

RX130 Group

Touchless Button Electrode Board Sample Software

Introduction

This Application Note describes the Touchless Button Electrode Board sample software as an application example of the self-capacitance method used in Capacitive Touch Sensor Unit (CTSU) hardware. CTSU detects human touch by measuring the electrostatic capacitance generated between the touch electrode and the human body.

Target Device

RX130 Group

Related Documents

1. RX Family Development of Capacitive Touch Applications using QE and FIT (R01AN4516)
2. RX Family Firmware Integration Technology User's Manual (R01AN1833)
3. RX Family Board Support Package Module Firmware Integration Technology (R01AN1685)
4. RX Family QE Touch Module Firmware Integration Technology (R01AN4470)
5. RX Family QE CTSU Module Firmware Integration Technology (R01AN4469)
6. Capacitive sensor Microcontrollers Touchless Button Electrode Board (R12AN0115)
7. RX130 Group RX Capacitive Touch Evaluation System CPU Board User's Manual (R12UZ0003)

Contents

1. Overview	3
2. Operating Environment.....	5
3. Software Structure	6
4. File Structure	7
5. Sample Application	8
5.1. Overview of Operation.....	8
5.2. Touch Interface Configuration	9
5.3. Change of Tuning Value.....	10
5.3.1. Change of Drive Pulse Frequency	10
5.3.2. Change of Threshold Value.....	10
5.4. LED Turn On	12
5.5. Sound Output	13
Revision History	14

1. Overview

This Application Note describes the sample software that runs on the touchless button electrode board based on capacitive touch detection.

This software is provided in e2studio project format including the sample application.

The file structure is the same as that of a general touch button using QE for Capacitive Touch (hereafter QE), which is a development support tool for capacitive touch sensor application, and FIT module.

A general touch button is tuned with QE while a finger is touching the electrode. On the other hand, the touchless button is set with QE tuning while a finger is hovered above the electrode. Appropriate tuning can be made when the used jig is fixed, or otherwise the threshold values can be set by correcting QE output file. This software is set with the latter.

For the specification of the touchless button electrode board, please refer to the related document, 'Capacitive Sensor Microcontrollers Touchless Button Electrode Board (R12AN0115)'.

There are 2 types of touchless button electrode boards, with housing type and without housing type. Figure 1.1 shows each type of board connected to the CPU board.

The sample software is configured with standard settings with housing for 3 types: 4 buttons, 9 buttons, and 12 buttons.

For standard settings with housing, please refer to '2.1 Product Configuration (with housing)' of 'Capacitive Sensor Microcontrollers Touchless Button Electrode Board (R12AN0115)'.

For configuration with non-standard settings with housing or configuration without housing, please retune the project for each electrode.



Figure 1.2 Touchless Button Electrode Board (Left: with housing, Right: without housing)

As shown in Figure 1.3, the touchless button electrode board is configured so that the electrodes of the touch detection board can be replaced. The touch electrodes are attached to the back of the acrylic plate and touch is judged based on the detected count value with hand approach.

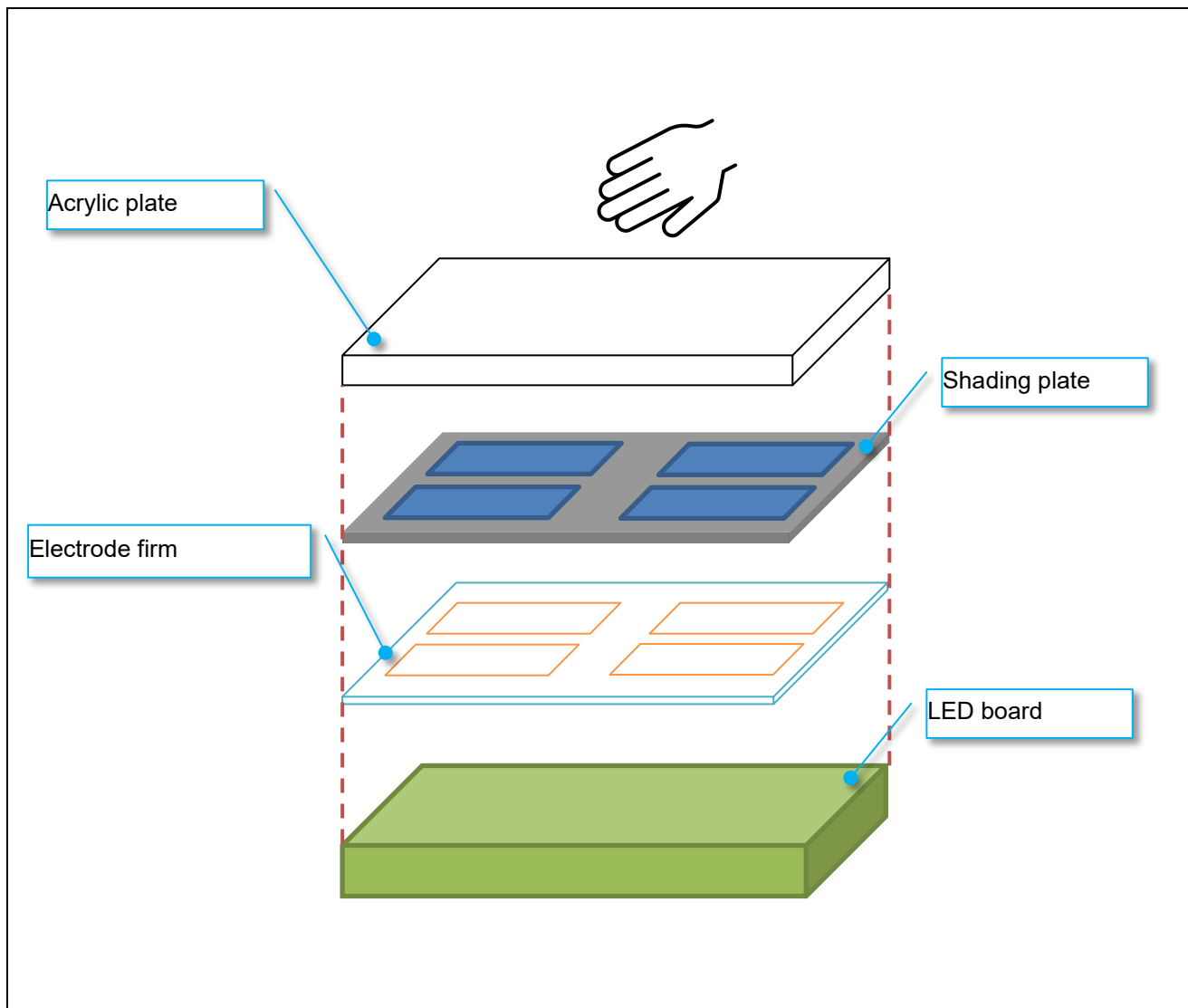


Figure 1.4 Touchless Button Electrode Board Configuration

2. Operating Environment

Table 2.1 and 2.2 show the software operating environment with/without housing, respectively.

Table 2.3 Operating Environment 1

Item	Description
CPU Board	RX130 Group RX Capacitive Touch Evaluation System CPU Board (RTK0EG0004C01002BJ)
Electrode Board	Touchless Button Electrode Board (with housing) (RTK0ES1001D01001BJ)
Microcontroller	RX130
Operating frequency	32 MHz
Operating voltage	5.0 V
Integrated Development Environment	e ² studio Version: 2020-07 (20.7.0)
C compiler	CC-RX V3.03.00
Capacitance touch IDE	QE for Capacitive Touch V1.1.0

Table 2.4 Operating Environment 2

Item	Description
CPU Board	RX130 Group RX Capacitive Touch Evaluation System CPU Board (RTK0EG0004C01002BJ)
Electrode Board	Touchless Button Electrode Board (w/o housing) (RTK0ES1001D02001BJ)
Microcontroller	RX130
Operating frequency	32 MHz
Operating voltage	5.0 V
Integrated Development Environment	e ² studio Version: 2020-07 (20.7.0)
C compiler	CC-RX V3.03.00
Capacitance touch IDE	QE for Capacitive Touch V1.1.0

3. Software Structure

Figure 3.1 shows the software structure.

QE Touch FIT module detects touch from the electrostatic capacitance measurement results of QE CTSU FIT module.

The application informs the touch detection result to the user by LED light of the touchless button electrode board and sound output.

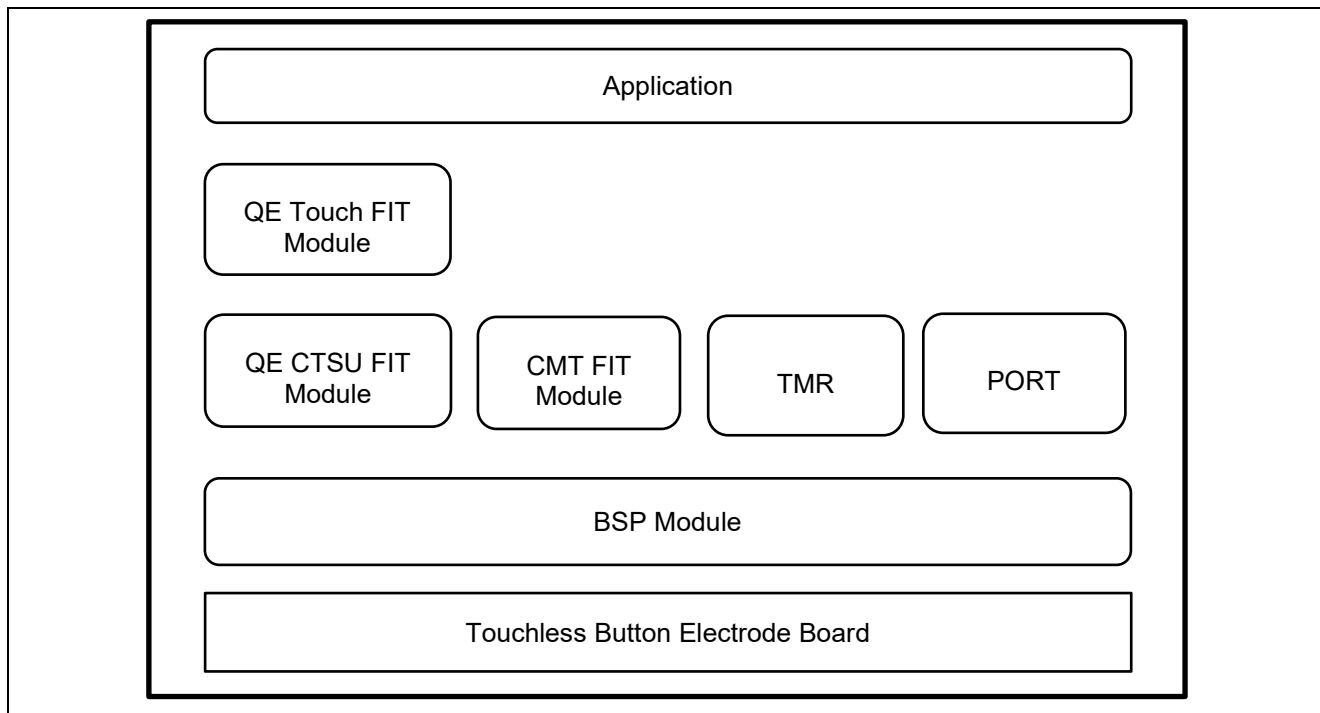


Figure 3.2 Software Structure

Table 3.1 shows the version of FIT modules and code generations which are used in this software.

Table 3.2 Version of FIT and Code Generation

FIT Module	Version
BSP	5.61
CTSU	1.11
Touch	1.11
CMT	4.70
Code generation	Version
Port	2.0.2
8bit timer	1.7.0

4. File Structure

Table 4.1 shows the file structure of this software and the changes from Smart Configurator generation file. The FIT modules are not changed. For FIT modules, please refer to each Application Note.

Table 4.2 File Structure

Folder/File Name	Changes
Project	-
src	-
qe_common.c	-
qe_common.h	-
qe_config01.c	Adjustment of the tuning value
qe_config01.h	Adjustment of the tuning value
main.c	Sample application
smc_gen	-
Config_PORT (File structure omitted)	-
Config_TMR0	-
Config_TMR0.c	-
Config_TMR0.h	LED application
Config_TMR0_user.c	LED application
Config_TMR1	-
Config_TMR1.c	-
Config_TMR1.h	-
Config_TMR1_user.c	Sound output application
general (File structure omitted)	
r_bsp (File structure omitted)	
r_cmt_rx (File structure omitted)	
File structure omitted	
r_ctsu_qe (File structure omitted)	
r_pincfg (File structure omitted)	
r_touch_qe (File structure omitted)	

5. Sample Application

The following describes the sample application.

5.1. Overview of Operation

Figure 5.1 shows the operation overview of this software.

1. After power-on, start initialization.
2. When the offset tuning is completed normally, the LED turns on for 1 sec according to the electrode configuration, then turns off. (When it is completed abnormally, the LED keeps blinking until reset.)
3. After the LED turns off, the touch measurement loop starts to judge touch.
4. When touch is detected, the LED turns on and sound is output. For LED turn on, refer to '5.4 LED Turn On'. For sound output, refer to '5.5 Sound Output'.

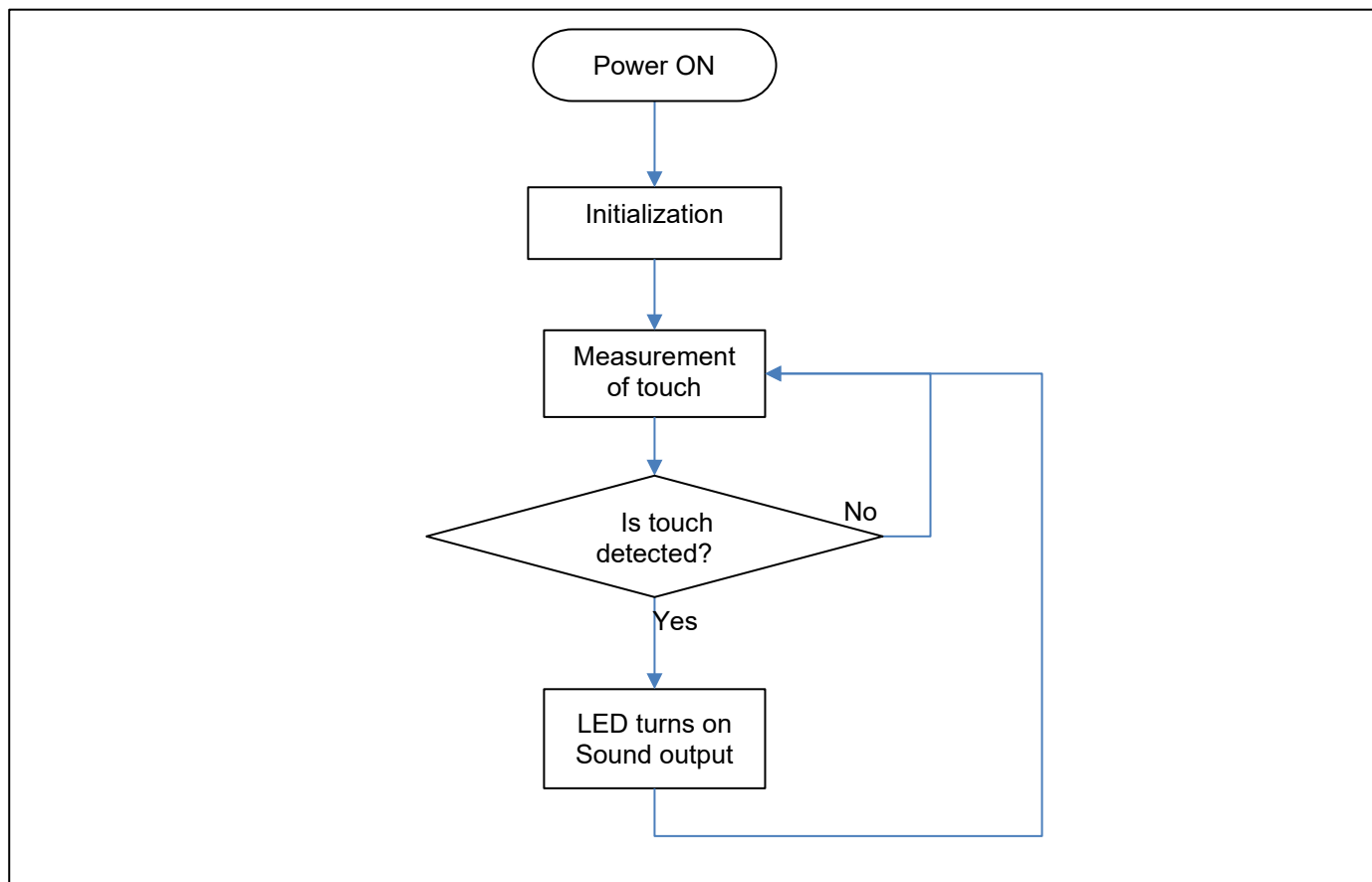


Figure 5.2 Overview of Operation

5.2. Touch Interface Configuration

Figure 5.3 shows the settings of TS pins of this software.

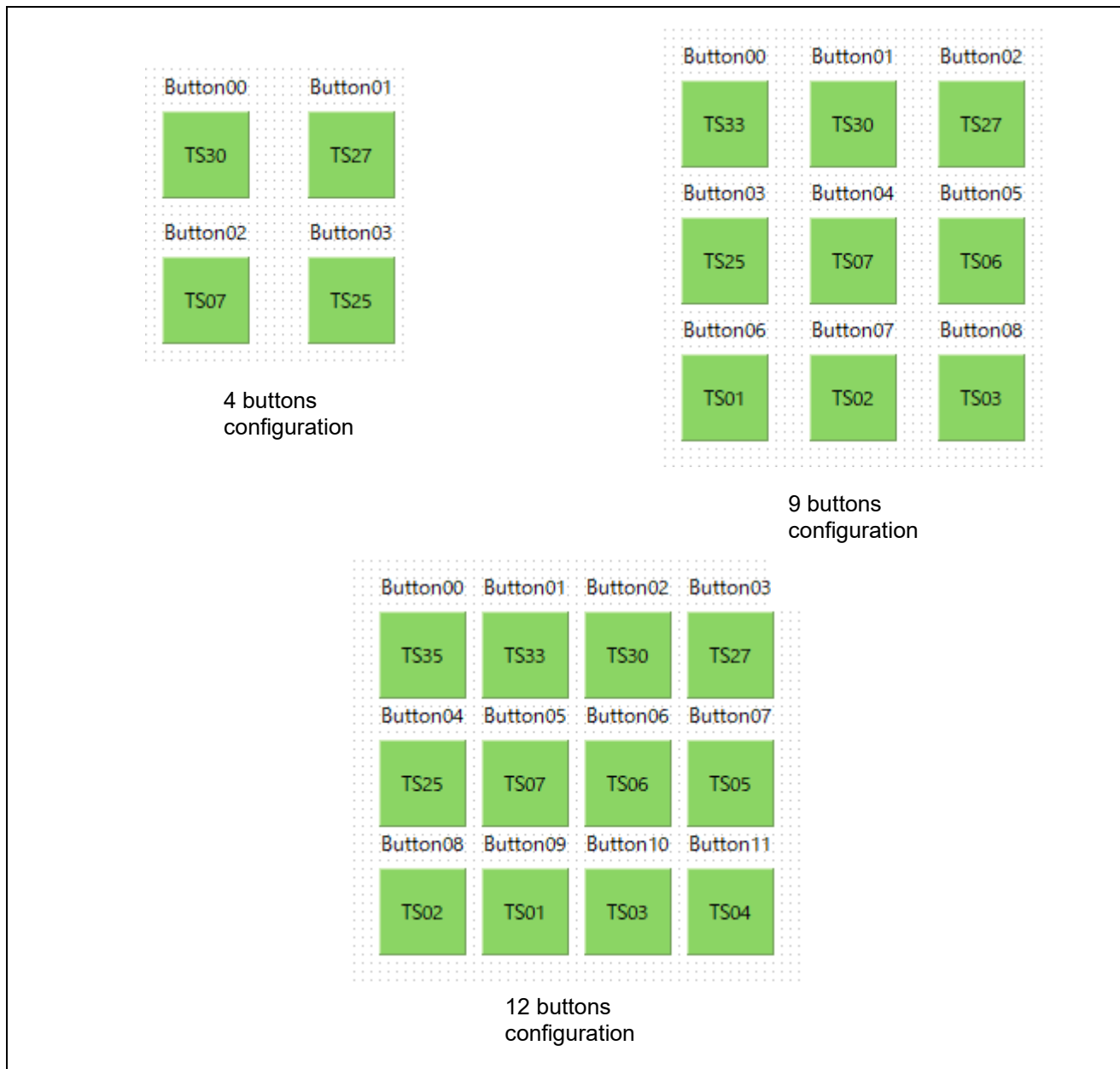


Figure 5.4 Touch Interface Configuration

5.3. Change of Tuning Value

5.3.1. Change of Drive Pulse Frequency

The parasitic capacitance of the touchless button electrode board differs for each electrode. Therefore, the drive pulse frequency is set differently for each electrode by auto-adjustment of QE tuning.

As the different drive pulse frequency makes a difference in sensitivity, the drive pulse frequency is fixed at 2MHz in this sample software.

To fix the drive pulse frequency, use 'Advanced Configuration' of QE. Specifically, check 'Enable Advanced Configuration' before QE tuning, then select 'Start Tuning' of the 'Setup CTSU Sensor Drive Pulse Frequency' to go to the screen where you can set the drive pulse frequency. Change the drive pulse frequency of each TS pin to 2MHz there and start tuning.

5.3.2. Change of Threshold Value

The threshold values and hysteresis of QE output file `qe_config01.h` are changed in this sample software.

As the threshold values are fixed, the touch detection distance differs for each electrode.

Table 5.1, 5.2, and 5.3 list the constant name and setting value changed for each electrode configuration, and the touch detection distance of the electrode.

Table 5.4 Changed Variable and Touch Detection Distance (4 buttons)

Constant name	Setting value	Touch detection distance	
		One finger (mm)	Palm (mm)
CONFIG01_BUTTON00_THR_OFFSET	600	20	40
CONFIG01_BUTTON00_HYS_OFFSET	30		
CONFIG01_BUTTON01_THR_OFFSET	600		
CONFIG01_BUTTON01_HYS_OFFSET	30		
CONFIG01_BUTTON02_THR_OFFSET	600		
CONFIG01_BUTTON02_HYS_OFFSET	30		
CONFIG01_BUTTON03_THR_OFFSET	600		
CONFIG01_BUTTON03_HYS_OFFSET	30		

Table 5.5 Changed Variable and Touch Detection Distance (9 buttons)

Constant name	Setting value	Touch detection distance	
		One finger(mm)	Palm(mm)
CONFIG01_BUTTON00_THR_OFFSET	600	10	15
CONFIG01_BUTTON00_HYS_OFFSET	30		
CONFIG01_BUTTON01_THR_OFFSET	600		
CONFIG01_BUTTON01_HYS_OFFSET	30		
CONFIG01_BUTTON02_THR_OFFSET	600		
CONFIG01_BUTTON02_HYS_OFFSET	30		
CONFIG01_BUTTON03_THR_OFFSET	600		
CONFIG01_BUTTON03_HYS_OFFSET	30		
CONFIG01_BUTTON04_THR_OFFSET	600		
CONFIG01_BUTTON04_HYS_OFFSET	30		
CONFIG01_BUTTON05_THR_OFFSET	600		
CONFIG01_BUTTON05_HYS_OFFSET	30		
CONFIG01_BUTTON06_THR_OFFSET	600		
CONFIG01_BUTTON06_HYS_OFFSET	30		
CONFIG01_BUTTON07_THR_OFFSET	600		
CONFIG01_BUTTON07_HYS_OFFSET	30		
CONFIG01_BUTTON08_THR_OFFSET	600		
CONFIG01_BUTTON08_HYS_OFFSET	30		

Table 5.6 Changed Variable and Touch Detection Distance (12 buttons)

Constant name	Setting value	Touch detection distance	
		One finger(mm)	Palm(mm)
CONFIG01_BUTTON00_THR_OFFSET	600	10	12
CONFIG01_BUTTON00_HYS_OFFSET	30		
CONFIG01_BUTTON01_THR_OFFSET	600		
CONFIG01_BUTTON01_HYS_OFFSET	30		
CONFIG01_BUTTON02_THR_OFFSET	600		
CONFIG01_BUTTON02_HYS_OFFSET	30		
CONFIG01_BUTTON03_THR_OFFSET	600		
CONFIG01_BUTTON03_HYS_OFFSET	30		
CONFIG01_BUTTON04_THR_OFFSET	600		
CONFIG01_BUTTON04_HYS_OFFSET	30		
CONFIG01_BUTTON05_THR_OFFSET	600		
CONFIG01_BUTTON05_HYS_OFFSET	30		
CONFIG01_BUTTON06_THR_OFFSET	600		
CONFIG01_BUTTON06_HYS_OFFSET	30		
CONFIG01_BUTTON07_THR_OFFSET	600		
CONFIG01_BUTTON07_HYS_OFFSET	30		
CONFIG01_BUTTON08_THR_OFFSET	600		
CONFIG01_BUTTON08_HYS_OFFSET	30		
CONFIG01_BUTTON09_THR_OFFSET	600		
CONFIG01_BUTTON09_HYS_OFFSET	30		
CONFIG01_BUTTON10_THR_OFFSET	600		
CONFIG01_BUTTON10_HYS_OFFSET	30		
CONFIG01_BUTTON11_THR_OFFSET	600		
CONFIG01_BUTTON11_HYS_OFFSET	30		

5.4. LED Turn On

The LED is mounted on the LED board and lights up the location of the touched electrode according to the button configuration of 4 buttons/9 buttons/12 buttons.

Figure 5.5 shows the correspondence of the LED control ports and each electrode.

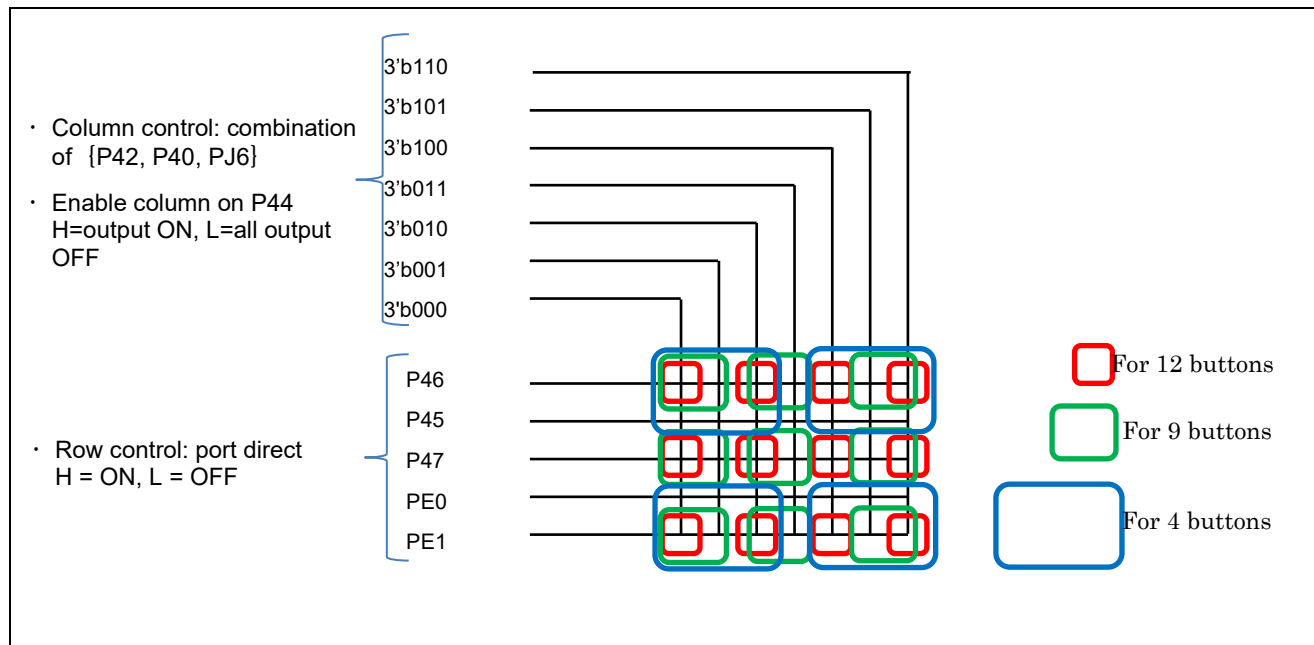


Figure 5.6 Correspondence of LED Control Ports and Each Electrode

The LED control port consists of a 5 x 7 matrix as Figure 5.7, and it is realized by dynamic lighting using the timer.

Touch judgement is executed at a touch measurement cycle of 20ms interval, and the touch status is stored with `R_TOUCH_GetAllBtnStates()` in the global variable.

The above global variable is checked with interrupt of the timer for LED dynamic lightning, and only the LED of the button with touch judgement turns on.

Code is added to the user code area of `Config_TMR0_user.c`.

Table 5.7 shows the settings of the LED lightning timer.

Table 5.8 Settings of LED Lightning Timer

Timer	Timer cycle	Board switching count	Total cycle
8bit timer	250us	7	1750us

5.5. Sound Output

The buzzer is mounted on the LED board and outputs sound according to touch.

There are 2 ports for sound output, and PD2 is used in this sample software.

The sound is output from the buzzer by repeating H/L from the port at the specific frequency (523Hz, at which a music scale C is output) for a certain period of time. The timer is used for H/L output.

Same as LED turn on, the global variable is checked with the timer interrupt and the sound is output. The sound is the same at all buttons.

Code is added to the user code area of Config_TMR1_user.c.

Table 5.9 shows the settings of the sound output timer.

Table 5.10 Settings of Sound Output Timer

Timer	Timer cycle	H/L cycle
8bit timer	956us	1912us

Revision History

Rev.	Date	Description	
		Page	Summary
1.00	2021.5.6	-	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.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.
5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
6. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.

"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.

7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION ("Vulnerability Issues"). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.
8. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.5.0-1 October 2020)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
www.renesas.com/contact/.