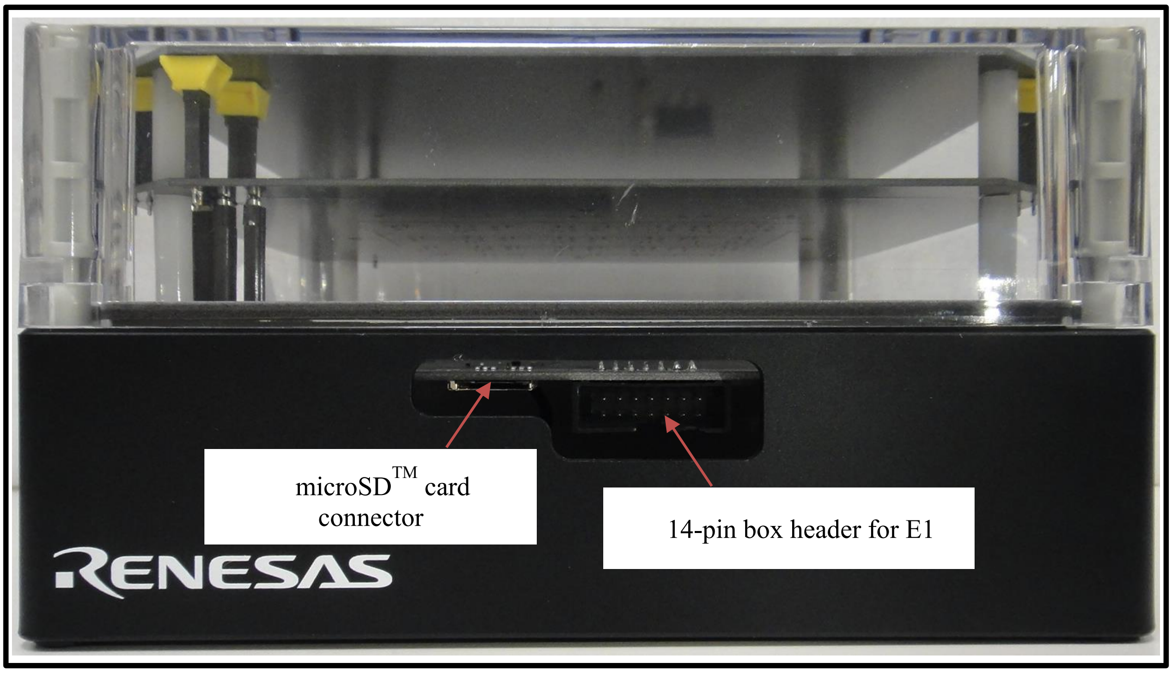



**Figure 2-4 External Appearance (left side view)**

# 3. Hardware Specification

**Table 3-1 Hardware Specification**

| Item | Description | Notes |
|---|---|---|
| Board size | 160.0×160.0[mm] | Upper board: electrode board<br>Middle board: relay board<br>Lower board: CPU board |
| CPU | RX231<br>(R5F52318BDFP) | ROM: 512KB RAM: 64KB<br>Data flash: 8KB<br>Package: 100-pin LFQFP (0.5mm pitch)<br>Encryption: yes CAN: yes<br>SD host interface: yes<br>Operating ambient temperature: -40～85℃ |
| Clock input | RX231 main clock: 16MHz | Crystal unit |
| | RX231 subclock: 32.768kHz | Crystal unit |
| | Audio D/A converter:<br>11.2896MHz | Crystal oscillator (option) |
| | Wireless module built-in CPU subclock for RL78/G1D:<br>32.768kHz | Crystal unit |
| LEDs | Function display:<br>2 orange, 2 green | CPU board control |
| Switches | Push switch: 3 | ・CPU reset switch<br>・Left switch<br>・Right switch |
| | DIP switch: 1 | USB boot mode setting |
| Gesture detection electrodes | Receiver electrode: 4 | Top, bottom, left, right |
| | Transmitter electrode: 1 | |
| Wireless module | RL78/G1D built-in module:<br>RY7011A0000DZ00 | Bluetooth v4.1 specification<br>(Low Energy, single mode) |
| USB interface | USB Micro B connector | Full-speed transfer |
| Debug interface | 14-pin box header for E1 | |
| SD host interface (option) | microSD™ card connector | Default speed mode |
| Audio output (option) | Audio connector:<br>ϕ3.5mm stereo mini jack | Output level:<br>1Vrms (0dB at playback, IC output terminal)<br>External load resistance: 12Ω or more |
| | D/A converter IC:<br>PCM1774 (manufactured by TI) | |
| Power supply | Power supply connector (DC jack): 5V | Φ5.5mm, center plus<br>board internal voltage: 3.3V |

# 4. Block Diagram

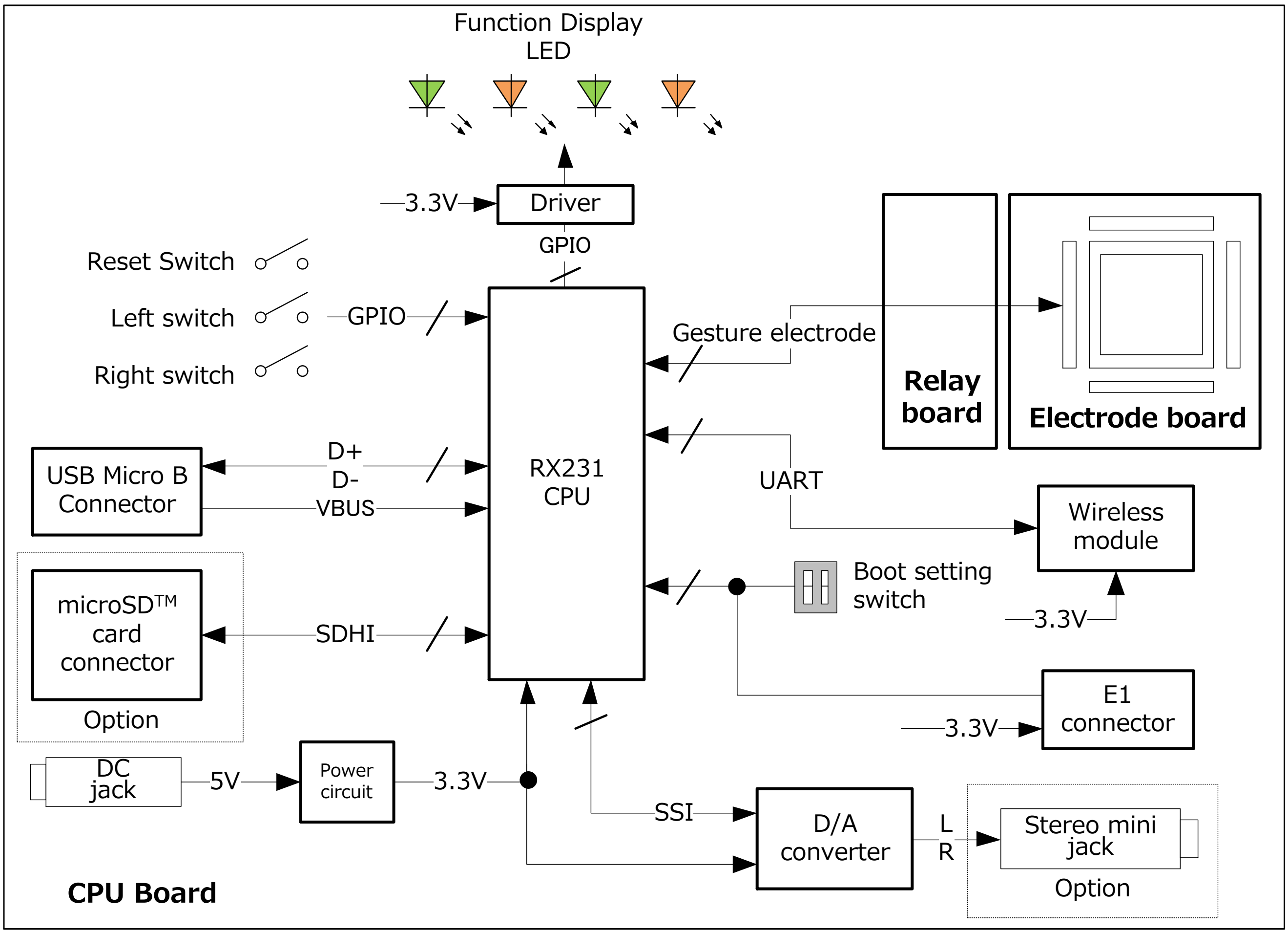



**Figure 4-1 Block Diagram**

# 5. Circuit Diagram

## 5.1 CPU Board

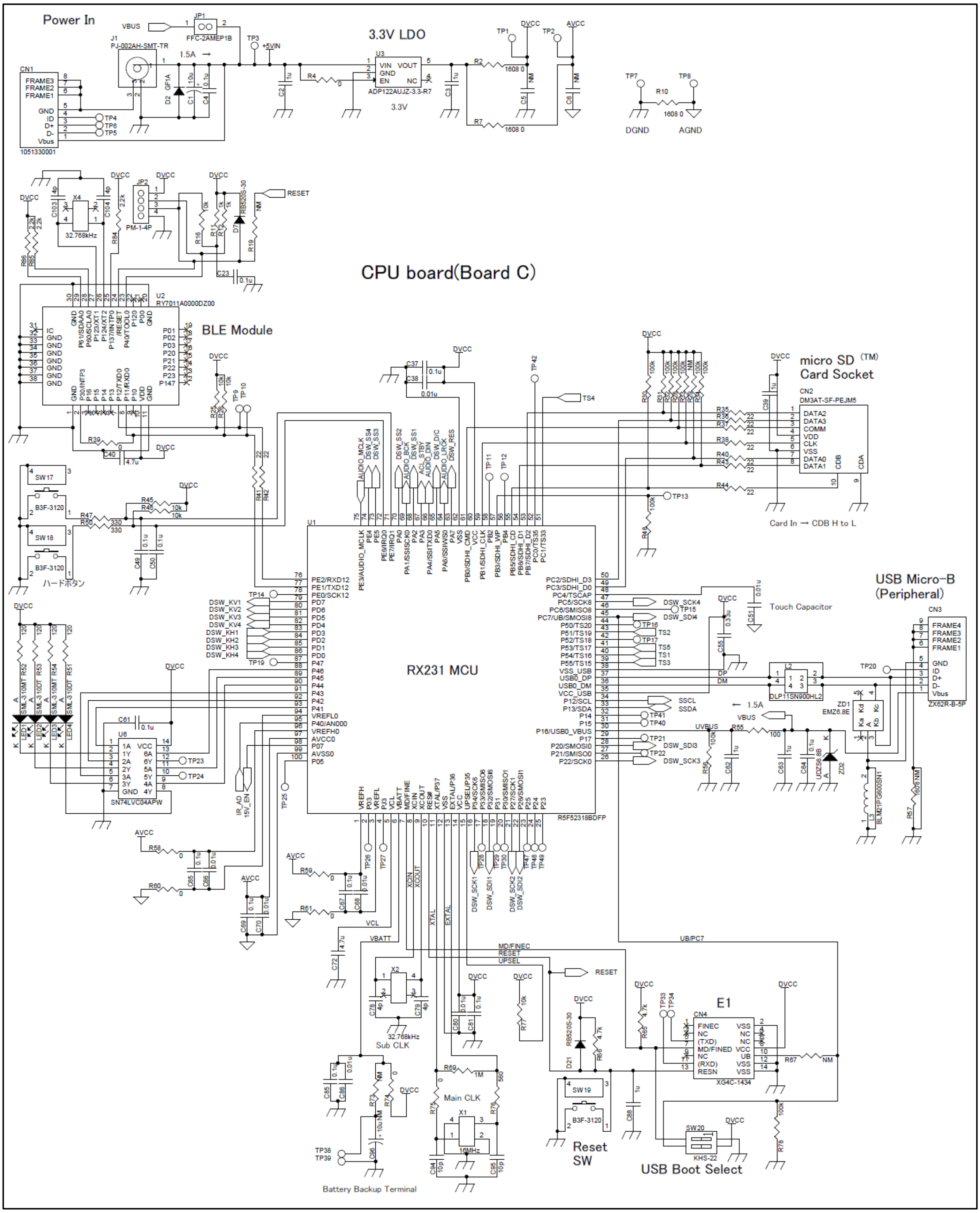


**Figure 5-1 CPU Board Circuit Diagram (1/2)**

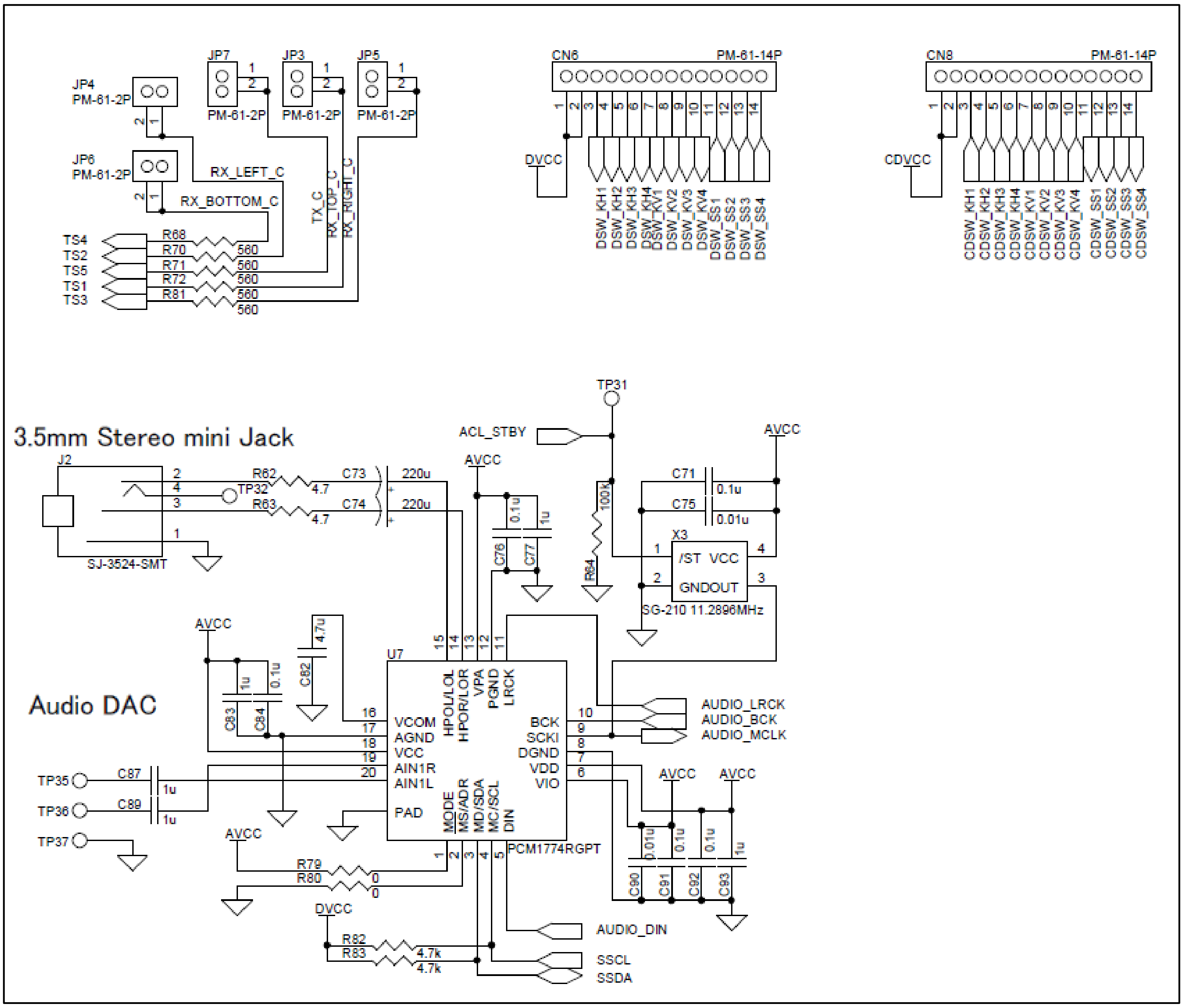



**Figure 5-2 CPU Board Circuit Diagram (2/2)**

## 5.2 Relay Board

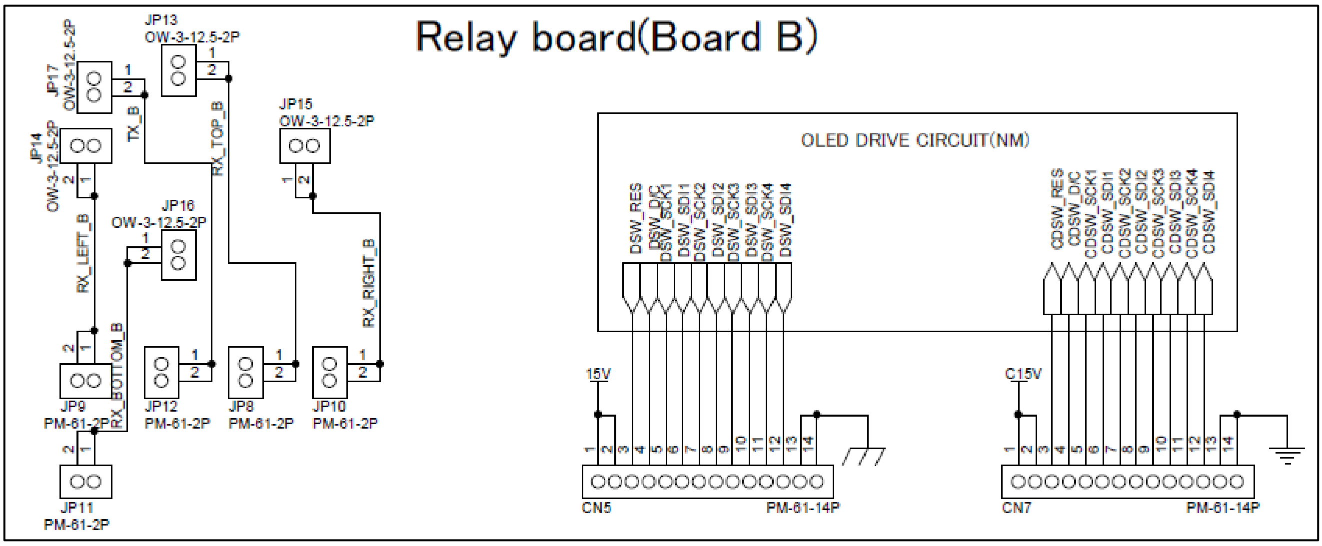



**Figure 5-3 Relay Board Circuit Diagram**

## 5.3 Electrode Board

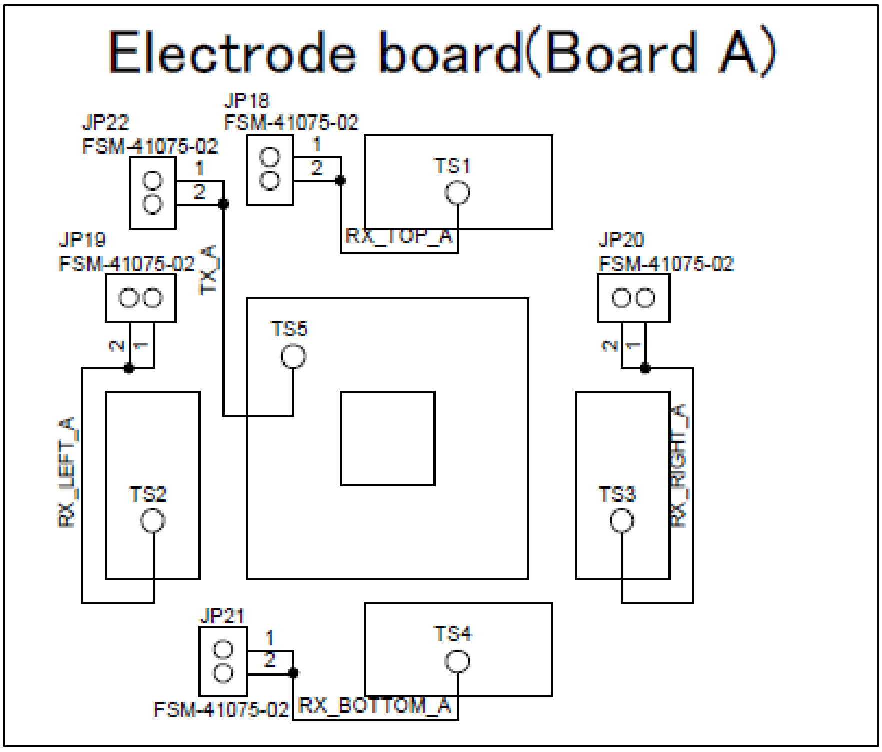



**Figure 5-4 Electrode Board Circuit Diagram**

## 6. BOM (parts list)

**Table 6-1 BOM (1/2)**

| Item | Quantity | Reference | Part | Manufacture | Part number | Remarks |
|---|---|---|---|---|---|---|
| 1 | 1 | CN1 | 1051330001 | Molex | 1051330001 | NM |
| 2 | 1 | CN2 | DM3AT-SF-PEJM5 | HIROSE | DM3AT-SF-PEJM5 | |
| 3 | 1 | CN3 | ZX62R-B-5P | HIROSE | ZX62R-B-5P | |
| 4 | 1 | CN4 | XG4C-1434 | OMRON | XG4C-1434 | |
| 5 | 4 | CN5,CN6,CN7,CN8 | PM-61-14P | MAC EIGHT | PM-61-14P | NM |
| 6 | 1 | C1 | 10u | Nichicon | UWX1C100MCL2GB | 10uF,16V |
| 7 | 11 | C2,C3,C39,C62,C63,C77,C83,C87,C88,C89,C93 | 1u | MURATA | GRM188B31A105KA61 | |
| 8 | 17 | C4,C23,C37,C49,C50,C61,C64,C65,C67,C69,C71,C76,C81,C84,C85,C91,C92 | 0.1u | MURATA | GRM188B11E104KA01 | |
| 9 | 2 | C5,C6 | NM | | | 1608 CAP PAD |
| 10 | 9 | C38,C51,C66,C68,C70,C75,C80,C86,C90 | 0.01u | MURATA | GRM188B11H103K | |
| 11 | 3 | C40,C72,C82 | 4.7u | MURATA | GRM188B31A475KE15 | |
| 12 | 1 | C55 | 0.33u | MURATA | GRM188B11A334K | |
| 13 | 2 | C73,C74 | 220u | Nichicon | UUD1A221MCL1GS | |
| 14 | 4 | C78,C79,C103,C104 | 4p | MURATA | GRM1885C1H4R0CA01D | |
| 15 | 2 | C94,C95 | 10p | MURATA | GRM1885C1H100JA01D | |
| 16 | 1 | C96 | 10u NM | Nichicon | UWX1C100MCL2GB | NM |
| 17 | 1 | D2 | GF1A | Vishay | GF1A-E3/67A | |
| 18 | 2 | D7,D21 | RB520S-30 | ROHM | RB520S-30 | |
| 19 | 1 | JP1 | FFC-2AMEP1B | HONDA TSUSHIN KOGYO | FFC-2AMEP1B | NM |
| 20 | 1 | JP2 | PM-1-4P | MAC EIGHT | PM-1-4P | NM |
| 21 | 10 | JP3,JP4,JP5,JP6,JP7,JP8,JP9,JP10,JP11,JP12 | PM-61-2P | MAC EIGHT | PM-61-2P | |
| 22 | 5 | JP13,JP14,JP15,JP16,JP17 | OW-3-12.5-2P | MAC EIGHT | OW-3-12.5-2P | |
| 23 | 5 | JP18,JP19,JP20,JP21,JP22 | FSM-41075-02 | HIROSUGI-KEIKI | FSM-41075-02 | |
| 24 | 1 | J1 | PJ-002AH-SMT-TR | CUI | PJ-002AH-SMT-TR | |
| 25 | 1 | J2 | SJ-3524-SMT | CUI | SJ-3524-SMT | |
| 26 | 2 | LED1,LED3 | SML-310MT | ROHM | SML-310MT | |
| 27 | 2 | LED2,LED4 | SML-310DT | ROHM | SML-310DT | |
| 28 | 1 | L2 | DLP11SN900HL2 | MURATA | DLP11SN900HL2 | NM |
| 29 | 1 | L3 | BLM21PG600SN1 | MURATA | BLM21PG600SN1 | NM |
| 30 | 3 | R2,R7,R10 | 1608 0 | ROHM | MCR03EZPJ000 | |
| 31 | 10 | R4,R39,R58,R59,R60,R61,R74,R75,R79,R80 | 0 | ROHM | MCR03EZPJ000 | |
| 32 | 2 | R11,R12 | 1k | ROHM | MCR03EZPJ102 | |

**Table 6-2 BOM (2/2)**

| Item | Quantity | Reference | Part | Manufacture | Part number | Remarks |
|---|---|---|---|---|---|---|
| 33 | 6 | R16,R25,R26,R45,R46,R77 | 10k | ROHM | MCR03ERTJ103 | |
| 34 | 4 | R19,R33,R67,R73 | NM | | | 1608 RES PAD |
| 35 | 10 | R28,R29,R30,R31,R32,R34,R48,R56,R64,R78 | 100k | ROHM | MCR03ERTJ104 | |
| 36 | 9 | R35,R36,R37,R38,R40,R41,R42,R43,R44 | 22 | ROHM | MCR03ERTJ220 | |
| 37 | 2 | R47,R50 | 330 | ROHM | MCR03ERTJ331 | |
| 38 | 4 | R51,R52,R53,R54 | 120 | ROHM | MCR03ERTJ121 | |
| 39 | 1 | R55 | 100 | ROHM | MCR03ERTJ101 | |
| 40 | 1 | R57 | 1608 NM | | | 1608 RES PAD |
| 41 | 2 | R62,R63 | 4.7 | ROHM | MCR03ERTJ4R7 | |
| 42 | 4 | R65,R66,R82,R83 | 4.7k | ROHM | MCR03ERTJ472 | |
| 43 | 6 | R68,R70,R71,R72,R76,R81 | 560 | ROHM | MCR03ERTJ561 | |
| 44 | 1 | R69 | 1M | ROHM | MCR03EZPJ105 | |
| 45 | 3 | R84,R85,R86 | 2.2k | ROHM | MCR03EZPJ222 | |
| 46 | 3 | SW17,SW18,SW19 | B3F-3120 | OMRON | B3F-3120 | |
| 47 | 1 | SW20 | KHS-22 | OTAX | KHS-22 | |
| 48 | 5 | TP1,TP2,TP3,TP7,TP8 | WL-1 | | | 1.5mm DIA SMD PAD |
| 49 | 39 | TP4,TP5,TP6,TP9,TP10,TP11,TP12,TP13,TP14,TP15,TP16,TP17,TP19,TP20,TP21,TP22,TP23,TP24,TP25,TP26,TP27,TP28,TP29,TP30,TP31,TP32,TP33,TP34,TP35,TP36,TP37,TP38,TP39,TP40,TP41,TP42,TP47,TP48,TP49 | WL-1 | | | 1mm DIA SMD PAD |
| 50 | 5 | TS1,TS2,TS3,TS4,TS5 | WL-1 | | | ELECTRODE PATTERN |
| 51 | 1 | U1 | R5F52318BDFP | RENESAS | R5F52318BDFP | |
| 52 | 1 | U2 | RY7011A0000DZ00 | RENESAS | RY7011A0000DZ00 | |
| 53 | 1 | U3 | ADP122AUJZ-3.3-R7 | ANALOG DEVICES | ADP122AUJZ-3.3-R7 | |
| 54 | 1 | U6 | SN74LVC04APW | TI | SN74LVC04APW | |
| 55 | 1 | U7 | PCM1774RGPT | TI | PCM1774RGPT | |
| 56 | 1 | X1 | 16MHz | EPSON | FA-238 16MHz | |
| 57 | 2 | X2,X4 | 32.768kHz | SII | SSP-T7-FL 32.768kHz | |
| 58 | 1 | X3 | SG-210 11.2896MHz | EPSON | SG-210 11.2896MHz | |
| 59 | 1 | ZD1 | EMZ6.8E | ROHM | EMZ6.8ET2R | |
| 60 | 1 | ZD2 | UDZS6.8B | ROHM | UDZSTE-176.8B | |

”NM” marking means that component is not fitted by default.

# 7. Circuit Board Layouts

## 7.1 CPU Board

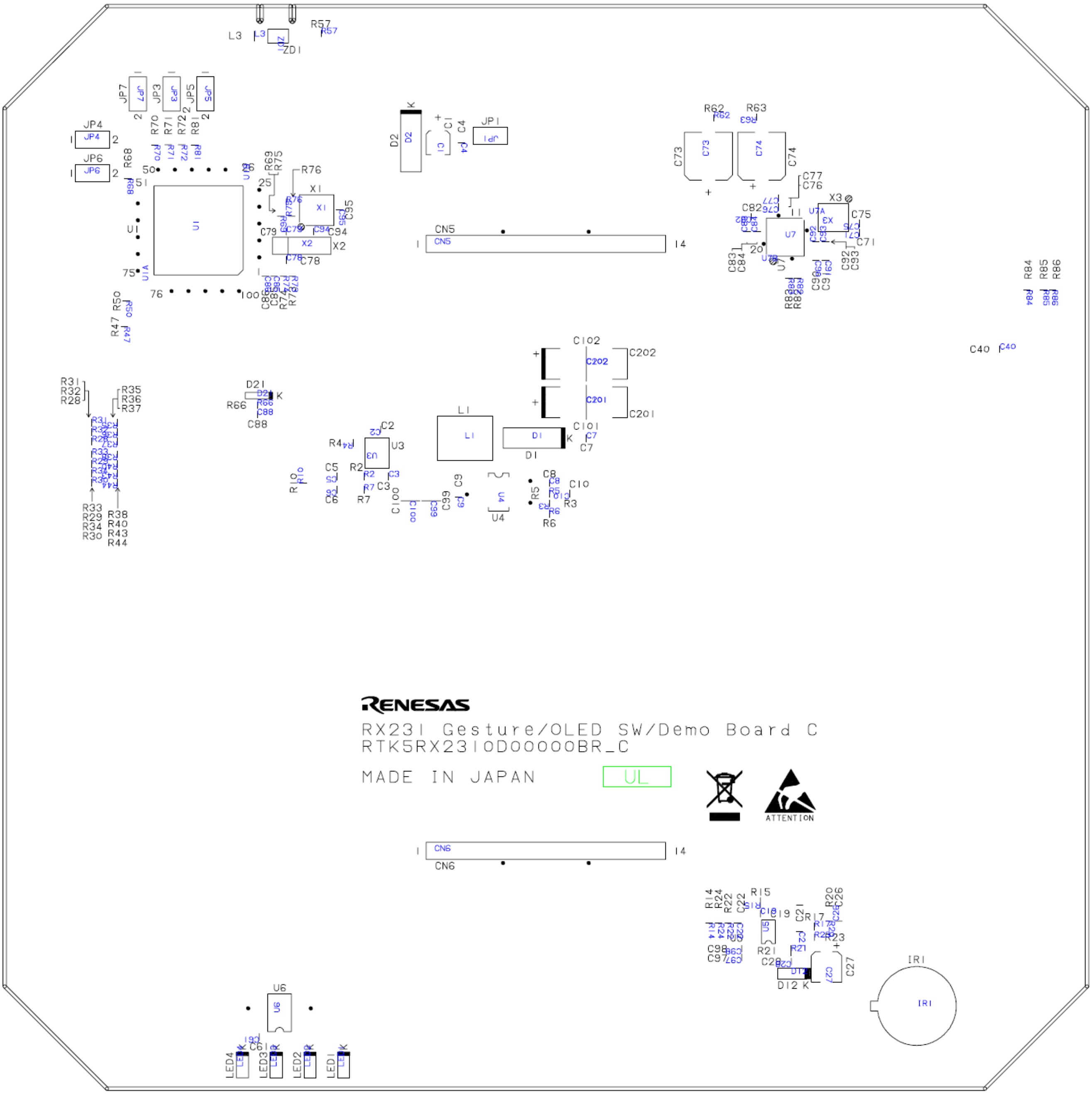



**Figure 7-1 Component Side Silkscreen (top view)**

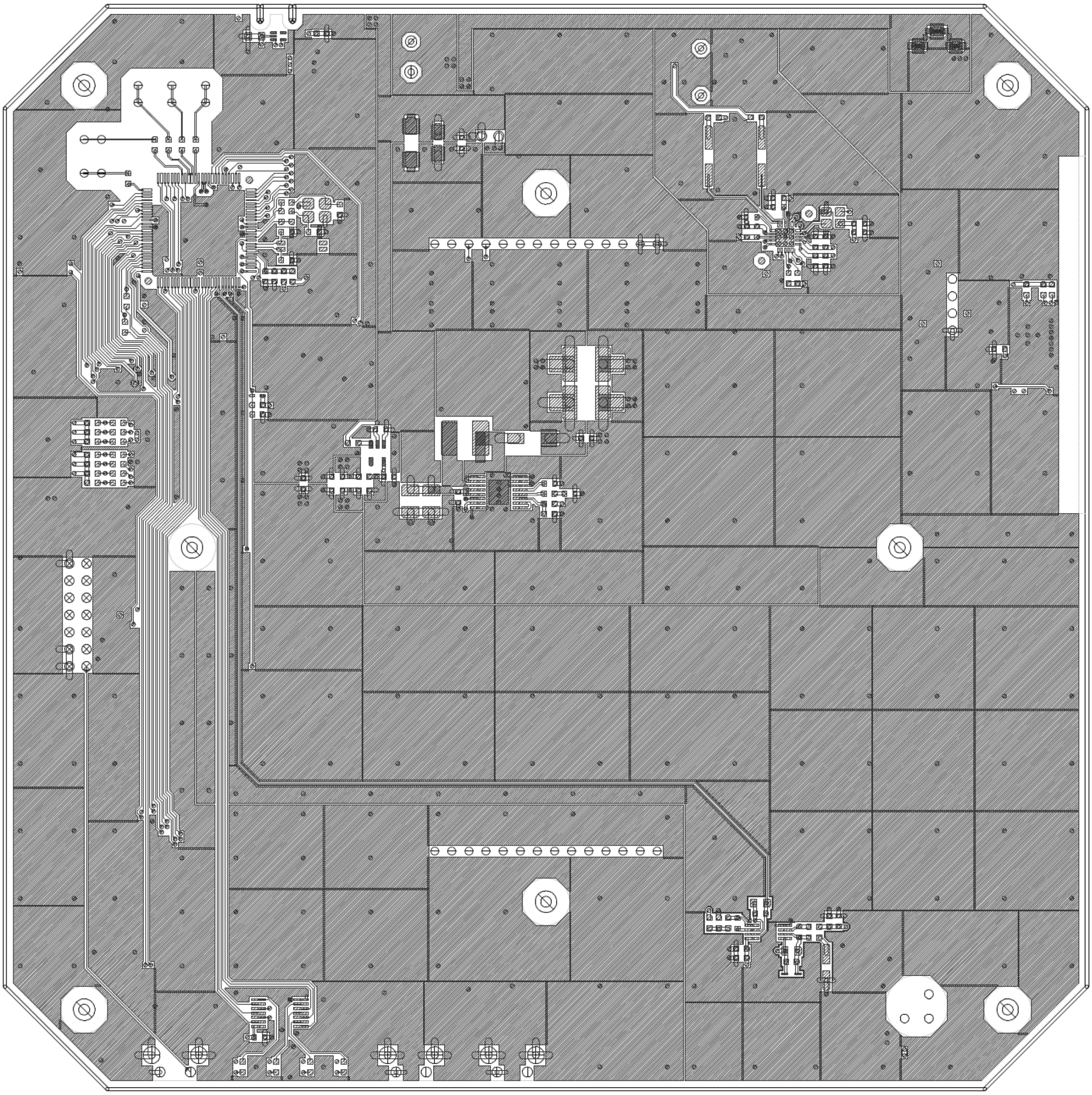


**Figure 7-2 1st Layer Pattern (top view)**

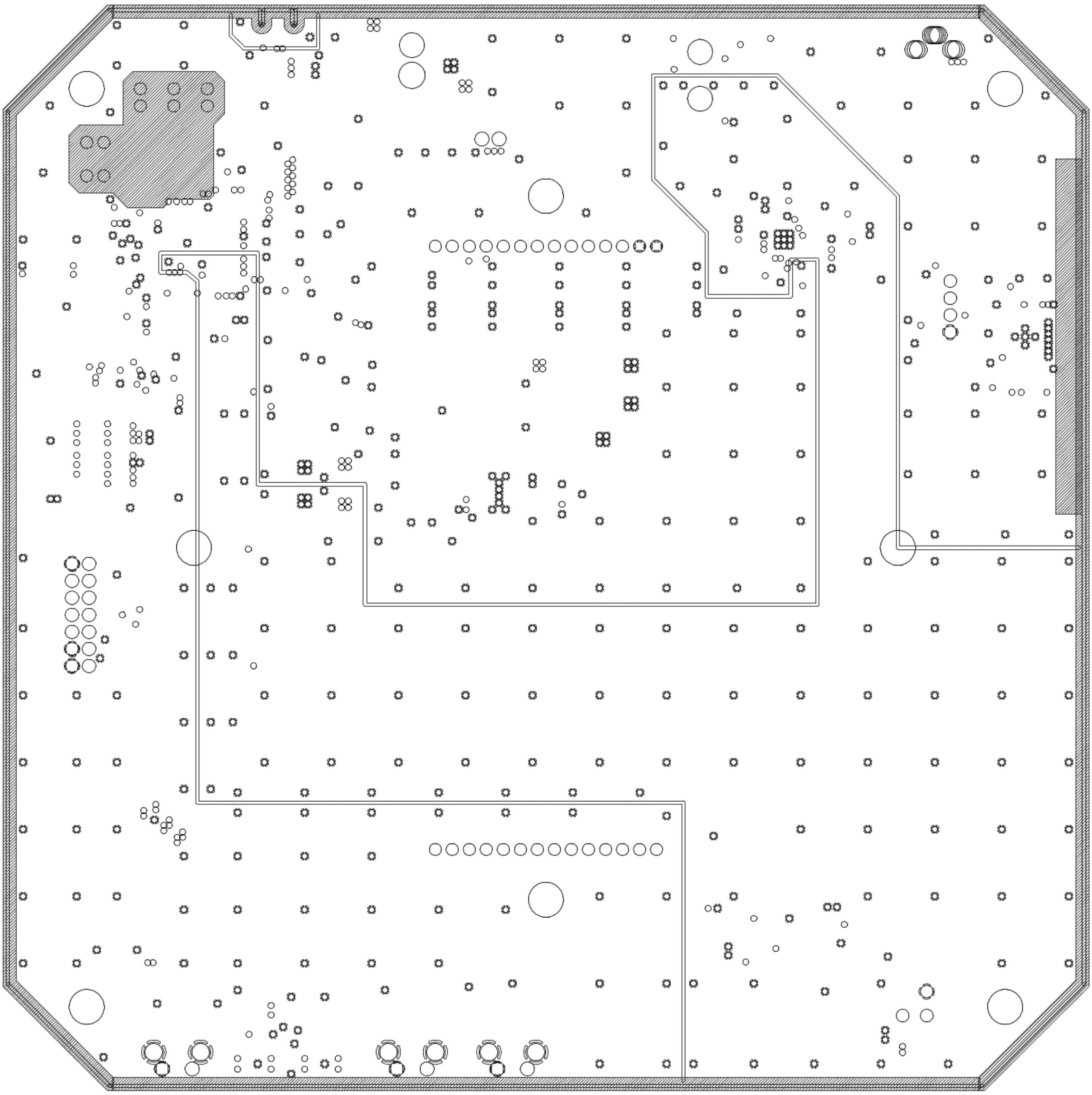


**Figure 7-3 2nd Layer Pattern (top view, negative-positive inversion)**

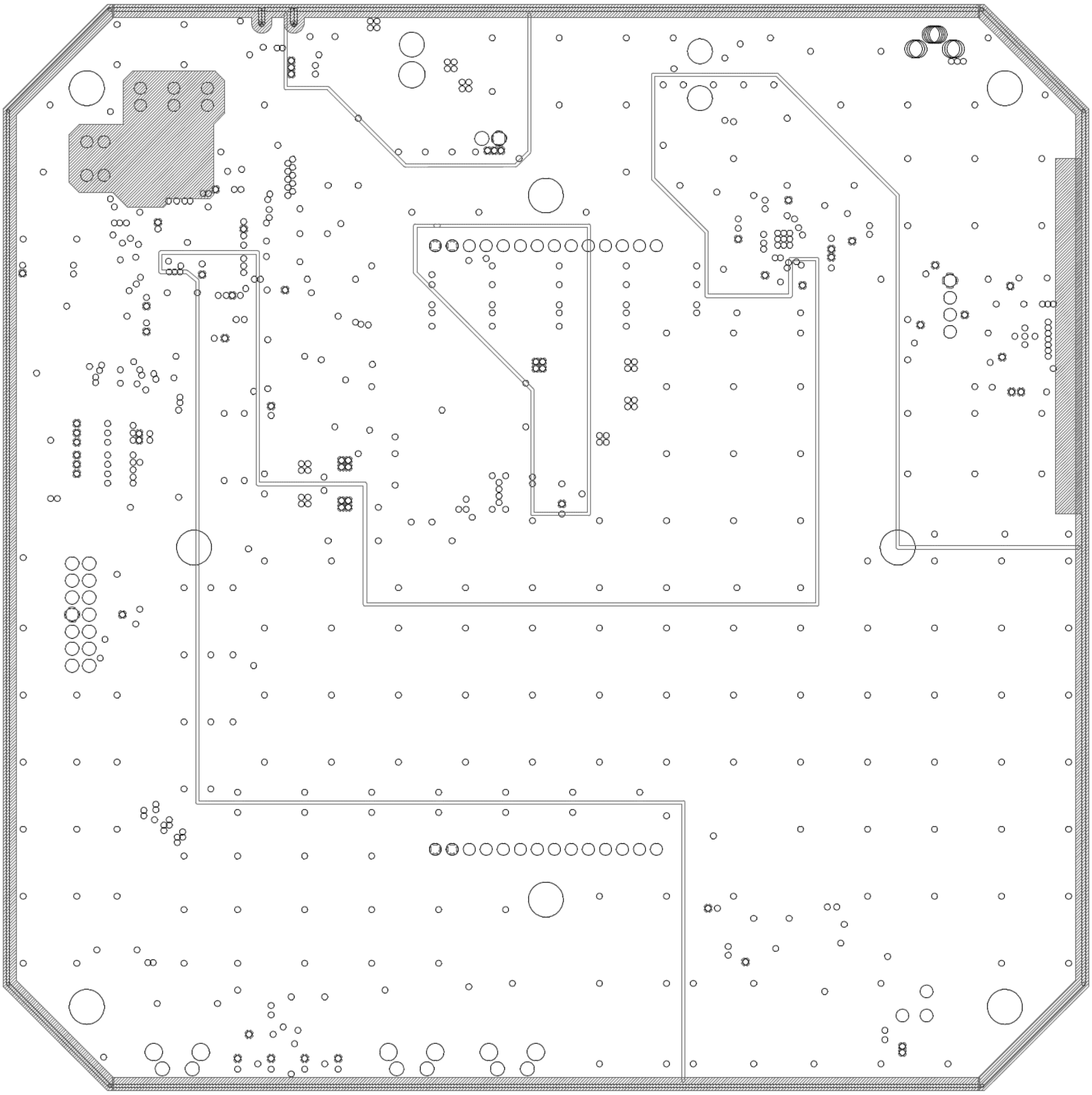


**Figure 7-4 3rd Layer Pattern (top view, negative-positive inversion)**

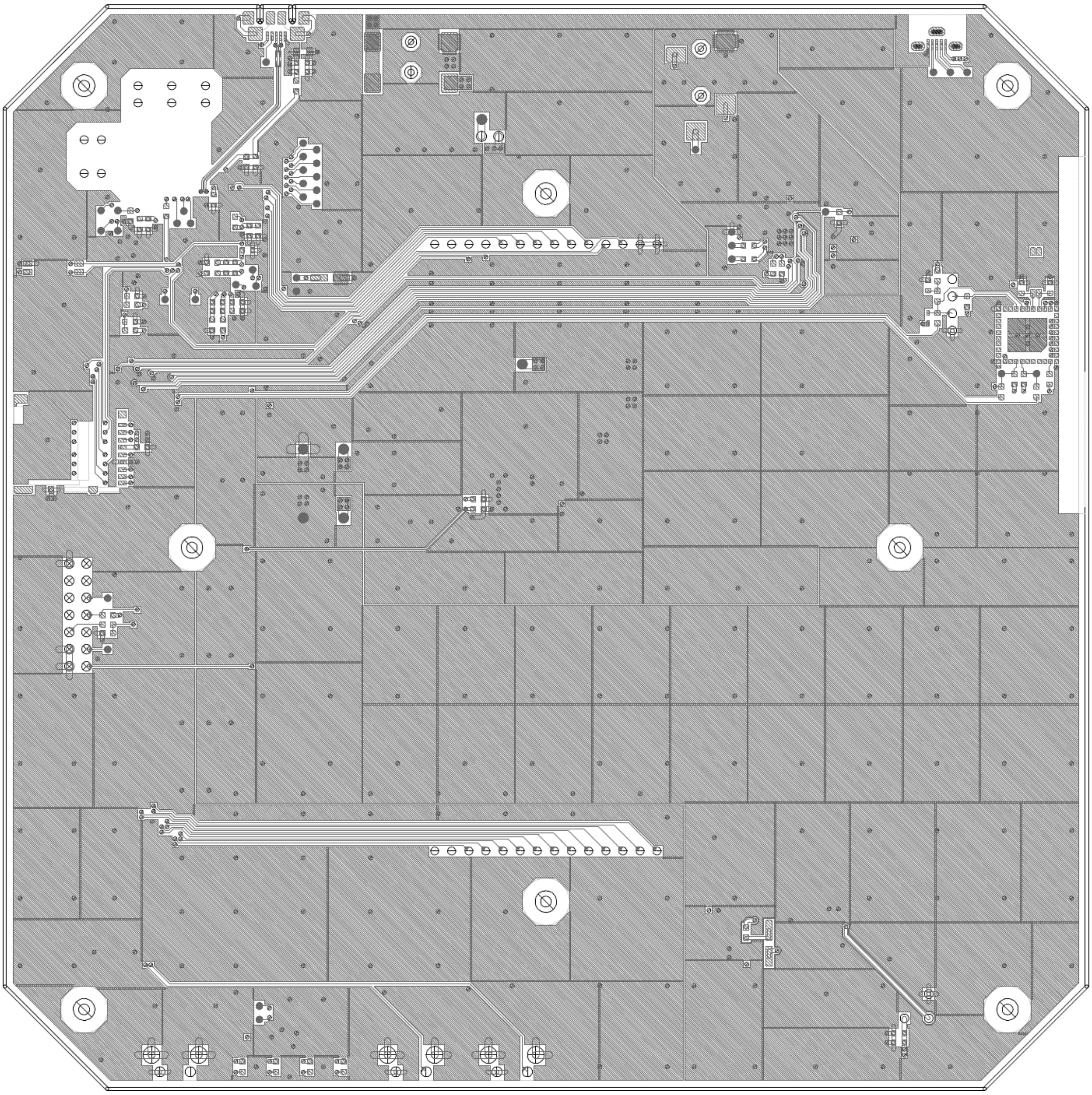


**Figure 7-5 4th Layer Pattern (top view)**

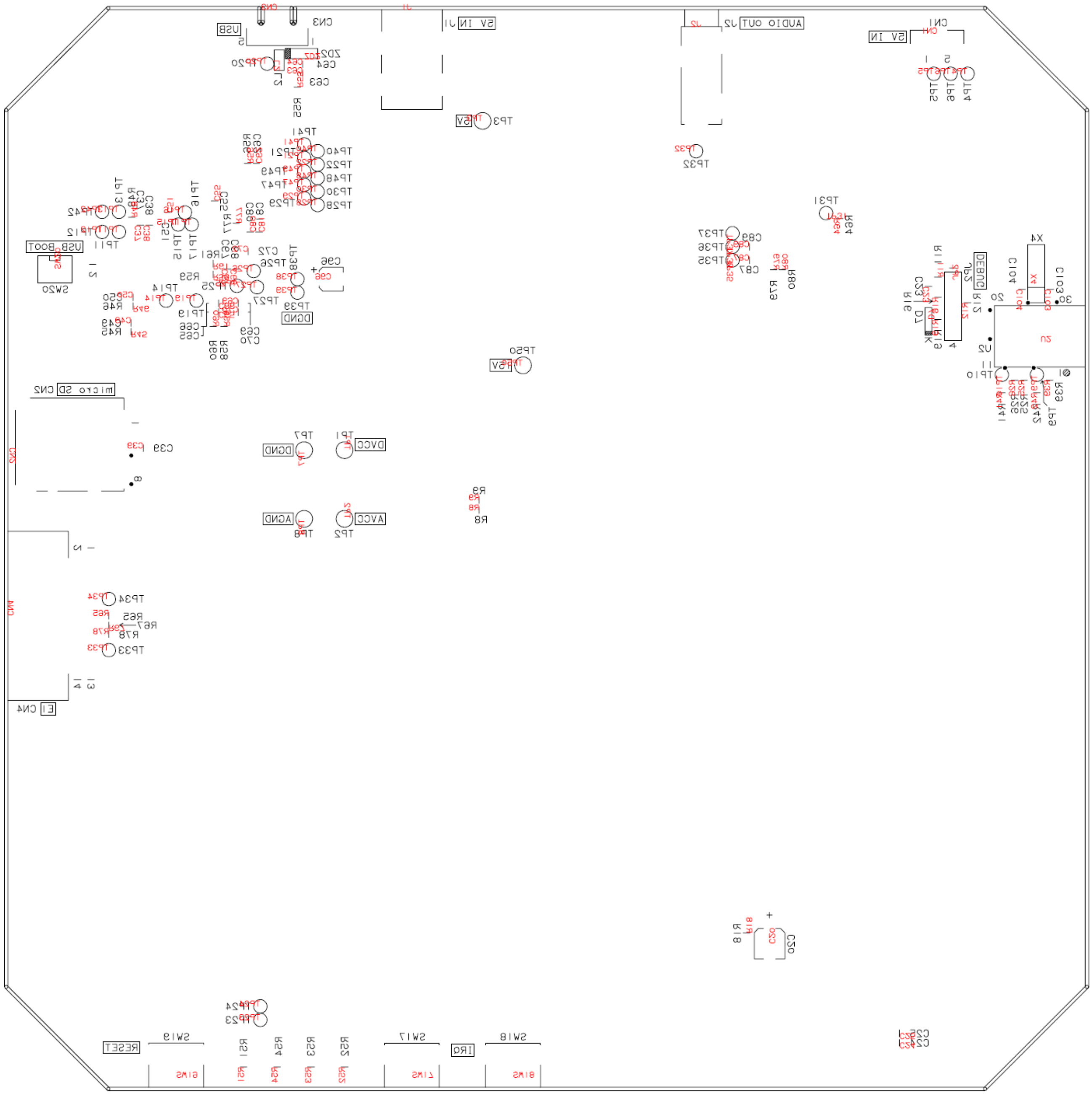


**Figure 7-6 Solder Side Silkscreen (top view)**

## 7.2 Electrode Board

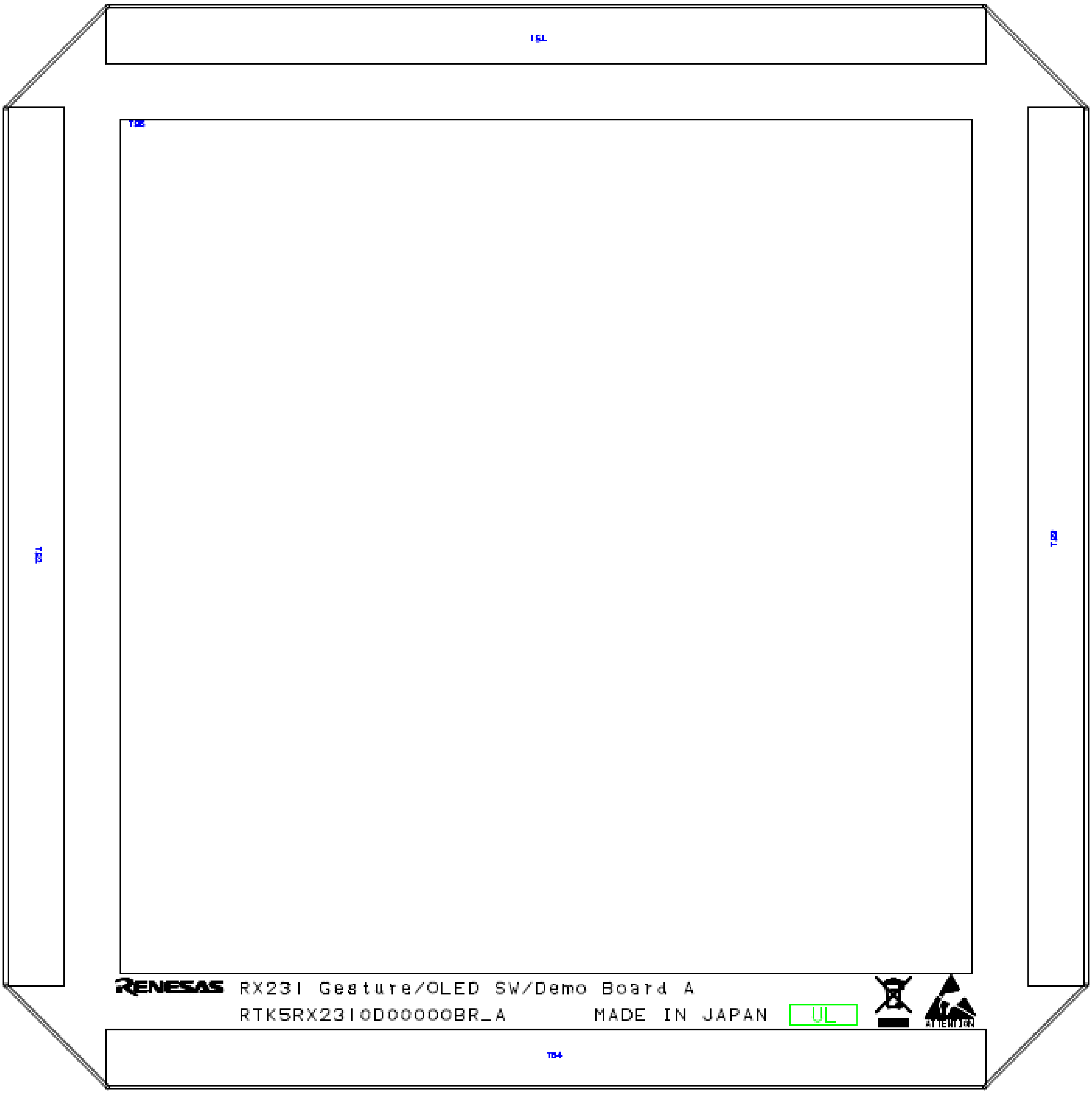



**Figure 7-7 Solder Side Silkscreen (top view)**

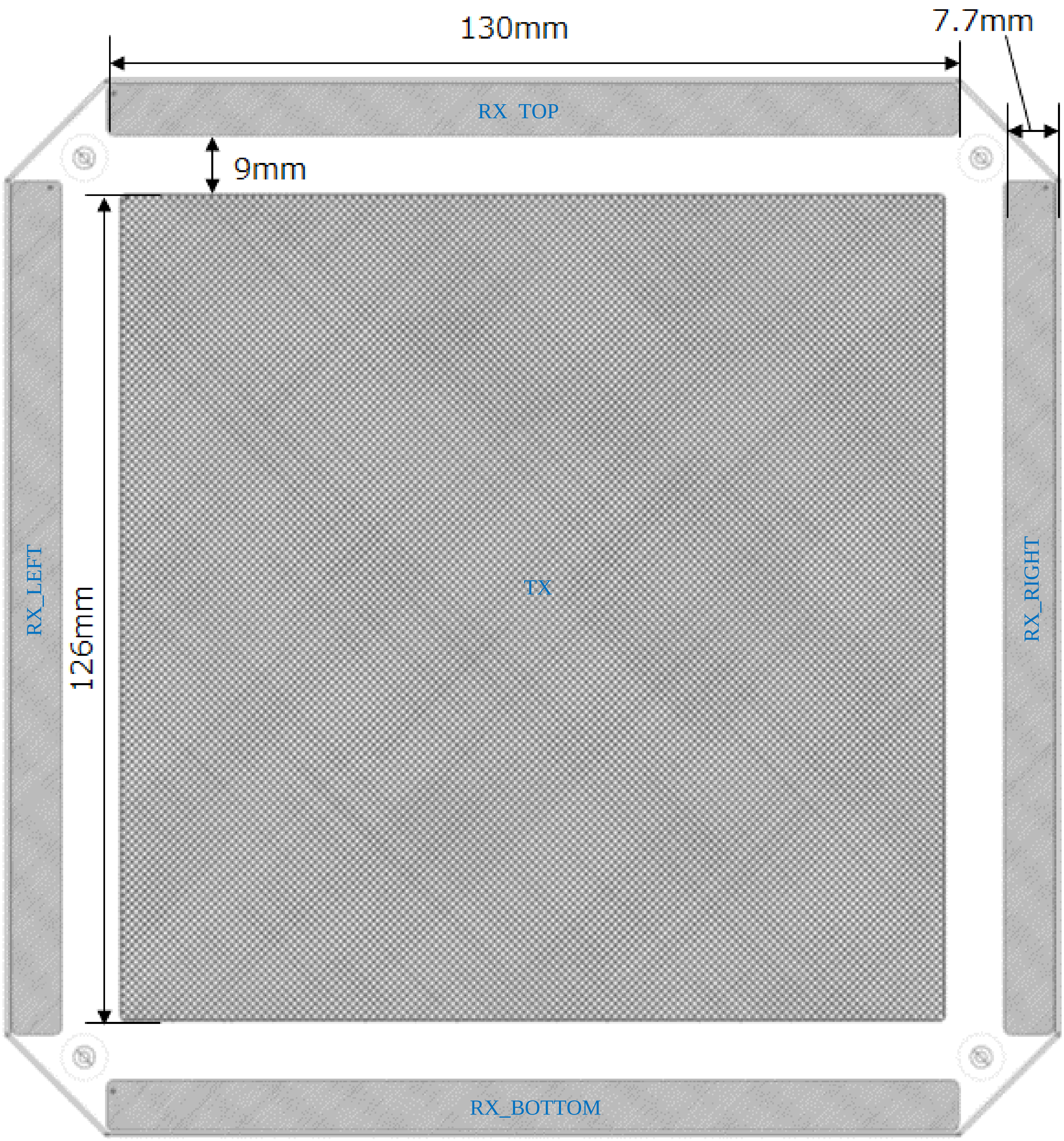
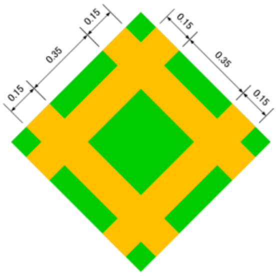



**Figure 7-8 Solder Side Pattern (top view)**

The TX electrode is a mesh pattern with a copper to blank ratio of 3 to 7. ⇒




The four RX electrodes are copper solid patterns.

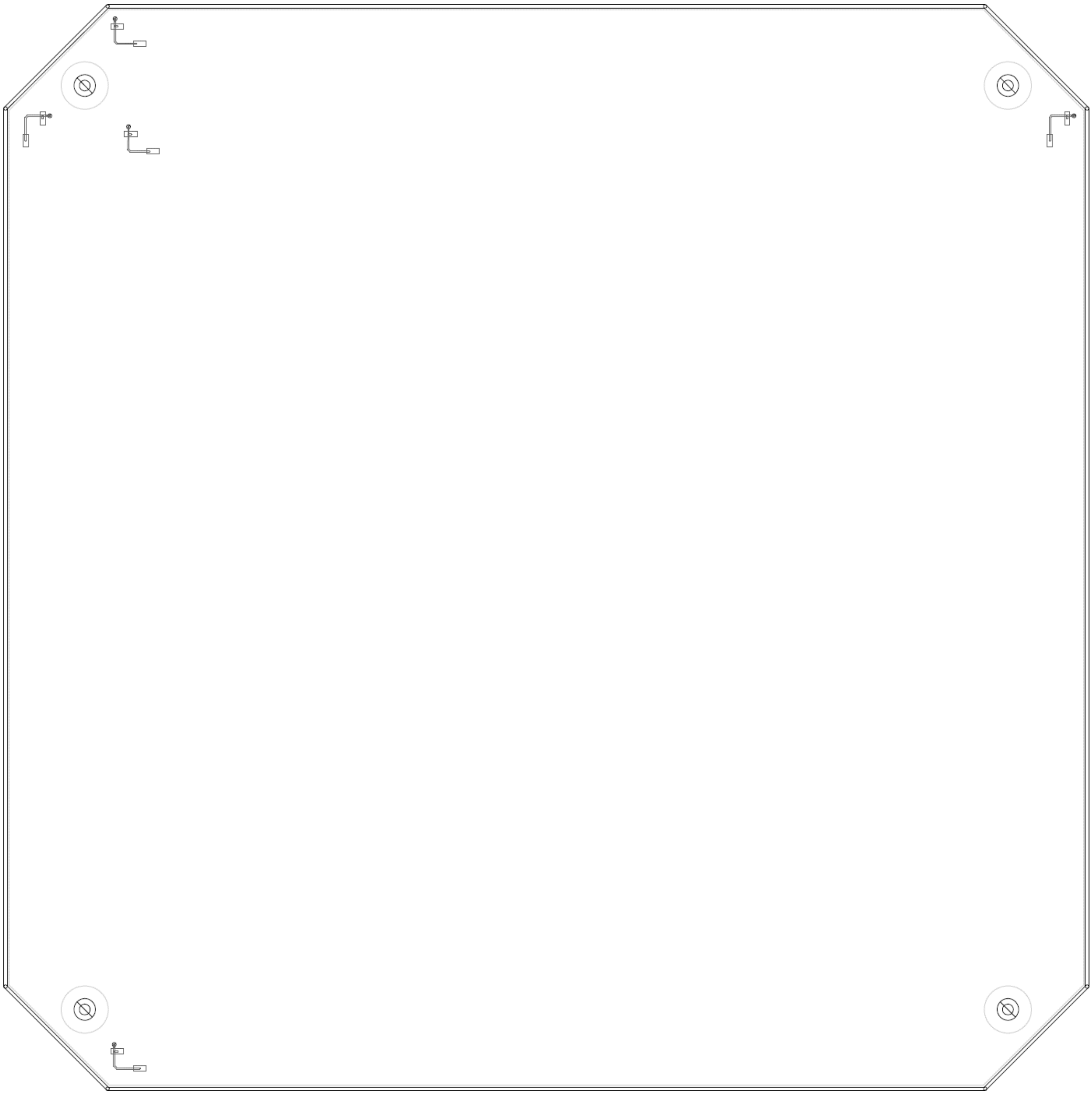


**Figure 7-9 Component Side Pattern (top view)**

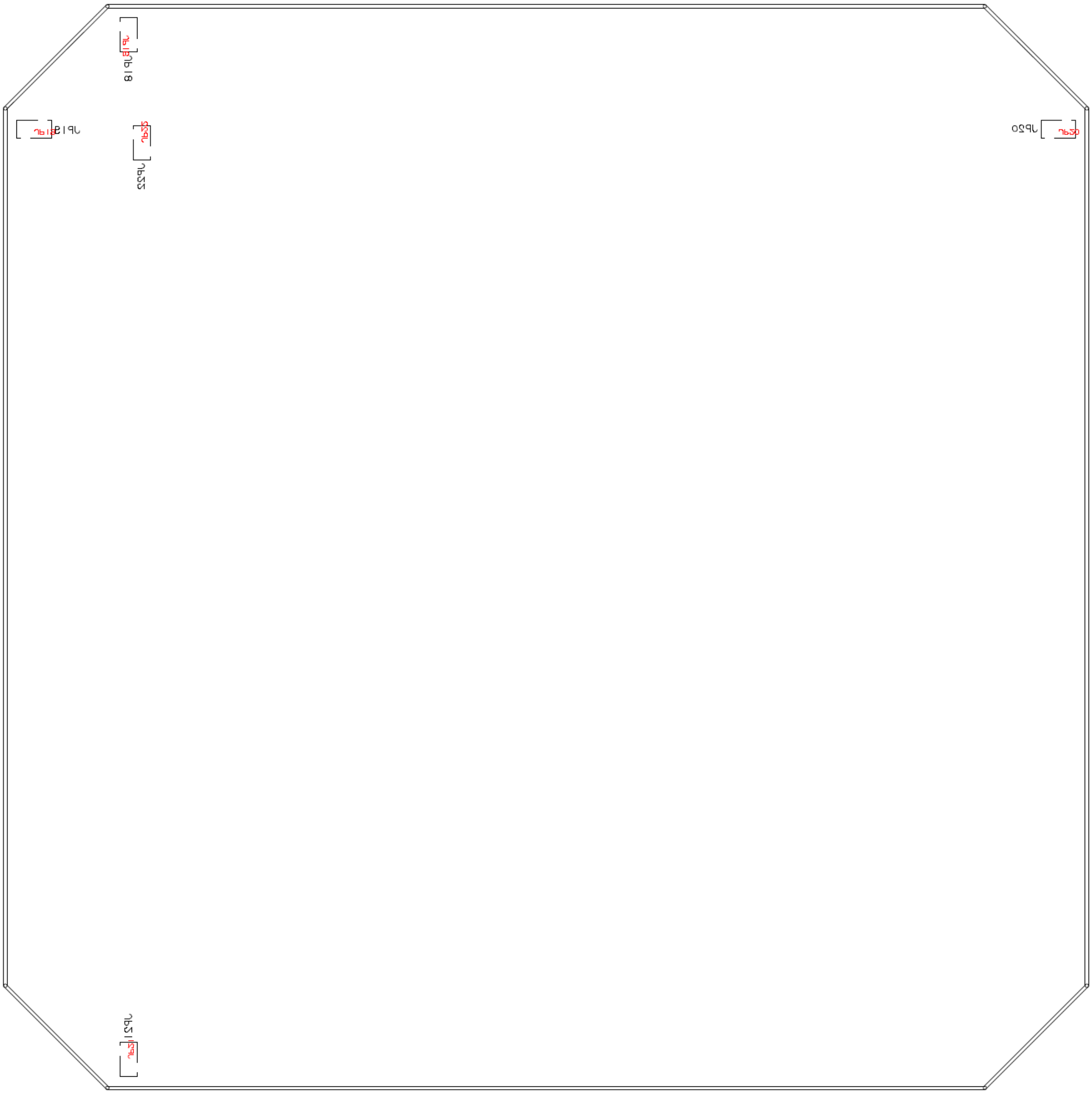


**Figure 7-10 Component Side Silkscreen (top view)**

## 7.3 Relay Board

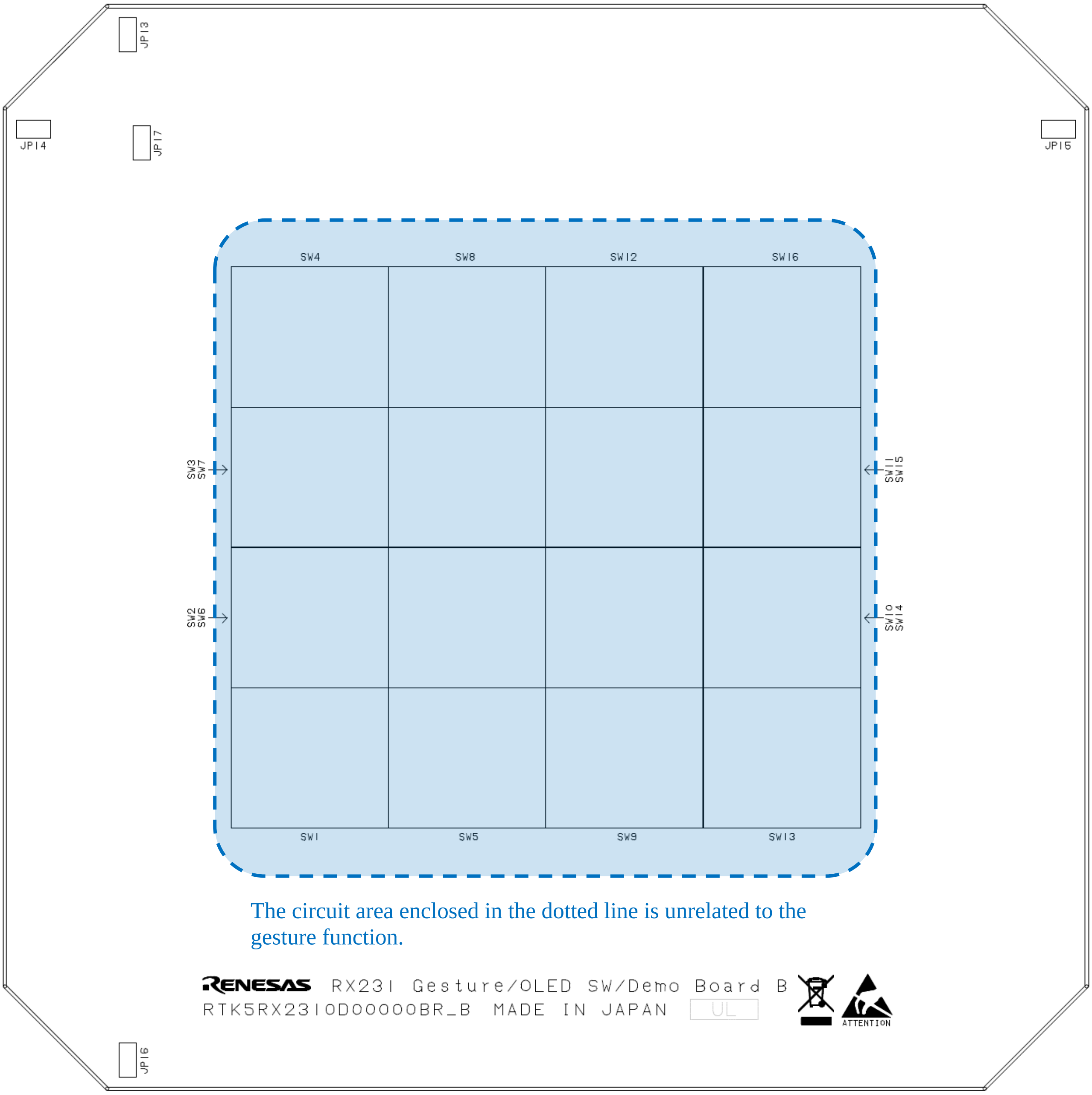



**Figure 7-11 Component Side Silkscreen (top view, SW1 to SW16 not used)**

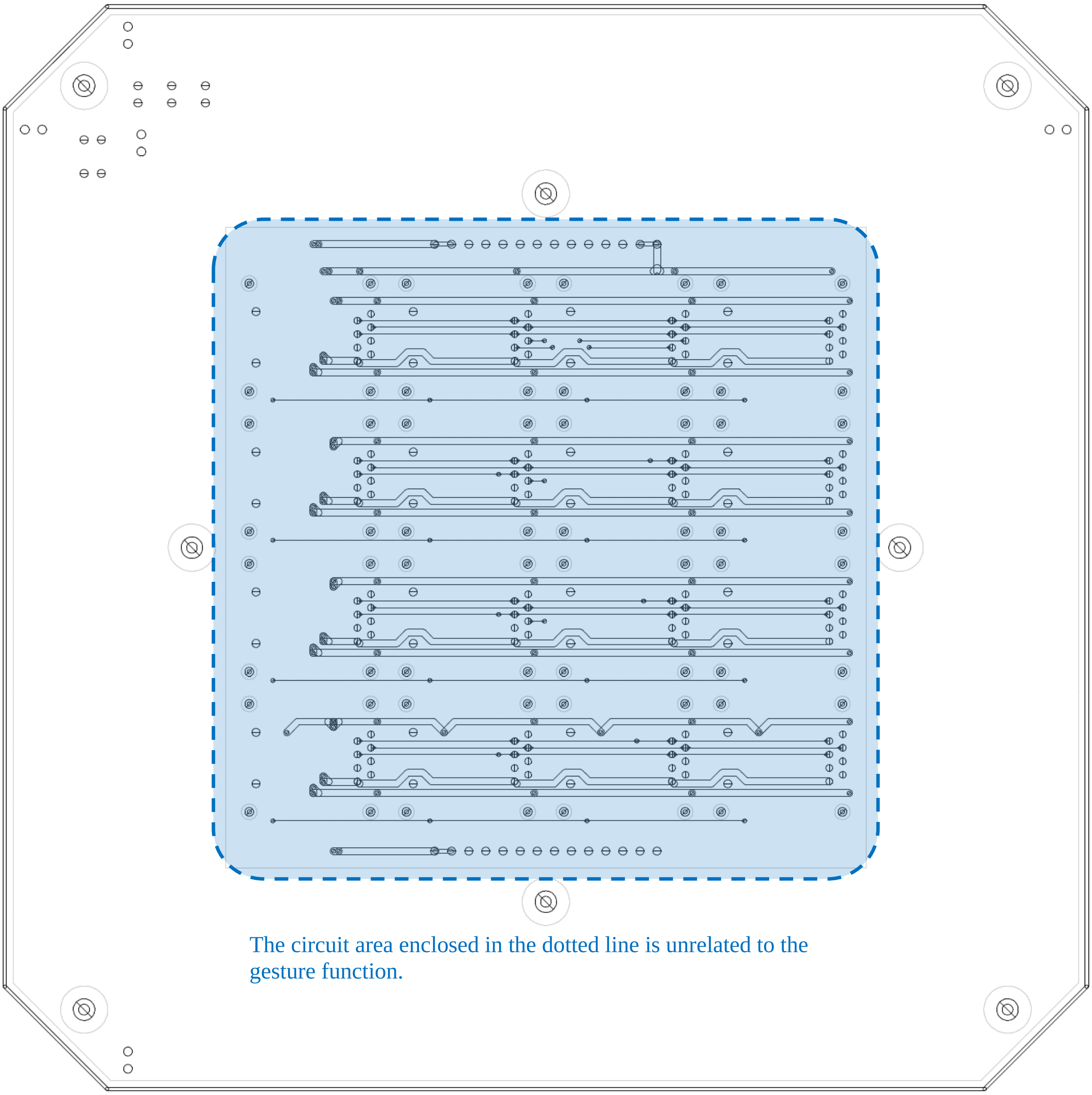



**Figure 7-12 Component Side Pattern (top view)**

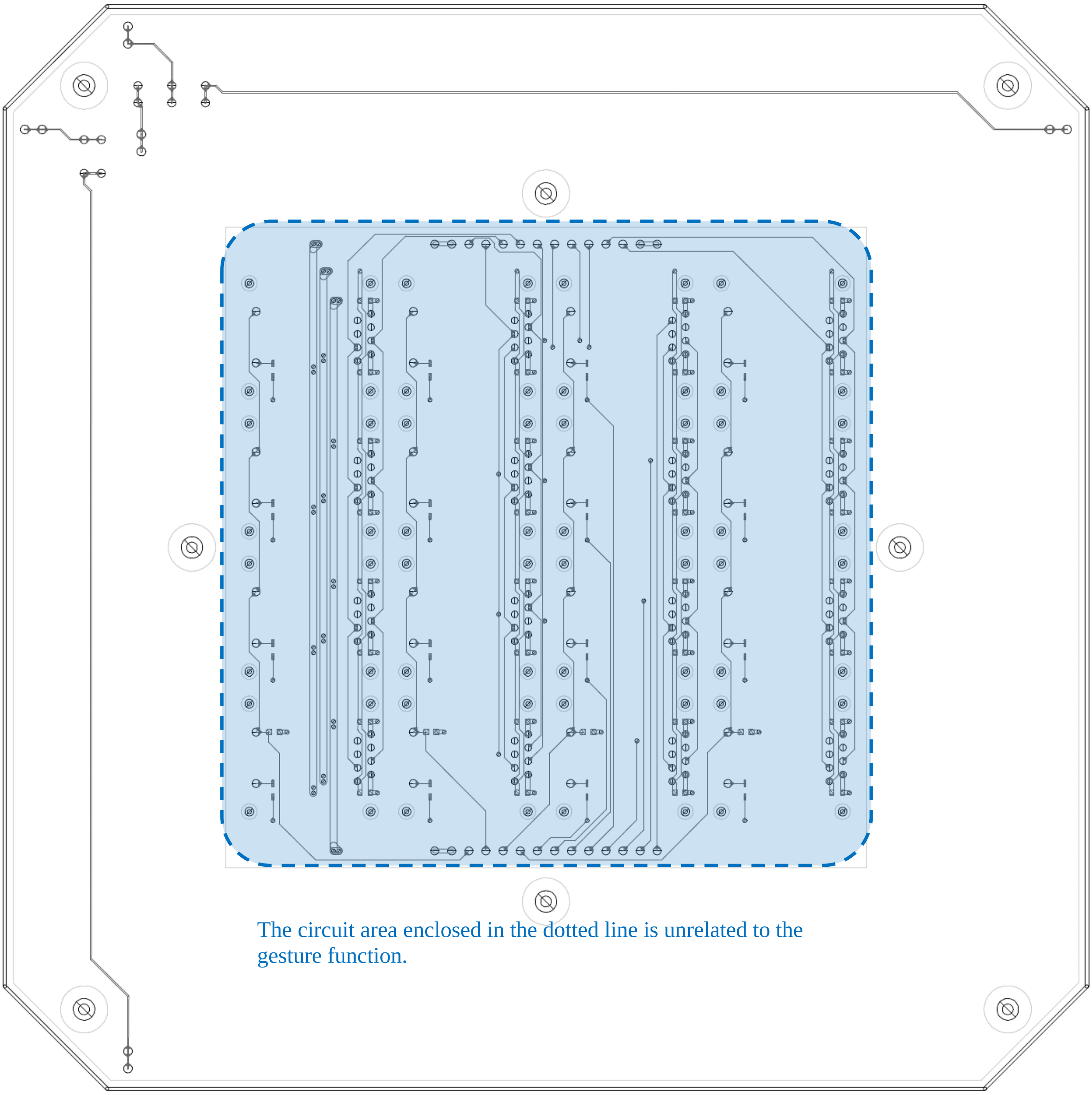
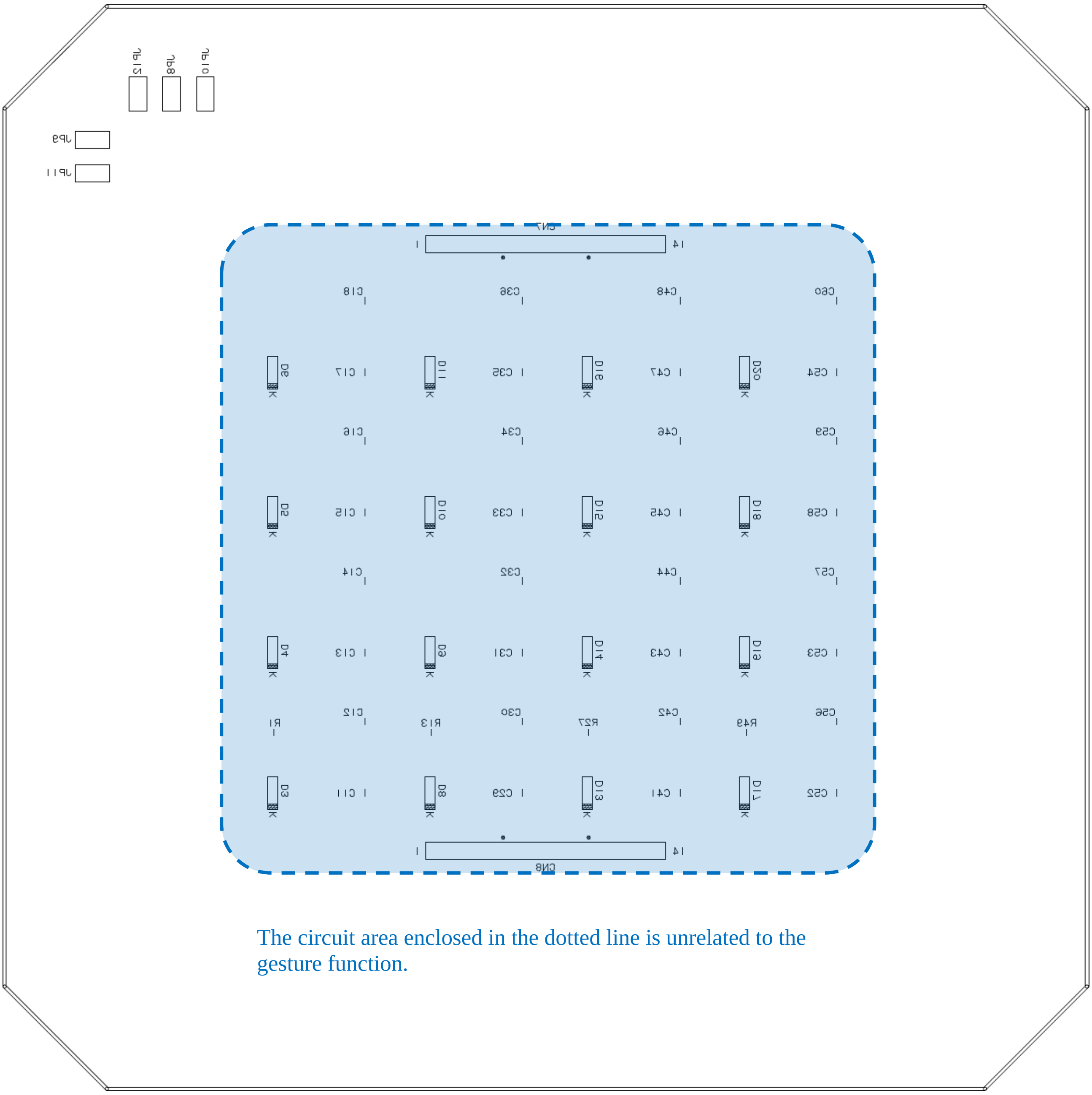



**Figure 7-13 Solder Side Pattern (top view)**



The circuit area enclosed in the dotted line is unrelated to the gesture function.

**Figure 7-14 Solder Side Silkscreen (top view, jumpers other than JP8 to JP12 are not used)**

# 8. EMC Countermeasure Examples

Detection of 3D gestures uses linear data sampled at regular time intervals. Therefore, unlike switches that only judge two values, i.e. ON/OFF, EMC countermeasures for 3D detection is difficult because a noise margin cannot be secured.

In this demo set, countermeasures are implemented from both hardware and software standpoints. This document describes examples of hardware-based countermeasures.

Required noise immunity and countermeasures differ depending on user system specifications. The countermeasure shown here are just a few examples and may not applicable to all systems. When implementing countermeasures, please carry out thorough evaluations on your product system.

## 8.1 Power Input Section Filter

In this demo set, the filter circuit shown in Figure 8-1 is added to suppress noise input and output from the power cable during EMC evaluation.

## 8.2 Metal Plate Shielding

For EMC evaluation, this demo set is shielded with the metal plate shown in Figure 8-1 to improve the coupling between the ground (earth) and the MCU board GND as well as strengthen the GND.

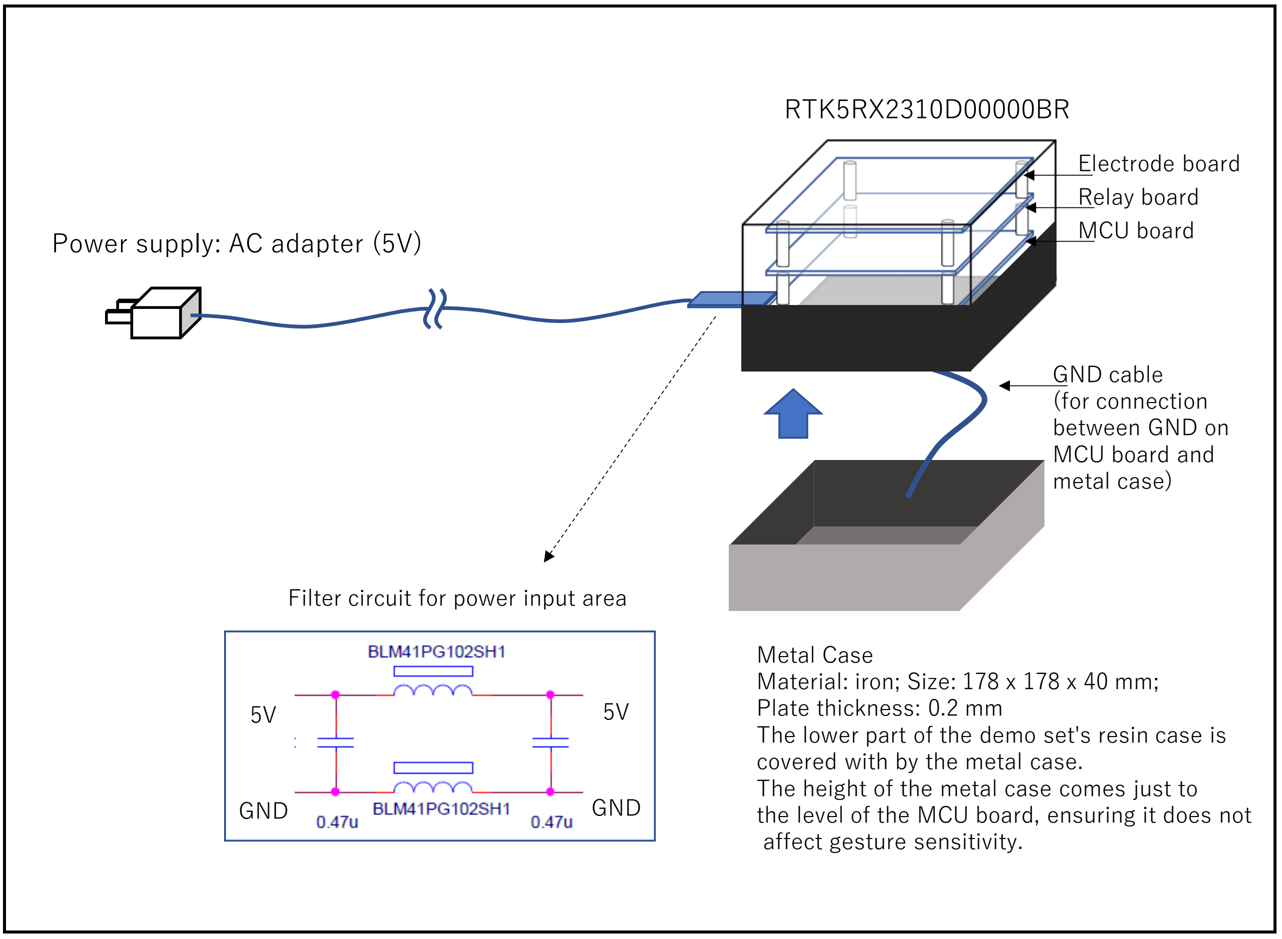



**Figure 8-1 EMC Countermeasure Example**

## Website and Support

Renesas Electronics Website
http://www.renesas.com/

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## Revision History

| Rev. | Date | Description | |
|---|---|---|---|
| | | Page | Summary |
| 1.00 | Jan 16, 2018 | | 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. 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 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 a product with a different part number, confirm that the change will not lead to problems.

   — The characteristics of Microprocessing unit or Microcontroller unit products in the same group but having a different part number may differ in terms of the 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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